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Henry Radio

Where superb amateur equipment points the way to tomorrow's technology in high reliability R.F. equipment for commercial, industrial, medical, military, scientific research applications.

More than half a century in the communications business has made Henry Radio a tradition, and our original commitment to the amateur radio fraternity is no less important today than it was then. Over these many years our products and services have expanded to include a complete line of superb quality high power HF linear amplifiers and solid state VHF and UHF amplifiers. Our own Tempo line of synthesized handhelds for amateur use at 144, 220 and 440 MHz has now expanded to include commercial channelized handhelds and solid state amplifiers, all FCC type accepted. We are also a major manufacturer of a broad line of industrial and medical RF power supplies and plasma generators providing reliable continuous duty HF and VHF in the power range of 500 to 10,000 watts.

If your requirements fall into any of these areas Henry Radio may have just what you're looking for. We guarantee to provide the same personal service and superior products that has enabled us to serve the free world's communications needs for 53 years. The name "HENRY" has always symbolized quality, reliability, responsibility and service. What more can we say? Tell us how we can help you with your communications and R.F. power requirements.
The perfect addition to any amateur radio installation! Complete, automatic send/ receive of Morse code (Cw) Baudot code (RTTY) and ASCII code (RTTY). Works with any video monitor.

7-Channel Battery Back-Up Memory, the Theta 7000E has seven keyboard-selectable, non-volatile, random access memory channels each of which can hold 64 characters. Data in these memories is alterable at any time and is retained when power is removed. Messages in these memory channels can be repeated 1 to 9 times via keyboard command. All channels may be daisy-chained for continuous read-out.

Self Contained Demodulator, three-step shift selects either 170 Hz, 425 Hz or 850 Hz shift with manual fine tune control of space channel for odd shifts. High/low tone pair select. Mark only or space only copy capability for selective fading.

CONVENIENT KEYBOARD FEATURES, automatic keyboard-operated transmit, (KX) or manual keyboard transmit. Unshift on space, reverts to LETTERS case after reception of each space character in Baudot code. CRULF is automatically inserted every 60, 72 or 80 characters while transmitting. Cw identification, in RTTY mode Echo function, prerecorded cassette tapes can be read and transmitted. Test messages, "RY" and "QBF" Transmit word mode, characters can be transmitted in word groupings.

Model 7000 Drake Theta 7000E Terminal $1095.00
Model 7009 Drake TR-930 Video Monitor $ 185.00

Crystal Controlled AFSK Modulator:

| High Tone Pairs | Shift   | 170 Hz | 425 Hz | 850 Hz |
|                 | Mark    | 2125   | 2125   | 2125   |
|                 | Space   | 2295   | 2550   | 2975   |

| Low Tone Pairs  | Shift   | 170 Hz | 425 Hz | 850 Hz |
|                 | Mark    | 1275   | 1275   | 1275   |
|                 | Space   | 1445   | 1700   | 2125   |

- Printer Interface for Hard Copy, all modes for parallel ASCII printers.
- Loop keyer for conventional teleprinters.
- Composite Video Output, for any standard video monitor.
- Kansas City Standard AFSK Output, KC5 tone pair for ASCII.
- Large Capacity Display Memory, two page display memory contains 32 x 16 lines per page.
- Split-Screen, with a keyboard command, the display can be divided into two, the upper half for transmit and the lower half for receive. Messages can be composed while receiving.
- Buffer Memory, 53 character type-ahead keyboard buffer.
- Word Wrap-Around, in receive mode, word wrap-around prevents the last word on a line from becoming split in two. Moves whole word to next line.
- Automatic Letters Code Insertion, if desired.
- LETTERS (diddle) code can be transmitted continuously in a pause of transmitting from the keyboard.
- Audio Monitor, a built-in audio monitor circuit with automatic transmit/receive switching enables checking of the transmit/receive tones.
- Transmitter Keying Circuitry, keys either grid block, cathode keyed, or solid-state transmitters.
- Power Requirement, The Theta 7000E requires only 13.6 Vdc @ 1 amp. Plugs into 13.6 Vdc accessory jack on PS7 or PS75 power supplies.
- Effective Packaging for RFI Protection, well designed metal cabinet and protective circuits prevent RFI.
- Terminal Size: 15.8" W x 11.8" D x 4.7" H (40 x 30 x 12 cm) • Weight: 11 lbs (5 kg) • Monitor Size: 8.7" W x 9.8" D x 8.9" H (22 x 24 x 22.6 cm) • Weight: 11 lbs (5 kg)

LA7 Line Amplifier $49.95 Suggested List

Line output, input levels as low as 15 mV rms (47 kohms) will result in an output of 1 mV nominal into a 600 ohm balanced line. Output level adjustable by internal pre-set level control. Interfaces low level audio to RTTY terminal unit or phone line that requires a 600 ohm balanced/unbalanced input. One 36" phono to phono cable supplied. • Size: 4.5" L x 1.3" H x 2.5" W (11.4 x 3.3 x 6.4 cm) • Weight: .3 lbs (.14 kg)

Specifications, availability and prices subject to change without notice or obligation.
THE FT-707 "WAYFARER"

The introduction of the "WAYFARER" by Yaesu is the beginning of a new era in compact solid state transceivers. The FT-707 "WAYFARER" offers you a full 100 watts output on 80-10 meters and operates SSB, CW, and AM modes. Don't let the small size fool you! Though it is not much larger than a book, this is a full-featured transceiver which is ideally suited for your home station or as a traveling companion for mobile or portable operation.

The receiver offers sensitivity of .25 µV/10 dB SN as well as a degree of selectivity previously unavailable in a package this small. The "WAYFARER" comes equipped with 16 poles of IF filtering, variable bandwidth and optional crystal filters for 600 Hz or 350 Hz. Just look at these additional features:

**FT-707 with Standard Features**
- Fast/slow AGC selection
- Advanced noise blanker
- Built-in calibrator
- WWV/JJY Band
- Bright Digital Readout
- Fixed crystal position
- Factory-installed WARC bands
- Unique multi-color bar metering—monitors signal strength, power output, and ALC voltage.

**FT-707 with Optional FV-707DM & Scanning Microphone**
- Choice of 2 rates of scan
- Remote scanning from microphone
- Scans in 10 cycle steps
- Synthesized VFO
- Selection of receiver/transmitter functions from either front panel or external VFO
- "DMS" (Digital Memory Shift)

Impressive as the "WAYFARER" is its versatility can be greatly increased by the addition of the FV-707DM (optional). The FV-707DM, though only one inch high, allows the storage of 13 discrete frequencies and with the use of "DMS" (Digital Memory Shift) each memory can be band-spread 500 KHz. These 500 KHz bands may be remotely scanned from the microphone at the very smooth rate of 10 Hz per step.

The FT-707 "WAYFARER" is a truly unique rig. See it today at your authorized Yaesu Dealer.
We asked for it and we sure got it. We’ve received a huge response to our survey in the May issue. It was designed to find out just who you our readers are, what your Amateur Radio interests are, what you think of the job we’re doing, and what changes if any you would like to see in the magazine as we continue to work to fine tune the combined ham radio/HORIZONS that we put together earlier this year.

The number of returns and the amount of information we’ve collected are virtually overwhelming. Not only did we get a tremendous response to the questionnaire itself, but we also received a large number of thoughtful and very helpful letters from readers who felt that the necessarily limited questions we had asked did not give them enough of an opportunity to properly express themselves. We have already put many days of effort into trying to reduce this information into a useful and meaningful form. It isn’t enough just to come up with the raw percentages of answers given to each question. We are putting a good deal of effort into cross-tabulating this data in order that we may learn just why those who like what we’re doing feel that way, and why those who think we’re going astray hold their opinion.

Many of the answers came out much as we had expected. Former HORIZONS readers missed their old magazine, but were increasingly satisfied with the changes we have been making, while some former ham radio readers lamented the changes to their favorite magazine. At the same time many offered constructive ideas as to what they would like to see in the magazine. Perhaps the most exasperating part has been the several features which seem to show up at both extremes of reader opinion. One group of readers will list a feature as most disliked while a similar sized group think the same item is the best part of the magazine.

It was very interesting to find out just who our typical readers are. For instance, we learned that engineers and technically employed people were the largest single active job category among former HORIZONS readers. We expected this from ham radio readers, but it came as quite a surprise to find out that 45 percent of all our readers are in that category.

By now you are probably wondering just how our report card came out. Have we been doing a good job or haven’t we since combining our two magazines into one publication? Well 56 percent said that they like us as much or even better than before, while 44 percent preferred our previous approach, when we were publishing two separate magazines. And even among those who preferred our previous approach, very nearly half listed the new ham radio as their favorite Amateur Radio publication. These figures represent a great number of loyal readers.

Although not as high as we might like, these numbers do offer us very real encouragement. We’re looking very carefully at the group who feel the new magazine is not as much to their liking as before and we’ll be trying to offer a bit more to them while at the same time continuing to appeal to those who say we’re doing just fine now.

Although we are far from having completely digested all of what you’ve told us, we are going to begin responding to your stated preferences by running a number of articles which will be a bit more in the traditional ham radio mold — although whenever possible we will try to edit them so that the reader who is technically less sophisticated can also learn a lot from them. Every reasonable effort shall be made to maintain ham radio’s pre-eminent technical reputation, while at the same time we maintain the greater balance we feel we’ve given to ham radio in recent months.

While we’re on the subject of new features, it is with a great deal of pleasure that we direct your attention to a new series of license-upgrading articles by Robert L. Shrader, W6BNB, which starts in this issue. He is the author of the extremely popular license text Electronic Communication, which is by far the most thorough study guide in print for all FCC exams, both Commercial and Amateur. Bob’s very complete yet easy to understand way of presenting material has led to many, many successful exam papers. His new series here in ham radio will add to that reputation I am sure. In fact, even many of you who are not in the process of upgrading will find this review of the technical basics valuable. Even our staff has been learning from Bob.

We’ve still got quite a way to go in evaluating and learning from the data you’ve given us (in fact we’re still receiving over 25 replies each week), but when it’s all over I think all of us, readers and editors, will find this time taken to reflect on where we stand and where we are going to have been very well spent. I’d personally like to thank all of you who have helped make this survey so successful. We have what we feel is the best magazine in Amateur Radio and we want to do everything we can to strengthen and further solidify that position.

Skip Tenney, W1NLB
ICOM VHF Mobile
Amateur Communications using Space Age Techniques

ICOM's smallest 2 meter FM mobile, the IC-25A offers extremely compact size (5½” x 2” x 7” deep) without sacrificing features: 25 watts, 5 memories, 2 scanning systems, priority channel, 2 VFO's and touchtone™ HM-8 microphone standard.

The best 2 meter multimode mobile on the market today, the IC-290A has features to make multimode mobile a snap. 2 VFO's, 5 memories, priority channel, memory and band scanning, squelch on SSB, selectable AGC and NB, and RIT. Touchtone™ encoding provided with HM-8 microphone standard.

6 meter mobile at its best with the IC-560, a multimode mobile transceiver for working FM repeaters or sideband simplex, local or DX, 3 memories, 2 VFO's, scanning, squelch on SSB.

Sensible and affordable, the IC-22U offers simplicity with ease of operation. Easy to use push buttons for up and down tuning. 800 channels at the push of a button. 4 MHz coverage. EX-199 optional removable frequency selector.

2112-116th Avenue NE, Bellevue, WA 98004/3331 Towerwood Drive, Suite 307, Dallas, TX 75234

All stated specifications are approximate and subject to change without notice or obligation. All ICOM radios significantly exceed FCC regulations limiting spurious emissions.
on-air tune-up

Dear HR:

I enjoy Bob Locher’s DX stories, but he certainly does not set a good example for the young aspiring DXer. Bob says, "'OK Jerry, I hear him. Thanks a lot.' I move my VFO a couple of kHz above him and start tuning. The linear plate current, grid current, and rf output start climbing as I advance the exciter drive control."

Well, his rig blew — as should all who tune up in the band. No, I really don’t mean that. But I guess Bob has never heard of a dummy load! Hey! The bands are full of creepies who tune their rigs on the bands. I for one am persistently plagued by tuner-uppers on stations I am working, and it seems invariably it’s the really weak ones too!

When it comes right down to it, a dummy load is so darned easy to switch in for tune-up that it really is ridiculous not to use one. They are cheap too!

Fred Streib, W6NA
Palo Alto, California

Yes, I do tune up on the band, as does virtually everyone else. I have a dummy load, an excellent one, and I can switch it on line in a second or so. And, on the frequencies I operate on, it is virtually dead flat.

But my antennas are not! They display good SWR readings on the frequencies I normally operate on, but they are not perfect. Not only that, but they change a bit depending on the weather conditions. Wind or rain will change their characteristics slightly.

So, if I load up into my dummy load, I still have to retune once I am into a real antenna, or face poor harmonic rejection from a mistuned final, not to mention stress on the finals.

I do have preset tuning points marked on all my gear, and almost invariably I can complete a tune-up in less than five seconds of key-down time on the air. And I always check the frequency before I do to insure that I cause no interference.

"No tune up" would be really nice, but in the real world using the equipment most Amateurs use it is impossible, even with solid-state finals which often require an antenna tuner with them. But, as Mr. Streib suggests, we have an obligation to avoid QRMing another QSO.

Bob Locher, W9KN1
Deerfield, Illinois

baluns

Dear HR:

I read with interest the fine article entitled "A Coreless Balun" by Roy N. Lehner, WA2SON, in the May, 1981, issue of Ham Radio magazine.

The first reference to this interesting device was in the Collins Radio Company’s “Single Sideband Manual” (1965). Unfortunately, no construction data was given. I built several coaxial baluns and made measurements on them; in the February, 1966, issue of CQ magazine I gave several practical designs in an article entitled “A Broadband Balun for a Buck.”

A replica of this design has appeared in each edition of the Radio Handbook for 14 years. Additional information on similar balun designs is included in the 21st edition of the handbook, which is published by Howard W. Sams Co., and available through Ham Radio’s Bookstore.

Also discussed in the Radio Handbook are the small, air-core baluns wound of Formvar or enameled wire. Roy, WA2SON, claims the coaxial design is “much better” than the enameled wire balun, but this is like comparing apples and oranges. Each balun design has attributes that the other does not possess.

The enameled wire, air-wound balun is more compact than the coaxial design, weighs less and is not subject to coaxial cable “cold flow,” wherein the center conductor migrates about and may short out to the shield — especially when the cable is wound into a small-diameter coil. And when properly designed, the enamel-wire balun has a somewhat greater frequency range of operation than the coaxial balun; that is, it is more “transparent” to the antenna system, as far as induced SWR goes, than is the coaxial design.

The coaxial cable balun, on the other hand, can probably withstand much more brute power than the wire balun because of the higher breakdown voltage of the cable. Over the normal operating range, at normal ham power levels, there isn’t much choice between the designs except on the basis of size or weight.

So you pays yer money and takes yer choice. But don’t write off one particular balun design as being worse than another one. It isn’t.

William I. Orr, W6SAI
San Carlos, California

nit-picker

Dear HR:

In the May, 1981, edition you have an article by John W. Frank, WB9TOQ. This is a very interesting concept and will be of some help to the Amateur community. I wish I had thought of it.

But being the nit-picker that I am, I couldn’t help but notice two errors. The first is the use of the symbol K (eq. 2). This is usually used to designate a constant, not a reflection coefficient, which is designated by the symbol ρ. In the interest of clarity, the correct symbol should be used.

Second is the assertion that SWR will increase line losses. To examine this point let’s look at a line of unit length with a 3 dB loss per unit length. With a generator and load matched to this line we find that when 100 watts is delivered into this line only 50 watts is delivered to the
# More Keyer Features for Less Cost

**AEA Invites You to Compare the AEA Keyer Features to Other Popular Keyers on the Market.**

<table>
<thead>
<tr>
<th>Keyer</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MM-1</strong></td>
<td>MorseMatic™ Keyer Trainer</td>
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<tr>
<td><strong>KT-1</strong></td>
<td>Morse Trainer</td>
</tr>
<tr>
<td><strong>MT-1</strong></td>
<td>Contest Keyer</td>
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<tr>
<td><strong>CK-1</strong></td>
<td>Morse Keyer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Important Keyer and/or Trainer Features</th>
<th>AEA MM-1</th>
<th>AEA KT-1</th>
<th>AEA MT-1</th>
<th>AEA CK-1</th>
<th>AEA MK-1</th>
<th>Competitor B</th>
<th>Competitor C</th>
<th>Competitor D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Range (WPM)</td>
<td>2-99</td>
<td>1-99</td>
<td>1-99</td>
<td>1-99</td>
<td>2-99</td>
<td>8-60</td>
<td>5-50+</td>
<td>5-50</td>
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<tr>
<td>Memory Capacity (Total Characters)</td>
<td>500</td>
<td>500</td>
<td>35</td>
<td>1</td>
<td>35</td>
<td>1</td>
<td>5-50+</td>
<td>400</td>
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<tr>
<td>Message Partitioning</td>
<td>Soft</td>
<td>Soft</td>
<td>Soft</td>
<td>Soft</td>
<td>Soft</td>
<td>100/400</td>
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<tr>
<td>Automatic Contest Serial Number</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Selectable Dot and Dash Memory</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Independent Dot &amp; Dash (Full) Weighting</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Calibrated Speed, 1 WPM Resolution</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Calibrated Beacon Mode</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Repeat Message Mode</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Front Panel Variable Monitor Frequency</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Memory Resume After Paddle Interrupt</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Semi-Automatic (Bug) Mode</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Real-Time Memory Loading Mode</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Automatic Word Space Memory Load</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Instant Start from Memory</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Message Editing</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Automatic Stepped Variable Speed</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>2 Presettable Speeds, Instant Recall</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Automatic Trainer Speed Increase</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Five Letter or Random Word Length</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Test Mode with Answers</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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<td>No</td>
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<td>Random Practice Mode</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Standard Letters, Numbers, Punctuation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>All Morse Characters</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**Advertised Price:**

- **MT-1P (portable version of MT-1) with batteries, charger, and earphone:** $139.95
- **ME-1 2000 character plug-in memory expansion for MM-1:** $59.95
- **AC-1 600 Ma. 12 Volt wall adaptor for MM-1 with ME-1:** $14.95
- **AC-2 350 Ma. 12 Volt wall adaptor for all AEA keyer and trainer products except MM-1 w/ ME-1:** $9.95
- **DC-1 Cigarette lighter cord for all AEA keyers and trainers except MT-1P:** $5.95
- **MT-1K Factory conversion of MT-1 to KT-1:** $40.00

**Options:**

- **All our keys (except the MT-1) will operate with any popular single lever or iambic squeeze paddle and will key any type of modern amateur transmitter with no external circuitry required. AEA keyers are as easy to operate as a four function calculator. The internal AEA computers are all pre-programmed for the features shown above. Each AEA product is fully RF protected and receives a complete elevated temperature burn-in and test before it is shipped from the factory.**

Ask a friend how he likes his AEA keyer compared to anything else he has ever tried, then JUDGE FOR YOURSELF. See the AEA keyer and trainer family at your favorite dealer.

Advanced Electronic Applications, Inc., P.O. Box 2160, Lynnwood, WA 98036. Call 206/775-7373

**AEA Brings you the Breakthrough!**

More Details? CHECK-OFF Page 98
Proving the existence of the additional line loss takes about 26 pages of higher mathematics; I made the assumption that it is common knowledge.

John W. Frank, WB9TQG

at a loss

Dear HR:

I can’t believe it, that what’s given in fig. 1 ("Measuring Coax Cable Loss," May, 1981, page 34) is really SWR. How about:

\[
\text{SWR} = \frac{1 + \frac{|R - Z|}{R + Z}}{1 - \frac{|R - Z|}{R + Z}}
\]

Since when is the reflection coefficient equal to the reflected power/forward power — which the meters don’t read anyway?

If the line is (presumably) an open circuit it will be difficult to deliver 100 watts to it — unless it’s very lossy.

I suggest you see the February, 1981, issue of QST, page 26. It can be done this way:

\[
P_1(\text{FWD}) - P_1(\text{REFL}) - P_2(\text{FWD}) = \text{loss}
\]

John W. Frank, WB9TQG

blow your own horn

Dear HR:

After reading the Comments in ham radio (May, 1981), one might get the impression that experts don’t want too much to do with anyone who might be coming up the ladder or maybe received his license without a complete knowledge of electronics.

Many permits and licenses are issued today with little or no knowledge — namely marriage, hunting, and driver’s — at least with a ham license you won’t kill anyone.

I am a professional driver and have driven tractor trailers, buses, motor homes, and cars the equivalent of eighty times around the world, but this does not mean that a novice driver with two hours of instruction and practice can’t take a 400-horsepower car on the interstate and do battle with the experts.

So all you super pros in Amateur Radio (who I trust are in the minority) keep blowing your own horns and someday when we meet on the road, I’ll blow mine.

Fish Gilpin, KA3DNT
Greentown, Pennsylvania
MFJ-941C 300 Watt Versa Tuner II

Has SWR/Wattmeter, Antenna Switch, Balun. Matches everything 1.8-30 MHz: dipoles, vees, random wires, verticals, mobile whips, beams, balanced lines, coax lines.

Flexi antenna switch selects 2 coax lines, direct or through tuner, random wire/balanced line, or tuner bypass for dummy load.
12 position efficient air wound inductor for lower losses, more watts out.
Built-in 4:1 balun for balanced lines. 1000V capacitor spacing.
Works with all solid state or tube rigs.
Easy to use, anywhere. Measures 8x2x6", has 50-239 connectors, 5-way binding posts, finished in eggshell white with walnut-grained sides.

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Matches everything from 1.8-30 MHz: dipoles, inverted vees, random wires, verticals, mobile whips, beams, balanced and coax lines.
Run up to 300 watts RF power output.
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Matches coax, random wires 1.8-30 MHz. Handles up to 200 watts output; efficient air wound inductor gives more watts out. 5x2x6".
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September 1981
SATellite-Related Amatuer Radio Packet communications became a reality in Canada in July when packets were exchanged over the ANIK-B research satellite. The pioneering contact was made by VE3POL in Ottawa and VE7APU in Vancouver, operating from the satellite ground stations at 1200 bits/second.

The Satellite Channels have been made available to Amateurs on a "space available" basis, under an authorization granted by the Department of Communications. Tie-ins with local "computer bulletin boards" and other computer hobbyist activities are also planned, so eventually not only Amateurs but non-Amateurs will be using the Amateur-built system.

Strong organized support for Amateur Radio is being proposed by a newly formed group in California, the Society for the Protection of Amateur Radio (SPAR). SPAR, the brain-child of K6OYO and W6POU (Santa Barbara County SCM), states as its purpose "to support when needed the interests of Amateur Radio as defined by the ARRL, with the strongest possible political action against harmful regulation and legislation, and to support that regulation and legislation which is beneficial." The SPAR articles of incorporation, which were signed June 14, are highly supportive of the ARRL but very critical of the FCC...in particular, the plain language rewrite.

SPAR says it will support Amateur Radio through organized letter writing campaigns, introducing legislation and legal actions, and eventually by putting a "full-time legislative advocate" in Washington. The organization plans to work with and through the League, but feels it would be in a position to accomplish things that the ARRL cannot. Thus far it has received strong support from ARRL Southwestern Division Director W6EJJ, who plans to keep League officials aware of its progress. SPAR was discussed at the June executive committee meeting, but no position on it was taken.

SPAR's Support So Far is mostly from southern California, where it seems to be catching on rapidly. Interested Amateurs can write (SASE) SPAR, Box 41, Santa Barbara, California 93108 or call (805) 969-5304, 969-5623, or 642-7141.

Spread Spectrum has been proposed for the Amateur service in a Notice of Inquiry and Proposed Rulemaking announced by the FCC July 1. In this action the Commission proposes limiting use of the sophisticated broadband technique to the 6, 2, and 13 meter bands, by Advanced and Extra Class licensees only. Though some technical details are proposed in the item, the principal limitation is that emissions be contained within the given band. Further details are not yet available. However, the document will pose a number of questions on such topics as how Amateur spread spectrum transmissions could be monitored and what potential interference would result from them. The complete text of FCC 81-290 should be in the Federal Register and available from the usual FCC sources.

Spread Spectrum Radiolocation in the 420-450 MHz band has also been proposed in a related action, FCC 81-291. In responding to a petition by Del Norte Technology, this FCC NPRM would let Del Norte use radiolocation equipment, previously limited to offshore areas, within the United States. Such use would, however, be on a non-interference basis with government and Amateur use of the band.

Comments are due on both items but are not yet been announced, but a long comment period, at least on the Amateur item, is expected.

Spread Spectrum Operation on the lower-frequency Amateur bands has already taken place under an FCC Special Temporary Authority. A detailed report on these first Amateur experiments, by AMRAD members W4KL, K2SZE, and WA3ZW using commercial spread spectrum rigs on 75 meters, appears in the July AMRAD Newsletter. Amateurs interested in following the progress of this mode, as well as packet radio and application of computer technology to Amateur Radio, should join AMRAD. Membership is $12 a year, to treasurer N4GA.

Antenna problems have brought another Amateur to the Courtroom. N5SW of Kryder Electronics is suing Oklahoma City, after the city building inspector informed him his 78-foot tower was in violation of the city's 50-foot tower ordinance, and the city variance Board denied him a variance for it.

The Suit, Which Was Filed June 11, has received much media attention in Oklahoma City and was picked up by UPI. In it, N5SW asserts the 50-foot restriction "limits my freedom of speech and violates my civil right to control my own property." In addition, he maintains the tower is "a necessary requirement in the exercise of my avocation" and the ordinance "limits the exercise of my federally granted Amateur Radio privileges."

N5SW was Arrested in his home eight days after the suit was filed in Federal District Court and charged with violating the 50-foot ordinance. Contributions are being solicited to assist in the action by the Oklahoma City Antenna Defense Fund, c/o ADIS, Box 32735, Oklahoma City, Oklahoma 73123.

ARRL Is Watching N5SW's case closely, along with a half dozen others that were reviewed at the June 20 Executive Committee meeting. The League, under its tax exempt status, cannot assist an individual member financially in such a case unless its participation would benefit all its members. The League can assist only if the case is precedent setting, or would upset a previous precedent.
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CIRCLE 146 ON READER SERVICE CARD
upgrade your license:
part 1

The first article
in a continuing series
designed to help you
upgrade your ticket

If you are reading this magazine, you probably already hold an Amateur Radio Service license of some grade. Maybe you are a Novice. More likely you are a Technician, General, or better. A good theory review now and then is a good idea for all of us, Extras included.

frequencies and types of emission — right? Does it bother you that someone else can use them but you can’t? Well, it was a challenge for all of those Extra-class hams who are using those frequencies, but they did something about it: they upgraded.

This means that not only did they learn more radio theory but they also improved their code sending and receiving abilities, which enables them to function better in an emergency where phone equipment is either not working or unavailable. Maybe they found out that code communications is a heck of a lot of fun when you get to the point where you can sit back and copy in your head, and not bother to write everything down on paper. Really, that transcribing the code is for the birds! We will talk about this later, but right now be sure that each day you have at least one good QSO on the air using CW, to raise yourself above that crawling along at 5 or 13 words per minute (WPM).

Probably the largest group of readers interested in upgrading are in the Technician/General category. For this reason, we will first concentrate on upgrading this group to the Advanced class license. Later we will take on the Extra class — so keep working on that 20 WPM code speed goal. If you are a Novice (or not yet a Novice), you will find that the fundamentals we are going to work on first should enable you to work up to the Technician/General level. At the beginning of each article we will point out what FCC topics are to be discussed in that article. In this month’s article, the first in the series, you will find

By Robert Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472
basic electrical topics suitable for Novice, Technician/General, and Advanced license questions.

The first few articles will lay out the groundwork, so that we will all be speaking the same electronic language. If we say such things as current, resistance, reactance, or impedance, it should mean the same to all of us. Once we all understand the basic language we can better discuss the more advanced subjects.

The study of Amateur Radio theory requires some knowledge of electricity (volts, ohms, amperes, resistors, magnetism, coils, capacitors), electronics (diodes, transistors, vacuum tubes), basic circuits (oscillators, amplifiers), combinations of circuits which we will call systems (receivers, transmitters), antennas, FCC rules and regulations, radio telegraph code, and proper on-the-air operating procedures.

The FCC is basing its present license tests on nine areas of information:

a. Rules and Regulations
b. Operating Procedures
c. Radio Wave Propagation
d. Amateur Radio Practice
e. Electrical Principles
f. Circuit Components
g. Practical Circuits
h. Signals and Emissions
i. Antennas and Feedlines

FCC test topics

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

- ampere
- voltage
- volt
- conductors and insulators
- watt
- energy and power
- fuses: appearance, applications, symbol
- open and short circuits
- direct current
- alternating current
- metric prefixes: mega, kilo, centi, milli, micro, pico
- hertz
- audio frequency
- radio frequency

The following Technician/General test topics are discussed in this article, but should be understood by Advanced applicants also:

- resistance
- resistors: appearance, types, characteristics, applications, symbols
- resistors in series
- ohm
- Ohm's law
- power calculations
- power measurement
- electrical power calculations
- root-mean-square value of a sine-wave alternating current
- inductance
- inductors: appearance, types, characteristics, applications and symbols
- henry, millihenry, microhenry
- capacitance
- capacitors: appearance, types, characteristics, applications, and symbols

The following Advanced class test topics are discussed in this article:

- sine, square, sawtooth waveforms
- root-mean-square value
- fields, energy storage, electrostatic, electromagnetic

For additional information on these subjects you might refer to Electronic Communication, by Robert L. Shrand, McGraw-Hill Book Co., both a commercial and Amateur license text, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048 ($26.95 plus $1.00 shipping).
Under these categories the FCC lists many specific topics. They do not indicate the questions they will ask, only what subjects the questions will cover.

All of the Amateur license tests contain one or more questions on all of the specified areas. For the Novice exam the level of knowledge required is rather rudimentary. For the Technician/General exam you'll need a good basic understanding of radio. For the Advanced class license the qualifications are definitely higher, and some of the questions seem to come from out in left field somewhere. As for the Extra-class license, well, you are supposed to know a lot about a lot of things. A word of warning is advisable here. Although they do not say so, the FCC tends to reach back down to lower level license topics for some of their test questions. You might find some Technician/General questions on Advanced license tests. But if you have passed the lower license you should not have too much trouble.

This series of articles will try to cover the whole field for you. We are sure that many hams who have had a license for several years have managed to forget most of the theory that they learned previously. So, to refresh their memories and to help those of you who do not have at least a Technician/General license, we will first go over the basic Electrical Principles and the Circuit Components, as taken from the FCC list above. Other categories of information will be covered in later articles.

There is no way that we can guess what the FCC is going to ask you on their present or on future tests. But if you have a good, basic understanding of the topics in the FCC list, you stand a good chance of choosing the correct answer in their multiple-choice test questions. Happily, you can miss a few and still get your license. After all, a 75 percent grade on a test gives you just as valid a license as a 100 percent score would. You might feel better if you made the 100 percent grade, but how many of us are perfect?

The idea of this series is to put radio theory into words you can understand, even if you have little or no training in this field. We are not out to produce electrical engineers, just knowledgeable Amateur Radio operators. If you want more information than you find here, there are textbooks that you can read once you understand the basic ideas.

One thing more. You must have a copy of Part 97, FCC Rules and Regulations, obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.* Space here is too limited to permit us to repeat all of the information on rules and regulations. Let’s get started.

**electrical current**

Every electrical or radio device operates because a current of “things” moves through the copper wires and the device. The “things” that move are called electrons. We probably all know that everything that can be seen or felt is made up of atoms, usually in chemical combination with other atoms to form molecules. An atom consists of a central nucleus, which is made up of relatively heavy, zero-charged particles called neutrons and positively charged particles called protons. Essentially, the nucleus of an atom is never altered. Nothing we can do, short of nuclear fission or fusion, will alter it.

![fig. 1. Representation of an atom that would make a good conductor.](image)

Surrounding the nucleus, however, are orbiting electrons, fig. 1. The electrons have a negative charge and are attracted to the positive charges of the nuclear protons. These constantly moving electrons travel in orbits around the nucleus, somewhat similarly to the way in which the planets orbit the sun. The earth is attracted to the sun by gravitational forces; electrons are attracted to the nuclear protons by electrostatic (negative to positive) forces.

The outermost electrons of some atoms are susceptible to external effects. For example, if a single, outer-orbit electron is brought near a higher positive charge it may be stolen from its parent atom. This leaves the atom minus one electron, and therefore with one excessive positive charge in its nucleus. We say the atom has been ionized by losing the electron, and is now a positive ion. (We may think of this as being an electron hole in the ionized atom.)

In our real world we have dry cells (called batteries if two or more are used together) that have the ability to chemically separate electrons from atoms and pile

*Also published in The Radio Amateur's License Manual, available from Ham Radio's Bookstore, Greenville, NH 03048 ($4.00 plus $1.00 shipping).
the electrons on the negative terminal of the cell, leaving the opposite terminal electron-less, or positively charged. The chemicals can move only a given number of electrons across the cell before the electrical difference (electrostatic force) stops any further chemical action. In the common dry cell this occurs when an electrostatic force of 1.5 volts is across the cell. (Voltage is discussed in the next section.)

If we connect a flashlight lamp across the dry cell, using three pieces of copper wire and a switch, a simple electric circuit is formed, fig. 2. (Copper is used as connecting wire because it has one free, or easily moved, electron in its outermost orbit.) When the switch is closed, the excess electrons on the negative pole of the dry cell have a chance to move to the positive pole through the lamp and circuit. As a result, a current of electrons develops throughout the circuit. The copper wires allow the current to flow with almost no opposition, but the lamp’s filament, made of tungsten or some other metallic wire, has fewer free electrons and tends to oppose the flow of the electron current. Because of this frictional opposition, energy is lost in the filament wire and it heats. Tungsten can be heated to a red, orange and even to a white-hot temperature without melting. Thus, while the copper connecting wires may heat slightly or not at all, the lamp filament heats white hot and light is radiated from it. When the switch is opened the current stops; the filament cools and it no longer radiates heat or light.

In the dry cell, when electrons begin to enter the positive terminal, the electrical difference across the cell becomes less and the chemicals start working again, pumping more electrons to the negative pole from the positive. When the chemicals can no longer continue to move electrons across the cell, the cell is discharged, or dead. The cell converts chemical energy to electrical, and the lamp, or “load” on the circuit, converts the electrical energy to radiant (heat and light) energy.

An interesting sidelight to the subject of current is its direction of flow in a circuit. You can see that electrons must travel from the negative terminal of the source (the cell) through the outside circuit (the lamp or load), being attracted to the positive terminal. Back in the early days when electricity was first being investigated, cells were labeled positive and negative the same as today. It was only natural to assume that if something was traveling in the wires of electric circuits that it must travel from the terminal that had the most (positive) to the one that had the least (negative). So they said that current flowed from + to −, and they wrote all the textbooks that way.

In the early 1900s, when vacuum tubes were first being developed, it was found that hot filaments boiled free electrons off of their surfaces. A metal plate was put inside the vacuum area of a lamp; the plate could be made positive by connecting it to the positive terminal of a battery, provided the filament was connected to the negative terminal. A current could now flow through the plate circuit whenever the filament was hot, fig. 3. This proved that electric current actually flowed from the negative terminal of a source through the circuit to the positive terminal.
Well, that wasn’t the way the textbooks said it was. Since nobody wanted to rock the boat, they just continued to teach that current flows from + to −, and the heck with the electrons! So, now we have two theories of current flow, one the original, “conventional” + to −, theory, the other the electron theory. You will notice that all of the symbols on solid-state diodes, transistors, and so forth, have their arrows indicating current flowing in the conventional current direction. So, remember that symbols show conventional current direction, not the electron theory direction.

In fig. 5 we have added a lamp as the load in the fig. 2 circuit and substituted the correct symbol for a vacuum diode (two-element device). We have also added an ammeter in series with the lamp and the plate circuit B-battery. The ammeter measures the value of the current flowing through it, and therefore the current in the plate circuit. It is called an ammeter because current is measured in amperes, A. An ampere of current is considered to be 6.25 x 10^18 electrons flowing past a point in a circuit in 1 second. Remember that 10^18 means that you move the decimal place of the 6.25 over 18 places to the right (if the exponent were negative, 10^-18, you would move the decimal point 18 places to the left). That makes the number of electrons 6,250,000,000,000,000. From this you might deduce that an electron is a pretty small thing, and you would be right. A group of 6.25 x 10^18 electrons is known as a coulomb (C), which is the basic unit of electric quantity (Q).

In modern radio we may more often measure current in thousandths of an ampere, called milliamperes, or mA. A microampere, or μA, is a millionth of an ampere. A billionth of an ampere is called a nanoampere, or nA.

The metric based prefixes used with electrical units of measurement are listed in table 1. You should know these.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Value</th>
<th>Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pico</td>
<td>p</td>
<td>10^-12</td>
<td>times</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>10^-9</td>
<td>times</td>
</tr>
<tr>
<td>Micro</td>
<td>μ</td>
<td>10^-6</td>
<td>times</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>10^-3</td>
<td>times</td>
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<tr>
<td>Centi</td>
<td>c</td>
<td>10^-2</td>
<td>times</td>
</tr>
<tr>
<td>Deci</td>
<td>d</td>
<td>10^-1</td>
<td>times</td>
</tr>
<tr>
<td>No prefix</td>
<td></td>
<td>unity</td>
<td></td>
</tr>
<tr>
<td>Deka</td>
<td>da</td>
<td>10^1</td>
<td></td>
</tr>
<tr>
<td>Hecto</td>
<td>h</td>
<td>10^2</td>
<td>times</td>
</tr>
<tr>
<td>Kilo</td>
<td>k</td>
<td>10^3</td>
<td>times</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>10^6</td>
<td>times</td>
</tr>
<tr>
<td>Giga</td>
<td>G</td>
<td>10^9</td>
<td>times</td>
</tr>
<tr>
<td>Tera</td>
<td>T</td>
<td>10^12</td>
<td>times</td>
</tr>
</tbody>
</table>

Table 1. Metric-based prefixes.

Voltage, resistance, and Ohm’s law

The pressure exerted on electrons by chemical action in a dry cell has been explained as producing a moving force that makes electrons flow in a circuit. This pressure is known as electromotive force, or EMF, and is symbolized as E or e. Since it is measured in units called volts, it is also known as voltage, which is symbolized as V or v.

The opposition that the lamp filament had to the flow of electrons or current is properly known as resistance, symbolized as R. Resistance is measured in units called ohms, symbolized as Ω (the Greek letter omega).

One of the most important formulas for computing electrical circuit operation is Ohm’s law, which simply states that if 1 volt of pressure is applied across 1 ohm of resistance, the resulting current value will be 1 ampere. Ohm’s law is usually written as:

\[ I = \frac{E}{R} \]

where

- \( I \) = intensity of current in amperes (amps for short)
- \( R \) = resistance in ohms
- \( E \) = EMF in volts

Note that you cannot use milliamperes in this formula. The milliamperes must be converted to the basic unit of amperes before it will work in the formula.

Here is an example of the use of Ohm’s law: If the dry cell in fig. 2 has an EMF of 1.5 volts and the lamp’s filament has 30 ohms resistance, then the current flowing must be:

\[ I = \frac{1.5}{30} = 0.05 \text{ amps} \]

A value of 0.05 amps might also be expressed as 50 mA, or 50,000 μA, and even 50,000,000 nA. We will be using Ohm’s law again and again. Be sure you know the formula.

The resistance of the tungsten filament in the lamp is not constant: the resistance varies directly with its temperature. The filament, when hot and glowing, will have a resistance many times its resistance when cold. Electronic components known as resistors, however, are made of substances that maintain their constant resistance whether operated cool or warm. Such substances are said to have a zero temperature coefficient of resistance. Tungsten has a positive coefficient.
fig. 5. Vacuum diode with a filament or A-battery, a plate circuit or B-battery, ammeter in the plate circuit, and a lamp as the load.

fig. 6. Symbols for fixed resistor, two ways of indicating rheostats, and a potentiometer.

fig. 7. Circuit to be investigated for currents, voltages, and powers.

“UPGRADE”

temperature coefficient. In fact, most metals have positive temperature coefficients; carbon and other semiconductors have negative temperature coefficients. Thus, fixed-value resistors are usually made of both carbon and metals to produce the desired resistance as well as a nearly zero temperature coefficient.

Fixed-value resistors are usually constructed in tubular form with connecting wires out each end. They may range in length and diameter from perhaps 0.25 x 0.1 inch (7 x 2 mm) for the smaller sizes (0.1-watt, as discussed in the next section) to about 0.7 x 0.3 inch (17 x 8 mm) for medium sizes (2-watt types). Wire-wound types may be up to several inches long and an inch in diameter. There are all manner of intermediate sizes and wattages for fixed resistors. They are usually covered with an insulating (nonconducting) material.

There are variable resistors which consist of a contact arm that can be moved across an uninsulated resistance. If the variable resistor has a movable arm and only one end of the resistor is used, the device can be called a rheostat, fig. 6. If connections are made to both ends and the sliding arm, the device is known as a potentiometer. Potentiometers are used as voltage dividers in most applications, such as volume or gain controls on amplifiers or receivers.

**power and energy**

The term watt was used in conjunction with resistors. Watts of power indicate the energy that a resistor can safely dissipate without overheating. To determine power in watts we normally use the formula:

\[ P = EI \]

where \( P \) = power in watts (W)

\( E \) = EMF in volts

\( I \) = intensity of current in amps

As an example, consider fig. 2 again. If the voltage of the dry cell is 1.5 volts and the current through the lamp is 0.06 amps, the rate at which energy is being dissipated by the filament is \( P = EI \), or 1.5 (0.05), or 0.075 watt. Note that we say the rate (which involves time, \( t \)) at which energy is being dissipated. This is because a watt is a volt times an ampere \( (P = EI) \), and an ampere is a coulomb-per-second \( (C/s, \text{ or Q}/t) \).

If we remove the time \( (\text{second}) \) from a power computation we are left with pure energy. Thus, energy can be expressed as

\[ \text{energy} = EI/t \]

which divides the time out of the right-hand part of the equation. If an ampere is a coulomb-per-second, and the second is cancelled, then energy must be equal to \( E \) (volt-coulombs). A volt-coulomb is commonly termed a joule, or a watt-second. (In the watt-second the second is added to cancel out the time in the watt.) Remember that energy is timeless and power is a rate.

Let’s see how many things we can determine from the circuit shown in fig. 7. First, there are three new components shown, a fuse, a voltmeter \( (V) \) across
the circuit, and a wattmeter (W) in “series” with the circuit and also across or in “parallel” with the circuit. The 1-amp fuse has a wire inside it which will melt if more than an ampere flows through it. The voltmeter is across the source of voltage as soon as the switch is closed. It indicates the EMF of the source in volts. The wattmeter must consider both voltage and current at the same time \( P = EI \). It must be connected in series with the circuit to obtain the current value, and across the circuit to determine the voltage value. It considers both of these factors and indicates the product of the two in watts. Also, we have two load resistors connected in series across the source. The total resistance the source sees is \( R_1 + R_2 = 20 \text{ ohms} \).

When the switch is closed, the voltmeter reads 10 volts. The ammeter reads \( I = E/R \), or 10/20, or 0.5 amp. The wattmeter reads \( P = EI \) or (10)(0.5), or 5 watts. Assuming the meters require almost no power to operate them, every second the source would be delivering 5 joules of energy to the two resistors. Between the two resistors, 5 watts are being dissipated. But, how much does each resistor dissipate? Let’s apply what we have been discussing so far.

We know that the current through the two resistors is 0.5 amp, and since they are in series, \( R_1 \) must have 0.5 amp flowing through it, the same as \( R_2 \) has. Therefore the voltage drop across \( R_1 \) must be \( E = IR \), or 0.5(5), or 2.5 volts. With 2.5 volts across \( R_1 \) and 0.5 amp flowing through it, the power being dissipated must be \( P = EI \), or 2.5(0.5), or 1.25 watts. What would a voltmeter read if it were connected across \( R_1 \)? If across \( R_2 \)? How much power is being dissipated by \( R_2 \)? You have all the information needed to compute this. Before reading on, try answering these three questions. (There are at least two ways of finding two of the answers.)

A voltmeter would read a 2.5-volt voltage drop across \( R_2 \). If there is a voltage drop of 2.5 volts across \( R_1 \) and the source is 10 volts, then there must be the difference, or 7.5 volts across \( R_2 \), right? You can also compute the \( R_2 \) voltage drop by \( E = IR \), or 0.5(15), or 7.5 volts. If the total power being dissipated is 5 watts and \( R_1 \) is dissipating 1.25 watts, then \( R_2 \) must be dissipating the difference, or 3.75 watts. You could also compute the \( R_2 \) power by \( P = EI \), or 7.5(0.5), or 3.75 watts.

Suppose \( R_2 \) were shorted out (copper wire connected across it). Why would all of the meters read zero after the switch is closed for a second? The answer is that the 1-amp fuse would blow out, but why? According to Ohm’s law, the current flow in the circuit would be \( I = E/R \), or 10/5, or 2 amps. Since the fuse is rated 1-amp it would melt when fed a 2-amp current. This would produce an open fuse, and an open circuit, even with the switch closed. The fuse is a protective device. Magnetic or other types of circuit breakers could be used in place of the fuse, and could be reset after the short-circuit is removed from the circuit. The usual radio fuse is to be a glass or other insulation material with metal caps at the ends and a fuse wire running down the center of the tube.

We might consider the power formula, \( P = EI \), as being the fundamental way of determining power. However, by substituting the Ohm’s law formulas into this power formula we come up with two other equally important power formulas. Consider using the \( IR \) portion of the Ohm’s law formula \( E = IR \) in place of the \( E \) in the \( P = EI \) power formula:

\[
P = EI \text{ becomes } (IR)I, \text{ or } P = I^2R
\]

Similarly, by substituting the \( E/R \) part of the \( I = E/R \) Ohm’s law formula for the \( I \) in the power formula:

\[
P = EI \text{ becomes } E(E/R), \text{ or } P = \frac{E^2}{R}
\]

So, if you remember \( E = IR \) and \( P = EI \), by a little algebraic manipulation of the letters of the two formulas you can come up with six very useful formulas.

Refer back to fig. 7 again. Try using the \( P = I^2R \) and the \( P = E^2/R \) formulas to determine the dissipation of \( R_1 \) and \( R_2 \). You should obtain the same answers as were computed above. Come on now, try at least a couple of formulas on \( R_1 \) or \( R_2 \)!

**Alternating Current**

Up to this point the current that has been flowing in our circuits is known as direct current, or dc. When it flows it always moves in the same direction (− to + for electron current), and at the same strength or amplitude. If a variable resistor is added in series with a dc circuit the current varies as the resistance value changes. This produces varying dc, or VDC. In radio circuits all power supplies produce dc. When this dc is fed to amplifiers or oscillators these circuits usually change the dc to VDC, or if the current drops down to zero periodically, it becomes pulsating dc, or PDC. The graphs of fig. 8 illustrate dc, VDC, and PDC, in which the amplitude of the current or voltage is plotted (vertically) against time (horizontally). In (a), once the current or voltage starts it continues at the same amplitude. We sometimes call this smooth dc. In (b) the current or voltage varies periodically higher and lower. In (c) the current or voltage actually stops periodically, making
pulses of dc. The pulses may be smooth-curve shaped, square-wave shaped, or saw-tooth shaped, depending on what is producing the pulsations.

Most radio circuits deal with dc (either VDC or PDC) and alternating current, or ac. Alternating current is produced by sources which have their EMF alternating from one direction to the opposite for some reason. For example, a transistorized oscillator circuit produces an output with an ac component as a result of the dc fed to it from its supply power. Any load on the oscillator will have current flowing through it in one direction for a fraction of a second, and then the current alternates and flows through the circuit in the opposite before alternating again. The current continues to alternate as long as power is fed to the oscillator circuit. Ac can be graphed as in fig. 9. In (a) two cycles of sinusoidal, or sine-wave-shaped, ac are shown. In (b) two cycles of square-wave ac are graphed, and in (c) two cycles of sawtooth ac are shown. The ac that we will be most interested in at this time is sine-wave ac. This is the form taken by ac generated from radio oscillators, transmitters, by utility companies, and by electro-mechanical ac generators which are properly termed alternators.

In ac work a full cycle is considered as having 360 degrees. Therefore a half cycle will consist of 180 degrees, and a quarter cycle will have only 90 degrees, fig. 10. If the ac cycle is a perfect sine-wave, at 30 degrees (also 150, 210, and 330 degrees) the amplitude of the voltage or current will be exactly 0.5 of the maximum value. At 60 degrees (also 120, 240, and 300 degrees) the amplitude of the wave will be exactly 0.866 of the maximum, or peak value. You will find these 0.5 and 0.866 values in a Table of Natural Trigonometric Functions, or on a slide rule, or they may be obtained from more advanced pocket calculators. You can find sine values given for every tenth of a degree for the first 90 degrees. The second, third, and fourth 90-degree quadrants will have the same values as the first 90 degrees.

If all of the sine values for each degree of the first 90 degrees are added and this total is divided by 90, the average value of the sine-wave would result. For sine-wave ac this will always be 0.636 of the peak value. Can you see that the average value of a square-wave ac would have to be 1.0 or equal to the peak value? The average value is usually considered only in power supplies and in meters.

A much more important value is the root-mean-square, RMS, or effective value. The RMS comes from taking the square root of the average (mean) of the squares of the sine values for each of the first 90 degrees of the sine curve. This results in a factor of 0.707 of the peak value for sine-wave ac. This 0.707 factor is very interesting because it represents the equivalent dc voltage that would be needed to produce the same amount of heating in a resistor as it
just as bad a shock as a - 100 volt peak will. The cur-
tions, but at the same effective or "ouch" value.

stand at least 170 volts, and preferably two or three
times 170 volts.

If an ac alternates 100 times a second it is said that
the ac has a frequency of 100 cycles per second
(cps), or 100 hertz (100 Hz). The human ear can hear
sound waves developed by a loudspeaker being fed
all frequencies from about 15 Hz up to about 20,000 Hz
(20 kHz). Older persons, however, may have diffi-
culty hearing above 12 or 15 kHz. The audible fre-
quencies are called audio frequencies. Ac currents of
between 15 Hz and 20,000 Hz are needed to produce
air-wave vibrations of these frequencies, which the
ear can recognize as sound. Dogs and other animals
may hear sounds up into the 25 to 30 kHz range,
sounds which are inaudible to humans.

Some of the common bands of frequencies are
listed in table 2. Previously used abbreviations of
kilocycles (kc) and megacycles (mc) are indicated.

Amateur Radio bands fill in the medium through
extremely high frequencies bands. When we speak
of "radio frequency" we mean rf frequencies from 10
kHz through 300 GHz (VLF through EHF). Micro-
waves are usually 1 GHz through 300 GHz.

inductance and transformers

Radio circuits involve dc sources, resistances,
coils, capacitors, and transistors or vacuum tubes. A
coil is just what its name implies, a piece of wire
usually coiled around a tubular form made of an insu-
lating material. It will be found that if a smooth dc
current is flowing through a straight piece of wire,
fig. 11, a stationary field of force will be developed
around the wire. We can represent this magnetic
field by drawing a few circular field lines around the
wire. With the current flowing from left to right we
indicate the field direction as coming out below the
wire, passing upward on this side of the wire, pass-
ing over the top, and going down behind the wire.
Arrowheads may be drawn on the field lines to indi-
cate relative field direction, as shown.

If the current decreases, the field collapses back
into the wire. As the current increases, the field
expands further outward. The interesting thing about
these expanding and contracting lines of magnetic
force is that they induce a voltage in the wire as they
expand and collapse. If the current is flowing from
left to right and is increasing in amplitude, the
magnetic field expands and induces a voltage of its
own in the wire itself, but in a direction opposite to
the source voltage and the circuit current direction.
This reverse-direction induced voltage is called a
counter-EMF. The counter-EMF acts to prevent a
rapid current increase in the wire.

When the magnetic field collapses as current
decreases, the counter-EMF is now developed in the
direction of the current flow, tending to increase the
circuit current. Whatever the current wants to do,
the counter-EMF developed in a wire tries to counter-
act that effect.

If the wire is coiled, fig. 12, the field lines of each
turn add together to form a concentrated field in the

---

**table 2. Frequency bands**

<table>
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<tr>
<th>Frequency Band</th>
<th>Example Range</th>
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<tr>
<td>audio frequencies</td>
<td>15 Hz to 20 kHz (kc)</td>
</tr>
<tr>
<td>power frequencies</td>
<td>50, 60, and 400 Hz (cps)</td>
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**electromagnetic radiation (EMR)**

<table>
<thead>
<tr>
<th>Band</th>
<th>Range</th>
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<tr>
<td>extremely low frequencies (ELF)</td>
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</tr>
<tr>
<td>super-low frequencies (SLF)</td>
<td>300 to 3000 Hz</td>
</tr>
<tr>
<td>very-low frequencies (VLF)</td>
<td>3 to 30 kHz</td>
</tr>
<tr>
<td>low frequencies (LF)</td>
<td>30 to 300 kHz</td>
</tr>
<tr>
<td>medium frequencies (MF)</td>
<td>300 to 3000 kHz</td>
</tr>
<tr>
<td>high frequencies (HF)</td>
<td>3 to 30 MHz (mc)</td>
</tr>
<tr>
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<td>30 to 300 MHz</td>
</tr>
<tr>
<td>ultra-high frequencies (UHF)</td>
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</tr>
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<tr>
<td>extremely-high frequencies (EHF)</td>
<td>30 to 300 GHz</td>
</tr>
</tbody>
</table>

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produced by the sine-wave ac voltage. For example,
asinusoidal 20-volt-peak ac voltage will produce the
same heating effect as will 20 \((0.707) = 14.14 \text{ volts} dc\). The RMS, or effective value, puts dc and ac on an
equal basis for many things. You will find that the
120-volt ac sold to you by your utility company is
actually \((1/0.707)(120)\), or 1.414 times 120 volts. It
has a peak value of about 170 volts. So, if you want
to insulate something to prevent your 120-volt RMS
from sparking, it will be necessary that the insulation
stand at least 170 volts, and preferably two or three
times 170 volts.

Can you see that the RMS, or effective value, of a
square-wave ac would be equal to the peak value,
since the current or voltage is always at either the
positive or the negative maximum value? Incidentally,
the \(+100\) volt peak of an ac cycle will give you
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act that effect.

If the wire is coiled, fig. 12, the field lines of each
turn add together to form a concentrated field in the
core of the coil. The end of the coil where lines of force emerge from the core is called the north pole (N) of the coil. Where the lines enter the core is the south pole (S) of the coil. The coil in this case can be called an electromagnet. An air-core coil’s magnetic strength can be increased by a factor of thousands by winding the coil on an iron core or ferrite core (a powdered iron-oxide compound bond together with an insulating substance). The more turns and the more current, the more ampere-turns — and the more magnetism developed in the core.

A relay utilizes an electromagnet, fig. 13. A few volts and relatively little current applied to the coil creates a magnetic field that pulls down an iron armature, against the tension of its return-spring. This closes a circuit between points A and C. When the relay switch is opened the magnetic lines collapse back into the coil and the armature is pulled back upwards by the spring, breaking the contact between points A and B. Relays are used to open or close remote circuits, particularly when high currents or high voltages are involved.

The single armature and two-contact relay shown is called a single-pole-double-throw (SPDT) type. With only one contact, the relay would be a single-pole-single-throw type (SPST). With two armatures and four contacts, the relay would be a double-pole-double-throw (DPDT) type. Both relays and switches are made in SPST, SPDT, DPDT, as well as more complicated forms. A relay coil must be fed dc, VDC, or PDC for it to hold its armature down. If ac is used across the coil, the core will be alternately magnetized in one polarity and then in the other, which causes the armature to vibrate. However, if half of the top of the iron core piece is encircled with a copper ring, there will be an induced current in the ring that produces its own field which tends to hold the armature while the magnetic fields are alternating. This makes an ac relay.

Any wire or coil of wire is said to have self-inductance because it induces counter-EMF into itself. A coil is often referred to as an inductor. If an inductor has a 1-amp-per-second increasing current fed to it, and this results in 1 volt of counter-EMF, the inductor is said to have an inductance of one henry. The symbol for inductance is L, and the symbol for its unit of measurement, the henry, is H. Inductances used in radio may range from several henrys in choke coils to milli-, micro-, nano-, and picohenrys. They all store energy in their magnetic fields when current is flowing through them. When the current stops, the energy in the fields is returned to the inductor wires.

The straight-core, or solenoid, type of coils shown so far have a tendency to allow their fields to expand a considerable distance from them, causing interference with nearby circuit operations. This can be reduced by shielding the coils by placing them in aluminum cans. If the core is made in a toroidal (doughnut) shape, fig. 14, all of the field lines are essentially contained in the core material and there are no external lines leaking out into the surroundings. Many modern tuned circuits in radio equipment now use toroid coils, since they require no shielding.
One of the important components in radio is the transformer. A simple transformer consists of two wires laid side by side, fig. 15. When the switch is closed, current flows in the "primary" wire, developing a counter-EMF in it. However, the expanding magnetic lines of force also induce an EMF into the "secondary" wire as they cross it. This produces a pulse of current through the load resistor across the secondary. When the switch is opened, the field around the primary collapses and in so doing induces an opposite-direction EMF in the secondary wire, and another pulse of current flows through the load resistor. Thus, one pulse of primary current produces one cycle of ac in the secondary circuit.

A much more efficient transformer has its primary and secondary wires wound on either a straight core or on a toroidal core, fig. 16. If the primary winding has 200 turns and the secondary has 400 turns, the transformer will step up the ac component of any voltage fed to the primary by a factor of two. We say the transformer has a voltage step-up ratio that is directly related to the number of turns on the primary and the secondary. If there are fewer turns on the secondary than on the primary the transformer has a step-down ratio.

The current ratio of a transformer is just the opposite of its voltage ratio. If there are more turns on the primary and fewer on the secondary, the secondary current will be greater than the primary. This is because the product of the primary E and I (remember, \( P = EI \)) will always be slightly more than the product of the secondary E and I, the difference being due to core losses and other inefficiencies. Since the power output can never exceed the power input, the power ratio is usually considered to be about 1:1 for all iron-core transformers.

Power frequency and audio frequency transformers use laminated iron cores (made of multiple, insulated thin sheets) to reduce eddy current losses in the core. Their secondaries are usually wound right over the primary windings. Radio frequency transformers use air or, in many cases, ferrite cores to reduce hysteresis loss, which is an energy loss that results from the flipping over of magnetic iron molecules when the primary current alternates and remagnetizes the core in the opposite direction. Primaries and secondaries are usually separated slightly.

Iron-core inductors are used as choke coils in power supplies, making use of their ability to oppose any current changes. They produce a smoother dc from varying or pulsating dc. Air and ferrite inductors are used in radio frequency choke (RFC) coils, tuned circuits, and when coupled together, in rf transformers. Symbols for the various inductor applications are shown in fig. 17.

**Capacitance and Capacitors**

Capacitance exists whenever two conductors of any kind are separated from each other by some form of insulator. Two wires laying next to each other have a small capacitance between them. A component made to have capacitance is called a capacitor (originally called a condenser). A basic capacitor is shown in fig. 18. It consists of two metal plates separated, in this case, by air. When the DPST switch is closed, the top plate is connected to the negative terminal of the battery and the bottom plate to the positive terminal. Electrons rush through the lamp into the top plate, and electrons on the bottom plate are repelled and made to flow into the positive terminal of the battery. This charges the capacitor plates, and an electrostatic field develops between them.

If the capacitor is large and battery voltage is high enough, the charging current may pulse the lamp on for an instant. When the switch is opened, electrons will be trapped on the plate of the capacitor and it remains charged. If the left terminal of the lamp is now connected to the positive plate of the charged capacitor, a discharge current will flow through the lamp, possibly pulsing it on again for an instant. The greater the resistance of the lamp the slower the capacitor will charge and discharge.

The insulation between the plates, in this case air, is called the dielectric. It would be possible to draw lines across the dielectric to represent the electro-
static field, just as lines were used to represent magnetic fields. Magnetic and electrostatic fields are not the same, however, although both will be developed in all working radio circuits. Inductors store energy in their magnetic fields. Capacitors store energy in their electrostatic fields.

If a capacitor can store one coulomb of charge in itself when across 1 volt of EMF, it is said to have one farad (F) of capacitance. The farad is a very large value of capacitance. We usually use capacitors with microfarad (µF), or picofarad (pF) ratings in radio circuits.

Variable capacitors are usually made by using intermeshing plates. When the plates are completely intermeshed the capacitance is at its maximum. When the plates are completely unmeshed the capacitance is at its minimum. Usually, one set of plates is fixed in position; these are called the stator plates. The movable plates are called the rotors. Adjustable — as opposed to variable — capacitors depend on their plates being compressed together by screwdriver action.

If the air-dielectric capacitor shown in fig. 18 has a sheet of mica, paper, ceramic, or plastic slipped in between the plates, the capacitor will store more electrons than it would otherwise, given the same source voltage. The capacitor will have greater capacitance because these new dielectric materials can accept more lines of electrostatic force than air can. Such dielectric materials are said to have a higher dielectric constant. Air has a dielectric constant of 1. Mica, waxed paper, and plastics have constants that are between 5 and 10. Ceramic dielectrics may range in the thousands. All of these capacitors will be nonpolarized. That is, they may be connected into a circuit without regard as to which leads are used where. They may be used in ac, dc, VDC, or PDC circuits, although paper capacitors are not used in circuits where the frequency is expected to exceed about 2 MHz.

Two high-capacitance types of polarized capacitors are electrolytic and tantalum capacitors. They are made of sheet aluminum plates held apart by some material and dampened in a chemical solution. When manufactured they are connected across a dc voltage or potential and the plates “form,” developing an oxide on one of the plates. This oxide layer is very thin and has a very high dielectric constant. Such capacitors always carry a polarity marking (+) on one lead and must be connected in the circuit according to this polarity. If not, they will deform, heat, and burn out. These capacitors can not be used in ac circuits: only in dc, VDC or PDC circuits.

Fixed capacitors may be made in flat oblong or flat round shapes, or they may be in tubular form. They may have their leads emerging from the far ends. If made to be soldered into printed circuit (PC) boards, the leads will both come out the same side of the device. Capacitors range from tiny BB-shot size to the size of a small book.

Capacitors are used in conjunction with inductors in tuned circuits, both audio frequency and rf. Their ability to oppose any change in voltage allows them to be used to smooth (filter) varying or pulsating dc. They are also used to pass ac-effects without any direct connections, and are used to “bypass” ac energy to ground. Symbols of various types of capacitors are shown in fig. 19.
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simplifying the multipurpose UHF oscillator

Some modifications making use of inexpensive and easy-to-find components

An earlier article\(^1\) in *ham radio* described a low-power, voltage-tuned oscillator operating above 1000 MHz. It was designed primarily for use as a local oscillator in microwave television converters.

Two means of frequency control were described: 1) a free-running mode involving continuous tuning by means of a potentiometer, and 2) a phase-lock mode for click-stop tuning. These circuits are incapable of producing the degree of waveform coherence in a UHF oscillator for narrowband systems involving CW and SSB. In the free-running mode the circuit Qs are too low, and in the phase-locked-loop mode switching noise and oscillator subharmonics generated by the prescaler produce too much phase noise. In either case, however, the spectrum is clean enough for microwave TV applications.

By using more sophisticated circuitry it's possible to provide almost any degree of spectral purity. These advanced circuits are based on the oscillator described here and will be the subject of a future article. They will allow Amateurs to use CW and SSB modes in the microwave region as we do today on the high frequency-bands.

In developing the original UHF oscillator, I paid very little attention to component parts cost. I used parts on hand. Typical of this extravagance are the Plessey prescalers, which together cost about $40.00. Other examples are the tuning diode and the HP35821 transistor, which cost about $25.00 and $15.00 respectively in small quantities. Few can afford the luxury of such expensive components; those who can may find them difficult or impossible to procure in small lots.

The development work that followed my original effort was dedicated to simplification and cost reduction. These goals were to be met without sacrificing performance. Also all components were to be readily available in small quantities.

**modifying the UHF oscillator**

Much effort went into developing the circuit changes and making the modifications to meet the design goals. While the original electrical circuit configuration was retained, I made major changes to the PC board to accommodate new components. Those that were changed include the oscillator transistor, tuning diode, prescaler, and voltage regulator. Also, the PC board was scaled down in size to fit inside an inexpensive and readily available enclosure.

**component changes**

I used a Motorola MRF-901 high-frequency plastic

---

By Norman J. Foot, WA9HUV, 293 East Madison Avenue, Elmhurst, Illinois 60126
transistor to replace the more expensive HP-35821 to help meet the design goals. While the MRF-901 is specified primarily for use as a low-noise amplifier and switch, it also performs very well as an oscillator. This transistor has become very popular with Amateur experimenters because of its favorable performance characteristics and modest cost in small quantities. It has a typical \( f_T \) of 4.5 GHz with 15 mA collector current. Although the pinout is intended for common-emitter circuits, I designed the UHF oscillator PC board to accept this configuration without difficulty.

A Motorola MV2201 plastic 6.8-pF tuning diode (70 cents in small lots) has replaced the expensive and hard-to-find GC type 1607 diode. The capacitance tolerance of this diode is 5.5-8.0 pF at 4.0 volts bias. The MV2101, which sells for about $1.25 and has a lower tolerance of 6.1-7.5 pF, can also be used. The \( Q \) of the MV2201/2101 is low compared with that of the more expensive devices. Theoretically, a small amount of oscillator power that would otherwise be available at the rf output jack replaces the tuning-diode loss. Despite this drawback, this modified UHF oscillator described here easily provides 10 mW of rf output power. Thus, modest tuning diode \( Q \) is an acceptable compromise.

An RCA CA3179G 1.25-GHz prescaler replaces the more expensive Plessey types. The 3179G costs less than $10.00 each in small quantities. The RCA CA3163G, which has an identical pinout, is a suitable substitute. These prescalers divide by 256 when connected in the UHF mode.

The modified prescaler circuit is less complex than the original one. It uses fewer components, and expensive 0.1-watt resistors have been eliminated.

The Plessey prescalers used in the original UHF oscillator\(^1\) provided division by 40. It was recommended that an external divide-by-25 circuit be added to allow a counter to display, in kHz, the oscillator frequency in MHz. In retrospect, while the divide-by-40 circuit was a novel idea, it offered nothing in terms of oscillator performance that would justify the high cost of the prescalers. For experimental purposes, the CA3179G, which divides by 256, together with a simple conversion chart or hand-held calculator, will do just as well. Therefore, in keeping with the goal of availability and reduced cost, I decided to use the CA3179G prescaler.

You can get along without the prescaler if you have access to a digital counter that operates to about 1400 MHz. In most applications it’s not necessary to display the oscillator frequency continuously, but it’s useful to have the prescaler available for tune up and frequency adjustment. In my design I included a switch to disable the prescaler when not in use.

There are several reasons why I added this switch. First, I found that careful shielding was necessary to prevent small but measurable amounts of subharmonic signal power, generated by the prescaler, from appearing at the rf output jack.

Another reason for the switch is to reduce drift of the oscillator. The prescaler dissipates 325 mW of power, and 456 mW more is dissipated in the 5.0-volt series-pass regulator. The oscillator’s frequency stability is considerably improved when the prescaler is inoperative; otherwise, over a period of time, the additional 780 mW of heat increases the temperature of the oscillator module and causes some frequency drift. The component most affected by temperature changes is the tuning diode.

Two voltage regulators, an MC78L12 and an MC78L05, are connected in series to provide regulated +12 and +5 volts. These regulators have become very popular with Amateur experimenters because they are inexpensive and available in small quantities. Originally the +12 volts was supplied by a 723 IC, and a separate negative supply was needed for the prescalers. The modified UHF oscillator unit requires only a single positive supply voltage of between +15 and +19 volts at a current of about 100 mA.

The enclosure for the modified UHF oscillator consists of a RACO 11.5-cubic-inch (188.4-cm\(^3\)) extension box (92 cents) at hardware stores. The RACO box is made of welded steel and is normally intended for electrical house wiring purposes. Experience has shown that the PC board containing the UHF oscillator should be mounted inside of a rigid electrostatic enclosure. At UHF, fm microphonics may occur if the box is not rigid; furthermore, a good rule is to make the box rf tight to avoid the unpleasant consequences of rf leakage.

The RACO box meets these requirements. It measures 1-1/2 inches (38 mm) high, 2 inches (50 mm) wide, and 4 inches (102 mm) long. It is open both at the top and bottom. A flat 0.074-inch-thick (1.9-mm) aluminum plate 2-1/8 \( \times \) 5-5/8 inches (54 \( \times \) 143 mm) is attached with four screws to the bottom of the box. Matching holes, drilled into the bottom of the box, are tapped for 4-40 (M3) screws for that purpose. The plate extends out 5/16 inch (8 mm) from the box on each side where 1/8-inch (3-mm) holes are drilled to provide means for mounting. The top of the RACO box is fitted with a 0.020-inch-thick (0.5-mm) aluminum cover with 1/4-inch (6.4-mm) flaps turned down on all four sides. Except for the oscillator line and grounding shims to be described, the top and bottom covers are the only two sheet metal parts that need to be fabricated. These relatively simple parts are illustrated in fig. 1.
the oscillator line

The mechanical details of the oscillator line L1 are shown in the original article and therefore will not be duplicated here. However, the line should be shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm). This is necessary to compensate for the parasitic (lead) inductances of the inexpensive MV2201 tuning diode.

assembly procedure

You can make the PC board yourself from the full-scale patterns shown in fig. 2 or obtain them from Rock Engineering Supply Company, Inc., 1769 Armitage Ct., Addison, Illinois 60101. Another option is to procure a kit of parts including the PC board from RadioKit, Box 411, Greenville, New Hampshire 03048.

In simplifying the UHF oscillator, the expensive feed-through capacitors have been eliminated. All bypass capacitors are ceramic disc types except for C6, which is a 24-pF dipped mica. The schematic diagram is shown in fig. 3. C6 is soldered directly on the foil side of the board with extremely short leads. The original article describes how to prepare this capacitor before installation.

It is recommended that parts be assembled on the component side of the board first, including the voltage regulators, prescaler, the 2N5179 transistor and associated parts. Next, oscillator line L1 should be mounted on the foil side of the board. The pointed end of this inductance fits into the insulated hole near the MRF-901 transistor. The other end of L1 is supported by a 3/32-inch-thick (2.4-mm) epoxy fiberglass shim. Apply two-part, five-minute epoxy glue sparingly to the shim and each end of the line to secure them in position.

mounting the varactor tuning diodes

Because the MV2201 is equipped with wire leads, solder should be applied as close to the plastic body as possible to minimize lead inductance. The anode is soldered to the large pad under the oscillator line, while the cathode lead is bent at a right angle and soldered to the top of the line. Fig. 4 shows the installation of the diode. For operation at approximately 1100 MHz, the tuning diode should be soldered to the oscillator line at 1-1/4 inches (31.8 mm) from the collector end of the line.

mounting the PC board in the enclosure

The PC board is mounted in a RACO box about 1/2 inch (12.7 mm) from the top. It is held in place by means of L-shaped spring-brass shims soldered to the top and bottom of the rf output edge of the board. These shims also serve as rf grounds. I used scissors to cut my shims from a discarded piece of weather stripping; then I bent them at an angle of about 120 degrees using a bench vise as a makeshift brake. The dimensions of the L are 1/8 x 1/2 inch (3.2 x 12.7 mm); the small dimension is soldered to the board. The board is secured in position by means of 4-40 (M3) screws through both the wall of the box and the shims.

There are two holes located at the rear edge of the board, which are intended for through-grounds. Insert a short piece of tinned copper busbar in these holes, fold over and solder on each side.

operating frequency range

I built the modified UHF oscillator primarily to operate at its fundamental frequency in the range between about 1100 and 1200 MHz. However, by adjusting the position of the tuning diode on the line, the range can be moved up or down as in the original design. It's also possible to use frequency multipliers for higher-frequency operation, as described in the original article.¹

output coupling

The output-coupling circuit is similar to the original
one; however, a 3/16 inch-diameter (4.8 mm) powdered iron slug inserted in the output coupling loop and screwed to the board has been added to increase the coupling. The slug acts as a magnetic dipole, which aids the output current in the loop. Although it may seem surprising, carbonyl C iron made by Cambion (Cambridge Thermionic Corporation), which is normally intended for use at much lower frequencies, gave very good results. Power output was measured to be in excess of 10 dBm with the slug.

The rf coupling loop is formed from 3/16-inch (4.8 mm) wide 12-mil (0.3 mm) shim stock. The rf output jack should be mounted in a 3/8-inch-diameter (9.5 mm) hole centered on the middle knockout. The rf coupling loop terminates on the large pad under the BNC connector. The pad acts as an rf bypass capacitor and also allows dc power to be brought into the box by way of the coaxial center conductor.

To ensure a good rf output termination, a 3/16-inch-wide (4.8 mm) piece of copper foil is soldered to the flat on the threaded portion of the BNC connector. The other end of the copper foil is soldered to the ground foil on the edge of the PC board under the BNC connector. It is important that this ground foil be made as short as possible.

**test and adjustment**

Provisions have been included on the PC board to monitor the MRF-901 collector current for tune-up purposes. Temporary leads should be tack soldered to the doughnuts on each side of the gap in the PC conductor leading to the +12V oscillator pad. When the adjustment is complete, a jumper will be soldered across this gap, as illustrated in fig. 4.

The feedback capacitor, not shown, is made of 1/8-inch-wide (3.2 mm) copper foil. One end is soldered to the emitter, while the other end extends out over the top of a 1/32-inch-thick (0.8 mm) epoxy fiberglass insulator cemented with epoxy to the top of the oscillator line. See fig. 4 for details.
fig. 3. Schematic diagram of the improved UHF oscillator. The more expensive oscillator transistor, tuning diode, and prescaler used in the original circuit have been replaced with the components shown. Oscillator line L1 in the original design has been shortened from 2-1/16 inches (52.4 mm) to 1-3/4 inches (44.5 mm).

tune-up procedure

The procedure for tuning up the MRF-901 is somewhat different than for the HP35821B transistor used in the original model. First of all, a 100-ohm current-limiting resistor (which also acts as an rf choke) tends to maintain a relatively constant collector current. The 1.8k and 18k biasing network should set the collector current between 15 and 20 mA for most MRF-901s. Do not permit the collector current to exceed 30 mA. To reduce the collector current, increase the value of the 18k resistor to 20 or 22k as required.

The oscillator frequency is highly dependent on the capacitance between the emitter and collector. To adjust frequency, set the tuning pot output voltage to zero (12 volts tuning-diode bias). Connect a counter to the prescaler output jack; adjust the value of the feedback capacitor until the oscillator frequency is equal to the desired high-end frequency. Either clip the foil or bend it back on itself to increase frequency. Note that the counter readout corresponding to a frequency of 1100 MHz should be 4.2969 MHz. After making this adjustment, apply a very small amount of epoxy cement to the feedback capacitor to secure it to the epoxy insulator.

fig. 4. Details of oscillator assembly. Feedback capacitor C2 in fig. 1 is made by bending the unused emitter lead of the MRF-901 up and over the top of the transistor. A 1/4 x 1/8 inch (6.4 x 3.2 mm) piece of copper foil is then slid under the emitter and over the epoxy insulator and soldered to the emitter. (This capacitor is not shown in the drawing. See text for adjustment.)
The tuning range of the modified oscillator is smaller than with the original model — about 3 percent of the center frequency instead of ten percent. This is due primarily to the relatively high capacitance of the tuning diode. This range may be increased by using two tuning diodes in series.

The tuning range of the new oscillator has deliberately been reduced to permit use of a single-turn instead of ten-turn tuning pot. This is in keeping with the goal of cost reduction.

You may want to provide means to tune the UHF oscillator from a remote location. If so, remove the tuning pot and insert a phono jack in its place. Connect a 470-ohm, 1/4-watt resistor from +5 volts to the junction of the 1.5k resistor and the 0.01 μF bypass capacitor. Then connect the junction to the center conductor of the phono jack. The 2k pot can then be located at the far end of a shielded cable. Solder a phono plug on the near end.

**conclusion**

The UHF oscillator as described in reference 1 leaves something to be desired in terms of component cost and availability, which explains the reason for further development. Although its performance is outstanding in most respects, the original model was complex and difficult to construct. Also there was measurable rf leakage because some of the components were not totally shielded. Nevertheless, it proved to be a good starting place.

The modified UHF oscillator overcomes the problems of the original unit while retaining its good points. Because the RACO box is rugged and provides full shielding, stability and drift are negligible by comparison. For example, the warm-up drift of my modified oscillator operating in the free-running mode measured 650 kHz. After stabilizing in four minutes from a cold start, the frequency drifted only 0.06 percent at 1100 MHz. When buffered with a 3-dB pad, the effect of changing the load from a short to an open circuit through all possible angles caused a frequency change of less than 1.5 percent. Finally, despite the fact that the MRF-901 has less power-handling capability than its predecessor, it delivers a full ten milliwatts into a 50-ohm load.

Without compromising the important performance characteristics, the UHF oscillator can now be constructed easily with components that are readily available at a fraction of the cost of the original unit. The design goals specified at the beginning of this article have been met.

**reference**


*ham radio*
Making a crystal from a pair of eyeglasses! From time-to-time I receive interesting letters based on material in this column, and I'd like to share some of them with you.

G.W. Thomas, G5YK, of Suffolk, England, writes, "I was very interested to read your April issue...on 10 meters.

"I was also on 10 meters in those days and the first India-European contact was made on February 10, 1929: I established contact with VT2KT on that day using about 50 watts."

"I was also fascinated in the making of a crystal from a quartz slab. The price of a crystal in those days was more than my weekly wage, so I found a way of making one cheaply and with less effort. From an optician's shop I bought old quartz spectacle lenses and slowly and painstakingly ground them down to 80 meters. They were marvelous, and a friend (then G5YX) and I had a little business going as a sideline for a short while. Oh, those were the days!"

Charles Atwater, W2JN

A real old timer passed away a short time ago: Charlie Atwater, W2JN. Located in Upper Montclair, New Jersey, Charlie established the first-ever, 10-meter transatlantic QSO, with ef8CT in France. Ten meters had until then been considered a worthless band. W2JN exploded this idea around 1928 with a two-hour, 100-percent contact. Using an experimental license, Charlie made this record before the 10-meter band was opened for general Amateur use. The nu2JN transmitter (fig. 1) is an eye opener today! Doesn't look much like a Kenwood, does it?

W1BVL was there!

A note from Dick Briggs, W1BVL, says, "Your article in the April, 1981, ham radio of great interest to me, particularly your description of W1XM's 10-meter crystal-controlled transmitter of 1928. The four-tube driver unit using 201A tubes was built and used for my thesis at MIT in May, 1927. In 1928, a year after my graduation, the unit was used as described by Howard Chinn in November, 1981, QST magazine."

"At that time little was known about frequency doubling with vacuum tubes. My thesis made an analysis of the operating parameters. Also it was found that frequency changers could be made somewhat regenerative to enhance the gain per stage.

"My first DX QSO on 10 meters was with Bill Eitel, W6UF, on October 21, 1928, at 3:40 pm, EST. My transmitter was a tuned-plate, tuned-grid (TPTG) oscillator with a UV-203A with about 80 watts input from a chemical rectifier. The antenna was 70 feet long slanting up from 30 feet to 55 feet and a counterpoise wire slanting down from 30 feet to 8 feet."

"All the above brings back memories of those old times. I am now a retired vacuum-tube engineer and do consulting on microwave magnetrons."

the final word on 10 meters

George Elliott, W6ENC, sends the final word on 10 meters — a beautiful copy of the Ten-Ten International Net bulletin celebrating 50 years of 10-meter activity. The complete story of the famous nu2JN contact is in the bulletin, plus many other articles of interest to the 10-meter operator. The Ten-Ten International Net monitors 28,800 kHz daily except Sundays and publishes an interesting quarterly bulletin, chock-full of articles of interest to 10-meter ops. Full information on the net and the bulletin can be ob..."
Fig. 2. This photo explains why K6QXY has such a robust signal on 6 and 2 meters. The 6-meter array is composed of four seven-element KLM LPY Yagi antennas. Inside the array is the 2-meter beam, which consists of two twenty-element expanded collinear arrays.

Fig. 3. The base for K6QXY's new moonbounce antenna consists of three lattice towers arranged in a triangle. The first sections are up in the photo. The towers will go up to about 80 feet (24.4 meters), tied together every 10 feet (3 meters). Twenty-three cubic yards (17.6 cubic meters) of concrete will be poured into the base.

How to be LOUD on 6 and 2 meters

Have you ever heard the ear-splitting signal of Bob Magnani, K6QXY, on 6 or 2 meters? No? Then you must be off the air. Bob has an outstanding signal, and the pictures he sent me tell why. Fig. 2 shows the present installation, which consists of four seven-element KLM LPY Yagi antennas spaced one wavelength apart for 50 MHz. Estimated gain over a dipole — about 17 dB. Inside the 6-meter array is the 144-MHz array, which consists of two twenty-element expanded collinear arrays providing about 16 dB gain over a dipole.

Fig. 3 shows Bob's new antenna project, which seems to me to be comparable to building the pyramids of Egypt. This shows the base assembly for his new moonbounce antenna. It consists of three Rohn 25 towers in a triangle, 10 feet (3 meters) on a leg. In the center of the triangle is a stressed steel and concrete sub-base that has 6 cubic yards (4.6 cubic meters) of concrete in it, going down 10 feet (3 meters). The top pour, which will cover the excavation, will have 17 cubic yards (13 cubic meters) of concrete in it, for a total of 23 cubic yards (17.6 cubic meters). Two towers will go up about 80 feet (24 meters), tied together every 10 feet (3 meters). An antenna, steerable in azimuth and elevation, will go at the top. It is planned to have eight seven-element KLM LPY antennas providing a power gain of about 21 dB, with six-
teen fourteen-element "Junior Boomers" for 144 MHz nestled inside the bigger antenna. This will provide about 25 dB gain on 2 meters.

So if you haven’t heard K6QXY yet, you soon will!

**a long wire antenna for field day**

"Wait until next year!" That’s the cry of the Field Day enthusiast. And sure enough, the antennas for 1982 will be bigger and better than those used in 1981 for portable work.

Bob Walton, W6CYL, has the perfect scheme for getting a long wire antenna up in the air with a minimum of fuss and bother. He uses an arm-brace slingshot. This is a device that has a lightweight aluminum frame mounted at the bottom of the vertical handle, which rests back on the forearm and reduces the force on the handle when you draw back on the rubber tubing bands for a long shot into a tall tree.

Bob places a 6-ounce (170-gram) fishing line sinker on a heavy monofilament nylon line wound on the reel of a take-apart Japanese-imported trout rod. This setup will take about 200 feet (60 meters) of line. Bob mounts the pole and reel on a ground stake and releases the drag on the reel. Then, with the slingshot, he shoots the sinker up and over a tree using the fishing line as a messenger cable to pull up a long wire antenna. He puts an egg insulator on the end of the antenna wire so that he can see when the end is getting near the tree leaves and branches.

Bob has also tried the bow-and-arrow technique of shooting an antenna into a tree. He says that works, too, but it requires more expertise to spot the antenna wire where you want it. Bob says that you can buy a reel of braided copper antenna wire (part number AS-2071 CRT-3) at Fair Radio Sales, Box 1105, Lima, Ohio 45802.

After he gets the monofilament line safely up into a tree, with the sinker down at ground level, he attaches the braided copper wire to the line, unreels the wire and pulls in the sinker and line. Up she goes! When he’s finished operating, he releases the fishing line from the tie-down at ground level, and reels in the braided copper wire. In the event of a snag, he pulls on the wire and the nylon line breaks, freeing the balance of the wire.

Bob says, "Operating from a trailer, as I often do, requires searching for a parking spot that will permit a long wire antenna. Here, trees are ham’s best friends. And when you put up the antenna, stand by for a rash of CBers who descend upon you with all kinds of questions. Some even report inventing radio and the thrill of working skip, etc.!

Bob shows how it’s done in fig. 4.
the 2-meter quad at K3AC

K3AC, Malcolm Williams, lives in a high-rise apartment, as do many other Amateurs. The building frame is steel, and the use of an indoor antenna is out of the question. But K3AC puts out a powerful 2-meter signal with the aid of his portable four-element quad antenna. In a matter of minutes the quad can be assembled and placed onto the porch. And in bad weather, the quad can be used indoors, shooting out through the sliding glass doors (fig. 5). Dimensions for a quad of this type, cut to 146 MHz are: reflector loop, 21-1/2 inches (54.6 cm) on a side; driven element loop, 20-1/4 inches (51.4 cm) on a side; two director loops, each 19-1/4 inches (49 cm) on a side. Reflector-to-driven-element spacing is 16 inches (40.6 cm); driven-element-to-director spacing is 13 inches (33 cm). Spacing between directors is 13 inches (33 cm).

For vertical polarization the driven loop is broken in the middle of one vertical side and fed with a random length of RG-58/U coaxial line. The line is brought back to the boom and then run down the supporting mast. For horizontal polarization, the driven loop is broken in the middle of the bottom for the coaxial line. The reflector and director elements are the same in either case; they "don't know" the polarization of the driven element!

A duplicate of this quad beam is easy to build. The boom can be a 4-foot (1.2-meter) length of 1-inch (2.54-cm) diameter wood dowel rod, varnished to protect it from the weather. The loops are built from lengths of 1/4-inch (0.6-cm) diameter wood dowel rods, fitted into holes drilled in wood blocks. The blocks, in turn, are drilled to press-fit over the boom. The loops are made of No. 20 (0.8 mm) enameled wire.

To space the loops properly on the X-frame, the wire can be temporarily positioned with the aid of short pins pushed into the dowel rods. Once the position of the wires has been determined, the dowel tips are drilled to pass the wire element. The loop is made taut by pulling the dowels out of the holes in the center block a bit before epoxy cement locks the dowels to the block.

The array is collapsed by sliding the loops off the dowel boom. For a more portable affair, the loops themselves can be made to collapse.

There's no reason the vertical mast can't be lashed to the balcony and rotated by hand. K3AC mounts his quad on a small case, which provides a base and container for the quad when it is not used.

fig. 5. The compact 2-meter quad at K3AC is ideal for the apartment dweller. Sometimes Mal uses it indoors, shooting the signal through the sliding-glass doors. See text for dimensions and construction details.

what about your antenna?

Do you have an interesting antenna? Send me a description of it and if it appears in this column, ham radio will send you a free, one-year subscription to this magazine (or extend your subscription for a year if you already have one). Send your material to me, care of the magazine (address on the contents page 3 of every issue).
the half-wave vertical

A 40-meter DX antenna without a radial-wire ground system

A current-fed vertical antenna, such as a quarter- or five-eighths-wavelength monopole, must have a radial-wire ground system for maximum efficiency.\textsuperscript{1-3} This is known as a groundplane.

the groundplane

What is the purpose of this groundplane? Will it provide the low-angle radiation necessary for working distant stations? The radial-wire ground system under the antenna must provide a low resistance to reduce ohmic losses in the system. The ground-loss resistance, referred to the base of the antenna can, by a groundplane, be made low with respect to the system radiation resistance. For a quarter-wave vertical, the radiation resistance is approximately 36 ohms. The radiation efficiency is therefore high. The radial-wire groundplane system is therefore important, since the length and number of radials, as well as the conductivity of the ground, determine this terminal loss resistance.

The parameters of the antenna, however, to launch sky waves at low angles above the horizon extend to distances well beyond the antenna and its ground system. In fact, the conductivity of the ground, fifty or more wavelengths from the antenna, is important in that it influences the vertical radiation pattern of the antenna. And this effect is significant, especially for launch angles of less than 10 degrees above the horizon.

Fig. 1A shows the theoretical vertical radiation pattern for a 6-MHz quarter-wave antenna over poor, good, and very good ground (sea water). The pattern for an antenna over very poor ground, but with an extensive ground system,\textsuperscript{4} is shown in fig. 1B. It is clear that, while the radiation efficiency of the antenna is improved by using a ground screen, the power gains for elevation angles less than 10 degrees becomes vanishing small.

the half-wave antenna

An alternative approach is to use a half-wave radi-

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ator. Since its radiation resistance is high compared with the ground-loss resistance, the radiation efficiency can be high, even without wire ground radials. The base resistance of a half-wave antenna depends on its height-to-diameter ratio. For a tower antenna, the base radiation resistance is about 500 ohms; for thin wire antennas this resistance is several thousand ohms. Furthermore, if the antenna feedpoint is elevated from the ground, the influence of the finite conductivity of the ground on the input impedance of the antenna is even further reduced. The antenna will therefore radiate with good efficiency, even with no ground screen at all. Of course, the far-field vertical radiation pattern, especially at low elevation angles, is affected by the conductivity of the ground as discussed above; but we have little control over this except to erect the antenna over a salt marsh or over alkaline flats in the prairies.

The coaxial vertical, or sleeve antenna, (fig. 2), is a half-wave radiator. This antenna is used extensively at VHF. It can also be used effectively at high frequency, at least for frequencies greater than 7 MHz. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and the tower but connected by a skirt wire at the lower ends. The antenna is fed by a coaxial
fig. 2. The 40-meter coaxial-sleeve antenna. The coaxial sleeve is composed of a cage of four wires connected to the top of a tower, insulated from ground and tower, but connected by a skirt wire at the lower ends.

cable that runs up the center of the mast. The outside conductor of the coax is connected to the top of the tower; the center conductor is connected to the base of a free-standing, base-insulated whip at the top of the tower. (For base-station use, the tower should be grounded for lightning protection.)

The optimum height, measured from the center of the antenna above the ground, is one-half wavelength, since the antenna and its image are then separated by one wavelength. This is the height for maximum gain, which for a perfectly conducting ground, would be 6.27 dB over a dipole in free space. However, this height can be decreased to about 0.35 wavelength before ground losses appreciably affect the input impedance.5

antenna fundamentals

A vertical antenna of physical length or height, $H$, is related to its electrical length, $G$, by a factor $k$:

$$H = kG$$  \hfill (1)

where $H$ is height

$k$ is a factor (less than 1)

$G$ is electrical length (degrees)

That is, the physical height, $H$, is less than the electrical height, $G$, due to a) end effects and b) the velocity of propagation of the wave along the radiator, which is less than its velocity in free space. Usually $G$ will be one-quarter, one-half, or five-eighths wavelength (90, 180, or 225 electrical degrees). If $G$ is measured in meters rather than in degrees, (as for example, we express wavelength in meters), then the physical height, $H$, or in this case, $h$, will also be in meters.

The factor $k$ depends on the length-to-diameter ratio ($H/D$) of the radiator and on its electrical length. Fig. 3 shows the experimentally determined relationship between these parameters. In fig. 3 the percent increase of $G$ over $H$ is plotted versus the electrical diameter, $D$, (degrees), for a very wide range of values of $D$. Thus for thin antennas, this factor is approximately 5 percent, and for fat antennas, the percent increase is considerable. The experimental values were obtained from various sources. I measured those labeled 2 in fig. 3 for first and second resonance. Previous investigators, for example Brown and Woodward,6 got into difficulty for the larger values of $D$ because of the capacitance of the base plate since the disk they used, which closed the bottom of the cylindrical radiator, formed a shunt capacitance across the terminals of the radiator. In my measurements I used rods rather than tubes, and the radiators were tapered to a point at their bottom end (but the taper was over a distance small with respect to the length of the radiator) to minimize this effect. I have used the curves in fig. 3 for antenna design.

The curve for $G = 225$ degrees probably lies midway between those for $G = 90$ degrees and 180 degrees.

Towers are not usually of circular cross section. For triangular towers $d = 0.48b$ \hfill (2)
and for square towers
\[ d = 1.18b \quad (3) \]

where \( b \) = face width of tower
\( d \) = effective diameter of the tower

**design of the coaxial-sleeve antenna**

Suppose we design a coaxial-sleeve antenna for a frequency of 7.15 MHz (\( \lambda = \frac{984}{f MHz} = 137.6 \) feet or 42 meters, and a quarter wavelength = 34.4 feet, or 10.5 meters). The antenna arrangement is sketched in fig. 2.

The Shakespeare™ whip had a diameter of 1-1/4 inches (31.8 mm) at its base, and 1/4 inch (6.4 mm) at the top of the radiator. The effective diameter is therefore \( \frac{1.25 + 0.25}{2} = 0.75 \) inch, or 19 mm (0.0625 foot, or 0.02 meter).

Thus \( D_0 = \frac{0.0625 (360)}{137.6} = 0.16 \) degrees. In metric terms, \( D = \frac{0.02 (360)}{42} \).

The percent lengthening is therefore approximately 5 degrees, or \( k = \frac{1}{1.03} = 0.95 \). However, for fiberglass whips, the conducting wires are embedded in fiberglass. The velocity of propagation is therefore further reduced by the velocity of propagation in fiberglass, which is about 0.95 times the velocity in free space. Hence
\[ k_{eff} = 0.95k \]
\[ = 0.95 (0.95) = 0.9 \]

The length of the whip is therefore: \( 0.9 (34.4) = 31\) feet (9.5 meters).

The effective diameter of the coaxial sleeve is estimated as follows. The top of the sleeve is the diameter of the supporting tower, which for a triangular tower 8 inches on side is \( 0.84 \left( \frac{8}{12} \right) = 0.56 \) foot (0.17 meter).

The four wires of the cage that form the sleeve are tied to stakes forming a 3-foot (0.9-meter) radius about the base of the tower (see fig. 2).

Visualize these tie points to form the corners of a square, which at ground level has a side length of \( 2\sqrt{2} = 4.24 \) feet (1.3 meters). Thus the effective diameter is \( 1.18 (4.24) = 5 \) feet (1.52 meters). The effective diameter at the end of the sleeve is approximately \( \frac{30}{40} (5) = 3.75 \) feet (1.14 meters). The average effective diameter of the sleeve is therefore \( 3.75 + 0.56 = 2.15 \) feet or 6.57 meters. (that is, 5.6 degrees). Hence (see fig. 3), the percent lengthening for \( D = 5.6 \) degrees, \( G = 90 \) degrees is 19 percent. The antenna factor \( k = \frac{1}{1.19} = 0.84 \). The length of the sleeve is therefore 0.84 times the length of a free-space quarter wavelength, or 0.84 (34.4) = 29 feet (8.8 meters).

The antenna* was built according to these dimensions, and indeed it was resonant in the middle of the 40-meter band. Since the input impedance of the antenna (which was not measured) is expected to be closer to 72 ohms than to 50 ohms, the feed cable should be RG-11/U. If 50-ohm cable is preferred (RG-8/U), the feeder cable should be cut so that it is an integral multiple of one-half wavelength (a cable one wavelength long would be 90.83 feet, or 27.7 meters). This is because such a transmission line, regardless of its impedance, transfers to the feedpoint the terminal impedance without introducing reactance.

**a practical antenna**

The antenna that we constructed for use at a field-day site is shown in the photos. A full-wave delta loop (apex down, apex fed) was also used. This antenna has quite a different vertical radiation pattern (dominantly high angle). Switching from one antenna to the other provided reception from quite a different zone — a very desirable feature for field day.

**acknowledgments**

I would like to thank Harry, VE2RO, and Arn, VE2SD, for help in constructing the antenna. Thanks are also due to the field-day crew who raised the antenna, and to Geof, VE3KID, who took the photographs.

*The 40-foot (12.2-meter) tower employed is just marginally high enough, since the height of the antenna measured from its center is approximately 0.3 wavelength. Ideally, a 70-foot (21.4-meter) tower should be employed.

**references**

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avoiding built-in digital-circuit problems, part one

Many problems common to analog circuits pose no problems at all for well-designed digital circuitry, but digital circuits may be subject to built-in errors caused by inattention to logic timing, improper power-supply filtering, or radio-frequency interference (RFI). Examples of some problems and cures are presented, including oscilloscope waveforms for several divider circuits. Output pulse stretching modifications are shown for dividers with low repetition rates. Attention to logic-state timing is stressed, and the "logic race" condition is explained.

Methods of improving power-supply distribution are presented, concentrating on decreasing supply-source impedance. Off-board wiring can act as an antenna for RFI, and improvements shown here demonstrate filtering methods for RFI. Adding gating with dc control lines restricts data selection. Mechanical-switch-contact bounce is shown, and a debounce circuit given. The author suggests studying past mistakes to avoid future problems.

A nice feature of digital circuitry is that it's not sensitive to drift, noise, or realignment problems, which are common to analog designs. A good digital circuit performs the same function each time. But a few digital designs are not well executed by the designer, usually the result of lack of experience.

A constant problem is the race condition. This phenomenon occurs when two or more sequence paths are mixed with improper time delays among each path. The circuit may work, but it's not clear how much margin exists and glitches may appear that affect circuitry further downstream.

A glitch-generating condition is shown in the simple flip-flop circuit of fig. 1 and the waveforms of fig. 2. The flip-flop circuit could be used to generate a string of dashes in a keyer (input clock speed in this example was increased to make the negative glitch clearly visible).

By Penn Clower, W1BG, 459 Lowell Street, Andover, Massachusetts 01810

September 1981

One can thus “build-in” problems; and the purpose of this article is to help you learn how to “build them out”.

There are several ways to spot a poor digital design: a project may work only over a limited supply-voltage range. Interchanging identical devices may not be possible, or certain portions of the circuit may be critical. Strange things may happen when switches are thrown. Worst of all, the circuit may be sensitive to rf pick-up.

Tracking down and fixing these problems can be difficult. The underlying cause may show itself only during a transition, and not be obvious from an examination of resting states. Useful troubleshooting tools are a fast multi-channel oscilloscope, good data books, and lots of experience.

Professionals have access to good scopes and also have the design experience. Good data books are available, and pitfalls are easy to avoid once understood. But the mass of data on each device may be overwhelming to the eyes of the inexperienced. So let’s expose the critical factors.

The greatest design problem is poor timing. Modern logic operates with nanosecond transition and delay times. These times are so fast that they may appear instantaneous when compared with a 50-WPM keyer, for example. Nanoseconds are important, though, and the proper sequencing of logic signals is crucial to the success of a circuit design.

Many logic designs work because the designer was lucky: the arrangement of propagation delays just barely allowed proper sequencing. Copying such designs, using long leads, will add time delay and may make the circuit marginal. Inadequate power-supply bypassing may fail to remove glitches (unwanted, short spikes), which can make the circuit inoperative.

the logic race

A constant problem is the race condition. This phenomenon occurs when two or more sequence paths are mixed with improper time delays among each path. The circuit may work, but it’s not clear how much margin exists and glitches may appear that affect circuitry further downstream.

A glitch-generating condition is shown in the simple flip-flop circuit of fig. 1 and the waveforms of fig. 2. The flip-flop circuit could be used to generate a string of dashes in a keyer (input clock speed in this example was increased to make the negative glitch clearly visible).
fig. 3. Using ruled paper to analyze timing. Note how propagation delays have been exaggerated to show glitch formation. Circuit of A is the same as in fig. 1; B adds a gate to eliminate the output spike.

The negative spike is the result of a race condition: the input clock signal reaches both the flip-flop and gate at the same time. Since the flip-flop has some delay in changing state, a brief time occurs when both gate inputs are high, to produce a low gate output.

Each race condition must be judged for a particular application. Some don’t matter. If the circuit of fig. 1 were used as a keyer, the CW transmitter would ignore a 50-nanosecond spike since carrier envelope response is usually several milliseconds. On the other hand, if the output were used to clock or gate some other logic, the spike would not go unnoticed! A problem spike should be modified so that the race is always won by the designer.

**a simple race analysis tool**

This tool is simply a piece of lined paper turned sideways. Paper lines provide time markers for the input waveform. This technique is used in fig. 3. It shows the original fig. 1 circuit and timing in A, one solution in B.*

The solution toggles the flip-flop on the opposite edge and adds a gate delay to the flip-flop clock input. Output-gate inputs will “line up” without glitches. Use of this fix will depend on remaining circuitry; note that the opposite clock edge does the flip-flop toggling.

**judging a race**

An important point to remember is that races can result from many causes: device delays, board layout, temperature, and operating voltage, which can vary a spike width. Such races may be hard to spot because of time differences. Even a fast scope can’t display a short spike at a low repetition rate. Troubleshooting may require a fast rate for test or simply the paper analysis tool. More than one device has been discarded because it was properly responding to “invisible” spikes!

**the brief but necessary spike**

Some medium-scale integrated (MSI) devices generate very short output pulses by design. This forces close attention to board layout because long lines can distort short pulses and cause trouble.

The divider circuit of fig. 4 is an example. The 74193 counters are connected in a down-count mode with preset of 20. When the second stage borrow goes low, the preset condition is loaded into the counters. The input clock then counts down until both counters reach all-zero, causing the borrow out-

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*Propagation delays should be taken from data books, but the paper sketch can exaggerate the delays for clarity.
put to go low, and the process repeats.

Fig. 5 shows the input and output waveforms with a 1-kHz input rate. The output appears to have nothing, but it is working.

A 74193 device has a direct asynchronous preset load feature. Borrow out is determined by all-zeros, but this is also the preset load. Width of the output pulse is determined by the propagation delays of borrow output and load: about 30 nanoseconds in this case.

Fig. 6 is an expanded time-scale version of fig. 5. It shows the negative edge of the 20th clock pulse in relation with the output pulse. A delaying-sweep oscilloscope is required for this brief-but-necessary spike, but other problems exist.

Distributed capacitance and series-lead inductance of long lines may distort the output and prevent proper loading. (Long lines tend to form lowpass filters.) Both counters should have borrow and load propagation delays within specification; out-of-specification device problems are covered later.* It doesn’t make sense to choose a circuit requiring fast-pulse layout with a 1-kHz clock. Three added NAND gates will improve things.

**improved divider with visible output**

The circuit of fig. 7 adds a set-reset latch (U1, U2) between borrow and load. U2-6 is held high by clock inverter U3. The low borrow from the second counter will flip the latch and make U2-6 low, enabling the preset load. The load will remain low for one-half clock cycle through the inverter.

Once the latch has been set and preset load enabled, the latch is reset only when the input clock goes high. The positive edge of the clock would normally toggle the counter, but the 74193 is designed to inhibit counting until the load pin returns high. This means the circuit of fig. 7 will skip one input clock.

The input-output waveforms of fig. 8 show a visible output pulse, one for every 21 inputs. The same preset connections as in fig. 4 were used. A proper division by 20 requires a preset connection one less than the desired count.

Layout problems are reduced, and the output is visible, but two gates and an inverter are required. (If these are not available, another device may be chosen.)

**a different device but same function**

Another way out of the fast-spike problem is to

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*Sometimes these problems are caused by off-brand ICs.
design with a device such as the 74163. It features synchronous loading; the preset loading occurs only when the required clock edge is received. A divide-by-20 circuit is shown in fig. 9, with waveforms in fig. 10.

Operation is similar to that in fig. 7 except that the 74163 is an up-counter. Preset is maximum count, minus desired count, minus one. It is the binary complement of fig. 7.

Ripple carry output goes high on full count, then it's inverted for the preset load input. The 74163 is designed to inhibit counting when the load pin is low. The clock enables preset loading instead, and the counters have an entire clock cycle to settle before the first up-count.

reliability

The important thing to remember about these examples is that a reliable design must allow sequences in a nice, orderly fashion, with plenty of time for setup and settling. The designer must hold device speed limits and observe propagation delays. Layout and wiring problems then have easier, low-frequency solutions.

The next part of this article will show some other problems and solutions, plus methods of reducing radio-frequency interference (RFI).

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fall equinox propagation outlook

September, like March, is a special time of year for propagation, and therefore DX. Equinox is the reason: equal-length nights and days; the sun is directly overhead at noon on the geographic equator. At this time, with the radiation from the sun hitting the earth broadside, and because the auroral zone ionospheric geographic equator. At this time, with the radiation from the sun hitting the earth broadside, and because the auroral zone ionospheric

equatorial plane of the earth and the plane of the sun’s equator nearly coincide, particles from the sun’s eruptions (flares) and coronal holes (thin places in the sun’s gases) have a bull’s-eye path to the earth. These charged particles, called the solar wind, enter the earth’s atmosphere in the polar regions. They also build up in the Van Allen belts around the earth above the equatorial region. When full, the belts dump into the polar auroral zone, on the Canadian-U.S. side after about 2200 local time. This is a geomagnetic storm.

Coincident with the geomagnetic storm are three ionospheric processes that affect propagation and DX. First, the particles coming into the auroral zone ionospheric D and E regions absorb the energy from the signal, lowering the S-meter reading. Weak signals on east-west paths and few signals across the poles are the result. Second, the particles form a reflective curtain along the equator side of the auroral zone for VHF auroral scatter propagation openings. Third, the F region of the ionosphere toward the equator from the auroral zone is depleted to form a trough where the maximum usable frequency (MUF) for a particular path through this area decreases by 30 to 50 percent. Paths through the trough require the lower frequency bands. However, north of the geomagnetic equator a similar-size enhancement of the F region MUF takes place to give the evening trans-equatorial openings during the equinox and winter seasons. These three effects are not steady but quite variable on any time scale (hours, minutes, or seconds); therefore fading is an almost normal occurrence. The effects continue to occur each night for 2 to 3 days before ionospheric equilibrium is obtained again. The bigger the geomagnetic storm (higher K or A value) the closer to the equator these effects occur.

You’ll remember during the last spring equinocial period, March, April, and into May, seven periods were experienced with these phenomena going on for days at a time. This was the most disturbed period so far this solar cycle. We may not have a fall equinox like the spring disturbances, but if so, you can be on the lookout for those effects. When the ionosphere is this variable, DX openings come at very odd times and locations with weak and fading signals. Be on the lookout for those needed country or just have a lot of fun.

gray-line DX

Another equinox propagation phenomena for interesting DX is known as gray-line DX. This propagation enhances DX on north-south paths over the polar regions during quiet geomagnetic conditions. The best times for openings are just as dawn or sunset comes upon your location with your antenna pointed north or south. Signals will be unbelievably strong and clear, reminiscent of sporadic E (Es) one hop. By the way, there may be a few short-skip openings from Es left for this summer’s Es season, if you’re lucky enough to catch them. Let’s look at the September forecast.

The 27-day solar minimum is expected about the 13th of September, building to a maximum about the 27th. Geomagnetic disturbances from solar flares are expected as short periods during ascending activity around September 23 and even more likely on the descent about the 30th. A longer disturbance may be experienced about the 10th if a solar coronal hole develops near the minimum solar activity. Solar flux should be building somewhat into the winter months for better DX.

Full moon is on the 14th and perigee on the 17th this month. The time the equinox occurs is on September 23rd at 0305UT.

band-by-band summary

Six meters will provide some excellent openings to South Africa from the eastern U.S. and from the western and central U.S. to Australia and New Zealand around local nighttime. The openings are more probable during high solar flux values.

Ten, fifteen, and twenty meters will be full of signals from morning into early evening almost every day and to most areas of the world. The openings will be shorter on the higher bands and concentrated more near noon for the path of interest. High solar flux values and geomagnetic disturbance will favor these bands for trans-equatorial contacts.

Forty, eighty, and one-sixty meters are the night DXer’s bands. The bands are open beginning just before sunset and lasting until just as the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don’t affect these bands much. Geomagnetic disturbances may cause much signal attenuation and fading on polar paths.
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*Look at next higher band for possible openings.*
40 W, 15 memories/offset recall, scan, priority, DTMF touch-pad

TR-7850

Kenwood's remarkable TR-7850 2-meter FM mobile transceiver provides all the features you could desire, including a powerful 40 watts RF output. Frequency selection is easier than ever, and the rig incorporates new memory developments for repeater shift, priority, and scan, and includes a built-in autopatch touch-pad (DTMF) encoder. A 25-watt output version, the TR-7800, is also available.

TR-7850 FEATURES:

- **Powerful 40 watts power output**: Selectable high or low power operation. High 40-watt output provides reliable signal for wide area coverage.

- **15 multifunction memory channels, easily selectable with a rotary control**
  - MI-M13... memorize frequency and offset (±600 kHz or simplex). M14... memorize transmit and receive frequencies independently for nonstandard offset.
  - MO... priority channel, with simplex, ±600 kHz, or nonstandard offset operation.

- **Internal battery backup for all memories**
  - All memory channels (including transmit offset) are retained when four AA NiCd batteries (not Kenwood supplied) are installed in battery holder inside TR-7850. Batteries are automatically charged while transceiver is connected to 12-VDC source.

- **Extended frequency coverage**
  - 143.900-148.995 MHz, in switchable 5-kHz or 10-kHz steps.

- **Priority alert**
  - MO memory is priority channel. "Beep" alerts operator when signal appears on priority channel. Operation can be switched immediately to priority channel with the push of a switch.

- **Built-in autopatch touch-pad (DTMF) encoder**
  - Front-panel touch pad generates all 12 telephone-compatible dual tones in transmit mode, plus four additional DTMF signaling tones (with simultaneous push of REV switch).

- **Front-panel keyboard**
  - For frequency selection, transmit offset selection, memory programming, scan control, and selection of autopatch encoder tones.

- **Autoscant**
  - Entire band (5-kHz or 10-kHz steps) and memories. Automatically locks on busy channel; scan resumes automatically after several seconds, unless CLEAR or mic PTT button is pressed to cancel scan.

- **Up/down manual scan**
  - Entire band (5-kHz or 10-kHz steps) and memories, with UP/DOWN microphone (standard).

- **Repeater reverse switch**
  - Handy for checking signals on the input of a repeater or for determining if a repeater is "upside down."

- **Separate digital readouts**
  - To display frequency (both receive and transmit) and memory channel.

- **LED bar meter**
  - For monitoring received signal level and RF output.

- **LED indicators**
  - To show: +600 kHz, simplex, or -600 kHz transmitter offset; BUSY channel; ON AIR.

- **TONE switch**
  - To activate subaudible tone module (not Kenwood-supplied).

- **Compact size**
  - Depth is reduced substantially.

- **Mobile mounting bracket**
  - With quick-release levers.

More information on the TR-7850 is available from all authorized dealers of Trio-Kenwood Communications, Inc., 1111 West Walnut Street, Compton, California 90220.

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Matching accessory for fixed-station operation:
- KPS-12 fixed-station power supply for TR-7850

Other accessories not shown:
- KPS-7 fixed-station power supply for TR-7800
- SP-40 compact mobile speaker

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

Processor, N/W switch, IF shift, DFC option

**TS-130S/IV**

An incredibly compact, full-featured, all solid-state HF SSB/CW transceiver for both mobile and fixed operation. It covers 3.5 to 29.7 MHz (including the three new Amateur bands!) and is loaded with optimum operating features such as digital display, IF shift, speech processor, narrow/wide filter selection (on both SSB and CW), and optional DFC-230 digital frequency controller. The TS-130S runs high power and the TS-130V is a low-power version for QRP.

**TS-130 SERIES FEATURES:**

- **80-10 meters**, including three new bands
  Covers all Amatuer bands from 3.5 to 29.7 MHz, including the new 10, 18, and 24-MHz bands. Receives WWV on 10 MHz. VFO covers more than 50 kHz above and below each 500-kHz band.
- **Two power versions...easy operation**
  TS-130S runs 200 W PEP/160 W DC input on 180-15 meters and 160 W PEP/140 W DC on 12 and 10 meters. TS-130V runs 25 W PEP/20 W DC input on all bands. Solid-state, wideband final amplifier eliminates transmitter tuning, and receiver wideband RF amplifiers eliminate preselector peaking.
- **CW narrow/wide selection**
  "N" W switch allows selection of wide and narrow bandwidths. Wide CW and SSB bandwidths are the same. Optional YK-88C (500 Hz) or YK-88CN (270 Hz) filter may be installed for narrow CW.
- **Built-in speech processor**
  Increases audio punch and average SSB output power, while suppressing sideband splatter.
- **SSB narrow selection**
  "N-W" switch allows selection of narrow SSB bandwidth to eliminate QRM, when optional YK-88SN (1.8 kHz) filter is installed. (CW filter may still be selected in CW mode.)
- **Sideband mode selected automatically**
  LSB is selected on 40 meters and below, and USB on 30 meters and above. SSB REVERSE position on MODE switch.
- **Built-in digital display**
  Six-digit green fluorescent tube display indicates actual operating frequency to 100 Hz. Also indicates external VFO or fixed-channel frequency, RIT shift, and CW transmit/receive shifts. Backed up by an analog subdial.
- **IF shift**
  Allows IF passband to be moved away from interfering signals and sideband splatter.
- **Built-in RF attenuator**
  For optimum rejection of intermodulation distortion.
- **Single-conversion PLL system**
  Improves stability as well as transmit and receive spurious characteristics.
- **Built-in VOX**
  For convenient SSB operation, as well as semibreak-in CW with sidetone.
- **Effective noise blanker**
  Eliminates pulse-type interference such as ignition noise.
- **Compact and lightweight**
  Measures only 3-3/4 inches high, 9-1/2 inches wide, and 11-9/16 inches deep, and weighs only 12.3 pounds.

**Matching accessories for fixed-station operation:**

- PS-30 base station power supply (remotely switchable on and off with TS-130S power switch)
- YT-9S (180 Volts) and YT-9SN (180 VDC) CW filters.
- YK-88S (2.8 kHz) narrow SSB filter.
- AT-10 compact antenna tuner (80-10 m, including 3 new bands)
- MS-100 mobile mounting bracket (6 m bands)
- MC-30S and MC-35S noise canceling hand microphones
- SP-120 external speaker
- VFO-120 remote VFO
- MC-5450B/5059 desk microphone
- PC-1 phone patch
- TL-922A linear amplifier
- HS-5 and HS-4 headphones
- RC-10 world digital clock
- PS-20 base station power supply for TS-130V
- SP-34 compact mobile speaker
- VFO-230 digital VFO with free memories

**Other accessories not shown:**

- YK-88C (500 Hz) and YK-88CN (270 Hz) CW filters.
- YK-88SN (1.8 kHz) narrow SSB filter.
- AT-10 compact antenna tuner (80-10 m, including 3 new bands)
- MS-100 mobile mounting bracket (6 m bands)
- MC-30S and MC-35S noise canceling hand microphones
- SP-120 external speaker
- VFO-120 remote VFO
- MC-5450B/5059 desk microphone
- PC-1 phone patch
- TL-922A linear amplifier
- HS-5 and HS-4 headphones
- RC-10 world digital clock
- PS-20 base station power supply for TS-130V
- SP-34 compact mobile speaker
- VFO-230 digital VFO with free memories

More information on the TS-130 Series is available from all authorized dealers of Trio-Kenwood Communications Inc., 111 West Walnut Street, Compton, California 90220.
RFI cures:

avoiding side effects

Advice on preventing additional problems when making RFI fixes to home-entertainment equipment

Many Amateurs have had it happen: You’re on the air and the phone rings, or there’s a loud knock on your door. It’s a neighbor who says, “Your signals are getting into my stereo and clock radio.” Whatever the device, you are expected to do something about it. The problem still exists today, despite advances in engineering. If you want to stay on the air and keep peace in the neighborhood, you might offer to add a few components to the affected equipment to make it less susceptible to RFI.

Much has been published in the Amateur literature on cures for Amateur-caused radio-frequency interference (RFI) to these devices. If you handle the problem diplomatically and apply the appropriate cure to your neighbor’s equipment, the interference from your Amateur transmitter may disappear, but you may be faced with more problems. What happens when your neighbor’s precious stereo set doesn’t have the original audio response it had before you made the fix? Suppose your friendly neighbor’s phono preamp develops a 60-Hz hum after you’ve added components to cure RFI?

By John W. Frank, WB9TQP, P.O. Box 5113, Madison, Wisconsin 53705
If the interference is entering the stereo through the ac line, the cord can be wrapped around a ferrite rod to form a bifilar choke.

This article is based on my experience with RFI problems in commercial home-entertainment devices. It offers some advice on dealing with the side effects that can occur when trying to tame such devices. Such side effects include parasitic oscillations and high-frequency attenuation in audio amplifiers, hum in phonograph preamps, and the so-called “hot-chassis” syndrome.

a personal experience

Not long ago, a neighbor and I were victims of RFI. After determining that the offending CB transceiver was being operated legally, we added the standard filtering and shielding to our stereos only to encounter the side effects of these commonly accepted RFI cures. The side effects included parasitic oscillations, high-frequency attenuation, the hot-chassis syndrome, and a 60-Hz hum. Since each of these side effects is the result of a different cure, each must be considered separately.

Parasitic oscillations and high-frequency attenuation (described in the text) can be avoided by installing a toroid on each speaker lead.

parasitic oscillations

Bypass capacitors on speaker leads are sometimes unnecessary and often their effect can be disastrous. Fortunately I didn't destroy the audio output transistors in my receiver. Another RFI victim in my neighborhood wasn't so lucky: capacitors on the speaker leads of his stereo set caused feedback, and the resulting high-frequency oscillations destroyed the audio power amplifier.

Some solid-state amplifiers will oscillate when bypass capacitors are placed across their output. Quite often, these oscillations occur at frequencies too high to be audible. These parasitic oscillations can cause overheating of the output transistors and put an extra burden on the power supply. The sad part is that often bypass capacitors aren't needed on the speaker leads. Many articles on RFI suppression recommend bypassing speaker leads for rf. But unless the leads are acting as an antenna, there's no need for this cure.

How can you tell if the speaker leads are acting as an antenna? If you're using a receiver with a headphone jack, disconnect all speakers at the receiver output, plug in a set of headphones, and listen. If the receiver doesn't have a headphone jack, disconnect all speakers at the receiver and connect headphones to the receiver output with short jumper wires. If the interference disappears when the speakers are disconnected, it's safe to assume that the speaker wires are acting as an antenna. If the interference remains, you'll need to keep looking and listening to find out how the offending signal is getting into the stereo set.

high-frequency attenuation

Another approach to keeping rf on the speaker leads from getting into the receiver is to use an rf choke in series with the speaker leads at the receiver (fig. 1). In theory this works fine; in reality it creates a new set of problems. The inductive reactance of the rf choke will prevent rf from reaching the receiver, but the choke will have enough reactance to attenuate higher audio frequencies as well.

fig. 1. An rf choke in series with a speaker lead can cause high-frequency attenuation as described in the text. An alternative is to use a ferrite bead on each speaker lead or thread each lead through a toroid core.
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For example: 2.5 mH at 15 kHz will have a reactance of approximately 235 ohms. At 500 Hz that same 2.5 mH will have a reactance of less than 8 ohms. The load on the receiver will be changing because the reactance of the choke will constantly be changing with frequency. A substantial amount of power will be lost in the choke. Most small, pi-wound chokes are designed for small amounts of current, generally 1 ampere or less. At higher audio frequencies, the reactance of the choke will limit current through the series combination of choke and speaker. But, at lower frequencies and higher power levels, the current through the choke could reach several amperes, until the choke overheats and acts like a fuse. Now the audio output stage is looking into an open circuit.

Some receivers and amplifiers can tolerate loads of varying impedance; others can't. An alternative to the rf choke is to slip a ferrite bead over the speaker lead at the receiver or, in more stubborn cases, thread the lead through a toroid core (see photo).

Another cause of high-frequency attenuation is excessive capacitance in the signal path. In my stereo, the CB signal was getting into the phono preamp through the magnetic phono cartridge. This problem was confirmed by removing the cartridge from the tone arm without hearing any interference.

The simplest approach to this problem was to add rf bypass capacitors to the phono preamp inputs. When 100-pF capacitors were installed, as shown in fig. 2, a noticeable deterioration occurred in the high-frequency response. The reason for the attenuation of high frequencies is that the total capacitance in the signal path exceeded the maximum load capacitance the cartridge could tolerate. Fig. 3 illustrates the factors that contribute to the total capacitance in the circuit.

How much capacitance is too much? Specification sheets for good-quality phono cartridges include data for the optimum load resistance and maximum load capacitance. High-frequency attenuation can be avoided by keeping the total capacitance well below the maximum tolerable capacitance.

**Hum**

Phono preamps are high-gain, high-impedance circuits. Adding any unshielded components to their inputs can result in an annoying hum. The side effect is the result of installing rf chokes in the preamp input circuits, as shown in fig. 4. Although rf chokes will solve the interference problem without causing high-frequency attenuation, any nearby magnetic fields will induce enough voltage in the choke to cause a 60-Hz hum. Depending on the intensity of the magnetic field and the type choke used, the hum could range from barely audible to loud and objectionable.

**The Hot Chassis Syndrome**

Occasionally, rf will find its way into a stereo by way of the ac line cord. The commonly accepted cure for this type of RFI consists of placing bypass capacitors across the primary of the power transformer (fig. 5). While this will prevent rf from getting into the stereo through the ac line, it might create a shock hazard. This problem arises from the fact that almost all consumer audio equipment uses a two-wire line cord. The chassis is almost never at ground potential and, with the addition of the bypass capacitors, the potential between chassis and ground terminal of a three-wire outlet can be as much as 20 volts. (This number is based on my own measurements and may vary, depending on the type of equipment and the value of the bypass capacitors as well as other factors).
avoiding side effects

There’s nothing mysterious about avoiding side effects of RFI cures. All it takes is a basic understanding of electronic theory and some common sense in application.

Parasitic oscillations can be avoided by not putting bypass capacitors on speaker leads unless it’s absolutely necessary, and then only when recommended by the manufacturer of the equipment affected.

Since high-frequency attenuation can be caused by either of two cures, there are two ways to avoid such attenuation. If it’s necessary to use rf chokes on the speaker leads, use the smallest amount of inductance that will do the job. If one or two ferrite beads placed on each speaker lead at the amplifier don’t provide enough inductance, try a toroid, as shown in the photo.

When high-frequency attenuation is caused by too much capacitance in the signal path, the solution is to reduce the capacitance wherever possible. If a bypass capacitor is needed on each preamp input, use the smallest value that will cure the RFI problem. An old rule of thumb states that the reactance of the bypass capacitor should be one tenth the impedance of the circuit being bypassed at the lowest frequency encountered. If poorly shielded patch cords contribute to an RFI problem, replace them with RG-59 coax cable. Why use RG-59 when RG-58 is less expensive and more flexible? Answer: RG-59 cable has less capacitance per unit length.

Hum can be avoided by not adding unshielded components to high gain circuits. If an rf choke is needed on a preamp input to block out the offending signal, very carefully remove the first amplifying transistor from the circuit and slip a ferrite bead over the input lead.

If the rf is entering the receiver or amplifier on the ac line, the hot-chassis syndrome can be prevented by using a bifilar choke, as shown in the photo.

If wrapping the ac-line cord around a ferrite rod to form a bifilar choke is too bulky or inconvenient, the hot-chassis syndrome can still be avoided. When installing capacitors across the power-transformer primary winding, make sure the caps have a high-enough voltage rating to withstand the peak ac voltage plus any surges, spikes or transients that may occur. A 600-volt rating is usually adequate. Also make sure the capacitors have a very high leakage resistance. One final step you can take is to add a three-wire line cord. When the chassis is grounded through the line cord, a shorted capacitor will blow the fuse.

some final thoughts

Because of the variety of tuners, turntables, tape decks, preamps, power amplifiers, graphic equalizers, and speakers on the market, no two cases of RFI are exactly alike. Add to this the variety of antennas and transmitters available to the Amateur-Radio operator and very few sources of RFI are exactly alike.

The point is that one audiophile might suffer from interference and his neighbor might not. One audio amplifier might have an adverse reaction to a commonly accepted RFI cure, and another might not.

The intent of this article has been to make you aware of some of the common side effects of RFI cures and how they can be avoided. However, when in doubt consult the manufacturer! For example, if an audio amplifier uses inverse feedback to reduce distortion, the manufacturer can tell you if adding capacitors across the output will send it into a frenzy of oscillation.

I repeat! When in doubt, consult the manufacturer.

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Tell 'em you saw it in Ham radio!
the how and why of multiplexing

An interesting communications technique with practical suggestions for Amateur use

Those who have studied for an Amateur license know that radio signals are modulated to transmit intelligence. Such modulation may be thought of as one form of multiplexing — transmitting and receiving simultaneously two or more messages or signals over a common medium.

To consider modulation and multiplex systems, it’s best to consider electromagnetic radiation in two different forms or domains. Engineers look at such signals in the time domain, as in a waveform displayed on an oscilloscope; and in the frequency domain, as in a signal displayed on a spectrum analyzer.

Fortunately, there’s a convenient way to transform the information contained in one form to that contained in another. It is called the Fourier transform. Any college text on communications systems will have a description of the Fourier transform and its use. The complete derivation of such a transform is mathematically complex and difficult to handle. For the purposes of this article, we’ll say that signals can be described in both time and frequency domains. Fig. 1 shows a few examples of how signals look in these domains. The acronyms used in the article are defined at the end of this article.

There are a number of ways to modulate a carrier with intelligence. Before discussing multiplexing, let’s look at the advantages and disadvantages of the different modulation types.

signal modulating systems

The simplest form of modulation suitable for voice transmission is amplitude modulation (a-m). This form of modulation is created by modulating the strength, or amplitude, of a carrier-frequency wave at an audio rate. The simplest case of a-m is shown in the modulated waveform of fig. 1C. Amplitude modulation has advantages and disadvantages. One advantage is in the simplicity of the receiver. This is why this form of modulation was used in the first commercial broadcasts and continues to be used today. Among the disadvantages are a waste of transmitter power and a signal-to-noise ratio that can be improved.

The term “signal-to-noise ratio” is used here to denote the quality of a communications system. All communications systems contain some amount of noise. With more signal and less noise, the signal-to-noise ratio increases. All modulation methods can be compared mathematically on the basis of the expected signal-to-noise ratio. In commercial applications, this comparison often determines what is suitable and what is not.

Double sideband. Other derivatives of the amplitude-modulation technique are used by Amateurs. Double-sideband, suppressed carrier, and single-sideband, suppressed carrier are forms based on amplitude modulation. They can, in fact, be created by filtering unwanted components from a normal a-m signal. Double-sideband, suppressed carrier has

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the advantage of transmitting information on the signal and eliminating wasted power created by transmitting the carrier signal. It does, however, duplicate the transmission of the information signal by transmitting the same information in both sidebands.

**Single-sideband.** Single-sideband, suppressed carrier transmission provides some of the most efficient use of the radio spectrum. The intelligence is not transmitted in duplicate, and the power used in transmitting the carrier in other modulation systems is used instead for intelligence.

There is one disadvantage, however. Single-sideband, suppressed carrier provides no reference signal for the receiver to determine accurately the signal center frequency. In many control and signalling applications, this is a serious shortcoming. Without accurate frequency control, for example, Touch-Tone™ signalling is not possible. In Amateur high-frequency applications, the advantages of this mode far outweigh the disadvantages. Operators become accustomed to the sound of single sideband and can eventually understand the signal, even when tuned off frequency.

In critical commercial and military applications, this problem is overcome in a different way. Cesium frequency standards with exceptional accuracy and stability control both transmitter and receiver.

**Frequency modulation.** Another of the most common modulation forms is fm. It is formed by varying the instantaneous frequency of the transmitted signal at an audio rate (or more precisely, at an intelligence rate). The frequency of the modulating signal

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*Touch-Tone is a registered trademark of The American Telephone and Telegraph Company.*
is determined by how many excursions across the center frequency are made in a given period. The amplitude of the modulating signal is determined by the amount of actual frequency change. A wider frequency excursion is indicative of a higher modulating amplitude. The comparison of an fm signal in the time and frequency domains is more complex than that of an a-m signal (fig. 2).

Frequency modulation can take on different characteristics depending upon the width of the signal, or deviation.* When the signal is modulated to produce a signal approximately the same width as a standard double-sideband a-m signal, it provides a signal-to-noise ratio equal to that of an a-m signal. This is the case with the modulation used on 2-meter fm.

It does have some advantages over a-m, however. One of the advantages is that fm can be amplified by a class-C amplifier. On first inspection this may not seem to be such a tremendous advantage. There are cases, however, where it’s either impossible or impractical to create a good class-A or class-B amplifier. It’s much easier in most cases, for example, to operate a microwave system with fm rather than a-m. In the past, it was not possible to produce and amplify an a-m signal at these frequencies.

Fm exhibits a very interesting threshold effect. In the reception of fm, once the signal level has increased beyond a particular level, there is no significant improvement in signal-to-noise ratio that can be obtained by an increase in power. This effect can be used to advantage in an fm system.

Where fm really comes into its own is in wide-band applications. An improvement in signal-to-noise ratio

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* That is, the excursion of the modulated signal in the frequency domain.

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fig. 2. A comparison of an fm signal in the time domain (top two drawings) and in the frequency domain (bottom drawing). The modulating signal is depicted in (A), with the resultant transmitted signal shown in (B). The same signal and its nominal bandwidth, which is a function of deviation, is shown in (C).

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fig. 3. Pulse-amplitude modulation (PAM) signals in the time domain. (A) represents a PAM signal with modulation-following pulses; (B) represents a PAM signal with flat-topped pulses; (C) represents the unity sampling function. PAM signals are generated by the addition of this signal to the amplitude of the modulating signal.
can be achieved at a sacrifice of bandwidth. For many years this phenomenon was not appreciated. After all, it doesn't make sense that a wider bandwidth, which allows more noise energy to enter the system, would allow better reception. There are a couple of ways to implement this effect, and it usually involves detectors in the receiver that apply frequency-compression feedback. In this process, the receiver i-f bandwidth is made to look narrower than the transmitted signal. Many critical commercial applications make use of this method when the spectrum bandwidth is available.

digital-modulation methods

Some of the greatest technical strides have recently been made in digital modulation techniques. There are a number of different methods:

**Pulse-amplitude modulation.** This form of modulation, as in all digital methods, relies upon a principle called sampling. The sampling theorem states that, if the information signal is sampled at a fast enough rate, the signal can be reconstructed on the basis of the sample values. This is further refined in the Nyquist theorem, which states that the minimum frequency at which the samples may be taken is twice the frequency of the highest frequency component in the information signal.

The samples may be thought of as having been taken instantaneously and transmitted in the same way. This, then, provides the amplitude of the information waveform at discrete intervals of time. In pulse-amplitude modulation, this information is used to determine the amplitude of the transmitted pulse, as the name implies. This modulation method is shown in fig. 3. Note that the pulses can be modulated as flat-topped pulses (fig. 3B) or following the signal waveform during its period of transmission (fig. 3A). If the pulses are transmitted sufficiently fast that time is still available between them, the possibility exists to put other information in the spaces. (We will examine this in more detail a little later.) PAM is one of the easiest forms of digital modulation to recover, since a lowpass filter will recover the original modulating waveform. In fact, most forms of digital modulation are converted back into PAM in the demodulation process to recover the signals.

**Pulse-duration modulation.** The next modulation form we will consider is pulse-duration modulation (PDM). In this method, the amplitude of the modulating signal controls the width of the transmitted pulse. An example is shown in fig. 4. The simplest way to generate the pulses is to allow a time-constant circuit to charge or discharge to the modulating signal amplitude and allow the duration of this process to control the pulse length. In the demodulation process, as stated above, the PDM signal is usually converted into a PAM signal, then demodulated as a PAM signal.

The PDM signal has a very interesting advantage. The receiver must make a relatively simple decision — is the pulse there or is it not? This can be compli-
fig. 6. Example of frequency-division multiplexing (FDM) depicted in the frequency domain. Individual SSB signals are combined and transmitted by one transmitter. An example might be an OSCAR downlink.

cated by noise; but in general, it allows for improvement of the signal-to-noise ratio in otherwise marginal conditions. The received signal can be hard-limited, removing all amplitude information, to overcome a fairly large amount of amplitude variation or QSB.

**Pulse-code modulation.** Another form of digital modulation is pulse-code modulation (PCM). It is produced by transmitting some digital representation of the signal rather than the signal itself (fig. 5). For example, the binary-coded decimal value of the voltage at the time of the sampling could be transmitted directly. This would result in the transmission of a series of pulses for each sample rather than the single transmitted pulse for each sample as in PAM and PDM. PCM has the advantage, shown by PDM, in that the detector must make the simple decision of whether the pulse was, or was not, transmitted.

Other interesting properties may also be used in PCM. The transmitted code can be specially formulated to improve the signal-to-noise response of the system. In this way, the code predicts what a typical noise burst would do to the received signal and attempts to provide a received signal that will allow less ambiguity. This system is presently the subject of much interest and research in commercial and military areas.

Well, this has been a fairly rough overview of most of the modulation systems. All can and are used in multiplexing. So what is this multiplexing, anyway?

**Multiplexing**

The dictionary defines multiplex as "...a system for transmitting or receiving simultaneously two or more messages or signals over a common circuit, carrier wave, etc." Amateur Radio operators, in general, don't know too much about this technology. In general, we don't have much need for it. Most Amateur communications are conducted on one simplex circuit with no need for simultaneous transmission. Let's look at some ways we can make use of multiplex systems.

In commercial and military communications areas, multiplex is a necessity. These users are concerned with the transmission of many messages at the same time. Imagine the expense it would require to use a separate radio for each telephone conversation! Many different multiplex methods are used to accomplish this requirement.

We've seen that signals can be represented in both the frequency and time domains; this suggests two ways to multiplex signals. In fact, methods are used in which signals are multiplexed in both time and frequency. First let's look at methods of multiplexing signals in the frequency domain.

One method involves the placement of many different signals side-by-side in frequency in the transmitted signal — called frequency-division multiplex, or FDM. A way of looking at this is to consider a number of FM signals being transmitted in a given band. All these signals could be transmitted by a single transmitter rather than the many signals required for single-signal transmission.

The individual information signals could also be modulated by amplitude-modulation-based techniques. This could use single-sideband modulation to reduce the spectrum space required by the signals. In this way the transmitter of the OSCAR satellites could be thought of as a multiplex system. All of the input signals are combined and transmitted by one transmitter on the downlink side. Fig. 6 shows how the transmitted signal might look in the frequency domain with separate single-sideband signals multiplexed.

There is another form of frequency multiplexing — the frequency modulation of the main carrier with frequency-modulated subcarriers. The representation of the final modulated signal is much more complex than that of normal FDM as shown in fig. 6. This is due to the rather complex nature of the display of FM in the frequency domain, as shown in fig. 2. This is the most common of multiplex systems used in common-carrier microwave systems, as we shall see later. It can be referred to as FM-FM.

Digital-modulation types offer relatively simple
multiplexing in the time domain. Taking another look at figs. 3, 4, and 5 we see that there is space between the transmitted pulses in each case. If the pulses are transmitted in a short enough period of time, there is enough room to insert many additional signals. This is called time-division multiplex, or TDM. All this requires is that each individual signal be sampled (and the sample transmitted) faster than the Nyquist rate (discussed previously). The samples can be transmitted as they are taken, or they can be stored to be transmitted at an appropriate time.

Any of the digital modulation types can be used in TDM. All that is required of them is that they be separated from the other signals in the time domain at the receive demultiplexer. In fact, digital signals of different types and different data rates can be combined in one TDM signal. The entire combination of signals transmitted in one interval is called a frame. An example of a TDM frame is shown in fig. 7. Often a group of signals can be combined into a TDM frame before they are combined with another similar group for the final transmitted frame. This can be referred to as low-speed and high-speed TDM. The low-speed TDM frames are combined to be transmitted as one high-speed TDM frame.

commercial multiplex applications

Now that we know what multiplex is, what are some of the commercial applications? Broadcast television can be thought of as a form of FDM. The video and audio information is transmitted by the same transmitter using separate carriers for the two signals. In this particular case, the audio is transmitted using fm and the video with a form of a-m — vestigial sideband amplitude modulation. In vestigial sideband, one of the sidebands is suppressed beyond a certain cutoff frequency but the carrier is transmitted at full power.

Broadcast fm stereo (often called fm multiplex) uses another special form of multiplex technique. In this type of signal, the main frequency-modulated signal carries the information for the left plus the right channels. A monophonic receiver detects only this signal. A double-sideband, suppressed-carrier signal transmitted with the fm signal carries the left minus the right channel information. The stereo receiver detects this signal, then algebraically subtracts it from the fm signal to produce the right and left channel information.

Another form of multiplex with commercial applications is voice frequency carrier telegraph, or VFCT. In this system a group of FSK (frequency shift keying) signals are combined in a form of FDM. The individual FSK signals are produced by shifting them over a narrow range of frequencies in the audio range. The resultant signals are then combined and transmitted with a single transmitter. The most common use of this system is in the simultaneous transmission of a group of teletypewriter signals. Different standards exist for the number of channels and the audio frequencies used, based upon the speed and necessary quantity of individual circuits.

In an earlier paragraph I made reference to an fm-fm system. This is the most common type of multiplex used in normal microwave circuits. In this method individual circuits are combined into groups. The groups are then combined into supergroups, and the supergroups are combined into a mastergroup. The normal commercial standard calls for twelve channels to be combined to form one group. Five groups are combined into one supergroup. Eleven supergroups are then combined into one mastergroup. This produces a link that will support 660 circuits (or channels) on one mastergroup. Mastergroups can then be combined to form multigrand mastergroups. One commercial standard calls for the combination of six such mastergroups.

It can be seen that the resultant signal that is finally transmitted will be quite complex. It requires extensive frequency modulation detection, and the modulation for any given channel is effectively distributed across the entire transmitted spectrum. This system was the standard for many years because of the relative ease of modulating a tube microwave system with fm signals. In later years TDM techniques have proven more desirable.

With the advent of low-cost digital integrated circuits, TDM systems have been able to demonstrate distinct advantages at an over-all reduction in price over analog techniques. Standards have been developed to modulate the audio signals from a telephone and process them through the complete telephone exchange and send them out on long-distance microwave links, still in digital form.

One form of TDM gaining wide commercial acceptance calls for the combination of a group of audio signals, reduced to PCM data streams, onto a single PCM signal at a rate of 1.544 megabits per second (1.544 \times 10^6 \text{ binary digits per second}). These signals can then be further combined into larger PCM systems before transmission.

Commercial systems are also being created to handle digital information; that is, information which is already in digital form, using PCM networks. This technique is ideal for computer or teleprinter traffic. Systems have been demonstrated that allow signals of various data rates to be supported by a common system. The possible uses of such a system are limited only by the imagination of the users.

Amateur applications

Now that we have seen the different multiplex sys-
fig. 8. Suggested repeater interconnection network using time-division multiplex.

Repeater links. Another possible Amateur application is the interconnection of a group of repeaters. In this system users could select, through a remote-control system, which of the repeaters would be interconnected. A multiplex link could be provided from each of the repeaters in the group to each of the others. The control system would then decide which of the multiplex channels to interconnect. The multiplex system itself could use either the FDM or TDM techniques described above.

Now we can examine some firm proposals for such a repeater interconnecting multiplex system. TDM systems are taking over as the preferred method in the commercial field and would probably be best for us to use as well. TDM has some very real advantages for our uses. Foremost is its capability to support various data rates in one TDM system. This would allow normal voice repeaters to be connected to other similar repeaters in the system as well as provide separate channels for signaling applications. These signaling channels could use much lower data rates than those required for voice yet provide superior interconnecting control reliability. The same TDM system could also support interconnections of RTTY repeaters. Many RTTY channels could be placed in the same space as that required for one voice channel. In the long run, the same TDM system could support television repeaters. The video and audio signals could be digitized and transmitted as just another TDM component.

Hardware and bandwidth considerations. TDM equipment from commercial manufacturers is presently quite expensive, and few or no surplus sources exist. Fortunately, though, the equipment is fairly easy for Amateurs to construct to their specifications. The primary ingredients are digital integrated
circuits, which are not all that expensive. Also, their use is fairly well understood by many Amateurs. About the only disadvantage to the use of TDM is the need to place the TDM signal on an Amateur frequency where pulse transmission is permitted. In general, the spectrum bandwidth necessary to transmit the digital representation of speech is wider than that required to transmit a normal amplitude-modulation representation.

Fig. 8 shows how some of these repeaters could be interconnected. This is just an example of the way the interconnection would be made. Many more repeaters of all types could be provided, rather than the limited number shown. Let's consider how this would be put in use to provide interconnections for twenty repeaters all along the West Coast.

Suggested repeater interconnection system. Each repeater would have the primary capacity of operating as an independent repeater — just as an existing repeater would do now whether the modulation is audio, RTTY, or television. In addition to this capability, each repeater would have a microwave radio transmitter and receiver, which would provide a link to the TDM interconnection. The microwave equipment would transmit all the TDM channels just as they had been received except for a) one channel designated as the incoming channel, and b) one channel designated as the outgoing channel for that particular repeater. On those channels, the multiplex equipment would demodulate the incoming signal and modulate the outgoing one. This in itself would be a tremendous advantage over FDM systems.

In FDM systems, a separate modulator system would be required for each channel, when in fact only one channel would be used at a particular time. This requirement exists because the individual channel modulators would have to be tuned to the subcarrier to be used. It would be very difficult to have the system function with a single modulator that would be somehow made to retune to the desired channel. In a TDM system, all that is required is that the system wait for another period of time before extracting or inserting the desired channel information from the TDM frame. A single-channel TDM multiplexer and demultiplexer would be all that the station required. As an alternative, a second channel could also be used for signaling, both incoming and outgoing. This channel would be shared by all the stations and be a common signaling channel. Fig. 9 shows an example of the TDM frame received and transmitted at a particular station.

Note that in fig. 9 the only real change in the frame is the contents of the TDM channel designated for Station 3 out. Station 3 combines the signal coming into the station on the Station 3 in channel with the normal output of the repeater. In this method, all the switching is done at the station originating the interconnection. Let's look at how this action would be performed.

Operation. To initiate the process, a user would call in to the repeater connected to the system that would be most easily accessed. Upon hearing no traffic on the repeater, the user would initiate the control sequence requesting the interconnection. This could consist of Touch-Tone™ digits for the address of the repeater requested. A TDM system at the repeater used by the caller would then select the channel from the TDM frame that carried the information for the requested repeater's output channel. This would be connected to the normal downlink transmitter from the originating repeater. The system would also transmit a short tone on the downlink from the repeater to indicate that the interconnection had been made. It would then connect the input signal from the user to the originating repeater to the in channel on the TDM frame for the requested repeater. When traffic is heard on the requested repeater, the user could make the call. Or, the user could just listen to the distant repeater and make no call — just wait for his party to show up.

Other uses. In the long run the system could be standardized, and even the frequencies of the repeaters themselves could be reused. This would allow a user with a small crystal-controlled handheld radio to access the system from many of the repeater locations and communicate through the entire system.

The uses of such a repeater interconnection are again limited only by our own imagination. It would be possible to interconnect many different types of repeaters with the same TDM network, as shown in fig. 8. A repeater that had become a part of the system (and had a microwave TDM system with a radio relay) could decide not to participate for some reason. All that would be necessary to remain out of the interconnection net would be to block the output TDM channel from that station.

The system could also be used to provide a very wide area of autopatch access for participating stations. This could be of tremendous value in remote areas during disasters. When normal commercial telephone communications are lost in an area, the interconnection system could be used to access an autopatch at any of the participating repeaters.

In the Amateur traffic area, such a system could have great value. The system could support data to many different points at very different data rates in an automated teleprinter traffic environment. Particular nodal stations could guard a given TDM channel and relay the traffic into other traffic nets, either with
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1296 MHZ EQUIPMENT
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Many other college-level textbooks are available containing detailed descriptions of multiplex techniques.
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September 1981

More Details? CHECK—OFF Page 98
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**CB type crystals**

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</tr>
<tr>
<td>1400.00</td>
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Power Supply PCB 4.99
Downconverter PCB 19.99
Instructions for any separate item 10.00

NEW TRANSFORMERS

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<td>F-18X 6.3 VCT @ 6Amps</td>
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<td>F41X 25.2VCT @ 2Amps</td>
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<td>P-8380 10VCT @ 3Amps</td>
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<td>E30554 Dual 117V @ 1Amp</td>
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DIODES

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<td>NCP717 1.5 A, 1000 PIV .20 ea., $10 for $15.00</td>
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<td>D6100 1.5 A, 1000 PIV .15 ea., $10 for $12.00</td>
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<tr>
<td>BVK 1153 25 mA, 20,000 PIV $1.00 ea., $10 for $10.00</td>
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<tr>
<td>Fairchild LEDs FLV 5007 &amp; 5009 std. Case type TO-32. 6/$1.00</td>
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<tr>
<td>SCMS 10K 15 ma, 10,000 PIV $1.49 ea., $10 for $10.50</td>
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<tr>
<td>High-voltage diode EK500 1000 Volts, 50 ma .99 each</td>
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<tr>
<td>Motorola SCR TO-92 Case, 0.8 Amp, 30 V. Ig 0.2 Vct 0.8. Same as HM600. 4/$1.00 or 100/$15.00</td>
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<tr>
<td>Diacode Type 555-2003 LED 5 VDC with builtin resistor. 69 each</td>
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<tr>
<td>Motorola MA 752 Rectifier 6 Amps, 200 PIV 4/$1.29</td>
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More Details? CHECK OFF Page 98

September 1981 73
Questions and Answers

Entries must be by letter or postcard only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month’s winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

radio waves
How fast does a radio wave travel, at the speed of light or slower? — Eugene Gabry, WB9VTF.

The velocity of a radio wave depends on the dielectric constant of the medium through which the wave travels. Air has a dielectric constant of unity, and radio waves travel through this medium at a speed very near to that of light in a vacuum, which is approximately 186,000 miles per second (3 x 10^8 meters per second).

In a medium that has a dielectric constant greater than unity, the radio wave travels at a lower velocity. For example, coaxial transmission line using polyethylene foam insulation has a dielectric constant of about 1.08, so radio waves propagate through this coax at something less than the speed of light through a vacuum. Thus when determining the electrical length of a transmission line, the velocity of propagation of the radio wave through the line, as well as other factors, must be taken into account.

FCC rules
I would like a correct interpretation of the FCC rules concerning third-party traffic. — Ralph R. Schlick, N0BOQ.

As of this writing, the FCC rules pertaining to third-party traffic consist of section 97.79, “Control Operator Requirements,” and section 97.114, “Third-Party Traffic.”

Section 97.79 states: “The licensee of an amateur radio station may permit any third party to participate in amateur radio communication from his station, provided that a control operator is present and continuously monitors and supervises the radio communication to insure compliance with the rules.”

Section 97.114 states: “The transmission or delivery of the following amateur radiocommunication is prohibited.

“(a) International third party traffic except with countries which have assented thereto.”

“(b) Third-party traffic involving material compensation, either tangible or intangible, direct or indirect, to a third party, a station licensee, a control operator, or any other person.”

The FCC has proposed a revision of all the rules governing the Amateur Radio service, including those quoted above, in an effort to make them more understandable. Called the “plain-language” revision (Docket 80-729), the new rules might well become effective in the foreseeable future.

Reading the sections regarding third-party traffic in the existing rules, it is easy to understand how they could be confusing. In its new, “plain-language” revision, the FCC has attempted to define “third-party messages” and has simplified the existing rules. They have also added information on transmitting one-way communications for third parties, the reason being that one-way communications do not meet the existing definition of third-party messages. Other changes have been made to make the proposed rule consistent with Article 41 of the ITU rules, which refers only to the transmission of third-party communications being prohibited.

It’s hoped that the new “plain language” rules will be easier to interpret. We’ll just have to wait and see.

SWR meter
Is there any way to troubleshoot a defective SWR meter without a manual? I knew the instrument was defective after having placed a second meter that I knew was OK in the line. The meter was made in Japan and the only name on it is “MARS Standing Wave Indicator SW-10.” — Lewis I. Hegyi, N2BPO.

Without knowing anything about your meter, I find it difficult to offer any definite advice. If it is an inexpensive reflectometer, it probably contains a bridge circuit and a meter to indicate when bridge balance has been achieved. Most are not calibrated and therefore cannot be used to measure actual standing-wave ratio. Such instruments are generally used in conjunction with matching networks to indicate minimum reflected voltage or power.

Assuming there is no mechanical damage of components, you can make some simple tests to determine if the bridge elements are defective, either by substitution or by measuring resistance and capacitance. The resistors making up the bridge arms should be equally matched to obtain a good null on the meter. It’s possible that the meter movement is burned out, as these simple reflectometers are usually designed to be operated at very low power.

I. Hegyi, N2BPO.

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September 1981
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Specifications

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ATLAS DD6-C and 350X, Digital Dial Frequency Counters, $125.00 plus $3.00 UPS. AFC Stop VFO drift. See June 79 HR. $65.00 plus $3.00 UPS. Mical Devices, P. O. Box 343, Vista, CA 92083.

VACKAR VFO KITS. Write Direct Conversion Technique, Box 1001, Dept. 9FM, 535 N. Michigan Ave., Chicago, Illinois 60611.

WANTED: Help in completing the largest collection of Hamfester equipment in the world. Urgently needed are old receivers with aluminum colored panels, back lighted plastic dials with “airplane” hands, early transmitters, unusual accessories, etc. Chuck Dachi, WD5EOG, “The Hamfester Collector.” 4500 Russell Drive, Austin, Texas 78745.

DIRECT RECEIVING RECEIVER KITS. Write Direct Conversion Technique, Box 1001, Dept. 9FM, 535 N. Michigan Ave., Chicago, Illinois 60611.

FREE AD with subscription to Rigs & Stuff (20 words free, extra 10¢ each) Ham Buy, Sell, Trade Want Ads, 12 issues, $3.00. WA405HR’s Rigs & Stuff™ Dept. H9, Box 973, Mobile, AL 36601.

SUPER ORP with Direct Conversion’s 5 watt transmitter kits. Write Direct Conversion Technique, Box 1001, Dept. 9FM, 535 N. Michigan Ave., Chicago, Illinois 60611.

RECIPIROCATING DETECTOR Construction Handbook. $10 ppd. Peters Publications, P.O. Box 62, Lincoln, MA 01773.


ELECTRONIC BARGAINS, CLOSEOUTS, SURPLUSES! Parts, equipment, stereo, industrial, educational. Amazing values! Fascinating items unavailable in stores or catalogs anywhere. Unusual FREE catalog. ETCO-912, Box 762, Plattsburgh, N.Y. 12901. SURPLUS WANTED.

FOR SALE: Heathkit HW-12 80 meter transceiver with HP-138 mobile power supply, 80 meter mobile resonator and both manuals. Good condition. $125.00, 715-223-2135, WA40ZCO, Box 278, Abbotsford, Wisconsin 53405.

KEYER PADDLES, laminate, more features, better action. Kits available $15.00 prepaid. Write Earl Snyder, 213 W. Davis, Sapulpa, OK 74066.

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NEEDED: Western Electric and Bell System manuals on residential telephones and accessories, including model 500, Trimline, Touch-A-Matic, speakerfone, jack, installation procedures, etc. C. Sarver, 256 West 88th St., New York, NY 10024, 212-874-3529.

ETCH IT YOURSELF PRINTED CIRCUIT KIT, Photo-Positive Method — No darkroom required. All the supplies for making your own boards, direct from magazine article in less than 2 hours. Only $24.95, S.A.S.E. for details. Excel Circuits Co., 4412 Fernlee, Royal Oak, MI 48073.

OSCAR STATION: KLM Echo II, KLM Echo 70cm, 2m & 70cm yagis, coax, $525. Package only. Hamtronics 220 MHz ktrv, return, built & tested, $600. Chip Appel, P.O. Box 251, Electric City, WA 99123.

MIRROR-IN-THE-LID, and other pre-1946 television set wanted. Paying $500 for any complete RCA "TRK" series, or General Electric "HM" series also. Also looking for 12AP4, MW-313 picture tubes, parts, literature on pre-war television. Arnold Chase, W41RZ, 9 Rushleigh Road, West Hartford, Conn. 06117 (203) 521-5725.

PRINTED CIRCUIT BOARDS: From $0.25 to $0.40 per square inch. No minimum charges. For more details, Com- munications Design, Inc. 1105 Lehr, West Memphis, AR 72301.

MUSEUM for radio historians and collectors now open. Free admission. Old amateur (W2AN) and commercial station exhibits, 1925 store and telegraph displays, 15,000 items. Write for details. Antique Wireless Assn., Box 242, Blacksburg, VA 24060.

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Century Electronics offers a wide assortment of fixed resistors in an attractive and convenient storage case. The GL-25 Econo-Pak Resistor Organizer contains 940 top-quality 1/4-watt resistors in forty-two of the most commonly used resistance values for the experimenter as well as for the shop and laboratory repairman.

Each resistor value is packaged in its individual compartment, thus ensuring fast and accurate selection of any desired value. The compact Econo-Pak Resistor Organizer measures only 7-1/2 x 6-1/8 x 3 inches (19 x 15.6 x 76 cm) and is priced at $29.95, from the factory. Order directly from Century Electronics Corporation, 3511 North Cicero Avenue, Chicago, Illinois 60641.

isolated BNC dual line protectors

Model C10 is designed to protect up to ten data line pairs employing BNC connectors that connect to computers, modems, terminals, and other sensitive electronic equipment from the effects of transients caused by lightning, switching surges, and heavy machinery. The protector interfaces between the signal lines and sensitive circuits to provide a sophisticated blend of high speed voltage limiting and brute force protection. The signal line protector recovers automatically to standby in preparation for further protection. Clamping can be provided from 6 volts to 200 volts, depending on customer requirements.

The dual line protector has a clamp voltage to ± 50 volts (in 5-volt steps), an energy handling capacity of 50 joules (min)/circuit, and a maximum frequency to 3 MHz. Contact MCG, 160 Brook Avenue, Deer Park, New York 11729.
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Five bands 80, 40, 20, 15 and 10 meter operation with one antenna.
Complete with 60 ft. RG8 coax and PL-259 Easy installation.
Only two adjustments required. Only 10 feet long.


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The new Hustler 220-MHz vertical fixed-station Amateur antenna, designated the Model G7-220, has 7-dB gain for both transmitting and receiving, making it the most powerful omnidirectional 1-1/4 meter antenna available. The all-new design of the Hustler G7-220 antenna keeps the signal radiation pattern at the lowest possible angle to the horizon for maximum efficiency and longest range.

The Model G7-220 has an SWR of 1.5:1 across its entire 5 MHz bandwidth, with SWR at resonance of 1.2:1 at 20 to 170 MHz, Hi Kit, Cat. No. 035106. Specify when ordering. $7.02 ea.

The radiating element of the Hustler G7-220 is dc grounded and the antenna has a 50-ohm base impedance.

The G7-220 weighs 7 pounds and is easily mounted on any capable vertical support up to 1-3/4" OD. Wind loading of the antenna is only 26 pounds at 100 mph velocities.

The Hustler G7-220 MHz (1-1/4 meter) Amateur vertical fixed-station antenna has a suggested list price of $142.95 and is available now. For further information write Sales Department, Hustler, Inc., 3275 North B Avenue, Kissimmee, Florida 32741.

Kantronics varifilter

You can vary the frequency and the bandwidth of the Kantronics Varifilter,™ a new addition to the "family-design line" of products. The varifilter can be set to maximize one signal (peaking), or to minimize an interfering signal (notching), and it works with CW, single-sideband, and a-m signals. The varifilter circuitry is designed to provide optimum results without ringing, oscillating, or instability.

The bandwidth is variable from less than 30 Hz to over 1000 Hz. The frequency range runs from less than 150 Hz to over 3000. Once it has been set,
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If you're serious about direction finding, you want the best, most dependable and proven equipment for a fast fix, whether it's for a downed aircraft or a repeater jammer.

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Our units will DF on AM, FM, pulsed signals and random noise.

The meter reads left-right in the DF mode for fast, accurate bearings and left to right signal strength in the RECEIVE mode (120 dB total range with the sensitivity control). Its 3 dB antenna gain and .06 uV typical DF sensitivity allow the crystal-controlled unit to hear and positively track a weak signal at very long ranges. It has no 180° ambiguity.

Over 3,000 of our units are in the field being used to save lives, catch jammers, find instrument packages, track vehicles. Prices start at under $250 for factory-built equipment backed by warranty, money-back guarantee, and factory service and assistance. Write today for a free brochure and price list.

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**MICROWAVE TELEVISION**

The standard RP downconverter package shown above gives you a proven converter design mounted in a weathertight antenna that features low wind loading and easy installation. With this package you are ready for hours of Amateur television entertainment. Just aim the antenna, connect one 75 cable from the antenna to the power supply and a second line from the power supply to your TV and you are on the air.

All downconverter models use microstrip construction for long and reliable operation. A low noise microwave preamplifier is used for pulling in weak signals. The downconverter also includes a broad band output amplifier matched to 75 ohms. The RP model is recommended for up to 15 miles. Over a range of 15 to 25 miles, the RP+ has a lower noise and higher gain RF amplifier stage provides better television reception. These ranges are necessarily approximate, as signal strength is very sensitive to line of sight obstructions. For installations over 25 miles, an RPC unit which uses a separate antenna is available. All models are warranted for one year.

Prices including UPS shipment are as follows:
- Model RP receiver package: $150
- Model RP+ receiver package: $170
- Model RPC receiver package: $170

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the bandwidth will remain constant regardless of changes in the frequency-range setting. This feature has not been readily available in variable filters until now.

The varifilter has its own internal power supply which is switchable from 115 Vac to 230 Vac. It is able to run from 12 to 18 Vdc as well. Each unit has a tuning eye that lets the operator see when he has filtered the signal he wants to.

A full-year warranty backs the varifilter. It is available from Kantronics dealers and from the factory. Suggested retail price of the varifilter is $139.95.

For further information contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, Kansas 66044.

mobile antenna
Avanti Communications has recently modified its 5 dB gain on-glass mobile antenna designed for use in two-way and Amateur Radio communications.

The new 3/4-meter, 410-512 MHz AP450.5G features a straight 30-inch whip with a small center-position phasing coil. By popular request the former loop section has been eliminated and replaced with a small, sleek coil measuring only 1-1/2 inches in length and a maximum diameter of 3/8-inch, making it the smallest UHF 5-dB-gain whip and phasing coil combination on the market.

As with each of Avanti’s on-glass communications antennas, the new AP450.5G offers improved performance, requires no holes be drilled, features shorter installation time, and requires no metal ground plane. Thus it may be used in many more applications than conventional mobile antennas.

For more information contact Avanti Communications, 340 Stewart Avenue, Addison, Illinois 60101.
This circuit controls the 70 MHz IF BOARD and is intended for amateur radio use. The local oscillator is voltage controlled (i.e., making the i-f range approximately 4 to 80 mc (Channels 2 to 7).

PC BOARD WITH DATA: $19.99
PC BOARD WITH CHIP CAPACITORS 13: $44.99
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INTRODUCING THE HOWARD/COLEMAN TVRO CIRCUIT BOARDS

DUAL CONVERSION BOARD
This board provides conversion from the 3.7-4.2 band first to 900 MHz where gain and bandpass filtering are provided and, second, to 70 MHz. The board contains both local oscillators, one fixed and the other variable, and the second mixer. Construction is greatly simplified by the use of Hybrid IC amplifiers for the gain stages.

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

70 MHz IF BOARD: $25.00
This circuit provides about 43 dB gain with 50 ohm input and output impedance. It is designed to drive the HOWARD/COLEMAN TVRO Demodulator. The board band pass filter can be tuned for bandwidths between 20 and 35 MHz with a passband ripple of less than ½ dB. Hybrid ICs are used for the gain stages.

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

DEMODULATOR BOARD: $40.00
This circuit takes the 70 MHz center frequency satellite TV signals in the 10 to 200 millivolt range, detects them using a phase locked loop, demodulates the audio subcarrier, a DC voltage proportional to the strength of the 70 MHz signal, and AFC voltage centered at about 2 volts DC.

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

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

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This circuit controls the VTO's, AFC and the S Meter.

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Frequency response 40 MHz to 300 MHz
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Alittech: 473 225 to 400 mc AM/FM Signal Generator 750.00

Singer: MFS/VS-4 Universal Spectrum Analyzer with 1 kHz to 27.5 mc Plug In $1200.00
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Avalon: 2036/2438/1102A Calibrated Display with an SSB Analysis Module and a 10 to 40 mc Single Tone Synthesizer 1500.00

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120 Vac at 40 Amps
Input Voltage 3 to 32 Vdc
240 Vac at 40 Amps
Input Voltage 5 to 32 Vdc
Your Choice $4.99

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240 Vac at 40 Amps
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YOUR CHOICE $24.95

NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!

More Details? CHECK — Off Page 98

September 1981 87
**MRF454**

$21.83

**NPN SILICON RF POWER TRANSISTORS**

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

**MRF472**

$2.50

**NPN SILICON RF POWER TRANSISTOR**

- designed primarily for use in large-signal output amplifier stages, intended for use in Citizen-Band communications equipment operating at 27 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits.
  - Specified 12.5 Volt, 27 MHz Characteristics –
    - Output Power = 4.0 Watts
    - Minimum Gain = 10 dB
    - Efficiency = 50%

**MRF475**

$5.00

**NPN SILICON RF POWER TRANSISTOR**

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

**Tektronix Test Equipment**

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<td>DC to 100 MHz Scope with a 20 MHz Dual Trace and 12 MHz Sampling Plug In</td>
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**Scopes with Plug-ins**

- **512A**
  - DC to 100 MHz Scope with a 20 MHz Dual Trace and 12 MHz Sampling Plug In
  - Price: $600.00

- **560**
  - DC to 100 MHz Dual Beam Scope with a 2 GHz Diff. and a 200 MHz Diff. Plug In
  - Price: $900.00

- **560**
  - DC to 100 MHz Scope with an 82 MHz Dual Trace High Gain Plug In
  - Price: $900.00

**Tubes**

- **512B**
  - Price: $5.00

- **4C100F**
  - Price: $3.00

- **4C100FJ**
  - Price: $3.00

- **4C100FJ**
  - Price: $3.00

- **4C100FJ**
  - Price: $3.00

**NEW — TOLL-FREE NO. 800-528-0180 — please, orders only!**
General Microwave

Hewlett Packard

- **H487B** 100 ohms Neg. Thermistor Mount (NEW) $150.00
- **H487B** 100 ohms Neg. Thermistor Mount (USED) $100.00
- **4748** 200 ohms Neg. Thermistor Mount (NEW) $100.00
- **4748** 200 ohms Neg. Thermistor Mount (USED) $125.00
- **478A** 500 ohms Neg. Thermistor Mount (NEW) $150.00
- **478A** 500 ohms Neg. Thermistor Mount (USED) $125.00
- **48R** 8.2 to 12.4 GHz Variable Attenuator 0 to 50 db $250.00
- **49R2A** Waveguide Adapter $65.00
- **8403A** Bandpass Filter 0 to 12.4 GHz $75.00
- **8471A** Rf Detector $50.00
- **HS32B** 7.05 to 10 GHz Frequency Meter $300.00
- **G532A** 3.95 to 5.85 GHz Frequency Meter $300.00
- **JS53A** 5.65 to 8.2 GHz Frequency Meter $300.00
- **804** Gage and a 4 Wire Slotted Line Tuned Detector $175.00
- **X347A** 8.2 to 12.4 GHz Noise Source $500.00
- **S347A** 2.8 to 3.8 GHz Noise Source $600.00
- **G347A** 3.95 to 5.85 GHz Noise Source $500.00
- **J347A** 5.65 to 8.2 GHz Noise Source $500.00
- **H304** 7.05 to 10 GHz Noise Source $540.00
- **4340A** 400 to 6000 MHz Noise Source $310.00
- **P352A** 12.4 to 18 GHz Frequency Meter $400.00
- **M552A** Frequency Meter $500.00
- **P392A** 0.50 GHz Attenuator $520.00
- **35B5** 5 Watts 50 Ohm DC to 1.000 MHz Attenuator $132.50
- **NK292A** Adapter $100.00
- **903** Microwave Switch $100.00
- **33001C** Pin Absorption Modulator $295.00
- **11065A** Tracking Generator Shunt $50.00
- **11048C** Feed-through Termination $25.00
- **10103B** Termination $25.00
- **H421A** 7.05 to 10 GHz Crystal Detector $75.00
- **H424A** 7.05 to 10 GHz Crystal Detector — Matched Pair $200.00

Merrimac

- **AU-262/A** B01162 Variable Attenuator $100.00

Microlab/FXR

- **X838S** Horn 8.2 to 12.4 GHz $60.00
- **601B18** X to N Adapter 8.2 to 12.4 GHz $35.00
- **Y8726** Coupler $75.00

Narda

- **4013C-10** 2250A Directional Coupler 2 to 4 GHz 10 dB Type SMA $90.00
- **4014C-10** 2250B Directional Coupler 3.85 to 8 GHz 10 dB Type SMA $90.00
- **4015C-10** 2250C Directional Coupler 3.85 to 8 GHz 6 dB Type SMA $100.00
- **4015C-3V** 23100 Directional Coupler 1.4 to 12 GHz 10 dB Type SMA $95.00
- **3044-20** Directional Coupler 4 to 8 GHz 20 DB Type N $125.00
- **3044-20** Directional Coupler 4 to 8 GHz 20 DB Type N $125.00
- **3043-20** 22000 Directional Coupler 1.7 to 4 GHz 20 DB Type N $125.00
- **3043-20** 22011 Directional Coupler 2 to 4 GHz 10 DB Type N $125.00
- **3043-20** 22012 Directional Coupler 2 to 4 GHz 10 DB Type N $125.00
- **3043-20** 22015 Directional Coupler 2 to 4 GHz 20 DB Type N $125.00
- **22015** 22015 Directional Coupler 2 to 4 GHz 20 DB Type N $125.00
- **3033** 22015 Directional Coupler 2 to 4 GHz 20 DB Type N $125.00
- **3033** 22015 Directional Coupler 2 to 4 GHz 20 DB Type N $125.00
- **3033** 22015 Directional Coupler 2 to 4 GHz 20 DB Type N $125.00
- **764** 2230 Variable Attenuator 100 dB $550.00
- **764** 2230 Variable Attenuator 100 dB $550.00
- **764** 2230 Variable Attenuator 100 dB $550.00
- **764** 2230 Variable Attenuator 100 dB $550.00
- **2237** Waveguide to Type N Adapter $35.00
- **720-6** Fixed Attenuator 8.2 to 14.4 GHz 6 dB $50.00
- **3003** Waveguide $25.00

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- Lets your antenna radiate—not your coax
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- Rated 5 KW peak—accepts substantial mismatch at legal limit
- DC grounded—helps prevent against lightning
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Rugged custom Cycloac® case, UV resistant formulation
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Heavy threaded brass contact posts

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3.5-30 MHz
$17.95
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optimized 14-30 MHz includes hardware for 2" boom
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90 [HM] September 1981
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New and unique Lightning Protection
... an industry first

Experience of more than 30 years in Amateur Radio, in part as Sales Manager of a major amateur radio manufacturer, has given me a unique opportunity to evaluate most radio equipment, and to gain an insight into the needs of the amateur, and the professional communicator.

The first project demanding our attention is in a critical but unserved area—that of providing specially designed field-serviceable lightning surge protectors for solid state communications equipment.

Don Tyrrell WB4AD

TRANSI-TRAP SURGE PROTECTORS
with the exclusive, field-replaceable Arc-Plug™ Cartridge

Solid state communications equipment is far more sensitive to the effects of lightning-induced transients than tube equipment, making conventional protection techniques ineffective. Considering the high cost of solid state equipment, a better type of protection is now necessary.

Although a lightning-induced transient is very short (about 250 μsec wide) it can do enormous damage to semiconductors, even if not caused by a near-hit. Even a distant storm front, out of the operator's sight, sends enough energy to ruin solid state components, leaving no external sign of damage (especially to front-end PIN diodes).

The problem with a standard "lightning arrester" is that it doesn't fire until a fast-rising lightning pulse has reached about 3000 volts or more. When it does fire, a fairly high 30 to 80 volts still exists across the arc, enough to damage semiconductors even if not caused by a near-hit. Even a distant rising lightning pulse has reached about 3000 volts or more. When it does fire, a fairly high 30 to 80 volts still exists across the arc, enough to damage semiconductors.

The unique AlphaDelta Transi-Trap Protection System solves these problems and more. Two models are available which can be used together to form a complete protection system: One is a high voltage type to protect linear amplifiers and transmitters, and the other is a low-level model that fires at the proper transient voltage to protect solid state receivers and transceivers.

Both offer super-fast response time (100 nanoseconds) and very low voltage across arc.

Unique Field Service Flexibility—these protectors feature field-replaceable Arc-Plug cartridges which utilize a rugged ceramic, hermetically sealed gas-filled element. They can fire many hundreds of times, but replacement, when necessary, is much less expensive than discarding the entire protector.

Unique State-of-the-Art Design— including mini-inductance brass circuitry, brass hardware, and an Arc-Plug cartridge with no lead wires. A complete rf and pulse test program is employed using a special multi-kV transient generator designed by John Tyrrell, W8AD.

Unique Isolated Ground System—provides direct earth ground for the arc, but prevents arc coupling to the equipment chassis through connector shields. This is the only system providing maximum protection from the closer near-misses.

Unique Design maintains Receiver Front-End performance— unlike certain other designs, Transi-Trap protectors have no effect on receiver intermod, crossmod, or intercept point.

Models available:

**Transi-Trap Model R-T Low Level Protector**—for use with solid state receivers, transceivers or transmitters running up to 200 watts at 50 ohms (hf to uhf)...

- $29.95 ea., plus $4.00 shipping and handling

**Transi-Trap Model HV High Voltage Protector**—for use with linear amplifiers running up to 2 kW at 50 ohms (hf to uhf)...

- $32.95 ea., plus $4.00 shipping and handling

(These devices can be used in addition to Model R-T to form a system)

**Replacement Arc Plug Cartridge**
for Model R-T...

- $5.95 ea., plus $2.00 shipping and handling

for Model HV...

- $12.95 ea., plus $2.00 shipping and handling

Ohio residents add Sales Tax to prices.  
Master Card, Visa, checks accepted. Order by phone or mail.

AlphaDelta Transi-Trap Protection Systems are designed to reduce the hazards of lightning-induced surges. These devices, however, will not prevent fire or damage caused by a direct stroke to antenna or other structure.
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<th>Arizona</th>
<th>Florida</th>
<th>Kansas</th>
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<td>AGL ELECTRONICS, INC. 1898 DREW STREET</td>
<td>ASSOCIATED RADIO</td>
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<tr>
<td>CORPORATION INDIAN</td>
<td>CLEARWATER, FL 33515 813-461-HAMS</td>
<td>8012 CONSER, P. O. BOX</td>
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<tr>
<td>602-242-6030 or 242-8990</td>
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<td>913-381-5900</td>
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<td>Arizona's #1 &quot;Ham&quot; Store. Kenwood, Yaesu, Icom and more.</td>
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<tr>
<td>1000 S. BASCOM AVENUE</td>
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<tr>
<td>SAN JOSE, CA 95128</td>
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<tr>
<td>408-998-5900</td>
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<tr>
<td>Serving the world's Radio Amateurs since 1933.</td>
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<tr>
<td>SHAVER RADIO, INC.</td>
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<tr>
<td>1378 S. BASCOM AVENUE</td>
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<td>SAN JOSE, CA 95128</td>
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<tr>
<td>408-998-1103</td>
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<tr>
<td>Azden, Icom, Kenwood, Tempo, Ten-Tec, Yaesu and many more.</td>
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<tr>
<td>Connecticut</td>
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<tr>
<td>HATRY ELECTRONICS</td>
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<tr>
<td>500 LEDYARD ST. (SOUTH)</td>
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<tr>
<td>HARTFORD, CT 06114</td>
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<tr>
<td>203-527-1881</td>
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<tr>
<td>Connecticut's Oldest Ham Radio Dealer</td>
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<td>Delaware</td>
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<td>DELAWARE AMATEUR SUPPLY</td>
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<tr>
<td>71 MEADOW ROAD</td>
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<tr>
<td>NEW CASTLE, DE 19720</td>
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<tr>
<td>302-328-7728</td>
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<tr>
<td>Icom, Ten-Tec, Swan, DenTron, Tempo, Yaesu, Azden, and more.</td>
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<tr>
<td>One mile off I-95, no sales tax.</td>
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<tr>
<td>Indiana</td>
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<tr>
<td>THE HAM SHACK</td>
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<tr>
<td>808 NORTH MAIN STREET</td>
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<tr>
<td>EVANSVILLE, IN 47710</td>
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<tr>
<td>812-422-0231</td>
<td>Discount prices on Ten-Tec, Cubic,</td>
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<tr>
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<td>Hy-Gain, MFJ, Azden, Kantronics,</td>
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<tr>
<td></td>
<td>Santec and others.</td>
<td></td>
</tr>
<tr>
<td>Delaware</td>
<td></td>
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</tr>
<tr>
<td>Delaware: YOU SHOULD BE HERE TOO!</td>
<td>Contact Ham Radio now for complete details.</td>
<td></td>
</tr>
<tr>
<td>Dealers:</td>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
</tr>
<tr>
<td>2</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
</tr>
<tr>
<td>3</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
</tr>
<tr>
<td>4</td>
<td>YUP &quot;HOMOY DAYS&quot; PARTY 11:00 AM to 7:00 PM</td>
</tr>
<tr>
<td>5</td>
<td>NEW ENGLAND DIVISION CONVENTION - Mohegan Sun, CT (NO LECTURE)</td>
</tr>
<tr>
<td>6</td>
<td>BLOOMINGTON ARC &quot;HOOSIER BACKYARD HamFEST&quot; - 229 Van Buren, Bloomington, IN - 9:00 AM</td>
</tr>
<tr>
<td>7</td>
<td>SOUTHERN JERSEY RADIO ASSOCIATION ANNUAL HAMFEST - Perquimans Oaks Manor, Buena Vista, NJ - 9:30 AM to 1:00 PM</td>
</tr>
<tr>
<td>8</td>
<td>SOUTH FOXFORD AMATEUR RADIO ASSOCIATION 4TH ANNUAL HAMFEST - Southern Foxford, IA - 9:00 AM to 3:00 PM</td>
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<tr>
<td>9</td>
<td>CALHOUN COUNTY AMATEUR RADIO ASSN 3RD ANNUAL HAMFEST - Mason City Recreation Center, 1733 Central Ave, Mason City, IA - 9:00 AM to 5:00 PM</td>
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<tr>
<td>10</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>11</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
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<tr>
<td>12</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
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<tr>
<td>13</td>
<td>MARS O'HARA BL Bid - Coquon, WA - 9:00 AM to 5:00 PM</td>
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<td>14</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>15</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
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<tr>
<td>16</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
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<tr>
<td>17</td>
<td>CALHOUN COUNTY AMATEUR RADIO ASSN 3RD ANNUAL HAMFEST - Mason City Recreation Center, 1733 Central Ave, Mason City, IA - 9:00 AM to 5:00 PM</td>
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<tr>
<td>18</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>19</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
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<tr>
<td>20</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
</tr>
<tr>
<td>21</td>
<td>CAHOONDME AMATEUR RADIO ASSN 3RD ANNUAL HAMFEST - Mason City Recreation Center, 1733 Central Ave, Mason City, IA - 9:00 AM to 5:00 PM</td>
</tr>
<tr>
<td>22</td>
<td>CAHOONDME AMATEUR RADIO ASSN 3RD ANNUAL HAMFEST - Mason City Recreation Center, 1733 Central Ave, Mason City, IA - 9:00 AM to 5:00 PM</td>
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<tr>
<td>23</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>24</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
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<tr>
<td>25</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
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<tr>
<td>26</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>27</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
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<td>28</td>
<td>AMSAT Mid Continent Net 3500 kHz 9:00 PM CST (01:00Z Wednesday) Morning</td>
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<tr>
<td>29</td>
<td>AMSAT East Coast Net 3500 kHz 9:00 PM EST (01:00Z Wednesday) Morning</td>
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<tr>
<td>30</td>
<td>AMSAT HamNet 3500 kHz 5:00 PM EST (23:00Z Wednesday) Morning</td>
</tr>
<tr>
<td>31</td>
<td>CALHOUN COUNTY AMATEUR RADIO ASSN 3RD ANNUAL HAMFEST - Mason City Recreation Center, 1733 Central Ave, Mason City, IA - 9:00 AM to 5:00 PM</td>
</tr>
</tbody>
</table>

**WIATW Schedule**

April 21 to October 25, 1981

UTC | Code Practice
---|---
MMF: 0200 | 1200: 2300
TT2: 1900 | 2000: 2100
MMF: 2000 | 1100: 1200
TT2: 1900 | 2000: 2100
MMF: 0200 | 1200: 2300

**Code Practice**

UTC | Code Practice
---|---
MMF: 0200 | 1200: 2300
TT2: 1900 | 2000: 2100
MMF: 2000 | 1100: 1200
TT2: 1900 | 2000: 2100
MMF: 0200 | 1200: 2300

**CW Practice**

UTC | Code Practice
---|---
MMF: 0200 | 1200: 2300
TT2: 1900 | 2000: 2100
MMF: 2000 | 1100: 1200
TT2: 1900 | 2000: 2100
MMF: 0200 | 1200: 2300

For times and durations, see the schedule.
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22 wpm code for 20 minutes
25 wpm code for 20 minutes

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35 wpm code for 20 minutes
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- Low impedance, low distortion, adjustable sinewave output, 5v peak-to-peak.
- Instant start-up.

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<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Test Tones:</th>
<th>Touch Tones:</th>
<th>Burst Tones:</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.9 KZ</td>
<td>85.4 YA</td>
<td>103.51A</td>
<td>127.33A</td>
</tr>
<tr>
<td>71.9 KA</td>
<td>86.5 YB</td>
<td>107.21B</td>
<td>131.83B</td>
</tr>
<tr>
<td>74.4 WA</td>
<td>91.5 ZZ</td>
<td>110.922</td>
<td>136.542</td>
</tr>
<tr>
<td>77.0 XB</td>
<td>94.8 ZA</td>
<td>114.82A</td>
<td>141.34A</td>
</tr>
<tr>
<td>79.7 SP</td>
<td>97.4 ZB</td>
<td>118.82B</td>
<td>146.24B</td>
</tr>
<tr>
<td>82.5 YZ</td>
<td>100.012</td>
<td>123.032</td>
<td>151.452</td>
</tr>
</tbody>
</table>

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

**TE-12PB**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Test Tones:</th>
<th>Touch Tones:</th>
<th>Burst Tones:</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>697</td>
<td>1209</td>
<td>1600</td>
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<tr>
<td>1000</td>
<td>770</td>
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<td>852</td>
<td>1477</td>
<td>1700</td>
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<td>2175</td>
<td>941</td>
<td>1633</td>
<td>1750</td>
</tr>
<tr>
<td>2805</td>
<td></td>
<td></td>
<td>1800</td>
</tr>
</tbody>
</table>

- 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

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