DECEMBER 1982

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- 40-meter transmitter-receiver
- data bandwidths compared

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**R-2000 FEATURES:**

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  - 50-Hz step, switchable to 500-Hz or 5-kHz, using front panel pushbutton switches. F. LOCK switch provided.
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  - Complete information on frequency, band, and mode is stored in memory, assuring maximum ease of operation. Each memory may be tuned as a VFO. Original memory frequency may be recalled. AUTO, M switch for automatic storage of current operating data, or, when off, selective storage of data using M. IN switch.
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  - Permits programming two different time zones. Timer for ON and OFF programming. Timer REMOTE output on rear panel (not for AC power).
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- **Large front mounted speaker.**
- **Tone control.**
- **RF step attenuator. (0-10-20-30 dB.)**
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- **High and low impedance antenna terminals.**
  - A high impedance (500 ohm) terminal, and a low impedance (50 ohm) co-axial connector are provided.
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**Other features.**

- **RECORD output jack.**
- **Audible “beeper” (through speaker).**
- **Carrying handle.**
- **Headphone jack.**
- **External speaker jack.**

**Optional accessories:**

- **HS-4, HS-5, HS-6 headphones.**
- **DCK-1 DC cable kit.**
- **YG-455C 500-Hz CW filter.**
- **HC-10 World digital quartz clock.**

More information on the R-2000 is available from all authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street Compton, California 90220.

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I must share this with you. I must blurt this out before I bust. We at *ham radio* magazine are so pleased with the turn of events and even more importantly with our glimpse at the future: a larger staff, a very welcome increased advertiser response (it’s nice to be adding pages in groups of eight at the last minute), and so very importantly, your response to us. Yes, all the letters will be answered, the many article suggestions considered and encouraged. Reflections is our attempt at looking in both directions, remembering the past technical excellence of our hobby, individuals, and industry, while keeping an eye toward the future.

I feel very fortunate to be able to address so large a group of technical and knowledgeable individuals through this page and am taking the opportunity to throw out to the “floor” possibly the first question of our new technical forum section. The problem: Normal communications channels down. A fine gentleman, while honorably serving his country, suffered a wound that resulted in Padget’s disease. For those not familiar with it, this is a progressively degenerative bone malady. Fortunately, through modern medicine, its destructiveness has been arrested. However one quite intelligent human being with a fine mind is now deaf and almost totally blind. The two normal means of communications that most of us take for granted — seeing and hearing — are “down.” But his speech is excellent and his ability and desire to learn new techniques are great. They are surpassed only by his desire to carry on normal communications. I might add that his memory is outstanding. He knows the Morse code (from army days) and he has very slight shadow vision. Are techniques available (such as aural to tactile converters, aural to light converters and so forth) that can be used to provide faster inputting under these circumstances? I am aware of articles on this subject that have appeared in some of the ham magazines. Do any of our readers know of, or have ideas for, other techniques that might help?

Presented below is a preview of some of the subject areas *ham radio* magazine will cover in 1983. Please feel free to respond with your suggestions for additions or changes:

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Two thousand miles of almost non-stop driving during my move from Denver, Colorado, to join *ham radio* in Greenville, New Hampshire, gave me plenty of time to reflect on and appreciate another wonderful aspect of ham radio, the ability to communicate with a cross-section of Amateurs from Salinas and Topeka, Kansas; Kansas City and St. Louis, Missouri; Indianapolis, Indiana; Zanesville, Ohio; Wheeling, West Virginia; Pittsburgh and Scranton, Pennsylvania; through Binghamton, New York — to name a few. The miles melted away with the good company provided by local hams as we discussed everything from lightning protection for highly exposed repeaters to elaborate test procedures for squeezing out that last tenth of a dB in a high-gain Yagi array. There is real joy in hearing a warm voice coming from the 2-meter transceiver telling one very weary driver that there are motels just ahead where a late arrival might find a welcome bed. How I appreciated each transistor, resistor, and capacitor in my mobile unit, the repeaters I worked through, Maxwell’s equations, and, most of all, the operators and technicians who made it all possible. To the many Amateurs I talked to during this recent trip, a hearty thank you.

Rich Rosen, K2RR
technical editor

December 1982
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More Details? CHECK - OFF Page 132

December 1982
Dear HR:

After reading the April issue of *Ham Radio*, I would like to comment on the Ham Notebook item by Mr. Foot, WA9HUV. He is not alone in his desire for a method of BCD addition and subtraction. However, Motorola already solved this problem many years ago with the introduction of a chip pair combination, the MC14560B and the MC14561B. The first is an NBCD adder and the second is a 9s complementer.

Connecting the units as shown in the data sheets (and reprinted in fig. 1) permits the user to choose a thumbwheel-selected number to program his synthesizer, or shift the number a fixed amount plus or minus. This feature is useful for setting a frequency source at a particular channel and then being able to shift its output to the upper or lower sideband.

The approximate cost per BCD digit is $5.40 in unit quantities. It’s a slightly more expensive approach, but one that does not require clocking and can be easily cascaded. For further reading and more application assistance, I would recommend Motorola’s application note AN-738, which covers the subject more completely.

Jeffrey L. Schiffer, Pres.
Phasetec Corporation
West Peabody, Massachusetts

quad versus Yagi

Dear HR:

Quad lovers awake! We are again being attacked by the Yagis (*Ham Radio*, May, 1982, “Quad Owner Switches”). It is not immediately apparent that the quad was given a fair shake by the test procedure. For example, a five-element Yagi on a 32-foot boom is matched up against a three-element quad on a 27-foot boom on 20 meters. On 15 meters a five-element Yagi was up against a four-element quad. On 10 meters, where the correlation is best except for the reversal of directivity, the match is five versus five.

The next problem I had was whether there were any matching devices at the antennas. Were baluns used, were their losses equal, was each antenna delivering maximum power to the line?

What bugs me most is that the authors took boom height as a reference height for both the quad and the Yagi. If the quads were fed at the center of the lower element, that point should be taken as the height of the quad. This would put the current loop for each antenna at the same height. It would seem that the procedure used in the tests handed the Yagi a height advantage on the order of 12 feet on 20 meters, 9 feet on 15 meters, and 6 feet on 10 meters. This would be expected to affect the vertical angle of the main lobe of the quad. Some Amateurs have advocated feeding the center of the upper element of the quad to improve the gain. Of course, there is a current loop in each of the horizontal elements if they are fed, but the loop at the feedpoint will be greater.

C’mon home, guys. Wouldn’t you rather fight than switch?

Howard B. Mouatt, W6BQD
Palm Desert, California

---

**fig. 1.** Connections for an NBCD adder and 9s complementer allowing a thumbwheel selected number or a number shift of a plus or minus fixed amount.
Hear Police/Fire Weather
on 2 Meter Handsets with this MFJ VHF Converter.

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New MFJ VHF converter turns your synthesized scanner to 2 meter handheld into a hot Police/Fire/Weather band scanner. 144-148 MHz handsets receive Police/Fire on 154-158 MHz with direct frequency readout. Heat NOAA weather, maritime coastal plus on 160-164 MHz. Mounts between handheld and rubber ducky. Feedthru allows simultaneous scanning of both 2 meters and Police/Fire bands. Crystal controlled. Good input filter and 2.5 GHz transistor gives excellent uniform sensitivity over both bands. Crystal controlled. Bypass/Off switch allows transmitting. Won't burn out if you transmit (up to 5 watts) with converter on. Low insertion SWR. Uses AAA battery. 2½x1½x⅞ in., BNC connectors. Enjoy scanning, memory, digital readout, etc., as provided by your handheld on Police/Fire band.

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MFJ-312, like MFJ-313 but for mobile 2 meter rigs. Transmit up to 40 watts thru converter without damage. SO-239 connectors. Mobile mounting brackets. Rugged, “ON” LED. Use 12 VDC or AAA battery. 3¾x⅞ inch. Order from MFJ and try it-no obligation. If not delighted, return within 30 days for refund (less shipping). One year unconditional guarantee.

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More Details? CHECK-OFF Page 132

December 1982
"CQ 30 METERS" HAS FINALLY BECOME A REALITY for U.S. Amateurs. FCC Commissioners voted October 28 to grant "temporary access" to the new band. Acting on a suggestion made by Senator Barry Goldwater, K7UGA, in an August letter to Chairman Mark Fowler (October Presstop), the Commissioners permitted General class and above to use 250 watts input, narrow-band (CW and RTTY) modes only, from 10.1 to 10.15 MHz. The 10.109-10.115 MHz slot, however, was held back to protect existing users. The band was opened at 1900Z on the 28th, with W1AW, K7UGA, and W9MU among the many taking part in the U.S. 30-meter inaugural.

A Possible Conflict with the new band and also the 18 and 24 MHz bands has surfaced in FCC General Docket 82-625, released mid September. This Notice of Proposed Rule Making would open many segments of the 2-25 MHz HF spectrum, including the three new WARC bands (but no other Amateur frequencies), to various licensees in industrial radio services. Telephone and power companies plus oil, gas, and mineral exploration firms would all be authorized to use these frequencies when it was in the "national interest."

These Proposals Conflict With Other New WARC 79 Assignments as well as with the new Amateur bands, but it's predicted that frequencies conflicting with WARC allocations will be deleted as the NPRM is reviewed. The ARRL did, however, file comments pointing out the conflict prior to the comment closing date of November 5.

A "SPACE DXPEDITION" IS ALMOST CERTAIN FOR NEXT YEAR, when astronaut Owen Garriott, W5LFL, will fly the space shuttle Columbia's ninth mission. After lengthy negotiations, NASA Houston agreed to let him take a specially reworked 2-meter handheld along, to operate when possible with ATLA\$-KIZZ, W1KL\$, and WBGGVO. The unusual ruling was to "protect" the pay TV company, since they do not own the frequency as the NPRM issued October 28 to grant "temporary access" to the new band. It should be released as an RM shortly.

\textbf{NOVICE EXAMS WOULD BE PREPARED AND GRADED} as well as administered by Amateur volunteer examiners under an NPRM put forth by the Commissioners at their October 19 agenda meeting. It's proposed that examiners would make up an exam using the FCC Novice syllabus as a guide, let the applicant answer the questions, and then grade it. If the applicant passes both the written and the CW test, the examiner would note that on the applicant's Form 610, which would still need to be maintained. Comment due date for PR Docket 82-726 had not been released at press time.

The ARRL Proposed Proposal for the preparation and administration of exams by Amateurs was delivered to the FCC on October 28. It should be released as an RM shortly. The ARRL Proposed Proposal for the preparation and administration of exams by Amateurs was delivered to the FCC on October 28. It should be released as an RM shortly.

\textbf{AMATEUR LOGBOOK REQUIREMENTS WOULD BE ENTIRELY ELIMINATED} by another NPRM agreed to at that same agenda meeting. In this proposal the few remaining operating log requirements, such as noting changes in control operator, would be deleted, though certain station records would still need to be maintained. Comment due date for PR Docket 82-727 had not been released at press time.

\textbf{SACRAMENTO AMATEURS MUST GET PERMISSION} from a local pay TV Company before acquiring microwave equipment, according to a preliminary injunction issued by a superior court judge. He issued the order after hearing a suit from California Satellite Systems, Inc., against a local pay TV dealer who was also selling down-converters and antennas for the 2150 MHz pay TV band. He made the unusual ruling to "protect" the pay TV company, since they do not encode their signals and Amateur 2300-MHz equipment could be used to intercept the movie channel signals.

"AUTOMATIC CONTROL" OF AMATEUR RADIO BEACONS was authorized by the Commissioners on October 21. This means that operators of U.S. Amateur beacons will no longer have to shut down when they are unavailable to perform control operator functions.

\textbf{CW CREDIT FOR ANY CLASS AMATEUR LICENSE} was also granted to holders of any class commercial CW ticket at the same meeting.

\textbf{BURBANK CITY OFFICIALS ARE IN DEFAULT} under federal court rules for having failed to respond to the complaint filed against them to test their severe antenna restrictions (see Observation and Opinion, August, 1982, Ham Radio, and recent Presstops). The judge hearing the case has set November 4 for a status report by the parties. Attorney W9MU, representing Burbank, filed a motion for class certification and preliminary injunction prior to the November 4 court date to keep pressure on Burbank officials.

\textbf{FCC'S POWER MEASUREMENT NPRM, PR Docket 82-624,} proposes changing power limits for all classes except Novices to 1500 watts PEP output. Novices would be limited to a 200-watt PEP output. Due date for comments is February 15, 1983; reply comments are due by March 1.

\textbf{SONIC CABLE TV WAS FINED} $6,000 by the FCC for 2-meter interference following a two-year battle by WBGGVO. One third of the fine was for failing to correct the cable channel E problem after citation by an FCC engineer, while the remaining $4,000 was imposed for the California company's on-going illegal interference to Amateur operations on 2 meters.
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More Details? CHECK-OFF Page 132

December 1982
low cost linear design and construction

Practical design techniques using common power tubes and parts provide 10-40 meter kilowatt amplifier

Constructing a linear amplifier is one way an Amateur can save money. It's not so much that commercial amplifiers are overpriced for the components they contain, but because of OEM pricing, components bought singly may add up to more than the cost of an assembled unit. Home construction allows you to take advantage of a readily available supply of parts (well-stocked junk pile) that can be used or traded for other items.

When constructing your own amplifier, it's usually not possible to exactly duplicate a published design. Modifications are often required to accommodate differences in components. For this reason, a specific design, and more importantly, the steps used to arrive at it, are presented. By providing sufficient data, minor and even major deviations from the specific design can be made while still obtaining good performance.

A review of amplifier design information, such as found in Bill Orr's Radio Handbook, in addition to this design data, is helpful prior to starting the project. Other good source material may be found in the ARRL Handbook and articles by W6SAI.

tubes

Tubes, and their availability, greatly influence the design approach to be taken. Good sources for low cost tubes are:

1. Surplus, often WW-II
2. Pull-outs from stations on a maintenance schedule
3. TV sweep tubes

A strong recommendation is in order: get 'the tubes you want to use before you start and get at least twice as many as you need, preferably two complete sets of spares. This will save you much trouble later, and possibly much expense (such as buying a low-production tube or making a design change). Test the tubes first, if at all possible, in a friend's rig or by

By R.P. Haviland, W4MB, 2100 S. Nova Road, Box 45, Daytona Beach, Florida 32019
using a pair of transformers, one with the proper filament voltage, and a second at 300-700 volts. Test the tube as a diode with a series resistor to give rated current. This test lets you separate out most bad tubes.

Some of the common tubes to look for are listed in table 1. Though possibly considered old-fashioned, out of style and even obsolete, they are inexpensive and perfectly usable. If you have a set, with spares, or can find a set, don’t be afraid to use them. This includes out-of-date or unusual tubes such as the 810 or the 715. There are some design considerations to look out for, however. These will be covered later.

TV sweep tubes have two ratings, one for average loads and another for peak loads, such as the flyback pulse in a sweep circuit. Average peak and duty cycle terms are important in the operation of any tube, and consequently are important design factors.

In amplifiers used in fm or teleprinter service a constant signal is present at all times, that is, the duty-cycle is 100 percent. With CW, the carrier is keyed on and off with a resulting duty cycle of approximately fifty percent. With SSB voice, the average energy is far below the peak, normally 10-16 dB down. This results in a duty cycle of ten percent or less. Use of clippers and other speech processors can raise SSB signal duty cycles to fifty percent or more. However, thirty to forty percent is probably nearly optimum. Low average power requirements of SSB service is the reason why modern linears can be made so small and why separate ratings are required for SSB and CW operation.

It makes quite a difference in component size if the rig is to be used for SSB only, or if it must also handle FSK teleprinter. This is one of your major design choices. If you are primarily interested in one mode, it’s best to design for it and accept the performance you get with other modes.

In my case, eight 4-125s and four 813s were available. A review of some of the local ham stock showed more 813s available. Though nearly equivalent, the greater ruggedness of the 813 plate and the more severe cooling design requirements of the 4-125s tilted the choice toward the 813s.

The next factor considered is the design for input power level. I have never used a linear except on SSB. There didn’t seem to be much reason for a linear unless it was well above the output of a normal rig (provided by most modern transceivers). This indicated a 2 kW PEP design. Experience indicates that a moderate amount of speech processing is best, with heavy processing only needed during pile-ups. Consequently, a normal duty-cycle of twenty to thirty percent seemed appropriate, with a capability of increasing to fifty percent. This allows for pile-up processing and CW if ever needed. It’s preferable to design for peak outputs of at least twenty percent greater than normally used. A design capable of thirty percent duty-cycle at 2200 watts input, but with normal operation set for about 1800-1900 watts, would satisfy this requirement.

Amplifier efficiency for SSB operation is normally fifty percent at an average input level, versus sixty-five percent for CW. At an average input of 600

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### Table 1. Low-cost tubes for linears.

<table>
<thead>
<tr>
<th>tube type</th>
<th>$E_p$, volts</th>
<th>$I_p$, mA, max.</th>
<th>rated/class C maximum dissipation</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>6DQ5</td>
<td>800</td>
<td>250</td>
<td>24/100</td>
<td>1</td>
</tr>
<tr>
<td>6J66</td>
<td>800</td>
<td>242</td>
<td>30/100</td>
<td>1</td>
</tr>
<tr>
<td>811</td>
<td>1200-1700</td>
<td>160</td>
<td>50/65</td>
<td>2,4</td>
</tr>
<tr>
<td>812</td>
<td>1200-1700</td>
<td>160</td>
<td>50/65</td>
<td>2,4</td>
</tr>
<tr>
<td>813</td>
<td>2000-2500</td>
<td>250</td>
<td>100/125</td>
<td>2,4</td>
</tr>
<tr>
<td>4-125</td>
<td>2000-3000</td>
<td>260</td>
<td>125</td>
<td>3</td>
</tr>
<tr>
<td>572B</td>
<td>2750</td>
<td>275</td>
<td>160</td>
<td>3</td>
</tr>
<tr>
<td>810</td>
<td>2500</td>
<td>300</td>
<td>125/175</td>
<td>2</td>
</tr>
<tr>
<td>4-250</td>
<td>4000</td>
<td>345</td>
<td>250</td>
<td>3</td>
</tr>
<tr>
<td>250TH</td>
<td>2000-3000</td>
<td>350</td>
<td>250</td>
<td>3</td>
</tr>
<tr>
<td>304TH</td>
<td>2000-3000</td>
<td>900</td>
<td>300</td>
<td>3</td>
</tr>
<tr>
<td>4-400</td>
<td>4000</td>
<td>317</td>
<td>400</td>
<td>3</td>
</tr>
</tbody>
</table>

**Notes:**

1. Average/peak ratio
2. CCS/ICAS ratio
3. Rated dissipation (ratings nomenclature depends on reference used)
4. A number of these tubes are no longer manufactured. Obtain spares prior to starting the design.
watts, approximately 300 watts of dissipation is indicated. This requires three 813s, with some safety factor, or two 813s with some overloading or operation at reduced power levels.

However, average dissipation is not the whole story. Peak operation must also be considered. At 2200 volts a 2200 watt capability means one ampere of plate current. This is twice the rating of a pair of 813s, and thirty-three percent more than three would supply.

One solution is to use four 813s. However, there is another approach. To see this, look at the tube ratings in table 2. Note that the major differences between continuous commercial and Amateur service is a lower plate dissipation, plate voltage, and current. The instantaneous plate voltage is allowed to go to 3200 volts and the peak plate current to 300 mA in the CCS a-m service, and even higher, to 4000 volts and 400 mA in the Amateur a-m service. Continuously-applied voltage is allowed to go to 2500 volts in the Amateur af amplifier service. However, in all cases, the plate dissipation must not exceed the CCS and Amateur limits of 100 and 125 watts, respectively.

The point is, we can choose a combination of operating conditions to suit the service we plan, within reasonable limits, as long as we do not exceed the rated plate dissipation. For example, for the 813:

For several continuous hours of teleprinter
\[ E_p = 2,000, \quad i_p = 180 \text{ mA}, \quad P_{out} = 275 \text{ watts} \]

For typical CW
\[ E_p = 2250, \quad i_p = 220 \text{ mA}, \quad P_{out} = 375 \text{ watts} \]

For non-processed SSB, at peak input
\[ E_p = 2500, \quad i_p = 300 \text{ mA}, \quad P_{out} = 450 \text{ watts} \]

For SSB, with compression, at peak input
\[ E_p = 2250, \quad i_p = 220 \text{ mA}, \quad P_{out} = 375 \text{ watts} \]

We could even raise the plate voltage for SSB to 1.5 times the normal commercial voltage, or approximately 2700-3000 volts. This isn't really good for the 813, since the internal construction leakage path is short. Other tubes, such as the 250th or even some sweep tubes, have longer leakage paths but they already have maximum specified high voltage ratings. (Higher voltage operation makes it easier to drive the tube to peak output.)

We can now make another selection, the amplifier input, and the number of tubes required. Let's assume that a full "gallon" was the goal. For continuous teleprinter use, three 813s are required. CW could be handled with two 813s, and SSB operation, with or without processing, requires three tubes. (The allowable PEP input decreases from 2 kW with no compression, since the average input must be kept under 1000 watts, as indicated by a meter.)

Other types require an even larger number of tubes. The extreme would be the sweep tubes, where eight or even ten would be required to achieve 2 kW PEP. As we will see, the design for this is special, but by no means impossible.

Incidentally, during the design stage we find there is some difference in circuit parameters for the CW, teleprinter, and SSB conditions. Simple designs represent performance compromises for some services. An alternative is to change the tube voltage-current operating point to suit the circuit, as done in the big Henry amplifiers.

I chose three 813s, with plate voltages between 2250 and 2500. Since SSB was the primary mode of operation, no special provision for CW or teleprinter seemed necessary. However, each designer should decide what modes are important and how much of a performance trade-off he's willing to accept.

**power supply, part 1**

At this point it's a good idea to consider some of the other large components — those in the power supply. The plate transformer is the key to this, and you may find some trading or surplus purchasing necessary (have you priced new kW supply transformers lately?).

Though large-capacity high voltage electrolytic capacitors aren't as common as they were a few years ago, they are still available. Because of size and weight problems, choke input and half-wave filtering are not attractive. The remaining choices are full wave, bridge and full-wave doubler circuits. For these, and capacity input, the transformer should have an RMS high voltage rating of about the plate voltage times 1.12, 0.56, and 0.3, for the three types respectively. DC voltages of 2200-2500 equate to 2500-2800 volts (CT) for the full wave, 1250-1400 volts for the bridge, and about 675-750 volts for the doubler.

 Transformer power ratings are 1 kW continuous for teleprinter and CW, about 2 kW intermittent for heavily-processed SSB, but as low as 300-500 watts for SSB with no processing. This amounts to perhaps 60, 40, and 20 pounds, respectively — quite a difference due to duty cycle.

When you get a transformer with the required voltage and rating, you are ready to proceed with the design. My transformer turned out to be 925 volts each side of center tap, at 500 mA dc, ample for 300 watts continuous or a full gallon at a thirty percent duty
table 2. Typical operating characteristics.

<table>
<thead>
<tr>
<th>tube type</th>
<th>811</th>
<th>572B</th>
<th>813</th>
<th>4-125</th>
</tr>
</thead>
<tbody>
<tr>
<td>E&lt;sub&gt;FIL&lt;/sub&gt;</td>
<td>6.3</td>
<td>7.5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>I&lt;sub&gt;FIL&lt;/sub&gt;</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>6.5</td>
</tr>
<tr>
<td>E&lt;sub&gt;B&lt;/sub&gt;</td>
<td>1700</td>
<td>2400</td>
<td>2500</td>
<td>2500</td>
</tr>
<tr>
<td>I&lt;sub&gt;B&lt;/sub&gt;</td>
<td>30</td>
<td>20</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>I&lt;sub&gt;max&lt;/sub&gt;</td>
<td>160</td>
<td>250</td>
<td>200</td>
<td>110</td>
</tr>
<tr>
<td>I&lt;sub&gt;max&lt;/sub&gt;</td>
<td>28</td>
<td>45</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>R&lt;sub&gt;k&lt;/sub&gt;</td>
<td>320</td>
<td>215</td>
<td>270</td>
<td>340</td>
</tr>
<tr>
<td>R&lt;sub&gt;L&lt;/sub&gt;</td>
<td>5200</td>
<td>4500</td>
<td>7000</td>
<td>13500</td>
</tr>
<tr>
<td>drive power</td>
<td>15</td>
<td>30</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>input power</td>
<td>270</td>
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<td>500</td>
<td>275</td>
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<tr>
<td>output power</td>
<td>175</td>
<td>350</td>
<td>350</td>
<td>190</td>
</tr>
<tr>
<td>average dissipation</td>
<td>65</td>
<td>160</td>
<td>150</td>
<td>85</td>
</tr>
</tbody>
</table>

for 2 kW PEP input

<table>
<thead>
<tr>
<th>no. tubes</th>
<th>4</th>
<th>4</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z plate</td>
<td>1300</td>
<td>1150</td>
<td>1750</td>
<td>3350</td>
</tr>
<tr>
<td>C tank-in (note 1)</td>
<td>300 pF</td>
<td>450 pF</td>
<td>225 pF</td>
<td>128 pF</td>
</tr>
<tr>
<td>L tank (note 1)</td>
<td>7.9 µH</td>
<td>5.4 µH</td>
<td>10.1 µH</td>
<td>17 µH</td>
</tr>
<tr>
<td>C tank-out (note 1)</td>
<td>1420 pF</td>
<td>1850 pF</td>
<td>1100 pF</td>
<td>50 pF</td>
</tr>
</tbody>
</table>

Notes:
1. Component values are given for 3.5 MHz
2. Design data is for 2 kW PEP grounded-grid linear service. Based on Radio Handbook data.

The plate circuit

With the basic tube operating conditions established, final design can start. As is common today, a single-ended design with tubes in parallel is assumed, since multi-band operation is much simpler.

The plate circuit looks like a generator, with an impedance of

\[ R_p = \frac{E_p}{k \times I_{\text{design}}^2} \text{ ohms} \]

where \( k \) equals 1.57 for a linear amplifier and 2 for a Class C amplifier. For an amplifier designed with reserve power capability, for example, one ampere at 2200 volts in linear operation, the plate resistance is 1400 ohms. For Class C operation it would be 1100 ohms. (Alternately, we could change the operating conditions of the tube to give the same impedance, say to 2500 volts at 850 mA.) The other alternative is to operate Class B for CW as well as SSB. This was the approach taken in this design.

A pi-matching circuit is normally used to transform this impedance to 50 ohms, needed for coax feed. The input capacitor reactance is:

\[ X_C = \frac{R_p}{Q} \text{ ohms} \]

where a Q of ten is considered optimum. For the 813 design, this amounts to a reactance of 140 ohms, corresponding to an input capacitance of about 35 pF at 30 MHz, and to 340 pF at 3.5 MHz.
Here we run into a small problem. The plate circuit capacity of a single 813 is 14 pF, so we are faced with a capacity of 42 pF for the tubes alone. Adding 5 pF for strays, and 10 pF for tuning-capacitor minimum gives a pi-input capacity of 57 pF, too much for a Q of ten. The problem would be even worse if sweep tubes are used, eight in parallel giving as much as 160-pF plate capacity, with a total circuit capacitance of 180 pF. (Of course, the plate circuit resistance goes down also, to about 320 ohms, so a Q of 10 would allow as much as 150 pF.)

One way of solving this problem is to accept a higher Q on 10 and perhaps 15 meters. Using the previous values, this equates to a Q of 12, normally considered somewhat high, but acceptable.

Another way to handle this is to abandon the pi-network circuit. A push-pull tank could solve the problem. Past editions of the ARRL Handbook show a tapped-coil sweep-tube design, fine for a single band, but a nuisance for multiple band operation. Or, we could simply regard the output as a low impedance capacity-shunted source, as is done in transistor designs.

There is another approach which doesn’t seem to have been described before. As a matter of fact, it should be considered in any matching design network above 14 MHz. The approach regards the output circuit as two networks in series. One of these is the normal pi-output circuit, and the second is the L network composed of tube and associated stray capacitance, plus the inductance of the lead from the tube or tubes to the pi-network. Its equivalent circuit with the given design parameters is shown in fig. 1.

To see the importance of the technique use the given values: 1400 ohm plate impedance and $42 + 5 = 47$ pF of tube and stray capacitance. Assume that the lead from the tank circuit to the tubes is only four inches long, with a diameter of one-eighth inch, giving an inductance of about 0.05 μH, and a reactance of about ten ohms at 30 MHz. Performing the parallel-to-series conversion, reducing the capacitive reactance by this amount and converting back again, gives an equivalent driving point impedance of 1170 ohms, and a shunt reactance of 109 ohms, or 50 pF. With a tank circuit Q of 10, the value of $X_{cl}$ becomes 117 ohms, or 55 pF. A capacitor of 5 pF minimum capacity can be used and still obtain a pi-section Q of 10.

If the allowable capacity is still less than the tube and stray capacitance, the length of the plate lead can be further increased. However, the equivalent drive resistance will also decrease. Several more repetitions may be needed to obtain a workable combination.

Once the values have been obtained for the highest band, repeat the calculation for the next few lower bands. When the equivalent resistance approaches the tube resistance, use this for the lower bands, while maintaining a Q of 10. The values of the pi-network elements are then calculated using the formulas in fig. 2. Don’t forget to use the equivalent impedance for $R_1$ at the higher bands.

What type of inductance should be used? Roller coils allow one to closely adjust circuit parameters for maximum efficiency, but they are expensive. Tap switching is perfectly acceptable, and there are many old tuner switches available that provide rugged low-resistance design. Looking ahead with eight bands between 3 and 30 MHz, the number of taps may be excessive. You may want to consider having one linear for 1.7-7.5 MHz, and another for 10-30 MHz.
This was my choice. It certainly makes design a lot easier.

**The input circuit**

The driving-point impedance, \( Z_K \), of a grounded-grid amplifier is

\[
Z_K = \frac{e_{g \text{max}}}{i_C + 1.5 i_{\text{max}}} \approx 0.6 i_p
\]

where
- \( e_g \) = rms grid drive voltage
- \( i_C \) = cathode current
- \( i_{\text{max}} \) = fundamental current

For most combinations of tubes, this will probably be between 50 and 150 ohms.

The input circuit must be reasonably well-matched to the driving amplifier. It must also provide a load to the amplifier when the tube is cut off (Class C), or nearly so (Class B).

While the drive power used in grounded-grid operation is much greater than for grounded-cathode service, provisions must be made to prevent an overdrive condition from occurring. (Modern transceivers have more than sufficient output power). An automatic overdrive protection circuit is one possibility.

The usual way of preventing overdrive is to use a low Q tuned circuit in the cathode, say a Q of 2, plus ALC feedback to set the level. This is perfectly acceptable if the ALC is not forced to work too hard. However, the added coil switching is a nuisance.

An alternate method that doesn’t use switching is shown in fig. 3. A lowpass filter, used in the drive circuit, provides an impedance transformation from 50 ohms to the tubes’ input resistance. The filter output drives the tubes’ cathodes and a resistor bank. The latter provides a load to the driver during the entire input cycle, and dissipates part of the driver’s excess power.

Circuit losses and a varying driver load complicate the calculation of the required resistance. As an approximation for designs where between thirty to fifty percent of the rated driver output is required, a resistance of five times the cathode impedance has worked well. Basically, start with a higher resistance and monitor the drive level. If it is still excessive reduce the loading resistance until the exciter’s maximum output just drives the amplifier throughout its linear range.

High power-rating resistors are not needed. For example, if the total drive is 50 watts, the resistors dissipate only 10-12 watts of it (using the above rule of thumb). A bank of six two-watt resistors will do.

Even though 813s have an isolated cathode, a filament choke is a good idea. For a kW amplifier, the choke core can be a 6-8 inch (150-200 mm) long, \( \frac{3}{4} \) -inch (12.7 mm) diameter ferrite rod. If the amplifier is to cover only the higher bands, 10 through 40, the winding can be trifilar, with two elements the filament conductors, the third a nylon cord, or other non-moisture absorbing spacer with the same wire diameter. For low frequency use, the filament leads can be bifilar wound. Number 12 wire is ample for three 813s, but be sure to estimate the voltage drop and allow for it when selecting a filament transformer. Low filament voltage causes problems with linearity and tube life.

One nice feature of the 813 is that it doesn’t require bias in grounded-grid operation. If the operating mode requires bias, it can best be obtained by using a Zener diode. Shunt it with a resistor that will draw approximately ten percent of the expected grid plus plate current. This helps prevent instability. If a power Zener is not available, the circuit of fig. 4 can be used.

**Power supply, part 2**

Let’s return to the power supply, keeping it simple. Our basic requirements are:

1. Apply only filament power for an adequate warm-up period.
2. Initially apply power to the plate circuit at a low level, to hold capacitor charge current down.
3. Apply full power to the plate circuit.
4. Remove plate and filament power simultaneously, or plate before filament.

We also want adequate protection for ourselves and the equipment. We can accomplish these functions manually, semi-automatically, or in a fully automatic mode. However, cost increases as the system becomes more automatic (complex).
A simple way of achieving partially protected manual operation is to use a progressively-operated switch for the transformer primary, as shown in fig. 5A. The first position turns on the filaments. After a short delay, the switch is placed in the second position, feeding power to the plate transformer through a dropping resistor. After an additional (short) delay full power is achieved by placing the switch in the operate position. This can be further modified by including one more intermediate voltage switch position.

For 120-volt operation, a single section switch can be used, as shown. Old TUs and Navy surplus are a good source of multi-position or rotary type switches. For 220-volt operation, both sides of the line should be switched for safety.

A simple semi-automatic version is shown in fig. 5B. Filament power goes on when the master switch is on. This enables a relay circuit, picked up when the transmitter is keyed. It applies power to the plate circuit and a series resistor holds this low until the capacitors charge up. This is controlled by another relay across the transformer primary, which activates when the charging current drops, shorting the series resistor. The first relay can be the antenna changeover relay.

This circuit is easily made automatic by activating the first relay from a time delay device, such as a fluorescent lamp starter. The relay removes power from the delay device when it activates. It should be separate from the antenna relay.

metering, antenna switching and ALC

Though simple metering is desirable, it must be remembered that good metering can help improve performance and extend tube life. Also, the FCC requires input power-level monitoring if it exceeds 900 watts (or 1800 watts PEP).

If automatic drive limiting is used and set at the 1800 watt level, safe, legal operation with simplified metering is possible. Figs. 6A and 6B show two possibilities, the first measuring cathode current only, the second measuring grid and plate current. An external output wattmeter should also be used.

A plate voltage indication is also useful, and can serve as an ON indicator. An inexpensive type uses a neon bulb, connected across the bottom capacitor of the filter bank. The indicator warns of unusual conditions, including shorted or open capacitors, and excessive drain. Note that two resistors are shown across each filter capacitor. One serves as a bleeder and voltage-equalizing resistor and is normally wired. The second is a composition resistor, of 1 watt rated dissipation. It is a safety device that ensures filter discharge in case the wirewound resistor opens up. Good design practice is to choose the bleeder resistors so that the sum of their drain plus the
**TVI Prevention**

Prevention of TVI is a design goal for any transmitter. Most of the basic steps can be handled fairly late in the design stage, but there are a few that must be initially considered. One of these is the nature and extent of needed output coax filtering. Lower circuit $Q$ increases the need for filtering. For example, with a $Q$ of 10, a two-section, lowpass filter will probably be sufficient though a three-section filter is better. For higher harmonic rejection, it's a good idea to install a form of suck-out trap. On a low-frequency transmitter, it can be placed across the plate circuit. However, the added capacitance is undesirable on the higher-frequency bands. For these, a trap at the point of attachment of the output coax to the pi-section loading capacitor is indicated. The trap can be a high-pass filter, with a small bank of load resistors to dissipate any harmonic energy present. A design using a 50-ohm load seems to work well. The cutoff frequency should be between the highest operating frequency and the TV i-f frequency of 45 MHz.

The filters will probably not be effective if the self-resonant frequencies of the grid and plate circuits occur at the same frequency and near any of the TV bands. Unfortunately, there is a version of Murphy's idling current of the tubes is about ten percent of the design peak current.

I prefer to use a multiple pole relay in the antenna change-over circuit, wired as shown in fig. 7A. This provides protection for a receiver-transmitter combination, or a separate receiver used with a transceiver. (A 6-10 dB pad can be connected in this separate circuit to reduce signal loss in the main path due to paralleling mismatch.) Separate contacts on the relay can be used for power control, or for control of external devices.

While the trick of loading the input circuit can eliminate the need for an automatic level control, it's still a good idea to provide this. For one thing, you may want to use a different transmitter than designed for, and the back-up protection is beneficial.

The simplest approach to ALC is to use an rf level measurement technique to develop a threshold voltage. An ALC circuit is shown in fig. 7B. Assuming the grid loading has been adjusted, the ALC threshold control is set to give a barely discernible deflection on a VTVM at maximum design output. It can then serve as a backup for improper load.

---

**Figure 6**. Metering circuits. At (A), a single meter is used to read total cathode current. At (B), two meters read plate and grid currents. At (C), a neon tube indicates plate voltage, and serves as a safety indicator.

**Figure 7**. (A). Antenna changeover relays provide a spare contact to feed an auxiliary receiver and ground it during transmit. (B). An ALC circuit provides an adjustable threshold voltage from the plate tank circuit.
law which applies here. Try to design the circuit components and layout to give high self-resonant and well-separated frequencies. The filter-drive grid circuit helps, but the plate load modification using series inductance can be a handicap, forcing a high $Q$ tank for TVI prevention. Measure the resonant frequencies as the construction progresses, and modify the design if necessary.

In addition, all the standard TVI prevention practices should be followed. Each lead should have an LC filter where it enters the shield enclosure. Internally, use shielded (high capacity) leads. Dial shaft holes should be small, and a metal shaft should have a ground spring contact on the inside of the cabinet. It should have this for safety anyway if high voltage is near it. Meters should be metal-cased, with filters at the terminals, or have a piece of screen wire across the face, with the entire meter case inside the formed shield.

Internally, watch the ground current paths. Keep joints out of the path, and don't forget to provide a path for the rf flowing through the tuning capacitor to get back to the tube cathode. If the tube is to be recessed below a chassis, make the mounting holes sufficiently large.

Parasitics, another cause of TVI, are reduced or eliminated by placing suppressors in the plate circuit. Neutralization may be called for in grounded-grid design, and certainly in grounded-cathode circuits. The use of loading to absorb excess driving power greatly reduces the problem, however, and may be a sufficient measure in itself. It might eliminate the need for neutralization. This is easily added by a small tertiary winding on the filament choke, grounded at one end and coupled to the plate from the other end through a variable neutralizing capacitor.

**mechanical construction**

Kilowatt amplifiers, especially single package types, are large. Don't try to shoehorn everything in. Try to leave at least two-inch clearance for all rf components. The power supply isn't critical, but don't
forget cooling. This is vital for the tubes. Cool tubes are less likely to fail prematurely.

Symmetry in the tube area of a multiple tube design is recommended. Keep lead lengths the same. These techniques help equalize the load distribution. Elsewhere, symmetry is not necessary. Don't force the layout to give a symmetrical front panel.

For homebrew construction, a dual-chassis layout seems to work well. A horizontal section contains the tubes and rf components, and a vertical section the power supply. Input and control elements are under the horizontal section. Front and rear panels, plus a U-shaped top and end and a flat bottom part, complete the mechanical elements. Use angles along the top and sides of the panels.

Perforated aluminum is fine for the top, ends, and bottom of this design, but a lot of screws will be necessary to make the joints rf-tight. A better way of fastening is to use 1/8-inch aluminum strap along all edges, clamping the thin perforated metal between this and angle sections, with screws every six inches or so. Front panel appearance is improved if the strap projects a 1/4-inch (6.4 mm) over the shield edge.

A compact linear layout is possible if the power supply is built separately. The two-chassis design works well with the tubes mounted horizontally. Four 811s or even 872s can be placed in a cabinet measuring 5-1/2 x 10 x 12 inches (140 x 254 x 305 mm). Rf components will be a little crowded, though, and a good cooling fan is a must.

Home-built designs don't need to be sloppy in appearance. Be careful to avoid dents and scratches, and paint the completed unit, either to match other gear or to contrast with it. (Don't paint mating-shield surfaces.) Use appropriate size stick-on or transfer lettering to label controls and the unit itself.

A special note: use honest-to-goodness dials, with engraved marks or a digital readout that can be preset to one degree or better. Keep a log of readings for each band. If manufacturers were more careful with their dial designs, we would have far less tune-up QRM on the bands.

**putting it all together**

Fig. 8 is the schematic of the linear used at W4MB for several years. These basic design goals were considered:

1. Legal limit with good linearity
2. Drive from two 6146s
3. 10-40 meter operation, with new band operation considered
4. Separate antenna tuning
5. Separate lowpass filter

fig. 9. General view of the amplifier of fig. 8. Note the T-type bar knobs, and the vernier dials with calibrated scales for tune and load (makes band changing easier). Note the screen-wire shield over the meter.

fig. 10. Top view of the amplifier. The rf section is at the top, the plate supply on right, and the filament transformer at the lower left. The harmonic trap is just above the filament transformer. The tank coil is constructed from a continuous length of heavy wire. The ALC circuit is at the bottom center.

fig. 11. Bottom view of the amplifier. The copper plate in the center grounds all grids to chassis using metal standoffs. The grid filter and loading resistors are at the upper right. The coil is adjusted by spreading or squeezing turns to set the cut-off frequency above the 10-meter band.
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Fig. 12. Linear performance of the W4MB-W4LDY three (tube) 813 amplifier is shown. Actual flat-topping starts at about 1250 mA of plate current, well above the legal limit. This illustrates how an extended linearity design is an important factor in providing a clean signal.

6. Use tubes and components on hand
7. Simple switching

Fig. 9 provides an overall view of the transmitter, fig. 10 the inside top view, and fig. 11 the bottom view. Note the use of a copper plate to connect the various drive grounds together, and the arrangement for making filament lengths the same. Plate leads are also the same length. The layout lead length brings the effective Q of the tank circuit to about 10.5 on 10 meters.

A graph of amplifier linearity is shown in fig. 12. More output is possible, but the combination of input loading and ALC limits the maximum input to 1800 watts PEP (note that this is above the legal limit if appreciable speech processing is used).

As seen in the photographs, there are no parasitic suppressors in the plate circuit in this design. No instability was noticed during testing. There have been one or two reports of a wide signal, so possibly some instability can arise as a result of load variation or mis-tuning. All solicited critical signal checks have agreed with the data and with unsolicited reports. This amplifier, as intended, produces a clean signal, and, because of its simplicity, is also a pleasure to operate.
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<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<td>PLF-2E</td>
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<td>$79.95</td>
</tr>
<tr>
<td>PT-2E</td>
<td>$84.95</td>
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December 1982
an improved TouchTone* decoder

ITT's device provides simple, reliable crystal-controlled decoding of DTMF signals

Several years ago, ITT (International Telephone and Telegraph) introduced a single integrated circuit capable of decoding TouchTone signals. Using this device, we can construct a decoder system suitable for use in remote control applications with a microprocessor.

Nearly all remote control of Amateur Radio equipment, be it of a repeater, an autopatch, or a remotely controlled station, is at least in part accomplished by the use of TouchTones, also known as DTMF (Dual-Tone, Multiple-Frequency) signals. Since most modern Amateur VHF and UHF equipment now on the market is available with DTMF-encoded keyboards that provide either twelve or sixteen combinations, the transmitter end of a control link is readily available.

At the receiving end, some means must be provided to detect and decode the incoming DTMF signals (as the name implies, each signal consists of a pair of tones transmitted simultaneously). In the case of a twelve-key pad, one of a set of three tones is combined with one of a set of four tones, to provide twelve different codes. For a sixteen-key encoder, eight tones total are needed, as shown in fig. 1. The decoder must detect these tones and provide some indication that a valid DTMF code has been received; at the same time, the decoder must not be spoofed by the randomly occurring tones in speech sent over the same channel.

prior technology

In the past, Amateurs have often used decoder circuits consisting of a detector tuned for each of the seven or eight tones. The detectors are usually either resonant reed filters, or more recently, monolithic tone-decoder PLL (phase-locked loop) integrated circuits, usually type 567.

My own experience is with this type of decoder system. Typically, they consist of seven 567 ICs, one for each frequency, a demultiplexer circuit to convert the two-of-seven output to a more useful code, such as one-of-ten, or binary. Such decoders work, but they can be a bit tedious to align initially, as each PLL must be individually adjusted. Furthermore, since the accuracy of each PLL detector depends on its RC network, they can drift with temperature changes or with time as the frequency-determining components age. These problems are usually depressingly familiar to anyone who has tried to keep a repeater autopatch decoder operating for any length of time.

an integrated decoder

In the last few years, the telecommunications industry, fueled by tremendous growth in the commercial markets, has begun to integrate many previously discrete components into more compact monolithic circuitry, in order to reduce the size and cost of communications equipment. Examples of this process are seen in ICs that replace the hybrid transformer in telephones, in the replacement of bulky analog filters by monolithic active filters and, recently, with the development of integrated DTMF decoder circuits.

One such DTMF decoder IC is ITT’s 3201, which can decode all sixteen standard TouchTone signals to provide a four-bit binary output (see table 1). It uses an inexpensive 3.57945 MHz TV colorburst crystal as the frequency reference, so that temperature and age drifts are practically eliminated. In addition, it has excellent immunity to false outputs caused by

*TouchTone is a trademark of the Bell Telephone Company.

By Jerry Hinshaw, N6JH, 4558 Margery Drive, Fremont, California 94538

24 / December 1982
Microprocessor Controlled

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ROW 1
697 Hz  1      2      3      A

ROW 2
770 Hz  4      5      6      B

ROW 3
852 Hz  7      8      9      C

ROW 4
941 Hz  *      0      #      D

Fig. 1. Sixteen-key TouchTone pad shows how each key is assigned a discrete pair of tones.

Table 1. Code list of the output of ITT's 3201 DTMF decoder IC.

<table>
<thead>
<tr>
<th>input TouchTone code</th>
<th>binary</th>
<th>outputs</th>
<th>decimal equivalent</th>
</tr>
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<tr>
<td>1</td>
<td>0001</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
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<td>4</td>
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<td>5</td>
</tr>
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<td></td>
<td>6</td>
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<td>7</td>
<td>0111</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td></td>
<td>8</td>
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<td>10</td>
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<td>*</td>
<td>1011</td>
<td></td>
<td>11</td>
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<td>#</td>
<td>1100</td>
<td></td>
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<td>A</td>
<td>1101</td>
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<td>B</td>
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<td></td>
<td>14</td>
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<tr>
<td>C</td>
<td>1111</td>
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<td>15</td>
</tr>
<tr>
<td>D</td>
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Speech or noise on its input. In this single IC are all the functions that my old 567-type decoder board failed to duplicate fully with ten ICs.

Fig. 2 shows that the 3201 is a CMOS LSIIC (large-scale integrated circuit) housed in a 22-pin DIP. It requires only a single power supply, and draws little current. No front-end filtering is required, nor does the input have to be split into high and low bands, as some other DTMF ICs require. Audio from the receiver is fed directly to the 3201, and is automatically decoded.

The only catch, if there is one, is that the price is still higher than for the 567-type decoder. At the time of writing, the single-piece price for the 3201 is about $43.00, but that price should fall as the production quantity increases. In fact, the price has already fallen quite dramatically since the introductory price of $35.00. (The trend in semiconductors is that they are expensive when introduced, and the price then steadily falls as the volume of use rises; this IC should not be an exception to that industry-wide rule).

My own feeling is that the cost of the device, if a bit high, is more than compensated for by the utter simplicity of its construction and adjustment, and by the long-term benefits of stable, crystal-controlled operation.
circuit description

In fig. 3, audio from the receiving system is fed to the high-impedance analog input of the 3201. If the input signal is a valid DTMF tone pair, the 3201 produces an output on the four data lines. During the time a tone is being received and decoded, the DV (Data Valid) output goes to the logic-high state.

The DV line serves as a signal that the four data outputs contain valid data; while DV is high, the data are good, and so the transition of DV from low to high can be used to latch the output of the decoder. The data latch (U3 in the diagram) is needed so that fleeting input signals (which may be as short as 40 milliseconds in length) can be held and read at a later time.

The output of the 3201 is CMOS level, and is not directly compatible with the usual TTL interface circuitry used in most microcomputers. This incompatibility is corrected by U2, the 74C902, a CMOS-to-TTL level converter.

Thus, when a valid DTMF signal is fed to the input of the 3201, properly-decoded output signals appear at the output lines of U2, and the DV output goes high. This transition of DV from low to high is used to clock U3, the 74LS374 octal data latch, which holds the decoded equivalent of the last DTMF signal received.

In order for a microcomputer system to tell the difference between a newly received DTMF input and a previously stored word, a handshake circuit has been included. This handshake is set by the DV line, and is reset after the word has been read by the computer. In other words: the output of the handshake latch goes high when the 3201 puts a new word into the data storage latch, and is reset again when the computer reads the output of the data latch. Therefore, if the computer is programmed to first look at the handshake output, it can determine if a new word is waiting to be read.

Since any computer that monitors the decoder can scan the output lines much faster than an operator’s finger can press a button on the DTMF encoder keyboard, it is also a good idea to have the computer watch the DV line so it can tell a long input tone, which it has already read, from a newly received tone. The DV line, used in this way, is a form of key debouncing and prevents reading one tone as a series of several digits.

construction and testing

Layout and construction of this circuitry is non-critical. The few discrete components, such as the crystal and the bypass capacitors, can be soldered to the IC socket pins, and the rest of the wiring com-
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 precooded with wire-wrap interconnections. (I built my decoder on a small prototype board with an edge connector to which the input and output were wired.)

Once the wiring is completed, and the supply voltages have been checked at the socket pins, the ICs can be installed. Keep in mind that the high-impedance input of the 3201, which is a CMOS device, is sensitive to damage by static electric charges. It is a good idea to keep the 3201 in the protective packaging it comes in until it is to be installed, and then equalize the potential of the circuit and the protective package by touching them together. Remove the 3201 and install it in its socket. Once the IC is installed, the danger of static charge damage is reduced.

There are no adjustable components (this is my kind of circuit!) so the unit should work when power is turned on and a DTMF signal is applied to the analog input. The circuit shown in fig. 4 is a simple test set that uses a standard TouchTone telephone to determine if the decoder is properly decoding the DTMF signals. The telephone is disconnected from the phone lines, and hooked as shown to the network, which provides power for the phone's internal tone generator and matches the normal line impedance of 600 ohms.

If the decoder fails to work, check the wiring first. The DV line at the 3201s pin 18 should rise to nearly +12 volts when a DTMF signal is applied; if it does, the problems are probably elsewhere than in the 3201's circuitry.

summary

This decoder is a simple, modern alternative to the DTMF decoders of the past. It provides dependable performance, and should make remote-control systems easier to set up. Except for the 3201, all the components are standard types and widely available. The 3201 can be obtained from the manufacturer at this address: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, Florida 33441; telephone 305-421-8450.

ham radio

fig. 4. Simple test set uses a TouchTone telephone and a matching network to provide DTMF signals.
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a rotary dial and encoder for digital tuning

A digital controller using multiple dials and microprocessor logic

The shift to digital and microprocessor control of ham gear makes rotary dial encoding more popular. Earnshaw's approach to dial encoding, simplified and improved by Opal, offers a practical method for the Amateur builder.1,2 Both require discrete components for each dial.

This article describes another method incorporating multiple dials using microprocessor logic.3 This method reduces the number of components necessary and is suitable for digital controllers having concurrent tasks.

why encode the rotary dial

Switches are inherently digital; they are either on or off. Conventional tuning dials have an infinite number of positions. A digital tuning dial is not infinite; you must select the position closest to a desired setting.

Most 2-meter fm gear uses some form of discrete, digital frequency selection. This is difficult to use on lower bands without channelized frequencies: that rare DXCC contact may be between positions and will never be reached.

If you have a digitally-controlled master oscillator, one tuning solution is to use a potentiometer (pot) with an analog-to-digital converter. This has limits: an inexpensive pot has less than a full turn and an expensive, ten-turn pot can't be spun continuously (nor does it have the range) of conventional tuners.

A better way is to use the continuous, segmented digital rotary dial and an encoder to determine direction and amount of rotation. Each dial position, or state, is used to drive a counter. The counter provides an input to the controlled function. Encoding may be accomplished through discrete circuitry or through a microprocessor program. The position resolution is limited only by the dimensions and construction quality of your encoding design. I resolve two hundred positions per revolution easily. Opal resolved four hundred, with a larger encoder disk and better construction.

the technique

Earlier rotary dial methods provided continuous updating of dial position, or state-change. This system polls four dials in sequence, to determine if any dial status has changed from the previous poll.

I selected a four-dial input because a station can require several. Four uses might be main tuning, bandspread, filter frequency setting and keyer or keyboard speed control. Four inputs also work well with an 8-bit microprocessor.

the basic dial

Fig. 1 shows the progression of logic states from a pair of optical interrupters scanning the marks on a disk. For any given state, movement of the dial disk

By C.A. Eubanks, N3CA, P.O. Box 127, Valencia, Pennsylvania 16059
will yield a new state that defines direction of rotation.

Table 1 summarizes all possible state-change combinations, original state to new state. Valid rotation is implied if only one of the optical interrupter inputs changes. Invalid rotation sensing occurs if both interrupters see a change; this change must be ignored. Invalid sensing could occur if the polling speed is too slow, or sensing could indicate the wrong direction if an even number of state changes were missed.

The microprocessor system used in dial sensing performs other tasks as well. Polling speed is subject to trade-offs. To test the speed, I tentatively selected Opal's fifty-mark encoder disk. Some experimentation with a conventional transceiver proved that the dial spins easily at one revolution per second. This became the design rotation-rate goal. Assuming the rotation algorithm senses all state changes: (1 rev./Sec) × (50 marks/rev.) × (4 states/mark) = 200 states/Sec. All else being equal, polling rate must occur once every five milliseconds.

Everything else is not equal, however. First, the dial spin rate is not constant. Sudden starts and stops create faster state changes. Second, interrupters are not ideally spaced; some state changes occur at a lesser angular displacement and the state-change rate can increase.

With these factors in mind, I finally selected a two millisecond polling rate. The encoder still loses a few counts on rapid dial movement, but I've noticed no erroneous counts.

**Table 1.** Matrix diagram (Karnaugh Map) of all possible logic states of one dial's optical interrupter detector. A₀ and B₀ are the previous A and B interrupter states while A₁ and B₁ are the current states. L indicates left motion in fig. 1, R is right motion. N/C is no change; dial has not moved. N/A is a not-applicable condition resulting from non-allowed state-change progression of motion in either direction. The logical expression is used by the process subroutine shown in fig. 4.

<table>
<thead>
<tr>
<th>A₁A₀</th>
<th>00</th>
<th>01</th>
<th>11</th>
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L =  \overline{A}_1\overline{A}_0B_0 + \overline{A}_1A_0B_1B_0 + \overline{A}_1\overline{A}_0B_1B_0 + A_1A_0B_1B_0

R =  \overline{A}_1A_0B_1B_0 + A_1A_0B_1B_0 + \overline{A}_1A_0B_1B_0 + A_1A_0B_1B_0

Fig. 2 is a schematic for one application card of the Intelligent Controller.³ The darlington output of each optical interrupter is buffered by 7414 hex schmitt inverters. This buffer provides hysteresis to prevent jitter.

![fig. 1. Encoder optical interrupter detectors relative to encoder disk and resulting logic states. Logic 1 is a mark seen by the detector, logic 0 a space.](image-url)

The application card and one rotary dial assembly. Optical interrupters are visible at the disk bottom, just above the bracket for the ribbon cable DIP socket. The large chip on the card is the 8255 PPI with hex inverters at top center. Other card components are for another application not described here. The clamp is for photographic support of the dial assembly.
An Intel 8255 Programmable Peripheral Interface (PPI) is the link between the inverters and the Intelligent Controller's HAM BUS. The 8255 was chosen because it is compatible with other system components, readily available, and one of the least expensive input/output (I/O) devices available.

The PPI is shown with connections to port B. Each 8255 has three ports, and the remaining two ports may be used for other functions in the Intelligent Controller.

motion algorithm

This algorithm was developed for a 6502 microprocessor but is of general nature and should work equally well on other microprocessor systems. General flow for motion sensing is shown in fig. 3, and is executed once every two milliseconds. Any state change detected due to dial motion will call the process subroutine detailed in fig. 4.

Twelve bytes of storage are required by both routines. Three are temporary, for scratch-pad storage, labelled TEMP1, TEMP2, and TEMP3 on the charts. OLDIAL holds the status of all four dials from the previous poll. Four bytes are the old dial logic (ODL) registers, one for each dial. The remaining four are direction registers (one for each dial), to indicate dial position.

Direction registers may be used in a service routine to remember dial motion. In my application they indicate positive ($01 to $7F) on the increments and negative ($80 to $FF) on decrements.

The microprocessor program allows other tasks to be executed between dial readings. Details on the flow charts and program operation are found in the appendix.

construction

As a disclaimer, I am more impressed with K3CU's mechanical construction than my own. For breadboarding purposes, I used parts taken from a ten-turn pot for its shaft and bushing. The dial and optical interrupters were mounted on a small piece of unetched PC board stock. It is very desirable to
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mount the interrupters with the shaft bushing for proper optical adjustment.

The dial subassembly holds a 16-pin DIP socket for interconnection to the application card. Flat-cable DIP plug cables are readily obtained. (Mine was an 18-inch (46 cm) cable from Radio Shack, part number 276-1976.)

I made the encoder disk in two steps: first I made a photocopy from the optical mask in fig. 1 of Opal's article, then transferred it to a thermal-contact transparency. This gives satisfactory results, but you can purchase finished disks directly from K3CU.*

Opal suggested cementing the disk to a large knob for support. I soldered a circular piece of PCB stock to the shaft and attached the disk with rubber cement. My technique takes less space, while Opal's is easier.

The exact location of the optical interrupters is not critical. The illuminator center should be near the mark mid-radius. Once assembled, the relative interrupter positions can be set by bending the leads. Two cautions: keep the interrupter leads long enough and be careful not to pull off the PC board foil.

The dial shaft should have some friction device to prevent drift or coasting. I included a short piece of helical compression spring between bushing and encoder disk. This takes up any axial play and provides the necessary friction.

The inverters and PPI were mounted on a Radio Shack prototype board (part number 276-157). This is compatible with the intelligent controller. The extra chips seen in the photo are to support a Morse keyboard. The two spare 8-bit ports of the PPI may be used for other purposes.

**operation**

I had some initial problems providing sufficient signal for inverter inputs. I believe the interrupter collector resistor values given in fig. 1 to be adequate for variations in both the interrupters and inverters. To make certain, the inverter and interrupter outputs can be checked with a high-impedance voltmeter. Inverter output should be low when interrupter output is high, and vice versa.

I wrote a simple program to drive a display for 256 counts to test the device. Depending on the spacing between interrupters, the count may go in either direction. The proper direction is obtained by repositioning the interrupters or modifying the service routine. I prefer the latter, having had some bad experiences with interrupter leads and foil peeling on the encoder subassembly.

Program documentation and burned 2716 EPROMs for the Intelligent Controller are available from the author. Please send a self-addressed, stamped envelope for information.

**acknowledgment**

The author wishes to express appreciation to Chet B. Opal, K3CU, for his comments and review of this article.

**references**


**appendix**

The flow chart details presented here will be useful if you are interested in converting to a microprocessor other than a 6502 or are not familiar with programming.

---

*Photo disks are available from K3CU for $1.00 each. Please send SASE to Chet B. Opal, K3CU, 5414 Old Branch Avenue, Temple Hills, Maryland 20748.*
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The dial routine in fig. 3 is invoked by a two-millisecond timer interrupt in the Intelligent Controller. This routine reads the status of all dials and compares that status with the previous status stored in the ODLIAL register. If there is no change, the routine returns from processor interrupt.

Change of dial input is indicated by one or more bits set to logic 1 after the exclusive-OR with ODLIAL. Each dial is then polled in a loop. The loop starts with dial status in the accumulator as follows:

A0 A1 A2 A3 B0 B1 B2 B3

The accumulator is first pushed onto the stack (temporarily saved), then masked by ANDing with a bit pattern of 00010001 ($11 in hexadecimal notation). The result, on the first loop pass, will have A2 in bit 4, B2 in bit 0, and all other bits zero. If all bits are zero, no change in that dial occurred; the accumulator is restored by pulling it from the stack, and the accumulator is shifted right once. The index register (loop counter) is decremented, tested, and program flow continues at the loop start.

The purpose of right-shifting the accumulator is to provide separation in the $11 AND for the next dial. The second loop pass will have A2 in bit 4, B2 in bit 0. Each loop pass will test individual dials in decreasing order.

Any non-zero result of the AND accumulator with $11 will jump to the process subroutine shown in fig. 4. Entry to this subroutine will have TEMP1 holding an individual dial status in bits 4 and 0. Another mask with $11 is assurance that the three accumulator left-shifts and ORs with TEMP1 will have an individual dial input arranged as:

A A A A B B B B

The accumulator is exclusive-ORed with a bit pattern of 10011100 or $9C. The result of the exclusive-OR will set up the accumulator for subsequent testing of motion direction. Logic representation in the accumulator is now:

A A A A B B B B

Bit patterns in the accumulator will be as follows for the four possible optical interrupter state combinations:

A B = 01100011 A B = 10011100

Only one pattern will exist for one dial, stored in TEMP2.

The next two instructions set the accumulator to hold a logic 1 in one of the higher four bits for one of the previous state combinations. This is done by left-shifting the accumulator four times, then ANDing with TEMP2. The next two instructions (four right-shifts and OR with TEMP2) will duplicate the higher four accumulator bits into the lower four. The accumulator is now set for motion determination and is stored in TEMPS. The accumulator and TEMP3 will have one of the following bit patterns dependent on dial status:

A B = 00100010 A B = 00010001

One of these bit patterns will be loaded into a dial’s ODL on subroutine exit.

The first motion decision occurs when the accumulator is shifted left once, then ANDed with the existing ODL (from a previous subroutine call). The result is ANDed again with 01111000 ($78) to strip any extraneous bits. If the second AND yields a non-zero accumulator, right motion was detected and the direction register for that dial is incremented.

The second motion decision is made by loading the accumulator with TEMP3, shifting the accumulator right once, then ANDing with the existing ODL. The second AND with $78 strips any extraneous bits. A non-zero result indicates left motion and the direction register is decremented. The final operation is updating the ODL with the current dial logic stored in TEMPS.

A key element in motion decision is the direction of accumulator shift prior to ANDing with the ODL register. This can be seen by examining the logic expressions in table 1, or the following state-change progression:

Right motion: AB → AB → AB → AB → AB → AB → AB → AB

Left motion: AB → AB → AB → AB → AB → AB → AB → AB

The current state combination must always be compared to the previous one.

Any out-of-sequence state combination will pass through the subroutine without effect on the direction register. Start-up may produce an arbitrary bit pattern in the ODL register byte and may cause an increment or decrement of the direction register; only one change occurs since subroutine exit will update ODL to the new dial logic. Set-up prior to motion decision ensures a minimum number of direction register glitches.

Each left-shift assumes a zero entering the least-significant bit. Each right-shift assumes a zero entering the most-significant bit. 6502 coding uses ASL and LSR instructions, respectively. TEMPS is the Y-register of the 6502 with the X-register used as an index for each ODL and direction register in RAM.

Calculated execution time of the four-dial program in the Intelligent Controller is 141 μs with no dial change, 355 μs with one dial change, and 436 μs with two dial changes. Clock period is one microsecond and there is adequate time between 2-millisecond interrupts to execute other tasks in the controller program.
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Tell 'em you saw it in HAM RADIO!
A 40-meter transmitter and receiver using semi-break-in keying is described in this article. It uses transistors in all the circuits except for the final tube, driver and T-R switch.

This article indicates problem areas and cures. Many hobbyists like myself build circuits acquired from handbooks and magazine articles and they don't always work. During construction things change. Perhaps the layout, perhaps a fine copper short on a PC board which can only be seen with a magnifying glass. I have spent hours searching for opens on parts which appeared to be soldered only to find no connection actually existed. I now scrape all component leads before I solder to ensure good electrical contact.

Access to parts represents another variable and the constructor must choose from his collection or from other sources. For example, I had silver-plated, nylon-covered wire available which I used for the VFO coil. It works quite well and provides stable VFO operation.

PC board construction

Printed circuit board construction takes practice and experience. I start by cutting the copper PC board with a hacksaw, holding the board in a vise between two pieces of angle iron. I smooth the edges and rub the surface of the copper with steel wool until it's bright. Black paper tape and drafting dots are used for circuit layout, and I keep a pencil sketch of the work. The dots and holes are center-punched. The board is placed in a cut-out milk container and ferric chloride solution is poured over it. Fresh etching solution is used each time since it weakens after several applications. A 75-watt lamp, placed over the container, hastens the etching process. I use steel tweezers to turn the board and pick it up because the solution can stain your fingers badly. Don't spill or drop any of it on the floor or sidewalk — it won't come off!

After the board is etched and washed the tape is removed and cleaned with paint thinner and the board is rubbed with steel wool again. Sometimes I put the board in a tinning solution if I have any on hand. If not, I hot solder-wipe the board. Holes are made with a number 60 drill and parts mounted and soldered one at a time with the board secured in a vise. Always check the board after you are done wiring. Run a scribe between the segments and look at the board with a magnifying glass. This sounds like a small point but can prevent problems such as shorts and open circuits.

Making boards by hand may seem to be time-consuming, but you will find it is fun and a good way to build. More elaborate methods include making negatives of the artwork and exposing photo-sensitized copper plates. However, that is a more expensive technique.

Occasionally, breadboarded circuits do not perform when printed on copper boards. Once again poor layout should be suspected. Above all, don't try to build an entire circuit and expect it to completely work initially. Build and test one section at a time.

Power supply

A good place to start is by building a power supply. I built two receivers with an inexpensive 18-volt rms transformer using an LM 340-T regulator IC. The first two units worked. However, after constructing the third unit all the LM 340-Ts self-destructed though neither a capacitive nor resistive load had yet been connected. Exchanging the T unit with an LM 340-k-12 apparently solved the problem. An added benefit of this change was a total elimination of audio motor-boating. (A better transformer had also been introduced).

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037
Some experimenters use batteries (12-volt storage or Ni-Cds) to independently power their circuits. It also helps pinpoint causes of hum, unwanted oscillations and audio motor-boating. It's a good idea to run all the stages to a separate point, isolating each power lead with a 100-ohm resistor and five or more microfarad by-pass capacitors. This prevents inter-stage coupling.

**audio amplifier**

Now you have a working power supply, the next logical circuit to build is the audio stage. LM 380N chips work well and provide sufficient audio output. A 0.1 μF capacitor on the input pin prevents hum when the volume control is lowered.

A common practice is to use between two and ten microfarad capacitors for coupling audio stages. I found the audio stage would block with this large a value and reduced it to 0.02 μF. For CW low-frequency coupling is not necessary. The audio stages in this set are left on at all times to enable sidetone oscillator injection for CW monitoring.

**product detector**

A 40673 MOSFET is used as a detector and gain element. It eliminates the need for another i-f stage. Sufficient CW signal output is obtained from the mixer when a 1.5 V rms BFO level is injected. The 1k resistor and 0.05 microfarad capacitors form a filter that suppresses high frequency hiss (a mixer by-product), preventing its introduction into the audio stages.

**bfo**

A crystal BFO is simpler to build than a variable one. However, it is more difficult to make the 453.5 kHz crystal stage oscillate. After some research, the circuit in fig. 1. was tried. By placing an rf choke in the collector lead, and adjusting the capacitors from base to ground, the oscillator provided 10 volts rms output. I used a variable capacitor to experimentally determine the optimum values (200 pF from base to ground and 70 pF from collector to ground). The transistor oscillated only when the emitter was not grounded.
fig. 18. Schematic diagram for the 40-meter transmitter-receiver.
i-f stage and filter

I-f filters are expensive and hard to find. A CW and SSB filter can be constructed using two low-frequency crystals, one at 455 kHz and the other at 453.5 kHz. The J.W. Miller crystal-matching i-f transformers, types 1725 and 1726, complete the crystal filter assembly. The transformers can be mounted on a PC board and must be grounded. Care must be observed when tuning the i-f slugs. Do not screw the slug in too far or it will damage the internal wiring. Peaking is accomplished by listening to off-air signals or by feeding in a 455 kHz signal.

The i-f stage transformers are small potted toroids which resonate at 455 kHz with a 100 pF capacitor. A J.W. Miller 330 microHenry unit also works. A paral-
fig. 1D. Schematic diagram for the 40-meter transmitter-receiver.
Parts List

coils  J.W. Miller Co., 19070 Reyes Ave., Compton, California 90224.

semi-conductors  Semiconductors from Circuit Specialists, Box 3047, Scottsdale, Arizona 85267 or telephone 1-800-528-1417.

Some semi-conductors can be found at Integrated Circuits Unlimited, 7889 Clairemont Mesa Blvd., San Diego, California 92111.

printed circuit tape  Drafting tape for printed circuits. Mesa Design Reprographics, 4925 Convoy St., San Diego, California 92111, telephone 714-565-4724.

dots  Dots are called donut pad D144 for .150 od x .031 inch (3.81 mm x 0.79 mm).

tape  I use Bishop precision slit tape #201-250-11 which is .250 inch wide (6.35 mm). Tape 201-125-11, .125 inch (3.18 mm).

Also some .062 inch wide tape is useful. The tape comes in all widths, from Bishop Graphics, Westlake Village, California 91359.

toroids  Amidon Associates, 12033 Otsego St., North Hollywood, California 91607.

i-f coils  Radio Shack sometimes has an assortment bag of coils. Check here for i-f coils. Those used in this set were potted in ceramic, red color and have two leads projecting out. No number for stock.

etching  Try WA3OJF, PO Box 398, New Cumberland, Pennsylvania 17070. You can get mixed solution at your local chemical supply house.

leled 18k resistor reduces the Q and chance of oscillation. The FET's source by-pass capacitor was left off to reduce the possibility of self-oscillation in the i-f stage.

rf and mixer stage

The rf and mixer stage is keyed by the relay for semi-break-in. Amidon (red) toroids are satisfactory for the coils as long as they resonate on 40 meters. Slug-tuned coils can be used as well. However, it is easier to tap down on toroid windings. The idea here is to sharpen the tuning without loading the circuit too heavily.

1N914 diodes inserted back-to-back on the antenna link coil reduce the rf if it exceeds 1 volt. The T-R switch reduces the transmitter leak-through rf level to about 2 volts.

vfo

A Colpitts' configuration is preferred for the receiver VFO. The 500 pF coupling and two fixed 530 pF capacitors are appropriate values needed for oscillation. The tuning capacitor, affected by these capacitors, requires careful matching for specific range coverage. The MFP-102 transistor stage provides 1.4 volts, enough to drive the buffer and emitter follower. This circuit eliminates frequency pulling by reducing mixer influence. The base voltage on the buffer is adjusted to read between 3 to 4 Vdc. This is accomplished by carefully selecting the 12k and 10k resistors. The 1.5 volts from the crystal filter provide one of the mixer inputs. Its injected level determines the mixer output.

transmitter

The transmitter VFO was designed for 80-meter operation to prevent 40-meter rf interference. The VFO is actuated when the relay closes. Better performance is achieved using this technique rather than keying the VFO directly. Drive is increased by placing an rf choke in the collector lead and taking the output from the collector rather than from the emitter. The emitter by-passing increases the rf drive to the 6AU6 doubler on 40 meters. The 6AU6 provides enough drive to the 2E26 with 300 volts on the plate. When lightly-loaded, the 2E26 plate has a pronounced tuning dip if sufficient drive is applied. The 6AU6 and 2E26 output stages are keyed and isolated by 1N4007 diodes. The keyed semi-break-in and sidetone circuits are also isolated from each other by diodes. A keying network, introduced by VU2JN, produces a clickless signal.

relay circuit

When the key is closed a positive pulse is transmitted to the 2N2219A base. The two 1N914 diodes ensure 2219A cutoff when the key is released. The diode across the relay eliminates any hang-up problems. The relay hold-in time is determined by the delay potentiometer and the 50 μF capacitor. A positive voltage, from the sidetone keyer, applied to the base of the 2N2222 turns it on. The sidetone oscillator, which provides a clean, adjustable level, monitoring signal, is lightly-coupled to the LM 380N input.

ham radio
data bandwidths compared

Bandwidth requirements for four competitive data modulators

With increasingly crowded Amateur bands, will hams begin using more sophisticated digital-data modulation schemes in the future? FSK (frequency-shift keying) is the predominant modulation scheme used to transmit data in the Amateur service; but this may not always be the case, because there are several other possible schemes which are better than FSK in some ways. This article will compare the bandwidth requirements for four competitive methods of modulation data.

It is in our interest to use our limited spectrum space as efficiently as we can. I will be discussing FSK, CW, and two forms of PSK (phase-shift keying), that is, two-phase PSK, also called Binary PSK, or BPSK; and four-phase PSK, also called Quaternary PSK, or QPSK.

the fast-Fourier transform

In the discussion that follows, the signal spectra presented were generated by performing a spectrum analysis on a computer simulation of typical data modulated by each of the different schemes. This was done by creating a mathematical model of a data signal consisting of a sequence of 128 samples with 156 microsecond spacing and modulating it by each of the four methods. The results were then processed by a Fast-Fourier Transform computer program that produced a power spectra plot (showing energy content as a function of frequency) for each of the signals. I will not be discussing how this program operates, but only the results of this analysis.

The horizontal axis of each plot is frequency (in Hertz), and the vertical axis is the signal power for each frequency component in (dB relative to the strongest component). As a convenient reference, we will define the bandwidth of the signals as the band over which frequency components greater than −15 dB relative amplitude are present. This standard will allow bandwidth comparisons between the different modulation schemes.

frequency-shift keying

FSK is the most popular data mode today because it is comparatively simple to generate and demodulate. The output frequency of the transmitter is shifted between one of two different frequencies (mark or space) depending upon the data bit being sent (0 or 1). The demodulator can be two simple filters, one for each of the frequencies, and rectifiers and a slicer to determine which frequency channel has the most energy at any time.

An FSK signal using 1200 Hz and 1600 Hz was modelled for this analysis, and a data rate of 400 BPS (bits per second) was used. (This is about the maxi-

By J.T. Dijak, W9JD, 215 Tareyton Drive, Ithaca, New York 14850
We could also send data using a CW signal where

**CW**

the others.

thin, and we will use it as a reference in discussing

the signal of 900 Hertz bandwidth. This is our first spec.

Fig 6. Analysis of CW signal: the 400 Hertz data rate requires
of the FSK method.

only 160 Hertz bandwidth, but twice as many bits per second than that

Fig 7. Analysis of frequency-shift keying signal: the data rate

moderate error protection.

of 400 BPS requires a bandwidth of 900 Hertz, and provides
the presence of the signal could indicate a mark, and the absence, a space. This signal is also very simple to generate, and simple to demodulate. The error rate versus signal-to-noise ratio is not as good as that for an FSK signal, however. This is because it is easier to tell a mark from a space when we are considering two different frequencies than when we must determine the presence or absence of one signal in a noisy channel.

For this analysis, a CW signal at a 400 BPS data rate using 1600 Hz as the center frequency was used. The same data pattern used with the FSK signal was used with this signal.

Fig. 2 shows the spectrum plot for the CW signal. We can see that (considering only -15 dB components or greater) the signal bandwidth (500 Hz) is narrower than for the FSK signal. We can also see that there are now other components farther out from the carrier. We can expect a small amount of signal distortion in the demodulator if we use filtering to limit our bandwidth to something on the order of what was required for FSK.

It is reasonable to expect the CW data signal to show higher harmonic spectral components than the FSK signal. The FSK waveform had smooth transitions between mark and space bits. The only difference between the two signals was a difference in frequency, and the transitions were made at a zero-crossing of the signal. Therefore, there were no abrupt changes in the FSK waveform. The CW signal, on the other hand, imposes very abrupt changes in the signal when it goes from mark to space — from no signal present, to full signal present. We know that higher harmonic terms are required in a signal spectrum to accomplish any abrupt transition like this in the waveform.

**BPSK**

Binary PSK sends a continuous carrier at one frequency, but the phase of the signal is shifted 180 degrees for a space bit. This signal, while requiring more complicated modulators and demodulators than either FSK or CW, provides an error rate superior to either other mode for a given signal-to-noise ratio.

Fig. 3 shows the spectrum plot for the 400 BPS BPSK signal. The same data pattern used in the previous examples was again used. We can see that the BPSK signal is wider than either the CW or FSK signals. This is not a surprise, since we know the BPSK waveform has very abrupt transitions at the bit boundaries where the phase of the carrier signal goes from +180 degrees to 0 degrees. In order to reproduce these abrupt transitions, the signal requires the higher harmonic spectral components that we see.

From this we can say that an unfiltered BPSK signal will require a wider signal bandwidth than CW or FSK for the same data rate; however, due to the superior synchronous detection process used (and required) with PSK, we can discard many of the
higher harmonic spectral components (by filtering). This blurs the transitions between bits, but does not seriously disturb the most important signal information for each bit. We could use a filter at the transmit-
battery charge sensor

A small sensor that warns you before your Ni-Cds discharge

Many a nickel-cadmium cell has been destroyed by depletion of its charge below the protective voltage level. As many Amateurs know, when a Ni-Cd cell is discharged to near zero voltage there is a good possibility the cell may take on a reverse charge. The reason for this is the small differences in capacitance between cells; the cell reaching full discharge first is reversed charged. This condition can be prevented if the protective voltage level is detected and the cell is recharged.

My slightly vintage crystal 2-meter rig (a Kenwood TR2200A) uses ten Ni-Cd AA cells arranged in a four- and six-pack as its power source. The rig does have provision for monitoring the voltage level of the battery pack using the combination RF/S/battery-meter. This is fine if you operate in enough light to read the meter, which is, even under best conditions, somewhat inconvenient and difficult to read. But suppose you have no light — such as on your patio in the evening or in the forest on a camping trip. The battery meter is not of much use under these conditions.

My solution to this problem is a sensor circuit designed to continuously monitor the battery voltage and detect the approaching protective voltage level. When this level is reached, the sensor activates an alarm, which in my rig flashes the built-in channel pilot lamp at a 1-Hz rate. I chose to set this voltage level to 11 Vdc, which allows some additional time after the alarm to end a QSO. The lamp will automatically stop flashing when, during charge, 11 Vdc is exceeded. The sensor circuit and lamp are powered in such a way that the main ON/OFF power switch will turn off everything.

By F.T. Marcellino, W3BYM, 13806 Parkland Drive, Rockville, Maryland 20853
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Because my 2-meter rig is a Kenwood TR2200A, placement of the sensor was not difficult. In the battery compartment, the manufacturer had installed a rectangular box to take up space next to the four-cell pack. The box is removable by taking out two Phillips-head screws. The inside measurements of the box are $1 \times 1-3/4 \times 5/8$ inches, which lends itself to housing a miniature circuit board. Fig. 1 shows the removable portion of the box and how I mounted a hand-wired circuit board in place. Fig. 2 is the circuit board showing layout of parts.

**circuit description**

Assume the Ni-Cd battery pack has a charge between 11 Vdc and full charge. Under those conditions, the zener diode, CR3, will be biased into its forward breakdown region, developing a voltage at the junction of R1 and R2. If this voltage is above 0.65 Vdc, Q1 will be saturated with its collector pulled down essentially to ground. This condition prevents Q2 from conducting, and so the ground pin No. 1 of the 555 will be held high near the battery voltage. The 555 will not start oscillating until pin 1 is grounded. The output of the 555 is pin 3 and it is internally held at the battery voltage at this time. A PNP transistor, Q3, is used to control the alarm/channel lamp. The lamp will light every time Q3's base is grounded — or flash if the base is pulsed to ground.

As the battery pack depletes itself and the terminal voltage approaches 11 Vdc, CR3, a 9.2-Vdc zener, will stop conducting because it is biased above ground by CR1, CR2, and the emitter-base diode of Q1. Fig. 3 shows the sensor circuit, including the zener voltage drops for battery levels of 11 Vdc to full charge. To achieve the proper protective voltage level it is necessary for CR1, CR2, and Q1 to be silicon devices. Germanium components will not do because of their lower forward bias voltages, placing the level far too low. When Q1 stops conducting, Q2 will saturate and ground pin 1 of the 555. At this time the channel lamp will begin to flash at a 1-Hz rate.

The sensor circuit is composed of fourteen components plus the circuit board. With a typical ham's junkbox, the sensor can be produced for less than five dollars. The circuit requires three hard-wired connections to the rig: a power ground, a connection to the ground side of the channel lamp, and a controlled positive battery voltage.

Normal operation of the TR2200A's front panel lamp switch is not impaired by the sensor circuit. The channel lamp can be turned on at any time — even when the lamp is flashing. The standby current drawn by the sensor is 5 mA at a battery charging voltage of 13.6 Vdc and it tapers to 2.28 mA just prior to the lamp's flashing at 11 Vdc. These current levels are constant and do not change under transmit conditions. I consider this current drain a small price to pay for Ni-Cd reverse-polarity protection. In my rig the original standby drain was 45 mA, so an additional 5 mA amounts to slightly more than 10 percent.

One nice feature of this sensor is that it can be removed quite easily for resale purposes. The rig would regain its original unmodified status with no unwanted front panel holes. But once the purpose of the sensor has been explained to the buyer, he probably would gladly accept the rig with the modification included.

**ham radio**

**reference**

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December 1982
The fall antenna construction season is almost over and the winter months are close at hand. Not much time left this year for antenna experimentation!

Even so, here's some interesting and useful data on the inverted-V dipole antenna. This simple antenna is very popular. It has the forgiving characteristics of the dipole (easy to get into operation), it is inexpensive, a good radiator and it can be supported from a single center point.

This past summer some extensive tests were run on the inverted-V dipole by JA5COY (Japan) and were reported in a recent issue of *CQ-ham radio*, published in Tokyo. JA5COY made measurements summarized in fig. 1. The first tests were on an 80-meter dipole (fig. 1A). The antenna exhibited a feedpoint impedance very close to 73 ohms, as expected, and the bandwidth between the 2-to-1 SWR points was about 330 kHz.

He then dropped the ends of the dipole to form an included angle of 120 degrees (fig. 1B). The feedpoint impedance dropped from 73 ohms to 50 ohms and the bandwidth dropped to 310 kHz. In addition, the resonant frequency of the antenna dropped about 15 kHz.

The last experiment was to decrease the included angle to 90 degrees (fig. 1C). The feedpoint impedance dropped down to 30 ohms at resonance and the bandwidth further decreased to 210 kHz between the 2-to-1 SWR points of measurement. And, finally, the resonant frequency dropped about 35 kHz from that of the straight, horizontal dipole. Antenna height during these tests was not noted.

This is handy information, as it provides all that is needed for a pre-cut inverted-V dipole antenna. The summation is:

Dipole antenna:
- Length for resonant frequency
  \[ \frac{468}{f(MHz)} \text{ feet} \]
  (Feedpoint impedance approximately 73 ohms.)

Inverted-V dipole antenna:
- Included angle = 120 degrees
- Length for resonant frequency
  \[ \frac{465.6}{f(MHz)} \text{ feet} \]
  (Feedpoint impedance approximately 50 ohms.)

Inverted-V dipole antenna:
- Included angle = 90 degrees
- Length for resonant frequency
  \[ \frac{463.3}{f(MHz)} \text{ feet} \]
  (Feedpoint impedance approximately 30 ohms.)

As an example, suppose you want an inverted-V dipole for 80-meter phone operation to cover the range of 3750 to 4000 kHz. This is a span of 250 kHz. An antenna with an angle of 120 degrees included will do the job as it provides a bandwidth of about 310 kHz and — best of all — has a feedpoint impedance of about 50 ohms when mounted at a reasonable height above ground.

The mid-point of the chosen range is 3875 kHz, so the dipole is cut for this frequency:

Inverted-V dipole length = \[ \frac{465.6}{3.875} \]
= 120.15 feet, or 120 feet, 2 inches (round it off to 120 feet).

![fig. 1. Comparison of feedpoint impedance (R) and bandwidth (BW) for dipole (A) and the two versions of the inverted-V dipole (B and C).](image)
Thus, the dipole will be 60 feet on a leg, with an included angle of 120 degrees and should cover the complete 80-meter phone region with an SWR of less than 2-to-1.

The antenna can be zeroed-in for minimum SWR by raising or lowering the ends of the dipole. As in the case of any antenna, the presence of nearby metallic objects (power lines, TV antennas, etc.) may alter the performance and SWR a bit.

more about TVI and RFI

TVI and RFI seem to be a sore subject these days. More hams and more entertainment equipment is the prime factor, plus the fact that solid-state circuits, as used in home entertainment equipment, operate at a lower signal level than does the older, tube-style gear. Nevertheless, the Amateur operator should make sure his equipment is clean and a few simple preventive, anti-TV steps should be taken even if there is no TVI or RFI. Better to be safe than sorry!

Cleaning up the exciter: at the very least, an rf line filter should be used with the exciter to prevent rf from finding its way into the primary power line. A simple and effective line filter, such as the J.W. Miller C-508-L, or equivalent, will be satisfactory. In addition, the exciter should be grounded (more about this later).

Cleaning up the linear amplifier: an rf line filter should be used on the linear amplifier. J.W. Miller Co., and others, make suitable filters, or you can build your own. A practical filter is shown in fig. 2.

Your antenna system: you’ll require a lowpass filter between your transmitter and your antenna. It should go in the 50-ohm coaxial line after all such devices as SWR meters or coaxial switches. That is, there should be nothing between the filter and the antenna except the interconnection line. Several makes of lowpass filters are available; a good one is the Barker & Williamson 425, rated at 1 kW.² (The model 424 filter is rated at 100 watts — just the thing for your exciter.) Both these filters are designed for 50-ohm coaxial systems.

Your ground system: the station ground is important, especially from the FCC point of view. If you are ever visited by the FCC or a TVI committee, one of the first questions they will ask is, “Is the transmitting equipment grounded?”

To protect yourself in this instance, you’ll need a ground lead from the equipment to the nearest ground point: either a water pipe ground or an external ground rod driven into the soil.

From a legal point of view, this satisfies the requirement. But I don’t have to tell you that such a ground is worthless as an rf ground. Unfortunately, a good rf ground is hard to get, unless your station is at ground level and the ground wire from the equipment to the ground is only a foot or two long! In most cases, this is an impossible requirement.

In my case, I am on the ground floor of my home. I connected all equipment (receiver, exciter, amplifier) together with flexible No. 10 insulated copper wire. I did not depend upon the shields of the coaxial interconnecting wires to do the job. The next step was to drill a small hole in the floor behind the operating table and drive an eight-foot (2.5 m) ground rod down into the earth through this hole, until only an inch of the rod protruded into the room. Then ran a No. 10 flexible wire from the equipment to the ground rod.

This provided a satisfactory ground on all bands except 10 meters. I found that I still had some rf floating around the equipment on that band, even though everything was supposedly at ground potential. I didn’t want to drive another ground rod under the house (it was a terrible job), so I drove one into the ground at the point where my coaxial line came from under the house and passed across the yard to the antenna tower. I grounded the shield of the coaxial line to this ground rod and then, spurred on by over-enthusiasm, I drove a third ground rod at the base of the tower and tied the coaxial shield and the tower to this rod. In addition, I bypassed all the rotor control wires to the ground rod at the base of the tower.

That seemed to do the job. All equipment was rf-cold on all bands, I used a lowpass TVI filter for the transmitter and all power leads were filtered and bypassed. That should make my equipment TVI-proof. Did it?

---

![Diagram](image-url)
cleaning up the TV receiver

The answer to the question, of course, is no. While my transmitting equipment was reasonably clean, both my TV receiver and those of my neighbors were wide open to strong local signals in the ham bands. My receiver (a ten year old RCA XL-100) turned black in the face when I went on the air with the linear amplifier — on any band!

When I removed the back from the set, the reason was apparent: a rat’s nest of interconnecting wires running between printed circuit boards and no sign of any filtering or protective circuits. (The TV set was much worse, from a TVI point of view, than my previous one — an old tube model with very good internal shielding).

To clean up this receiver, it was necessary to use a line filter (J.W. Miller C-508-L), plus a good high-pass filter on the antenna ribbon line. One of the best filters is the J.W. Miller C-513-T3. This is a multiple section design enclosed in an aluminum box. It provides more low frequency attenuation than simpler filters.

The combination of the line filter and the high-pass antenna filter did the job. Now I could operate at full power on all bands below 30 MHz with no TVI. Eventually, I got Miller line and high-pass filters for my nearby neighbors and now I am clean on their TV receivers.

what about stereo equipment?

Ham signals can easily get into stereo gear and can cause a lot of problems. Again, the cause is simple. The equipment is mostly solid-state, operates at low signal levels and has no shielding or filtering against strong nearby radio transmissions! The stereo market is very competitive and everything that can be done to save a penny is done, and this includes omission of any RFI suppression circuits.

Filtering and bypassing interconnecting leads usually solves this vexing problem, but the subject is too complex to cover in this short article. A recommended publication tells the whole story and gives you plenty of good data on RFI problems in general.3

two new, good books for Radio Amateurs

It is always refreshing to find publications of interest to Radio Amateurs. Prentice-Hall publishers (Englewood Cliffs, New Jersey) are entering this field with two new books by Doug DeMaw, W1FB. Doug, as you know, is the Senior Technical Editor of QST magazine.

Doug’s first book is Ferromagnetic-Core Design & Application Handbook.4 This hardcover, 256-page book covers design and use of inductors using toroids, rods and pot cores for ferrite and powered-iron materials.

Ferromagnetic materials are common today in receiver and transmitter circuits, power supplies, and antenna baluns, but the use and theory of these interesting devices are shroud-
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The TR5 is designed with modular construction techniques for easy accessibility and service.

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- Load Impedance: 50 ohms
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- Intermodulation Distortion: Greater than 30 dB below PEP
- Carrier Suppression: Greater than 50 dB
- Undesired Sideband Suppression: Greater than 60 dB at 1 kHz
- Duty Cycle: Sub, CW 100%
- Lock Key (w/o FA7 Fan): 30%, 5 minutes maximum transmit.
- Lock Key (w/FA7 Fan): 100%
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Model 7024 SL6000 AM Filter
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Model 1545 RV75 Synthesized Remote VFO
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Model 1507 CW75 Keyer
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The new Radio Handbook

The twenty-second edition of the Radio Handbook (Howard W. Sams Co., publisher) has been on the market for a few months. I have edited this book since the fourteenth edition (1956). It is interesting to note the tremendous advance made in Amateur Radio in 26 years!

The new edition is primarily devoted to solid-state equipment, side-band and linear amplifiers — the latter hardly mentioned or known in 1956. And in addition, counters, phase-locked oscillators, fm, satellite communication, moonbounce, slow-scan TV, RTTY, color TV, spectrum transmission, keyboards, keyers, solid-state amplifiers, and low noise reception are covered in the twenty-second edition of the Radio Handbook.

Ham radio

I have monitored the 10-MHz band almost daily during the past year. Over 50 countries permit Amateur operation on this band and such good DXers as FB8WG and VK9YC operate regularly in the 10-MHz region. By the date this is in print, the band should be open to American Amateurs.

It is interesting to compare those who should be in this region against those who are actually there. Table 1 shows the official International Telecommunications list of stations registered for operation between 10.1 and 10.15 MHz. Careful monitoring of the band during the summer showed that most of these stations really weren't there, with the exception of NAA's powerful RTTY signal at 10.130 MHz. Most of the rest of the ITU-registered stations were conspicuous by their absence. In their place was a rag-tag group of intruders who have less legal reason for being there than do Radio Amateurs.

the 10-MHz Amateur band

<table>
<thead>
<tr>
<th>ROTATOR MODEL</th>
<th>MOUNTED INSIDE TOWER</th>
<th>WITH STANDARD LOWER MAST ADAPTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR22XL or AR40</td>
<td>3.0 sq. ft. (0.28 sq. m)</td>
<td>1.5 sq. ft. (0.14 sq. m)</td>
</tr>
<tr>
<td>CD451</td>
<td>8.5 sq. ft. (0.79 sq. m)</td>
<td>5.0 sq. ft. (0.46 sq. m)</td>
</tr>
<tr>
<td>HAM IV</td>
<td>15.0 sq. ft. (1.4 sq. m)</td>
<td>N/A</td>
</tr>
<tr>
<td>TX</td>
<td>20.0 sq. ft. (1.9 sq. m)</td>
<td>N/A</td>
</tr>
<tr>
<td>HDR300</td>
<td>25.0 sq. ft. (2.3 sq. m)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

For HF antennas with booms over 26’ (8 m) use HDR300 or our industrial R3501.

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<table>
<thead>
<tr>
<th>ANTENNA WIND-LOAD CAPACITY</th>
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<tbody>
<tr>
<td>ROTATOR MODEL</td>
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<td>TX</td>
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<tr>
<td>HDR300</td>
</tr>
</tbody>
</table>

For HF antennas with booms over 26’ (8 m) use HDR300 or our industrial R3501.

ed in mystery for most Amateurs. Doug’s book tells the whole story in simple words and terms and covers circuit design and application from A to Z. The information is invaluable and the book should be in every ham’s library. Of great help is the section covering available cores and rods. Now when some article specifies a core with a red dot on it, or Q-2 material, I’ll know what the author is talking about!

Doug’s second book is Practical RF Design Manual, a hardcover book of 246 pages. This is a gold mine of information for the experimenter who designs and builds his own equipment, or for the inquisitive Amateur who wants to know how his gear works. It covers the important circuitry used in today’s exciters, receivers and transceivers. It contains in-depth coverage that general-coverage handbooks can’t afford to include, mainly because of a restriction on the total number of pages in the publication.

The book has an impressive section on receiver dynamic range, and equally handy sections on frequency control systems, very useful to the home constructor. It also includes more data on small- and large-signal amplifiers than I have ever seen in one publication. Best of all, the book is written in language the average Amateur can understand.

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1. A copy of the J.W. Miller catalog can be obtained free by writing to: Bill Courtney, J.W. Miller Division, Bell Industries, Box 5825, Compton, California 90224.
2. A copy of the B&G catalog can be obtained free by writing Elmer Bush, Barker and Williamson, 10 Canal St., Bristol, Pennsylvania 19007.
3. RFI is no problem if you don’t have it, but many headaches if you do. Recommended reading on this subject is the Interference Handbook, by William Nelson, WA6FOG, former RFI investigator, Southern California Edison Company. This Ham Radio Bookstore has this Handbook, or it may be ordered from Radio Publications, Box 149, Milton, Connecticut 06867.
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More Details? CHECK—OFF Page 132

December 1982
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Add the Heathkit SA-1480 Remote Coax Switch. When changing bands, the proper antenna will be selected automatically.
Ten-Tec 645 ultramatic keyer mods

I run my station on battery 100 percent of the time, and am always looking for a way to trim a few milliamps of drain. I became concerned with the appetite of my Ten-Tec 645 Ultramatic Keyer the first time I put a meter in series and discovered a quiescent drain of over 300 mA. After opening the case and pulling the board, I burned my thumb on the two 68 ohm 2-watt resistors used to drop the 12 Vdc line.

I removed R17, R18, and D3, a 5.6 volt zener diode. In this same space I mounted an LM340 T-5 three-terminal regulator and a small heatsink. The regulator mounted easily after I drilled a single hole for the middle (ground) wire. I could then put the keyer back in its original shape without a lot of telltale holes in the board.

Because this regulator is some distance from the 12 volt supply, I used an external bypass capacitor of 0.22 µF on the input terminal of the regulator. Mount it as close as possible to the regulator. The 0.1 µF capacitor recommended for the output is provided by C9 already in place.

Next socket the ICs and substitute some 7400 LS chips for the original 7400s. I did this on a trial and error basis and found it worked for IC-1, IC-2, IC-3 but not IC-4 and IC-5. Thus, you need two 74LS00 (IC 1 and 2) and one 74LS10 (IC-3). A check showed 120 mA quiescent, almost a two-thirds reduction! Not enough to fool with if you are using commercial ac, but enough to make a difference for extended battery operation.

Adding an extra key jack in parallel with the output of the 645 keyer allows you to use a straight key. Mount the phono jack on the rear panel and bypass with a 0.01 µF capacitor.

The low speed range of the keyer can be expanded by changing the value of R1 from 4.7K to 8.2K. Unless you really need 50 WPM, it is much nicer to be able to accurately adjust in the 10-20 WPM range; the top end is still above 40 WPM.

A stereo (three conductor) jack can be added to the rear panel to allow the use of the 645 paddles to feed a memory keyer (such as the Autek MK-1). Use a shorting jack and the paddles return to the 645 when the plug is removed. This saves getting used to new paddles for contest work.

Gil Frey, Jr., K4JST
fig. 2. Wiring block diagram.
The ultimate team... the new Drake "Twins"

The TR7A and R7A offer performance and versatility for those who demand the ultimate!

TR7A Transceiver
- CONTINUOUS FREQUENCY COVERAGE — 1.5 to 30 MHz full receive coverage. The optional AUX7 provides 0 to 1.5 MHz receive plus transmit coverage of 1.8 to 30 MHz, for future Amateur bands, MARS, Embassy, Government or Commercial frequencies (proper authorization required).
- Full Passband Tuning (PBT) enhances use of high rejection 8-pole crystal filters.
Newl Both 2.3 kHz ssb and 500 Hz cw crystal filters, and 9 kHz a-m selectivity are standard, plus provisions for two additional filters. These 8-pole crystal filters in conjunction with careful mechanical/electrical design result in realizable ultimate rejection in excess of 100 dB.
Newl The very effective NB7 Noise Blanker is now standard.
Newl Built in lightning protection avoids damage to solid-state components from lightning induced transients.
Newl Mic audio available on rear panel to facilitate phone patch connection.
- State-of-the-art design combining solid-state PA, up-conversion, high-level double balanced 1st mixer and frequency synthesis provided a no tune-up, broadband, high dynamic range transceiver.

R7A Receiver
- CONTINUOUS NO COMPROMISE 0 to 30 MHz frequency coverage.
- Full passband tuning (PBT).
Newl NB7A Noise Blanker supplied as standard.
- State-of-the-Art features of the TR7A, plus added flexibility with a low noise 10 dB rf amplifier.
Newl Standard ultimate selectivity choices include the supplied 2.3 kHz ssb and 500 Hz cw crystal filters, and 9 kHz a-m selectivity. Capability for three accessory crystal filters plus the two supplied, including 300 Hz, 1.8 kHz, 4 kHz, and 6 kHz. The 4 kHz filter, when used with the R7A's Synchro-Phase a-m detector, provides a-m reception with greater frequency response within a narrower bandwidth than conventional a-m detection, and sideband selection to minimize interference potential.
- Front panel pushbutton control of rf preamp, a-m/ssb detector, speaker ON/OFF switch, i-f notch filter, reference-derived calibrator signal, threeagi receive times (plus AGC OFF), integral 150 MHz frequency counter/digital readout for external use, and Receiver Incremental Tuning (RIT).

The "Twins" System
- FREQUENCY FLEXIBILITY. The TR7A/R7A combination offers the operator, particularly the DX'er or Contestor, frequency control agility not available in any other system. The "Twins" offer the only system capable of no-compromise DSR (Dual Simultaneous Receive). Most transceivers allow some external receiver control, but the "Twins" provide instant transfer of transmit frequency control to the R7A VFO. The operator can listen to either or both receiver's audio, and instantly determine his transmitting frequency by appropriate use of the TR7A's RCT control (Receiver Controlled Transmit). DSR is implemented by mixing the two audio signals in the R7A.
- ALTERNATE ANTENNA CAPABILITY. The R7A's Antenna Power Splitter enhances the DSR feature by allowing the use of an additional antenna (ALTERNATE) besides the MAIN antenna connected to the TR7A (the transmitting antenna). All possible splits between the two antennas and the two system receivers are possible.

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This Month Only: Delivery Anywhere In The Continental USA At No Additional Cost.
Today's communications receiver is expected to detect and extract information from signals of varying levels in a crowded spectrum. Earlier designs were concerned primarily with good sensitivity and selectivity. New requirements call for a high degree of rejection of spurious products produced by nonlinear interaction of many strong signals, sometimes far removed from the receiving frequency.

One method of determining the quality of receiver performance is to specify both an upper and lower signal-handling power limit, that is, a spurious-free dynamic range. To establish performance criteria requires a knowledge of the receiver's sensitivity (MDS), its third-order intercept point (defined later), system noise figure, and i-f bandwidth. Let's first define dynamic range.

Dynamic range is the power range over which a device such as a radio receiver provides useful operation. The upper limit of the dynamic range ($P_u$) is limited by the level of two equal input signals that create a third-order intermodulation product, which is equal in amplitude to the Minimum-Detectable-Signal (MDS)* level. The MDS is considered as the lower limit ($P_L$) of the dynamic range, and is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth. The minimum detectable signal can be found through eq. 1.

$$P_L(dBm) = MDS(dBm)$$
$$= -171 dBm + NF(dB) + 10 \log (BW)_{IF}$$

Where: $MDS$ is the low-power limit of dynamic range in dBm.
$NF$ is system noise figure in dB.
$BW_{IF}$ is i-f bandwidth in Hz.
$P_L$ is lower power limit of dynamic range in dBm.

The upper limit of the dynamic range can then be expressed by eq. 2.

$$P_u(dBm) = \frac{1}{3} (MDS + 2IP)$$
$$= \frac{1}{3} (-171 dBm + NF dB) + \frac{1}{3} IP(dBm)$$

Where: $P_U$ is the upper power limit of the dynamic range in dBm.
$IP$ is receiver's third order input intercept point in dBm.

By combining the two equations, we can find eq. 3 for the total spurious-free dynamic range:

$$SFDR \ (dBm) = P_U (dBm) - P_L (dBm)$$
$$= \frac{1}{3} (MDS + 2 IP) - MDS$$
$$= \frac{2}{3} (IP - MDS)$$
$$= \frac{2}{3}(IP(dBm) - NF(dB) - 10 \log BW_{IF} (Hz) + 171 dBm)$$

* Sometimes referred to as the noise floor.
† $KTB + 3 dB = -171 dBm.$

By Cornell Drentea, WB3JZO, 7140 Colorado Avenue, N., Brooklyn Park, Minnesota 55429

December 1982
Where: SFDR is the spurious free dynamic range.

This equation shows that the dynamic range is directly proportional to the intercept point (IP) and inversely proportional to the noise figure (NF), and i-f bandwidth (BWIF).

We can then say that the dynamic range improves with lower noise figures, narrower i-f bandwidths and higher intercept points.

The following example shows a practical application for the dynamic-range formula. Assume a typical high-performance receiver with a noise figure of 8 dB, an i-f bandwidth of 2.1 kHz and an input intercept point of +20 dBm. Substituting these quantities in eq. 3 yields:

\[
SFDR = 2/3 \left( +20 \text{ dBm} - 8 \text{ dB} - 10 \log 2100 \text{ Hz} + 171 \text{ dBm} \right) \\
= 99.85 \text{ dB.}
\]

The total distribution of this number can best be understood by examining the graph in fig. 1. We know that the total spurious-free dynamic range (SFDR) for our receiver is 99.85 dB, but what is not known is where this range fits in the total picture of the receiver's sensitivity, and once this is found, what this range means from a practical performance point of view. We had previously determined that the lower limit of the dynamic range is given by the Minimum Detectable Signal (MDS). If, using eq. 1 for our example, we find the lower limit of the receiver's dynamic range to be −129.77 dBm.

\[
MDS = -171 + 8 + 10 \log 2100 = -129.77 \text{ dBm.}
\]

We can then say that the system's noise level for an i-f bandwidth of 2.1 kHz is 3 dB below this number, or −132.7 dBm (MDS is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth).

Knowing the MDS, the IP (20 dBm) and with the help of eq. 2, we can determine the upper limit of our 99.85 dB dynamic range:

\[
P_u = 1/3 (-129.77 + 40) = -29.92 \text{ dBm.}
\]

The same result would be obtained if we added the total dynamic range of 99.85 dB to the MDS:

\[
P_u = 99.85 + (-129.77) = -29.92 \text{ dBm.}
\]

This last procedure could be used to verify the validity of eq. 2.

If these numbers are plotted as shown in fig. 1, we can conclude that the receiver in our example will perform undisturbed for all input signals varying from approximately −30 dBm to −130 dBm, with the receiver tuned to a third-order intermodulation product produced by two strong signals equal in amplitude and differing in frequency from each other. The amplitude of these signals, as well as the difference frequency (Δf), were represented in our example by the +20 dBm input-intercept point. In practice, this quantity is a function of the output intercept of all non-linear elements, such as mixers, amplifiers, etc., involved in the design of the receiver, as we will see next.

**intercept method**

Fig. 2 shows the intercept method, used as an evaluation method for the strong-signal handling capability of a radio receiver. In practice, the dynamic range of a receiver is measured with the setup shown in figs. 3 and 4.

First, the MDS is found as shown in fig. 3. The +20 dBm input-intercept point. In practice, this quantity is a function of the output intercept of all non-linear elements, such as mixers, amplifiers, etc., involved in the design of the receiver, as we will see next.
tor G (expressed in dB), to produce a 3 dB increase in audio output over the noise level of the receiver. The MDS is specified for a given i-f bandwidth. The greatest bandwidth should be used for a worst-case analysis.

Knowing the MDS, the setup in fig. 4 can be used to actually find the output intercept, and with this information, the input intercept can be plotted as shown in fig. 2.

To find the output intercept point, the outputs of the two signal generators \( G_1 \) and \( G_2 \) are combined in a hybrid combiner. The output of the combiner (which now contains a two tone signal) is applied through a calibrated step attenuator to the receiver.

The two generators are usually 10 kHz apart, with the receiver tuned to \( 2F_2-F_1 \) or \( 2F_1-F_2 \), a third order product. The attenuator is then varied until the response of the receiver at the frequency of the third-order product is the same as that produced by the MDS found earlier. The performance is specified by measuring and plotting the output intercept as shown.

If the receiver is well designed, the desired output signal and the distortion product curve will intersect as high as possible, as shown in our example. This is the output intercept which describes the intermodulation response of the receiver.

The input intercept can also be plotted from the intercept point. This number can then be used to find the spurious-free dynamic range as previously discussed.

In conclusion, the receiver processes a weak signal in the presence of many adjacent strong signals. Because of the deficiencies in the design of the first mixer and the front end, if a preamplifier is used, the receiver may not be able to copy the weak signal, and it may be completely blocked out. The receiver’s ability to perform under such conditions is expressed by the spurious-free dynamic range.

This article was adapted from the book *Radio Communications Receivers* by the author, published by TAB Books Inc. It is available from the Ham Radio Bookstore, Greenville, NH 03048, for $13.95 plus $2.50 shipping and handling.

**bibliography**


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ham radio
last-minute forecast

December is probably the best month for winter DX. The low signal absorption combined with high daytime MUFs result in excellent signals on the higher DX bands (10 and 20 meters). On the other end of the frequency spectrum, the long nights make for excellent DX on 40 through 160 meters.

Expect the 27-day solar maximum just at the end of November and again on the 23rd of December: consequently, the higher DX bands should be active the first week and the last week-and-a-half of the forecast period. The days in between should favor the lower frequency bands. December is traditionally one of the quietest insofar as geomagnetic disturbances are concerned, but the days of highest probability will be around the 9th, 18th, and 28th.

The winter solstice will take place on the 22nd at 0439 UT. A partial eclipse of the sun (74 percent obscured) will occur on the 15th across Europe, extreme northeast Africa, and west Asia, and on the 30th there will be a total eclipse of the moon across North America, Asia, and Australia. Lunar perigee will be on the 2nd at 1100 UT and the 30th at 2200 UT; by coincidence, full moon will be on the 1st and 30th.

The Geminid meteor shower, which reaches its peak on December 13th and 14th provides the richest and most reliable display of the year, with rates of 60 to 70 per hour (determined mainly by radio, because of the poor weather in December). Also, a smaller portion of the shower (15 to 20 per hour) is observed on December 22.

more on the radio-quality index

If you have talked Santa into bringing you a home computer for Christmas, you may want to use it to enhance your ham radio DX operating by programming a radio-quality index into it. A formula was given in the DX Forecaster column in the August, 1982, ham radio. Further programming and debugging help is given below.

I have divided the formula into three sections, a term and factors, and given representative values within the ranges of the variables. First is the seasonal term, $\theta$, which is raised. This term is needed to increase quality in the summertime, probably representing increased signal strength from sporadic-E layer propagation. It varies from 0.7375 in winter to 1 near summer solstice as in the following table:

<table>
<thead>
<tr>
<th>Day</th>
<th>$\phi$ (0.49315x)</th>
<th>$\cos^2 A$</th>
<th>$\theta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Jan)</td>
<td>0.49315x</td>
<td>0.999925</td>
<td>0.7375</td>
</tr>
<tr>
<td>80 (Mar)</td>
<td>39.45200</td>
<td>0.59626</td>
<td>0.8435</td>
</tr>
<tr>
<td>172 (Jun)</td>
<td>84.82180</td>
<td>0.008215</td>
<td>0.9978</td>
</tr>
</tbody>
</table>

Day number $x$ is the day of the year, starting with January 1 as 1. January 1 would be 32, and so on. Use trig identity, $\cos^2 A = \frac{1}{2}(1 + \cos 2A)$.

The radio flux factor, $\log \left( \frac{4\sqrt{\phi}}{A} \right)^{\theta}$, is the log to base 10 of the fourth root of the radio flux number, right from WWV. The $\phi$ varies from about 65 to 400, and the value of this factor for three values of $\phi$ and the $\theta$ extremes of 1.0 and 0.7375 are as follows:

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\log \phi$</th>
<th>June</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>1.84510</td>
<td>0.461</td>
<td>0.340</td>
</tr>
<tr>
<td>150</td>
<td>2.17609</td>
<td>0.544</td>
<td>0.401</td>
</tr>
<tr>
<td>375</td>
<td>2.57403</td>
<td>0.643</td>
<td>0.475</td>
</tr>
</tbody>
</table>

The magnetic factor is $e^{-0.01A}$, where $A$ is the magnetic number (estimate) for the day from WWV. The exponential function $e^x$ is used. A table of representative values is as follows:

<table>
<thead>
<tr>
<th>$A$</th>
<th>$e^{-0.01A}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.9512</td>
</tr>
<tr>
<td>10</td>
<td>0.9048</td>
</tr>
<tr>
<td>50</td>
<td>0.6065</td>
</tr>
<tr>
<td>100</td>
<td>0.3679</td>
</tr>
</tbody>
</table>

Finally, putting the factors all together with the 10-times factor and the +0.82 term to shift the scale to a 0 to 9 range of numbers, an overall example for March 21, 1982, (day 80) with solar flux of 150 and $A$ of 10 is calculated as follows:

$Q = 10 \left( \frac{0.8435}{4} \right) (2.17609)(0.9048)$

$+ 0.82 = 4.15 + 0.82 = 4.97$ or 5

band-by-band summary

Ten, fifteen, and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day. Long skip and one-long-hop trans-equatorial openings toward evening can be opportunities for new DX locations. Look for them during the few disturbed geomagnetic periods, otherwise watch for high solar flux days for ten and fifteen meter openings.

Forty, eighty, and one-sixty meters are the night DXer’s bands. Excellent extended periods of long skip, albeit over shorter distances than on the higher bands, can make a cold winter night enjoyable. Low noise and quiet geomagnetic conditions generally result in pleasant operating this time of year. Happy Holidays, and lots of DX during the coming new year!
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**PUBLICATION**
- **Title**: Amateur Radio
- **Date of Publication**
- **Frequency of Issue**
  - Monthly
  - Price: 12 $1.50

**Statement**

**Publication Address**
- Communications Technology, Inc.
- Main Street, Greenville, MI 48838
- T. H. Tenney, Jr.
- Main Street, Greenville, MI 48838

**Known Bondholders, Mortgagees, and other Security Holders owning or holding 1% or more of total amount of bonds, mortgages or other securities**

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- Main Street, Greenville, MI 48838
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BEWARE

In any field of endeavor cheap imitations attempt to ride on the coattails of the successful leader. These imitations resemble the original and are many times passed off as such. This is especially true in our business.

To protect our product and name from this deception, we are now serial numbering all our fiberglass dishes. This will enable you to easily identify our product and rest assured you are getting the quality you expect.
How to avoid being burnt by more than rf

Willie Hambone earned the name “Bargain Willie” at his local radio club for good reason. He always knew the price of the latest radio equipment, and had a feeling for what a seller would expect when it was offered at a ham flea market. He was, of course, a veteran of the Dayton Hamvention; after Willie had made the pilgrimage to Dayton for several years, his acquaintances wondered what equipment he didn’t have. But when the annual local hamfest — one of the largest in the state — came, Willie was there.

This time Willie’s eagle eye fastened on the latest model Modzilla 870, complete with power supply, Modzilla mike, and 870-RV remote VFO. No manual; but the seller assured Willie that since it was a current model, he would have no trouble getting one from the U.S. distributor for $10, and he’d shave that off the price. Price? Well, the current market price was $1,350 — but since the seller was about to take a job working for an oil exploration company in South America, and needed some cash to pay his wife’s hospital bill, he’d take $675 — exactly half price — less the $10 to buy a manual.

Not everybody goes to a hamfest with $665 in his pocket, but Willie always said that cash talks, and his hot little hands soon pulled that bargain price out of his wallet, gave it to the seller, and proceeded to carry his new acquisition to his car. The rest of the hamfest was anti-climactic for Willie; he could hardly wait to get his new gear home and on the air. Since it was a class piece of equipment, he decided he ought to check with another ham in town who had a Modzilla 870; and after his friend had reviewed the tune-up procedure with him over the telephone, Willie plugged it in for the smoke test.

It worked beautifully. The path to Europe was open on 15, and it was no trouble to work Qs and DLs with the barefoot rig, one station after another. During the next few days, Willie checked the rig out on other bands, and found it even brought in QSOs on 160. In short, he was delighted, both with the rig and with his bargain. He was tempted to forget about the instruction manual, lack of which had shaved $10 off the price — but when he thought that someday he’d sell the rig for a later model, he wrote a letter to Modzilla’s U.S. distributor in La Squinta, California, enclosing $10 for a manual, carefully noting the serial number of the equipment so that he would get the proper edition for his new 870.

Willie’s joy seemed unlimited. The heatsink on his 870 hardly had a chance to cool down, so happily did Willie describe his bargain far and wide during the next few weeks. Then, on Saturday afternoon, it happened.

the problem arises

The doorbell rang, and with some disgust, Willie — who was home alone — answered. The caller turned out to be a Deputy Sheriff with a folded sheet of paper in his hand. “Willie Hambone?” he inquired.

“That’s me,” Willie acknowledged.

“Mr. Hambone,” the deputy went on, “I have a search warrant signed by Judge Green of the County Court, authorizing me to search your premises for pieces of stolen radio equipment. They are called a Modzilla Model 870 and an 870-RV; and I have a picture of this type of equipment. If you have it here and want to show it to me, fine; otherwise, my partner and I will have to go through your house, room by room.”

Willie felt the floor sinking beneath him. “Look, officer, I have a Modzilla 870, and you’re welcome to look at it; but I paid good money for it. I didn’t steal it from anybody; I bought it, and it’s mine!”

They proceeded to Willie’s shack, where Willie announced, “Here it is. These are produced by the

By George H. Goldstone, W8AP, 1010 Burnham Road, Bloomfield Hills, Michigan 48013
thousands. Maybe a few get stolen, but I paid for this one.’”

“You may have paid for it, Mr. Hambone, but if this equipment carries serial number 89-6634, you are in possession of stolen property. May I look at the serial number on the back?”

Willie already knew the number; his heart sank. His request for an instruction manual, giving the serial number . . . of what was a stolen rig!

It didn’t take the deputy long to check the number. But if Willie felt bad about losing $665, he felt even worse after the deputy’s next announcement:

“Mr. Hambone, you are under arrest, charged with receiving and concealing stolen property of a value sufficient to constitute a felony. I must advise you that you are not required to make any statement; any statement you make can be used against you in court; you are entitled to counsel; and if you cannot afford counsel, an attorney will be provided for you. You must come with me to the County Jail, where you will be booked, and you will be allowed to call an attorney from there.”

Willie’s bargain had evaporated. In fact, so had his world.

what happened to Willie

Willie hired a competent lawyer, whose services were not inexpensive. At a preliminary hearing, his lawyer raised the defense that Willie had no knowledge the transceiver was stolen; that such knowledge is an essential element of the crime of receiving stolen property. The judge agreed and dismissed the charge, but his remarks to Willie are worth noting:

“Mr. Hambone, I am dismissing the charge of receiving stolen property, although I hesitate to do so. You are an Amateur Radio operator, and I feel quite sure you knew the true value of this equipment at the time you bought it. Such knowledge of value would permit this court to draw an inference that you sensed the equipment was stolen. Since you have no criminal record, I am dismissing the complaint; but if you are ever again found to have stolen equipment in your possession, the court will take a different attitude.”

Some bargain, that transceiver! Willie not only lost the $665 he had paid for the Modzilla 870; he paid his attorney’s fee, and in local ham circles, he was now known as “the ham who has been had.”

The unhappy situation fictionalized here may well have happened, at least in many details. We all know expensive Amateur Radio equipment is stolen from time to time. The elaborate high-frequency mobile installation is almost a thing of the past. VHF and some HF equipment is now made small enough that the owner can unplug the major component — a transceiver — and carry it in his briefcase.

The development of the ARRL insurance program, to a considerable extent, is the result of growing radio equipment theft. This article is not designed to tell you how to avoid theft of your equipment; it is designed to suggest ways in which you may avoid the purchase of stolen equipment.

Traditionally, physical possession is considered one indication of ownership. While it may be an indication of ownership, it does not prove your title to the property. So, where do you obtain some proof of title? As to new merchandise — and let us take a typical transceiver purchased from an established dealer — you will receive a paid invoice, identifying the goods by make, model, and serial number. Considering the importance of equipment warranties, every buyer should insist that a serial number be included on his invoice. This invoice is evidence of a contract of sale, and by law, a contract of sale implies a warranty of good title to the merchandise sold, and that the transfer is a rightful one.

At any flea market, the majority of vendors are not merchants regularly dealing in Amateur Radio equipment. More often, they are individuals with usable gear they no longer want or need, which they want to convert into money or other ham gear. We normally do not expect such a casual seller to furnish ownership documentation; it is unusual when he furnishes a receipt for the goods you purchase. If a seller will accept your check in payment, you may note on the back, “In payment for Johnson Invader Serial No. 116628,” but this only shows what the check paid for; it does nothing to prove that the seller was the owner.

proof of ownership

It is not too much to ask a seller of any major item of equipment to furnish some evidence the goods are his. Every ham should staple his purchase invoice onto the back of the instruction manual for reference at the time it is sold. There are tactful ways to ask for title evidence; you will not make friends by saying “How do I know it isn’t stolen?” but you can easily say, “Do you have an invoice to show where this gear was purchased?”

Not everyone keeps sales invoices. Sometimes we want to forget how much money went into one piece of gear! But there is no reason why a Bill of Sale cannot be given, preferably in a form which will identify both buyer and seller, say where the seller obtained the equipment, state the selling price, contain a warranty of title in all cases, a warranty against liens, and a warranty of condition whenever condition is vital to the sale. A suggested form for a Bill of Sale is shown in fig. 1. It can easily be reproduced in quantity to use at hamfests and flea markets; perhaps the club
BILL OF SALE

The Seller, ________________________________

(Name of Seller)

in consideration of the price of $ ________________________________ paid to him, receipt of which is acknowledged, hereby sells to ________________________________

(Name of Purchaser)

the following equipment:

(Quantity) (Description) (Serial No.)

originally purchased from ________________________________

(Seller)

Seller represents and warrants that he is the owner of the equipment sold, and no other person has any interest in it, or lien upon it by way of an unterminated Financing Statement, or otherwise. As to the condition of the equipment, Seller makes the following representations:

☐ 1. The equipment is in good working condition.
☐ 2. The equipment is sold “as is”, and Seller makes no representation as to its performance.
☐ 3. The equipment requires repairs (other than normal alignment) in order to meet the performance specifications of the manufacturer.

Witness: ________________________________

(Signature of Seller)

Date of Sale: ________________________________

fig. 1. Sample Bill of Sale form.

sponsoring the affair can have them printed, and make them available at printing cost.

**effect of a Bill of Sale**

Between seller and buyer, the Bill of Sale is clear proof that the seller has transferred whatever ownership he had to the buyer. In most cases, possession of a Bill of Sale by the buyer precludes any criminal intent on his part, should the gear prove to be stolen; without criminal intent, you would not end up with a charge of receiving stolen property as suggested in poor Willie’s example.

If the seller has valid title to the property, the Bill of Sale effectively transfers it to the purchaser. But if the seller does not have good title to the property, the purchaser acquires no more ownership than the seller had. It is certainly worthwhile to protect yourself against criminal liability by asking for and receiving a Bill of Sale. Would you want to make a deal with someone who refuses to give a Bill of Sale?

**possible liens**

Much new radio equipment is bought on credit. Some radio supply houses reputedly make more money on their credit operations than on the sale of the gear itself, which can occur when a supplier does the financing rather than using Master Charge, VISA, etc. If the gear has been financed by the purchaser, the seller or the financing agency has probably filed what is called a Financing Statement. When a Financing Statement has been recorded, the party extending credit may have rights to the goods after the date of recording which are legally superior to those of the purchaser. If you acquire an expensive piece of relatively new gear from someone who has a reputation for buying everything on credit, you would be wise to check with your County Clerk or Register to see if there is the lien of a Financing Statement recorded against what you plan to buy. A Bill of Sale should include a representation that no such lien exists.

**some common-sense conclusions**

No one wants his own equipment stolen, nor does anyone want to help thieves of Amateur Radio equipment by furnishing them a market. We can all help shrink the stolen equipment market by retaining our purchase documents, complete with serial numbers. When buying used gear, insist on evidence of ownership; ask for purchase records, but take a Bill of Sale in any event. The Bill of Sale, if properly drawn up, will show that you purchased the equipment in good faith, will identify the seller, and can also serve as a warranty of the condition of the equipment. Taking into account the present cost of equipment — either new or good used gear — insisting on a Bill of Sale is a wise precaution!

**references**

1. Uniform Commercial Code, Section 2-312.
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More Details? CHECK-OFF Page 132
Heil EQ200 mike equalizer

We always thought we had good audio from our transmitter. No one ever complained about garbled speech or hard-to-understand transmission. Granted, we had people tell us we sound like Demosthenes, the Greek orator who practiced with stones in his mouth... that was before Bob Heil sent us his latest product, the EC200 microphone equalizer.

Bob Heil is well-known throughout the audio field as an expert on sound reproduction. Besides being a professional organist, he is in constant demand by music groups from rock bands to Philharmonic orchestras. He knows his audio. In a conversation with Bob, he stated that the most misunderstood and neglected part of any ham station is the microphone/audio circuitry. Sure, there have been compressors, clippers, and whatever. But they do more to compound the problems of poor audio than solve them.

With this in mind, Bob determined to apply his professional expertise to solve the problem. Looking through manufacturers specifications, Bob found most modern transmitters and transceivers have filter networks that limit audio input to the 300-3,000 Hz range. But most microphones are designed to cover a much broader range of frequencies, since they are used in services as diversified as stereophonic reproduction to paging services. The broader response of the microphone will be transmitted, and this will unnecessarily broaden your output.

The solution he came up with is the EQ200. The basic circuit is two 741 op amps (cm 1458). One-half of the first IC is used as a preamplifier and a transformer to provide proper impedance matching. The other half of the IC is used as a peaking lowpass active filter. The second IC is used as a shelving highpass filter and a line summing amplifier.

There are three controls on the front panel of the unit. The mike preamp gain may be adjusted from 0 to +20 dB. Heil advises that this be set so the microphone will not overload or clip. The LO control is used as a boost and cut control. Boost refers to increasing the level, cut reduces the level. The boost and cut is ±12 dB. The low filter is centered at 490 Hz. The HI control is also a boost and cut, with the filter centered at 2800 Hz.

As mentioned before, most microphones used today were not designed for ham use; their audio response is usually much greater than is necessary. Since all microphones are different, there is no universal setting. Heil has some recommended settings, but it best to set the processor through a trial-and-error process. Luckily, we have a friend who received an EQ200, so we tested and set our processors together. It was interesting to actually hear how the high and low tones can be emphasized and deemphasized to create a truly pure-sounding signal.

The only problem we found was that we chewed up batteries. That can be remedied easily by installing a 9 Vdc supply or adding a low drain LED to remind you the unit is on. This is more of an inconvenience than a problem. Bob Heil tells us a newer model will incorporate these changes.

Finally, Bob provides some helpful hints about how to use the microphone properly, such as keeping adequate spacing between mouth and microphone and making sure your operating room is not full of echoes.

The EQ200 is a nice item to have between your rig and microphone. Price is $49.95 for the basic unit. For more information, contact Heil Sound, Box 26, Marissa, Illinois 62257.

As an added feature, the EQ200 can be modified to work as a two-tone generator for SSB tuning and testing. A parts kit is available from Heil Sound for an additional $7.00.

new high-frequency equipment line

Yaesu Electronics Corporation is pleased to announce the availability of the new FT-102 line of high-frequency equipment. The FT-102 transceiver uses an all-new transmitter section, featuring three 6146B final tubes for extremely low distortion. In addition to VOX and an RF clipping-type speech processor, the FT-102 transmit audio may be adjusted for optimum response to the operator’s voice.

The FT-102 receiver uses JFET components in the front end for wide dynamic range. A number of filter options are available, with wide/narrow filter selection independent of the mode switch. Audio peak filtering for CW, audio shaping for all modes, and an i-f notch filter provide intelligence recovery. The noise blanker is highly effective against the Woodpecker and pulse noises.

Equipped for SSB and CW operation, the FT-102 option list includes an a-m/fm module for activating those modes. Other accessories for the FT-102 are the FV-102DM synthesized VFO, the SP-102 speaker with audio filter, the SP-102P speaker/patch, and the FC-102 1.2-kw an-
tenna tuner with optional remote antenna selector.

For further details, contact Yaesu Electronics Corp., P.O. Box 49, Paramount, California 90723.

electronic parts by mail

A new, free catalog lists over 1500 electronic items which can be ordered through the mail. Parts are high quality, no rejects or seconds. Large line of semiconductors, LED displays, lamps, connectors, sockets, headers, jumpers, switches, meters, amplifiers, generators, etc. Some items are available in kit form or assembled. All items can be shipped immediately from stock.

For more information, contact Sintec Company, Drawer Q, Milford, New Jersey 08848; telephone 1-800-526-5960 (New Jersey residents dial 201-996-4093).

photovoltaic battery charger

The Phaeton II Photovoltaic Battery Charger manufactured by International Solar Products Corporation of Durham, North Carolina, produces 4.8 volts of direct current power at 240 milliammps in peak sunlight. Four AA cells, two C cells, and two D cells can be charged with the unit. Batteries are fully recharged in 14 to 16 hours of sunshine.

Phaeton II measures 6 x 7 inches and weighs less than two pounds. It is constructed with anodized gold or silver frame, heavy-duty aluminum battery cradles and the same silicone covering used to protect the solar cells on orbiting communication satellites. The unit contains no plastic parts.

The manufacturer states the average consumer could spend as much as $100 per year on throw-away batteries to power portable radios, tape recorders, toys, games, flashlights, cameras, and other electronic appliances found in many homes today. At $49.50, the Phaeton II can totally replace this annual cost after it pays for itself in the first 6 to 7 months of use.

The unit is available directly from the manufacturer, International Solar Products Corporation, 1105 W. Chapel Hill St., Durham, North Carolina 27701; telephone 919-489-6224.

frequency counter program

A cassette program that turns the Apple II computer into an audio frequency counter with an accuracy of 30 parts-per-million. You may consider this a rather expensive frequency counter, especially when it doesn't cover rf at all. However, it is aimed primarily at those experimenters who already have an Apple II computer.

This counter has a twist to it. Unlike most frequency counters, it does not gate the unknown for a fixed reference period. Rather it counts an approximately equal number of clock pulses over an exact (but arbitrary) multiple of whole cycles of the unknown. Then it calculates the frequency from this average, much as a period counter would. The result is that the full stated accuracy is achievable in less than two seconds, over the entire audio range. This means that in less than two seconds you can find out the frequency of your subaudible tone encoder to within 0.01 Hz. The counter can achieve even
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greater accuracy if you have a little patience. It also keeps a running average of the last N (default is 50) samples. If fewer than N have been taken, it will average them. The result is accuracy approaching 1 PPM.

Although the Apple's time base (which is the reference for this program) isn't calibrated or compensated, it is crystal controlled and therefore relatively stable over short periods once it has temperature stabilized. Included is a procedure (need only your cassette recorder, microphone, and a color TV) to calibrate it in software, using the 15734.26 Hz horizontal oscillator frequency of a color TV receiver. This signal is of course locked to the station it is receiving, which, if a network program is being viewed, is in turn locked to a cesium 3.579545 MHz reference at the network.

A copy of the cassette costs $15.

For more information and dealer prices, contact Wilton Helm, WAGGOO, 827 Vinton Court, Thousand Oaks, California 91360.

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220 MHz H.T. amplifier

Mirage Communications Equipment, Inc., announces the release of its new 220-MHz amplifier. The C22 solid-state all-mode 220 to 255 MHz amplifier has the same famous five-year warranty (one year on rf power transistors) as all Mirage products.

The C22 has many features, including bias as a linear amplifier I.E: fm, SSB, CW; it can be keyed with as little as 300 mW; 2 watts in with 20 watts out; and dc power 13.6 Vdc at 3 amps (full output).

For additional information, contact Mirage Communications Equipment, Inc., P.O. Box 1393, Gilroy, California 95020; telephone 408-847-1857.

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300-watt antenna tuner

Palomar Engineers introduces the new PT-407 antenna tuner. The PT-407 is a general-purpose tuner for 1.8-30 MHz, for matching antennas fed with coaxial or open wire lines, single wire, or mobile antennas. The 300-watt power rating makes it just right for most transceivers. The PT-
Hamtronics® kits

The R76 VHF fm receiver kit is a new version of the R75 receiver for 10 meters, 6 meters, 2 meters, 220 MHz, or the adjacent commercial bands. It features a very low noise front end, pump-resistant squelch with hysteresis to lock on fading signals, onboard volume and squelch controls for easy wiring, and fixed i-f filters for easy alignment. It has also been reduced in size — now only 3 1/4 x 4 inches (8.25 x 10.16 cm). It is available in two selectivity options, starting at $84.95.

The model R451 UHF receiver kit includes the features in the R76 kit as well as automatic frequency control to lock on drifting transmit signals. Kits are available with various options starting at $94.95.

Hamtronics® new line of low-noise amplifiers resembles the popular P30 and P432 receiver preamps, but the circuit is new. The LNA 28, LNA 50, LNA 144, LNA 220, and LNA 432 units are optimized for lowest noise figure at the ham bands, but they can also be used on adjacent commercial bands. The LNA 432 also provides very good gain and noise figures for UHF TV signals and the new 800 MHz commercial band: 0.5 dB at 28 and 50 MHz, 0.6 dB at 144 MHz, 0.7 dB at 220 MHz, and 0.95 dB at 432 MHz. Gain runs from 33 dB at 28 and 50 MHz to 17 dB at 432 MHz. The price is $39.95 for the VHF units and $44.95 for the UHF unit.

The Shuttle receiver kit, a special version of the Hamtronics R110-450 UHF a-m aircraft receiver to listen to the space shuttle, is now available off the shelf for $94.95.

For further information, contact Hamtronics, Inc., 65-V Moul Road, Hilton, New York 14468-9535; telephone 716-392-9430.

regulated dc power supply

The precision-regulated dc power supply from Tripp-Lite converts 120 Vac into 13.8 Vdc. It allows users to operate dc mobile equipment on ac home power, and it saves money, as this unit is inexpensive and eliminates the need for buying ac equipment.

Features include solid-state integrated circuits for precise regulation; filter insuring low noise operation; current limiting electronic foldback for automatic overcurrent protection; heavy duty power transformer for complete line isolation; ripple voltage from 0 to full load is only 0.1 volts maximum; on/off indicator light and on/off switch on face-plate; UL listed ac cord and plug type SPT-2.

For more information, contact Tripp-Lite, 500 N. Orleans, Chicago, Illinois 60610.
radiator providing increased efficiency and range for handheld radios.

Designated Style F, the new antenna for VHF frequency bands from 118-174 MHz is fitted with a BNC connector.

For more information, contact

Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501-2846; telephone 402-467-4491.

special keyboard

Pipo Communications has just announced a specially designed keyboard compatible with the Collins KWM-380 high-frequency radio. The new sixteen-button keyboard is color-coordinated and has the fourth row buttons marked to indicate their function. This will facilitate ease of operation by eliminating the need to memorize what the buttons do. The keyboard sells for $20 and has a frame available for $3.

For more information or to order, please contact Pipo Communications, P.O. Box 3435, Hollywood, California 90028; telephone 213-852-1515.

6-meter transceiver

ICOM has announced the IC-505, a fully synthesized multimode transceiver covering 50 to 54 MHz (option), USB, LSB, and CW on fm. It uses an internal battery pack (9 C-size batteries), and puts out three watts of rf power when run on its batteries, or ten watts when connected to an ex-
ternal 13.6 volt dc source. Low power is 0.5 watts.

Features include an LCD frequency display for low battery consumption, provision for internal memory back-up, dual VFOs, five memories plus a call channel, memory scan, program scan, sideband squelch, LCD annunciators for VFO, scan, memory channel, call and split, and split frequency operation.

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

**GaAs FET VHF/UHF amplifiers**

Lunar Electronics announces a line of narrow-band tuned receiving preamplifiers for the VHF and UHF communities. Typical specifications exceed previously available receiving preamplifiers by up to ten times in performance. Exhibiting very high gain at VHF, typically 22-24 dB, moderate gain at UHF, typically 16 dB, plus a very low noise figure, typically 0.3-0.4 dB at VHF and 0.5-0.6 dB at UHF land mobile frequencies, these units are also well suited to high rf environments, exhibiting 1 dB compression power levels of +10 dBm or more. The good gain, coupled with very low noise figure, effectively reduces a typical repeater receiver sensitivity to that of ambient limitations. Improvements in receiver performance have been consistently reported by users at 6-10 dB in a typical repeater installation between the duplexer and receiver input.

Units are built to customer's specified frequency, but do exhibit a typical bandwidth of 5 percent CF with little degradation in performance. Dc input is well filtered and regulated, which allows accepting any dc voltage between 12 and 28 volts, drain approximately 35 mA. VHF connector options include BNC, SMA, N in and out; UHF connector options are SMA, N in and out, with SMA in BNC out the standard option. SMA to RG-58 connectors are included as option for UHF units. Frequencies are available from as low as 15 MHz to the 800 MHz land mobile bands.

For more information, contact Lunar Electronics, 2775 Kurtz Street, Suite 11, San Diego, California 92110; telephone 714-299-9740.
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**QSL Cards**

QSLs & Rubber Stamps — Top Quality! Card Samples and Stamps Incl. — Eberhard Graphics 5R, Box 70, Westerville, Ohio 43081.

**Travel Pak QSL Kit** — Converts post cards, photos to QSL. Stamps available. Material should be typed or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. Ham Radio cannot check each ad and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

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**Jumbo Beads Toroids**

- Includes:
  - 100, F50-Q2, F114-Q1
  - 2 ea., F23-Q1, F23-Q2, F37-Q1
  - F37-Q2, F50-Q1, F87-Q1

**Experimentor's Kits**

- Includes:
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**Ferrite Beads slip over 18 ga. wire**

- For sale: Heath HW-8 and supply $100. Heath GDO $35; Astatie D104/U82 $50. All $1 each. WB2ZGP, T. Woodrup, Box 847, Pierrepont Mont., NY 13674.

- For Sale: Heath SB-200 with 10m $225, KLM 2m linear PA 15-808L $75. Both FCB my QTH. Neil (201) 362-9262.

- **Antenna Trouble?** For $5.00, Antenna Analyst, 41 Benefit Hl., Wakefield, RI. 02879. Will check your head-ache, or refund your money.

- **Pre-1946 Television Sets** wanted for substantial cash. Finder's fee paid for leads. Also interested in spinning drum, mirror in-th-lid, early color sets, S7AP picture tubes. Arnold Chace, 9 Rushing Road, West Hartford, Conn. (06117) (203) 521-5280.

- **Rtty and ASCII for Atari.** Plans and a printed PC board to build your own modem. ASCII and RTTY programs on disk all for $25. Robert Hossel, 1775KD/KH2, Box 4426, AA8B Br. Yigo Guam 96912 (USA).

- **Apple II Computer OWNERS!** The RADCOM PLUS+ package consists of a quality TU interface that installs in the APPLE, connects to your rig and uses the most advanced feature packed software ever developed for sending and receiving RTTY and Morse code. Detailed information from A. Massimo, AF6W, 4041 - 41st Street, San Diego, CA 92105.

- **Tubes** wanted for cash trade. 304T, 4C4/1000A, 4PR60C, 4CX1000A, 4PR60C, WE300, 777, 777, 57, 6LSM. Any high gain special purpose tubes of Elmac/Varian. DCO, 10 Schuyler Avenue, No. Arlington, VA 22201. (703) 526-1270.

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Send Material To: Flea Market, Ham Radio, Greenville, N. H. 03048.
FOR SALE: Popular Kenwood TS-520S w/G filter, VOX and CW never used. Rig used very little and in mint condition. Original carton and manual $500. Morris Shashoff, W6RIP, 613 S. Breed St., Los Angeles, CA 90023. (213) 262-4596.


WANTED: Buy or swap Model 28 paper winders (LPW 300). Top prices paid for complete units or parts. Call or write Van, W2DLT, In NJ 800-212-1311, outside NJ 800-520-3662 Box 217, Berkeley Hts., NJ 07592.


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WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

WANTED: Early Hallicrafters Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachs, WS6EG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.


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## GaAs, TUNNEL DIODES, ETC.

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COAXIAL RELAY SWITCHES SPDT

Electronic Specialty Co./Raven Electronics
Part # 25028
Part # SU-01
260dc Type N Connector, DC to 1 GHz.

Amphenol
Part # 316-10102-8
115Vac Type BNC DC to 3 GHz.

Fxr
Part # 300-11182
120Vac Type BNC DC to 4 GHz.
FSN 5985-543-1225

Fxr
Part # 300-11173
120Vac Type BNC Same
FSN 5985-543-1850

BNC To Banana Plug Coax Cable RG-58 36 inch or BNC to N Coax Cable RG-58 36 inch.

$29.99

$39.99

$39.99

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Svdc turn on
PRICE EACH $3.50

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PRICE EACH $7.50

Grigsby/Barton Model GB7400
Svdc turn on
PRICE EACH $7.50

NOTE: *** Items may be substituted with other brands or equivalent model numbers. ***
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The Recall Phone Telephone employs the latest state of art communications technology. It is a combination telephone and automatic dialer that uses premium-quality, solid-state circuitry to assure high-reliability performance in personal or business applications. $49.99

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This pad contains all the electronics to produce standard touch-tone tones. New with data. $9.99 or 10/$89.99

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Perfect for those unscrambler projects. New with data. $19.99 or 10/$149.99

INTEGRATED CIRCUIT.

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FERRANTI ELECTRONICS AM RADIO RECEIVER MODEL ZN414 INTEGRATED CIRCUIT.

Features:
- 1.2 to 1.6 volt operating range
- Less than 0.5ma current consumption
- 150KHz to 3MHz Frequency range
- Easy to assemble, no alignment necessary
- Effective and variable AGC action
- Will drive an earphone direct
- Excellent audio quality
- Typical power gain of 72dB
- TO-18 package
New with data $2.99 or 10 For $24.99

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AA Battery Pack of 6 These are Factory New. $5.00

SUB C Pack of 10 2.5Amp/Hr. $10.00

Gates Rechargeable Battery Packs
- 12vdc at 2.5Amp/Hr. $11.99
- 12vdc at 5Amp/Hr. $15.99

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December 1982
### Eimac Tube Sockets and Chimneys

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### Prices

- 1 to 10 - .99¢
- 101 to 1000 - .60¢
- IS A SPECIAL PRICE: 10 for $7.50
- 11 to 50 - .90¢
- 101 & Up - .35¢
- 51 to 100 - .80¢
- 1000 For $350.00

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**TUBE CAPS (PLATE)**

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**Watkins Johnson WJ-V907**

Voltage Controlled Microwave Oscillator $110.00

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<th>Power output</th>
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<td>Spurious output suppression Harmonic (in dB)</td>
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<td>Residual FM, pk to pk, Max. 5kHz, pushing factor, Max. 8kHz/V, Pulling figure (1:5 VSWR), Max. 60MHz, Tuning voltage range +1 to +15 volts, Tuning current, Max. ~0.1mA, modulation sensitivity range, Max. 120 to 30MHz/V, Input capacitance, Max. 100pF, Oscillator bias +15 to +0.05 volts @ 55mA, Max.</td>
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**MHZ Electronics**

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**(For orders only)**

**Prices Subject to Change Without Notice**
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**TUBES**

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NOTICE ALL PRICES ARE SUBJECT TO CHANGE WITHOUT NOTICE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
TUBES MAY EITHER BE NEW OR SURPLUS CONDITION !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
"TVRO BOARD LIST"

**70 MHz IF BOARD:** This circuit provides about 43 dB gain with 50 ohm input and output impedance. It is designed to drive the Demodulator. The on-board bypass filter can be tuned to bandwidths between 20 and 35 MHz with a passband ripple of less than 4 dB. Hybrid ICs are used for the gain stages.

**SINGLE AUDIO BOARD:** 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 9052 coil tunes for recovery of the audio.

**DUAL AUDIO BOARD:** Duplicate of the single audio but also covers the 6.2 range.

**DC CONTROL BOARD:** No description.

---

**DUAL AUDIO BOARD**

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**DC CONTROL BOARD**

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<tr>
<td>1meg 1/4w</td>
<td>$.15</td>
</tr>
<tr>
<td><strong>TOTAL KIT PRICE</strong></td>
<td>$97.62</td>
</tr>
</tbody>
</table>

---

**DEMODULATOR BOARD**

<table>
<thead>
<tr>
<th>Printed Circuit Board</th>
<th>PRICE EACH</th>
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<tbody>
<tr>
<td>$40.00</td>
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<tr>
<td>1ufmd 35vd</td>
<td>$.59</td>
</tr>
<tr>
<td>47ufmd 50vd disc</td>
<td>$.35</td>
</tr>
<tr>
<td>470ufmd 25vd</td>
<td>1.29</td>
</tr>
<tr>
<td>100ufmd 16vd</td>
<td>$.69</td>
</tr>
<tr>
<td>2ufmd 35vd</td>
<td>$.59</td>
</tr>
<tr>
<td>47ufmd 35vd</td>
<td>$.59</td>
</tr>
<tr>
<td>4300pf sm</td>
<td>$2.00</td>
</tr>
<tr>
<td>330pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>100pf sm</td>
<td>$.10</td>
</tr>
<tr>
<td>91pf sm</td>
<td>$.10</td>
</tr>
<tr>
<td>2pf sm</td>
<td>$.10</td>
</tr>
<tr>
<td>2 to 8pf ceramic trimmer</td>
<td>$1.00</td>
</tr>
<tr>
<td>100uf choke</td>
<td>$1.50</td>
</tr>
<tr>
<td>4.7uf choke</td>
<td>$1.50</td>
</tr>
<tr>
<td>2.7uf choke</td>
<td>$.50</td>
</tr>
<tr>
<td><strong>TOTAL KIT PRICE</strong></td>
<td>$86.65</td>
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</tbody>
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**SINGLE AUDIO BOARD**

<table>
<thead>
<tr>
<th>Printed Circuit Board</th>
<th>PRICE EACH</th>
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<tbody>
<tr>
<td>$15.00</td>
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<tr>
<td>3pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>11pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>50pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>68pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>91pf sm</td>
<td>$1.00</td>
</tr>
<tr>
<td>.001ufmd</td>
<td>$.35</td>
</tr>
<tr>
<td>.01ufmd</td>
<td>$.35</td>
</tr>
<tr>
<td><strong>TOTAL KIT PRICE</strong></td>
<td>$55.14</td>
</tr>
</tbody>
</table>

---

**TVRO BOARD DESCRIPTION AND PARTS LIST**

**DUAL CONVERSION BOARD:** This board provides conversion from the 3.7-4.2 band first to 70 MHz where gain and bandwidth 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.

**DEMODULATOR BOARD:** This circuit takes the 70 MHz center frequency satellite TV signal in the 18 to 200 mill伏 voltage range, detects then using a phase lock loop, de-emphasizes and filters the result to produce standard NTSC video. Other outputs include the audio subcarrier, a DC voltage proportional to the strength of the 70 MHz signal, and AFC voltage centered at about 2 volts DC.

---

**70 MHz IF BOARD**

<table>
<thead>
<tr>
<th>Printed Circuit Board</th>
<th>PRICE EACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25.00</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL KIT PRICE</strong></td>
<td>$97.62</td>
</tr>
</tbody>
</table>

---

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<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency Range</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>95/90 DC</td>
<td>350MC Prescaler divide by 10/11</td>
<td>$8.50</td>
</tr>
<tr>
<td>95/91 DC</td>
<td>350MC Prescaler divide by 5/6</td>
<td>$6.50</td>
</tr>
<tr>
<td>110/90 DC</td>
<td>650MC Prescaler divide by 10/11</td>
<td>15.50</td>
</tr>
<tr>
<td>11091 DC</td>
<td>650MC Prescaler divide by 5/6</td>
<td>15.50</td>
</tr>
<tr>
<td>110C06 DC</td>
<td>UHF Prescaler 75MC D Type Flip Flop</td>
<td>12.30</td>
</tr>
<tr>
<td>110C05 DC</td>
<td>1GHz Counter Divide by 4</td>
<td>(Regular price $75.00) 50.00</td>
</tr>
<tr>
<td>110C01FC</td>
<td>High Speed Dual 5/4 Input NO/INOR Gate</td>
<td>15.40</td>
</tr>
<tr>
<td>82590</td>
<td>Presettable High Speed Decade/Binary</td>
<td></td>
</tr>
<tr>
<td>Counter used with the 110C90/91 or the 9589091 Prescaler can divide by 100 (Signetics)</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>110C240 DC</td>
<td>This chip is the same as a Motorola MC4024/4324 Dual TTL Voltage Control Multivibrator.</td>
<td>3.37</td>
</tr>
<tr>
<td>110C440 DC</td>
<td>This chip is the same as a Motorola MC4044/4344 Phase Frequency Detector.</td>
<td>3.37</td>
</tr>
</tbody>
</table>

GENERAL ELECTRIC CO. GUNN DIODE MODEL 2167F

- Freq. Gap (GHz) 12 to 18, Output (Min.) 100mW, Duty (%) CW, Typ. Bias (Vdc) 8.0, Type: Oper. (mAdc) 550, Max. Thres. (mAdc) 1000, Max. Bias (Vdc) 10.0 | $39.99 |

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- Noise Figure | 11dB | 23dB to 3dB |
- Power Output | +17dB | -2dB to |
- Gain Flatness | 1dB | 2dB to |
- Input Power Vdc | +24 | +15 |
- mA | 100 | 10 |

**PRICE** $75.00 $75.00

HEWLETT PACKARD MIXERS MODELS

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency Range</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10514A</td>
<td>2MHz to 500MC</td>
<td>10514B</td>
</tr>
</tbody>
</table>

Input/Output Frequency L & R | 200KHz to 200KHz |
Input/Output Frequency L & R | 500MC to 500MC |
Input/Output Frequency L & R | DC to 500MC |
Noise Performance (SSB) (A) | 7dB |
Noise Performance (SSB) (B) | 9dB |
Noise Performance (SSB) (C) | 9dB |

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FREQUENCY SOURCES, INC MODEL MS-74X MICROELECTRONIC SIGNAL SOURCE

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DELIVERY: Orders are normally shipped within 24 hours after receipt of customer's order. If a part has to be back-ordered the customer is notified. Our normal shipping method is UPS F.O.B. Chicago. When the purchase order is shipped, the package is normally shipped at the customer's expense. All claims for damage in transit must be filed with the carrier. In no event shall we be liable for loss or damage resulting from acts of God.

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Stuck with a problem?

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

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

**TE-12PA**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>67.0 XZ</th>
<th>85.4 YA</th>
<th>103.5 1A</th>
<th>127.3 3A</th>
<th>156.7 5A</th>
<th>192.8 7A</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.9 XA</td>
<td>86.5 YB</td>
<td>107.2 1B</td>
<td>131.8 3B</td>
<td>162.2 5B</td>
<td>203.5 7B</td>
<td></td>
</tr>
<tr>
<td>74.4 WZ</td>
<td>91.3 ZW</td>
<td>110.9 2Z</td>
<td>136.4 4Z</td>
<td>167.9 6Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77.0 XB</td>
<td>94.8 ZA</td>
<td>114.8 2A</td>
<td>141.3 4A</td>
<td>173.8 6A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>79.7 SP</td>
<td>97.4 ZB</td>
<td>118.8 2B</td>
<td>146.2 4B</td>
<td>179.9 6B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82.5 YZ</td>
<td>100.1 3Z</td>
<td>123.0 3Z</td>
<td>151.4 5Z</td>
<td>186.2 7Z</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

**TE-12PB**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>600</th>
<th>697</th>
<th>1209</th>
<th>1600</th>
<th>1850</th>
<th>2150</th>
<th>2400</th>
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</thead>
<tbody>
<tr>
<td>1000</td>
<td>770</td>
<td>1336</td>
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<tr>
<td>1500</td>
<td>852</td>
<td>1477</td>
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<tr>
<td>2175</td>
<td>941</td>
<td>1633</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>2805</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></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

$89.95

**COMMUNICATIONS SPECIALISTS**

426 West Taft Avenue, Orange, California 92667
(800) 854-0547/California: (714) 998-3021
The long-awaited new generation of Yaesu HF technology has arrived! New research in improved receiver filtering and spectral purity is brought to bear in the competition-bred FT-102, the HF transceiver designed for active Amateurs on today's intensely active bands!

Unique Cascaded Filter System
The FT-102 utilizes an advanced 8.2 MHz and 455 kHz IF system, capable of accepting as many as three filters in cascade. Optional filters of 2.9 kHz, 1.8 kHz, 600 Hz, and 300 Hz may be combined with the stock 2.9 kHz filters for operating flexibility you've never seen in an HF transceiver before now!

All New Receiver Front End
Utilizing husky junction field-effect transistors in a 24 volt, high-current design, the FT-102 front end features a low-distortion RF preamplifier that may be bypassed via a front panel switch when not needed.

IF Notch and Audio Peak Filter
A highly effective 455 kHz IF Notch Filter provides superb rejection of heterodynes, carriers, and other annoying interference appearing within the IF passband. On CW, the Audio Peak Filter may be switched in during extremely tight pile-up conditions for post-detection signal enhancement.

Variable IF Bandwidth with IF Shift
The FT-102's double conversion receiver features Yaesu's time-proven Variable Bandwidth System, which utilizes the cascaded IF filters to provide intermediate bandwidths such as 2.1 kHz, 1.5 kHz, or 800 Hz simply by twisting a dial. The Variable Bandwidth System is used in conjunction with the IF Shift control, which allows the operator to center the IF passband frequency response without varying the incoming signal pitch.

Wide/Narrow Filter Selection
Depending on the exact combination of optional filters you choose, a variety of wide/narrow operating modes may be selected. For example, you may set up 2.9 kHz in SSB/WIDE, 1.8 kHz in SSB/NARROW, and then select 1.6 kHz for CW/WIDE, and 600 Hz or 300 Hz for CW/NARROW. Or use the Variable Bandwidth to set your SSB bandwidth, and use 600 Hz for CW/WIDE and 300 Hz for CW/NARROW! No other manufacturer gives you so much flexibility in selecting filter responses!

Variable Pulse Width Noise Blanker
Ignition noise, the "Woodpecker," and power line noise are modern-day enemies of effective Amateur operation. The FT-102 Noise Blanker offers improved blanking action on today's man-made noise sources (though no blanker can eliminate all forms of band noise) for more solid copy under adverse conditions.

Low Distortion Audio/IF Stage Design
Now that dynamic range, stability, and AGC problems have been largely eliminated thanks to improved technology, Yaesu's engineers have put particular attention on maximizing intelligence recovery in the receiver. While elementary filter cascading schemes often degrade performance, the FT-102's unique blend of crystal and ceramic IF filters plus audio tone control provides very low phase delay, reduced passband ripple, and hence increased recovery of information.

Heavy Duty Three-Tube Final Amplifier
The FT-102 final amplifier uses three 6146B tubes for more consistent power output and improved reliability. Using up to 10 dB of RF negative feedback, the FT-102 transmitter third-order distortion products are typically 40 dB down, giving you a studio quality output signal.

Dual Metering System
Adopted from the new FT-101E transceiver, the Dual Metering System provides simultaneous display of ALC voltage on one meter along with metering of plate voltage, cathode current, relative power output, or clipping level on the other. This system greatly simplifies proper adjustment of the transceiver.

Microphone Amplifier Tone Control
Recognizing the differences in voice characteristics of Amateur operators, Yaesu's engineers have incorporated an ingenious microphone amplifier tone control circuit, which allows you to tailor the treble and bass response of the FT-102 transmitter for best fidelity on your speech pattern.

VOX with Front Panel Controls
The FT-102 standard package includes VOX for hands-free operation. Both the VOX Gain and VOX Delay controls are located on the front panel, for maximum convenience.

WARC Bands Factory Installed
The FT-102 is factory equipped for operation on all present and proposed Amateur bands, so you won't have to worry about retrofitting capability on your transceiver. An extra AUX band position is available on the bandswitch for special applications.

Full Line Of Accessories
For maximum operating flexibility, see your Authorized Dealer for details of the complete line of FT-102 accessories. Coming soon are the FV-1020M Synthesized VFO, SP-102 Speaker/Audio Filter, a full line of optional filters and microphones, and the AM/FM Unit.

Price And Specifications Subject To Change Without Notice Or Obligation

YAESU ELECTRONICS CORP., 6851 Walthall Way, Paramount, CA 90723 (213) 633-4007
YAESU Eastern Service Ctr., 9812 Princeton-Glendale Rd., Cincinnati, OH 45246 (513) 874-3100

582
Digital DX-terity...

General coverage, Superior dynamic range, 2 VFO's, 8 memories, Scan, Notch... COMPACT!

TS-430S

The TS-430S combines the ultimate in compact styling with advanced circuit design and performance. An all solid-state SSB, CW, and AM transceiver, with FM optional, covering the 160-10 meter Amateur bands, it also incorporates a 150 kHz-30 MHz general coverage receiver having a superior dynamic range, dual digital VFO's, 8 memories, memory scan, programmable band scan, IF shift, notch filter, all-mode squelch, and built-in speech processor.

TS-430S FEATURES:

- **160-10 meter operation, with general coverage receiver**
  With 160-10 meter Amateur band coverage, including WARC 30, 17, and 12 meter bands, it also features a 150 kHz-30 MHz general coverage receiver. Innovative UP-conversion digital PLL circuit, for superior frequency stability and accuracy. UP/DOWN band switches for Amateur bands or 1-MHz steps across entire 150 kHz-30 MHz range. Two digital VFO's continuously tunable from band to band. Band information output on rear panel.

- **USB, LSB, CW, AM, with optional FM**
  Operates on USB, LSB, CW, and AM, with optional FM, internally installed. AGC time constant automatically selected by mode.

- **Compact, lightweight design**
  Measures only 10-5/8 (270) W x 3-3/4 (96) H x 10-7/8 (275) D. Inches (mm), weighs only 14.3 lbs. (6.5 kg).

- **Superior receiver dynamic range**
  Use of 2SK125 junction-type FET's in the Dyna-Mix high sensitivity, balanced, direct mixer circuit provides superior dynamic range.

- **10-Hz step dual digital VFO's**
  10-Hz step dual digital VFO's operate independently, include band and mode information. Different band and mode cross-operation possible. Dial torque adjustable. STEP switch for tuning in 10-Hz or 100-Hz steps. A-B switch quickly shifts "B" VFO to the same frequency and mode as "A" VFO, or vice-versa. VFO LOCK switch provided. RIT control tunes VFO or memory. UP/DOWN manual scan possible using optional microphone.

- **Eight memories store frequency, mode, and band data**
  Memories store frequency, mode, and band data. Eight memory stores receive and transmit frequencies independently. M.CH switch for operation of memory as independent VFO, or fixed frequency.

- **Lithium battery memory back-up**
  Estimated five-year life.

- **Memory scan**
  Scans memories in which data is stored.

- **Programmable automatic band scan**
  Scans programmed band width. Scan-speed adjustable. HOLD switch interrupts band or memory scan.

- **IF shift circuit for minimum QRM**
  IF passband may be moved to place interfering signals outside the passband, for best interference rejection.

- **Tunable notch filter built-in**
  Deep, sharp, tunable, audio notch filter.

- **Narrow wide filter selection**
  NAR wide switch for IF filter selection on SSB, CW, or AM, when optional filters are installed. (2.4 kHz IF filter built-in.)

- **Speech processor built-in**
  Improves intelligibility, increases average "talk-power".

- **Fluorescent tube digital display**
  Indicates frequency to 100 Hz (10 Hz modifiable).

- **All solid-state technology**
  Input rated 250 W PEP on SSB, 200 W DC on CW. 120 W on FM (optional), 60 W on AM. Built-in cooling fan, multi-circuit final protection. Operates on 12 VDC, or 120 VAC, or 220-240 VAC with optional AC power supply.

- **All-mode squelch circuit, built-in**

- **Noise blanker, built-in**

- **RF attenuator (20 dB)**

- **Vox circuit, plus semi-break-in with side-tone**

Optional accessories:

- **PS-430 compact AC power supply.**
- **PS-30 or KPS-AC AC power supplies.**
- **SP-430 external speaker.**
- **MB-430 mobile mounting bracket.**
- **AT-130 compact antenna tuner.**
- **80-40 m inl. WARC.**
- **AT-230 base antenna tuner.**
- **160-10 m inl. WARC.**
- **FM-430 FM unit.**
- **YK-88C (500 Hz) or YK-88CN (270 Hz) CW filters.**
- **YK-88SN (1.8 kHz) narrow SSB filter.**
- **YK-88A (6 kHz) AM filter.**
- **MC-42S UP/DOWN hand microphone.**
- **MC-60A deluxe desk microphone, UP/DOWN switch.**

More information on the TS-430S is available from all authorized dealers of Trio-Kenwood Communications, 1111 West Walnut Street, Compton, California 90220.

KENWOOD...

pacesetter in amateur radio

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