NOVEMBER 1977

- general-coverage receiver with digital readout 10
- noise blanker design 26
- noise effects in receiving systems 34
- direct-conversion receivers 44
- receiver spurs and their cures 82
- and much more...

third annual receiver issue
## The new 2KD-5 linear amplifier...a one piece desk model with the power and reliability of a console

At Henry Radio, we know how to build only one kind of amplifier—the best. We want you to compare the 2KD-5 with any other desk model at any price. Remember, the 2KD-5 is only one model in the world's broadest line of amplifiers—both vacuum tube and solid state—for HF, VHF and UHF...fixed station and mobile...low power and high power.

Never before has any one company offered such a cornucopia of high power RF amplifiers. Remember also that Henry Radio offers a broad line of commercial and FCC type accepted amplifiers covering the range of 3 MHz to 500 MHz. Henry amplifiers are in use all around the world. Commercial and export inquiries are invited.

### 2KD-5...LINEAR AMPLIFIER

Offers engineering, construction and features second to none. Provides a long life of reliable service, while its heavy duty components allow it to loaf along even at full legal power. Operates on all amateur bands 80 thru 10 meters. If you want to put that strong clear signal on the air that you've probably heard from other 2K users, now is the time. Move up to the 2KD-5. Floor console...$995.00

### TEMPO 6N2

Brings the same high standards to the 6 and 2 meter bands. A pair of advanced design Eimac 8874 tubes provide 2000 watts PEP input on SSB or 1000 watts on FM or CW. Complete with self-contained solid state power supply, blower and RF relative power indicator. $895.00

### TEMPO 2002

The same line specs and features as the 6N2, but for 2 meter operation only...$745.00

### TEMPO 2006

Like the 2002, but for 6 meter operation...$795.00

### TEMPO VHF/UHF AMPLIFIERS

Solid state power amplifiers for use in most land mobile applications. Increases the range, clarity, reliability and speed of two-way communications. FCC type accepted also.

<table>
<thead>
<tr>
<th>Model</th>
<th>Drive Power</th>
<th>Output Power</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW BAND VHF AMPLIFIERS (35 to 75 MHz)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tempo 100C30</td>
<td>30W 100W</td>
<td>$159</td>
<td></td>
</tr>
<tr>
<td>Tempo 100C20</td>
<td>2W 100W</td>
<td>$179</td>
<td></td>
</tr>
<tr>
<td>Tempo 100C10</td>
<td>1W 100W</td>
<td>$149</td>
<td></td>
</tr>
</tbody>
</table>

**HIGH BAND VHF AMPLIFIERS (135 to 175 MHz)**

<table>
<thead>
<tr>
<th>Model</th>
<th>Drive Power</th>
<th>Output Power</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tempo 130A30</td>
<td>30W 130W</td>
<td>$189</td>
<td></td>
</tr>
<tr>
<td>Tempo 130A10</td>
<td>10W 130W</td>
<td>$179</td>
<td></td>
</tr>
<tr>
<td>Tempo 130A20</td>
<td>2W 130W</td>
<td>$199</td>
<td></td>
</tr>
<tr>
<td>Tempo 80A30</td>
<td>30W 80W</td>
<td>$149</td>
<td></td>
</tr>
<tr>
<td>Tempo 80A10</td>
<td>10W 80W</td>
<td>$139</td>
<td></td>
</tr>
<tr>
<td>Tempo 80A20</td>
<td>2W 80W</td>
<td>$159</td>
<td></td>
</tr>
<tr>
<td>Tempo 50A10</td>
<td>10W 50W</td>
<td>$99</td>
<td></td>
</tr>
<tr>
<td>Tempo 50A20</td>
<td>2W 50W</td>
<td>$119</td>
<td></td>
</tr>
<tr>
<td>Tempo 30A10</td>
<td>10W 30W</td>
<td>$99</td>
<td></td>
</tr>
<tr>
<td>Tempo 30A20</td>
<td>2W 30W</td>
<td>$99</td>
<td></td>
</tr>
</tbody>
</table>

**UHF AMPLIFIERS (400 to 512 MHz)**

<table>
<thead>
<tr>
<th>Model</th>
<th>Drive Power</th>
<th>Output Power</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tempo 70D30</td>
<td>30W 70W</td>
<td>$210</td>
<td></td>
</tr>
<tr>
<td>Tempo 70D10</td>
<td>10W 70W</td>
<td>$240</td>
<td></td>
</tr>
<tr>
<td>Tempo 70D20</td>
<td>2W 70W</td>
<td>$270</td>
<td></td>
</tr>
</tbody>
</table>

### TEMPO 100AL10 VHF LINEAR AMPLIFIER

Completely solid state, 144-148 MHz. Power output of 100 watts (nom) with only 10 watts (nom) in. Reliable and compact...$199.00

**TELEMETRO 100AL10/B BASE AMPLIFIER...$349.00**

Tempo solid state amplifiers are available at Tempo dealers throughout the U.S.

---

Henry Radio

11240 W Olympic Blvd. Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid. Anaheim, Calif. 92801 714/772-9200
816/679-3127

Prices subject to change without notice.
thoughts to consider about the new

DRAKE UV-3
UHF-VHF FM SYSTEM
only $995 for 3-band UV-3

How does the cost of the Drake system really compare to alternative methods of getting on 144-220-440 MHz fm?

A First of all, there is no direct comparison possible, because the Drake UV-3 is the only rig in the world offering 144-220-440 MHz fm in a single box — and it is fully synthesized on each band.

B The nearest comparison would be to add the suggested list prices of 3 separate units of the most popular fm rigs presently available. It would work out approximately as follows:

- **2 Meters** (Synthesized to 5 kHz) $400.00
- **220 MHz** (12 channels, crystal) $230.00
- **440 MHz** (12 channels, crystal) $300.00
- **Crystals** (Assuming 20 per radio) $200.00

**TOTAL** $1,130.00

But wait — even at that price you’d be missing features included in the UV-3:

1. Full synthesis on all three bands
2. Extra diode-programmable fixed channels on each band
3. Priority scan feature on each band
4. Remote, trunk mount operation (optional)
5. Everything in a single box!

For your homework, then, ponder the following — at a suggested amateur net of $995.00, the Drake UV-3 (144-220-440) is, to say the least, an incredible value.
Call toll-free 800-647-8660 for products by MFJ ENTERPRISES

$69.95

MFJ-16010 ST Super Antenna Tuner
This NEW MFJ Super Antenna Tuner matches everything from 160 thru 10 Meters; dipoles, inverted vees, long wires, verticals, mobile whipss, beams, balance lines, coax lines. Up to 200 watts RF OUTPUT. Built-in balun, too!
- Operate all bands with one antenna
- Works with all solid state and tube rigs
- Ultra compact: 5 x 2 x 6 inches
- Uses toroidal cores

$39.95

MFJ-16010 Antenna Tuner
Now you can operate all bands — 160 thru 10 Meters — with a single random wire and run your full transceiver power output — up to 200 watts RF power OUTPUT.
- Small enough to carry in your hip pocket. 2-3/16 x 3-1/4 x 4 inches
- Matches low and high impedance by interchanging input and output. SO-239 coaxial connectors. 12 position tapped inductor. Stacked toroid cores. At 1.8 MHz tuner matches 25 to 200 ohms.

$29.95

CWF-28X Super CW Filter
This MFJ Super CW Filter gives you 80 Hz bandwidth, and extremely steep skirts with no ringing for razor sharp selectivity that lets you pull signals out of heavy QRM. Plugs between receiver and phones or connect between audio stage for speaker operation.
- Selectable BW: 80, 110, 180 Hz
- 60 db down one octave from center frequency of 750 Hz for 80 Hz BW
- Reduces noise 15 db
- 2-3/16 x 3-1/4 x 4 inches
- CWF-2PC, wired PC board.

$69.95

MFJ-8043 IC Deluxe Electronic Keyer
This NEW MFJ Deluxe Keyer gives you more features per dollar than any other keyer available.
- Uses Curtis-8043 keyer chip
- Sends sematic, automatic semi-automatic, manual
- Uses Squeeze, single lever, or straight key
- Dot memory, self-completing dots and dashes, jam proof spacing, instant start, RF proof
- Solid state keying: 3,000 V max
- Weight, tone, volume, speed controls
- Uses 4 C-cells, external power jack
- 6 x 6 x 2 inches
- Sidetone and speaker
- Optional Squeeze key $29.95

$54.95

CMOS-8043 Electronic Keyer
State of the art design uses CURTIS-8043 Keyer-on-a-chip.
- Built-in Key
- Dot memory
- Lambs operation with external squeeze key
- 8 to 50 WPM
- Sidetone and speaker
- Speed, volume, tone, weight controls
- Ultra reliable solid state keying: 3,000 volts max
- 4 position switch for TUNE, OFF, SIDETONE OFF, Uses 4 penlight cells.
- 2-3/16 x 3-1/4 x 4 inches

$49.95

LSP-5208X II Log Speech Processor
Up to 400% more RF power. Plugs between microphone and transmitter.
- Gives your audio punch power to slice through QRM
- 30 db IC log amp and 3 active filters. RF protected
- 9 V battery
- Two Mic jacks: 1/4 phone jacks, uncommitted 4 pin jack
- Output cable: 2-1/8 x 3-5/8 x 5-9/16 inches
- LSP-5208X in standard MFJ enclosure, electronically identical.

$29.95

SBF-28X SSB Filter
Dramatically improves readability.
- Optimizes your audio to reduce sidetone splatter, remove low and high pitched QRM, hiss, static crashes, background noise. 60 and 120 Hz hum
- Reduces fatigue during contact.
- DX and ragchewing
- Plugs between phone and receiver or connect between audio stage for operator
- Selectable bandwidth IC active audio filter
- Uses 9 volt battery
- 2-3/16 x 3-1/4 x 4 inches

$29.95

MFJ-200BX Frequency Standard
Provides strong, precise markers every 100, 50, or 25 kHz well into UHF region.
- Exclusive circuitry suppresses all unwanted markers
- Markers are gated for positive identification. CMOS ICs with transistor output
- No direct connection necessary
- Uses 9 volt battery
- Adjustable trimmer for zero beating to WWV
- Switch selects 100, 50, 25 kHz or OFF.
- 2-3/16 x 3-1/4 x 4 inches

$29.95

MFJ-103BX Receiver Preselector
Clearly copy weak unreadable signals (increases signal 3 to 5 "S" units).
- More than 20 db low noise gain
- Separate input and output tuning controls give maximum gain and RF selectivity to significantly reject out of band signals and reduce image responses
- Dual gate MOS FET for low noise
- Strong signal handling abilities
- Completely stable
- Optimized for 10 thru 30 MHz
- 9 V battery
- 2-1/8 x 3-5/8 x 5-9/16 inches

$17.95

CPO-555 Code Oscillator
For the Newcomer to learn the Morse code.
- Send crisp clear code with plenty of volume for classroom use
- Self contained speaker, volume, tone controls, alumnun cabinet
- 9 V battery
- Top quality U.S. construction.
- Uses 555 IC timer
- 2-3/16 x 3-1/4 x 4 inches
- TK-555, Optional Telegraph Key $1.95

$19.95

C-500 Digital Alarm Clock
This digital alarm clock is also an ID Timer. Assembled, too!
- Gives ID buzz every 9 minutes automatically, or after tapping ID tone button
- Pressing ID tone button displays seconds
- Large, 63 inch digits
- Easilyzeros to WWV
- AM and FM LED indicators
- Power out indicator
- Fast set, slow set buttons
- 110 VAC, 60 Hz
- 3-1/8 x 3-3/4 x 3-3/8 inches
- One year warranty by Farnclrd

Order any product from MFJ and try it. If not delighted, return within 30 days for a prompt refund (less shipping).
Order today. Money back if not delighted. One year unconditional guarantee. Add $2.00 shipping/handling.
Order By Mail or Call TOLL FREE 800-647-8660 and Charge It On

MFJ ENTERPRISES
P. O. BOX 494
MISSISSIPPI STATE, MISSISSIPPI 39762
In Europe contact: ING I. STERN, Lohkoppelstrasse 27, 2000 Hamburg 76, West Germany. Tel.: (040) 299-6110, Telex: 2161808 STEX D
contents

10 high performance general-coverage communications receiver
Wayne C. Ryder, W6URH

26 noise blanker design
Wesley D. Stewart, K7CVT

30 calculating preamplifier gain from noise-figure measurements
H. Paul Shuch, N6TX

34 effects of noise in receiving systems
Ulrich L. Rohde, DJ2LR

44 direct-conversion receiver
D. W. Rollema, PA0SE

56 20-meter receiver with digital readout, part 2
M. A. Chapman, K6SDX

66 crystal-controlled harmonic generator
Kenneth W. Robbin, W1KNI
John R. True, N4BA

71 improved receiver selectivity and gain control
Michael J. Goldstein, VE3GFN

82 receiver spurious response and its cures
Leonard H. Anderson

90 high-dynamic range active mixer
Ulrich L. Rohde, DJ2LR

4 a second look
98 ham notebook

150 advertisers index
94 letters

133 flea market
8 presstop

146 ham mart
150 reader service
It was just thirty years ago, on December 23rd, 1947, to be exact, that a group of scientists at Bell Laboratories built a one-stage amplifier circuit around the world’s first transistor, giving birth to a whole new era of electronics and communications. But the beginning of the story was not in 1947, but long before. There had been hints of amplification in semiconductors as early as the 1920s but few experimenters could duplicate the results. Nobody realized the effect of semiconductor impurities nor understood the action of semiconductor materials.

In 1930, Dr. Julius Lilienfield, a German physicist, actually patented a semiconductor amplifier that could be compared to today’s mosfet. Although Dr. Lilienfield’s amplifier worked, it could not be duplicated by other workers, and it slowly slipped into oblivion.

In 1939, Dr. William Shockley made an entry into his lab notebook at Bell Labs, “It has today occurred to me that an amplifier using semiconductors rather than vacuum is in principle possible.” It was nearly eight years before this concept would bear fruit. A large part of this period was spent in learning more about that old bugaboo, semiconductor impurities.

The IN21 crystal detector, developed during World War II and the workhorse of wartime radar receivers, provided some of the impetus. After the war a solid-state research team at Bell Labs, co-headed by Dr. Schockley, started experimenting with germanium and silicon, two semiconductors that were easy to work with. As one of the group said recently, “We felt that the area was so fertile that you could devise an experiment in the morning, go out in the lab and try it in the afternoon, and write a paper about it that evening.”

The first device the group attempted to build was what is now called an insulated-gate fet. The device didn’t work. The group scrambled around, dug into the literature, and spent long hours discussing the alternatives.

Dr. Walter Brattain tried an experiment where he covered a metal point with a thin layer of wax and pushed it down on the surface of a piece of silicon. He then surrounded the point with a drop of water and made contact to it. The water was insulated from the point by the wax layer. He found that voltages applied between the water and the silicon would change the current flowing from the silicon to the point. Power amplification had been achieved! Unfortunately, the drop of water evaporated almost as soon as things were working well.

This led to experiments with other electrolytes that didn’t evaporate so readily. Then, they discovered a thin oxide layer on the surface of the semiconductor under the electrolyte and decided to eliminate the electrolyte and use a spot of gold as a field electrode.

When this was tried, an electrical discharge between the point and the gold spoiled a spot in the middle — when they washed off the electrolyte they had inadvertently washed off the oxide film, which was soluble in water. However, by placing the point around the edge of the gold spot they observed a new effect — when a small positive voltage was applied to the gold, the current flow was greatly increased. Four days later two gold contacts less than two-thousandths of an inch apart were made to the same piece of germanium and the first transistor was born.

Nine years later, in 1956, the three inventors, Dr. William Shockley, Dr. John Bardeen, and Dr. Walter Brattain were awarded the Nobel prize in physics. Little did they realize that their crude laboratory device would spawn a multi-billion dollar semiconductor industry that today affects all our lives.

Jim Fisk, W1HR
editor-in-chief
FURTHER ADVENTURES OF

The Mobile Marvel

ICOM, VHF MOBILE'S PEERLESS LEADER GOES ONE STEP BEYOND

The matchless IC-22S, the measure of quality and performance for all VHF mobile transceivers, now materializes with its splendid new frequency synthesizer as a flexible phenomenon. Faster than a digit switch, able to leap great frequencies in a single bound, the IC-22S Mobile Marvel is empowered with instant programming for 256 possible frequencies, making available any frequency on anybody's band-plan in a matter of minutes, while disguised as a mild mannered 22 channel radio.

It "hears through solid walls" with a magnificent high sensitivity receiver, employing a 1st IF monolithic crystal filter and two 2nd IF filters for improved rejection of 15 KHz adjacent channel signals. And with spurious attenuation far exceeding FCC specifications for even commercial type radios, the ICC-22S mobilizes 10 Watts of power.

Instantly available from your dealer, the IC-22S comes to you ready to perform amazing feats for even less than the cost of most old fashioned crystal controlled units. The meek and the mighty can avail themselves of the most in VHF mobile with the IC-22S, ICOM's Mobile Marvel.
SEPARATE REPEATER LICENSES will no longer be required and an Amateur operating a repeater will be able to do so simply by signing his regular call with the suffix /"RPT" on CW or "Repeater" on phone when in the repeat mode. This far-reaching deregulatory action came as a Report and Order on Docket 21033. Though agreement was universal throughout the Commission that separate repeater licenses were useful, it was agreed they required more Commission investment in time and money than they were worth.

The Repeater Subbands were also expanded, with an additional one MHz — 144.5 to 145.5 — now opened to repeaters on two meters and all Amateur frequencies above 220 MHz, with the exception of the 435-438 MHz space communications slot, now available for repeater use. The 10- and 6-meter repeater limits remain unchanged.

Licensees Will Receive another 500 kHz, down to 144.5 MHz, so they'll be able to use the new two-meter repeater subband, which neatly avoids the OSCAR activity just below 146 and also manages to straddle (assuming 600 kHz input-output separation) existing SSB and A-M simplex operation between 145.0 and 145.2. An interesting suggestion from W3LOY is that users of the new repeater subband standardize on 20 kHz channels, providing more repeater pairs than 30 kHz but without the adjacent channel problems that have plagued many users of the 15-kHz split.

20-kHz Channel Spacing for the new 2-meter repeater subband is receiving very strong support nationwide. The Northern Amateur Relay Council met in Sacramento the end of September and unanimously proposed a band plan with 144.51-144.89 for repeater inputs and 145.11-145.49 for corresponding repeater outputs. They designated the 144.9-15.1 slot for non-channeled SSB and CW use, with FM simplex relegated to outside the new one-megahertz band; 19 of the Northern California systems represented volunteered to move into the new band when it becomes available November 4.

FCC'S DECISION ON BANNING LINEARS for 10 meters and the Type Acceptance of Amateur of Amateur equipment has been put off until at least this month. The Commissioners have strongly supported type Acceptance, now limited to only Amateur linear amplifiers, and that docket — 21117 — alone would have passed without difficulty. However, a decision has been made to permit oral arguments on both dockets.

POINT-OF-SALE CONTROL of Amateur transmitting equipment was stressed by both the ARRL and Drake at the September 15 Congressional hearings on rewriting the Communications Act. Dick Horner, E.F. Johnson’s President, made a strong pitch for 220-MHz CB and drew some fire from the Amateur Radio representatives. Some observers felt the hearings were a bit disjointed, with our side making some good points but major emphasis on CB — particularly CB problems — rather than Amateur Radio.

A "TVI-PROOF" TV RECEIVER, built for the FCC by Texas Instruments, is reported to look very promising in preliminary tests. If the techniques TI has developed to reduce or eliminate TVI problems could be quickly adopted by the industry, a lot of the pressure for repressive rule making could be taken off the FCC. Amateur as well as CB and TV manufacturers are expected to be watching the Commission's tests with a great deal of interest.

DISTINCTIVE PREFIXES SUCH AS KG6 and KV4 are being discontinued for various Pacific and Caribbean Islands. Instead of their present unique prefixes, all Pacific area U.S. Amateurs will be issued KH6 calls while those in the Caribbean will receive KP4 prefixes. Present holders of calls with the discontinued prefixes will, however, be permitted to retain them indefinitely — the change applies only to new applicants from those areas.

The Prefixes Involved include KG6, KS6, KB6, KJ6, KM6, KP6, KW6, KV4, and KC4 (Navassa). The reasons for the change include freeing up a large number of Amateur call signs for future Amateur growth and reduction of the processing burden.

KANSAS CITY'S DISASTROUS FLOOD found Amateur Radio providing communications supporting police, fire, and other area relief agencies. The six area repeaters operated 'round the clock after 12 inches of rain flooded much of the city and drowned at least 23 people. W8DOAY, the emergency station located in the underground disaster center in Lee's Summit, operated from the center's emergency power system while providing key liaison between the Amateurs and municipal authorities. Area CBers were also valuable contributors to the volunteer communications effort, providing local communications which were relayed to the civil authorities via Amateur repeaters.

PRE-1917 AMATEUR LICENSEES must apply for "Grandfather" credit toward an Extra Class license before next March 1, after which it will no longer be offered. Grandfather credit has been available for quite a few years but no one has claimed it for some time.

General Class Amateurs licensed before 1933 would be grandfathered to Advanced if a petition filed with the FCC by Paul Halmacher of Milwaukee were granted. Comments on the petition, RM-2864, may be filed through October 19.
This ones for you.

Because you asked for it... we built it. The all-new JR. MONITOR™ Antenna Tuner.

Call it what you will—antenna tuner, matchbox, or matching network, the JR. MONITOR™ has it all wrapped up in one neat 5¼”W x 2½”H x 6”D all metal cabinet.

Here are the features you said you wanted:


With so many special features—think of the unlimited possibilities you’ll have for experimenting with dozens of antennas! For instance, the DenTron All Band Doublet fed with balanced feed line hooked to the JR. MONITOR™ covers 1.8-30 MHz in one antenna... or try this mobile suggestion: 108” mobile whip fed with coax to the JR. MONITOR™ located under the dash will give you 10-80 meter mobile coverage and no coils to change!

It’s easy to understand the excitement the JR. MONITOR™ has created. Wherever you are—home, boat, car, plane, or campsite you’ll always be in contact. It’s a fun little tuner that easily fits in a briefcase or coat pocket—but why would anyone want to smuggle it into their radio room?

JR. MONITOR™  $79.50
ALL BAND DOUBLET $24.50

DenTron
Radio Co., Inc.
2100 Enterprise Pkwy.,
Twinsburg, Ohio 44087
(216) 425-3173
The new standard of performance for Tribanders is the Wilson System One!!! A DX'ers delight operating 20 meters on a full 26' boom with 4 elements, 4 operational elements on 20-15-10, plus separate reflector element on 10 meters for correct monoband spacing. Featured are the large diameter High-Q Traps, Beta matching system, heavy duty Taper Swaged Elements, rugged Boom to Element mounting...and value priced at $259.95. Additional features: • 10 dB Gain • 20-25 dB Front-to-Back Ratio • SWR less than 1.5 to 1 on all bands.

MODEL SY-1 SPECIFICATIONS:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matching Method</td>
<td>Beta</td>
</tr>
<tr>
<td>Band MHz:</td>
<td>14-21-28</td>
</tr>
<tr>
<td>Maximum Power Input</td>
<td>Legal Limit</td>
</tr>
<tr>
<td>Gain</td>
<td>10 dB</td>
</tr>
<tr>
<td>VSWR (at Resonance)</td>
<td>1.5 to 1</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 ohms</td>
</tr>
<tr>
<td>F/B Ratio</td>
<td>20-25 dB</td>
</tr>
<tr>
<td>Boom Length</td>
<td>26'</td>
</tr>
<tr>
<td>No. of Elements</td>
<td>5</td>
</tr>
<tr>
<td>Longest Element</td>
<td>26' 7&quot;</td>
</tr>
<tr>
<td>Turning Radius</td>
<td>18' 6&quot;</td>
</tr>
<tr>
<td>Mast Diameter</td>
<td>2&quot; O.D.</td>
</tr>
<tr>
<td>Boom Diameter</td>
<td>2&quot; O.D.</td>
</tr>
<tr>
<td>Surface Area</td>
<td>7.3 sq. ft.</td>
</tr>
<tr>
<td>Windload Area</td>
<td>146 lbs.</td>
</tr>
<tr>
<td>Shipping Weight</td>
<td>50 lbs.</td>
</tr>
</tbody>
</table>

ADVANCED DESIGN LARGE DIAMETER HIGH-Q TRAPS FOR MINIMUM LOSS AND MAXIMUM POWER CAPACITY

INSULATED DRIVEN ELEMENT WITH PRECISION BETA MATCH AND HEAVY DUTY ELEMENT MOUNTS

AMATEUR PRODUCTS DEALERSHIPS FOR MANY AREAS ARE AVAILABLE!!!
If you are interested in the profits you can make as a Wilson Dealer, contact us.

For complete specifications on the above products or a copy of our new Amateur Products Buyers Guide, write:
Consumer Products Division

Wilson Electronics Corp.
P.O. BOX 19000 • LAS VEGAS • NEVADA • 89119 • (702) 739-1931 • TELEX 684-522
Don’t Buy an Amplifier on Toothpaste Claims

Buy a tube of toothpaste on the basis of outrageous exaggerations as to what it’ll do for your social life and it still may clean your teeth.

BUT if you buy a linear amplifier on the basis of toothpaste claims — or ambiguous specifications — you may end up with a real turkey!

Large differences in quality and performance exist among so-called “2 KW PEP” amplifiers. Thinking of buying another model that’s “just as good” as an ALPHA? Better thoroughly investigate the manufacturer’s reputation... and what, exactly, is promised in his specifications and warranty. Unless, of course, you like surprises.

EXAMPLE — Power Output & Efficiency:
An ALPHA 76 running key-down at one kilowatt DC input delivers well over 600 watts rf output, averaged over the 160 thru 10 meter amateur bands. Another current model “deluxe” linear managed less than 400 watts average output in identical tests using the same instrumentation. You’d never suspect it from reading the manufacturer’s claims and specs — and the deficiency was largely concealed by gross errors in the internal metering circuits!

EXAMPLE — Duty Cycle:
Ratings are sometimes ambiguous and can be misleading. One prominent amplifier manufacturer rates his desk model for full power in “intermittent amateur service.” (Just how intermittent he doesn’t say.) Another manufacturer hedges his “continuous” rating with time limits for one model, but not for a second model.

ALPHA specs say clearly, “No Time Limit.” And every ALPHA is backed by a factory warranty that extends 18 months — six times as long as other amplifier warranties!

It’s understandable why certain of our competitors hedge: the ALPHA 76’s forty-five pound transformer alone weighs as much as some of the complete linears for which they claim capability equal to the 76’s. And every ALPHA power transformer is efficiently cooled by ETO’s exclusive ducted air system. You owe it to yourself, before buying, to check how (if at all) the smaller transformers in those other desk-top linears are cooled.

To get the facts about what an ALPHA linear amplifier can do in your station, call or write your dealer or ETO direct for detailed literature. And ask for a free copy of our newly-updated guide to comparing linears.

ALPHA: Sure you can buy a cheaper linear... But is that really what you want?

Ehrhorn Technological Operations, Inc.
P.O. Box 708  ·  Cañon City, Colorado 81212  ·  (303) 275-1613

More Details? CHECK — OFF Page 150

november 1977
high-performance
general coverage
communications receiver

From the very early days of radio, receivers have been a compromise between performance and the available components, (and technology). At first there was the frustration of adjusting a coherer, and later, electrolytic, carborundum, and galena detectors. Then the tuned rf (TRF) receiver was developed; it eliminated tedious detector adjustments, but selectivity was poor and varied as the receiver was tuned. If the owner of a TRF receiver was unfortunate enough to live near a powerful transmitter, that was probably the only station he heard — regardless of where he tuned the receiver!

Some operators discovered that they could improve the selectivity of their receivers by using regenerative feedback which increased the effective Q of the tuned circuits. Tuning this super-regenerative receiver was critical, however, and frequently it oscillated, causing unwanted interference to nearby receivers.

In the mid 1920s some operators started using superheterodyne receivers which heterodyned the incoming signal down to 50 kHz or so. This arrangement provided uniform selectivity and good gain over the entire tuning range, but it wasn’t long before operators discovered the receiver responded nearly as well to signals 100 kHz from the desired operating frequency. A new i-f at 455 kHz provided a compromise between image rejection and selectivity.

In the early 1930s a single crystal was added for “single signal reception.” This simple filter worked well on CW, but was unusable on phone; and as the frequencies above 40 meters became popular, images became a problem. Up to three tuned circuits were placed in front of the first mixer to gain more selectivity in the front end, but this didn’t satisfactorily cure the problem. Some designers started using 1600 kHz (or higher) i-f systems to get rid of the images, but selectivity suffered. To restore the needed selectivity, double-conversion systems were introduced which used a 1600 kHz i-f for image rejection, and a 455 kHz i-f for selectivity. When high-frequency crystal filters became economical in the 1960s, they quickly found their way into amateur receivers. This is approximately where we stand today.

Although the single-conversion scheme with a crystal filter in the 5 to 10 MHz range works well for an amateur-band receiver, it can’t be used for a general-coverage receiver because the rf tuning range must avoid the passband of the crystal filter. In addition, front-end tuned circuits are still required to minimize response to image signals.

receiver design considerations

When you design a communications receiver, the first thing to do is to write down a list of the design goals. In most cases the goals are chosen to represent the difference between an existing receiver and one with better performance. Following is a list of design goals for the receiver described in this article:

1. Frequency range: 500 kHz to 30 MHz.

2. Sensitivity: 1 µV for 10 dB signal-to-noise ratio in a 6 kHz bandwidth; greater sensitivity invites overload problems and is usually not required.

3. In-band intermodulation distortion: suppressed 20 dB or more.

4. Out-of-band intermodulation distortion: down 70 dB or more.

5. Agc sensitivity: 100 dB change in rf signal level produces less than 10 dB change in audio output.

6. Frequency stability: 100 Hz drift per hour maximum in constant ambient temperature after 10-minute warmup.

7. Frequency display: digital, 1 kHz resolution or better.

8. Frequency lock: designed so no retuning will be required when the receiver is locked.

9. One-knob tuning: no thumbwheel switches or preselector adjustments when the receiver is tuned from one frequency to another.

By Wayne Ryder, W6URH, 115 Hedge Road, Menlo Park, California 94025
fig. 1. Block diagram of a high-performance communications receiver that tunes from 500 kHz to 30 MHz. The design features digital frequency readout, upconversion to 60 MHz, i-f selectivity at 10.7 MHz, and a unique digital control system to maintain frequency stability.

**Choice of i-f.** There are a number of factors which influence the selection of the receiver's i-f, including image response, oscillator tuning range, and i-f rejection. If the chosen i-f is too close to the highest input frequency, signals will leak through the rf stages to the i-f amplifiers. An i-f that is too close to the desired rf input frequency also enhances undesired image response. Finally, as the frequency of the i-f is increased, the local oscillator frequency must also be increased — and it's more difficult to build a stable oscillator at higher frequencies.

If you wish to tune the complete band from 500 kHz to 30 MHz, the i-f must be placed outside the tuning range, preferably above 30 MHz (placing it below 500 kHz leads to undesired image response, as discussed previously). When choosing an i-f above 30 MHz, select a frequency where there are no high level rf signals (between two vhf television channels, for example). Furthermore, choose an i-f which has no high level rf signals at the image frequencies. A receiver with an i-f at 40 MHz which tunes from 500 kHz to 30 MHz, for example, requires a local oscillator which tunes from roughly 41 to 70 MHz so images fall in the range between 71 MHz and 100 MHz; since this frequency range covers television channels 5 and 6 as well as a good part of the fm broadcast band, this i-f is obviously not a good choice.

For a high-frequency general coverage receiver, an i-f at 60 MHz represents a reasonable compromise. It falls between television channels 2 and 3, and its image frequencies are between 120 and 150 MHz, bands occupied primarily by low-power aircraft communications and other relatively low-power radio services. This is the i-f I chose for the receiver described in this article.

A low-frequency oscillator, say 5 to 6 MHz, could be mixed with thirty different crystals to provide the 60 to 90 MHz injection signal, but this would cause several problems: the 5-6 MHz signal falls within the passband of the receiver and many crystals are required. In addition, a large number of filters would be required to eliminate unwanted mixer products.

Another approach would be to build a 60 to 90 MHz oscillator which is electrically and mechanically stable, and provide an electronic lock circuit to keep the oscillator on frequency. This can be done with a

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>500 kHz to 30 MHz continuous change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>1 ( \mu )V for 10 dB signal-to-noise ratio (6 kHz bandwidth)</td>
</tr>
<tr>
<td>Image rejection</td>
<td>-87 dB</td>
</tr>
<tr>
<td>i-f rejection</td>
<td>-85 dB</td>
</tr>
<tr>
<td>Out-of-band IMD</td>
<td>-35 dB</td>
</tr>
<tr>
<td>Cross modulation</td>
<td>-25 dB</td>
</tr>
<tr>
<td>Agc range</td>
<td>100 dB for less than 10 dB change in audio</td>
</tr>
<tr>
<td>Audio distortion</td>
<td>less than 3 per cent</td>
</tr>
<tr>
<td>Audio output</td>
<td>3 watts</td>
</tr>
<tr>
<td>Power consumption</td>
<td>approximately 50 watts</td>
</tr>
</tbody>
</table>
up/down frequency counter if you add digital storage — a 7475 quad latch for each stage of the counter. When the lock button is pushed, the digital storage or memory is frozen. The counter continues to count the local oscillator and compares the measured frequency with that stored in memory. A dc voltage which corresponds to the error tunes a varactor diode in the oscillator, thus keeping the local oscillator locked on the frequency contained in memory. This is essentially the system used in this receiver. A block diagram of the receiver is shown in fig. 1; operating specifications are listed in table 1.

Front end. There are two filters preceding the rf amplifier: a 2-MHz highpass filter, and a 30-MHz lowpass filter. The 2-MHz highpass filter minimizes cross modulation of signals above 2 MHz caused by strong signals in the a-m broadcast band; it is automatically disconnected below 2 MHz by logic circuitry in the counter. Response of this filter is down 0.5 dB at 1.9 MHz, and 60 dB down at 1 MHz. If the receiver is not located within several miles of one or more 50 kW broadcast transmitters, this filter may not be required.

The 30-MHz lowpass filter attenuates signals above 30 MHz, particularly signals at the image frequencies between 120 and 150 MHz. The response of this filter is 45 dB down at 50 MHz, 70 dB down at 100 MHz, and at least 60 dB down out to 460 MHz, the upper frequency limit of the test equipment I had available.

The rf amplifier provides about 10 dB gain and will handle signal levels as high as 1 volt rms without appreciable overload or cross modulation. A double-balanced mixer, MX101, mixes the incoming signal with the 60.5-90 MHz first local oscillator to provide the 60-MHz first i-f. Since the 60-MHz lowpass filter is not resistive, a 200-ohm resistor at the output assures termination at all frequencies; 60-MHz lowpass and highpass filters follow the mixer.

The mixers I used require +7 dBm (5 mW) of local oscillator drive; I used +13 dBm (20 mW) oscillator injection to increase the dynamic range of the receiver. If even greater dynamic range is required, high-level double balanced mixers such as the Mini-Circuits SRA-1H should be used: this mixer requires an injection level from +15 to +22 dBm (32 mW to 158 mW).

First local oscillator. I tried several oscillator circuits including the Colpitts and the popular grounded-base oscillator which is popular in TV receivers and fm tuners; all suffered from problems with power supply hum and frequency drift. The modified Vackar oscillator I used in the final design is very stable and has negligible power supply hum. During the past half hour, as I was working on this article, I have been listening to a ssb net on 20 meters — no retuning of the receiver was required.

In the first local oscillator (see fig. 2) Q201 is a free running fet oscillator which is tuned by C210 from 60.5 to 90 MHz. The oscillator is followed by a source follower, Q202, and a grounded base amplifier, Q203. The ferrite bead in the base of Q203 prevents it from oscillating at about 600 MHz; this bead should not be omitted here or in other places where a 2N5179 is used as an amplifier.

Q301 provides gain and isolation between the oscillator and the first mixer; Q302 and Q303 provide isolation from the counter. Isolation is required because signals generated within the counter tend to leak backwards into the first mixer and produce spurious signals.

60-MHz amplifier. C401, C402, and L401 transform the 50-ohm output of the 60-MHz bandpass filter to about 1500 ohms. Q401 provides about 10 dB of gain to compensate for loss in the first mixer and the two 60-MHz filters; the gain is set by R401. MX401 combines the 60-MHz i-f with the second local oscillator signal at 49.3 MHz to produce the 10.7-MHz second i-f. Q402 provides isolation and gain from the second local oscillator to MX401. The output of MX401 is terminated with 200 ohms, like the first mixer, and transformed up to 1600 ohms by C403, C404, and L403 to drive a 6-kHz wide crystal filter. The output of the crystal filter drives Q403 which provides gain.

In the second local oscillator Q501 is a grounded-base crystal oscillator operating at 49.3 MHz; Q502 provides gain and isolation. Bandpass filter FL501 attenuates harmonics from the oscillator.

Information filters. Q601 provides matching to the filters. The filters are switched on by applying +18 volts through S1A to the diodes associated with each filter. The drive and termination values should be those specified by the filter manufacturer. The USB and LSB filters I used required 500 ohms, and the a-m filter required 1600 ohms. To provide uniform gain the output of the a-m filter is attenuated with an 1100-ohm resistor.

10.7 MHz i-f. U701 provides further i-f gain; Q701 provides 10 volts p-p voltage to drive the detectors; CR701 and CR702 comprise the agc detector. The output of the agc detector is set at approximately +3 volts and goes negative when a signal is applied. This detector has fast attack, about 10 ms, and slow decay to eliminate the necessity of shutting off the
Top view of the general-coverage receiver, showing layout of the logic ICs for the digital readout and digital frequency control. The second local oscillator and filter FL501 are in the shielded compartment to the left. The S-meter is in the upper right-hand corner.

agc and using an rf gain control for ssb and CW reception; CR703 and CR704 are the a-m detector. Q801 is a 10.7-MHz crystal-controlled oscillator which provides carrier for Q802, the product detector. Oscillator drive is about ten times greater than the signal level.

In the audio amplifier stage R1 is the audio level control which is connected to one half of an LM379 audio amplifier; the amplifier provides about 3 watts of audio. In the metering circuit S901 switches between the S-meter and vco error voltage. Q901, a source follower, provides a current source for the S-meter.

frequency counter

One half of an MC1004, U8, is a 1-MHz oscillator; the other half is used as a buffer. Transistor Q10 translates the ECL level from the MC1004 to TTL level for the 7490 divider chain. Note that only this ECL chip is operated between +5V and ground; all other ICs use -5V and ground. U18, U27, U36, and U45 divide the 1-MHz signal down to 100 Hz; U44 divides 100 Hz by 12; this counter is reset to four rather than zero because it must always go to count 15 in order to reset. Counts 4 through 13 provide 10 Hz or a 0.1 second counting period. Count 14 is decoded by U26, a 7420, and used to strobe the latches. Count 15, from pin 15 on U44, provides reset or preset for the counters.

The counters, U10 through U15 and U34, have two modes of operation. In the unlock condition they up-count the frequency of the first local oscillator; in the lock mode the counters are preset to the number located in latches U1 through U6 and U16, and count down to zero. U34, an MC10137 up-down counter, has four operating modes which are determined by the voltages on pin 7 (S1) and pin 9 (S2).

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>low</td>
<td>preset</td>
</tr>
<tr>
<td>low</td>
<td>high</td>
<td>count up</td>
</tr>
<tr>
<td>high</td>
<td>low</td>
<td>count down</td>
</tr>
<tr>
<td>high</td>
<td>high</td>
<td>hold (stop count)</td>
</tr>
</tbody>
</table>

For the 74192 up-down counters to count up, the input signal must be connected to pin 5; for count down the input signal is connected to pin 4. Clear is determined by the level on pin 14; load or preset is determined by the voltage on pin 11.

Unlock operation. Signals from the first local oscillator are fed to U34. The U34 outputs (Q1 through Q4) are translated to TTL level by U25 and fed to U16. During the strobe period the display is updated; during the reset period U34 is reset. Gates U33 and U20 direct U34 to count up, hold or reset. The 1000- and 1200-ohm resistors convert the TTL output to ECL level. Since one input to each gate in U7 is zero during unlock operation, the counter will always reset to zero.

The output from U34 goes through a ECL to TTL level converter into U32, a one-shot multivibrator. The purpose of U32 is to widen the pulse being counted to about 50 ns. During unlock U23, pin 9 is high, and the signal being counted goes to U15, pin 5, count-up input. At the end of the count, during the strobe period, information stored in U6 updates the 100-Hz display. Counters U10 through U14 operate in a similar manner.

Count period. 10 units or 0.1 second. The counters count the input frequency.

Strobe period. 1 unit or 0.01 second. The counters hold their count, and this latest count is transferred into the display through the 7475 latches.

Reset period. 1 unit or 0.01 second. The counters are reset to zero and held there until the start of the next count period. Note that the 10-MHz display is connected to its latch, U1, differently than the others. This is done so the 10-MHz display will read the frequency to which the receiver is tuned rather than the actual frequency of the first local oscillator.

Lock operation. When the lock button is pushed, the circuit remembers the frequency of the first local oscillator in the 7475 latches, and when it drifts, brings it back to this frequency. Pushing the lock button sets an RS flip-flop which debounces the
null
Fig. 2. Schematic diagram of the high-performance general-coverage receiver. All feedthrough capacitors are 1000 pF or other.

Ceramic disc: Capacitors marked 0.01 to 2.2 μF are ceramic, monolithic, or tantalum types. Larger value capacitors are electrolytic.

Capacitors between 1 μF and 2000 μF are silver mica. The 0.001 μF bypass capacitors are ceramic disc; capacitors marked 0.01 are feedthrough capacitors.
FL-501 4 windings no. 24 (0.5mm) wire on 1/2" (13mm) form, 1/2"(13mm) between windings
L-402 7 turns no. 26 (0.4mm) on a 1/4" (6.5mm) slug-tuned form
MX-101, MX-401 Mini-circuits SRA-1 double-balanced mixer
T1 4 turns no. 30 (0.25mm) trifilar wound on a ferrite bead
T2 2 µH. Turns ratio of 3.3:1 (transformers used by the author were unmarked and probably were intended for an fm i-f strip)
T101, T102 Watkins-Johnson BT8. Construction as for T1 would probably be satisfactory
T501 10 turns no. 18 (1.0mm), 3/8" (9.5mm) diameter; secondary is 1 turn
T701 Primary is 40 turns, secondary is 15 turns, no. 32 (0.2mm) wire on Micrometals T30-6 toroid form
Beads Stackpole 57-180 or Amidon FB 43-101
pushbutton. Once the button is pushed and the RS flip-flop is set, it stays set even if the switch opens for an instant. The 7474 is connected as a divide by 2; each time the 7474 receives a positive edge trigger it changes state.

Signal is fed from the 7474 to the counter lock circuit. At the same time a relay is activated which switches the first local oscillator from a fixed voltage (developed by the two 10k resistors) to vcc control. The 5.1k and 300 $\mu$F capacitor on the base of the 2N3904 transistor driving the relay ensure the oscillator is not put into lock until the proper frequency is stored in the 7475 latches.

Back in the counter U22 receives the lock signal and waits until the strobe period to send a lock command to the counter. The counters cannot be put into lock when they are counting because they would record a partial count; this would cause the first local oscillator to attempt to lock to a frequency other than the frequency to which the receiver was tuned. The latches now contain the frequency at the time the lock button was pushed. They will retain this number until the lock button is again pushed to unlock the counter.

The latches are held closed by changing the level on U33 pin 2 to a zero; U7 is activated. During the reset period U34, instead of being reset to zero, is preset to the number stored in U16 and counts down from the number stored in U16 rather than counting up. The 74192 counters are loaded with the numbers contained in their 7475 latches and count from that number to zero.

error detector

U23, U19, and Q1 through Q5, a sample and hold circuit, provide compensation for oscillator drift. U23, an RS flip-flop, sets when it receives a borrow pulse from U10. The borrow pulse from U10 occurs when all counters have reached zero.

Operation when the oscillator stays on frequency, drifts up, and drifts down, is described below, but the examples are exaggerated. The first local oscillator, after a few minutes warm up, is sufficiently stable in unlock for at least 5 minutes of ssb reception without retuning.

Oscillator frequency remains constant. If the oscillator remained exactly on frequency, a borrow pulse would occur exactly at the end of the count period; U19A would not change state because U23 holds it in reset. U19B would not change state because it receives an S signal holding it in reset at the time it receives the signal from U23.

Oscillator increases frequency. If the oscillator frequency changed from 70 to 80 MHz, for example, the increased number of pulses would cause the counters to reach zero before the end of the count period; the borrow pulse would set U23. This would change the state of U19B and turn off Q2 which is normally held on by the $\bar{Q}$ output of U19B. This results in a positive-going signal at the collector of Q2 which turns on Q4. Q4 then partially discharges C1. This decrease in voltage passes through Q5, a source follower, causing an increase in varactor capacitance in the first local oscillator, thus reducing its frequency. At the end of count period U19B is reset by the S signal; U23 is reset during the reset period.

Oscillator decreases frequency. It should be noted that when the counter is in lock, the counters are allowed to continue counting during the strobe period. If the oscillator frequency was to go from 70 MHz to 60 MHz, U26 would not be set until sometime after the start of the strobe period. At the start of the strobe period U19B is held in reset. The U19A clock input receives the strobe pulse, thus changing its state and turning off Q1. This results in a positive-going signal which turns on Q3, increasing the charge across C1. This increase passes through Q5, the source follower, and on to the varactor diode in the oscillator. As the frequency of the oscillator increases the borrow pulse sets U23 and resets U19A; U23 is reset during the reset period.

low-frequency detector

U28, a 7430 8-input NAND gate, looks at U1 and U2 — if the first local oscillator is between 60 and 62 MHz the output of U28 goes low. This turns off the transistor located at the 2 MHz highpass filter, which in turn deactivates relay K1 and disconnects the 2-MHz highpass filter.

some initial problems

Initially the receiver was built on sheets of copper-clad circuit board with normal bypassing and decoupling, but without enclosing individual stages. The two mixers were on separate boards but completely exposed. When the receiver was together and working, there were two serious problems. First, without an antenna connected, at least 50 carriers could be heard in the receiver when tuning from 0.5 to 30 MHz. I first thought that this was caused by harmonics of the two local oscillators beating against one another and installed a filter at the output of the second local oscillator; this didn't cure the problem.

A 1000-MHz spectrum analyzer was then coupled into various points in the receiver. In the vicinity of the mixers, harmonics of the oscillator increased dramatically. This is due to the fact that mixers are switches being turned on and off by the local oscillator; switching generates square waves and square waves contain many odd-order harmonics. The rf and i-f assemblies were boxed up; amplifiers
Fig. 3. Schematic for the digital frequency readout and digital frequency control system. Although not shown here, install a 0.1 pF bypass capacitor at every fifth IC (+Vcc to ground). 22 pF, 15 volt bypass capacitors are installed on the +12, -12, +5 and -5 volt supplies. Digital displays are Hewlett-Packard type 5082-7300.
with low reverse gain were installed close to each mixer local oscillator input. Finally, the circuitry was rearranged to reduce radiation from the rf and i-f ports of the mixers. This involved adding a 60-MHz lowpass filter after the first mixer because of blowby from the 60-MHz bandpass filter.

The results were gratifying. The strongest birdie left had an equivalent signal level of about 1 \( \mu \)V. It is very possible this birdie is the result of feedthrough from the first mixer to the second mixer. A 60-MHz crystal filter would both increase selectivity and reduce feedthrough, but such filters are relatively expensive. If you build this receiver without the enclosures and shielding, signals will abound, with or without an antenna!

The second problem partially involved the first problem. One of the first signals heard when an antenna was attached turned out to be the audio from television channel 44 about 30 miles (50km) away. It was caused by harmonics from one of the mixers in combination with leakage through the 30-MHz lowpass filter. The response of the original 30-MHz elliptical lowpass filter started dropping off at 30 MHz but went back up at about 200 MHz. An M-derived filter solved the problem.

All amplifiers were evaluated using the 1000-MHz spectrum analyzer. The 2N5179 amplifiers were found to be oscillating at about 600 MHz. In every case a ferrite bead in the base lead stopped this oscillation.

**construction**

Most of the assemblies for this receiver are built on 1/16-inch (1.5mm) thick, single-sided copper-clad printed-circuit board. The same material is used for shields between successive stages. All stages except the last i-f have paper-thin copper foil (available at hobby stores) wrapped over the surfaces where the covers are attached. This reduces radiation into and out of the circuits, and minimizes TVI caused by the first local oscillator. All dimensions shown in the layout drawings (figs. 4 through 12) are inside dimensions. The lock control, audio amplifier, 2-MHz highpass filter, and S-meter circuitry are all built on PC boards without shielding or feedthrough by-passing.

![fig. 5. Layout of the 60-MHz bandpass filter. The coil form is a \( \frac{1}{8} " \) (13mm) slug-tuned National XR50. Tuning capacitance is provided by a slug mounted through the side of the shielded filter enclosure. Winding for each coil is 24 turns no. 30 AWG (0.25mm), spaced one wire diameter.](image)

### Counter

The counter is built on a board with space for forty-five ICs. The analog circuitry is installed on a piece of copper-clad circuit board mounted underneath the counter and is surrounded by a 2-inch (50mm) high frame with perforated top and bottom covers. A wire mesh covers the display. All dc connections have four ferrite beads, and 0.1 and 0.001 \( \mu \)F feedthrough bypass capacitors. This is important because of the high level of rf radiation from the counter circuitry.

The heatsink measures 3-1/2 x 2 x 1 (95x63x25.5cm) and is mounted so it doesn’t conduct heat to the main chassis. All high-power components — the counter and heatsink — are mounted on top of the chassis and air is allowed to convect around them for cooling. The circuitry below the chassis consumes relatively little power so heat generation is held to a minimum; this results in greater oscillator stability when the receiver is out of lock.

### Power supply

The power transformers, rectifiers,
Other components. The air variable capacitor used several years. Many of the parts I used in this receiver the 60-MHz in the first local oscillator, and the coil forms used in the original sources are unknown. The quality equipment will provide better results. You have available, but remember that the better test and align the receiver. Use the test equipment

Chassis and front panel. The chassis is 13-1/4 inches (33.7cm) wide, 10 inches (25.4cm) deep, and 2-3/4 inches (7cm) high. The front panel of the receiver is 13-7/8 inches (35.2cm) wide and 5-3/4 inches (14.6cm) high. These dimensions were chosen to fit into a cabinet I already had and are not critical.

test and alignment

Following is a list of test equipment which I used to test and align the receiver. Use the test equipment you have available, but remember that the better quality equipment will provide better results.

1. Rf signal generator covering 2 to 60 MHz with a calibrated attenuator, 0.1 μV to 0.1 volt rms (Measurements 80 or equivalent).

2. Rf signal generator covering 500 kHz to 2 MHz, 0.1 μV to 0.1 volt rms (necessary only if you want to check sensitivity below 2 MHz).


4. Rf voltmeter (such as the HP 410) or rf power meter (HP 430) to measure levels from zero dBm to +15 dBm.

5. Audio voltmeter with 30 mV full-scale sensitivity or oscilloscope with similar sensitivity.


7. Oscilloscope with minimum 10-MHz bandwidth (50 MHz bandwidth preferred).

Power supply. First check the input to the voltage regulator to verify that the voltages are approximately those shown on the schematic. Measure the output of all regulators for correct voltage output, and check to see that the supplies don’t lose regulation at 105 Vac line voltage.

Second local oscillator. Use a grid-dip meter to verify that the 49.3-MHz crystal oscillator is oscillating and crystal controlled. Connect an rf voltmeter or power meter to the second mixer input and adjust bandpass filter FL501. The windings in this filter are critically coupled and require careful step-by-step tuning. Using a small screwdriver, short capacitor C512; adjust C511 and C513 for maximum deflection on the rf indicator. Short C511 and adjust C510 and C512 for maximum output. Now make slight adjustments to C510 through C514. This run-through may need to be done several times to optimize the filter. Replace the rf indicator with a counter and adjust C501 so the oscillator frequency is

fig. 6. Layout of the first i-f assembly (60-MHz i-f amplifier, second mixer, 6-kHz crystal filter, and 10.7 MHz i-f amplifier; fig. 2). The unit is 1-inch (25mm) high.

fig. 7. Layout of the information filter assembly. The filters are mounted from the opposite side; standoffs are used to mount this unit to the chassis. The size and shape of this unit may be modified to accommodate filters which are available to the builder. Unit is 1-inch (25mm) high; last compartment is nearly empty.

49.30000 MHz. Adjust the J501 link so the level is about +13 dBm (about 1 volt rms). Connect drive to the second mixer. Install the cover and readjust C501 if necessary; replace the counter with the rf indicator and readjust C510 through C514.

First local oscillator. Connect the counter to the first local oscillator. Squeeze or spread turns on L201 so the oscillator will tune from 60.5 to 90 MHz. The 56 pF capacitor may require a change in value to achieve this range (installing the cover will slightly detune the oscillator). Replace the counter with an rf

<table>
<thead>
<tr>
<th>Components</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>C501</td>
<td>32 pF</td>
</tr>
<tr>
<td>L201</td>
<td>100 µH</td>
</tr>
<tr>
<td>C510</td>
<td>32 pF</td>
</tr>
<tr>
<td>C511</td>
<td>68 pF</td>
</tr>
<tr>
<td>C512</td>
<td>32 pF</td>
</tr>
<tr>
<td>C513</td>
<td>68 pF</td>
</tr>
</tbody>
</table>

The windings in the crystal filter, will probably have to be readjusted.
voltmeter or power meter and verify that the level is +13 dBm ±3 dBm from 60.5 through 90 MHz. Connect drive to the first mixer.

**I-f and rf alignment.** In fig. 13 is a block diagram showing sensitivity at various points in the receiver. The alignment can be done one assembly at a time, but using this diagram and checking one stage at a time can provide some comparison of sensitivity.

Adjust the signal generator to 10.7 MHz, 30 percent modulated with 400 Hz. Be sure the generator output impedance is 50 ohms; use a 6 dB pad if necessary. Connect an audio voltmeter (30 mV rms) to the output of the detector and turn the agc pot to minimum. Always maintain the generator output level so the voltage output at the detector is 30 mV or less.

The expected input to each stage, as shown in fig. 13, is provided by the rf generator; this level should provide 30 mV rms at the output of the a-m detector. The numbers shown are only approximate and will vary somewhat from receiver to receiver. In addition, the output of some rf-generators is not constant with frequency, so keep this in mind when making this test.

Connect the generator to the last i-f and terminate it with 50 ohms. Adjust the 60 pF variable capacitor for maximum indication on the output meter. Now move the generator to the input of information filter assembly and terminate in 50 ohms. Adjust all coils for maximum output. Go to USB and LSB and verify that the filters are working; slight adjustment of generator frequency will be required.

Switch back to a-m. Adjust the generator frequency to 60 MHz and connect it to the input of the i-f assembly. Adjust the coils and capacitor for maximum output. Now connect the generator to the input of the 60-MHz lowpass filter. Adjust the 60-MHz bandpass filter for maximum output; there is some interaction so it may require several adjustments. Connect the generator to the antenna input and verify that sensitivity is 1 µV or less for 10 dB signal-to-noise ratio.

**Product detector.** Connect the counter to the test point and adjust the trimmer for 10.700 000 MHz; verify LSB and USB operation.

**Agc and S-meter.** Connect the VTVM or dc-coupled scope to the agc line. Note that with no signal the agc line will be at about +3 volts. Now connect the signal generator to the receiver and tune both to about 10 MHz. Set the generator level at about 1 µV and turn the pot in the last i-f assembly so the agc voltage goes to about 2 Vdc. Turn the generator to 100,000 µV. If the receiver saturates, turn the agc level up until the receiver is out of saturation; the agc voltage should be about −0.25 volt. Disconnect the generator. Adjust R901 so the S-meter reads zero; connect the generator and adjust for 100 µV. Set the S-meter to S9 or wherever you would like it to indicate 100 µV.

**Counter check-out**

**Crystal oscillator.** Connect the counter to U18 pin 11 and set the trimmer so the oscillator is at 1.000 000 MHz. A fixed capacitor across the trimmer may be required to bring the oscillator on frequency. If the oscillator is not operating, increase R1 until oscillation starts. Turn the receiver ON and OFF several times to ensure that the oscillator always starts. If everything is working properly, the first local oscillator will now lock on frequency when the pushbutton is pressed. Turn S901 to vco error and adjust R903 for a midscale reading. Note that adjusting the tuning will cause the meter to move away from the center. At about 2 volts and 8 volts, the oscillator will go out of lock.

**Counter troubleshooting.** If the counter will not go into lock, the following test procedure may be used to localize the problem. Note that most problems are caused by wiring errors, faulty ICs, or bad sockets.

**Table 2. ECL and TTL logic levels.**

<table>
<thead>
<tr>
<th>Logic Level</th>
<th>TTL</th>
<th>ECL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logic Zero</td>
<td>0 to 0.8 V</td>
<td>-1.5 to -5.0 V</td>
</tr>
<tr>
<td>Logic 1</td>
<td>2 to 5 V</td>
<td>-0.5 to -0.9 V</td>
</tr>
</tbody>
</table>

All logic levels should be within the voltages shown in table 2. TTL for example should always be below 0.8 V or above 2.0 V; never in between.

Bring the counter out of lock; the meter will go to...
almost full scale. Check for 100 Hz at U44 pin 2. Check for a 10 ms wide strobe pulse at U35 pin 11 and pin 12; check for similar reset pulses at U35 pins 3 and 4. Verify that U32 pin 9 changes state each time the lock button is pushed. See if U22 pin 12 is changing state; if not check the lock board. The 7400 RS flip-flop should change state each time the button is pushed and go back to its original state when the button is released. The 7474 should change state each time the button is pushed and stay until the button is pushed again.

The frequency being counted comes out of U34 as a 20 ns wide pulse and is stretched out to 50 ns by U32. This 50 ns pulse becomes very difficult to see as it is divided down by the counters. Therefore, a low-frequency generator, at 1 MHz for example, makes investigation much easier.

Keep in mind that the most significant digit (MSD) has been modified to display receiver frequency so it will not correctly show the oscillator frequency.

Feed about 50 mV rms at 1 MHz into transformer TI and look for 100 kHz pulses at U42 pin 3 (ECL level) and U42 pin 4 (TTL level) interrupted by strobe and reset pulses. The pulse from U32 pin 6 may be temporarily widened by adding a 200 pF capacitor between U32 pins 10 and 11. Check that the counter continues to count in lock.

Now remove U32 and connect the signal generator through the interface shown in fig. 14 to U32 pin 6. Set the generator level to 3 or 4 V p-p; unlock the oscillator. Check for the pulse on pin 5 of U10 through U14. Push the lock button and check for the pulse on pin 4 of U10 through U14. By changing the frequency of oscillator, U23, an RS flip-flop, should be set momentarily and then reset with the reset pulse. U19 pins 6 and 8 should normally be high and go low depending upon the arrival time of the borrow pulse.

Connect a voltmeter to Q5 source and remove U19. Connect the signal generator through a TTL interface circuit to U19 pin 8. The voltmeter should indicate about +10 volts or more. Now connect the generator to U19 pin 6; the voltmeter should read +2 volts or less.

2-MHz filter driver. Connect the oscilloscope to U28 pin 8. The output should be high when the receiver is tuned above 2 MHz, and low when the receiver is tuned below 2 MHz.

**receiver performance tests**

There are several ways to check each parameter of receiver performance, and each of the tests described here can be accomplished in many other ways.

**fig. 10. Layout of the product detector which contains the carrier oscillator (Q801) and the mixer (Q802). The unit is 1 inch (25mm) high.**

**Signal-to-noise ratio** is a measure of how much signal is required to be 10 dB greater than the internally generated noise of the receiver. This test must be performed with the agc turned off (or set to minimum). Use caution not to overload the receiver. Tune the receiver and generator to 10 MHz (or other desired frequency) and set the modulation on the generator to 30 per cent. Connect an audio voltmeter to the a-m detector. Increase the signal generator output until the signal at the detector output is 10 dB above the receiver's noise floor. Output from the generator should be 1 µV or less; on my receiver it was 0.5 µV at 10 MHz, and 0.6 µV at 28 MHz.

**Receiver intermodulation.** There are two types of receiver intermodulation (IMD) tests. The first is to check the level of intermodulation products of signals outside the passband of the receiver; the second is to measure the intermodulation of two signals within the receiver's passband.

**Out-of-band intermodulation.** Tune the receiver
**Agc range.** This is a measure of the change in audio output for a level change of the incoming rf signal. When changing the signal generator level from 1 µV to 100 mV the audio level in my receiver changed less than 10 dB (this measurement will vary with the setting of the agc control).

**I-f rejection.** This is sometimes called i-f blowby and indicates how far down leakage is at the first i-f with reference to the operating frequency. Tune the generator to 60 MHz and note the generator level for a 10 dB signal-to-noise ratio. Now tune the generator and receiver to 10 MHz and note the generator level for a 10 dB signal-to-noise ratio. The measured difference in my receiver was 85 dB.

**Image response.** This is a comparison between response to a desired in-band signal and its image. In the receiver described here a desired signal at 10 MHz has an image at 130 MHz. The measured difference in input level for the same output was 87 dB.

**Cross-modulation.** For this test two signal generators are connected as shown in fig. 16. One generator is tuned to 11 MHz and the output level is set to 200,000 µV, 30 per cent modulated; this is the interfering signal. The other signal generator is tuned to 10 MHz and the output level is set from 30 to 11 MHz and adjust the variable 100 dB attenuator pad so the signal level is at the noise floor of the receiver (fig. 15). Subtract 3 dB from this reading because two generators are used, and write down the result. Now tune the receiver to 10 MHz and reduce the attenuator level so an audio voltmeter at the detector indicates the same as the first reading. The difference should be 80 dB or more. In my receiver it was 85 dB.

**In-band intermodulation.** Tune both signal generators into the passband of the receiver, signals spaced 2 kHz (fig. 15). Connect a spectrum analyzer to the last i-f, or a wave analyzer to the a-m detector. Note the difference between one generator and the first product removed from this generator signal displayed on the spectrum analyzer, or the difference in level between the 1 and 2 kHz signals on the wave analyzer. The difference should be 20 dB or more for 10 per cent distortion, which is acceptable for radio communications. The measured difference in my receiver was about 35 dB.

!![Image of the assembly containing the second local oscillator and the oscillator filter.](image)

**fig. 11.** Layout of the assembly containing the second local oscillator and the oscillator filter. FL501. This unit is 1½ inches (45mm) high; the increased size is needed to minimize detuning of the filter. Holes, ¼ inch (6.5mm) in diameter, are provided in the top for tuning up the oscillator and filter.

**fig. 12.** Construction of the first local oscillator. The total height of this unit is 2½ inches (57mm), including the ¼ inch (8.5mm) thick baseplate; a cover is provided to shield the oscillator circuitry and the tuning capacitor. This assembly is mounted on the main chassis with three 4-40 (M3) screws, and rubber grommets on the chassis. The tandem 6:1 and 36:1 Jackson Brothers drives provide an overall ratio of 216:1 at the front panel. The tuning capacitor is a 100 pF double-bearing air variable with brass plates. The oscillator coil is 6 turns no. 18 (1.0mm) enameled on a 3/8 inch (9.5mm) diameter form (slug removed).
TO
IN914
U32
PIN 6

fig. 14. Interface circuit for connecting the signal generator to U32 when troubleshooting the counter circuit.

100,000 μV, 30 per cent modulated. The receiver is tuned to 10 MHz. In this receiver, modulation from the interfering signal is 25 dB below that of the desired signal when the level of the desired signal is between 30 and 100,000 μV.

receiver performance

One of the best tests of receiver performance is to check to see at how many places on the dial a given frequency other than those listed in table 2. I have heard harmonics of KDFC and KGEI but this is not a fault of the receiver.

I built this receiver for two reasons: to see if it was possible to build a practical receiver with up conversion — and to see if it was feasible to build a practical up-conversion receiver with frequency lock. Both have been proven to my satisfaction. However, there are several useful features which are not built in, including a noise blanker, receiver incremental tuning (possibly with a varactor), notch filter, audio filter for CW reception, and receiver muting (or send/receive switch). Any or all of these features could be added by the experienced builder.

There are no plans for making printed-circuit boards for this receiver because standard PC construction would produce many unwanted spurious signals in the rf and i-f stages. PC construction might also lead to TVI from the first local oscillator.

I would like to thank Fred Scholtz, K6BXI, for help in the preparation of the article, and Marvin Kolber, K6PJU, for taking the photographs.

I would like to hear from anyone who makes any improvements in this receiver without degrading its overall performance.

references

1. J. Fisk, W1DYT, "Receiver Noise Figure, Sensitivity, and Dynamic Range," *Ham Radio*, October, 1975, page 8.

![fig. 14. Interface circuit for connecting the signal generator to U32 when troubleshooting the counter circuit.](image)

![fig. 15. Test set-up for checking intermodulation distortion. See text for test procedure.](image)

![fig. 16. Test set-up for measuring receiver cross-modulation. See text for test procedure.](image)
HEATHKIT: The name in Amateur radio...and now computers!

SB-104A Amateur Transceiver
The world-famous SB-104 with significant improvements. We've increased the sensitivity to 0.5 $\mu$V on all bands and included a fully assembled and tested receiver front end circuit board for reduced assembly time. The optional 400 Hz filter is independently selectable for CW operation. We've maintained the features that made it famous too — totally broadband, all solid-state, digital frequency readout and more. Make the SB-104A the "heart" of your station. Only $669.95

HW-2036 2-Meter Mobile Transceiver
Our value-standard 2-meter rig offers true digital frequency synthesis in 5 kHz steps and a built-in tone encoder to access most repeaters! Also features built-in simplex, $+\text{ and } -600 \text{ kHz offsets}$, and an aux. position that lets you add your own crystal for any other offset crystal you may want. The HW-2036 has 0.5 $\mu$V receiver sensitivity and a transmitter that can operate into an infinite VSWR without damage! Come on up to 2-meters with one of the best mobile rigs you can get. Only $269.95

FREE!
HEATHKIT CATALOG
Nearly 400 kits for you to build! Whatever your interest—hi-fi, television, automotive, marine, home appliances, test gear—it's all in our big new catalog.

Prices are mail order net F.O.B. Benton Harbor, Michigan. Prices and specifications subject to change without notice.

More Details? CHECK — OFF Page 150

HEATHKIT: The name in Amateur radio...and now computers!

SB-104A Amateur Transceiver
The world-famous SB-104 with significant improvements. We've increased the sensitivity to 0.5 $\mu$V on all bands and included a fully assembled and tested receiver front end circuit board for reduced assembly time. The optional 400 Hz filter is independently selectable for CW operation. We've maintained the features that made it famous too — totally broadband, all solid-state, digital frequency readout and more. Make the SB-104A the "heart" of your station. Only $669.95

HW-2036 2-Meter Mobile Transceiver
Our value-standard 2-meter rig offers true digital frequency synthesis in 5 kHz steps and a built-in tone encoder to access most repeaters! Also features built-in simplex, $+\text{ and } -600 \text{ kHz offsets}$, and an aux. position that lets you add your own crystal for any other offset crystal you may want. The HW-2036 has 0.5 $\mu$V receiver sensitivity and a transmitter that can operate into an infinite VSWR without damage! Come on up to 2-meters with one of the best mobile rigs you can get. Only $269.95

FREE!
HEATHKIT CATALOG
Nearly 400 kits for you to build! Whatever your interest—hi-fi, television, automotive, marine, home appliances, test gear—it's all in our big new catalog.

Prices are mail order net F.O.B. Benton Harbor, Michigan. Prices and specifications subject to change without notice.

More Details? CHECK — OFF Page 150

HEATHKIT: The name in Amateur radio...and now computers!

SB-104A Amateur Transceiver
The world-famous SB-104 with significant improvements. We've increased the sensitivity to 0.5 $\mu$V on all bands and included a fully assembled and tested receiver front end circuit board for reduced assembly time. The optional 400 Hz filter is independently selectable for CW operation. We've maintained the features that made it famous too — totally broadband, all solid-state, digital frequency readout and more. Make the SB-104A the "heart" of your station. Only $669.95

HW-2036 2-Meter Mobile Transceiver
Our value-standard 2-meter rig offers true digital frequency synthesis in 5 kHz steps and a built-in tone encoder to access most repeaters! Also features built-in simplex, $+\text{ and } -600 \text{ kHz offsets}$, and an aux. position that lets you add your own crystal for any other offset crystal you may want. The HW-2036 has 0.5 $\mu$V receiver sensitivity and a transmitter that can operate into an infinite VSWR without damage! Come on up to 2-meters with one of the best mobile rigs you can get. Only $269.95

FREE!
HEATHKIT CATALOG
Nearly 400 kits for you to build! Whatever your interest—hi-fi, television, automotive, marine, home appliances, test gear—it's all in our big new catalog.

Prices are mail order net F.O.B. Benton Harbor, Michigan. Prices and specifications subject to change without notice.

More Details? CHECK — OFF Page 150
A discussion of the design requirements for noise blankers which will effectively eliminate high amplitude, low repetition rate noise.

The principles of noise blanking are not new. The first description of the idea was published by Lamb in 1936; however, there are subtle design considerations that have been overlooked in some previously published designs. This article will try to explain some of these considerations and the trade-offs that accompany a practical design. In addition, a brief description of a working circuit, used in one of my receivers, is given. First, however, you have to understand what noise blanking can and cannot do.

Under most conditions, noise blanking can minimize the effects of short duration, high amplitude, low repetition rate noise on a desired signal. Examples are some automobile ignition noise, certain electrical arcing noise due to power lines, and make or break switching.

Noise, with the opposite characteristics, long duration, low amplitude and high repetition rate, is difficult to control. This category includes lightning crashes, brush arcing, some powerline noise, and receiver generated thermal noise. These types of noise, as well as most others, are best dealt with at the source, if possible, or by minimizing them with other techniques such as lower noise amplifiers and directive antennas. (An article by Nelson is an excellent source of information on noise sources.)

The reason a noise blanker is ineffective on lower amplitude and long duration pulses can best be understood by remembering that it operates by first sensing the presence of a noise pulse and then silencing the receiver for the duration of that pulse. The sensing operation requires discrimination between the signal and noise. Obviously, the greater the ratio between the two, the easier discrimination becomes. Silencing of the receiver is only permissible if the duration does not become so excessive that intelligibility suffers.

basic circuit

Now that the limitations are understood, let's examine a typical system. As shown in fig. 1, the incoming path is split into two channels. One channel is referred to as the main channel; the other, the noise channel. (The noise channel also contains signal, but the terminology is by convention.)

fig. 1. Block diagram of a typical noise blanking circuit. The signal is split into two paths, the noise or control signal plus the original communications signal. The delay is introduced to ensure that the two signals arrive at the blanking gate simultaneously.

By Wes Stewart, K7CVT, 1801 East Canada Street, Tuscon, Arizona 85706
With the fundamentals behind us, look at some of the finer points. First of all, you must decide where, in the receiver, to place the blanker. For one thing, the blanking must be done prior to the narrow bandwidth i-f filter. The reason for this can be seen by examining fig. 2. The top trace of the photograph shows a simulated noise impulse which was applied to a mechanical filter with a 2-kHz bandwidth; the bottom trace is the output from the filter. While this is an extreme example of pulse stretching due to filter ringing, it shows the necessity of blanking at a point of wider bandwidth. However, it must be done before strong out-of-band signals become a problem. I have found a bandwidth of 50 to 100 kHz to be a reasonable compromise.

Another factor to be considered is amplifier overload. If you wait until the signal has passed through several amplifiers before blanking, the amplitude of the noise impulses may be high enough to have already overloaded one or more stages. The effects of nonlinear amplifiers are well known and need no further discussion.

So far, everything seems to indicate blanking very near the antenna. But, before going any further, take a look at the requirements for some of the other circuitry.

**Noise amplifier.** The input must be amplified to a level high enough to operate the threshold detector. Since the threshold point is generally in the range of...
0.5 to 1 volt, the required gain may be extremely high if the input is small. This suggests placing the blanker at a point of high signal level. Again, there are two conflicting requirements and compromise is necessary. Also, for reasons of simplicity, the noise amplifier should be fixed-tuned which means it must be placed somewhere between the mixer and the narrow i-f filter. The bandwidth of the amplifier must, of course, be large enough to accurately follow pulse rise-time and minimize delay. If, as in my case, agc is used to obtain automatic threshold adjustment, the amplifier should maintain all of its desirable characteristics with agc applied.

Detector. The ideal detector would have a very definite threshold below which it has no output and above which it has a large output. The response time must be very fast. There are many regenerative types of circuitry that would work, but I have found the simple transistor design used in the sample design (fig. 3) to be adequate.

Pulse generator. The function of the pulse generator was outlined earlier. Since the requirements will depend on the type of gate used, one circuit will not satisfy every need. A design that may come close is the retriggerable, one-shot multivibrator using CMOS ICs. The retriggering action inhibits the gate for the duration of the noise pulse and then recovers very quickly. Risetime is relatively fast, but not so fast as to cause excessive transients and ringing. The voltage swing (0 to +15V) is high enough to operate most blanking gates. If required, CMOS gates may be paralleled for additional current capability.

Delay network. Since it takes a finite amount of time to amplify, detect, and form a pulse, a commensurate time delay should be introduced in the main channel to insure coincidence between the noise impulse and the blanking pulse. This delay is admittedly hard to come by at the higher frequencies and is left out in many designs. For lower frequencies the phase shift, through lowpass filters, is a reasonable method of introducing an apparent time delay. The amount of delay, \( t_d \), can be calculated from:

\[
\theta = \frac{\theta}{360 \cdot f}
\]

where

\[
\theta = \text{the phase shift in degrees}
\]

\[
f = \text{the frequency of operation}
\]

Blanking gate. Last, but perhaps most important, is the selection of a suitable gate. The characteristics of an ideal gate are: zero insertion loss when on, infinite insertion loss when off, and no feedthrough of any switching transients to the output. This last point is extremely important. Some switching circuits, while doing a good job of cutting off the signal, can generate transients of larger amplitude than the original noise pulse!

I have tried many different types of gates, series and shunt diode bridges, switching fets, bipolar transistor switches, and even a double-balanced mixer (DBM) operated as a current-controlled attenuator. After evaluating all of the different possibilities, I settled on the DBM because of its good performance and simplicity. For those not familiar with this application of the DBM, fig. 4 is a plot of attenuation vs control current at two different signal power levels.

practical circuit details

Fig. 3 is the complete circuit diagram of my blanker design. This particular circuit is installed in a modified Collins ARR-41 receiver. It is inserted
gates of U3 are used to develop the proper phase and current amplitude to operate the blanking gate.

**circuit performance**

Figs. 5, 6 and 7 demonstrate the performance that can be achieved with the circuit of fig. 3. The top trace of fig. 5 shows a signal with a simulated noise spike of 10 dB greater amplitude. The bottom trace is the same signal at the output of the blanking gate.

Fig. 6, made under the same conditions as above, shows, on the top trace, the detected output of Q3. The middle trace is the output of the one-shot as seen at pin 4 of U3D. The bottom trace is the blanker output. The only change in fig. 7 from fig. 5 was to increase the noise to signal ratio to 40 dB and reduce the top trace vertical sensitivity to 500 mV per division. Almost total elimination of the noise at the output is clearly evident.

**references**

Calculating Preamplifier Gain from Noise-Figure Measurements

Discussion of a new technique for calculating the gain of VHF/UHF preamplifiers from noise-figure measurements.

Noise-measurement sessions have become a popular and regular feature of the various VHF/UHF conferences held around the country. In addition to giving the individual experimenter an opportunity to check out his VHF/UHF preamplifiers and converters on precision noise-measuring equipment, the published results allow an annual comparison against the previous year’s performance, and provide an index of technical progress in amateur receiver design. In addition, the noise-figure measurements foster a competitive spirit which spurs many experimenters into upgrading their VHF receiver performance. Those amateurs who provide the measuring equipment are similarly inspired to improve the accuracy of their instrumentation and noise-measurement techniques.

The technique presented here, which allows indirect measurement of preamp gain, is an illustration of the latter effect. When I was asked by Wayne Overbeck, N6NB, Chairman of the 1977 West Coast VHF/UHF Conference, to conduct the receiver noise-figure measurements, I was at once flattered and shattered. Flattered because it was an honor afforded to few amateurs — but shattered by the prospects of carting an automatic noise-figure indicator, two noise heads, an i-f strip, five converters, two step attenuators, two power supplies, three signal generators, a power meter, and assorted pads, adapters, and cables 300 miles (480 km) each way in the back seat of my small imported car. The most practical suggestion for coping with the latter problem came from one of my students: “Rent a trailer.” Not being as practical as he, I had another thought, “Find a way to make the measurements with less test equipment.”

Importance of Gain Information

Fully half the test equipment listed above is used not for measuring noise figure at all, but rather for measuring the gain of the preamplifiers being tested. Gain information is necessary if true preamplifier noise performance is to be evaluated, because to measure the noise figure (NF) of a preamplifier, it must be connected to a converter. The converter will add some noise to the system, and to accurately characterize a preamp, this noise must be subtracted from the measured noise figure. Since the converter’s effect on measured noise figure is a function of preamp gain, it is impossible to accurately measure a preamp’s noise figure without knowing its gain.

The relationship between preamp gain, converter NF, preamp NF, and the noise figure of the cascade is summarized by Friis’ well-known equation

\[ F_T = F_1 + \left( \frac{F_2 - 1}{G_1} \right) \]

where

- \( F_T \) = total Noise Factor
- \( F_1 \) = preamp Noise Factor
- \( F_2 \) = converter Noise Factor
- \( G_1 \) = preamp gain

all of the above measurements are power ratios (not dB).

Since both noise figure and gain are generally expressed in dB, it is necessary to convert to ratios before applying the above formula, thus:

\[ F \text{ (ratio)} = \text{Antilog} \left( \frac{NF \text{ (dB)}}{10} \right) \]

Why Measure Gain

Unless a preamp’s gain has been measured, eq. 1 results in two unknowns; to eliminate gain measurements (and avoid renting a trailer), it was evident that

By H. Paul Shuch, N6TX, Microcomm, 14908 Sandy Lane, San Jose, California 95124
I had to find a way to solve for both unknowns. My math students reminded me that this could be accomplished only with two simultaneous equations. Clearly what was needed was yet another expression for preamp performance which contained no parameters other than those which could be measured on a noise-figure meter.

Inspiration struck when I considered solving Friis’ equation for isolating the noise factor of a preamp of known gain, in front of a known converter, from the noise measurement of the cascade:

\[ F_I = F_T - \frac{(F_2 - 1)}{G} \]  

Imagine what the expression would be if the same preamp were measured in front of another converter of noise factor, \( F_3 \), yielding a new cascade noise factor, \( F_{T'} \). Now

\[ F_I = F_{T'} - \frac{(F_3 - 1)}{G} \]  

Since \( F_I, F_{T'}, F_2, \) and \( F_1 \) can all be measured on a noise-figure indicator, eqs. 3 and 4 represent two equations in two unknowns! This means we can now calculate gain solely as a function of noise-figure measurements; no gain measurements are required.

\[ F_T - \frac{(F_2 - 1)}{G} = F_{T'} - \frac{(F_3 - 1)}{G} \]  

\[ F_T = F_{T'} + \frac{(F_3 - 1)}{G} \]  

\[ G = \frac{(F_2 - 1) - (F_3 - 1)}{F_T - F_{T'}} \]  

\[ G = \frac{F_2 - F_3}{F_T - F_{T'}} \]  

And knowing gain, we can solve for corrected preamp noise factor using either eq. 3 or eq. 4.*

**eliminating the second converter**

From eq. 5 it can be seen that preamp gain data can be derived from two different cascade NF measurements (\( F_I \) and \( F_{T'} \)) of the preamplifier in front of two converters of known and different noise factors (\( F_2 \) and \( F_3 \)). Although we have eliminated the requirement for signal generators, step attenuators, power meters, and any other equipment associated with gain measurement, we now require two different instrumentation converters for each band at which preamps are to be measured. Hello again, U-Haul!

Actually, a single converter for each band can be used for both measurements, by preceding it with a precision pad for the second measurement to degrade its noise figure by a known amount. \( NF_1 \) (in dB) would be approximately equal to \( NF_2 \) plus the loss of the pad, both in dB.* Of course, these numbers would be converted to ratios using eq. 2, before calculating gain from eq. 5.

If a precision 10 dB pad is used to transform \( F_2 \) to \( F_3 \), the gain formula becomes:

\[ G = \frac{9F_2}{F_{T'} - F_T} \]  

The measurement procedure is relatively straightforward:

1. Measure \( NF_2 \), noise figure of the converter
2. Measure \( NF_{T'} \), noise figure of the preamp-converter cascade
3. Insert a precision 10 dB pad between the preamp and converter
4. Measure \( NF_{T''} \), noise figure of the preamp-pad-converter cascade
5. Convert the three NF measurements to power ratios using eq. 2
6. Calculate gain (ratio) from eq. 6
7. Calculate corrected preamp noise factor (ratio) from eq. 3
8. If desired, convert \( F_I \) to dB:

\[ NF_1 \ (dB) = 10 \log_{10} F_1 \ (ratio) \]

**accuracy limitations**

Contrary to popular belief, the process of measuring uhf receiver noise figure is highly imprecise, even with such precision equipment as the Hewlett-Packard 340 Automatic Noise-Figure Indicator with argon-discharge noise head. In the near future, Bob Stein, W6NBI, has promised to present a discussion of noise figure indicators and their relative accuracy.

*In fact, the converter-pad combination exhibits a noise figure slightly greater than the sum of pad loss and converter noise figure. This is because there are really two sources of NF degradation when the pad is inserted: the power loss of the pad (its marked attenuation value), and thermal noise generated within the resistance of the pad as a function of its being a warm body (relative to absolute zero). If the attenuation of the pad is fairly high (I use 10 dB), the thermal noise contribution becomes negligible and can be omitted from calculations.

*An HP-25 program for calculating noise figure and gain from these equations is available from the author upon receipt of a self-addressed, stamped envelope.
in *ham radio*. Without listing all the various error sources here, suffice it to say that measurements of the type traditionally taken at the regional vhf/uhf conferences are accurate to within only about ±1 dB.

Why then, do we bother with this annual ritual? Primarily because the measurements made at these conferences are a good relative indication of the comparative performance of various designs and devices. You may be confident that the 1296-MHz preamplifier yielding the lowest noise figure at a particular competition is indeed the lowest noise-figure device, although, of course, the actual numbers are of limited significance.

I must caution participants in noise-figure competitions against drawing firm inferences from the comparison of data taken on different occasions, on different equipment, or at different times. The fact that all two-meter converters measured this year had lower noise figures than those measured last year is not necessarily an indication of technological progress. It's quite possible that differences from year to year are merely a function of divergent measurement errors.

Nonetheless, the "tweak and optimize" procedure generally followed at these noise-figure measurement competitions is entirely valid because the measurements are a good relative indication of receiver performance. I should point out that extensive tuning is not noted for greatly improving noise performance. If the equipment under test is operating reasonably well on the air a minor tweak of the input circuitry, as well as a possible adjustment to bias level, will usually suffice. In fact, I have seen converters tuned to within an inch of their lives, only to end up delivering a much lower NF at some frequency out of the band (usually the image frequency).

Along the same lines, note that if tuning the converter's local-oscillator chain results in an indicated NF improvement, it is only because the spurious components generated by optimizing the LO result in multiple mixing products. In short, tweak sparingly!

Since preamp gain information is to be extracted from noise-figure measurements, the numbers derived for gain are subject to the same ambiguity which surrounds the measurement of noise figure. Further, considerable measurement error can result if the preamplifier gain should change between the measurement of \(F_T\) and \(F_T^r\). Since the input impedance of all converters is not necessarily 50 + j 0 ohms, it is likely that a preamp will see different load impedances with the 10 dB pad installed and removed; if the preamplifier's stability is marginal, the result may be a several db gain variation. This will adversely effect both gain and NF measurement accuracy, but can be minimized by placing yet another loss pad (aside from the one used to establish \(F_T^r\)) in front of the converter for both measurements, to mask input mismatch.

If preamp gain and converter NF remain constant throughout the measurement sequence, this method appears capable of estimating preamp gain to an accuracy on the order of ±1 dB per 10 dB of gain.

**Santa Barbara field trial**

I left my gain measuring gear at home and tried this technique at the West Coast VHF/UHF Conference in Santa Barbara in May, 1977. The results of measuring gain and noise figure of 57 different preamps in the 144, 220, 432, 1296, and 2304 MHz bands correlated closely both with theory and expectations. Several preamps registered unusually high gain, but errors were within the accuracy limits outlined previously. The only severe difficulty encountered was in measuring extremely high-gain (30 dB or so) multi-stage preamplifiers; these tended to overdrive the converters, sometimes introducing enough measurement error to yield values for \(F_T^r\) lower than \(F_T\). Needless to say, under these conditions the computations fall apart.

Most of the participants in the NF competition were reasonably satisfied with the NF and gain measurements derived from this technique. There were, of course, a few who said, "Your measurements are all screwed up — I know my preamp's better than that," but I hear this at all NF competitions, regardless of the equipment or techniques which are used. The method will probably be retained at future West Coast Conferences, and is being recommended for use at the Eastern and Central States events as well.

**disclaimer**

I make no claim whatever that the technique presented here for noise-figure measurements is original. However, I have never personally seen the technique applied before, and have no knowledge of anyone else either advocating or using it. But the measurement is so simple, the concept so obvious, that I would fully expect someone, somewhere, has thought of it before. That doesn't matter. What counts is that we hams have yet another measurement tool at our disposal, one which hopefully will enable us to upgrade our vhf and uhf receivers and skills. Please don't consider these measurements sacred; this is, after all, *amateur radio*.

**reference**

THE ALL SOLID STATE

ATLAS 350-XL

Its face has many interesting features:

- **350 WATTS SOLID STATE POWER**
- **SSB/CW TRANSCEIVER**
  - SSB with PTT or VOX operation and full break-in CW operation.
- **CW-LSB-USB FILTER**
  - Selection of upper or lower sideband with 2700 Hz bandwidth, 1.6 to 1 shape factor, or 500 Hz CW bandwidth with 2.5 to 1 shape factor.
- **AF NOTCH FILTER**
  - Provides better than 40 dB rejection of an audio frequency, adjustable from 300 to 3000 Hz.
- **ANALOG DIAL SCALE**
  - 0 to 500 kHz dial scale in 5 kHz increments. Velvet, smooth dual speed tuning, with 18 kHz per revolution of fine tuning control.
- **ANL AND NOISE BLANKER**
  - Automatic Noise Limiter reduces hash type noise interference which is not intermittent pulse type.
  - Blanker effectively reduces or eliminates pulse type noises.
- **RECEIVER INCREMENTAL TUNING**
  - Permits receiving up to 5 kHz above or below your transmitting frequency. Especially useful for CW operation or in a net of SSB stations that are on different frequencies.
- **10-160 METERS COVERAGE**
  - Provides a full coverage of all amateur bands in 500 kHz segments.
- **AUXILIARY RANGES**
  - Up to 10 additional 500 kHz ranges between 2 and 23 MHz can be added by plugging in auxiliary crystals. (Will not operate between 23 and 28 MHz, or 5 to 6 MHz.)

**ATLAS 350-XL (less options)**
- Model DD6-XL Digital Dial Readout...$229.
- Model 305 Plug-in Auxiliary VFO...$155.
- Model 311 Plug-in Auxiliary Crystal Oscillator...$135.
- Model 350-PS Matching Power Supply...$229.
- Plug-in Mobile Mounting Bracket...$65.

**Price:**
- Model DD6-XL Digital Dial Readout...$229.
- Model 305 Plug-in Auxiliary VFO...$155.
- Model 311 Plug-in Auxiliary Crystal Oscillator...$135.
- Model 350-PS Matching Power Supply...$229.
- Plug-in Mobile Mounting Bracket...$65.

**Special Customer Service Direct Line**
(714) 433-9591
A discussion of the many types of noise which affect communications receivers, including external noise, noisy local oscillators, and noise IMD.

Noise and interference (man-made noise) as emissions from electrical systems are two limiting factors that determine the full operation of all radio communications equipment. Before we get into a discussion of the effects of noise, however, we must differentiate between the different sources of radio noise — noise effects can be broken down into four general categories:

1. Atmospheric noise, precipitation static, galactic noise, and man-made noise.
2. Noise performance of the rf and i-f amplifier stages which, together with mixer losses, determine the overall noise figure of the receiver.¹
3. Noisy local oscillators which cause problems with blocking and reciprocal mixing.
4. Noise intermodulation distortion which occurs as in-band and out-of-band products.

Since the noise sources listed in category 1 have been widely discussed in the past,² they will be mentioned only briefly here. The main thrust of this article will be in categories 2, 3, and 4: noise performance of rf and i-f amplifier stages, noisy local oscillators, and noise IMD.

Effects of Noise in Receiving Systems

External Noise

Atmospheric noise is produced primarily by lightning discharges associated with thunderstorms, so the level of atmospheric noise depends upon frequency, season of the year, time of day, and geographical location. Graphs similar to that shown in Fig. 1, as well as plots of noise field strength such as that shown in Fig. 2, are available from the National Bureau of Standards. These can be used to determine received signal strength and signal-to-noise ratio, once the frequency, distance, and time of day are chosen.

Fig. 3 shows the optimum frequency for communications over a distance of 20 miles (32km). This particular plot is for a manpack radio application, but similar charts could be prepared for amateur radio communications. In this case 3.6 MHz is the opt-

---

¹ Noise performance of the rf and i-f amplifier stages which, together with mixer losses, determine the overall noise figure of the receiver.

² Since the noise sources listed in category 1 have been widely discussed in the past, they will be mentioned only briefly here. The main thrust of this article will be in categories 2, 3, and 4: noise performance of rf and i-f amplifier stages, noisy local oscillators, and noise IMD.

---

By Ulrich L. Rohde, DJ2LR, Professor of Electrical Engineering, University of Florida. Mr. Rohde’s address is 52 Hillcrest Drive, Upper Saddle River, New Jersey 07458

---

Fig. 1. Field strength in microvolts per meter for a 1000-watt transmitter as a function of local time and frequency.
fig. 2. Atmospheric noise field strength in dB above or below 1 μV per meter as a function of time and operating frequency (assumes 1 kHz bandwidth). If this noise chart is placed over the propagation chart in fig. 1, the signal-to-noise ratio can be calculated (S/N = receiving field strength minus noise field strength).

fig. 3. Optimum operating frequencies vs time of day for two man-pack radios operating over a distance of 20 miles (32 km). This data was gathered in September, 1989. The dashed line indicates the minimum required signal strength-readability product to understand the transmitting station.

Local Time

Paragraph text: Providing a dc dissipation path for any charge which may build up on the antenna.

Galactic noise (also called cosmic noise) is defined as rf noise which is caused by disturbances which originate outside the earth or its atmosphere. The primary causes of this noise, which extends well into the microwave region, are the sun and a large number of radio sources distributed along the Milky Way.

Man-made noise is generated by rotating electrical machinery and automobile ignition systems, among other things, and is the predominate external noise source if you live in (or near) an urban area.

definition of noise

The level of electrical noise is most conveniently referred to as noise power (assuming wideband noise):  

\[ P_n = k T_o B \]  

where \( P_n \) = available noise power  
\( k = \) Boltzmann's constant  
\( = 1.38 \times 10^{-23} \text{ joules/Kelvin} \)  
\( T_o = \) reference temperature  
\( \text{typically } 290^\circ \text{K} \)  
\( B = \) effective receiver noise bandwidth, Hz

This can also be written in terms of the root-mean-square noise voltage  

\[ e_n^2 = 4k T_o B R \]  

where \( e_n^2 \) is the open-circuit root-mean-square noise voltage, and \( R \) is the resistance (see fig. 4A). Since maximum signal will be transferred to a load when the load resistance is matched to the source resistance (fig. 4B), the root-mean-square voltage across the load, when it's impedance matched to the source, is given by  

\[ e_n^2 = 4k T_o B R_2 \]  

For example, if a receiver front end is matched to a 50-ohm resistor, and the noise bandwidth, \( B \), of the receiver is 2.4 kHz, calculate the noise voltage across the antenna terminals of the receiver at room temperature (\( T_o = 290^\circ \text{K} \)).

\[
e_n = \sqrt{4(1.38 \times 10^{-23})(290)(2.4 \times 10^3)(50/2)} = 3.1 \times 10^{-8} \text{ volts} = 31 \text{ nanovolts (nV)}
\]

When you're dealing with wideband communications systems where the noise bandwidth may be unknown, it is more convenient to work with noise factors or noise figures, rather than noise power or noise voltages.

In estimating the noise at the receiving system due to external sources, it must be remembered that noise power is proportional to the bandwidth, \( B \),
fig. 4. Mean noise voltage depends on temperature, resistance, and noise bandwidth (A); this is the open-circuit noise voltage. Maximum noise power is transferred to the load when the load resistance is matched to the source resistance (B); in the terminated condition only half the available noise power appears across the load (receiver) terminals.

assuming uniform white noise. The receiver noise factor is given by

\[ F = \frac{P_n}{kT_0} B = \frac{T_{eq}}{T_0} \tag{4} \]

where \( P_n \) is the available noise power and \( T_{eq} \) is the effective noise temperature (°K). If the noise factor of a receiving system is known, the noise voltage for a signal-to-noise ratio of unity \( (S/N=1) \) can be calculated from

\[ e_n^2 = F(4kT_0 BR) \tag{5} \]

For a noise factor of 10 (noise figure, \( NF = 10 \) dB), 2.4 kHz bandwidth, and \( R = 50/2 \)

\[ e_n = \sqrt{10 \cdot 4(1.38 \times 10^{-23})(290)(2.4 \times 10^3)(50/2)} = 98 \text{ nV} \]

Since most receiver specifications are written for a 10 dB signal-to-noise ratio, the terminated input voltage for this ratio is 310 nV or 0.31 µV.

Note that this calculation is made with noise factor, \( F \), not noise figure \( NF \). The two must not be confused. Noise figure is simply

\[ \text{Noise figure} = 10 \log \text{noise factor} \]

A simple graph for converting from noise factor, \( F \), to noise figure in dB or effective noise temperature, \( T_{eq} \), is presented in fig. 5. If you wish to specify antenna noise as a function of frequency, noise temperature is the most convenient way to do this, as shown in fig. 6.

The overall noise factor of a series of amplifier stages connected in cascade is given by

\[ F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots + \frac{F_n - 1}{G_1 G_2 G_3 \cdots G_{n-1}} \tag{6} \]

where \( F_1 \) and \( G_1 \) are the noise factor and available power gain of the first stage; \( F_2 \) and \( G_2 \) are those of the second stage; \( F_3 \) and \( G_3 \) are those of the third

fig. 5. Conversion table for noise figure, noise factor, and effective noise temperature. The dashed line shows a noise factor of 4 is equivalent to a noise figure of 6 dB or an effective noise temperature of 860°K.

fig. 6. Noise temperature of an antenna (unity gain) as a function of frequency under daytime and nighttime conditions. The dashed line shows that a receiver noise figure of 10 dB is sufficient up to about 36 MHz.
stage; $F_n$ is the noise factor of the nth (last) stage, and $G_{n-1}$ is the gain of the next to last stage. For the case of two amplifier stages, this equation can be simplified to

$$F = F_1 + \frac{F_2 - 1}{G_1}$$

(7)

Fig. 7 is a graphic solution to this formula for cascaded noise figure, in dB, for two stages. In the example shown in the chart, the first stage has a noise figure of 4 dB and a power gain of 10 dB; the second stage has a noise figure of 10 dB. The overall noise figure of the two cascaded stages is 5.3 dB. This is discussed further in reference 3.

amplifier noise

The noise performance of rf and i-f amplifiers is dictated by the transistors used in the circuit, and the selection of optimum operating points. Sometimes there are tradeoffs between low noise or low distortion; it is up to the circuit designer to decide which is more important. The noise figures of transistors and ICs are specified by the manufacturers, and while field-effect transistors generally have lower noise
analyze the noise performance of the oscillator let’s first assume that the oscillator does not have its feedback loop closed and operates as a linear amplifier. It has been proven experimentally that noise modulation, which results in so-called phase noise generated in rf amplifiers as a modulation of the carrier, will produce close-in noise of 115 dB/Hz. The worst and best cases are 100 and 120 dB/Hz, depending upon the transistor used in the circuit. This is especially true of noise 1 kHz to 5 kHz from the carrier, and is caused by flicker noise. In accordance with reference 3, close-in oscillator noise can be improved only through the use of negative rf feedback (emitter degeneration); I described several circuits using this technique in reference 4. The use of rf negative feedback allows a signal-to-noise improvement of 40 dB, which will result in 150 dB/Hz sideband noise close-in to the carrier.

To achieve the ultimate in signal-to-noise ratio, amplifiers which are driven by only one carrier require heavy feedback; they should be operated class A or class AB1 to avoid noise sideband intermodulation.

Noise sideband measurements have always been a gray area, and many publications have stated incorrect figures or shown bad circuits. As a general rule, when designing oscillators, use the following guidelines:

1. Oscillators should always use two stages: one operating in class A, and the other operating as a limiter. The limiter is also used as the feedback part (the intermodulation distortion introduced by the limiter is partially improved by the feedback loop).

2. Circuits which have agc applied to the oscillator transistor should be avoided because the agc will likely add noise. This is discussed in detail in reference 6.

The graph in fig. 8 shows the sideband noise of an oscillator stage using a high-$Q$, tuned LC circuit. To
3. Statements about the use of ECL integrated circuits as low-noise oscillators are basically wrong. In addition, the noise performance of field-effect transistor oscillators is not necessarily better by definition; feedback techniques must be used for good low-noise performance.

Fig. 9 shows the measured noise sideband performance of several signal generators, synthesizers, and oscillators. Fig. 10 shows a very low noise LC oscillator circuit, while fig. 11 shows a very low noise crystal oscillator circuit which can be used with both fundamental and overtone crystals.

In some applications it is desirable to have an oscillator circuit with low harmonic distortion — this can be accomplished with a differential oscillator circuit which combines low noise with low harmonic distortion. Fig. 12 shows an oscillator with low harmonic distortion output.

Crystal oscillator circuits which are used in frequency synthesizers are usually optimized for good aging performance and do not have the lowest noise figures. The noise figure of these oscillators can be improved by adding a crystal filter with less than 20 Hz bandwidth (the crystal filter is sometimes incorporated in the same proportional oven as the reference crystal). Fig. 13 shows the schematic of such a crystal filter. The bandwidth of a simple crystal filter such as that shown here is determined by the input and output impedance; the series resonant resistance, $R_s$, which determines the $Q$ of the crystal, is increased by the series connection of the input and output impedance, which effectively lowers the $Q$ of the crystal. Therefore, when building crystal oscillators for low-noise applications, it is vital that the drive and load impedance are equal or less than the series resonant resistance. The degradation of $Q$ results from the relationship

$$\frac{Q_o}{Q_L} = \frac{R_s}{R_T + R_{T1} + R_{T2}}$$

where $Q_o$ = unloaded $Q$

$ Q_L $ = loaded $ Q $

$ R_s $ = series resonant resistance

$ R_{T1}, R_{T2} $ = differential terminating resistors

In the circuit of fig. 13, this is accomplished by setting the collector current to 15 mA.

**noise in receiving systems**

Both external noise and oscillator noise have been
discussed, but there is still another source of noise to be considered. Certain intermodulation distortion products which are generated in the mixer, and are either produced from overloading the mixer or are reversed modulation of the oscillator sideband noise, must be considered in a receiving system.

Fig. 14 is a spectrum display of the output of a mixer with various frequencies fed to the input. If the mixer has a third-order intercept point of +30 dBm, this means that when two tones, each 0 dBm, spaced $\Delta f$ apart, are applied to the rf port, two mixing products, $\Delta f$ above and below the two input signals, will be generated at a level of $-60$ dBm or 224 $\mu$V.

If there are conditions of good radio propagation, the output of a full-size, wideband rhombic antenna will be between 30 and 100 mV. If we assume for a moment that there is a quasi-infinite number of stations operating between 9 and 12 MHz, spaced 5 kHz apart, then we will also have an intermodulation distortion product every 5 kHz, which will be 72 to 100 dB below the input signals. Under the worst conditions, this will produce an intermodulation distortion floor of $-72$ dBm or 60 $\mu$V. Under these conditions no signals below 60 $\mu$V can be detected.

Fortunately, on the average these spurious products are not closer than about 5 to 6 kHz. For ssb or a·m reception this means that a narrowband crystal filter immediately following the first mixer will cure the problem since all other third-order and higher products are outside the passband of the crystal filter. This simple solution wouldn't work if we had to deal with CW stations a few 100 kHz apart, but this is not usually the case. And it should be remembered that only broadcast, certain marine, and some point-to-point stations generate enough radiated power to create such large input signals.

When analyzing the shortwave broadcast bands, it's interesting to compare received signal strengths in America with those in Europe. The Eastern-bloc countries, which are transmitting with excessive power, are 20 dB stronger in Europe than they are here, so the design requirements for a short-wave receiver for commercial applications in the United States are somewhat less than they would be for the same application in Europe.

Going back to the question of CW stations, the single-conversion receiver, which uses the lowest possible bandwidth immediately following the first mixer, will practically always outperform a double-conversion receiver. This can be checked easily by comparing the single-conversion receiver in the Drake TR4C in the CW mode with the Drake R4C, which uses double conversion. During crowded CW conditions, such as a CW contest, some agc pumping occurs in the R4C. The only way to prevent this from happening is to keep the gain between the first and second mixer as low as possible, and to use a second mixer with the same basic intercept point as the first mixer.

In a recently published paper, the chief engineer of the Racal Company in England nicely demonstrated the response of double conversion and the influence of blocking or reciprocal mixing. While the idea of so many unwanted mixer products, even at low input levels, may be shocking, it must be remembered that the man-made noise splatter due to overmodulation of a·m and ssb transmitters, splatter because of high-speed CW, and other radiated rf energy, will fall above the receiver's sensitivity. Fig. 15 shows the energy distribution for five different interference

fig. 15. Typical energy distribution. Thermal noise = 31 nV (A), receiver noise = 95 nV (B), typical atmospheric noise (C), effect of reciprocal mixing (D), and third-order IMD (E).
sources which can affect the ultimate sensitivity of a receiver:

A. Thermal noise (290°K, \(-174\) dBm = 31 nV)

B. Receiver noise (2.4 kHz bandwidth, 95 nV)

C. Atmospheric noise as a function of frequency (typical)

D. Affect of reciprocal mixing (see reference B)

E. Third-order IMD products assuming an infinite number of stations.

Fig. 16 shows the effect of reciprocal mixing and cross modulation with wanted signals of 10 \(\mu\)V and 100 \(\mu\)V. It can be clearly seen that reciprocal mixing occurs long before cross modulation saturates the receiver.

**references**

above & beyond...

144-220 MHz

Specifications

- Fully synthesized to 5 kHz on all three bands 144, 220, 440 MHz.
- High power output — 25 watts on 144 MHz 10 watts on 220 and 440 MHz. Programmable low power is switch-selected.
- Four diode-programmable fixed channels on each band in addition to the synthesizer.
- Scanner continuously monitors synthesizer frequency when using fixed channels or vice versa.
- Standard offsets or simplex on each band, plus a total of three diode-programmable offsets for special repeaters.
- Remote operation with optional trunk-mount kit.
- Complete 3-band model available or begin with basic configuration and add on other band modules later. Standard band models are:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1346</td>
<td>Drake UV-3 (144-220-440)</td>
<td>$995.00</td>
</tr>
<tr>
<td>1344</td>
<td>Drake UV-3 (144-440)</td>
<td>$795.00</td>
</tr>
<tr>
<td>1343</td>
<td>Drake UV-3 (144-220)</td>
<td>$795.00</td>
</tr>
<tr>
<td>1345</td>
<td>Drake UV-3 (220-440)</td>
<td>$795.00</td>
</tr>
<tr>
<td>1340</td>
<td>Drake UV-3 (144)</td>
<td>$595.00</td>
</tr>
</tbody>
</table>

*Add-on modules expand band coverage of models which may have been purchased in a single band or two band configuration. Prices include factory installation which is necessary to meet FCC Receiver Certification requirements.

Designed and manufactured in USA.
Sale subject to FCC Receiver Certification.

Model 1504 Drake PS-3 AC Power Supply $89.95
Model 1525 Drake 1525 EM Encoding Mike $49.95
Model 1330 Drake UMK-3 Remote Trunk-Mount Kit $69.95
For the discerning FM enthusiast who wishes to reach above and beyond 2 meters we are proud to introduce the...

DRAKE UV-3
fully synthesized fm 3-band system

A total system, the UV-3 does not stop with 144 MHz, but can even include full synthesis on the entire 220 and 440 MHz fm bands as well. All of this coverage is now available in a single, bandswitched unit with add-on band capability for your convenience.

In addition to a synthesizer, fixed channels are diode-programmable for quick selection of your favorite frequencies. A built-in scan feature permits continuous scanning of dialed or programmed channels while operating on another channel. The UV-3 even lets you diode-program special offsets for those non-standard repeaters. A standard dynamic mike is included with the UV-3.

An optional remote trunk-mount kit (cable included) adds remote operation and security. The PS-3 AC Power Supply and 1525EM Encoding Mike (shown in photo) are available as options for further expanding the capabilities of the UV-3 system.

Write for a fully illustrated brochure on the Drake UV-3 System.

R. L. DRAKE COMPANY

540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 • Telex: 288-017

Western Sales and Service Center, 2020 Western Street, Las Vegas, Nevada 89102 • 702/382-9470
second thoughts on the direct-conversion receiver

Stage-by-stage account of direct-conversion receiver design — a real Dutch treat for receiver buffs

After some false starts the direct-conversion (DC) receiver now seems to be well established in amateur radio along with the classic superheterodyne. Simplicity is no doubt the main feature of the DC receiver. Compared with the superhet it lacks an i-f amplifier and second detector, but it has some assets that make it a very fine receiver indeed.

In this article we’ll review the basic elements of the direct-conversion receiver as well as some refinements that can be added. Strong and weak points of the design are discussed. Also presented are some ideas you can use should you wish to build a DC receiver to suit your own needs.

design principle

The DC receiver basic design is shown in fig. 1. The signal from the antenna enters the mixer after preselection by L1, C1. An rf amplifier could be included, but it is not necessary in most cases. In the mixer the signal is heterodyned with the signal from the local oscillator (vfo) — exactly as in the superhet — the frequency of which is determined by tuned circuit L2, C2. For ssb reception the vfo is tuned to the frequency of the suppressed carrier. For CW the vfo is detuned as many Hz as the pitch of the note you want to hear.

The DC receiver is not suitable for reception of amplitude-modulated signals. In practice, a-m speech can be heard by tuning zero-beat with the carrier, but this is not an elegant solution. Neither can fm be received. RTTY may be received, provided it is transmitted as fsk, not as a-m.

The mixer is followed by an af filter, which sets the selectivity. Filter bandwidth can be different for ssb and CW. An af amplifier increased the signal to the proper level for headphones or speaker.

In the past, receivers were judged mainly on their selectivity and sensitivity. Nowadays, receiver behavior in the presence of strong signals is a major consideration. It is interesting to compare the DC receiver and the superhet with regard to phenomena that can be called “unwanted signals.”

<table>
<thead>
<tr>
<th>unwanted signal</th>
<th>superhet</th>
<th>DC receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-f breakthrough</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Reception on image frequency</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Reception by mixing with oscillator harmonics</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Crossmodulation</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Intermodulation</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Breakthrough of a-m stations outside passband</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>

Because the first two unwanted signals don’t exist with the DC receiver, preselection can usually be somewhat simpler than with the superhet (more about this aspect later). Whether or not the DC

By Dick Rollema, PAØSE, v.d. Marckstraat 5, Leiderdorp, The Netherlands

44 [FR] november 1977
receiver suffers from images can indeed be a matter of opinion. As is well known, the difference in frequency between signal and image frequency amounts to twice the i-f in the case of the superhet. One could consider the DC receiver as a superhet with an i-f of zero hertz. In that case, the frequency difference between wanted signal and image frequency would also be zero. And that is indeed so: a signal 500 Hz above the tuned frequency, say, is received just as well as a signal 500 Hz below the tuned frequency. But instead of talking about images, one could also state that the DC receiver can't discern between upper and lower sideband.

And here we also have put our finger on one of the weak points of the direct-conversion principle. It is of course possible to incorporate means for suppressing one sideband (phasing), but to my mind this entirely spoils the main attraction — simplicity — of the DC receiver.

Breakthrough of strong a-m stations is typical for the DC receiver. We will thoroughly investigate this matter also. There are more, but less serious, snags: hum on peaking the input tuned circuit and microphonics of this circuit. These will also be dealt with.

mixer

We have already mentioned a-m breakthrough. This phenomenon manifests itself by a multitude of speech and music signals that are independent of vfo tuning. The signals come from extremely strong broadcast stations insufficiently attenuated by tuned circuit L1, C1 in fig. 1. In Europe one finds many of these strong stations between 4 and 8 MHz. Out of curiosity I once tuned the input circuit of my receiver to one of these stations near 4 MHz in the evening. The circuit uses a powdered-iron toroid for the coil. For an antenna I used one-half of my 40-meter long inverted vee transmitting antenna and an open-line feeder 20 feet (6m) long. The feeder was coupled to the tuned circuit by running the wire once through the hole in the toroid. At times a vtvm connected to the top of the otherwise unloaded circuit read 0.7 volt!

![Fig. 1. Block diagram of the direct-conversion receiver.](image)

The five-in-one vfo in its shielded box. Small box on left contains the buffer amplifier. The row of holes to the right on top and the tie point at left front are for a receiver incremental tuning control, a feature that has no significance in this case and therefore is not shown in the schematic of fig. 5.

The most important factor that determines whether or not a-m breakthrough occurs is the type of mixer used (or product detector, if you prefer). In many designs for DC receivers, a 40673 mosfet or similar device is used as a mixer, probably because an fet has considerable freedom from cross-modulation and intermodulation due to its quadratic characteristic. This benefits both superhet and DC receiver. However, one important aspect is often overlooked: a quadratic characteristic also produces detection of amplitude-modulated signals. Mathematical treatment of a receiver detector almost invariably starts on the assumption of a nonlinear device with a second-power characteristic. That a mixer with a second-power characteristic in a DC receiver does detect a-m has been noted by many users to their dismay.

The same problem occurs in a superhet of course, but the resulting audio signals in the mixer output can't pass the i-f amplifier output and thus won't be noticed. But in the DC receiver, no i-f amplifier is present, so every af component out of the mixer, whether from the wanted signal or an unwanted broadcasting station, reaches the output of the receiver.

It is possible to improve the rejection of a-m signals by using two transistors in a balanced mixer configuration. An example can be found in reference 1.
Fig. 2 comes from that article and shows the principle. The difficult part of this circuit is with transformer T1; the circuit should be designed for a high-impedance on the primary and secondary side and have a center tap on the input winding. For CW a tuned circuit can be used, as YU2HL did, but a suitable transformer may be hard to find for ssb.

In my opinion, the only correct solution is to use a mixer that does not depend on a nonlinear characteristic (of second or higher power) but on a switch that opens and closes with the vfo frequency — in other words, a switching-type demodulator. A diode alternately brought into conduction and nonconduction by the vfo signal can be used. During transition from one state to the other, a-m detection can still occur on the curved part of the diode characteristic. It is therefore important to make the duration of these transitions as short as possible by driving the diode hard with a strong oscillator signal. Moreover, the antenna signal is also present on the diode, and this signal should not influence the switching characteristic, as this would also cause trouble. Again, this requires an oscillator signal that is strong with respect to the antenna signal. Even if these precautions are taken, some a-m detection will occur when using a single diode.

The remedy is to put two diodes in a balanced-mixer. Several suitable circuits can be found in the literature, but all have one element in common: a potentiometer to set the balance. My experience has been that the setting of this pot depends both on the frequency being used and the oscillator-signal amplitude. This is rather awkward, and in a multiband receiver one must put the pot on the front panel. Another drawback of these single-balanced mixers is considerable conversion loss.

Another possibility is to use a single- or double-balanced mixer using bipolar transistors. I started my experiments with direct conversion using a Plessey SL640 integrated-circuit double-balanced mixer. The balance in such an IC mixer is inherently very good. Nevertheless, I found suppression of a-m breakthrough disappointing. Also the IC produced more noise than I liked, resulting in poor sensitivity.

My experiments led to the conclusion that the only entirely satisfactory mixer for the DC receiver is a double-balanced mixer using four diodes. I tried germanium, silicon, and hot-carrier (Schottky barrier) diodes and homemade input and output transformers, both on ferrite toroid cores and powdered iron cores with two holes. All gave good results. The rf signal at the mixer for a 10-dB signal-plus noise-to-noise ratio was of the order of 3.1 microvolts for the 1.8-21 MHz bands.

Suppression of a-m breakthrough was measured by injecting a 30-percent modulated 400-Hz signal into the receiver and noting the amount of generator amplitude required to cause a 10 dB s/n n/n ratio at the output. (The ssb filter was in operation for this test). The signal was detuned outside the receiver passband so that, without modulation, no output could be measured. An average of about 50 microvolts of the 30-percent modulated signal was needed. In practical terms this meant that, using my inverted-vee antenna with an antenna tuner coupled to the DC receiver, no a-m detection was noted on any band at any time.

The voltage mentioned is the emf of a signal generator with 50 ohms output impedance. Note that often the receiver input signal is mentioned as producing a certain s/n n/n ratio and, for this voltage, half the generator emf is taken. This is correct only when the generator is power matched to the device under test, and in many cases this cannot be relied upon. So it's better to state the generator emf and accept the fact that the sensitivity figures look poorer.

A great surprise came when I replaced the homebrew mixers with an Anzac MD108 double-balanced mixer (the most inexpensive on the Dutch market).* This mixer is specified for the range 5-500 MHz. However, I wanted my receiver to operate on 1.8 and 3.5 MHz as well. Any doubts proved to be unfounded as suppression of a-m breakthrough was about the same as my own mixers. But sensitivity improved to an average of 0.82 microvolt for the bands 1.8 through 21 MHz!

This reveals another very good reason for using a well-balanced mixer: it appears that with my homemade mixers, receiver sensitivity was limited by noise that amplitude modulated the oscillator signal. In a perfect double-balanced mixer this noise is balanced.

*And probably the most easily available to American amateurs as well. The MD108 is priced at 87.00 (plus postage) and is available from the manufacturer, Anzac Electronics, 39 Green Street, Waltham, Massachusetts 02154.
out, but my mixers obviously were far from perfect. It is for the very same reason that balanced diode mixers are used in radar receivers without rf amplification. So it's better to buy a good double-balanced mixer right away unless you know the secret of making a good one yourself.

input circuit

A schematic of my direct-conversion receiver without the vfo is shown in fig. 3. Resistor R1 is used to attenuate strong signals. Often this circuit appears as shown in fig. 4A. The result is that the tuned circuit becomes more heavily damped and thus less selective as the slider on R1 is moved downward to increase attenuation. Of course we would prefer it the other way. This is accomplished by the circuit of fig. 4B. Usually R1 is a carbon pot of about 500 ohms. I found that with his control response was uneven over the pot travel; moreover, the pot became defective after some use. Eventually I used a 220-ohm wire-wound pot for R1. Although a wire-wound pot at radio frequencies is completely against the rules, control was good. On higher-frequency bands maximum attenuation became less but was still more than enough.

The task of the input tuned circuit is to suppress products caused by signals mixing with vfo harmonics. If the double-balanced mixer were perfect and the vfo had no even harmonics, reception could occur only on odd harmonics (the third harmonic being the lowest). In practice the receiver shows some sensitivity on the second harmonic as well, although less than on the third. Experience shows that a single-tuned circuit with good loaded Q at the input is sufficient to suppress all but the strongest unwanted signals on harmonic frequencies. The one or two signals that remain are easily recognized as they peak at a different setting of C1.

As shown in fig. 3 I used two separate input tuned circuits: one for 15 through 40 meters and the other for 160 and 80 meters. Each circuit is tuned by one-half of a split-stator capacitor of the type used in broadcast receivers. The advantage is that no switching is necessary within the critical circuits: only input and output links are switched by a good-quality toggle switch. However, a single-variable capacitor could be used that is switched between two or more coils.

No coil-winding details are given for the input circuits as these coils depend on form factor and type of core. A toroid core of ferrite or powdered iron is preferable. L1 and L3 can, as a start, be made equal; the same applies to L4 and L5. If the link coils are small, the circuit will have little damping and selectivity will be good but signal loss will be large. With many turns for the links, little signal will be lost but...
frequency drift on the higher-frequency bands, but

fig. 4. Two ways of connecting a so-called "antenna attenuator." Method in (B) is preferred.

with care it can be accomplished to a satisfactory degree. An example is the Atlas transceiver.

The type of circuit chosen for the oscillator is less important than the way it's implemented. Many good designs for vfos are found in the amateur literature. My solution to the vfo problem is offered only as an illustration. It contains parts that were available in my junkbox and should not be considered as the one and only acceptable circuit.

The vfo schematic is shown on the left in fig. 5. It includes five separate vfos, one for each band, 1.8 through 21 MHz. Each oscillator is tuned by a section of C1, a five-gang variable capacitor of 70 pF per section. For the 40-, 20-, and 15-meter oscillators, C1 was modified to a single plate in the rotor. (The 40-meter band in the Netherlands comprises only 7000-7100 kHz; the 80-meter band 3500-3800 kHz).

Table 1 lists the values of L1, capacitors C1-C6, and R1, R2. (More about C6 later). Even if you have exactly the same values for C1-C5 and L1 available, there's a good chance that one or more of your oscillators won't oscillate. In this case your fets probably have less transconductance than the ones I happened to have. It's therefore better not to follow my design blindly but to use the parts you have on hand or can obtain, then tailor the circuit to your own requirements. A few guidelines: In principle C4 and C5 should be as large as possible and C3 as small as possible. This will provide loose coupling between fet and tuned circuit and will minimize the influence of the fet on the oscillation frequency. If you go too far in this direction, feedback will become too small and oscillation will stop. For a start, C4, C5 can be made equal.

The inductance of L1 is determined by the lowest-frequency in the band desired. L1 should resonate on that frequency with the total capacitance in parallel (C1 set to maximum). Variation of C1 with respect to the total fixed parallel capacitance determines the bandspread. This means fiddling with the capacitors and coil until the proper frequency range is covered while the oscillator still oscillates.

It seems that many amateurs shy away from this approach. But in practice it's not as bad as it sounds so long as you're well aware of what you're doing. Typical of this is the fact that the values of L1 in table 1 were not calculated in the design stage, nor were they measured. I computed them afterward for this article from the frequency ranges covered and the capacitor values, so these values are of very limited accuracy.

Supply voltage should be as low as possible consistent with reliable oscillator starting. I found 5 volts to be a good compromise. Current increases quickly with voltage; and as dissipation in the fet increases with voltage and current, frequency stability suffers. An improvement suggested by PA0TW and PA0HWE, which I haven't tried, is to use a small preset pot between the cold end of the rf choke in the source lead and ground (fig. 5). This seems to give smooth oscillation control. It is absolutely necessary to stabilize the supply voltage by a zener.
with an electrolytic capacitor in parallel to suppress noise from the zener.

Output is taken from the drain through a small resistor. This method is due to DJ1BZ and features minimum effect on oscillation frequency. Because the fet operates in class C, current pulses flow through R2, and the resulting voltage is far from sinusoidal. We can improve the waveshape — again according to DJ1BZ — by including C6. It is given such a value that its reactance is roughly equal to the value of R2 in ohms for the highest frequency of the band concerned. With the component values as in fig. 5 oscillator output voltage is about 0.5 V rms.

R1 is required only in case of vhf parasitics, which manifest themselves in erratic frequency jumps when rotating C1. R1 should not be any higher than necessary for good suppression of parasitics. In my case R1 was needed only in the 40-meter vfo, but this requirement is unpredictable.

The oscillator required for a band is activated by connecting the supply voltage to that oscillator. Diodes CR1 function as OR gates. Only CR1 of the selected vfo conducts and connects the rf output to the buffer amplifier. The other diodes are reverse biased. Any point-contact silicon diode is suitable. (I used unidentified ones salvaged from a computer board).

It is necessary to shield the vfos well. This is even more important when the DC receiver forms part of a QRP CW transceiver. The smallest leak of transmitter output into the vfo will cause frequency pulling and/or a bad note. Watch the shaft of C1: it can easily act as an antenna and allow rf into the shield box. The remedy is to use an insulated shaft or shaft coupler.

I made a box from aluminum sheet and rectangular stock. Although no admirer of printed circuits for home construction, I put the five vfos on a piece of epoxy board to save room. The photographs show packaging details. A good slow-motion drive on C1 is recommended. The one I used came from one of the popular (at least in Europe) war surplus SCR-193 tuning units. It has a 1:50 worm drive. Originally the worm was driven by a thumbwheel protruding through the front panel. Because this method of tuning is very tiring when done regularly, I moved the unit through 90 degrees. The shaft of the worm was extended so it can protrude through the side wall of the vfo box and the front panel of the receiver where it carries a big knob with a crank. The extension shaft was cemented to the worm shaft with epoxy.

The slow-motion drive fits one end of the capacitor shaft. The other end of the shaft protrudes through the end wall of the shield box. A drum-type frequency dial can be fitted to this shaft end with a separate frequency calibration for each of the bands. The dial can be read through a window in the receiver front panel.

buffer amplifier

The buffer amplifier increases the power level of the oscillator signal to about 5 milliwatts, which is needed by the MD108 double-balanced mixer. The circuit diagram is shown in the right-hand part of fig. 5. It is a broadband amplifier with two stages. The first stage with Q2 has series-negative feedback by nondecoupled emitter resistor R3. This causes both high input and output impedance, so Q2 causes negligible oscillator loading. Moreover its high input impedance is in parallel with the relatively low-valued resistors R2. The second stage with Q3 has shunt-negative feedback through R4, which also acts as collector resistor for Q2. Q3 therefore has low input and output impedance. The high output impedance of Q2 working into the low input impedance of Q3 causes a high mismatch, but it has the advantage that the two stages can be designed independently. Because of the low output impedance of Q3, variations in the loading impedance hardly affects amplifier operation.

Voltage amplification of the circuit is almost completely set by the ratio of R4 to R3 and is, to a large degree, independent of transistor characteristics, frequency, and supply voltage. This method of making broadband amplifiers with stages having alternate series- and shunt-negative feedback is due to E.M. Cherry and D.E. Hooper. The simple approach by Cherry and Hooper allows the amateur to design good wideband amplifiers without too much computation and/or test gear.

T1 matches the output of Q3 to the LO input port of the double-balanced mixer. This is an aspect that
Fig. 5. Vfos and buffer amplifier schematic. A separate oscillator is used for each band, which is selected by connection to the supply voltage. C1 is a five-gang capacitor with all but one plate removed in the rotor section for 7.14 and 21 MHz. CR1 can be any rf silicon diode such as a 1N914. Instead of the outdated RCA transistors, any modern rf silicon device can be used for Q2, Q3. Rf chokes are not critical; any type of 70 μH or higher inductance will do. Construction of wideband transformer T1 is shown at bottom; see text also.

doesn't get the attention it deserves in many published designs for DC receivers. For proper mixer operation it is important that LO drive be sufficiently strong; some overdrive is less harmful than insufficient drive. For the MD108, the manufacturer specifies mixer characteristics at a LO drive of 7 dBm; that is, 5 milliwatts. Input impedance of the LO port is 50 ohms. Before we can decide on the step-down ratio of T1, we need to know the optimum load impedance of Q3. The ac voltage at Q3's collector is set by the oscillator output voltage and the buffer amplifier voltage amplification. The unloaded voltage at the collector turns out to be about 2.6V.

Maximum power is delivered to the mixer when the ac through Q3 is maximum. The direct current is 10 mA. The rms current at the collector can therefore be about 7 mA at maximum (the peak value is then 10 mA). The optimum load impedance is that which passes 7 mA at 2.6V, which works out to be 371 ohms. So the stepdown voltage ratio of T1 should be \( \sqrt{371/50} = 2.72 \). Because of the construction of T1, the ratio can only be a whole number so we choose 3 as the nearest.

Construction of T1 is shown in fig. 5. T1 is an autotransformer with a trifilar winding. The core is powdered iron with two holes, as used in Europe for balun transformers in the input circuit of TV receivers. No doubt a suitable toroidal core of powdered iron or ferrite would do just as well. The number of turns is governed by the requirement of sufficient inductance at the lowest frequency to be used. Somewhat arbitrarily I decided that the inductive reactance of the winding between connections 1 and 2 should be four times the load impedance: 50 ohms at 1.8 MHz. A sample winding on the core in parallel with a known capacitor and coupled to a grid dipper revealed that five turns would be required between connection 1 and 2. To
obtain a transformer ratio of 3 a total of 15 turns will be necessary, of which 10 are between connections 2 and 3. I used silk-covered enamel wire of 32 AWG (0.2mm) because it happened to be available. Three pieces of wire are twisted, which is done conveniently with a hand drill, and the "rope" so formed is put five times through one hole of the core and back through the other. Connections are then made as indicated in fig. 5. Make the connections as near to the core as possible. The completed transformer is epoxy cemented to the buffer-amplifier shield box.

Any small box can be used for the buffer amplifier. The box is screwed to the oscillator housing, as shown in one of the photographs. A small feed-through carries the signal from the oscillators into the buffer-amplifier box. As an extra precaution against feedback I put a partition between the two stages of the amplifier, as indicated in fig. 5. However, as the voltage amplification between Q2 base and Q3 collector is only some five times, this extra shielding is perhaps unnecessary. It is recommended to feed the buffer amplifier from a zener-stabilized 9-volt supply.

It is very important that the buffer stages operate within the linear part of their transfer characteristic. As soon as a transistor bottoms out the isolation offered is gone. This can be easily checked: putting a load on the amplifier in fig. 5 should have little or no effect on frequency. If frequency shift occurs and shielding and decoupling are alright, then overdrive of the buffer may be the cause. Decreasing R2 lowers the input voltage to the buffer. If this appears to be the remedy then C6 has to be corrected as well, as explained earlier.

**audio filters**

I began my experiments with DC receivers using an SL640 1C mixer made by Plessey, which has 350 ohms output impedance. The mixer was followed by a filter for ssb with a 2700-Hz cutoff frequency. The filter was a so-called Cauer or elliptic function design, which offers the steepest possible transition between passband and stopband with a given number of coils and capacitors. Its disadvantage is that all components have odd values, so coils must be tailor-made by paralleling pot cores and capacitors of standard values. The filter did an excellent job, however.

I replaced the SL640 with a double-balanced mixer using OA154Q germanium diodes, which had a measured output impedance of about 125 ohms. Since the filter had to be redesigned for the different impedance, I decided to use the well-known 88-mH toroids for coils with standard-value capacitors. This would make duplication by others easier. The filter was accordingly designed to the rules of classical image-parameter filter theory.

These filters do not have the steep transition between passband and stopband offered by modern filters, so some compensation was sought by lowering the cutoff frequency to about 2000 Hz, which is sufficient for ssb reception. After some trials, the filter of fig. 6 emerged. The 22-mH coils were made from 88-mH toroids by placing the two windings in parallel.* It is important that the coils are connected so that the two windings don’t oppose each other. In the filter passband attenuation is of the order of 0.5 dB; cutoff occurs near 1900 Hz. If you wish to check the design, the filter prototype can be found in reference 4. It is built from four constant-k half sections.

For the CW filter I concluded that the passband should not be too narrow, because not only is it difficult to get the signal within the passband and keep it there but the tone is always of the same pitch, which becomes tiring during prolonged listening. This fact led to the filter of fig. 7, which consists of four 3-element series half sections. The passband (-3 dB) is between about 580 and 900 Hz. In musical terms, this means that the signal can be tuned through about a fifth without noticeable variation in amplitude. Attenuation increases faster on the high-frequency side of the passband. The CW filter is also useful as an outboard unit between any receiver and headphones in case the receiver or transceiver has insufficient i-f selectivity for CW use. Some resist-

*See also reference 3, which provides curves showing inductance values that can be obtained by removing turns from these popular surplus inductors.
ance padding will probably be required to match the filter to receiver output and headphone impedance. The signal loss that this entails is usually not serious, as in most cases more than enough signal is available for headphone operation. A breakdown of the CW filter in its four half sections is shown in fig. 8. The four coils, L1, combine to two coils of inductance 2L1.

By way of contrast, fig. 9 shows a bandpass filter as used in some DC receivers published in QST and the ARRL Handbook. With two coils only two half sections are realized. The slope of the attenuation curve outside the passband is therefore only half that obtained by the filter of fig. 8. Another disadvantage of the filter in fig. 9 is that the steepest slope is on the low-frequency side of the passband. Indeed, the same filter characteristic could have been obtained with only one coil if the other ends of the half sections in fig. 9 had been joined. The coil in that case would have become \( \frac{1}{2} L2 \) in value.

The source and termination resistance of the filters should be 140 ohms for the ssb filter and 104 ohms for the CW filter. This reasonably matched the 125-balanced mixer. Later I changed to the Anzac MD108 which has only 50 ohms output impedance. Luckily, filters based on the image parameter design method are a compromise on matching anyway, and in practice the mismatch on the input side does not noticeably detract from filter performance. Output matching is covered in the next paragraph.

Sometimes I'm asked why I use old fashioned coil-capacitor filters now that active filters without coils are available. In the first place I'm not sure that active filters with performance equal to my passive filters would be so simple; I'm afraid a considerable number of components would be needed. But I have also a more fundamental objection to the use of active filters in this particular application. The spectrum of signals offered to the filter by the mixer comprises a large dynamic range that could easily be some 80 dB or more. I fear this range is more than an active filter can handle. Either the weakest signals will drown in the noise of the device or the strongest will overload it. One should not forget that, especially in the case of steep cutoff filters, some parts of the circuit will carry much higher voltages than appear on input and output terminals — and at those points the danger of overloading is greatest. Therefore I prefer the classic LC filter. Construction should prove no problem at and the 88-mH toroids are inexpensive and plentiful.

### audio-frequency amplifier

In a DC receiver the input signal is only attenuated in the first stages. Amplification occurs for the first time after the af filters, so signal power reaches a minimum at the input of the af amplifier. Unless the mixer is poor and oscillator noise dominates, the receiver signal-to-noise ratio is determined by the af amplifier input stage. I again get the impression that this important consideration did not always receive the attention it deserved in some of the DC-receiver designs I've seen.

If a bipolar transistor is used in the first stage of the af amplifier, it should be a low-noise device; e.g., a type suitable for the input stage of a tape or cassette recorder. From the manufacturer's data sheet one can find the collector current for optimum noise factor, usually some tens of microamps. But these sheets show another fact: optimum noise factor is obtained with a specific output resistance of the signal source for feeding the transistor! Agreed, the curve for noise factor as a function of source resistance shows a rather broad minimum, but if the af filter is connected directly to the output of the af filters, as is often done, noise mismatch may be so serious that \( s/n \) ratio is degraded by several dB.

Professional designers of low-level af amplifiers use input transformers to obtain an optimum noise match if the source resistance differs widely from the optimum, as in the case of a dynamic microphone for example. We could do the same in our DC receiver. Source resistance in this case is the 50-ohm output resistance of the double-balanced mixer as seen through the af filters over the major part of the filter.

![fig. 7. Measured frequency response of CW filter.](image-url)
passband. Optimum source resistance for the af input transistor depends on device type and collector current and can vary between a few thousand and several tens of thousand ohms.

From these data a suitable transformer can be specified. But would you have one, or could you buy it somewhere? Perhaps. But don't run out to get one because there is another snag. Not only should the af amplifier have a certain resistance at its input; at the same time, the af filter in use should have the proper termination resistance at its output. The load on the filter will be the input resistance of the af amplifier, transformed by the transformer — so this requirement also fixes the transformer ratio. It would be most unlikely that the transformer ratio so found would coincide with the one for optimum noise matching, so we have a problem.

It would be nice if we could choose a transformer ratio for best s/n ratio at the af-input stage and control filter termination separately. We can by using an fet. An even better s/n ratio than with a bipolar transistor also occurs. The input resistance of an fet at audio frequencies can be considered infinite for our purpose, so there's no loading at the input. Noise of an fet is lower than in even low-noise bipolar transistors. Noise in the fet can be thought of as being generated in a noise-voltage source in series with the input (gate). The higher the signal input voltage is made, the better the s/n ratio becomes, as signal and noise voltage operate in series on the gate. So the higher the step up of the transformer between af filter and af amplifier, the better the s/n ratio becomes. The limiting factor is the transformer itself. With high ratios the capacitance of the secondary winding limits the high-frequency response. But this is of more concern to the hi-fi equipment designer, as the highest audio frequency we're interested in is about 2000 Hz.

Very suitable for our purpose are microphone transformers from communications equipment using tubes (war-surplus transmitters, obsolete mobile radios). Transformer T1 in fig. 3 came from Wireless Set type 19, a famous British WW II veteran. The photograph shows the unit in its shielded box. A test with an audio generator and af voltmeter showed the voltage step up from primary to secondary to be of the order of fifty. So signal-to-noise ratio is raised fifty times compared to a straight connection without a transformer.

The matter of filter termination is still to be settled. This is simply accounted for by R2 in parallel with the secondary winding. R2 is transformed to the input side of the transformer, divided by the square of the transformer ratio. The value of 1 megohm was suitable in my case. The filters are somewhat under-loaded at their outputs, but signal from the filters is larger than with proper termination. As stated before, filter matching is not very critical.

The remainder of the af amplifier is simple. There is considerable spread in the characteristics of fets. It is therefore better to use a variable resistor as source resistor R3 first and to adjust it for a dc voltage of 10 volts at the drain of Q1. The resistor is then measured and a fixed resistor of nearest standard value substituted.

The major share of the total amplification is provided by the popular 741 op amp. Resistors R4 and R5 are selected so that dc voltage at the output (pin 6) is half the supply voltage; i.e., 6 volts. If necessary R4 and/or R5 can be changed if the voltage at pin 6 differs too much from half supply voltage. Volume control R6 changes the feedback; this somewhat unusual system has advantages with op amps. Silicon diodes CR1 and CR2 will protect your ears in case a strong signal appears unexpectedly; they limit output voltage to a maximum of about 1.2 volt peak to peak.

Because the output resistance of an op amp is so low and becomes even less with feedback, connecting the diodes in parallel with the headphones would not be very effective. That's why they have been incorporated in the feedback circuit. When 600-ohm stereo headphones are used with both halves in parallel, the diodes don't conduct at normal listening level. If you prefer pop-group sound level, better omit CR1 and CR2.

When starting my tests with direct conversion I used a speaker. Instead of the 741 op amp I tried a

fig. 8. The CW filter is a combination of four half sections, shown to the right of the vertical line. Note how coils and capacitors in the individual sections are combined in the actual filter at the left of the dashed vertical line.
Siemens TAA300 and the Plessey SL630 as output IC amplifiers, but I like the sound from good headphones much better. Modern stereo headphones have very good bass reproduction, even very light hum is reproduced faithfully. It's difficult to avoid hum induction completely, because T1 is sensitive to the stray magnetic fields of power-line transformers, even if a foot (30cm) away. For this reason C2, in series with the output, is made rather small. The frequency response falls at 6 dB per octave below 350 Hz. This is also useful at ssb as the top is cut at 2000 Hz; attenuating the lows as well restores the tone balance.

**agc**

In the final version of my receiver, shown in fig. 3, no agc is used. Whether or not agc is desirable depends mainly on the use of the receiver. For CW it's not necessary. Only the more sophisticated forms, like hang agc, contribute to operating convenience. On ssb agc is not necessary either but is nice to have.

I have tried agc in my DC receiver. For this purpose the mixer was preceded by a Plessey SL610 rf amplifier. This IC can be directly connected to the mixer input without using a tuned circuit or other matching device. Audio agc voltage was generated by another Plessey IC, the SL621. This is a sophisticated circuit, providing hang agc without "hang" on short noise or interference bursts.

The SL610 has a control range of 50 dB. Of course this is not enough for a full-fledged agc, but it was sufficient for the range of signals appearing within one frequency band at a certain time. Control was very pleasant, but a nasty side effect spoiled performance: when tuning a strong carrier the agc voltage increased in a series of steps. I tried changing the time constants in the loop but nothing helped. Also the Plessey application engineer could not think of a remedy. It is clear that the SL610-SL621 combination was designed for the superhet — in which they perform excellently — but in the DC receiver they obviously do not feel at home. Eventually I dropped agc. First, the rf amplifier was not needed from a sensitivity point of view, and secondly my receiver is part of a QRP telegraphy transceiver and is very seldom used for listening to ssb.

**tunable hum**

Many DC receivers have hum that appears when the input circuit is tuned to the signal (oscillator) frequency. I think the explanation is that some oscillator power leaks through the mixer and finds its way to the input circuit. The voltage on the circuit peaks when the circuit is brought to resonance. Some of the power is fed into the antenna and radiated. If the antenna is unsymmetrical and works against ground, the antenna current also flows over the ground connection. Some or all of this path to ground is through power supply and ac line. The current finds its way to the ac line through the rectifier diodes in the supply and the capacitance between primary and secondary windings of the power transformer. But the diodes operate as switches that open and close 60 times a second (50 times in Europe), so the rf current is chopped (modulated) at this frequency as well. It is clear that because of this we find an rf signal on the input circuit that is amplitude modulated at line frequency. This is treated like any "normal" signal and finds its way through the receiver; the hum is demodulated in the mixer and becomes audible at the output.

The remedies are clear. A good solution is to use a 12-volt battery for primary power. With a total consumption of 25 mA, this is an attractive alternative. Of course a good ground connection is a must on battery-operated gear. Another possibility is to use an antenna that does not depend on a ground connection for its operation. When using my inverted vee with open-line feeders and an antenna tuner there is no trace of tuned hum. Still another solution is to use a good ground separate from the ac line. This alone is not sufficient; the path through the power supply should be made more unattractive to rf by putting an rf choke between receiver and power supply.

**input-circuit microphonics**

This effect is related to the previous one. Some
oscillator voltage is present on the input tuned circuit. If variable capacitor C1 is not mechanically rigid, the plates may vibrate. The resulting capacitance variations modulate the rf signal in the circuit both in amplitude and phase. The signal is demodulated in the mixer and the sound emanates from headphones or speaker. If the speaker is near C1, an acoustic howl may be set up in extreme cases. Apart from

using a good-quality capacitor for C1, it also helps to prevent the oscillator signal from appearing on the input circuit. This depends on good balance in the mixer, shielding of oscillator and buffer circuit, and the connection to the mixer. With the Anzac MD108, microphonics were not a problem in my case.

rf amplification, yes or no?

It is a real pleasure to operate the DC receiver. Signals stand out clearly against an almost quiet background. In poorly designed superheterodyne or DC receivers, even strong signals can sound blurred, almost always a sign that oscillator noise is modulating the incoming signals. Nothing of the sort happens in my receiver. Signals are as clear as a bell as soon as they are strong enough to override the noise.

The DC receiver seems much less "nervous" than a superhet, but it is only fair to admit that this is partly due to the absence of agc. Oldtimers, using a good DC receiver will no doubt be reminded of a tuned radio-frequency set, the old faithful of the twenties. Radio-frequency set, the old faithful of the twenties, but without its peculiarities. Sensitivity of my receiver, with an average 0.82 microvolt across 50 ohms for a 10 dB s + n/n ratio, may not seem impressive by modern standards and it is perhaps wise to give this matter a closer look. It would be nice to know the noise factor of the receiver. In my home lab I don't have a noise generator, so I can't measure noise factor directly, but it can be calculated from the measured sensitivity. It is necessary to know the noise bandwidth of the rig for this computation. This is an equivalent rectangular-shaped passband that, with the same height as the maximum of the real passband of the receiver, passes the same noise power. By taking the frequency response of the rf portion of the receiver, the noise bandwidth can be determined from the response curve. The noise bandwidth so-found was 1340 Hz, using the ssb filter. The rf bandwidth is twice this value in a DC receiver, which accounts for the noise power that is passed.

Noise factor can now be determined by computation, or more easily, by the use of a suitable chart. I obtained a noise factor of 15 dB at the mixer input. At the antenna terminals this will be a bit poorer because some signal is lost in the tuned input circuit. Assuming 2 dB for this loss, the noise factor at the receiver input is 17 dB. If this is not good enough, an rf amplifier is called for. But the strong-signal characteristics of the receiver — in particular a-m break-through, the most troublesome effect in a DC receiver — suffers just as many dB as the rf amplification you put in.

Is a 17-dB noise factor acceptable? To answer that question, refer to an excellent article by Jim Fisk, W1HR, in which a table lists the maximum noise factor a receiver may have so that, in a quiet location, receiver noise is 3 dB less than noise from outside. Of course, external noise is dependent on many factors and varies widely with time, location, and frequency so W1HR rightly warns that no guarantee is given that receiver noise will always be 3 dB weaker than external noise.

The following figures are given for the hf-bands: 1.8 MHz, 45 dB; 3.5 MHz, 37 dB; 7 MHz, 27 dB; 14 MHz, 24 dB; 21 MHz, 20 dB; and 28 MHz, 15 dB. As my receiver does not cover 28 MHz a 17-dB noise factor can be considered acceptable. Practice at my reasonably quiet location seems to bear this out: even when 15 meters is dead a slight rise in noise from the antenna is noticed when the input circuit is tuned to the signal frequency. If the receiver covered 28 MHz as well, an rf amplifier would certainly be needed to catch the really weak ones.

references

6. James R. Fisk, W1HR, "Receiver Noise Figure and Dynamic Range — What the Numbers Mean," ham radio, October, 1975, pages 8-25.

ham radio
A digital display on modern receivers is essential for accurate frequency determination of both received and transmitted signals. The division of the amateur bands into a multitude of operating modes, license restrictions, and accuracy in individual operator contacts makes the analog interpolating dial techniques difficult and leaves much room for frequency error. When crowded DX conditions prevail, the ability to change frequency to a special receiving frequency is a must for working that "Once-in-a-decade" contact.

Numerous articles have appeared that use the variable high-frequency oscillator (HFO) as a base for determining the received-signal frequency. These systems use the HFO frequency and presettable decade counter schemes to display the received frequency in kHz. Most systems display either a 0-500 kHz or 500-999 kHz readout, depending on band segments, and the operator mentally supplies the significant Megahertz digits. An excellent method so far as it goes — however, since we’re also changing our BFO frequency between USB, LSB and CW, and since small variations in the local-oscillator frequency of a dual-conversion receiver have thermal drifts, there is still considerable difficulty in determining exactly the received-signal frequency and the transmitting frequency when using the HFO as the only reference. Equally difficult is the accurate calibration of such a system, which is limited to the accuracy of only one oscillator reference, even after thermal equilibrium is achieved in the receiver system.

The digital display system described here provides accurate display of the received-signal frequency by counting the HFO, LO and BFO outputs, summing the counts from these oscillators, and displaying the actual received frequency. In addition, the basic BFO oscillator described in part one of this article includes a nominal (455-kHz) oscillator mode for zero beating the received signal to determine the transmitted signal resting, or center, frequency and not necessarily the ssb or CW beat frequency.

The digital counter may be used with receivers that...
are not of the dual-conversion type by excluding the local-oscillator beat frequency input signal to the shaping circuits. The counter may also be used to monitor a transmitter frequency by simple diode switching, using only one of the buffer input circuits.

**the digital-display system**

Consider that the signal being received is 14.125 MHz, as an example. From part one of this article, the first i-f is nominally 1500 kHz, and the second i-f is 455 kHz. We can sum the receiver oscillator outputs as follows:

- **HFO** 12.625 MHz
- **LO** 1.045 MHz nominal
- **BFO** 0.455 MHz nominal
- **DISPLAY** 14.125 MHz

The digital scheme that follows does exactly that — it counts each oscillator output individually, sums the counts, and displays the results.

As a reminder, **fig. 1** is a block diagram of the overall receiver. An input signal is obtained from each of the oscillator circuits, processed in a buffer gate circuit, then counted and displayed using a 5-digit, 7-segment LED readout. A clock circuit generates a stable reference for multiplex control, counting, and transfer of the updated frequency data at regular intervals.

The display update is 2.5 Hz. Several systems described in previous articles have used display rates of 10-20 Hz; however, my experience indicates that a fast display change rate is neither necessary nor desirable because of the flicker irritation. Display rate changes of 1-5 Hz seem psychologically less irritating and adequate for frequency readout. During rapid traversal of band-end to band-end, this error in frequency display is not objectionable, since familiarity with the counter operation and experience will quickly allow you to estimate the approximate stopping point between display rate changes for receiving a particular band segment.

**Counter.** The counter timing diagram is illustrated in **fig. 2**. For clarity, one full second of the system operation is shown. The basic clock frequency is 10 Hz. Each clock cycle is 100 milliseconds, and each display period is 400 milliseconds, at which time the display is updated and held for another 400-millisecond period. Considering an ideal 1-second case, during the first 100 milliseconds the HFO is counted; during the second 100 milliseconds the local oscillator is counted; and during the next 100 milliseconds the BFO is counted. The summed counts of the HFO, LO and BFO are then transferred to the display, and the counter is reset to start the cycle over again each 400 milliseconds. Transfer and display occur during the fourth 100-millisecond period of the control cycle.

The basic system is a ripple counter. To allow for all of the internal flip-flops of the counter to ripple through before transfer transition, a delay period is required before transfer of the ripple counter chain and reset. This action is accomplished by using a strobe pulse, which occurs during the multiplex A-B time period (**fig. 2**). The strobe pulse is derived by looking back into the 10-Hz clock decade counter and using the QC output, which occurs twice during
the multiplex \( A \bar{B} \) state. The strobe used in conjunction with the 10-Hz clock is then gated to provide the transfer and reset pulses at the correct timing point.

The gate-code table in fig. 2 illustrates the gating circuit codes that are generated from the multiplexer to accomplish each of the illustrated count-and-transfer activities. The gate codes are purely arbitrary and are not a part of device output terminal identification. They are merely a scheme for schematically illustrating the binary state of the controller and controller output.

Lower-power TTL and Schottky logic is used in this system. Selection of TTL and LS devices is presently the most cost-effective design in low part quantities such as this. A recent series of counter-latch LED driver chips has become available; however, for amateur procurement of low-quantity parts within reasonable delivery times, I chose to use a straightforward, easily duplicated design rather than one using hard-to-find ICs.

**Input buffer.** The oscillator outputs are buffered and shaped using the circuits shown in fig. 3. An fet buffer provides a high-input impedance to minimize loading, distortion, and frequency drift of previous oscillator stages. The fet-buffered output is capacitively coupled into a common-emitter driver, which is directly coupled to the input of a NAND gate shaper. The use of LS logic assures fast rise times and clean pulse trains from the oscillators. Generous use of decoupling capacitors and rf chokes minimizes feedback of spurious signals into the +12 volt source, which is common to the other rf and audio stages of the receiver.

**Gating system.** The gating technique is shown in fig. 4. The 3-input NAND gate always has one of the oscillator trains on its input. A multiplex generator logic level, tied into the other two inputs, either inhibits or allows the pulse train to pass through the gate. Assuming a pulse train appearing on the input of terminal \( C \) of the gate, both the \( A \) and \( B \) input lines must be in a logic one state (high) for the train to pass through the gate. If either the \( A \) or \( B \) input is low, the gate will be inhibited. It's important to understand that the NAND gate is an active low device. Each of the buffered and shaped oscillator lines is constantly looking into its individual 3-input NAND gate. The multiplex generator provides a series of logic levels in sequence to allow first one pulse train to pass, then the next, and finally the last oscillator train at the specified timing interval indicated in fig. 2.

The output of the multiplex-controlled gate of

---

fig. 2. Counter timing diagram for a 2.5 Hz count/display operation.

fig. 3. Input buffer and shaping circuits, counter section.

fig. 4. The 3-input NAND gate always has one of the oscillator trains on its input. A multiplex generator logic level, tied into the other two inputs, either inhibits or allows the pulse train to pass through the gate. Assuming a pulse train appearing on the input of terminal \( C \) of the gate, both the \( A \) and \( B \) input lines must be in a logic one state (high) for the train to pass through the gate. If either the \( A \) or \( B \) input is low, the gate will be inhibited. It's important to understand that the NAND gate is an active low device. Each of the buffered and shaped oscillator lines is constantly looking into its individual 3-input NAND gate. The multiplex generator provides a series of logic levels in sequence to allow first one pulse train to pass, then the next, and finally the last oscillator train at the specified timing interval indicated in fig. 2.

The output of the multiplex-controlled gate of
each oscillator train is, in turn, tied to the input of another 3-input NAND gate. Let's see how this works. Assume that the multiplexer generator puts the A and B inputs of the HFO 3-input NAND gate high. The gate will allow the pulse train to proceed to the output and into the count-output gate. If the multiplexer is operating correctly, the A and/or B input of the LO and BFO 3-input NAND gate must have at least one terminal at logic zero to inhibit the train (don't confuse the A and B input terminals with the symbols A and B used in the controller binary state code). When the A and B input terminals are high, the input count gate will pass the HFO train. The next multiplexer function will inhibit the HFO and BFO trains to pass the LO train of pulses, and subsequently the BFO pulse train. When the count gate is inhibited, the output C terminal will be high because of the active low characteristic of the device.

Because we're using active low outputs from the U2 gates (fig. 5), the 3-input NAND gate of U4 at pins 1, 2, and 13 will have at least two lines high during a count cycle state, allowing the count to proceed to U8. During the multiplexer state A B, the lines from U2 output are all high; thus pin 12 of U4, the gate output, is low and inhibits all pulse-train activity.

A complete schematic of the gating scheme is illustrated in fig. 5. The individual gates are controlled by the multiplexer to pass through a control gate and first decade counter. In addition, the multiplexer
generates a series of gating commands to two other 3-input NAND gates to generate the storage transfer and counter reset lines.

U1 and U3 gates provide the transfer reset clock, which is strobed by QC, clock (C), and NOT clock (C̅), as shown in fig. 5 using two 3-input NAND gates of U4. Since the output is active low, and transfer and reset occur on the leading edge of a pulse, two additional 2-input NAND gates (U3) invert the pulse to the correct polarity. The heart of the multiplexer system is a simple dual-D flip-flop (fig. 6), which generates a series of gate control pulses: 00, 01, 10, 11. These pulses, in combination with the clock, provide a continuous series of multiplex control lines: (000, 001, 010, . . . 1111), so that the various counter states are derived for count, transfer, and reset at specific timing intervals.

**System clock generator.** A stable and accurate 10-Hz clock is generated from a 100-kHz crystal oscillator, which is then decade-divided to produce a basic clock-NOT clock pulse train, identified as C and C̅. The circuit is illustrated in fig. 7. The entire accuracy of the system depends on the accuracy and stability of the clock. (This is not the place to use an inexpensive 100-kHz crystal!) Use extra effort in selecting a resonating capacitor, or use a small trimmer for frequency accuracy. Normal auto-ranging frequency counters will not provide sufficient accuracy for the clock oscillator frequency measurement. If possible, beg or borrow a frequency counter with 10- or 100-second gating capability and monitor the 10-Hz clock to ensure proper operation over extended time intervals. An alternative method of calibrating the entire clock and receiver circuitry using WWV at 15-MHz is discussed in the final alignment and calibration section of this article.

**Ripple counter and display circuits.** The ripple counter, latch drivers, and display are shown in fig. 8. The system is straightforward, but let's see just what's happening. From fig. 5 we have gated three input counts: the HFO, LO, and BFO. We sampled each of these pulse trains for 100 milliseconds. From our original example of the 14.125-MHz received signal, the HFO pulse train is 12.625 MHz divided by 100 milliseconds, or 1.2625 x 10^6 pulses; the LO and BFO are also sampled at the same period and are
thus $104.5 \times 10^3$ pulses respectively. The total accumulated counts after gating is the sum of the 100-millisecond-sampled oscillators, or:

$$1.2625 \times 10^6$$

$$0.1045 \times 10^6$$

$$0.0455 \times 10^6$$

$$1.4125 \times 10^6$$

These are the counts passing through the count output gate to the first decade divider, U8 (fig. 5). After decade division, the ripple counter chain could be considered as viewing a count rate of 141.25 kHz in our example.

Fig. 8 refers to the ripple counter input as CT1. This 141.125 kHz train first passed through an additional decade divider to produce CT2. In our example, this would now be a pulse train at a 14.125-kHz rate. Fig. 9 shows the functional diagram of the ripple-counter action. CT1 enters a divide-by-10 stage; its output is CT2. CT2 enters a decade divider

---

**fig. 8.** Ripple counter, latch, and segment display schematic.
with BCD output lines. Its output, CT3, enters an additional decade divider with corresponding BCD output lines and so on until we reach the last or most significant digit counter with its BCD lines.

**Fig. 10** is an abbreviated picture of the individual decade, latch, display driver, and display scheme. Each decade counter accumulates, in turn, the number of counts from the previous stages during the count cycle. Upon multiplex command, the storage register transfers the accumulated counts in each decade divider to the display driver; the storage-register output is held in this stage until the next transfer pulse. The display driver receives the BCD code from its corresponding 7490 counter and converts this binary code into a 7-segment LED for numerical presentation.

Since the storage register is held in its state until the next transfer pulse, the counter (ripple) can be reset and will proceed to sample the oscillator chain again, as described previously. Upon arrival of the transfer pulse, this updated data is cycled again into the display. This count, transfer, display, and reset continually cycles each 400-millisecond period (or two and one-half times a second).

The latch circuit is the familiar D-type flip-flop with a clear input so that fresh data may enter the D input lines and transfer to the output Q lines on the leading edge of the clock, or T pulse in this case. A complete illustration of the latch is shown in **fig. 11**.

In summary, the 14.125-MHz signal is displayed as 14,125 counts in that order. The LED has a decimal point feature so that we can display our received signal as 14.125, directly indicating the MHz and kHz distinctions.

**construction**

Construction of the digital counter and display is on two PC boards. One board (**fig. 12**) contains the input buffering, multiplexing, counters, and latch circuits. The second board (**fig. 13**) carries the LED drivers and LED display for convenient mounting behind the front panel. It would have made the construction much simpler to have used a double- or multiple-laminated board; however, when etching PC boards in the kitchen sink, the task of precision artwork and registration becomes extremely difficult. The tradeoff here is to use short jumper wires on the component side of the board or use wire-wrap sockets and wire-wrap interconnects.

The LED display is 0.3 inch (7.5mm) high. Easy visibility is obtained from as far as 20 feet (6m). I used a thin sheet of clear plastic in front of the LED display mounted to a bezel (smoked plastic may be used to
fig. 12. Component placement diagram for the main counter board.
enhance the red color wavelength of the diode segments and sharpen up the features).

There are a number of techniques for accurately calibrating the counter. The most obvious is to zero beat the heterodyned 100-kHz clock oscillator against WWV at 5 MHz or against a similar standard reference frequency. Recognizing that the availability of a WWV receiver is limited, I submit the following method as more practical.

My calibration technique was to use the receiver itself to tune WWV to 15 MHz. The HFO and rf tuned circuits are quite adequate for receiving 15 MHz signals.

1. Disconnect the HFO V_FV control voltage and, by using an external variable dc supply, the HFO oscillator will tune WWV at approximately 10 Vdc. Peak the RF TUNE and GAIN controls, and use the CW mode position to zero beat the WWV 15-MHz timing pulse, which occurs at 15.001 MHz.

2. Adjust the 100-kHz oscillator resonating capacitor for a 15.001-MHz display.

For a complete description of WWV timing pulse characteristics, you may research your local library or consult a recent edition of the ARRL Handbook.

Amateurs in the northwest may find that WWVH or the Canadian Ottawa 14.670-MHz frequency standards are easier to receive. There are several additional European and South American 15-MHz frequency standards that may be used as well. However, I had difficulty in obtaining precise data for the exact position of their timing pulse relative to the carrier resting frequency. WWVH at 15 MHz has a timing pulse whose peak amplitude occurs at 1200 Hz above the resting frequency, which must be considered when adjusting the 100-kHz oscillator for display readout.

The use of an accurately calibrated digital counter to set the 100-kHz oscillator or clock will not be ac-
curate for most applications. An error of ±2 kHz is probably the closest that can be achieved using a secondary counter as a reference. A small amount of LSD toggling will occur, especially when the summation of counts is between 1-kHz intervals. This error in the last digit display is to be expected and is not really bothersome.

operation

Heat is the biggest single driver for receiver operational stability. Ideally, all the heat-generating devices in the power supply, and heat-sensitive devices in the oscillator circuitry, should be isolated. In practice, however, obtaining an idealized thermal isolation system would be difficult and costly. Using the design and construction approach as illustrated, the normal time constant for good reception stability was on the order of 40 minutes. The entire receiver will take several hours to reach thermal equilibrium. At this point, the frequency drift will be less than 100 Hz per hour. Because of the low power consumption (less than 20 watts), the receiver should run continuously so that the thermal transient effects are minimal.

The thermal time constant will, of course, be a function of the mass and heat-transfer paths as well as characteristic of the chassis, panel, and cabinet construction. A large mass ratio will increase the time constant and minimize the effects of transient thermal changes to the oscillator stability.

Care in power supply heatsinking is also necessary to maintain dissipation and junction temperatures within manufacturer’s ratings. Before final alignment of the high-frequency oscillator and display circuits, the receiver should be left on continuously for several-hundred hours to settle in various components that have accumulated water hydration during their manufacture, shipment, and storage. This is extremely important if you’re interested in readout accuracy.

reference


appendix

bandspread techniques

The bandspread capabilities described in part one of this article were limited to the ability of the 10-turn potentiometer that controls the varactor diode voltage for the HFO. Assuming a bandwidth of 350 kHz for both CW and ssb reception, the tuning rate will be 35 kHz per revolution. This tuning rate is not optimal for high resolution CW or ssb reception in crowded conditions. Fig. A1 illustrates a simple voltage-divider technique for providing about twice the original bandspread capability by dividing the 20-meter band into two parts with a small overlap of about 3.5 kHz in the center. The V\(_{\text{HV}}\) control potentiometer value is increased by a factor of 10, and

![Fig. A1. Split bandspread for high-resolution tuning.](https://example.com/fig-a1)


a series voltage divider network of three resistors plus a simple dpst switch do the rest. Presuming that the original V\(_{\text{HV}}\) voltage is adjusted for a range of 360 kHz, so that both ends of the band overlap, the new tuning rate is now 18 kHz per revolution of the tuning dial — a significant improvement.

![Fig. A2. Ultra high-resolution bandspread scheme.](https://example.com/fig-a2)

fig. A2. Ultra high-resolution bandspread scheme.

Fig. A2 illustrates an even bolder approach. Using a simple double-pole rotary switch, the band can be divided into any number of segments. A fairly standard switch type is a Centralab 2P rotary switch with 2-6 positions.

Using this approach, the bands could be further subdivided into equal or unequal. Assuming five equal parts at the previous 350-kHz total bandwidth, the potential tuning rate could be reduced to 6 kHz per dial revolution. It should be apparent that, by using various voltage divider arrangements, any desirable bandspread configuration is possible. You could arrange the resistor network for dividing the band into its various operating class ranges or by simply putting emphasis on intervals of most interest.

It is extremely important to minimize the thermal heat load on this circuitry due to the high temperature dependency of the components and their resistance value. These parts should be kept away, or isolated from, any high-heat-generating components. Again, to eliminate the change in resistance value resulting from hydration and aging, a burn-in period is desirable before final receiver calibration.

ham radio

November 1977
The phase-locked loop is used with short-duration pulses from a reference oscillator to produce highly accurate harmonics. The phase-locked loop can be used to synthesize harmonically related frequencies. Several methods can be used to accomplish frequency synthesis. The direct approach used divide-by-n counters to reduce the voltage-controlled oscillator (vco) frequency to match that of a highly accurate crystal-reference oscillator. The reference output and the divide-by-n counter output are then applied to the phase detector where the phase and frequency are compared and a correction voltage is generated. The voltage is then impressed onto a voltage-variable capacitor (varactor) to capture the vco output and lock it into phase coherence with the reference oscillator output.

A second approach is to alter the reference-oscillator waveform to a pulse of very short duration. This harmonic-rich pulse is then applied to the phase detector with the vco output. When phase and frequency are compared, a correction voltage will be applied to the varactor. Thus the vco frequency will be a harmonic of the reference-oscillator frequency.

An article\(^1\) describing this approach has been researched and modified into a new version\(^2\) of the PLL harmonic generator. Fig. 1 shows the details of the new version.

The \(\mu L914\) crystal oscillator, U1, uses an RTL IC that starts readily, has good square-wave output, and is extremely stable when used with quality crystals. The SN74SOON Schottky IC, U2, produces pulses of about 100-nano-second duration. When these pulses are fed to the 1N914 diodes (CR1, CR2) at the same time, buffer amplifier U3 delivers the vco output to these diodes where the phase comparison is made, and the phase-frequency output is fed to U5, a general-purpose op amp. When the bias on U5 has been set, the gain control, which shunts the input and output, is set to minimum resistance, which decreases op-amp gain. This, in turn, increases the ability of the op amp to capture vco output. As the resistance is increased, the op amp locks the vco more tightly to the reference-oscillator output by increasing its control of the varactor. Effective varactor control is provided by a lead-lag network.

The vco uses a Hartley oscillator with moderately high Q, so it’s fairly stable by itself. However, it can be controlled by the correction voltage applied to the varactor. A high-gain fet and two hot-carrier diodes provide an agc voltage that is applied to the vco, which produces almost constant output throughout the required frequency range. The inductor and capacitors of this oscillator and its buffer-amplifier, U4, are designed to track each required harmonic of the reference (more on this later).

**Construction hints**

Plan parts layout in accordance with the schematic so that the shortest possible leads are used where indicated. The dashed line around the phase detector, CR1-CR2, indicates that all lead lengths in this part of the circuit are critical. These lead lengths should be \(1/4\) inch (6.5mm) long or less. A PC board or perf board with short lead lengths should be used here.

**Inductances.** The vco inductor, L1, is emitter-tapped at about one-third of the total winding. The turns ratio between the buffer-amplifier primary and antenna link (L2-L3) should be about 13:1 for correct impedance match.

I found that distributed capacitance of the vco was

---

**By Kenneth W. Robbins, W1KNI, 835 Woburn Street, Wilmington, Massachusetts 01887, and John R. True, N4BA, 10322 Georgetown Pike, Great Falls, Virginia 22066**
on the order of 55 pF, while the buffer-amplifier capacitance was only about 25 pF. If the same amount of inductance is used in both stages, a pad of about 30 pF should be used on the buffer (a fixed 22 pF capacitor at U4 pin 1, and about 3-15 pF trimmer capacitance on each inductor). Use 0.02 µF bypass capacitors on U3, U4 for frequencies below 5 MHz; if all harmonics are to be above 5 MHz, 0.01 µF will be adequate.

**Meter requirements.** The meter is used to monitor control voltage to the varactor. A meter movement with 100 µA-1 mA full scale would be a good choice. The multiplier resistor should be adjusted to read 5 volts at midscale. When the op amp is acquiring capture of the vco output, the meter needle will flop from side-to-side as the op amp locks in. Once locked, the meter should again read at midscale; if not, a loss of lock is indicated.

When the op-amp gain-control switch S1, is closed, potentiometer R1 and the 47k resistor, R2, shunt the input-output of U5 (pins 2-6), reducing U5's gain. When gain control R1 is in TUNE, only 47 kilohms remain in the circuit. Thus, the gain is reduced to a minimum, so that optimum capture of the vco signal occurs. When R1 is rotated to the opposite side (S1 still closed), U5's gain will be increased to lock the vco signal. When S1 is opened, maximum gain is available to provide tightest lock control.

Bias-set potentiometer R3 should be a small, multiturn trimpot. This control is extremely critical. It must provide an indicated voltage on U5 pin 6 that is *exactly* the same as the 5-volt supply voltage reading. Less than one-quarter turn of this control will cause the meter needle to flop from one side to the other as the bias is being set. Only at the proper setting will U5 have maximum control of the varactor and thus lock the vco. Once set, R3 should require no further adjustment unless a circuit revision is made; therefore, this control should be mounted on the rear of the circuit board out of reach of accidental change.

---

fig. 1. Schematic of the phase-locked loop, crystal-controlled harmonic generator. Circuit provides high-accuracy integer harmonics from a basic crystal-oscillator frequency.
Capacitors. Several of the capacitors in the circuit should be of good quality. Capacitor C1 in the Schottky network; capacitor C2; and capacitor C3 should be dipped mica components. Capacitor C4 should be a silver mica. Capacitors C5, C6 should be small 50-volt 0.01-μF disc ceramics with short leads.

With the exception of tantalum capacitors marked on the schematic, and electrolytic capacitors (marked +), all other capacitors may be disc ceramics. (If identical rf output is required on all harmonics, the vfo-buffer output inductors may require loading resistors; 1-2k should suffice.)

Power supply. The regulated 5- and 12-volt supplies can be built with transformers that have outputs of 8 and 16 volts, respectively. Fig. 2 shows a regulated supply using one center-tapped transformer secondary.

Diodes. All silicon diodes show some variable capacitance with reverse bias. The varactor I used is an IN4005 and has better Q than some diodes designed for varactor use. Referring to fig. 3, measure the vco frequency at 2-, 5-, and 8-volts reverse bias. If the frequency change from that of the 5-volt reading is greater than 0.8% of center frequency, the diode will be satisfactory as a varactor. Several diodes I tested showed good yields: the IN4005 was about 50%; the IN4007 about 20%, and the Motorola HEP 170 (four tested) showed over 1% frequency change at 5-MHz center frequency.

tuning and adjustment

A frequency counter that covers the desired frequency range is a decided asset. Aligning the vco

1. Set the meter switch (fig. 1) to position 1 and set gain-control pot R1 to maximum resistance (switch closed).
2. Note the 5-volt power-supply voltage reading.
3. Set meter switch to position 2 and adjust the bias-set pot on the op amp until the meter reads exactly the same as the reading in step 2. As noted previously, this bias-set pot control is extremely touchy.
4. Adjust the trimpot control until the meter again reads the same as the 5-volt supply reading.

operation

1. Shift the meter switch to position 3 for operation. The meter will now show the control voltage impressed onto the varactor under normal operating conditions.
2. Set the gain-control pot to minimum resistance (minimum gain) and tune in a harmonic to zero beat. Integer harmonics will be quite loud, while others will be weak.
3. Determine the harmonic frequency and adjust the components until the required harmonic output is obtained.
4. Increase gain and note the tighter lock that occurs. Increasing gain until the switch opens provides maximum gain. As a trial, note how sharply the audio signal of the heterodyne goes through zero beat when gain is minimum; also note the dial divisions that take it above audibility.
5. Now increase the gain to achieve lock and note how far the vco dial can be moved before lock is lost. Also note that the meter will go to one side or the other of midscale, which shows that the op amp is trying to hold the vco in lock by changing the varactor's reverse bias. If the meter needle suddenly flops to one side, you have lost lock.
6. Adjust the each inductor in the vfo and buffer to tune all harmonics with the capacitance previously mentioned. When all harmonics have been calibrated, log the switch and vco dial settings for each.

collection

The crystal-controlled PLL vco will provide high-accuracy integer harmonics from a basic crystal frequency. If frequencies to 50 MHz or more are required, I suggest a crystal frequency of at least 1 MHz unless closer channel spacing is required. If harmonics spaced 2, 3, or more MHz are required, consideration should be given to using a crystal with a fundamental frequency equal to the channel spacing

fig. 2. Suggested power-supply circuit, which provides regulated 5 and 12 volts.
required. However, if a lower channel spacing or lower frequency is the requirement, use a lower-frequency crystal or use a divide-by-10 and/or divide-by-n combination to arrive at the desired channel spacing.

If the final output frequency is very high and the channel spacing is very low, such as in two-meter work, generate the required channels as stated, then mix upward with a high-frequency crystal to arrive at the required output frequencies.

If the requirement is high accuracy, I recommend the use of a high-accuracy crystal. These are available with guaranteed accuracies on the order of a few parts per million. If used in a temperature-controlled oven, higher accuracies may be obtained.

The unit built by W400 uses a 1.000 000-MHz crystal* which supplies harmonics from 6-36 MHz for use as a local oscillator. This local oscillator will be mixed with a Collins PTO to provide a solid-state, continuous-coverage signal generator from 1.5-33 MHz. When compared with WWV at 15 MHz, the PLL vco showed – 10 Hz at turn-on, – 5 Hz after 5 minutes, and –3 Hz after 10 minutes. It went through zero error at 35 minutes. After two hours, it showed variations not in excess of 2 Hz — not bad for a unit without an oven or elaborate temperature compensation!

The unit draws only 30 mA from the 12-volt supply and 25 mA from the 5-volt supply. The rf output is approximately 150 mV rms into a 50-ohm load.

*International Crystal Co. Type H-A.

**references**


---

**Ham Radio**

---

**HAM RADIO CENTER, INC.**

8340-42 Olive Blvd  •  P.O. Box 28271  •  St. Louis, MO 63132

---

**November 1977**
Cushcraft engineers have incorporated more than 30 years of design experience into the best 3 band HF beam available today. ATB-34 has superb performance with three active elements on each band, the convenience of easy assembly and modest dimensions. Value through heavy duty all aluminum construction and a price complete with 1-1 balun.

Enjoy a new world of DX communications with ATB-34!

**SPECIFICATIONS**

- **FORWARD GAIN** - 7.5 dBo
- **F/B RATIO** - 30 dB
- **VSWR** - 1.5-1
- **POWER HANDLING** - 2000 WATTS PEP
- **BOOM LENGTH/DIA.** - 18" x 2 1/8"
- **LONGEST ELEMENT** - 32' 8"
- **TURNING RADIUS** - 18' 9"
- **WIND SFC** - 5.4 Sq.Ft.
- **WEIGHT** - 42 Lbs.
- **WIND SURVIVAL** - 90 MPH.
- **$239.95**
- COMPLETE
- NO EXTRAS TO BUY

**UPS SHIPPABLE**

IN STOCK WITH DISTRIBUTORS WORLDWIDE

CUSHCRAFT CORPORATION

BOX 4680, MANCHESTER, N.H. 03108
improved receiver selectivity and gain control

An alternative to the manually switched front-end attenuator for HF receivers — a PIN diode attenuator and cascaded IF filters

Once upon a time there was a receiver called the AR-88, which used cascaded RF amplifiers and a mixer that was far from crunchproof. People would listen to the signals from the receiver (many of which were not actually in the band) and wonder at the sensitivity of this receiver.

And it came to pass that high-frequency IF filters were invented, and double-conversion went the way of the dodo — receiver designs were changing. Solid-state front ends still generated distortion products, so the antenna attenuator was invented, thus creating a plethora of twitchy index fingers. Wise men said, “Ye shall not AGC the front end, for operating point changes causeth dynamic range to suffer.” And so the attenuator remained with us.

Then came Doug DeMaw, and certain German gentlemen and wise men from California. They produced crunchproof mixers saying, “Lo, the RF amplifier is no more, and we suggest cascading IF filters besides.” The world marvelled, hand on attenuator switch, awaiting developments. It was with such history in mind that the following ideas were born, while updating some previous receiver designs.

The antenna attenuator is a great idea, just in case the crunchproof mixer is less than ideal — but that front panel switch just had to go. A PIN diode RF attenuator, AGC controlled, was the alternative providing many dB of attenuation ahead of the mixer across the entire range of an HF receiver.

Previous experience showed that cascading IF filters, instead of merely switching them, resulted in greatly improved adjacent-channel selectivity — where it really counts. To change bandwidths, shorting the sharper filter seemed to be simple and effective.

Finally, all my previous receiver efforts seemed to suffer from inadequate AGC control range. Nothing short of 60 dB or better seemed satisfactory, so this range was set as a target number.

The following circuitry is the end result of these deliberations — another “great leap forward” in the endless quest for the ultimate in homebuilt receivers.

circuit description

The PIN diode attenuator (fig. 1) is designed to be inserted between the antenna and antenna input connector of any HF receiver. The PIN diode has a very low impedance when conducting a relatively high bias current and a very high impedance when the bias current is small. While most PIN diodes are designed to be used above 100 MHz, certain Hewlett Packard diodes are useful down to 1 MHz. The attenuator is built in a separate shielded enclosure, with coaxial connectors provided on each end. Depending on construction, the attenuator should provide up to 40 dB attenuation (and, therefore, AGC range) between 3-30 MHz when terminated in a 50-ohm impedance.

The PIN current source, buffer, and AGC circuits are built on a separate board or chassis. An npn transistor is used as a current source, providing more than 100 mA to the PIN diode. The current-source transistor is driven from the AGC circuit through a JFET buffer, Q3, which prevents the low impedance of

By Mike Goldstein, VE3GFN, 298 Warden Ave., Scarborough M1N3A4, Ontario, Canada
current source Q1 from loading the agc line and affecting its time constant. This time constant is determined by R1 and C1; values shown are a compromise between slow (ssb) and fast (CW) agc.

The agc voltage is audio-derived; audio from the top of the receiver audio gain control is amplified and rectified, with 200 mV rms at the input of U1 sufficient to cause maximum attenuation. The centertap

fig. 1. The PIN diode attenuator, A, and Pin-diode current source, buffer, and agc circuits, B. The attenuator should provide up to 40 dB attenuation between 3-30 MHz when terminated in a 50-ohm impedance.

fig. 2. I-f system uses cascaded filters. When used with the PIN-diode attenuator an agc range of more than 70 dB was measured. FL1 is a KVG XL-1 OM, 0.5 kHz bandwidth filter. FL2 is a KVG XF-9B 2.4 kHz filter. The rf choke is 1 mH.
of T1 can be grounded. However if it’s tied to the wiper of a potentiometer connected between ground and -12 Vdc, manual control of attenuation level, while maintaining the automatic feature, provides an rf gain control function for the receiver.

The i-f strip (fig. 2) uses an RCA CA3002, which provides 30 dB gain at 9.0 MHz and is specified as having 80 dB of agc control range. Used in conjunction with the PIN attenuator, agc range of more than 70 dB could be measured. If the spec-sheet people are honest, it should be around 120 dB, far beyond most instrumentation measurement capability.

The agc control pin of U2 is driven through Q2 from the PIN attenuator agc system. Circuit values are used that ensure only nominal attenuation by U2 until the attenuation limits of the PIN attenuator are approached; after this point, attenuation in the i-f IC increases very rapidly.

In front of the i-f chip, U2, two KVG 9-MHz crystal filters are installed so that in normal operation the two filters are cascaded. The sharp filter (500-Hz bandwidth) drives a mosfet amplifier, Q5, which has its own gain control. This amplifier is adjusted to have a gain that exactly compensates for the insertion loss of the sharp filter. This ensures that the i-f strip will have the same gain whether or not the sharp filter is in circuit. When a wider bandwidth is desired, the sharp filter and its compensation amplifier are simply shorted by activating a diode gate. The switch that controls the diode gate should also switch in the proper bfo crystal when the sharp filter is in use. The input circuit of the i-f board is designed to supply the dc operating voltage to the mixer which drives it.

Only the circuit layout of the PIN diode attenuator is critical. Attenuation can be compromised by stray capacitance, so all leads should be as short as possible. Only disc ceramic capacitors should be used. The attenuator uses a section of PC board as a chassis with ground connections soldered right on to the copper foil. The attenuator enclosure was also made from copperclad board. The entire assembly was soldered together after the final tests were completed.

references

The TS-520S combines all of the fine, field-proven characteristics of the original TS-520 together with many of the ideas and suggestions for improvement from amateurs worldwide.

FULL COVERAGE TRANSCEIVER
The TS-520S provides full coverage on all amateur bands from 1.6 to 29.7 MHz. Kenwood gives you 160 meter capability, WWV on 15.000 MHz., and an auxiliary band position for maximum flexibility. And with the addition of the TV-506 transverter, your TS-520S can cover 160 meters to 6 meters on SSB and CW.

DIGITAL DISPLAY DG-5 (option)
The Kenwood DG-5 provides easy, accurate readout of your operating frequency while transmitting and receiving.

OUTSTANDING RECEIVER SENSITIVITY AND MINIMUM CROSS MODULATION
The TS-520S incorporates a 3SK35 dual gate MOSFET for outstanding cross modulation and spurious response characteristics. The 3SK35 has a low noise figure (3.5 dB typ.) and high gain (18 dB typ.) for excellent sensitivity.

NEW IMPROVED SPEECH PROCESSOR
An audio compression amplifier gives you extra punch in the pile ups and when the going gets rough.

VERNIER TUNING FOR FINAL PLATE CONTROL
A vernier tuning mechanism allows easy and accurate adjustment of the plate control during tune-up.

FINAL AMPLIFIER
The TS-520S is completely solid state except for the driver (12B-7Y7A) and the final tubes. Rather than substitute TV sweep tubes or final amplifier tubes in a state of the art amateur transceiver.
Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity.

**TS-520 Specifications**

**Amateur Bands:** 160-10 meters plus WWV (receive only)

**Modes:** USB, LSB, CW

**Antenna Impedance:** 50.75 Ohms

**Frequency Stability:** Within ±1 kHz during one hour after one minute of warm-up, and within 100 Hz during any 30 minute period thereafter.

**Tubes & Semiconductors:**

<table>
<thead>
<tr>
<th>Tubes</th>
<th>3 (S-2001A x 2, 1287Y/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transistors</td>
<td>52</td>
</tr>
<tr>
<td>FETs</td>
<td>19</td>
</tr>
<tr>
<td>Diodes</td>
<td>101</td>
</tr>
</tbody>
</table>

**Power Requirements:** 120/270 V AC, 50/60 Hz, 13.8 V DC (with optional DS-1A)

**Power Consumption:**
- Transmit: 280 Watts
- Receive: 26 V (with heater off)

**Weight:** 16.0 kg (35.2 lbs)

**Dimensions:** 333(W) x 15(D) x 335(H) mm (inch)

**TRANSMITTER**

- **RF Input Power:** SSB: 200 Watts
- **CW:** 160 Watts DC

**Carrier Suppression:** Better than -40 dB

**Sideband Suppression:** Better than -50 dB

**Spurious Radiation:** Better than -40 dB

**Microphone Impedance:** 50k Ohms

**AF Response:** 400 to 2,600 Hz

**RECEIVER**

- **Sensitivity:** 0.25 mV for 10 dB

**Selectivity:**
- SSB: 2.4 kHz/-6 dB, 4.4 kHz/-60 dB
- CW: 0.5 kHz/-6 dB, 1.5 kHz/-60 dB (with optional CW-520 filter)

**Image Ratio:** Better than 50 dB

**IF Rejection:** Better than 50 dB

**AF Output Power:** 1.0 Watt (8 Ohm load, with less than 10% distortion)

**AF Output Impedance:** 4 to 16 Ohms

**DG-5**

The luxury of digital readout is available on the TS-520S by connecting the DG-5 readout (optional). More than just the average readout circuit, this counter mixes the carrier, VFO, and heterodyne frequencies to give you your exact frequency. This handsomely-styled accessory can be set almost anywhere in your shack for easy to read operation...or set it on the dashboard during mobile operation for safety and convenience. Six bold digits display your operating frequency while you transmit and receive. Complete with DH (display hold) switch for frequency memory and 2 position intensity selector. The DG-5 can also be used as a normal frequency counter up to 40 MHz at the touch of a switch. (Input cable provided.)

NOTE: TS-520 owners can use the DG-5 with a DK-620 adapter kit.
We told you that the TS-820 would be best. In little more than a year our promise has become a fact. Now, in response to hundreds of requests from amateurs, Kenwood offers the TS-820S—the same superb transceiver, but with the digital readout factory installed. As an owner of this beautiful rig, you will have at your fingertips the combination of controls and features that even under the toughest operating conditions make the TS-820S the Pacesetter that it is.

Following are a few of the TS-820S’ many exciting features.

**PLL** • The TS-820S employs the latest phase lock loop circuitry. The single conversion receiver section performance offers superb protection against unwanted cross-modulation. And now PLL allows the frequency to remain the same when switching sidebands (USB, LSB, CW) and eliminates having to recalibrate each time.

**DIGITAL READOUT** • The digital counter display is employed as an integral part of the VFO readout system. Counter mixes the carrier VFO, and first heterodyne frequencies to give exact frequency. Figures the frequency down to 10 Hz and digital display reads out to 100 Hz. Both receive and transmit frequencies are displayed in easy to read, Kenwood Blue digits.

**SPEECH PROCESSOR** • An RF circuit provides quick time constant compression using a true RF compressor as opposed to an AF clipper. Amount of compression is adjustable to the desired level by a convenient front panel control.

**IF SHIFT** • The IF SHIFT control varies the IF passband without changing the receive frequency. Enables the operator to eliminate unwanted signals by moving them out of the passband of the receiver. This feature alone makes the TS-820S a pacesetter.

*The TS-820 and DG-1 are still available separately.*
Experience the excitement of 6 meters. The TS-600 all mode transceiver lets you experience the fun of 6 meter band openings. This 10 watt, solid state rig covers 50.0-54.0 MHz. The VFO tunes the band in 1 MHz segments. It also has provisions for fixed frequency operation on NETS or to listen for beacons. State of the art features such as an effective noise blanker and the RIT (Receiver Incremental Tuning) circuit make the TS-600 another Kenwood "Pacesetter".

Experience the luxury of 450 MHz at an economical price. The TR-8300 offers high quality and superb performance as a result of many years of improving VHF/UHF design techniques. The transceiver is capable of F3 emission on 23 crystal-controlled channels (3 supplied). The transmitter output is 10 watts. The TR-8300 incorporates a 5 section helical resonator and a two-pole crystal filter in the IF section of the receiver for improved intermodulation characteristics. Receiver sensitivity, spurious response, and temperature characteristics are excellent.
Check out the new "built-ins":
digital readout, receiver pre-amp,
VOX, semi-break in, and CW sidetone!
Of course, it's still all mode, 144-148
MHz and VFO controlled.

Features:
- Digital readout with "Kenwood Blue" digits
- High gain receiver pre-amp
- 1 watt lower power switch
- Built-in VOX
- Semi-break in on CW
- CW sidetone
- Operates all modes: SSB (upper & lower), FM, AM and CW
- Completely solid state circuitry provides stable, long lasting,
trouble-free operation
- AC and DC capability (operate from your car, boat, or as a base station
through its built-in power supply)
- 4 MHz band coverage (144 to 148 MHz)
- Automatically switches transmit frequency 600 KHz for
repeater operation. Simply dial in your receive frequency
and the radio does the rest...
simplex, repeater, reverse
- Or accomplish the same by plugging a single crystal into one
of the 11 crystal positions for your favorite channel
- Transmit/Receive capability on 44 channels with 11 crystals

**VFO-700S**

Handsomely styled and a perfect companion to
the TS-700S. This unit provides you with the
extra versatility and the luxury of having a
second VFO in your shack. Great for split
frequency operation and for tuning off fre-
quency to check the band. The function switch
on the VFO-700S selects the VFO in use and
the appropriate frequency is displayed on the
digital readout in the TS-700S. In addition a
momentary contact "frequency check" switch
allows you to spot check the frequency of the
VFO not in use.
TR-7400A
Features Kenwood's unique Continuous Tone Coded Squelch system, 4 MHz band coverage, 25 watt output and fully synthesized 800 channel operation. This compact package gives you the kind of performance specifications you've always wanted in a 2-meter amateur rig.
Outstanding sensitivity, large-sized helical resonators with High Q to minimize undesirable out-of-band interference, and give a 2-pole 10.7 MHz monolithic crystal filter combine to give your TR-7400A outstanding receiver performance. Intermodulation characteristics (Better than 66dB), spurious (Better than -60dB), image rejection (Better than -70dB), and a versatile squelch system make the TR-7400A tops in its class.
Shown with the PS-8 power supply
(Active filters and Tone Burst Modules optional)

TR-7500
This 100 channel PLL synthesized 146-148 MHz transceiver comes with 88 pre-programmed channels for use on all standard repeater frequencies (as per ARRL Band Plan) and most simplex channels. For added flexibility, there are 6 diode-programmable switch positions. The 15 KHz shift function makes these 6 positions into 12 channels. 10 watt output, ±600 KHz offset and LED digital frequency display are just a few of the many fine features of the TR-7500. The PS-6 is the handsomely styled, matching power supply for the TR-7500. Its 3.5 amp current capacity and built-in speaker make it the perfect companion for home use of the TR-7500.

TR-2200A
The high performance portable 2-meter FM transceiver. 146-148 MHz, 12 channels (6 supplied), 2 watts or 400 mW RF output. Everything you need is included: Ni-Cad battery pack, charger, carrying case and microphone.
Kenwood developed the T-599D transmitter and R-599D receiver for the most discriminating amateur. The R-599D is the most complete receiver ever offered. It is entirely solid-state, superbly reliable and compact. It covers the full amateur band, 10 through 160 meters, CW, LSB, USB, AM and FM.

The T-599D is solid-state with the exception of only three tubes, has built-in power supply and full metering. It operates CW, LSB, USB and AM and, of course, is a perfect match to the R-599D receiver.

If you have never considered the advantages of operating a receiver/transmitter combination... maybe you should. Because of the larger number of controls and dual VFOs the combination offers flexibility impossible to duplicate with a transceiver.

Compare the specs of the R-599D and the T-599D with any other brand. Remember, the R-599D is all solid-state (and includes four filters). Your choice will obviously be the Kenwood.

---


dependable operation, superior specifications and excellent features make the R-300 an unexcelled value for the shortwave listener. It offers full band coverage with a frequency range of 170 KHz to 30.0 MHz • Receives AM, SSB and CW • Features large, easy to read drum dials with fast smooth dial action • Band spread is calibrated for the 10 foreign broadcast bands, easily tuned with the use of a built-in 500 KHz calibrator • Automatic noise limiter • 3-way power supply system (AC/Batteries/External DC) • take it anywhere • Automatically switches to battery power in the event of AC power failure.
Fine equipment that belongs in every well-equipped station

HF LINES

820 Series
TS-820S...TS-820 with Digital Installed
TS-820...10-160 M Deluxe Transceiver
DG-1........Digital Frequency Display for TS-820
VFO-820...Deluxe Remote VFO for TS-820/820S
CW-820....500 Hz CW Filter for TS-820/820S
DS-1A.....DC-DC Converter for 520/820 Series
520 Series
TS-520S...160-10 M Transceiver
DG-5......Digital Frequency Display for TS-520 Series
VFO-520...Remote VFO for TS-520 and TS-520S
SP-520...External Speaker for 520/820 Series
CW-520....500 Hz CW Filter for TS-520/520S
DK-520...Digital Adaptor Kit for TS-520
599D Series
R-599D.....160-10 M Solid State Receiver
T-599D...80-10 M Matching Transmitter
S-599.....External Speaker for 599D Series

VHF LINES

CC-29A....2 Meter Converter for R-599D
CC-69.....6 Meter Converter for R-599D
FM-599A...FM Filter for R-599D
TR-7500....100 Channel Synthesized 2 M FM Transceiver
TR-8300...20 CM FM Transceiver (450 MHz)
TV-506....6 M Transceiver for 520/820/599 Series

SHORT WAVE LISTENING

R-300 General Coverage SWL Receiver

VHF LINES

TS-600...6 M All Mode Transceiver
TS-700S...2 M All Mode Transceiver
VFO-700S..Remote VFO for TS-700S
SP-70......Matching Speaker for TS-600/700 Series
TR-2200A...2 M Portable FM Transceiver
TR-7400A...2 M Synthesized Deluxe FM Transceiver

MORE ACCESSORIES:

Description Model # For use with
Rubber Helical Antenna RA-1 TR-2200A
Telescoping Whip Antenna T90-0082-05 TR-2200A
Ni-Cad Battery Pack (set) PB-15 TR-2200A
4 Pin Mic. Connector E07-0403-05 All Models
Active Filter Elements See Service Manual TR-7400A
Tone Burst Modules See Service Manual All Models
AC Cables Specify Model All Models
DC Cables Specify Model All Models

The Kenwood HS-4 headphone set adds versatility to any Kenwood station. For extended periods of wear, the HS-4 is comfortably padded and is completely adjustable. The frequency response of the HS-4 is tailored specifically for amateur communication use (300 to 3000 Hz, 8 ohms).

The MC-50 dynamic microphone has been designed expressly for amateur radio operation as a splendid addition to any Kenwood rig. Easily converted to high or low impedance (600 or 50k ohm).

TRIO-KENWOOD COMMUNICATIONS INC.
1111 WEST WALNUT/COMPTON, CA 90220
receiver spurious response
and its cures

Spurs are for cowboys — not amateur communications receivers!

Recent literature has paid a good deal of attention to intermodulation distortion in receivers; this is one form of spurious signal generation but many others are possible. These sources can be improper frequency sets in mixers, overdriven amplifiers, digital circuits, parasitic oscillations, and inadvertent coupling. Whether in new designs or modifications, all can be eliminated or at least minimized.

Mixers are the most probable spur sources. Since a mixer must be nonlinear it will generate harmonics internally. A poorly chosen set of input frequencies can produce spur or birdies at the output. Intermodulation distortion spurs have been well covered in the past, so attention is directed to identifying good and bad frequency sets.

A lot of methods and charts, including an HP-25 program, have been generated. One of the very simplest and easiest to use is that of Fisk and involves finding the decimal ratio of the lower input frequency set divided by the higher input frequency set; a similar method was described by Stevens.

**decimal ratio method**

Division of lowest frequency set by the highest will always result in a number between zero and one. This quotient can then be used to identify good and bad sets with appropriate tables. It does not matter which input has what; either may have the lower frequency ($F_L$) or the higher frequency ($F_H$); either or both inputs may have a single frequency.

**Tables 1 and 2** show the ratio, spur-product at that ratio, spur order. The rightmost columns relate either $F_L$ or $F_H$ to the mixer output frequency at each ratio. **Table 1** is for difference outputs ($F_H - F_L$) while **table 2** is for sum outputs ($F_H + F_L$).

The sum of each spur product frequency multipliers is the order of the spur amplitude. A lower order produces the stronger spur. Maximum spur order has been limited to 6. Higher orders are a problem only in precision instrumentation.

**Example.** The conventional broadcast receiver tunes 550 to 1650 kHz with a 445 kHz i-f; the local oscillator range must be 1005 to 2105 kHz and reasonable input selectivity is assumed.

Spur analysis will use **table 1** since mixer output is the difference. Decimal ratios will be $F_L/F_H = 550/1005 = 0.547$ at the low end and $F_L/F_H = 1650/2105 = 0.784$ at the high end. Three spurs occur:

**By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352**
The zero beat column is found by equating the i-f to the difference, terms of lower frequency column. This allows identifying where the birdie is located on the dial.

Only the 910 kHz birdie will be found when the signal is strong, provided the rf stage (if used) is linear. Why the strong signal requirement? The nonlinear amplitude characteristic of the mixer produces less harmonic output at lower signal levels so there is a difference as to which frequency set has the stronger signal. An LO set of 95 to 1195 kHz (if possible) would still produce a 0.667 ratio but the spur would be more pronounced since F_H (1365 kHz) is the fundamental and the antenna input signal.

### predicting spur levels

The variety of circuits and different nonlinear characteristics makes it difficult to predict spur levels. Input power level differences vs F_L and F_H also make it difficult. The intercept point concept explained in a recent *ham radio* article is a great help for estimating spur level if the intercept point data is available.

Some integrated-circuit mixers such as the Texas Instruments SN76514 include typical spur product levels. If in doubt, a breadboard test with a frequency set known to produce a low-order spur is helpful. A spectrum analyzer is not required since a receiver with a calibrated attenuator will serve as well. Frequencies are chosen so that outputs are slightly separated between desired and spur-produced signals.

Lacking either data, spur-product multipliers should be examined and one input should be low. Spurs are down with greater level differences.

Balanced mixers will have a reduction of even harmonics. Double-balanced types using transformer coupling are designed principally for input-output isolation; they reduce even harmonics from the source, not those created internally.

External harmonics will increase the spur product level. If spur products are unavoidable, the higher level input should be as clean as possible.

The best way to avoid mixer spurs is to pick the right frequency set. Keep the order or harmonic number as high as possible if some spur ratios exist; select frequencies while still in the block diagram stage.

### starting a transceiver design

A two-meter, incremental tuning transceiver is to be built with a 9-MHz receiver first i-f. A mixing synthesizer is first considered for frequency control; the block diagram is shown in fig. 1. The method of generating each frequency set may be put aside until a spur check is made.

Each mixer upconverts to each output so table 2 is used for the check. Each frequency set is variable so the ratios have two limits: lowest frequency of one input vs highest frequency of the other, then the highest frequency of the first input vs the lowest of the other.

The LO output ratios are then 40.000/98.9 = 0.404 and 40.095/95.0 = 0.422. No problem. Transmit output ratios are 49.000/96.8 = 0.495 to 49.095/95.0 = 0.517 which crosses the 3rd order spur listed in table 2. Identification of zero beat is done by checking the 3rd harmonic of the F_L set for equality with 1.5 times the F_H set. Here it occurs at 147.000 MHz with birdies adjacent.

A possible spur source is direct coupling of the transmit side lower frequency set 3rd harmonic bypassing the mixer. These range from 147.000 to 147.285 MHz, all in-band. Shielding and supply decoupling have to be considered.

By altering the frequency set ranges, spurs and direct harmonics can be moved out of band. The alteration would be:

### table 1. Spur identification for difference output.

<table>
<thead>
<tr>
<th>F_L/F_H</th>
<th>spur</th>
<th>order</th>
<th>F_L</th>
<th>F_H</th>
</tr>
</thead>
<tbody>
<tr>
<td>ratio</td>
<td>product</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.143</td>
<td>6F_L</td>
<td>6</td>
<td>6F_L</td>
<td>6F_H/7</td>
</tr>
<tr>
<td>0.167</td>
<td>5F_L</td>
<td>5</td>
<td>5F_L</td>
<td>5F_H/6</td>
</tr>
<tr>
<td>0.200</td>
<td>4F_L</td>
<td>4</td>
<td>4F_L</td>
<td>4F_H/5</td>
</tr>
<tr>
<td>0.250</td>
<td>3F_L</td>
<td>3</td>
<td>3F_L</td>
<td>3F_H/4</td>
</tr>
<tr>
<td>0.333</td>
<td>2F_L</td>
<td>2</td>
<td>2F_L</td>
<td>2F_H/3</td>
</tr>
<tr>
<td>0.400</td>
<td>4F_L - F_H</td>
<td>5</td>
<td>3F_L/2</td>
<td>3F_H/5</td>
</tr>
<tr>
<td>0.500</td>
<td>F_L</td>
<td>1</td>
<td>F_L</td>
<td>F_H/2</td>
</tr>
<tr>
<td>0.667</td>
<td>4F_L - 2F_H</td>
<td>8</td>
<td>2F_L/3</td>
<td>2F_H/5</td>
</tr>
<tr>
<td>0.750</td>
<td>3F_L - 2F_H</td>
<td>5</td>
<td>3F_L/3</td>
<td>F_H/4</td>
</tr>
</tbody>
</table>
Lower transmit set                              32.000 to 32.095 MHz
Common higher set                              112.0 to 115.9 MHz
Lower LO set                                    22.000 to 22.095 MHz

Spur checks now give ratios of 0.264 to 0.276 on the transmit side and 0.190 to 0.197 on the LO side. No ratios fit any spurs, and harmonics of direct coupling are not in-band. The latter includes cross-coupling from transmit side to LO side or vice versa.

Even though no spurs exist, this may not be attractive from a system standpoint. We can try a single variable set upconverted with fixed frequencies.

This is shown in fig. 2 with the single variable set derived by a phase-locked-loop or manually-tuned oscillator. The single crystal oscillator at 4.5 MHz can be counted down for the PLL reference; it must be shielded to prevent second harmonic interference with the i-f.

A spur check shows the transmit side is okay with ratios of 0.600 to 0.644. The LO mixer ratios are 0.667 to 0.716 with a 5th order spur at 135 MHz (144.000 MHz input). This results from 3F_H - 2F_L or 4F_L - F_H. It may be at the band edge but a birdie is possible at 144.005 MHz.

The next consideration is the common lower frequency set. Ratios will be 0.200 to 0.289 with a 6th order spur at 54 MHz due to 6F_L or 2F_H - 4F_L. This is again at 144 MHz. If a PLL is used, it should have low pass filtering or a square-wave output to minimize even harmonics.

It is difficult to avoid spurs in a single-crystal scheme if a harmonic of the crystal falls in-band. Fortunately, the spur orders are high with low spur product levels and both land on the band edge frequency. (Note that the band edges should be locked out with PLL control logic.)

The circuit of fig. 2 is favored for simpler structure and adaptability to phase-locked-loop control of a single variable frequency set. It does have some spurs and possibility of i-f interference so the oscillator and multiplier power levels should be low. If power is needed, amplifiers and filters should be added after the mixers. In addition, the PLL is basically a digital device so some thought should be given to harmonics from such sources.

digital source harmonics

Assuming rise and fall times are equal, harmonic voltage magnitude can be calculated relative to peak waveform amplitude at video with

\[
e_n = \left( \frac{2A}{n^2 \pi^2 F_r} \right) \sin (n \pi F_r t_r) \sin (n \pi F t_v)
\]

Where:
- \(e_n\) = Peak harmonic voltage at nth harmonic
- \(A\) = Peak video waveform amplitude
- \(n\) = Harmonic number
- \(F\) = Waveform frequency, MHz
- \(t_r\) = Rise or fall time, microseconds
- \(t_v\) = Half-amplitude video pulse width, microseconds

Both sine arguments are in radians and absolute sine values are used. This is a simplification of the Fourier coefficient formula for equal rise and fall times.

A video waveform of width equal to half period will have only odd harmonics. Magnitude of the width sine term will be unity with \(n\) odd, zero with \(n\) even. Such simplification is all right for rough calculations, but don’t expect digital ICs to be that perfect. It is better to make worst-case calculations by offsetting a square-wave by half the data sheet rise or fall time. This is only part of the digital source harmonics.

supply line transition surges

TTL and CMOS digital ICs have a current surge
every time an output changes logic states. This surge is only nanoseconds wide, so the harmonic content reaches the uhf region. Current surge amplitude varies between devices and examples may be found in the manufacturer’s data books. Many digital designers ignore this RFI source with limited supply bypassing. These glitches seldom affect the digital circuit itself so it’s not their worry; it can be murder to receiver sensitivity.

A rule of thumb is to provide a 470 to 1000 pF bypass capacitor for every output pin on the IC, using disc ceramics with the shortest possible leads, installed right at the IC package. A good mounting location is on the foil side directly between Vcc and the ground pins. This may seem like overkill in bypassing, but try a receiver with a “sniffer” loop at the digital supply lines of a limited bypass circuit.

Generally, CMOS logic is quieter in surges with low supply voltages. Schottky TTL is quieter than low power TTL even though the speed-power product is better. Line driver or buffer packages have the highest surges.

digital source interfacing

Loose capacitance coupling is seldom a problem to a digital output. Such capacitance is usually less than the device test load. Rise and fall times of CMOS with capacitance loading will be nearly equal but TTL is different. A standard TTL totem pole output can sink 16 mA at logic 0 (+0.4V), but will only source 0.4 mA at logic 1 (+2.4V minimum). A high to low transition will always be faster with loading.

It’s another story to drive a filter. Drivers for 50- to 75-ohm lines are available but an open-collector gate output as in fig. 3 is less expensive. In this circuit, the collector resistor is the filter source impedance (approximately) and a 470-ohm value fits medium speed and low power Schottky TTL gates. All other outputs for purely digital use must also have pull-up resistors.

digital mixers

The technique of digital mixing has been largely unexplored. Any 2-input gate can mix two digital sources. Because of fast transitions, harmonic content is high so strict observance of spur products must be made. It is extremely simple and an open-collector 2-input NAND gate could serve as the PLL mixer in fig. 2. In this circuit the 45-MHz analog signal would require either a fast comparator or Schmitt-input inverter or gate as an interface. Schottky or high power TTL devices are required at such frequencies. A different frequency set is needed since the spurs at the lower edge will be more pronounced.

Digital mixers have the advantage that spurs are more easily predicted mathematically although a computer program may be necessary. It is a scheme open for experimentation.

zero i-f ssb receiver

The direct-conversion receiver has become popular for 40- and 80-meter work; a digital counter is invariably used to provide the necessary

fig. 3. Digital to analog interface through a filter using open-collector outputs.

quadrature LO phase. Unfortunately, a 40-meter receiver becomes susceptible to 15-meter pickup.

The cause is the counter for LO injection. A 20 nanosecond rise/fall time square-wave will have a third harmonic only 10 dB below the fundamental in voltage. This is high enough to provide mixing action although more conversion loss exists.

Adequate antenna input filtering is required. LO filters can’t be used since this destroys the quadrature relation. This is a good example of source-related spurs.

spur suppression when not in zero beat

Close birdies can be reduced by an active limiter interface such as the circuit from a broadcast fm i-f. Since a limiter is an amplifier driven to cutoff and/or saturation, the stronger the input, the more a low-level input is attenuated at the output; i.e., the low signal can’t get through unless the amplifier is in the linear amplitude level.

A relatively low cost linear is shown in fig. 4. The metal-can version MC1590 can be substituted in this circuit since it has the same chip as the MC1350. These Motorola devices are wideband, differential input and output amplifiers that also work well as limiters into the 50-MHz region.*

Ac input coupling is required. The input impedance is a constant 5k in parallel with a 5 pF at each input. Each output is an open-collector to allow a variety of loads and maximum voltage swing.

* Diode limiters will work well if the forward voltage of each is matched, but diodes absorb power. The object of use is as a combination buffer and suppressor with one mixer input level low to minimize spurs. The circuit shown has been test flown in three different avionics systems.
Transformer coupling the output reduces even harmonics. The input may be single-ended or push-pull with little output difference. These devices also make good mixers.9

**ground loop ghosts**

Hours can be spent hunting a ground loop that isn’t there. This usually occurs in a wire bundle carrying both high and low level signals, and coupling can occur even when both lines are coax. Why?

Woven braid outer conductor coax has only 98 per cent shielding, at best. This can drop to 90 per cent at sharp corners. The result is little coupling apertures all along the line with greater coupling at higher frequencies. One cure is to use double-braided coax; a cheaper method is to wrap each line with aluminum foil. For even better results, separate the high and low level lines.

**other sneaky paths**

A beautifully shielded source may be a marvel of mechanical work but it is all window dressing if the supply lines aren’t filtered. Watch out for bypass capacitor resonances; they can become inductors above resonance and lose all effectiveness. Parallel small, medium, and large value capacitors when in doubt.

Apertures become antennas at higher frequencies. A receiver with a sniffer loop will help find the cause. If the aperture can’t be easily closed, try aluminum foil held in place by a thin layer of contact cement.

Window screen material is fairly good for shielding and allows air circulation. One caution: make certain it is metal; a lot of screen material is plastic these days!

Control lines in the dc/audio range can be anten-

nas, so watch the routing and rf bypassing. The same is true of control shafts and shielding material that has oxidized.

**parasitics**

This is a local problem and is usually confined to power amplifiers running in class B or C. Amateur handbooks explain the problem and a receiver sniffer can help to find the offending circuit.

Switching power supplies can generate RFI through “cross-current conduction.” While this is mainly a problem for the supply,10 it can react with other components to produce rf bursts at switching times. Cure the cross-current conduction and you generally cure the RFI.

Emitter followers sometimes have parasitic oscillations. A couple of hundred ohms in series with the base usually helps but proper design is better.11,12 This type of spur results more in distortion of the signal; it is usually at vhf and rather unstable.

Spurious signals have many causes but can be identified with a little work. Most of them come from mixing so you can head them off while still in the block diagram stage. Others result when the schematic is converted to hardware. Careful circuit grouping and common sense will stop those.

Spurs are only for cowboys? Any experienced rider will tell you a good horse doesn’t need spurs at all.

**references**


*ham radio*
The M-34 mobile antenna gives you 10, 15, and 20 meters and great performance in a tough, rugged design for only $52.75.

Then whenever you want it you can buy the optional 160, 80 or 40 meter coil and top section for $20.00 to $25.00 depending on the band and make a full-capability four-bander out of it. One that never needs coil changes or adjustments after initial tuning. What's more, at no extra cost you get features like 500 watts PEP, low standing wave ratio at resonance, independent resonance adjustments on each of the four bands, exceptional bandwidth and a neat, clean, low-wind-resistance profile that also goes great with mobile homes, motor homes and apartments.

That's the kind of innovative, problem-solving thinking that goes into Swan mobile antennas. Not just the M-34 but these, too:

**742 Automatic**. Swan automates mobile antennas with the 742 tri-band antenna. Work 20, 40 or 75 meters with your 742 without need for coil change or other adjustments after initial tuning. A high Q mobile antenna designed for maximum efficiency capable of 500 watts PEP. $109.95

**Mobile 45**. This switch-adjustable 5-band antenna features a Swan HI-Q coil and positive-stop, 9-position switch with GOLD-PLATED contacts. Select 10, 15, 20, 40 plus five positions for 75 meters and go to work knowing this rugged antenna is doing its job. $119.95

**MMBX Impedance matcher**. Makes your transmitter and your antenna a perfect match at ratios of 1:1 to 1:0.06 in seven switch-selected increments. Reverse the coax connections and you've got a step-up impedance matcher. 500 watts P.E.P., 3 to 30 MHz. $23.95

You can't find mobile antennas that deliver more than Swan mobiles. Every time you press the mike button. Buy one today. Use your Swan credit card. Applications at your dealer or write to us.

(Prices FOB Oceanside, CA) Dealers throughout the world or order direct from SWAN ELECTRONICS A subsidiary of Cubic Corporation 305 Airport Road, Oceanside, CA 92054

---

**OUR NEW M-34 EXPANDABLE IS JUST ONE OF THE EXCITING MOBILE ANTENNAS FROM SWAN.**
When it comes to watts per dollar in full performance transceivers you can't top the new 350A, 350D and 750CW from Swan. They're part of Swan's new emphasis on solid value equipment that gets out and does the job better than gear costing a lot more.

THESE NEW TRANSCEIVERS GIVE YOU GLOBE-SPANNING PERFORMANCE AT DOWN-TO-EARTH PRICES.

750CW. $679.95. PSU-3 AC Power Supply $173.95.
**750CW**

- If you're ready for 700 loud-talking watts, you're ready for the new 750CW.
  - 700 watts P.E.P. input on SSB
  - 400 watts DC input on CW
  - CW audio filter selectable 80 or 100 Hz.
  - CW sidetone monitor with adjustable pitch and volume control
  - 80 through 10 meters, USB, LSB, CW
  - Selectable 25 or 100 KHz crystal calibrator
  - Standard 5.5 Mhz, 2.7 Hz bandwidth crystal filter or optional accessory 16 pole filter available with 140 Db ultimate rejection.
  - Oscillators are solid state and IC regulated for stability
- CW sidetone monitor with adjustable pitch and volume
- CW audio filter 80 and 100 Hz selectable
- Built in 117 VAC power supply and speaker. (220 VAC power supply available on special request)
- Crystal Calibrator (350A only)

**350A**

- 300 watts P.E.P. input SSB
- 200 watts DC input on CW
- 80 through 10 meters, USB, LSB, CW
- 5.5 Mhz, 2.7 KHz bandwidth crystal filter
- Oscillators are solid state and IC regulated for stability

**350D**

- Same basic features as 350A except added feature of:
  - 6 Digit LED frequency display with readout to 100 Hz

- CW sidetone monitor with adjustable pitch and volume
- CW audio filter 80 and 100 Hz selectable
- Built in 117 VAC power supply and speaker. (220 VAC power supply available on special request)
- Crystal Calibrator (350A only)

Both the 350A and the 350D are compatible with the same line of Swan accessories that has built a reputation for reliability and performance that's second to none. Including linear amplifiers to boost your power to the legal limit.

So they're perfect for novices or anyone else because you can build capability as you need it.

So put your money in a Swan transceiver. It buys a lot more rig now and later.

See the 350A, 350D or 750CW today at your Swan dealer, or contact the factory direct. Use your Swan credit card. Applications available at your dealer or write to us.
(Prices FOB Oceanside, CA)

---

350A: $599.95 with built-in A.C. power supply.

350D: $699.95 with built-in A.C. power supply.
During recent years, much research has been done on solid-state mixer design. One important design configuration was described by Rafuse, this circuit, using four single-gate mosfets, was incorporated into the Racal receivers built in the late 1960s. Even with the excellent intercept point of +28 to +30 dBm, this design suffered from the problem of excessive local-oscillator feedthrough back to the rf input. To cure the problem, an rf amplifier was added before the mixer. Another important contribution, in using field-effect transistors, came from Ed Oxner of Siliconix. But even the eventual development of the VMP4 power mosfets did not solve all the problems of the device's high input and feedback capacitance.

As I explained in a previous article, optimum performance of present-day active mixers can only be achieved under the right conditions. The schematic diagram of the active double-balanced mixer shows the configuration used in the Racal receivers. The toroid cores should be Indiana General F625-9-TC9 which provide a flat response from 100 kHz to 50 MHz.
The three photographs show spectrum analyzer presentations of double-balanced mixers. In each case the input signals were 0 dBm. The top line in the graticule also represents 0 dBm. A shows an ordinary passive double-balanced mixer with +7 dBm LO drive. B is an active double-balanced mixer, made in accordance with the Siliconix applications note, using a U350 fet. The intercept point is +17.5 dBm. C shows the performance of the circuit in fig. 1 run under the same conditions as B. In this case, the distortion products are suppressed 65 dB below the carrier levels. For the same LO-drive level, this means you have a 30 dB decrease in distortion products with roughly the same component costs and noise figure.

achieved when the i-f port is properly terminated. For example, if an i-f filter follows the mixer, the filter must present a constant impedance over a wide frequency range. If not, the intercept point will deteriorate due to the high impedance levels, causing current or voltage saturation of the active devices. Therefore, the passive double-balanced mixer, together with a proper wideband termination using fets in a grounded-gate push-pull configuration, has yielded a superior performance over a wider frequency range.

Recent developments in the transistor field have produced a group of CATV transistors that are characterized by low noise figures and high gain-bandwidth products. By applying new types of rf feedback, linear operation can be obtained that will provide superior IMD product performance over previous fet and tube designs.

Fig. 1 shows an active double-balanced mixer using four CATV transistors (2N5109) with a feedback circuit as described in reference 3. The rf feedback, together with impedance stabilization, avoids the drawbacks of the field-effect transistor mixer while giving a higher intercept point and stable gain. This increased performance is achieved with the same drive level as previous designs yet at the same time providing a noise figure of approximately 10 dB. The emitter resistors are used to reduce the amount of flicker noise in the system. With a local oscillator level of +13 dBm, a +40 dBm intercept point can be achieved. Lowering the LO level to +10 dBm causes little performance degradation but does decrease the distortion level.

references
Features:
Custom computer grade commercial components, capacitors, and tube sockets manufactured specifically for high power use — heavy duty 10kW silver plated ceramic band switches, Silver plated copper tubing tank coil—Huge 4" easy to read meters — measure plate current, high voltage, grid current and low RF output. Continuous duty power supply built in. State of the art zener diode standby and operating bias provides reduced idling current and greater output efficiency. Built-in hum free DC heavy duty antenna change-over relays. AC input 110V or 220V AC, 50-60Hz — tuned input circuits. ALC-rear panel connections for ALC output to exciter and for relay control. Double internal shielding of all RF enclosures. Heavy duty chassis and cabinet construction and much, much more.

HOLIDAY INTRODUCTORY SPECIAL!
New! Sigma Model AF250L Deviation/Modulation Meter
Features:
Extremely stable local oscillator for easy measurement of HF, VHF, and UHF bands employing negative feedback, to insure extremely high stability. Easy to read, accurate linear scale. Direct off the air signal measurement capability.

Specifications:

The New Sigma XR3000D Linear Amplifier

Features:
- Full bandwidth coverage 160-10 meters including mars.
- 2000 watts P.E.P. SSB input. 1000 watts input continuous duty, CW, RTTY & SSTV.
- Two Emac 3-500D conservatively rated finals.
- All major HV and other circuit components mounted on single G-10 glass plug in board. Have a service problem? (Very unlikely) Just unplug board and send to us.
- Heavy duty commercial grade quality and construction second to no other unit at any price!
- Weight: 90 lbs. Size: 9½" (h) x 16" (w) x 15¾" (d).

Sigma RF-2000

SwR & Power Meter
Cal PWR Scales 200W-2000W Freq Range 3.5-150 MHz Please do not confuse the RF-2000 with similar appearing lower priced units. RF-2000 is an individually calibrated professional quality instrument. Unequaled at many times the price. Size 7" (w) x 2½" (h) x 2½" (d).

Standard New 2 Meter FM Transceivers
Model SRC 146A Special Sale

- SRC 146A: $314
- USA 2 Deluxe Back Charger: $67
- PC344 Leather Case: $52
- AT1 Rubber Ant and Who: $50
- NiCd: $30
- Reg. $413
- New!!! Touch Tone pad completely wired and ready to plug in-$69.00

New! Nye Viking
Model MB-11 3,000 Watts

- $285
- Antenna Impedance Matching Network. Copper ribbon wound, silver plated variable inductor. Heavy duty 7000 volt varactor output capacitor. 10,000 volt bias capacitor. Silver plated RF conductors. Large, precise, easy to read dials. 360° readable. Overload protection for SWR meter.

AMATEUR-WHOLESALE ELECTRONICS
8817 S.W. 129th Terrace, Miami, Florida 33176
COURTESY PERSONAL SERVICE — SAME DAY SHIPTMENT — Prices subject to change without notice.
Telephone: (305) 233-3631 - Telex 51-5628 - Store Hours: 10-5 Mon.-Fri.
THE FUTURE NOW!

FM 2015 R

All Solid State CMOS PLL digital synthesized - No Crystals to buy! 5KHz steps - 144 - 149 MHz-LED digital readout PLUS MARS-CAP.*

● 5MHz Band Coverage - 1000 Channels (instead of the usual 2MHz to 4MHz - 400 to 800 Channels). 4 CHANNEL RAM IC MEMORY WITH SCANNING-MULTIPLE FREQUENCY OFFSETS - Electronic Auto Tuning, Transmit and Receive-Internal Multipurpose Tone Oscillator-RIT-Discriminator Meter ● 15 Watts Output - ● Unequaled Receiver Sensitivity and Selectivity-15 Pole Filter-Monolithic Crystal Filter and Automatic Tuned Receiver Front End-COMPARE! ● Superb Engineering and Superior Commercial Avionics Grade Quality and Construction Second to None at ANY PRICE.

INTRODUCTORY PRICE

$399.00

- FREQUENCY RANGE: Receive and Transmit: 144.00 to 148.995 MHz, 5KHz steps (1000 channels) - MARS-CAP.*
- AIRCRAFT TYPE FREQUENCY SELECTOR: Large and small coaxially mounted knobs select 100KHz and 10KHz steps respectively. Switches click-stopped with a home position facilitate frequency changing without need to view LED'S while driving and provides the sightless amateur with full Braille dial as standard equipment.
- FULL AUTOMATIC TUNING OF RECEIVER FRONT END AND TRANSMITTER CIRCUITS: DC output of PLL fed to varactor diodes in all front end RF tuned circuits provides full sensitivity and optimum intermodulation rejection over the entire band. APC (AUTO POWER CONTROL) - Keeps RF output constant from band edge to band edge and helps keep spurs down. No other amateur unit at any price has this feature which is found in only the most sophisticated and expensive aircraft and commercial transceivers.
- TRUE FM: Not phase modulation - for superb emphasized hi-fi audio quality second to none.
- 4 CHANNEL RAM SCANNER WITH IC MEMORY: Program any 4 frequencies and reprogram at any time, using the front panel controls-scan all or part of the memory-search for occupied (closed) channel or vacant (open) channels with internal Ni-Cad to retain memory. (No diode matrix to wire or change).
- MULTIPLE FREQUENCY OFFSETS: Three positions A.B.C. provided for installation of optional crystals.
- INTERNAL MULTIPURPOSE TONE OSCILLATOR: 1750Hz tone burst for "whistle on operation" and sub-audible tone operation possible by simply adding a capacitor across the terminals provided. Internal 1 position switch for automatic and manual operation, tone burst or sub-audible tone PL - adjustable 60-203Hz (100 Hz provided).
- RIT CONTROL: Use to improve clarity when contacting stations with off frequency carrier.
- MODULAR COMMERCIAL GRADE CONSTRUCTION: 6 Unitized modules eliminate stray coupling and facilitate ease of maintenance.
- ACCESSORY SOCKET: Fully wired for touch tone, phone patch, and other accessories. Internal switch connects receiver output speaker when connector is not in use.
- MULTI-PURPOSE METER: Discriminator Meter, Provides; "S" reading on receive and power out on transmit.
- RECEIVED: Better than 25uv sensitivity, 15 pole filter as well as monolithic crystal filter and automatic tuned LC circuits provide superior skirt selectivity.
- HIGH LOW POWER OUTPUT: 15 watts and 1 watt-switch selected low power may be adjusted anywhere between 1 and 15 watts fully protected-short or open SWR.
- OTHER FEATURES: Dynamic microphone-mobile mount external 5 pin accessory jack-speaker jack and much, much more-size 2½ x 7 x 7½. All cords, plugs, fuses, microphone hanger, etc. included. Weight 5 lbs.

Manufactured by one of the world's most distinguished Avionics manufacturers, Kyokuto Denshi Kaisha, Ltd.
First in the world with an all solid state 2 meter FM transceiver.

AMATEUR-WHOLESALE ELECTRONICS
8817 S.W. 129th Terrace, Miami, Florida 33176
Telephone (305) 233-3631, Telex: 51-5628
U.S. DISTRIBUTOR

Dealer Inquiries Invited.
Please order from local dealer or direct if unavailable.

November 1977
silver plating

Dear HR:

Recently you published an item on electroplating copper wire with silver, which had the advantage of improving the appearance and freedom from corrosion (although silver tends to become silver sulfide), a varnish coating being applied to prevent the latter. It was also stated that, electically speaking, the lower resistance of the silver was of little importance under 100 MHz. I have found the following:

1. Urethane varnish, diluted 1:6 with gasoline, makes a very durable coating so that silver plating may be unnecessary (for applications below 100 MHz).

2. Exhausted photographic fixer (fixer that requires at least twice the original time to clear the film [which can be made by fixing out waste film in a small amount of fixer, if desired]), will deposit a coating of silver upon clean, grease-free copper, by simply immersing it in the fixer. Used fixer can be obtained from firms doing offset printing; they use it for their negatives and usually dump it in the sewer when it becomes exhausted. Otherwise a friendly amateur photographer doing black-and-white work will be glad to donate his used hypo which is virtually worthless in small quantities.

To test photographic fixer for silver content, polish a piece of heavy copper wire or copper tubing with abrasive, then plunge it into the fixer — it will emerge with a bright coating if sufficient silver is present in the fixer solution.

Lloyd Jennett, WA0AGD
Des Moines, Iowa

contact bounce eliminators

Dear HR:

The short article by W9KNI in August, 1976, ham radio (page 80) on how to eliminate contact bounce problems in keyers can be solved by a simpler method. There is no such thing as a switch that has no bounce, either on make or break. To overcome the problem Motorola introduced the MC14490 Hex Contact Bounce Eliminator about a year ago. Using this IC, up to 6 contacts can be debounced. The only other component required is a small capacitor. The IC will interface with CMOS or TTL and either normally open or normally closed contacts.

Harry R. Hyder, W7IV
Scottsdale, Arizona

synthesizer design

Dear HR:

"Modern Design of Frequency Synthesizers" was one of the few articles, amateur or otherwise, that really got into the fine points of synthesizer design. The only point that I would take exception to regards the Motorola phase detector (MC4344). It is not a simple flip-flop, but a true frequency phase detector with infinite pull-in range like the CD4046. I have used both with essentially equivalent results.

The only difference is that the CD4046 has a charge pump. A better name would be tri-state output; the three states being raise frequency, lower frequency, and hold frequency. A flip-flop or shift register phase detector has only two states — raise or lower frequency. The CD4046 is capable of a full Vcc to Vss output voltage swing. Unlike the MC4344 (output of ± 0.7 volts) the CD4046 could be used to drive a VCO directly, without additional dc gain. The lack of external amplification could make a low-gain, one loop synthesizer, based on the CD4046, have a cleaner output.

Jerry Pulice, WB2CPA
Staten Island, New York

internal resistance of Radio Shack meters

Dear HR:

In the July, 1976, issue of ham radio W0MAY comments on the lack of information about the internal resistance of Radio Shack panel meters.* This information was made available to the stores in the monthly technical newsletter that the company uses to keep employees up-to-date on the various product lines.

The list is reproduced below for the information of your readers. Several of the meters listed have been discontinued, but the information is included for those who may still have them lying around.

<table>
<thead>
<tr>
<th>catalog number</th>
<th>scale</th>
<th>internal resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22-016</td>
<td>0-150 Vac</td>
<td>80</td>
</tr>
<tr>
<td>22-017</td>
<td>0-50 mA</td>
<td>100</td>
</tr>
<tr>
<td>22-018</td>
<td>0-1 mA</td>
<td>80</td>
</tr>
<tr>
<td>22-019</td>
<td>VU</td>
<td>750</td>
</tr>
<tr>
<td>22-020</td>
<td>&quot;S&quot; meter</td>
<td>80</td>
</tr>
<tr>
<td>22-036</td>
<td>0-15 Vdc</td>
<td>80</td>
</tr>
<tr>
<td>22-037</td>
<td>0-100 µA</td>
<td>1000</td>
</tr>
<tr>
<td>22-051</td>
<td>0-50 µA</td>
<td>1600</td>
</tr>
<tr>
<td>22-052</td>
<td>0-1 mA</td>
<td>80</td>
</tr>
<tr>
<td>22-063</td>
<td>VU</td>
<td>750</td>
</tr>
</tbody>
</table>

It seems as though W0MAY’s calculation of 1600 ohms for his 0-50 µA meter was right on the money! I hope your readers will find this list of use.

G. L. Katzenberger
Troy, Ohio

---

The way some people get attached to their Collins amateur equipment you'd think we weren't making it anymore.

But we are, and have been since 1933. That's when Collins started out to build a better transmitter and became one of the quality and performance leaders in amateur radio.

Collins quality starts with a careful and conservative design backed by rigid component selection and testing standards. And Collins performance speaks for itself with one of the cleanest, clearest signals on the air. It's Collins quality and performance that make the S/Line a standard of excellence in amateur radio.

Maybe that's why people get so attached to their Collins equipment. And why it has such a low depreciation rate on equipment value.

Whatever the reason, you can be sure that when you buy Collins equipment you're making a safe investment.

For more information on the incomparable Collins S/Line, write or call Amateur Radio Marketing, Collins Government Telecommunications Group, Rockwell International, Cedar Rapids, Iowa 52406; 319/395-4493.
All band operation (160-10 meters) with any random length of wire. 200 watt output power capability—will work with virtually any transceiver. Ideal for portable or home operation. Great for apartments and hotel rooms—simply run a wire inside, out a window, or anyplace available. Toroid inductor for small size: 4-1/4" X 2-3/8" X 3". Built-in neon tune-up indicator. SO-239 connector. Attractive bronze finished enclosure.

Only $29.95

**sst t-2 ULTRA TUNER**

Tunes out SWR on any coax fed antenna as well as random wires. Works great on all bands (160-10 meters) with any transceiver running up to 200 watts power output. Increases usable bandwidth of any antenna. Tunes out SWR on mobile whips from inside your car. Uses toroid inductor and specially made capacitors for small size: 5/8" x 2/4" x 2/8". Rugged, yet compact. Attractive bronze finished enclosure. SO-239 coax connectors are used for transmitter input and coax fed antennas. Convenient binding posts are provided for random wire and ground connections.

Only $49.95

**sst t-3 IMPEDANCE TRANSFORMER**

Matches 52 ohm coax to the lower impedance of a mobile whip or vertical. 12 position switch with taps spread between 3 and 52 ohms. Broadband from 1-30 MHz. Will work with virtually any transceiver—300 watt output power capability. SO-239 connectors. Toroid inductor for small size: 2-3/4" X 2" X 2-1/4". Attractive bronze finish.

Only $19.95

**GUARANTEE**

All SST products are guaranteed for 1 year. In addition, they may be returned within 10 days for a full refund (less shipping) if you are not satisfied for any reason. Please add $2 for shipping and handling. Calif. residents, please add sales tax. COD orders OK by phone.
Now you can afford the best! Free-standing or guyed, Tri-Ex Towers stress quality. All towers are hot dipped galvanized after fabrication for longer life. Each series is specifically engineered to HAM operator requirements.

**W Series**
An aerodynamic tower designed to hold 9 square feet in a 50 mph wind. Six models at different heights.

**MW Series**
Self-supporting when attached at first section — will hold normal Tri-Band beam. Six models.

**LM Series**
A 'W' brace motorized tower. Holds large antenna loads up to 70 feet high. Super buy.

**TM Series**
Features tubular construction for really big antenna loads. Up to 100 feet. Free-standing, with motors to raise and lower.

**THD Series**

Start with Top-of-the-Line Tri-Ex Towers. At basic prices. Write today, for your best buy.
simple crystal oscillator

National Semiconductor has a new IC designed to flash an LED from a single voltage cell. It is called LM3909N and is similar to the standard minidip. I've found that the LM3909 makes a very efficient crystal oscillator in the i-f range of 100-500 kHz. A 100 kHz crystal will generate strong harmonics beyond 30 MHz. Power drain is less than 0.5 mA at 1.2 volts; an AA cell should last for months.

All you need is the LM3909N, a minidip socket, a crystal, and a penlight cell. For ultra-low current drain, you may add up to 2000 ohms of resistance in series with the cell, which will drop the drain to about 0.25 mA.

For a low-power i-f signal generator, use a 465-kHz crystal. I couple the oscillator output to a receiver input via a 100-pF capacitor. For more precise frequency control, connect a capacitor in series with pin 8 of the IC. About 10 pF brought my 100 kHz crystal to zero-beat with WWV.

Isaac Queen, W2OUX

fm-ing on uhf multimode transceivers

Some users of the popular synthesized vhf ssb/fm transceivers have occasionally noticed a frequency shift (fm-ing) when the unit is operated on ssb. In my case, contact with the manufacturer of the transceiver failed to throw any light on the subject. The objectionable fm-ing was very noticeable on voice and gave a peculiar wavering quality to the modulation. Inquiries among other local vhf operators showed that this fault was not unique, nor was it limited to a single brand of equipment.

A series of tests finally revealed that the fm-ing was caused by a minute quantity of rf getting back into the frequency control circuits of the transceiver. Operation of the transceiver into a dummy load showed no fm-ing, yet operation into the station antenna revealed the presence of fm when the transceiver was in the ssb mode.

The solution to the problem was two-fold. First, the swr on the transmission line from the transceiver to the antenna had to be reduced to a very low value in that portion of the band where ssb operation was used. Second, the line had to be brought away from the transmitting antenna field in such a fashion that no rf was induced into the outer conductor of the line. This meant relocating the line so that it dropped down directly beneath the transmitting antenna instead of coming away at an angle.

The problem of achieving a low swr across the entire two-meter band was solved by switching from a Yagi antenna to a log-periodic bandpass Yagi having an equivalent power gain. This antenna provided an swr value of less than 1.4:1 across the entire two-meter band. Using the log periodic Yagi, plus relocation of the transmission line, completely solved my vexing problem.

Bill Orr, W6SAI

tower guying

Judging by some of the improper tower installations I've seen, it is clear that many amateurs do not understand the basic principles of tower guying. In addition to the very obvious function of preventing a tower from falling over in a high wind, guy wires also perform a second less obvious function: they prevent the tower from twisting, but only if properly installed. This is critical, because a tower with a large antenna load is vulnerable to twisting when the antenna starts whipping around in the wind. In most cases, a tower is much more likely to twist and buckle than it is to bend straight over.

Some people use nylon or polypropylene rope to guy their tower; they think that because it has the same ultimate breaking strength as the recommended steel guy wire, it's an acceptable substitute. The fallacy is that the rope will stretch and the steel guy wire will not. Also, the rope does very little to protect the tower due to twisting. Given a severe enough wind storm, it can come down with all guys intact.

Another common misapplication of
guying is to use steel guy wires but fail to tension them properly. Left too loose, even steel guy wire will not give adequate protection against twisting. The Rohn tower literature recommends tensioning each guy wire to 10 per cent of its ultimate strength. There is an easy method for determining the tension in a guy wire without resorting to the expensive dynometers.

A relationship exists between the tension in a guy wire and its resonant vibrating frequency. This relationship is defined by the formulas:

\[ n = \frac{1}{2l} \sqrt{\frac{T}{m}} \quad \text{and} \quad T = 4n^2 I^2 m \]

where

- \( T \) is the tension in foot pounds,
- \( n \) is the vibrating frequency in Hertz,
- \( l \) is the length of the guy wire in feet, and
- \( m \) is the mass per unit length of the guy wire in slugs per foot (1 slug = 32.17 pounds).

To find the resonant frequency, start the wire swinging back and forth, count the number of full cycles in ten seconds, and divide by ten. It will probably be necessary to push on the wire with each swing to keep it going for this length of time. The data in table 1 for different sizes of seven-strand galvanized steel guy wire is from the Rohn catalog. Using this data and the appropriate formula, the actual tension in any guy wire, and the vibrating frequency for the recommended tension can easily be determined.

There will always be cases where there is insufficient room to place guy anchor points as far out from the base of the tower as the manufacturer recommends. While an installation such as this is always something of a structural compromise, there are other means to help overcome this deficiency. The easiest technique is to use torque arms. These are assemblies that attach to the tower at each guy point, and the guy wires are in turn attached to the torque arms. For guying purposes, these make the tower more resistant to twisting. Another method is to use four guys at each level, spaced every 90 degrees instead of the usual three with 120 degree spacing. Other possibilities would include guying at more levels than the minimum recommended, using heavier guy wire, and making the guy anchor points stronger.

Put up your tower as high as you want, but guy it right. Then when the ice storms come and the hurricanes blow, you can relax. Your antenna may blow away, but a properly guyed tower will stay up through just about anything.

John Becker, K9MM

**SB200 CW modification**

Improved CW operation of the Heath SB200 amplifier can be obtained by reducing the key-up plate current to 0 (class C operation instead of AB). This simple modification will maintain the same amplifier output, and substantially increase tube life by reducing key-up idling power from about 200 to zero watts. The modification is performed by adding a 250-ohm, 10-watt resistor in series with the ANTENNA RELAY l.d, (fig. 1). By adding the resistor, the grid bias voltage, which is norr ally developed across a 33-ohm resistor,
32S-series ALC meter improvement

The drifting zero adjustment of the Collins S-Line ALC meter is quite common and annoying. It's due in part to the components involved, but basically this syndrome is caused by a change in line voltage which produces a corresponding change in the reference voltage taken from the screen of V3, the i-f amplifier. This voltage is in turn divided down by the combination of R22 and R23 and precise zero balance is accomplished by R20, the ALC meter zero adjustment potentiometer. Therefore, as the low-voltage supply changes, the zero adjustment also varies. When negative, it's most disturbing.

The solution is a rather simple change which also has a secondary beneficial effect. The change is shown in fig. 3, with the two additional components being shown with the heavy lines. First, a 500-mW, 100-volt zener diode (IN5271) is added from pin 6 of V3 to ground, and a 33k, 1-watt resistor in parallel with the existing screen dropping resistor, R18. The screen voltage is now reasonably well regulated, providing a relatively stable reference voltage for the ALC meter circuit. Also, because the developed ALC bias voltage is impressed on the grid of V3, the screen voltage rises as the plate current is reduced during normal peak speech excursions. The result is that the transconductance of V3 tends to rise as the ALC bias voltage simultaneously seeks to reduce the gain of the tube. With the added regulation, this potential problem is eliminated. The results have been quite favorable in my Collins 32S-3 with the ALC zero varying no more than plus or minus one minor division during five months of operation.

Marv Gonsior, W6FR

---

**SCR1000**

State of the Art in VHF FM Repeaters!

2M & NOW 220 MHz!

- 100% Solid State
- 30 Wts. Output
- Exclusive MOSFET/Hot Carrier Diode Rx
- Front end - greatly reduces IM & 'desense'
- Full Metering
- Lighted Pushbuttons & Status Indicators for ease of maintenance

---

**Some Plain Talk About Repeaters —**

Let's face it — your repeater group's success or failure hinges on the quality and reliability of your "Machine"! That's why the engineers at Spec Comm dedicated themselves to the production of the finest repeater available on the amateur market. The SCR1000 has been conservatively designed for years of trouble-free operation, and every consideration has been given to operator convenience and accessory interfacing. Features like full metering, lighted status indicators, full front panel control of every important repeater parameter, and accessory jacks for autopatch, xmt, control, etc. And audio so good and so full, your 30 watts will sound like 100! Think about it, and think about your users. The purchase of a Spec Comm Repeater is a sound investment in your group's future, and they'll be thanking you for years to come! Sold factory direct only. $950 Amateur Net.

Don't make a mistake — your group deserves the finest! Call or write the hams at Spec Comm today for further info!

Send for Data Sheets.

---

**SPECTRUM COMMUNICATIONS**

1055 W. GERMANTOWN PK • NORRISTOWN, PA 19401 • (215) 631-1710

- Full Break-In
- Full Band Coverage on 3, 5, 7, 14, 21 MHz Bands
- 1 MHz on 28 MHz Band
- 70 Watts Input
- Total Solid-State
- Receives SSB and CW
- Receiver Sensitivity 1 uV
- Instant Band Change
- No Tune-up
- Offset Receiver Tuning
- 3-Position Selectivity
- Adjustable Sidetone Level
- Linear Crystal-Mixed VFO
- Overload Protection
- Built-In AC Power Supply
- Black & Gray Styling
- HWD: 6¾" x 12¾" x 12¼" 15½ lbs.
- Matching Accessories

THE RECEIVER. Double-Direct-Conversion. Easy tuning. Just select the frequency and set the audio level. Excellent cross-modulation characteristics. Offset tuning so you can tune either side of zero beat to reduce QRMs. Front panel control selects one of 3 selectivity curves: 2.5 kHz for SSB reception, 1 kHz for normal CW, and 500 Hz for when the QRMs get rough. Plus separate AF and RF controls, headphone jack, and built-in speaker.

THE TRANSMITTER. Total solid-state. Push-pull Class C final amplifier. Individual low-pass filters are switched into the antenna line to reduce unwanted radiations, minimize TVIs. No tune-up needed when changing frequencies or bands. And full break-in allows incoming signals to be heard between transmitted characters. Now CW is real conversation!

THE VFO. Common to receiver and transmitter. Permeability tuned. Linear scale. 5-5.5 MHz basic frequency is crystal-mixed to the desired frequency so bandspread and stability are the same on all bands (crystals included for 3.5, 7, and 14 MHz bands).

THE POWER SUPPLY. Built-in, AC operated, and regulated. Monitors current demand, shuts down automatically when necessary for protection. Lighted input current meter shows proper Drive setting.

MATCHING ACCESSORIES. Model 670 Electronic Keyer, 6-50 wpm, self-completing characters, powered by the Century. Model 276 Calibrator for markers at every 100 and 25 kHz. Model 271 Crystal for 21-21.5 MHz, 272 Crystal for 28-28.5 MHz, 273 Crystal for 28.5-29 MHz.

570 Century 21 Transceiver $289
670 Century 21 Keyer $29
276 Century 21 Calibrator $29
271, 272, 273 Crystals ea. $5

See the surprise of the CENTURY 21 at your TEN-TEC dealer—or write for full details.

---

We have been notified that Motorola has been granted registration of the trademark "Triton." Consequently, TEN-TEC will refrain from using "Triton IV" when referring to our transceivers, beginning January 1, 1978. We say "goodbye" to the name, but certainly not to models 540 and 544.
Advance Registration $14.00 per person; with Hotel Sahara Late Show and two drinks $28.00 per person or with Hotel Sahara Congo Dinner Show (entree Cornish Hen), no drinks $35.00 per person. Tax and Gratuity included.

Entertainment in Hotel Sahara's Congo Room has not been selected at press time.

Advance Registration must be received by SAROC on or before December 22, 1977.

The NATION'S ANNUAL LAS VEGAS PRESTIGE CONVENTION

HOTEL SAHARA'S CONVENTION SPACE CENTER

January 5-8, 1978

- SAROC Registration includes: registration tickets, admission to technical sessions, Friday cocktail party hosted by TRI-EX Tower Corp.; Saturday cocktail party hosted by Ham Radio Magazine; Hotel Sahara Buffet Brunch on Sunday, Tax and Gratuity.

- Hotel Sahara room rate for SAROC registered delegates $22.00 per night plus room tax, single or double occupancy.

- Hotel Sahara room reservation request card will be sent only to SAROC registered delegates and exhibitors only until December 22, 1977.

Send your check or money order to SAROC, P. O. Box 945, Boulder City, NV 89005
Come to ABC Communications today for the best solution to your particular communication requirements, whether they be Amateur, VHF Marine, Business Band, Two Way Radio or Police Scanner.

ABC COMMUNICATIONS
17550 15th AVE. N.E.
SEATTLE, WASH. 98155
206-364-8300

TO PLACE ORDER CALL TOLL FREE IN STATE OF WASH.
1-800-562-7625
Wash. res. add sales tax

DENTRON MLA-2500
$799.50.

KENWOOD Transceiver
TS-820S 160 thru 10M $1048.

ATLAS Transceiver
160 thru 10M $995.

ICOM Transceiver 2M FM
SSB IC 211 $749.

We also handle Wilson, Cushcraft, Hy-Gain, Antenna Specialists, KLM, etc.

Attention Washington residents: Come on in for excellent service in our complete Communications Repair Shop.

Other locations:
(Walk-in customers only)
Bellevue — 12001 N. E. 12th
Everett — 6920 Evergreen Way
Open Mon. thru Sat.
Someday ... all radios will be tuned this way

First with SSB HF Digital Tuning, is only the beginning of what the amateur gets from the CIR Astro 200.

Standard Features:

The heart of the ASTRO-200 is the frequency synthesizer. The latest in phase-lock-loop technology is incorporated to provide the built-in versatility of all electronic tuning, crystal frequency stability at each frequency of operation, and over 40,000 HF channels displayed in 100 Hz increments ±50Hz fine tuning for continuous ham band coverage. The frequency synthesizer circuit board shown, illustrates the construction on high quality epoxy glass material, with clean design backed by years of experience in designing and manufacturing military and commercial communications equipment.

Reliability is built in for years of continued use. Each circuit board is "baked-in" for over 100 hours prior to installation in the transceiver assembly. After system testing, each transceiver is again "baked" prior to final system testing ... your guarantee of on-the-air performance.

Discover the ease and accuracy of electronic tuning. Calibrate all bands with WWV at the turn of a switch. Lowest frequency drift, with no VFO to calibrate. Only 2.8" high x 9.5" wide x 12.3" deep. Ideal for mobile use or, with accessories, provides complete fixed station operation. Net Price $995.00. Accessories: AC Power supply $135.00; Speaker in cabinet $29.95; Station operating console with phone patch, 24 hr. digital clock, speaker, 10 min. timer $295.00; Desk microphone $38.00; Mobile mount $12.00; Mobile mic $15.00; 400 Hz narrow band CW filter $50.00.

Write or phone for complete details:
CIR Industries, Inc. 1648 N. Magnolia Avenue, El Cajon, California 92020 U.S.A. (714) 449-7633 Telex 69-7969
the word's out
your ears tell you
there's a difference
with Külrod®

Just listen on VHF or UHF. Before long you’ll discover that the guy with the full quieting signal, the readable signal, the one that gets through best usually says: “... and I’m using a Larsen Külrod Antenna.”

This is the antenna designed, built and ruggedly tested in the commercial two-way field. It’s the fastest growing make in this toughest of proving grounds. Now available for all Amateur frequencies in 5 different easy-on permanent mounts and all popular temporary types.

Make your antenna a Larsen Külrod and you’ll have that signal difference too. Also good looks, rugged dependability and lowest SWR for additional pluses.

FREE: Complete details on all Külrod Amateur Antennas. We'll send this catalog along with names of nearest stocking dealers so you can get the full quieting “difference” signal.

* Külrod is a registered trademark of Larsen Electronics

Larsen Antennas
11611 N.E. 50th Ave. • P.O. Box 1686 • Vancouver, WA 98666 • Phone: 206/573-2722
In Canada write to: Canadian Larsen Electronics, Ltd.
1340 Clark Drive • Vancouver, B.C. V5L 3K9 • Phone: 604/254-4936

or write direct to CIR for free brochure

MORE DETAILS? CHECK—OFF PAGE 150

november 1977 P. 105
With a system of Omega-t HV-3 Triband Vertical Antennas and the 2000C Beam Steering Combiner, you can combine maximum antenna gain with beam steering throughout 360°. Now . . . you can work DX in the direction you select . . . blocking out QRM.

Start with a single HV-3, the new standard in vertical antennas. Later, add a second HV-3 plus the 2000C Beam Steering Combiner for a two element triband steerable array, allowing you to steer the pattern in 30 azimuth steps. Add two more HV-3s and two 2000CS switching units and you have the unprecedented gain and narrow beamwidths obtainable with a four element steerable phased array.

Prices— HV-3: $169.90; 2000C: $250; 2000CS: $298 per pair. Antenna matching units available for all frequencies in the 1.8 to 18 MHz range.

Write for details or contact your nearest amateur radio dealer.
Don't sacrifice maximum power output and high efficiency for linearrization. The BLUE LINE offers you the best of both designs. The BLUE LINE amplifiers are engineered using the latest state of the art stripline technology. This design technology means efficient broad band output with a very high degree of mechanical stability.

**Features**
- High efficiency means low current drain.
- Broad band design (no tuning).
- Direct 12 volt DC operation.
- Indicator lamps for On/Off and Relay switching (allows you to put amplifier in or out of circuit at the flip of a switch).
- Insertion loss of less than 1 dB.
- One year limited warranty on parts and labor.

**Look at these power supplies!**

**PS-3012 Commercial**
- Recommended for:
  - BLC 3/150
  - BLD 10/60
  - BLE 2/60
- Output Voltage: Adjustable, 11-15 VDC
- Output Current: 30 amps (50% duty cycle)
- Overvoltage Protection: Built in OVP crowbar
- Overcurrent Protection: Foldback current limiting at 30 amps
- Overcurrent Protection: Foldback current limiting at 30 amps
- Size: 13-1/4" x 7-1/8" W x 6-5/8" H
- Weight: 25 lbs.
- Finish: Black anodized aluminum

**PS-25M with Current Meters**
- Recommended for:
  - BLC 10/70
  - BLD 2/50
  - BLD 10/60
  - BLD 30/60
- Voltage Output: adjustable between 10-15V
- Load Regulation: 2% from no load to 20 amps
- Current Output: 50 mV at 20 amps
- Weight: 22-1/2 pounds
- Size: 12-1/4" x 6-3/4" x 7-1/2"

**PS-15C Low Cost**
- Recommended for:
  - BLE 10/40
  - BLD 1/40
- Voltage Output: adjustable between 12-14 V
- Load Regulation: 2% from no load to 10 amps
- Current Output: 50 mV at 10 amps
- Weight: 13 pounds
- Size: 11-1/4" x 5-1/2" x 4-3/4"

**WANT TO BRING YOUR AMPLIFIER INDOORS?**

- Black anodized aluminum finish.
- Electrostatic shield for added transient surge protection.
- A foldback output limiter operates for loads outside of the operating range.
- Isolation from ground. The circuit is isolated from the case and ground.
- 115/220 volt input - 50/60 cycle.

**PS-25M Kit** ........... $149.95
**PS-25M Wired & tested** ........ $169.95

**PS-15C Kit** ........... $79.95
**PS-15C Wired & tested** ........ $94.95

Export prices are slightly higher. Prices subject to change.

**VHF engineering**

DIVISION OF BROWNIAN ELECTRONICS CORP.

More Details? CHECK——OFF Page 150

BOX H / 320 WATER ST. / BINGHAMTON, N.Y. 13901
Phone 607-723-9674

November 1977
I Handymen! Hobbyists!

Let Kester Solder aid you in your home repairs or hobbies. For that household item that needs repairing—a radio, TV, model train, jewelry, appliances, minor electrical repairs, plumbing, etc.—Save money—repair it yourself. Soldering with Kester is a simple, inexpensive way to permanently join two metals.

When you Solder, go “First Class”—use Kester Solder.

For valuable soldering information send self-addressed stamped envelope to Kester for a FREE Copy of “Soldering Simplified”.

KESTER SOLDER
Litton 4201 WRIGHTWOOD AVENUE/CHICAGO, ILLINOIS 60639

This is easy—anyone can solder—
WITH
KESTER SOLDER

Handymen! Hobbyists!
DO-IT-YOURSELFERS!

FOR NEW OR USED AMATEUR RADIO GEAR—we're specialists and carry in stock most of the famous-brand lines. Or, we will talk trade.

FOR FAST, DOOR-STEP DELIVERY... give us a call. You'll be amazed: for we guarantee we'll ship your equipment the same day. Plus, most shipments are PRE-PAID.

TO SAVE MONEY... join thousands of our satisfied customers who buy from us as easily as from their local supplier. So, remember your call is Toll Free.

We welcome your Master Charge or Bank Americard
HAM RADIO CENTER, INC.
8340-42 Olive Blvd. P.O. Box 28271 St. Louis, MO 63132

This is easy—anyone can solder—
WITH
KESTER SOLDER

Handymen! Hobbyists!
DO-IT-YOURSELFERS!

FOR NEW OR USED AMATEUR RADIO GEAR—we're specialists and carry in stock most of the famous-brand lines. Or, we will talk trade.

FOR FAST, DOOR-STEP DELIVERY... give us a call. You'll be amazed: for we guarantee we'll ship your equipment the same day. Plus, most shipments are PRE-PAID.

TO SAVE MONEY... join thousands of our satisfied customers who buy from us as easily as from their local supplier. So, remember your call is Toll Free.

We welcome your Master Charge or Bank Americard
HAM RADIO CENTER, INC.
8340-42 Olive Blvd. P.O. Box 28271 St. Louis, MO 63132
Great gift ideas from Ham Radio's Bookstore.

- **1978 ARRL RADIO AMATEUR’S HANDBOOK**
  (AR-HB) $8.50

- **AMATEUR SINGLE SIDEBAND**
  Originally published by Collins Radio Company, revised by tremendous popular demand. The bible of SSB; a complete intro to SSB and its equipment. Softbound.
  (HR-SSB) $4.95

- **RADIO HANDBOOK 20th Edition**
  Famous communications handbook for engineers and Amateurs alike. How to design and build radio communications equipment and accessories.
  Holiday Special Save $2.00
  (24032) Only $17.50

- **1978 US RADIO AMATEUR CALLBOOK**
  Brand new format! Calls in new boldface, large, easy to read type. Over 350,000 entries vs. 303,000 last year. Thousands of new hams and new 1X2 calls. Same price as before.
  (CB-US) Only $14.95
  (Please include $1.50 shipping and handling)

- **Two Volume 5th Edition RADIO COMMUNICATIONS HANDBOOK**
  Completely revised edition from the RSGB. One of the most thorough and handsome books in Amateur Radio. The perfect gift.
  (RS-RCH12) Only $29.95

- **3rd Edition ELECTRONIC COMMUNICATION**
  The most fantastic Amateur and commercial license study guide we know of! Comprehensive, includes questions and answers.
  (MH-57138) Only $18.95

- **TUNE IN THE WORLD WITH HAM RADIO**
  Tells you what Amateur Radio is, how to pass the Novice exam and set up your first station. Includes booklet, code cassette and map.
  (AR-HR) $7.00

- **OSCAR-AMATEUR RADIO SATELLITES**
  The comprehensive book on Amateur satellites. Learn the principles, then examine OSCAR from concept to actual use. Softbound.
  (RS-O) $8.50

- **THE FRENCH ATLANTIC AFFAIR**
  A real spellbinder! High adventure and romance in a dynamic novel where Amateur Radio is the hero. A real thrill for DXers.
  (A-FAA) $10.95
  (Much sex and violence: for mature readers only)

- **80 METER DXing**
  A must for every DX'er. A foremost authority has compiled many of his secrets into this book. Meet this exciting challenge and get the most from your station.
  (HR-80MI) $4.50

Yes! Please enter my order as checked on the boxes by each book on this page.

Number of books checked
$-

- Check or money order enclosed
- Charge my Mastercharge
- Charge my VISA (BAC)

Acct. No. Exp. Interbank No.

Name
Address
City State Zip

Send to: HAM RADIO'S BOOKSTORE
GREENVILLE, NH 03048
or call TOLL FREE 800-258-5353
Seamless aluminum construction...and high performance make for years of trouble free activity with any CUSHCRAFT FM Beam.

DIRECTIONAL GAIN BEAMS
- Direct 52 ohm feed
- Rugged
- Seamless aluminum construction

DIRECTIONAL GAIN ARRAYS
Stacked for increased performance, CUSHCRAFT Power Pack arrays come complete. Ready for use when full quieting results are needed to access distant repeaters or long haul simplex contacts.

OMNIDIRECTIONAL GAIN ANTENNAS
CUSHCRAFT'S
- Ringos
- Rangers
- Stacked 4-pole antennas are recognized worldwide for their low angle of radiation, ease of assembly, and tremendous performance on all amateur FM frequencies. Regardless of the FM frequency, rely on Cushcraft to deliver "FULL QUIETING PERFORMANCE".

IN STOCK WITH DISTRIBUTORS WORLDWIDE
CUSHCRAFT CORPORATION
P.O. BOX 4680, MANCHESTER, N.H. 03108

ICOM
IC-22S
146 MHz FM 10 W TRANSCEIVER

IC-211
144 to 148 MHz SSB/FM/CW 10 W TRANSCEIVER
IMMEDIATE DELIVERY
SHIPPING PREPAID IN USA

MASTERS COMMUNICATIONS
7025 N. 57th DR.
GLENDALE, AZ 85301
PHONE 602-939-8356

FULLY AUTOMATIC C.W. IDENTIFIER
MODEL 12751 KIT
REGULAR $59.95 VALUE, NOW ONLY $359.75

- CONNECTS IN LINE BETWEEN MIC. AND MIC.
- JACK, REQUIRING NO MODIFICATION TO TRANSCEIVER
- SOLID STATE RELIABILITY
- AUTOMATIC TIMER CAN BE SET FROM 1 MIN. TO 10 MIN.
- ADJUSTABLE CODE SPEED FROM 5 TO 40 WPM
- ADJUSTABLE TONE AND AUDIO LEVEL
- EASILY PROGRAMMED
- SPECIALLY DESIGNED CIRCUITRY GENERATES SQUELCH TAIL & ASSURES CORRECT & FULL ID. EVERY TIME. OPERATES IN AUTOMATIC OR MANUAL MODES. IDEAL FOR BASE, MOBILE, OR REPEATER OPERATION.
- QUALITY 5 x 7 PCB, 20 pg. instruction & assembly manual.

NEW KITS AVAILABLE
MODEL 1176 - miniature 1½" x 2" CW Beacon IDer (great for 1750M band)
- Code speed programmable. ONLY $19.85/KIT
MODEL 11764 - semi-automatic modulated CW IDer. 1½" x 3" PCB adjustable code audio level + programmable code speed + tone & repeat interval. ONLY $29.95/KIT
- Memory elements factory programmed to your specifications (254 bits maximum).
MODEL 1776 universal auto/home alarm control module.
MODEL 1777 alarm timer module for 1776.
- Calif. res. add 6% tax. Incl. 32 shpg. -/dig. $4.00.

Write for additional information. AVAILABLE NOW! Send check or M.O. to:
Phone 400-294-8383
SECURITRON
P. O. Box 2499
San Jose, Ca 95154

More Details? CHECK — OFF Page 150

November 1977
WHERE
RELIABILITY
& ACCURACY
COUNT

INTERNATIONAL CRYSTALS
70 KHz to 160 MHz

HOLDER TYPES

International Crystal Manufacturing Co., Inc. guarantees every crystal against defective materials and workmanship for an unlimited time, when used in equipment for which they were specifically made.

CRYSTAL TYPES

(GP) for "General Purpose" applications
(CS) for "Commercial" equipment
(HA) for "High Accuracy" close temperature tolerance requirements

International Crystals are available from 70 KHz to 160 MHz in a wide variety of holders. WRITE FOR INFORMATION

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee, Oklahoma City, Oklahoma 73102
405/236-3741
Plug it in like a key and send perfectly timed Morse code as easily as typing a letter. Sidetone and buffer register make it simple to send at the speed you select.

Available directly from the factory for only $225 plus postage & handling. Mastercharge or BankAmericard accepted. Call or write to order or request complete specifications and options.

ATRONICS
BOX 2946, LAGUNA HILLS, CA 92653
(714) 830-6428

COLLINS & MORE
Collins 7553B, Ham rcvr $725.00
Collins 31284, Exc. cond. $275.00
Collins KWM-2 transcrv. V.G. $650.00
Collins CP-1 crystal Pack $195.00
Collins 3253, Ham Xntr. $750.00
Drake SPR-4, new, boxed, w/options $525.00
Collins 3031, like new $1750.00
Collins 31285 YFO, very good $495.00
Collins 7531 w/200 cycle filter, very good $975.00
Johnson KW Matchbox w/SWR, excellent $225.00

We stock good, used equipment from Collins, Drake, Heath and other manufacturers. Hundreds of test items also available. Call for specific requirements, or write for free catalog.

DAMES COMMUNICATION SYSTEMS
201-998-4256
10 SCHUYLER AVENUE
NORTH ARLINGTON, N.J. 07032

Armchair Copy
with new $67
RAK-7
Active Antenna
Shortwave Listening

Our ONLY occupation is supplying everything you need to tune the mediumwave and shortwave bands—and identify what you hear. Our NEW mini-catalog details Barlow Wadley, Drake and Yaesu receivers, WORLD RADIO TV HANDBOOK, logs, albums, ITU publications, RTTY displays, CONFIDENTIAL FREQUENCY LIST, clocks and all SWL books.

GILFER ASSOCIATES, INC
P.O. Box 239, Park Ridge, NJ 07656
SPECSCAN-S Programmable Scanner

... The ONLY Digital Scanner made for the IC-22S. It adds a whole new dimension to 2M FM. If any other accessory can make your IC-22S as versatile as the SPECSCAN-S does, Buy It!

- Scans the entire 146-147 MHz Band in 15 kHz steps, automatically, or manually.
- Automatically reads out your other 21 channels when they are used.
- Can be used as a remote programming unit with the radio hidden under the seat, etc.
- Exclusive VARI-SCAN™ control allows full control of scan rate in either direction!
- Full compatibility with the duplex mode.
- Uses state of the art CMOS logic.
- Low current drain. Less than 500 mA.
- RF immune. Unaffected by nearby equipment and in high RF areas.
- Large LED display lets you see every channel at a glance.
- Manual mode features lets you scan past any portion of the band and manually select a desired channel.
- Easy installation. Uses only one matrix position leaving the other 21 usable for manual programming.
- Plugs into 9 pin accessory socket.
- Adjustable scan delay feature.
- 90 day limited warranty.

ONLY 149.95

Send S.A.S.E. for more SPECSCAN info.

NOW AT SPECTRONICS ... MFJ
Station Accessories for just about any need!

MFJ-16010 Antenna Tuner
Now you can operate on all bands — 160 thru 10 Meters — with a single random wire and run your full transceiver power output — up to 200 watts RF power OUTPUT.
- Small enough to carry in your hip pocket, 2 3/16 x 3 1/4 x 4 inches • Matches low and high impedances by interchanging input and output • SO-239 coaxial connectors • 12 position tapped inductor • Stackable untuned cores • Available 1.8 Mhz tuner matches 25 to 200 ohms.

$39.95

CWF-2BX Super CW Filter
This MFJ Super CW Filter gives you 80 Hz bandwidth, and extremely steep skirts with no ringing for razor sharp selectivity that lets you pull signals out of heavy QRN. Plugs between receiver and phones or connect between audio stage for speaker operation.
- Selectable BW: 80, 110, 180 Hz • 60 db down one octave from center frequency of 750 Hz for 80 Hz BW • Reduces noise 15 dB • 9 V battery • 2 3/16 x 3 1/4 x 4 inches • CWF-2PC, wired PC board. $19.95.

$29.95

MFJ-8043 IC Deluxe Electronic Keyer
This MFJ Deluxe Keyer gives you more features per dollar than any other keyer available.
- Uses Curtis-8043 keyer chip • Sends Iambic, automatic, semi-automatic, manual • Use squeeze, single lever, or straight key • Dot memory, self-completing dots and dashes, jam proof spacing, instant start • RF proof • Solid state keying ± 300 V max • Weight, tone, volume, speed controls • Uses 4 C-cells: external power jack • 6 x 6 x 2 inches • Sidetone and speaker
- Optional squeeze key: $29.95.

$69.95

SBF-2BX SSB Filter
Dramatically improves readability.
- Optimizes your audio to reduce sideband splatter, remove low and high pitched QRN, hiss, static crashes, background noise, 60 and 120 Hz hum • Reduces fatigue during contest, DX, and ragchewing • Plugs between phones and receiver or connect between audio stage for speaker operation • Selectable bandwidth IC active audio filter • Uses 9 volt battery • 2 3/16 x 3 1/4 x 4 inches.

$29.95

SPECTRONICS, INC.
1009 GARFIELD
OAK PARK, IL. 60304
312-848-6777
TELEX 72:8310

SPECIAL PRE-WIRED PRICE
BRAND NEW IC-22S WITH
SPECSCAN DIGITAL SCANNER
Both for only $398.00
FEATURING THE...

HR-2B

The Master in 2 Meter FM

Positive performance at a practical price makes our HR-2B tops on 2 meters. Individual trimmer capacitors give bull's-eye accuracy for working repeaters or point-to-point. The .35μV sensitivity and Hi/Lo power switch insure your hearing and being heard clearly and reliably... the Regency way.

12 Channels
15 Watts
$229.00 Amateur Net

...AND THE

HR-440

UHF—The Ultimate in FM

440 is fresh... it's new... and with our HR 440 you can use UHF without using-up your budget. So, pioneer some new ground! Put a compact HR 440 under your dash or at your desk. It's the best way to usher yourself into UHF.

12 Channels
10 Watts
$349.00 Amateur Net

© 1976 Regency ELECTRONICS, INC. 7707 Records Street Indianapolis, Indiana 46226

10's OF THOUSANDS OF CRYSTALS IN STOCK!

Regency

THE FM LEADER

2 METER 220 MHz
6 METER 440 MHz

2-32 MHz RECEIVERS

AN/WRR-2 TRIPLE CONVERSION RECEIVER—2-32 MHz for reception of SSB: upper and lower sidebands separately or simultaneously. AM, CW, and CW tunes in 1 KHz increments, or continuously. Power required: 105-125 V, 60 Hz, 250 Watts. Size: 26 x 22 x 24". Wt.: 250 lbs.; Shpg. Wt.: 300 lbs. With power and RF connecting plugs and wiring diagram for making cables.

AN/WRR-2 — For table mounting, Used, Reparable...

$300**

AN/FRR-59A — Tunes in 500 Hz increments or continuously, for rack mounting. Used, Reparable...

$375**

RECEIVER — Checked, good operation, add $100**

MANUAL with purchase of Receiver only...

$20**

SASE for Data Sheet. Prices are F.O.B., Lima, Ohio. Please allow for shipping charges.

USE YOUR VISA or MASTER-CHARGE CARD!

Address: Dept. HR • Phone: 419/227-6573

FAIR RADIO SALES
1016 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

More Details? CHECK — Off Page 150
Be there first with the ultimate…

*KLM “661” ALL MODE 6 METER TRANSCEIVER*

- Complete, ready to operate. Microphone is included.
- Covers 50-54MHz. (Crystals are supplied for 50-52MHz).
- All modes: SSB with USB and LSB, CW, NBFM, AM.
- Built-in VFO covers 50-54MHz in 500 kHz increments.
- Four, crystal-controlled channels.
- Built-in low-pass harmonic filter.
- Meets F.C.C. 20777 specs.
- 10W min. power output (2.5W AM).
- Built-in power supply for 115 VAC and 13.8VDC.
- Clarifier.
- Noise blanker.
- Squelch.
- Triple conversion receiver with better than 0.25\(\mu\)V sensitivity.
- Built-in loudspeaker. Provision for external speaker.
- 100 kHz crystal calibrator and VOX options (soon available).

Soon at your favorite dealer.

Write for information.

Exceptional audio both transmit and receive. Outstanding AGC and sensitivity on receive.

KLM electronics, inc.
1725 Laurel Road, Morgan Hill, CA 95037 (408) 779-7363.

More Details? CHECK — OFF Page 150
"Wasyerbespriz?"

OK, so you want to save money — can't blame you for that!

After you have called the 800 numbers, got your "best price," sent your money — what do you get? A box. Suppose it doesn't work? (Murphy's law). Ship it back (at your own expense) and wait. Or — two weeks after the warranty expires — so goes the rig . . . what to do? And since you got that great discount how much attention will you get? Rotstaruck fella!

Today's amateur equipment is far more sophisticated than that of even a few years ago, and it's getting more so every day. Service becomes an important issue. At CFP we have decided to offer you an alternative: If you are willing to pay the regular list price on any Drake or Yaesu product, CFP will provide an additional 90 days of warranty protection. This warranty will be identical with the normal warranty with the exception that we will pay all charges including shipping both ways!

There may be occasions when we won't have the item you desire. Should you place an order and we don't, we will refund your money and advise you when it will be available. We won't sit on your money! If you wish a high demand item and want to make a deposit to ensure getting what you want — fine.

Because we are amateurs and concerned about the issues, we limit our transmitter and amplifier sales to licensed amateurs (a license photocopy will do).

Amateur radio is a great service and a greater hobby — lets keep it that way!

Mail Orders accepted. N. Y. residents add sales tax. SASE will get our list of used Amateur Equipment.

WANTED: GOOD CLEAN TRADES!
WA2KTJ
WB2LVW

CFP COMMUNICATIONS, INC.
211 NORTH MAIN STREET
HORSEHEADS, N.Y. 14845
PHONE: 607-739-0187

NEW FROM GLB

A complete line of QUALITY 50 thru 450 MHz TRANSMITTER AND RECEIVER KITS. Only two boards for a complete receiver. 4 pole crystal filter is standard. Use with our CHANNELIZER or your crystals. Priced from $69.95. Matching transmitter strips. Easy construction, clean spectrum, TWO WATTS output, unsurpassed audio quality and built in TONE PAD INTERFACE. Priced from $29.95.

SYNTHESIZER KITS from 50 to 450 MHz. Prices start at $119.95.

Now available in KIT FORM — GLB Model 200 MINI-SIZER.

Fits any HT. Only 3.5 mA current drain. Kit price $159.95 Wired and tested. $239.95 Send for FREE 16 page catalog.

We welcome Mastercharge or VISA

GLB ELECTRONICS
1952 Clinton St., Buffalo, N. Y. 14206

Mobile Communications Support Test Equipment
AVAILABLE FROM YOUR AUTHORIZED DISTRIBUTOR
WEBSTER COMMUNICATIONS
115 BELLARMINE ROCHESTER, MI 48063 CALL TOLL FREE 800-521-2333 MICHIGAN 313-375-0420

Just off the Press!

Originally Published by Collins Radio Company, now reissued by tremendous popular demand.

The bible on AMATEUR SINGLE SIDEBAND HAM RADIO in cooperation with the Collins Radio Group has reprinted what has been considered the Bible of Amateur SSB. Now available in paperback edition, introduces SSB, the nature of SSB signals, exciters, RF linear amplifiers, SSB receivers, test and measurements and what comprises a good SSB station.

A great buy for your dollar — order yours today!

HR-SSB Just $4.95

Order HR-SSB

enclose check or M.O.
VISA acc. no. exp. date
Mastercharge bank no./acc. no. exp. date
name
address
city state zip

More Details? CHECK-OFF Page 150
WOW – FREE
FROM NOW UNTIL
DECEMBER 31, 1977
RECEIVE ABSOLUTELY FREE — A SIX-DIGIT 12- OR 24-HOUR ELECTRONIC CLOCK KIT COMPLETE WITH POWER SUPPLY AND CASE AND WITH THE PURCHASE OF ANY ONE OF THE FOLLOWING FREQUENCY COUNTER KITS: HAL-600A, HAL-300A, HAL-50A OR THE ANALOG DIGILAB. JUST MENTION THIS AD WAS FOUND IN HAM RADIO MAGAZINE.
OR RECEIVE A GIFT CERTIFICATE WORTH $15.00 ON YOUR NEXT PURCHASE OF $50.00 OR MORE.

6 GOOD REASONS
FOR BUYING A HAL-TRONIX FREQUENCY COUNTER
(1) 100% COMPLETE KIT
(2) EASY ASSEMBLY
(3) COMPLETELY ENCLOSED IN METAL CABINET
(4) IC SOCKETS USED THROUGHOUT FOR EASY REPLACEMENT
(5) EASY ON YOUR POCKET BOOK, AND
(6) NO EXPENSIVE CHIPS TO REPLACE (EXAMPLE: IF YOU LOSE A DECODER, LATCH DRIVER IN A HAL-TRONIX COUNTER, THE AVERAGE COST OF REPLACEMENT OF THE LOW-COST TLLS IS LESS THAN $1.00 EXCLUDING CHIP IN SOME OF THE NEWER COUNTERS NOW BEING MARKETED BY MY COMPETITION. THEY ARE USING THE EXOTIC SIMPLE CHIP AND WOULD COST YOU CLOSE TO $30.00 TO REPLACE). THIS IS SOMETHING YOU SHOULD CONSIDER.

ANALOG-DIGILAB
KIT $139.50
DESIGNED BY HALTRONIX AND MIKE GOLDEN OF R. E. T. S. ELECTRONICS SCHOOL OF DETROIT. FOR RUGGED CLASSROOM USE.

FOR THE RADIO AMATEUR, THE STUDENT, THE EXPERIMENTER OR DESIGNER
SPECIFICATIONS: OUTPUT Voltages: +5V, +12V, -12V. Usable Current: 700ma; % Regulation at 500ma: 0.25%. Short-circuit limited at 1.0 amp. Thermal overload protected. Power requirements: 117VAC, 50Hz, 40 Watts. Generator Function: Frequency, Range: 1Hz to 100Hz in 5 bands. Amplitude adjustable from 0 to 10Vpp, DC offset adjustable from 0 to 20V. Waveforms: sine, square, triangular and TTL. Frequency determined by Function Generator. Output impedance: 1.2K ohm.

6-DIGIT CLOCK
$124.95
12/24 Hour Complete kit consisting of 2 PC G10 pre-drilled PC boards, 1 clock chip, 4 FND 503 readouts, 13 transistors, 3 caps, 9 resistors, 5 diodes, 3 pushbutton switches, holder, power transformer cord and instructions.

4-DIGIT ALARM CLOCK
$124.95
12 Hour Only Complete kit consisting of 2 PC G10 pre-drilled PC boards, 1 clock chip, 4 FND 503 readouts, 11 necessary transistors, 3 caps and 9 resistors including 5 pushbutton switches, molded power transformer cord plus speaker. Comes complete with instructions.

HAL-TRONIX BASIC COUNTER KITS
STILL AVAILABLE
THE FOLLOWING MATERIAL DOES NOT COME WITH THE BASIC KIT: THE CABINET, TRANSFORMER, SWITCHES, COAX FITTINGS, FILTER LENS, FUSE HOLDER, T-03 SOCKET, POWER CORD AND MOUNTING HARDWARE.
HAL-50X (Same Specifications as HAL-600A) $99.00
HAL-300X (Same Specifications as HAL-300A) $199.00
HAL-600X (Same Specifications as HAL-600A) $299.00

PRE-SCALER KITS
HAL-0-300P (Pre-drilled G10 board and all components) $19.95
HAL-0-300P/A (Same as above but with premic) $29.95
HAL-0-600P (Pre-drilled G10 board and all components) $39.95
HAL-10GHZ (New Item - Available in December) $124.95

PRE-BUILT COUNTERS AVAILABLE
(HAL-600A — $299.00) (HAL-300A — $199.00) HAL-50A — $199.00. ALLOW 4- TO 6-WEEK DELIVERY ON PRE-BUILT UNITS.

HAL-TRONIX BASIC COUNTER KITS
STILL AVAILABLE
THE FOLLOWING MATERIAL DOES NOT COME WITH THE BASIC KIT: THE CABINET, TRANSFORMER, SWITCHES, COAX FITTINGS, FILTER LENS, FUSE HOLDER, T-03 SOCKET, POWER CORD AND MOUNTING HARDWARE.
HAL-50X (Same Specifications as HAL-600A) $99.00
HAL-300X (Same Specifications as HAL-300A) $199.00
HAL-600X (Same Specifications as HAL-600A) $299.00

PRE-SCALER KITS
HAL-0-300P (Pre-drilled G10 board and all components) $19.95
HAL-0-300P/A (Same as above but with premic) $29.95
HAL-0-600P (Pre-drilled G10 board and all components) $39.95
HAL-10GHZ (New Item - Available in December) $124.95

HAL-TRONIX BASIC COUNTER KITS
STILL AVAILABLE
THE FOLLOWING MATERIAL DOES NOT COME WITH THE BASIC KIT: THE CABINET, TRANSFORMER, SWITCHES, COAX FITTINGS, FILTER LENS, FUSE HOLDER, T-03 SOCKET, POWER CORD AND MOUNTING HARDWARE.
HAL-50X (Same Specifications as HAL-600A) $99.00
HAL-300X (Same Specifications as HAL-300A) $199.00
HAL-600X (Same Specifications as HAL-600A) $299.00

PRE-SCALER KITS
HAL-0-300P (Pre-drilled G10 board and all components) $19.95
HAL-0-300P/A (Same as above but with premic) $29.95
HAL-0-600P (Pre-drilled G10 board and all components) $39.95
HAL-10GHZ (New Item - Available in December) $124.95

PRE-BUILT COUNTERS AVAILABLE
(HAL-600A — $299.00) (HAL-300A — $199.00) HAL-50A — $199.00. ALLOW 4- TO 6-WEEK DELIVERY ON PRE-BUILT UNITS.

HAL-TRONIX BASIC COUNTER KITS
STILL AVAILABLE
THE FOLLOWING MATERIAL DOES NOT COME WITH THE BASIC KIT: THE CABINET, TRANSFORMER, SWITCHES, COAX FITTINGS, FILTER LENS, FUSE HOLDER, T-03 SOCKET, POWER CORD AND MOUNTING HARDWARE.
HAL-50X (Same Specifications as HAL-600A) $99.00
HAL-300X (Same Specifications as HAL-300A) $199.00
HAL-600X (Same Specifications as HAL-600A) $299.00

PRE-SCALER KITS
HAL-0-300P (Pre-drilled G10 board and all components) $19.95
HAL-0-300P/A (Same as above but with premic) $29.95
HAL-0-600P (Pre-drilled G10 board and all components) $39.95
HAL-10GHZ (New Item - Available in December) $124.95
CRYSTAL FILTERS and DISCRIMINATORS

9.0 MHz FILTERS
XF9-A 2.5 kHz SSB TX $31.95
XF9-B 2.4 kHz SSB RX/TX $40.45
XF9-C 3.75 kHz AM $48.95
XF9-D 5.0 kHz AM $48.95
XF9-E 12.0 kHz NBFM $46.95
XF9-M 0.5 kHz CW (4 pole) $34.25
XF9-NB 0.5 kHz CW (8 pole) $63.95

9.0 MHz CRYSTALS (Hc25/u)
XF900 9000.0 kHz Carrier $4.00
XF901 8998.5 kHz USE $4.00
XF902 9001.5 kHz LSB $4.00
XF903 8999.0 kHz BFO $4.00

CX-05 Hc25/u Socket Chassis .50
CX-06 Hc25/u Socket P.C. Board .50

ALSO AVAILABLE FROM KVG
10.7 MHz CRYSTAL FILTERS AND XTAL DISC. OSCILLATOR CRYSTALS 50 kHz TO 150 MHz
Write for Details

PRE-SELECTOR FILTERS
ELIMINATE IMD "BIRDIES" FROM YOUR RECEIVER.
CLEAN UP YOUR TRANSMITTER OUTPUT.
432 MHz P1432 $36.70
1296 MHz P11296 $36.70
Shipping $3.50

RECEIVE CONVERTERS
MODELS FOR ALL BANDS 50 MHz THRU 1296 MHz. LOW NOISE OPTIONS AT 432 MHz.

STANDARD I.F. 10M.
6M AND 2M IF OPTIONS
POWER 12V D.C.
MMC144 N. F. 2.8 dB typ. $47.95
MMC432 N. F. 3.8 dB typ. $57.95

ANTENNAS (FOB) CONCORD
144-148 MHz
8 OVER 8 J-SLOT +12.3 dBd DB/2M $39.95
8 BY 8 VERTICAL POL. DB/2M-VERT. $48.70
8XY/2M $34.95

420-450 MHz MULTIBEAMS
48 EL. GAIN +15.7 dBd 70/MBM48 $44.95
88 EL. GAIN +18.5 dBd 70/MBM88 $69.95

1250-1340 MHz
1296 MHz LOOP YAGI
26 LOOPS GAIN +20 DBI 1296-LY $54.45

Send 25¢ (2 stamps) for full line catalogue of KVG crystal products and all your VHF & UHF equipment requirements.

GREGORY ELECTRONICS
The FM Used Equipment People.

2 METER F.M. SPECIALS
MOTOROLA T43A SERIES
150 MHz, 12 volt, 30 watts, transmitter narrow band with dynamotor power supply, receiver wide band (Sensicon "A" type) with vibrator power supply, 15" case. less accessories (not bench tested)........... $10.00
power and control cable, set.................. $5.00
control head (less mike and bracket)....... $3.00

G.E. MA/E33
150 MHz, 6/12 volt, 30 watts, vibrator power supply, transmitter narrow band, receiver wide band, less accessories and xtal ovens (not bench tested)........... $18.00
power and control cable, set.................. $5.00
control head (less mike and bracket)....... $5.00

K-ENTERPRISES
MODEL 4X6C
50 HZ—250 MHZ ............... $270.00

300 and 500 MHZ PRESCALERS
FREQUENCY STANDARDS
MARKER and PEAKING GENERATORS
POWER SUPPLIES AMPLIFIERS
WRITE FOR FREE CATALOG

K-ENTERPRISES
Box 410 (N.W. of town)
FAIRLAND, OK 74343

ANALOGS

GREGORY ELECTRONICS CORP.
245 R.I. 46, Saddle Brook, N.J. 07662
Phone: (201) 489-9000

K-ENTERPRISES

Spectrum
International, Inc.
Post Office Box 1084
Concord, Mass. 01742, USA

master charge

118 November 1977
You've requested it, and now it's here! The CT-50 frequency counter kit has more features than counters selling for twice the price. Measuring frequency is now as easy as pushing a button, the CT-50 will automatically place the decimal point in all modes, giving you quick, reliable readings. Want to use the CT-50 mobile? No problem, it runs equally well on 12 V dc as it does on 110 V ac.

Want super accuracy? The CT-50 uses the popular TV color burst freq. of 3.579545 MHz for time base. Tap off a color TV with our adapter and get ultra accuracy — .001 ppm! The CT-50 offers professional quality at the unheard of price of $79.95. Order yours today!

CT-50, 60 MHz counter kit ........................................ $79.95
CT-50 WT, 60 MHz counter, wired and tested .......................... $159.95
CT-600, 600 MHz prescaler option for CT-50, add .................. $29.95

CLOCK KIT

Want a clock that looks good enough for your living room? Forget about your competitor's kludges and try one of ours! Features: jumbo 4" digits, Polariod lens filter, extruded aluminum case available in 5 colors, quality 5"C boards and similar instructions. All parts are included, no extras to buy. Guaranteed one to two hour assembly time. Colors: silver, gold, black, bronze, blue (specify).

Clock kit, DC-5 .................................................. $22.95
Alarm clock, DC-8, 12 hour only ..................................... $22.95
Mobile clock, DC-7 .................................................. $25.95
Clock kit with 10 min ID timer, DC-10 ............................. $25.95
Assembled and tested clocks available, call $10.00

CLOCK KIT $8.95
DC4 Features
-6 digit 4" LED display
#5 12 or 24 format
PC Board includes board
PC Board Transformer $2.95 $1.49

600 MHz PRESCALER

Extend the range of your counter to 600 MHz. Works with all counters. Less than 150 mv sensitivity. Specify 50 or 750. Wired, tested, PSI-18 .................. $59.95
Kit, PSI-18 .......................................................... $44.95

600 MHz PRESCALER $69.95

CALIBER ALARM CLOCK

Has every feature one could ever ask for. Kit includes everything except case built-in 60-in. case, station, or even table. AUTODIMMER

4" dial, 5" high LED 12/24 Hour Format ............................. $25.00
Caliber Alarm clock, includes alarm, clock, alarm, and time base
12/24 Hour Alarm ............................. $25.00
60-in. digital clocks with time base and alarm. $25.00
Complete Kit, less case, Caliber Clock $34.95

LINEAR REGULATOR

MR-200 30 Watts 8 V 3000 VHF ............................. $11.95
NPN 2N3904 type 10/11.00
PNP 2N3906 type 10/1.00
PNP Power Tab 2.6 12/1.00
PNP Power Tab 2.6 12/1.00
NTU 2N2646 type 12/1.00
2N3905 NPN Power 7.5

DIODES

1N194A type 50/2.00

FND 350 ......................................... 79
FND 510 ......................................... 75
FD 707 ......................................... 75
HP 7730 ......................................... 75
Red Polaris Filter . 4 70 x 1.125 " 50

LED DISPLAYS

SOCKETS

7410 1P-14 5/1.00
16 PIN 5/1.00
24 PIN 5/1.00
40 PIN 5/3.00
SPECIAL

FERRITE BEADS

with info and specs 15/1.00
with info and specs 15/1.00
with info and specs 15/1.00
with info and specs 15/1.00

TELEPHONE ORDERS WELCOME

More Details? CHECK OFF Page 150

November 1977 119
New device opens up the world of Very Low Frequency radio.

Gives reception of the 1750 meter band at 160-190 KHz where transmitters of one watt power can be operated without FCC license.

Also covers the navigation radiobeacon band, standard frequency broadcasts, ship-to-shore communications, and the European low frequency broadcast band.

The converter moves all these signals to the 80 meter amateur band where they can be tuned in on an ordinary shortwave receiver.

The converter is simple to use and has no tuning adjustments. Tuning of VLF signals is done entirely by the receiver which picks up 10 KHz signals at 3510 KHz, 100 KHz signals at 3600 KHz, 500 KHz signals at 4000 KHz.

The VLF converter has crystal control for accurate frequency conversion, a low noise rf amplifier for high sensitivity, and a multipole filter to cut broadcast and 80 meter interference.

All this performance is packed into a small 3" x 1½" x 6" die cast aluminum case with UHF (SO-239) connectors.

The unique Palomar Engineers circuit eliminates the complex bandswitching and tuning adjustments usually found in VLF converters. Free descriptive brochure sent on request.

Order direct. VLF Converter $55.00 postpaid in U.S. and Canada. California residents add sales tax.

Explore the interesting world of VLF. Order your converter today! Send check or money order to:

PALOMAR ENGINEERS
P.O. Box 455, ESCONDIDO, CA. 92025 — Phone (714) 747-3343
ME-3 microminiature tone encoder

Compatible with all sub-audible tone systems such as: Private Line, Channel Guard, Quiet Channel, etc.

- Powered by 6-16vdc, unregulated
- Microminiature in size to fit inside all mobile units and most portable units
- Field replaceable, plug-in, frequency determining elements
- Excellent frequency accuracy and temperature stability
- Output level adjustment potentiometer
- Low distortion sinewave output
- Available in all EIA tone frequencies, 67.0 Hz-203.5 Hz
- Complete immunity to RF
- Reverse polarity protection built-in

$29.95 each

Wired and tested, complete with K-1 element

communications specialists
P. O. BOX 153
BREA, CALIFORNIA 92621
(714) 988-3021

K-1 FIELD REPLACEABLE, PLUG-IN, FREQUENCY DETERMINING ELEMENTS
$3.00 each
**Tee/Ax Presents; The First Coax Toggle Switch**

$39.95

Distributor Inquiries Invited

Mail Orders Accepted — Add 75¢ for Postage

**Patent Pending**

- 52 ohms
- SPDT, DPDT
- Power 1 kW
- All Brass Construction
- Teflon Insulated
- Captivated Internal Contacts
- Available in UHF, BNC, N, F, all series

**High Gain · Low Noise**

35dB power gain, 2.5-3.0 dB N.F. at 150 MHz 2 stage, R.F. protected, dual-gate MOSFETS. Manual gain control and provision for AGC. 4 1/8" x 1 1/8" x 1 3/8" aluminum case with power switch and choice of BNC or RCA phono connectors (be sure to specify), Available factory tuned to the frequency of your choice from 5 MHz to 250 MHz with approximately 3% bandwidth. Up to 10% B.W. available on special order.

N.Y. State residents add sales tax.

Model 201 price: 5-250 MHz $29.95

**Vanguard Labs**

196-23 Jamaica Ave.

Hollis, N.Y. 11423
SINGLE KNOB CHANNEL SELECTION

DIRECT FREQUENCY READOUT

SIMPLE, EASY INSTALLATION

LOW COST

INSTALLS IN PLACE OF ORIGINAL SWITCH

Now you can have all the 2-meter FM frequencies from 146.01 thru 147.99 on your IC-22S. The basic VIP-42 conversion provides 42 channels, including all the repeater pairs, all of the standard simplex frequencies, and any two other desired user programmed channels. The VIP-600 option adds simplex capability on channels 600kHz above the indicated channel. For example, you can operate 146.94 simplex by dialing up 146.34 and flipping the VIP-600 switch.

For split operation, the VIP-15 option provides the capability of moving the IC-22S 15kHz up from the indicated frequency, for example, to 146.565 when the dial indicates 146.55.

Valley Instrument’s VIP-42 conversion installs in place of the original 22 channel switch. Eight leads from the conversion switch to the IC-22S accomplish the selection of the 40 pre-programmed channels; two more leads activate any two additional channels you choose to program. The conversion is fast, simple and clean — it’s all inside the radio.

Order yours today! Make your fine transceiver even better!

Valley Instrument Products
(312) 741-8820 — P.O. BOX 339 BARTLETT, ILLINOIS 60103

VIP-42 conversion kit(s) at $29.95 each.

VIP600 option(s) at $3.50 each.

VIP15 option(s) at $3.50 each.

PLEASE SHIP _______ (3) BankAmericard
ALSO INCLUDE _______ VISA

Name ______________________ Call ____________
Address _____________________
City _________________________ ZIP _____________
State ________________________

I enclose $ ____ check or money order.

Please charge my VISA/BankAmericard $ ____________

Card number ____________ Expiration date ____________

Signature __________________

ILLINOIS RESIDENTS ADD 5% SALES TAX

november 1977 / 123
Barker & Williamson going strong in...

Components □ Accessories □ Test Instruments

Home-Brew Components
- Pi-Network Inductors
- Rotary Inductors
- Miniductors/Air-Wound Coils
- Dipole Center Connectors
- Cyclometer Counter
- Filament & Plate Chokes
- Dial Plates
- Plug-In Audio Phase Shift Net

Accessories
- Phone Patches
- Speech Limiters/Clippers
- Q Multipliers/Notch Filters
- Automatic Keyer
- RF Power/VSAR Meter
- Portable Whip Antenna
- Mobile Antennas
- Coax Changeover Relay
- Coax Switches
- TVI Filters

Test Instruments
- Audio Oscillator
- Dummy Load/Wattmeters
- Distortion Meter
- Solid State Dip Meter

Barker & Williamson
Professional quality since 1932

Write for our Catalog. And mention Ham Radio.

G.R. WHITEHOUSE & Co.
10 Newbury Drive, Amherst, N. H. 03031

RADIO WORLD
CENTRAL NEW YORK’S FASTEST GROWING HAM DEALER

FT-101E
TRITON IV

Featuring - Yaesu, Atlas, Denton, Ten-Tec, Swan, Regency, Standard, Tempo, KLM, Hy-Gain, Mosley, Larsen, Midland, Wilson. We service everything we sell. Write or call for quote. YOU WON'T BE DISAPPOINTED.

DOES YOUR RECEIVER NEED A SHOT?

We have been busy all summer developing a UHF preamp good enough to be a TREVOV product. If your receiver is not good enough, you need:

- SUPER SPECIFICATIONS
- GAIN: 15 dB NOMINAL @ 500 MHz
- NOISE: 2 dB, 1.5 dB TYPICAL @ 500 MHz
- SUPER SIZE
- SIZE: 1½" (4.5cm) x 1½" (3.2cm) x 5/16" (9.5mm)
- WEIGHT: 18.5 GRAMS
- WITH 8" TEFON COAX SIGNAL LEADS.
- SPECIAL LEAD CONFIGURATIONS AVAILABLE ON REQUEST.
- MODELS FOR: 220, 450, 900 MHz.
- COMMERCIAL LAND MOBILE, ETC.
- FACTORY PRE-ASSEMBLED AND TESTED.

$29.95

Prices subject to change without notice. NY residents add 7% tax. Canadian add U.S. shipping. Double reorders invited.

TREVOV Industries
PO Box 102, Getzville, NY 14068 (716) 825-8805

More Details? CHECK—OFF Page 150
NEW!

Convert Morse, RTTY and ASCII to Video

MODEL 200 TRI-MODE CONVERTER

Based on the powerful F-8 Microprocessor system, this new product from Info-Tech advanced technology is an addition to the popular Model 100.

It features:

- Morse reception with Automatic Speed and Wordspace
- RTTY reception with four manually selected speeds and automatic readout of incoming speed, with built-in T.U.
- ASCII reception at 100 w.p.m. (110 baud), with built-in T.U.
- Loop keyer for ASCII and RTTY
- Video display: Model 200A - 32 characters x 16 lines of 5x7 DOT matrix with scrolling
  Model 200B - 72 characters x 16 lines with scrolling

PRICE:

Model 200A — $500.00 (wired & tested)
Model 200B — $525.00 (wired & tested)

Master Charge Welcome • Send for Data Sheets

INFO-TECH INCORPORATED Specializing in Digital Electronic Systems
2349 Weldon Pkwy. St. Louis, Missouri 63141 Phone (314) 576-5489

More Details? CHECK — OFF Page 150
**TS-1 MICROMINIATURE ENCODER-DECODER**

- Available in all EIA standard tones 67.0Hz-203.5Hz
- Microminiature in size, 1.25x2.0x.65” high
- Hi-pass tone rejection filter on board
- Powered by 6-16vdc, unregulated, at 3-9ma.
- Decode sensitivity better than 10mvRMS, bandwidth, ±2Hz max., limited
- Low distortion adjustable sinewave output
- Frequency accuracy, ±25Hz, frequency stability ±1Hz
- Encodes continuously and simultaneously during decode, independent of mike hang-up
- Totally immune to RF

Wired and tested, complete with K-1 element

$59.95

K-1 field replaceable, plug-in, frequency determining elements

$3.00 each

**COMMUNICATIONS SPECIALISTS**

P.O. BOX 153
BREA, CALIFORNIA 92621
(714) 998-3021

---

**STEP UP TO TELREX WITH A TELREX "BALUN" FED-"INVERTED-VEE" KIT**

THE IDEAL HI-PERFORMANCE

INEXPENSIVE AND PRACTICAL TO INSTALL LOW-FREQUENCY

MONO OR MULTIPLE BAND, 52 OHM ANTENNA SYSTEM

Telrex "Monarch" (Trapped) I.V. Kit

Duo-Band / 4 KWP I.V. Kit $63.50

Post Paid Continental U.S.

Optimum, full-size doublet performance, independent of ground conditions! "Balanced-Pattern", low radiation angle, high signal to noise, and signal to performance ratio! Minimal support costs, (existing tower, house, tree). A technician can resonate a Telrex "Inverted-Vee" to frequency within the hour! Minimal S/W/R is possible if installed and resonated to frequency as directed! Pattern primarily low-angle, Omnidirectional, approx. 6 DB null at ends! Costly, lossy, antenna tuners not required! Complete simplified installation and resonating to frequency instructions supplied with each kit.

For technical data and prices on complete Telrex line, write for Catalog PL 7 (HRH)

---

**Vanguard now has a HOT 2m converter - at a price you can afford**

**MODEL C-144-A ONLY $39.95**

READ THE SPECIFICATIONS & SEE WHY IT’S THE BEST CONVERTER VALUE AVAILABLE ANYWHERE!!

- Dual-gate MOSFET r.f. stage with diode protected input.
- Dual-gate MOSFET mixer for minimum cross modulation. Every converter tested for noise figure (2.5 - 3.0 dB max.) with Hewlett Packard noise measuring equipment.
- 6 tuned circuits.
- More than 20 dB gain...1 microvolt sensitivity guarantee when used with receivers having 1 microvolt or better sensitivity.
- Complete with one .003% plug-in crystal to cover 144.146 or 146-148 MHz (be sure to specify which, or get both for only $5.00 more). Standard output is for 28-30 MHz.
- 16 gauge aluminum case with BNC receptacles and antenna/powerswitch. Measures 3½” x 2¾” x 1¼”
- Operates 12 Vdc at 15 ma.

IN STOCK NOW FOR IMMEDIATE C.O.D. SHIPMENT. Call Monday through Friday 9 AM to 4 PM (212) 468-2720.

VANGUARD LABS
LUNAR proudly announces a NEW 2-Meter AMPLIFIER/PREAMPLIFIER the 2M10-80P

The Marriage Between Power Amplifiers and Receiving Preamplifiers is Finally Consummated! Lunar Offers an SCS 2M10-80L Power Amp and an "Anglelinear" 144W Preamp in a Single, Functionally-Designed Package that Combines Two Superior Products Into One!

Features:
- Ten watts input — eighty watts output
- Harmonic reduction exceeds -60 dB to meet FCC R&O 20777 Specifications
- Variable T-R Delay for CW/SSB
- Functionally-Designed Extrusion Includes Mounting Lip
- Preamplifier Selectable Independently of Power Amplifier
- Automatic T-R Switching of Amp & Preamp
- Pream gain: Nominally 11 dB
- Noise Figure: Nominally 2.5 dB
- Remote Control Head Available Separately

Introductory Price: Lunar Model 2M10-80P $189.95

Please add $3.00 shipping and handling

NEW Model DX-555P Counter-Generator with prescaler

Call us for immediate shipment and/or delivery date. Use your BankAmericard or Master Charge.

Counter:
- 5 digit display, 7 digit readout capability. 10 Hz to over 30 MHz (250 MHz with prescaler). Input level 20mV RMS to 5 Vrms (Prescaler 200mV RMS to 2 Vrms). Base oscillator beats directly against WWV.
- Generators:
  - 440 kHz to 30 MHz in 3 ranges
  - Output displayed on counter and available at jack on rear panel 600 Hz modulation for AM receivers

General:
- 110 VAC fused supply
- Size (in.) 2.3H x 6.3W x 8.50
- Weight (lbs.) 4.4

The DX J' ANTENNA:
- Gold-plated aluminum radiators
- Requires no ground plane
- VSWR typ. 1.3:1 (146-148 MHz)
- Handles 250 watts plus
- Weight: 8 oz.
- 144, 220, or 440 MHz Models. Your Choice
- Price $29.95

MODEL DX-555P (to 250 MHz - incl. prescaler) $239.95
Please add $3.00 shipping/handling. Model without prescaler also available.

Write for descriptive brochure on all Lunar Products. Please add $3.00 shipping/handling.

Also From Lunar:
Available Now: Complete Line of Separate Preamplifiers 50-450 MHz
Coming Soon: Complete Line of 50-450 MHz Amp/Preamp Combinations, Preamps Through 2.5 GHz, Transverter Systems 50 MHz-2.5 GHz, Converters and Filters 28 MHz-2.5 GHz

California residents add 6%. Order today at your dealer or direct from:

LUNAR electronics
SUITE 10
2765 KURTZ ST
SAN DIEGO, CA 92110
714-290-9746
Louis N. Ancusa WB6NMT

More Details? CHECK - OFF Page 150
1977 ARRL FLORIDA GULF COAST CONVENTION
Clearwater Beach, November 19 and 20
Sponsored By
Florida Gulf Coast Amateur Radio Council
Only REAL Convention in the Southeast with Exhibitors, Flea Mkt., Technical Sessions, FCC Exams, Forums, QCWA, AWA, SMIRK, 10-10 Club, etc. Full Ladies activities plus hotel facilities on the Gulf.

Tickets: Adv'd. $3 Single; $5 Family + 2 Bonus tickets. Banquet: $9 (Reserve early)

Ray Spence, FCC Chief Eng., Bob and Ellen White, of ARRL as guest speakers at Forums. Saturday Eve Banquet with IARU President, Noel Eaton, VE3CJ, as guest speaker.

Full Info and reservation for Sheraton Hotel contact:
F.G.C.A.R.C. Convention
P. O. Box 157
Clearwater, Florida 33517

WANTED FOR CASH

490-T Ant. Tuning Unit
(Also known as CU1658 and CU1669)
Highest price paid for these units. Parts purchased.
Phone Ted, W2KUW collect. We will trade for new amateur gear. GRC106, ARC105 and some aircraft units also required.

We stand on our long term offer to pay 5% more than any other bonafide offer.
See last month's ad for other items available.

618-T Transceiver
(Also known as MRC95, ARC94, ARC102, or VC102)

THE TED DAMES CO.
308 Hickory Street
Arlington, N.J. 07032
(201) 998-4246
Evenings (201) 998-6475
EXCITING NEW PRODUCTS

RAP-200

A Complete Autopatch facility that requires only a repeater and a telephone line. Features include single-digit access/dial disconnect, direct dialing from mobile or handheld radios, adjustable amplifiers for transmitter and telephone audio, and tone burst transponder for acknowledgement of patch disconnect.

RAP-200 P.C. Card $199.50
RAP-200R Rack Mount $249.50

DATA TONE TO DIAL PULSE CONVERTER

The Data Tone to Dial Pulse converter Model DPC-221 provides full compatibility between Touch-Tone* encoders and rotary dial pulse telephone exchanges. Two separate outputs for the * and # digits provide remote control operation, and a cancel function permits the caller to automatically stop and reset the converter’s dialing circuits.

DPC-221 P.C. Board $219.00
DPC-221R Rack Mount $295.00

MIGHTY MOS

Complete CMOS keyer, versatile controls allow wide character-weight variations, speeds from 5- to 50-wpm plus volume and tone control. Solid state output switching transistors are compatible with both grid-block and solid-state transmitters. Unit also available in kit and wired p.c. board only versions.

MIGHTY MOS P.C. Card - Wired $29.50
P.C. Card - Kit $24.95

TTP-1 TTP-2

UNIVERSAL TOUCH-TONE ENCODERS

The Data Signal TTP Series of keyboard encoders is used to generate the standard 12 or 16 DTMF digits. The encoders provide fully automatic transmitter keying and feature a delayed Transmit Ready light, an interdigit timer, and a built-in audio monitor. Features also include all solid-state, crystal-controlled, digitally-synthesized tones and an optional internal Automatic Number Identifier (ANI).

TTP-1 (12-digit) $29.00
TTP-2 (16-digit) $39.00

*Touch-Tone is a registered trade name of AT&T.

Ask About Our Deluxe Receiver Preamplifier For HF & VHF

DATA SIGNAL AND DIGITRAN KEYBOARDS

<table>
<thead>
<tr>
<th>Style A</th>
<th>Style B</th>
<th>Style C</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Digitran Style A" /></td>
<td><img src="image2" alt="Digitran Style B" /></td>
<td><img src="image3" alt="Digitran Style C" /></td>
</tr>
</tbody>
</table>

2 1/8" x 3 1/8" 1 1/4" x 2 3/8" 2 1/4" x 2 3/4"

<table>
<thead>
<tr>
<th>Style D</th>
<th>Style F</th>
<th>Style G</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image4" alt="Digitran Style D" /></td>
<td><img src="image5" alt="Digitran Style F" /></td>
<td><img src="image6" alt="Digitran Style G" /></td>
</tr>
</tbody>
</table>

2 1/8" x 2 3/8" 2" x 2 5/16" 2 1/8" x 2 11/16"

More Details? CHECK OFF Page 150

DATA SIGNAL, INC.
2403 COMMERCE LANE
ALBANY, GA. 31707, 912-883-4703

November 1977
Repeater Jammers Running You Ragged?

Here's a portable direction finder that REALLY works—on AM, FM, pulsed signals and random noise! Unique left-right DF allows you to take accurate (up to 2°) and fast bearings, even on short bursts. Its 3dB antenna gain and 0.6μV typical DF sensitivity allow this crystal-controlled unit to hear and positively track a weak signal at very long ranges—while the built-in RF gain control with 120 dB range permits positive DF to within a few feet of the transmitter. It has no 180° ambiguity and the antenna can be rotated for horizontal polarization.

The DF is battery-powered, can be used with accessory antennas, and is 12/24V for use in vehicles or aircraft. It is available in the 140-150 MHz VHF band and/or 220-230 MHz UHF band. This DF has been successful in locating malicious interference sources, as well as hidden transmitters in "T-hunts", ELTs, and noise sources in RFI situations.

Price for the single band unit is $170, for the VHF/UHF dual band unit is $205, plus crystals. Write or call for information and free brochure.

L-TRONICS
5546 Cathedral Oaks Road
(Attention Ham Dept.)
Santa Barbara, CA 93111
(805) 967-4859

THE BEVERAGE ANTENNA HANDBOOK
Construct and operate your own Beverage Antenna. Defeat the broadcast stations on 40 meters. Has plans for three band Beverage, 1.8-3.5 MHz, with desirable null and direction switching. Contains complete single wire Beverage and loop Beverage, null steering, Direction switching, Antenna patterns. Effect of height, wave velocity, distributed element. E fwd transmissions. Ground system Construction diagrams. Circuit diagrams. Specifications. Shop Beverage, $15.00 pattern, trip. Load, ties, etc. Published by Vic Morris. W1GKR, Wilson Rd., Hudson, N. Y. 13601.
YOU ASKED FOR IT-

BOTH MORSE AND RTTY

The ULTIMATE in coded communications can now be yours with the new DS-3000 KSR TERMINAL (Version 3) and ST-6000 DEMODULATOR. Enjoy the convenience of composing and editing your messages BEFORE transmitting; decode and display CW as well as RTTY signals. Connect the HAL ST-6000 and DS-3000 KSR to your transceiver and antenna and work the world on RTTY and CW.

**ST-6000**
- 170-425-850 Hz Shift
- Low or High tones
- Crystal tone keyer
- Active band-pass filters
- Autostart and antispase
- ATC and DTH
- KOS for keyboard break-in
- Scope or meter tuning indicator
- AM or FM limiter modes
- Table or rack mounting
- 1/0 interface to current loop, RS-232, MIL-188, and CMOS

**DS-3000 KSR**
- MORSE, BAUDOT, and ASCII codes
- Full 72 character lines
- 16 lines of display
- Word wrap-around
- Edit with WORD, LINE, & PAGE modes
- Keyboard programmable HERE IS message
- Up to 175 WPM CW, 5 speeds BAUDOT & ASCII
- 8080A microprocessor controlled
- MORSE also output as ASCII or BAUDOT
- 1/0 interface to current loop or RS-232
- New streamlined 12 inch display
- On-screen indicators of WORD & PAGE modes

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS-3000 KSR V3</td>
<td></td>
<td>$1575.00</td>
</tr>
<tr>
<td>DS-3000 KSR V2</td>
<td>(NO MORSE)</td>
<td>$1195.00</td>
</tr>
</tbody>
</table>

ST-6000M (Meter) ......... $495.00
ST-6000S (Scope) ......... $595.00

Write or call us for our new amateur catalog.

HAL COMMUNICATIONS CORP.
Box 365
Urbana, Illinois 61801
217-367-7373

For our European customers see HAL equipment at:
- Richter & Co., Hannover
- I.C. Interko, Biscione
- Primelec Systems, Handen, Sweden
- Radio Shack of London

More Details? CHECK-OFF Page 150

november 1977
Flea Market

RATES Non-commercial ads 10¢ per word; commercial ads 60¢ per word both payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-profit organizations receive one free Flea Market word; commercial ads payable in advance. No cash discounts or agency commissions allowed.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (not all caps) and must include full name and address. We reserve the right to reject un·suitable copy. Ham Radio cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue.

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N.H. 03048.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

YAESU EQUIPMENT OWNERS — Present or Prospective — join the six-year-old, 2500 member, 42-country, International Fox-Tango Club. Members receive valuable monthly Newsletter, money-saving purchasing service, technical committee consultation, free ads, PT net, more. Back issues of Newsletter available from 1972. To join, send $5 for calendar year (includes all 1977 issues of Newsletter) and $1 creditable towards dues, for complete information and sample Newsletter. Milton Lowens, WA2AZQ/NAML, 245 Lake Drive, W. Palm Beach, FL 33411.

GRP TRANSMATCH with Preamp for HWT Ten-Tec, Send stamp for details to Peter Meacham Associates, 19 Lorretta Road, Waltham, Mass. 02154.

WANTED — Manual for International Fox-Tango Club Members receive valuable SCPA-4a Spectrum Analyzer — Judson Snyder, KPCBA, P.O. Box 1000, Greenville, N.H. 03048.

WANTED — For Panoramic Electronics Model SPA-4a Spectrum Analyzer — Judson Snyder, KPCBA, Petersburg, N.Y. 12138.

CANADIANS 1,000,000 surplus parts. Bargains galore. Free catalog. Etc-O-HR Box 741, Montreal, H3C 2V3.

PORTA PAK the accessory that makes your mobile really portable. $67.50 and $88.00. Dealer inquiries invited. P.O. Box 67, Somers, Wisc. 53171.

FOR SALE: One 20A Central Electronics Transmitter; One National 303 Receiver; Both in excellent condition. KEYBC John H. Smith, P.O. Box 156, 114 W. Chestnut, LaCygne, Kansas 66040.

BEARCAT 210 Scanner $265.00. Yaesu FT101E $690.00. SASE Catalog quotes. ROGERS ELECTRONICS. 1927 Barry, Chicago, IL 60657.

FREE Catalog: Solar Cells, Nicads, Kits, Calculators, Digital Watch Modules, Ultrasonics, Strobos. LEOS, Transmitting, LC's Unique Components. Chaney's, Box 27038, Denver, Colo. 80227.

OSL — BROWNE W3CJ — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 50¢.

TRAVEL PAK OSL KIT — Send call and 25¢; receive your call card and kit in return. Samco, Box 203, Wyantskill, N.Y. 12198.

NATIONAL NC-183 General Coverage receiver complete with many Power supply options. 2 x $40. Steven Terhaar, WAB*YXQ, 650 Beech, Moorhead, MN 56560.

MILLER 9065-1 A GDO, probe, & tone modulator $75.00; Bell & Howell equipment — #3 oscilloscope $55.00, transistorized meter $20.00, two design consoles $20.00 each. RCA Institute signal generator and VOM, both $30.00; RCA WV-8C senior volthavom $40.00; Sprague TO-6 Tel Omhika capacitor analyzer $90.00. Etc. equipment — $95 in circuit capacitor tester $25.00, 378 Audio Generator $40.00, 565 VOM $15.00, 1030 Regulated Power Supply $50.00, 1038 Battery Eliminator & charger $30.00, 1078 Auto Transformer $40.00; Heath IM-38 AC VTVM $30.00. Heath 1D-22 Electronic Switch $15.00. Knight equipment — KG-635 D.C. Oscilloscope $90.00, KG-690 signal tracer $30.00; Clarostat "Power Resistor" decade box $35.00. Everything above mint $600.00. Ralph Cooper, W3AQW, 149 Giadstone Street, Phila., Pa. 19148, 215-H0-2903.

SELL: ROBOT 70 monitor, 61 viewfinder, WAWXQ, Barry. Chicago, IL 60631. Send catalog or SASE for full line quotes. Carl Suriano, Box 294, Surgery, CA 90147.

RECONDITIONED TEST EQUIPMENT for sale. Catalog etc., Big Catalog 201-962-4695 Narwid Electronics. (516) 320-4439, evenings.

AUTHORIZED DEALER for Dentron, KLM, Larsen, Bear, etc. Big Catalog $20.00. Poor condition as is $10. Magnavox. 879 Beacon St., Boston, Mass. 02116.

YOUR CALL on a bumper sticker. Red or Yellow-Green letters on Black — $1.25 postpaid. R. Schweizer, Box 232, CA 92122.

MODERN CODE PRACTICE. 26062 1-201, 879 Beacon St., Boston, Mass. 02116.

SATELLITE HEADQUARTERS

See Erickson for all your Amateur Radio needs.

W98EBP, W98JKT, W98VIK serving you with...

- Ameco • ASP • Atlas
- Belden • Bird • CDE
- CES • Collins • Cushcraft
- Dentron • Drake • HAL
- Hy-Gain • Icom • KLM
- Kenwood • Larsen • MFJ
- Midland • Mosley • NPC
- Newtonics • Nye
- Regency • Shure • Swan
- Standard • TPL • Tempo
- Ten-Tec • Wilson • Yaesu

See Erickson for all your Amateur Radio needs.

More Details? CHECK — OFF Page 150

Erickson Communications 5935 Milwaukee Avenue Chicago, IL 60646 (312) 631-5181
CALL FOR QUOTES ON:

**AESU FT301D, FT301, KENWOOD TS520S, TS820S, TS600A, TR7400A, FT101E, TEMPO 20 & E/T-A-LPHA, ALL IN SEALED CARTONS. CALL FOR QUOTES ON ITEMS NOT LISTED. CALL FOR FAST QUOTE, OR WRITE AND INCLUDE TELEPHONE NUMBER, IF WE HAVE YOUR BARGAIN, WE'LL CALL YOU PREPAID.**

**TERMS:** All prices FOB Houston. Prices subject to change without notice. All items Guaranteed Standard of Quality. Ships F.O.B. Express for Amateur dealers price list. Texas residents add 8% tax. Please add postage estimate, if required.

**ALDELCO SEMI-CONDUCTOR SUPERMARKET**

**RF DEVICES**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N3906</td>
<td>2N3906 2N3906</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3907</td>
<td>2N3907 2N3907</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3819</td>
<td>2N3819 2N3819</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3924</td>
<td>2N3924 2N3924</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3926</td>
<td>2N3926 2N3926</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3927</td>
<td>2N3927 2N3927</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3928</td>
<td>2N3928 2N3928</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3929</td>
<td>2N3929 2N3929</td>
<td>10</td>
<td>$5.90</td>
</tr>
<tr>
<td>2N3930</td>
<td>2N3930 2N3930</td>
<td>10</td>
<td>$5.90</td>
</tr>
</tbody>
</table>

**COMBINATION DIGITAL CLOCK AND FREQUENCY COUNTER KIT**

- 60 MHz counter, $35.00
- 16 MHz counter, $35.00
- 100 kHz counter, $35.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00

**PHILMORE GT-2000**

- 120VAC, $50.00
- 240VAC, $50.00
Bearcat 210 Features
- Crystal-less - Without ever buying a crystal you can select from all local frequencies by simply pushing a few buttons.
- Decimal Display - See frequency and channel number - no guessing who's on the air.
- 5-Band Coverage - Includes Low, High, UHF and UHF "T" public service bands, the 2 meter amateur (Ham) band, plus other UHF frequencies.
- Deluxe Keyboard - Makes frequency selection as easy as using a push button phone. Lets you enter and change frequencies easily...try everything there is to hear.
- Patented Track Tuning - Receive frequencies across the full band without adjustment. Circuitry is automatically aligned to each frequency monitored.
- Automatic Search - Seek and find new, exciting frequencies.
- Selective Scan Delay - Adds a second delay to prevent missing transmissions when "calls" and "answers" are on the same frequency.
- Automatic Lock Out - Locks out channels and "skips" frequencies not of current interest.
- Simple Programming - Simply punch in on the keyboard the frequency you wish to monitor.
- Space Age Circuitry - Custom integrated circuits...a Bearcat tradition.
- UL Listed FCC Certified - Assures quality design and manufacture.
- Rolling Zeros - This Bearcat exclusive tells you which channels your scanner is monitoring.
- Tone By-Pass - Scanning is not interrupted by mobile telephone tone signal.
- Manual Scan Control - Scan all 10 channels at your own pace.
- 3-Inch Speaker - Front mounted speaker for more sound with less distortion.
- Squelch - Allows user to effectively block out unwanted noise.
- AC/DC - Operates at home or in the car.

Bearcat 210 Specifications

<table>
<thead>
<tr>
<th>Frequency Receiving Range</th>
<th>Low Band</th>
<th>32-50 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Ham&quot; Band</td>
<td>136-148 MHz</td>
<td></td>
</tr>
<tr>
<td>High Band</td>
<td>148-174 MHz</td>
<td></td>
</tr>
<tr>
<td>UHF Band</td>
<td>450-470 MHz</td>
<td></td>
</tr>
<tr>
<td>&quot;T&quot; Band</td>
<td>470-512 MHz</td>
<td></td>
</tr>
</tbody>
</table>

*Also receives UHF from 416-450 MHz

Size: 10 1/4" W x 3" H x 7 1/2" D
Weight: 4 lbs. 8 oz.

Power Requirements: 117V ac., 11W, 13.8 Vdc, 6W
Audio Output: 2W rms

Antenna: Telescoping (supplied)

Sensitivity: 0.6 µv for 12 dB SINAD on L & H bands
0.4 µv for 12 dB SINAD on "T" band
0.3 µv for 12 dB SINAD on U bands

Selectivity: Better than 60 dB @ ± 25 kHz

Scan Rate: 20 channels per second

Connectors: External antenna and speaker. AC & DC power

Accessories: Mounting bracket and hardware

The Bearcat 210 is a sophisticated scanning instrument with the ease of operation and frequency versatility you've dreamed of. Imagine, selecting from any of the public service bands and all local frequencies by simply pushing a few buttons. No longer are you limited by crystals to a given band and set of frequencies. It's all made possible by Bearcat space age solid state circuitry. You can forget crystals forever.

Pick the 10 frequencies you want to scan and punch them in on the keyboard. It's incredibly easy. The large decimal display reads out each frequency you've selected. When you want to change frequencies, just enter the new ones.

Automatic search lets you scan any given range of frequencies of your choice within a band. Push-button lockout permits you to selectively skip frequencies not of current interest. The decimal display with its exclusive "rolling zeros" tells you which channels you're monitoring. When the Bearcat 210 locks in on an active frequency the decimal display shows the channel and frequency being monitored.

With the patented track-tuning system, the Bearcat 210 automatically aligns itself so that circuits are always "peaked" for any broadcast. Most competitive models peak only at the center of each band, missing the frequencies at the extreme ends of the band.

The Bearcat 210's electronically switched antenna eliminates the need for the long low band antenna. And a quartz crystal filter rejects adjacent stations as well as noise interference.

Call toll-free 800-521-4414 now to place a BankAmericard or Master-charge order. This is our 24 hour phone to our order department and only orders may be processed on this line. To order in Michigan or outside of the U.S. dial 313-994-4441.

Add $5.00 for U.S. shipping or $9.00 for air UPS to west coast. Charge cards or money orders only please. International orders invited. Michigan residents add tax. Please write for quantity pricing.
**STOP!** Don’t order that counter kit until you see what EEB has come up with.

The New B & K 1827, 30 MHz counter (assembled and tested), a famous pre-scaler kit, hardware and complete instructions to result in 250 MHz Counter. ALL FOR $129.95 postpaid!

### Model 1827

- **30 MHz reading guaranteed.** 50 MHz typical.
- **Full 6-digit display with range switch allows 5-digit accuracy.**
- **1Hz resolution** — even at 30 MHz and beyond.
- Complete instructions for use anywhere.
- Exclusive battery saver features auto-shutoff of display to reduce battery drain.
- **Operates at 2.2A maximum current.** AC charger/adapter or 12VDc with optional power card/adaptor.

**SPECs:**

- **FREQUENCY CHARACTERISTICS**
  - Range: 10000 to 30 MHz (guaranteed); 50 MHz typical.
  - Accuracy: ± 1 count. Resolution: 1 ppb of a & full scale.
- **INPUT CHARACTERISTICS**
  - Impedance: 10 KΩ minimum. Connector: RCA.
  - Phase, Sine wave Sensitivity: 1000mV RMS; 200 kHz to 30 MHz: 200mV RMS; 50 MHz to 200kHz.
- **INTERNAL TIME BASE CHARACTERISTICS:**
  - 25°C, 20ppm/°C. Frequency and Type: 4.00 MHz crystal oscillator.
  - Stability: ± 0.25 ppm (± 1°C). Temperature Stability: Better than ±0.0001% (i.e. ± 10ppm) from 0°C to 50°C ambient.

**YOU PAY ONLY $129.95**

**AC Charger and NICADS** $43.00

**Test Antenna (BNC)** $4.00

---

### Flea Market

**Publications for trade:** duplicates Rider’s Radio & Sams Photofacts, ARRL Handbook, radio & electronic magazines and books, Need RADEX, WTH=SMX, 30Hz, 250 MHz Counter. ALL FOR $129.95.

**STOP!** Weight is only 3 pounds.

**SPECS:**

- **Weight is only 3 pounds.**
- **Size:** Time Base - 0.15 microsecond.
- **Accuracy:** ± 0.001 ± 0.1°C. TIME BASE - 0.1 microsecond. Accuracy: ± 0.001 ± 0.01°C.
- **Impedance:** 100ps to 30 MHz (guaranteed); 50 MHz guaranteed: 200ps to 200kHz.

**Teletypewriter parts:** gears, manuals, supplies, tape, cord/adapter.

**Authorized dealers lor**

- **Acroline**
- **ICOM**
- **Kenwood**
- **Ten-Tec**
- **Standard**
- **Dentron**
- **CDE**
- **Collins**
- **Hy-Gain**
- **Hosier Electronics**
- **Tecalemit**
- **Gary Ten-Tec**
- **Kenwood**
- **ICOM**
- **Collins**
- **Hy-Gain**
- **Hosier Electronics**

**Model 28 ASR Teletype**

**Sorry no shipping on this item**

**Pickup Only**

All items sold and shipped by:**

- **ALL ITEMS PPD USA**
- **SEND STAMP FOR LIST OF BARGAINS**
- **PA RESIDENTS ADD 6% SALES TAX**

**Fone 412-863-7008**

---

### Coming Events

**North Carolina QSO Party.** Sponsored by the Alamance Amateur Radio Club, Inc., from 1960 Dec. 2 through 1961 Dec. 4. **Suggested frequencies are:**

- 146.07-67 MHz and 146.52 simplex.
- **Time Base - 0.1 microsecond:** Downtown Tessman, Ohio. Unlimited parking. Starts 9:00 AM. Major prizes given away. Mobile station on 2016 W. Adams St., Marion, Ohio 43305. Please see the Marion Area QSO Party for all details.

**Western Michigan University:** will hold its 22nd annual VHF Conference, November 19, 1977. Contact Dr. Glade Wilcox, W9HFM, Dept. of Electrical Eng., WMU, Kalamazoo, Michigan 49008.

**Massillon ARC 18th Annual Hamfest & Auction**

- **Saturday, Nov. 20, 1977 at new location: Towne Plaza Shopping Center.**
- **Downtown Massillon, Ohio. Unlimited parking.** Starts: 9:00 AM. Major prizes given away. Mobile station on 2016 W. Adams St., Marion, Ohio 43305. Please see the Marion Area QSO Party for all details.

**Florida Gulf Coast Convention.**

- **Clearwater Beach, November 19 & 20. Sponsored by Florida Gulf Coast A.R.C. Exhibits, flea market, technical sessions, FCC exams, forums and much more. Full info and reservation for Sheraton International, contact: F.G.C.C. Convention, P.O. Box 157, Clearwater, FL 33717.

**Radio and Electronic Swap and Shop.**

- **Marshall County Amateur Radio Club.**
- **Will be held on Saturday, October 30, 1977, at the Plymouth, Indiana National Guard Armory, located at 1202 West Madison Street, from 8 AM to 5 PM. Free tables, no charge for set-up. Tickets $2.00 at the door. Door prizes, talk-in.**

---

**For more information contact:**

- **WAS/NM, Rt. 3, Box 526, Plymouth, Indiana 46563.
- **WAS/NM, Rt. 3, Box 526, Plymouth, Indiana 46563.**

---

**Shops of the World:**

- **Iambic Sending**
- **Dot and Dash Memories**
- **Built-In key**
- **Regulated AC Power Supply**
- **Sidetone with volume/tune control.**
- **Pitch externally adj.**
- **Available with Reed Relay or Transistor grid block output**
- **Heavy Alum. two-tone Cabinet.**

---

**K. E. Electronics.**

**130 N. SHERMAN AVE.**

**UNIT A**

**CORONA, CALIF. 91720**

---

**More Details? CHECK — OFF Page 150**
Learn the truth about your antenna.
Find its resonant frequency.
Adjust it to your operating frequency quickly and easily.

If there is one place in your station where you cannot risk uncertain results it is in your antenna. The Palomar Engineers R-X Noise Bridge tells you if your antenna is resonant or not and, if it is not, whether it is too long or too short. All this in one measurement reading. And it works just as well with ham-band-only receivers as with general coverage equipment because it gives perfect null readings even when the antenna is not resonant. It gives resistance and reactance readings on dipoles, inverted Vees, quads, beams, multiband trap dipoles and verticals. No station is complete without this up-to-date instrument.

Why work in the dark? Your SWR meter or your resistance noise bridge tells only half the story. Get the instrument that really works, the Palomar Engineers R-X Noise Bridge. Use it to check your antennas from 1 to 100 MHz. And use it in your shack to adjust resonant frequencies of both series and parallel tuned circuits. Works better than a dip meter and costs a lot less. Send for our free brochure.

The price is $49.95 and we deliver postpaid anywhere in U.S. and Canada. California residents add sales tax.

Italy write iWY, P.O. Box 37, 22063 Canto. Elsewhere send $52.00 (U.S.) for air parcel post delivery worldwide.

Fully guaranteed by the originator of the R-X Noise Bridge. ORDER YOURS NOW!

R-X NOISE BRIDGE

PALOMAR ENGINEERS
BOX 455, ESCONDIDO, CA 92025
Phone: (714) 747-3343

ALL-MODE VHF amplifiers

FOR BASE STATION & REPEATER USE

<table>
<thead>
<tr>
<th>MODEL</th>
<th>INPUT</th>
<th>OUTPUT</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V70</td>
<td>10-20W</td>
<td>60-70V</td>
<td>6298</td>
</tr>
<tr>
<td>V71</td>
<td>1.5W</td>
<td>60-70V</td>
<td>6529</td>
</tr>
<tr>
<td>V130</td>
<td>25-40W</td>
<td>110-130V</td>
<td>6389</td>
</tr>
<tr>
<td>V131</td>
<td>1.5W</td>
<td>110-130V</td>
<td>6419</td>
</tr>
<tr>
<td>V136</td>
<td>5-10W</td>
<td>110-130V</td>
<td>6419</td>
</tr>
<tr>
<td>V180</td>
<td>10-15W</td>
<td>180-200V</td>
<td>6525</td>
</tr>
</tbody>
</table>

Universal 19" Rack Mount $25

143-149 MHz No Tuning
AM - FM - CW - SSB
Low Harmonics
Heavy Duty
No Power Supply Needed
Illuminated Panel Meter
+ 13.5V/3 Amp Socket

Only two things are needed to put this power house on the air with your handy-talky or mobile transceiver: a two foot piece of coaxial cable and a 115 or 230 volt AC outlet. That's all. You do not need anything else. The mobile transceiver can be powered directly from the accessory socket located in the rear panel of the RFPL amplifier. It puts out +13.5 volts at 3 amperes. This is sufficient for powering most 15 watt transceivers.

RF POWER LABS, INC.
11013-118th Place N.E. • Kirkland, Washington 98033 • Telephone: (206) 822-1251 • TELEX No. 32-1042

FREE CATALOG

HARD-TO-FIND PRECISION TOOLS
Lists more than 3000 items: pliers, tweezers, wire strippers, vacuum systems, relay tools, optical equipment, tool kits and cases. Also includes ten pages of useful "Tool Tips" to aid in tool selection.

RF POWER LABS, INC.
11013-118th Place N.E. Kirkland, Washington 98033

DEALER INQUIRIES INVITED

UNITED STATES: Order from RF POWER LABS, INC.
INTERNATIONAL: Order from your nearest stocking dealer.

Curtis Keyer CHIP $24.95

Use this module as the heart of your homebrew receiver or transceiver. Your direct conversion receiver can have excellent sensitivity and still reject strong signals. Module operates from 9 to 15 volts with low idle current drain. Up to 1 watt output drives your speaker or headphones. Use with your VFO or build one from our kit.

Receiver module kit $39.95 ppd
VFO module kit $29.95 ppd

Specify 80 or 40 meters with order.

More Details? CHECK — OFF Page 150
SEND FOR FREE COMPLETE MAIL ORDER CATALOG

SST T-1 RANDOM WIRE ANTENNA TUNER


COAXIAL SWITCH SELECTOR CHART — BARKER & WILLIAMSON, INC.

<table>
<thead>
<tr>
<th>Model</th>
<th>PRICE</th>
<th>Outputs</th>
<th>Connector</th>
<th>Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td>375</td>
<td>18.95</td>
<td>6</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit.</td>
</tr>
<tr>
<td>375A</td>
<td>18.95</td>
<td>6</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit. Width is only 1/4 inch.</td>
</tr>
<tr>
<td>500A</td>
<td>14.00</td>
<td>5</td>
<td>Axial</td>
<td>PROTAX switch. Width is only 1/4 inch.</td>
</tr>
<tr>
<td>500C</td>
<td>12.50</td>
<td>2</td>
<td>Axial</td>
<td>PROTAX switch. Width is only 1/4 inch.</td>
</tr>
<tr>
<td>501A</td>
<td>17.50</td>
<td>2</td>
<td>Axial</td>
<td>Special 2 pole, 2 position switch used to select any RF device in slot of same connection in aerial line. See figure (below).</td>
</tr>
<tr>
<td>566</td>
<td>.95</td>
<td>0</td>
<td>Axial</td>
<td>Bracket only, for mounting of remote switch.</td>
</tr>
<tr>
<td>590</td>
<td>17.95</td>
<td>5</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit.</td>
</tr>
<tr>
<td>590C</td>
<td>17.95</td>
<td>5</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit. Width is only 1/4 inch.</td>
</tr>
<tr>
<td>592</td>
<td>16.50</td>
<td>2</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit. Width is only 1/4 inch.</td>
</tr>
<tr>
<td>595</td>
<td>18.50</td>
<td>6</td>
<td>Axial</td>
<td>PROTAX switch, grounds all except selected output circuit. Width is only 1/4 inch.</td>
</tr>
</tbody>
</table>

DENTRON

160-10AT SUPERTUNER Tuna antenna tuner to match everything between 160 and 10 through balanced line, coax line and random line. Super tuning is the one for you at just $129.50. 160-10AT SKY SKY MATCHER Tuna antenna tuner to match everything between 160 and 10 through balanced line, coax line and random line. Super tuning is the one for you at just $129.50. 160-10AT SKY SKY MATCHER Tuna antenna tuner to match everything between 160 and 10 through balanced line, coax line and random line. Super tuning is the one for you at just $129.50.

SLINKY! $39.95 kit

A LOT of antenna in a LITTLE space New Slinky® dipole with helical loading radiates a good signal at 1/10 wavelength long!

TLP Talk Power by TLP

TLP for an Economy Price? THAT’S RIGHT! introducing the ECONO-LINE

Model | Input | Output Voltage | Link Lead Regulation | Price/Box | Response | Price/Box | Current Continues | Current Limit | Current Feedback | Price/Box |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>600-1</td>
<td>12VDC</td>
<td>13.6 x 3 VDC</td>
<td>0.14 DC</td>
<td>$49.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-2</td>
<td>22VDC</td>
<td>13.6 x 3 VDC</td>
<td>0.14 DC</td>
<td>$49.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-3</td>
<td>22VDC</td>
<td>22VDC</td>
<td>0.14 DC</td>
<td>$49.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-4</td>
<td>22VDC</td>
<td>22VDC</td>
<td>0.14 DC</td>
<td>$49.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600-5</td>
<td>22VDC</td>
<td>22VDC</td>
<td>0.14 DC</td>
<td>$49.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ask about our Dealer Program

Novice Crystals (Specify Band Only)

TWO METER CRYSTALS IN STOCK

Standard | Icom | Heathkit | Ken | Clegg | Regency | Wilson | VHF Eng | Drake | And Others!

TWO METER CRYSTALS IN STOCK

Motorola HT 220 Crystals

$4.50 @ Lifetime Guarantee

BOMAR

Crystal Company

Novice Crystals (Specify Band Only)

Make/Model | Xmit Freq. | Rec. Freq. |
|------------|------------|-----------|

BOMAR TWO METER CRYSTALS IN STOCK

G-Two-Two-Two Crystals

NOW!

Motorola HT 220 Crystals In Stock!

FREE Gift With Every Order! ALL SALES FINAL!

TUFTS

209 Mystic Ave
Medford, MA 02155
(617) 395-8280

New England’s Friendliest Ham Store

ASK our Dealer Program

Master Charge & Bank America accepted on most orders.

Name ___________________________  Call ___________________________

Address __________________________

City ______ State ______ Zip ______

Open 9AM to 9PM
Mon.-Fri.
Sat. 9-6

Prices FOB Medford MA. All units can be shipped UPS. MA residents add 5% sales tax. Orders over $1200 deduct 5%. Add $3.50 for shipping & handling on all orders.
NEW! IC KEYER

The World’s Greatest Sending Device

Adjustable to Any Desired Speed

Now available from Palomar Engineers - the new Electronic IC KEYER. Highly prized by professional operators because it is EASIER, QUICKER, and MORE ACCURATE.

It transmits with amazing ease CLEAR, CLEAN-CUT signals at any desired speed. Saves the arm. Prevents cramp, and enables anyone to send with the skill of an expert.

SPECIAL RADIO MODEL

Equipped with large specially constructed contact points. Keys any amateur transmitter with ease. Sends Manual, Semi-Automatic, Full Automatic, Dot Memory, Squeeze, and lamicb - MORE FEATURES than any other keyer. Has built-in sidetone, speaker, speed and volume controls, BATTERY OPERATED, heavy shielded die-cast metal case. FULLY ADJUSTABLE contact spacing and paddle tension. The perfect paddle touch will AMAZE you.

Every amateur and licensed operator should know how to send with the IC KEYER. EASY TO LEARN. Sent anywhere on receipt of price. Free brochure sent on request. Send check or money order. IC KEYER $97.50 postpaid in U.S. and Canada. IC KEYER LESS PADDLE and nonskid base $67.50. Add 6% sales tax in California.

Italy write 12VTT, P.O. Box 37, 22063 Cantu.

Fully guaranteed by the world’s oldest manufacturer of electronic keys. ORDER YOURS NOW!

PALOMAR ENGINEERS

BOX 455, ESCONDIDO, CA 92025
Phone: (714) 747-3343

LEARN RADIO CODE

THE EASY WAY!

Based on modern psychological techniques - This course will take you beyond 13 w.p.m. in LESS THAN HALF THE TIME!

• No Books To Read
• No Visual Gimmicks To Distract You

Available in Cassette also for only $10.95.

 predictors

THE TOUCH.

by Regency

$329 List

$279.00

Experience the Ultimate in Scanners

LAFAYETTE RADIO ELECTRONICS

1811 HWY 17-92, MAITLAND, FL. 32751
305-831-2271

SUB-AUDIBLE GENERATOR for FM

• Inexpensive multi-tone encoder
• Compatible with PL-CG-OC
• Low distortion signal
• Input 8-18 VDC unregulated
• Rugged, plastic encased with leads
• Adjustable frequency (98-250 Hz). Lower available
• Excellent stability

Price $19.95
Frag. set at factory $500 extra
Calif. res. add 6%

Send for more info

The Touch.™

$9.95

Album contains three 12” LP’s
2½ hr. instruction

Available in Cassette also for only $10.95.

LEARN RADIO CODE

THE EASY WAY!

Based on modern psychological techniques - This course will take you beyond 13 w.p.m. in LESS THAN HALF THE TIME!

• No Books To Read
• No Visual Gimmicks To Distract You

Available in Cassette also for only $10.95.

Epsilon Records

508 East Washington St., Arcola, IL 61910

TONE ENCODER PAD

MODEL TTP-03

$54.95

POSTPAID IN U.S.A.

Texas residents add 5% sales tax.

See up-coming ad for new automatic unit - ATD-70 2 numbers, field programmable.

Satisfaction guaranteed

CLENG ELECTRONICS COMPANY

BOX 12171 DALLAS, TEXAS 75225
### DIODES/ZENERS

<table>
<thead>
<tr>
<th>Code</th>
<th>Voltage</th>
<th>Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N914</td>
<td>100V</td>
<td>10mA</td>
<td>.05</td>
</tr>
<tr>
<td>1N4005</td>
<td>600V</td>
<td>1A</td>
<td>.08</td>
</tr>
<tr>
<td>1N407</td>
<td>1000V</td>
<td>1A</td>
<td>.15</td>
</tr>
<tr>
<td>1N4148</td>
<td>75V</td>
<td>1mA</td>
<td>.05</td>
</tr>
<tr>
<td>1N753A</td>
<td>6.2V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1N758A</td>
<td>10V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1N759A</td>
<td>12V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1N4733</td>
<td>5.1V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1NS243</td>
<td>13V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1NS244B</td>
<td>14V</td>
<td>z</td>
<td>.25</td>
</tr>
<tr>
<td>1NS2458</td>
<td>15V</td>
<td>z</td>
<td>.25</td>
</tr>
</tbody>
</table>

### SOCKETS/BRIDGES

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-pin pcb .25</td>
<td>.25</td>
</tr>
<tr>
<td>14-pin pcb .25</td>
<td>.40</td>
</tr>
<tr>
<td>18-pin pcb .25</td>
<td>.40</td>
</tr>
<tr>
<td>22-pin pcb .45</td>
<td>.25</td>
</tr>
<tr>
<td>24-pin pcb .35</td>
<td>.10</td>
</tr>
<tr>
<td>28-pin pcb .35</td>
<td>.14</td>
</tr>
<tr>
<td>40-pin pcb .50</td>
<td>.25</td>
</tr>
</tbody>
</table>

Molex pins .01 To-3 Sockets .45
2 Amp Bridge 100-prv .120
2 Amp Bridge 200-prv 1.95

### TRANSISTORS, LEDS, etc.

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N2222 NPN</td>
<td>(.30) .15</td>
</tr>
<tr>
<td>2N2907 NPN</td>
<td>.15</td>
</tr>
<tr>
<td>2N3906 PNP</td>
<td>.30</td>
</tr>
<tr>
<td>2N3054 NPN</td>
<td>.35</td>
</tr>
<tr>
<td>2N3055 NPN 15A</td>
<td>.50</td>
</tr>
<tr>
<td>TIP125 PNP Darlington</td>
<td>.35</td>
</tr>
<tr>
<td>LED Green, Red, Clear</td>
<td>.15</td>
</tr>
<tr>
<td>D.L.747 7 seg 5/8&quot; high com-anode</td>
<td>1.95</td>
</tr>
<tr>
<td>XAN72 7 seg com-anode</td>
<td>1.50</td>
</tr>
<tr>
<td>FND 359 Red 7 seg com-cathode</td>
<td>1.25</td>
</tr>
</tbody>
</table>

### MEMORY CLOCKS

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>74S47</td>
<td>.15</td>
</tr>
<tr>
<td>74S74</td>
<td>.15</td>
</tr>
<tr>
<td>74S54</td>
<td>.35</td>
</tr>
<tr>
<td>74S374</td>
<td>.60</td>
</tr>
<tr>
<td>74S375</td>
<td>.50</td>
</tr>
</tbody>
</table>

### ICs

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>74LS00</td>
<td>.35</td>
</tr>
<tr>
<td>74LS01</td>
<td>.35</td>
</tr>
<tr>
<td>74LS02</td>
<td>.35</td>
</tr>
<tr>
<td>74LS03</td>
<td>.45</td>
</tr>
<tr>
<td>74LS04</td>
<td>.45</td>
</tr>
<tr>
<td>74LS05</td>
<td>.45</td>
</tr>
<tr>
<td>74LS06</td>
<td>.50</td>
</tr>
<tr>
<td>74LS07</td>
<td>.65</td>
</tr>
<tr>
<td>74LS08</td>
<td>.65</td>
</tr>
<tr>
<td>74LS09</td>
<td>.65</td>
</tr>
<tr>
<td>74LS00N</td>
<td>.65</td>
</tr>
<tr>
<td>74LS11</td>
<td>.65</td>
</tr>
<tr>
<td>74LS20</td>
<td>.25</td>
</tr>
<tr>
<td>74LS22</td>
<td>.25</td>
</tr>
<tr>
<td>74LS32</td>
<td>.35</td>
</tr>
<tr>
<td>74LS33</td>
<td>.35</td>
</tr>
<tr>
<td>74LS40</td>
<td>.45</td>
</tr>
<tr>
<td>74LS42</td>
<td>1.10</td>
</tr>
<tr>
<td>74LS51</td>
<td>.50</td>
</tr>
<tr>
<td>74LS74</td>
<td>.65</td>
</tr>
<tr>
<td>74LS86</td>
<td>.65</td>
</tr>
<tr>
<td>74LS90</td>
<td>.95</td>
</tr>
<tr>
<td>74LS93</td>
<td>.95</td>
</tr>
<tr>
<td>74LS107</td>
<td>.85</td>
</tr>
<tr>
<td>74LS112</td>
<td>1.00</td>
</tr>
<tr>
<td>74LS151</td>
<td>.95</td>
</tr>
<tr>
<td>74LS153</td>
<td>1.20</td>
</tr>
<tr>
<td>74LS157</td>
<td>1.85</td>
</tr>
<tr>
<td>74LS164</td>
<td>1.90</td>
</tr>
<tr>
<td>74LS367</td>
<td>.85</td>
</tr>
<tr>
<td>74LS368</td>
<td>.85</td>
</tr>
</tbody>
</table>

### TRANSMISTORS

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N2222 NPN</td>
<td>(.30) .15</td>
</tr>
<tr>
<td>2N2907 NPN</td>
<td>.15</td>
</tr>
<tr>
<td>2N3906 PNP</td>
<td>.30</td>
</tr>
<tr>
<td>2N3054 NPN</td>
<td>.35</td>
</tr>
<tr>
<td>2N3055 NPN 15A</td>
<td>.50</td>
</tr>
<tr>
<td>TIP125 PNP Darlington</td>
<td>.35</td>
</tr>
<tr>
<td>LED Green, Red, Clear</td>
<td>.15</td>
</tr>
<tr>
<td>D.L.747 7 seg 5/8&quot; high com-anode</td>
<td>1.95</td>
</tr>
<tr>
<td>XAN72 7 seg com-anode</td>
<td>1.50</td>
</tr>
<tr>
<td>FND 359 Red 7 seg com-cathode</td>
<td>1.25</td>
</tr>
</tbody>
</table>

### INTEGRATED CIRCUITS UNLIMITED

7889 Clairemont Mesa Boulevard, San Diego, California 92111
(714) 278-4394 (Calif. Res.)

All orders shipped prepaid
No minimum
Open accounts invited
COD orders accepted

Discounts available at OEM Quantities
California Residents add 6% Sales Tax
All IC's Prime/Guaranteed. All orders shipped same day received.

24 Hour Toll Free Phone 1-800-854-2211
MasterCharge / BankAmericard / AE

---

### 9000 SERIES

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>9301</td>
<td>.85</td>
</tr>
<tr>
<td>9309</td>
<td>.85</td>
</tr>
<tr>
<td>9322</td>
<td>.85</td>
</tr>
<tr>
<td>95403</td>
<td>.55</td>
</tr>
<tr>
<td>95601</td>
<td>.75</td>
</tr>
<tr>
<td>9502</td>
<td>.50</td>
</tr>
</tbody>
</table>

### MEMORY CLOCKS

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>74S188 (2123)</td>
<td>3.00</td>
</tr>
<tr>
<td>1702A</td>
<td>6.95</td>
</tr>
<tr>
<td>MMS514</td>
<td>3.00</td>
</tr>
<tr>
<td>MMS516</td>
<td>3.50</td>
</tr>
<tr>
<td>2101-1</td>
<td>1.75</td>
</tr>
<tr>
<td>2102L-1</td>
<td>1.95</td>
</tr>
<tr>
<td>TR 1602B/ TMS 6011</td>
<td>6.95</td>
</tr>
<tr>
<td>8080AD</td>
<td>15.00</td>
</tr>
<tr>
<td>8T13</td>
<td>1.50</td>
</tr>
<tr>
<td>8T23</td>
<td>1.50</td>
</tr>
<tr>
<td>8T24</td>
<td>2.00</td>
</tr>
<tr>
<td>21078-4</td>
<td>4.95</td>
</tr>
</tbody>
</table>

---

### 8266

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM320K5 (2905)</td>
<td>1.65</td>
</tr>
<tr>
<td>LM320K12</td>
<td>1.65</td>
</tr>
<tr>
<td>LM340T24</td>
<td>.95</td>
</tr>
<tr>
<td>LM340K12</td>
<td>1.15</td>
</tr>
<tr>
<td>LM340K15</td>
<td>1.25</td>
</tr>
<tr>
<td>LM340K18</td>
<td>1.25</td>
</tr>
<tr>
<td>LM340K24</td>
<td>.95</td>
</tr>
<tr>
<td>LM373</td>
<td>2.95</td>
</tr>
<tr>
<td>LM380</td>
<td>.95</td>
</tr>
<tr>
<td>LM7905 (8,14 PIN)</td>
<td>.25</td>
</tr>
<tr>
<td>LM711</td>
<td>.45</td>
</tr>
</tbody>
</table>

### 9038

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM201</td>
<td>.75</td>
</tr>
<tr>
<td>LM301</td>
<td>.25</td>
</tr>
<tr>
<td>LM308 (Mini)</td>
<td>.75</td>
</tr>
<tr>
<td>LM309H</td>
<td>.65</td>
</tr>
<tr>
<td>LM309K (340K-5)</td>
<td>.85</td>
</tr>
<tr>
<td>LM310</td>
<td>1.15</td>
</tr>
<tr>
<td>LM311D (Mini)</td>
<td>.75</td>
</tr>
<tr>
<td>LM318 (Mini)</td>
<td>.65</td>
</tr>
</tbody>
</table>

### LINES, REGULATORS, etc.

<table>
<thead>
<tr>
<th>Code</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM723</td>
<td>.50</td>
</tr>
<tr>
<td>LM725</td>
<td>1.75</td>
</tr>
<tr>
<td>LM739</td>
<td>1.50</td>
</tr>
<tr>
<td>LM741 (8,14)</td>
<td>2.25</td>
</tr>
<tr>
<td>LM747</td>
<td>1.10</td>
</tr>
<tr>
<td>LM1307</td>
<td>1.25</td>
</tr>
<tr>
<td>LM1458</td>
<td>.95</td>
</tr>
<tr>
<td>LM390</td>
<td>.50</td>
</tr>
<tr>
<td>LM3541</td>
<td>.65</td>
</tr>
<tr>
<td>NE555</td>
<td>.50</td>
</tr>
<tr>
<td>NE556</td>
<td>.95</td>
</tr>
<tr>
<td>NE558</td>
<td>1.75</td>
</tr>
<tr>
<td>NE567</td>
<td>1.35</td>
</tr>
</tbody>
</table>

### SPECIAL DISCOUNTS

<table>
<thead>
<tr>
<th>Code</th>
<th>Discount</th>
<th>Deduct</th>
</tr>
</thead>
<tbody>
<tr>
<td>$35-$99</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>$100-$300</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>$301-$1000</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>$1000-Up</td>
<td>20%</td>
<td></td>
</tr>
</tbody>
</table>
The Ultimate IAMBIC PADDLE…

- Full range of adjustment in tension and contact spacing
- Self-adjusting nylon and brass needle bearings
- Solid silver contact points
- Precision-machined, chrome plated brass frames
- Heavy steel base; non-skid feet

Available at selected dealers or send $39.95 plus $2.00 shipping and handling. Money-back guarantee.

BENCHER, INC.
333 W. Lake St., Chicago, IL 60606 • (312) 263-1808

The "STANDARD" by Heights

Light, permanently beautiful ALUMINUM towers

THE MOST IMPORTANT FEATURE OF YOUR ANTENNA IS PUTTING IT UP WHERE IT CAN DO WHAT YOU EXPECT.

RELIABLE OX-SIGNALS EARLIEST IN AND LAST OUT.

ALUMINUM

- Self-Supporting
- Easy to Assemble and Erect
- All towers mounted on hinged bases
- Complete Telescoping and Fold-Over Series available

And now, with motorized options, you can crank it up or down, or fold it over, from the operating position in the house.

Write for detailed literature

Write for 12 page brochure giving dozens of combinations of height, weight and wind load.

THE HEIGHTS MANUFACTURING CO.
In Almont Heights Industrial Park Dept. H
Almont, Michigan 48003
PS-14 HIGH CURRENT REGULATED POWER SUPPLY KIT
A low cost, no frills, heavy duty power supply. Designed for use and abuse!

12V @ 15A
- Better than 200MV load & line regulation
- Foldback Current Limiting
- Short Circuit Protected
- Thermal Shutdown
- Adjustable Current Limiting
- Less than 1% ripple
- 10 amps 11.5 to 14.5V
- All parts supplied including heavy duty transformer.
- Quality plated fiberglass PC board.

Less Case, meters & jacks

$39.95

UPS SHIPPING PAID!

OVERVOLTAGE PROTECTION KIT
Provides cheap insurance for your expensive equipment. Trip voltage is adjustable from 3 to 30 volts. Overvoltage instantly fires a 25A SCR and shorts the output to protect equipment. Should be used on units that are fused. Directly compatible with the PS-12 and PS-14. All electronics supplied. Drilled and plated PC board. (Order OVP-1)

$6.95

A COMPLETE CAPACITOR DISCHARGE IGNITION KIT for $9.95
You get all the electronics less the case and heat sinks.

SPECIAL SALE! The response to our anniversary sale on CDI’s was fantastic so here goes again...WHILE THEY LAST...Buy two CDI kits for $9.95 each, get the third CDI kit for $1.00!

MK-05 MINI MOBILE CLOCK
The smallest and best priced mobile clock kit on the market. Designed to be a mobile clock from the ground up. There has been no compromise on quality.

- Quartz crystal timebase
- Toroid & zener noise & overvoltage protection.
- Magnified .15", 6 digit LED readout.
- Complete with presettable 24 hr. alarm.
- 9-14 VDC @ 40 to 50 ma
- Readouts can be suppressed
- EASY, QUICK ASSEMBLY
- All components required included (you supply the speaker).

$12.95

With punched front aluminum case – $15.95

Ribbon Cable
26 conductors of no. 28 standard wire with a woven binder for easy separation. Super flexibility. For computers, and other projects.

10' ROLL 2.95
50' ROLL 9.95

No. 30 gauge silver plated wire wrap wire with Kynar® jacket.

500ft. 5.95

MINI ELECTRONIC GRANDFATHER CLOCK KIT
Complete Electronics!
- Chimes the hour (ie: 3 times for 3 O’clock)
- Unique “swinging” LED pendulum
- Tick tock sound matches pendulum swing.
- All CMOS construction.
- Custom case for above kit. Over 9¾” tall.

$19.95

SPECIAL
All phone orders over $10. from this ad will receive a FREE Warble Alarm Kit ($2.50 value). PHONE ORDERS ONLY!

More Details? CHECK – OFF Page 150
When the winter winds blow you need...

TOWER POWER
by TRISTAO

Superior Quality and Construction at a price you can afford.

Tristao is a pioneer. Years of designing and manufacturing show in structural performance and practical pricing. Certified welded construction, sandblasted surfaces; hot-dipped galvanized; heavy duty for capacity, strength, safety. Send for FREE Catalog.

Dealer Inquires always invited.

Self-supporting or Guyed
TOWERS

CZ SERIES
Self-supporting 38’ to 84’ for most tri-band beams in 80 mph winds. Equipped with heavy duty winch.

CTL SERIES
Guyed crank-up 18’ thru 105’ for tri-band beams to 8 sq. ft. Takes CDR HAM II and similar rotors. Complete installation packages available.

RESTORATION

TRISTAO

MAST MASTER
Self-supporting Rotating Crank-Up

SUPER AND STANDARD packages
Masts priced from $198.50

FULL LINE OF MINI-MAST ACCESSORIES

NEW EXCLUSIVE EXORDER BASE
For standard CDE or others including HAM II.

CUSTOM TOWERS BUILT TO YOUR SPECIFICATIONS

3000 MFD 100 Volt Capacitors.
1” Dia. x 3’ — 90 ea. or 3/$22.50 ppd.
3000 MFD @ 20V Capacitors. Same size as above, 100 ea. or 3 for $2.00 ppd.

ELECTROLYTIC CAPACITOR — PHILCO
QUAD SECTION .33M, 1/12 x 3/4 dia.
TWISTAB MTO.
100/150 MFD @ 400V and at 350V D.C.
and 20x50 MFD @ 250V — A nice unit for Xceiver, etc. $1.10 ea. or $3.25 ppd.

CRL Disc Capacitors. .1 MFD, 10V 1/4 dia., long leads, 10 for $1.00 ppd. 100/$14.40, 500/$36.60 (U.P.S. Only)

NEW EXCLUSIVE SUPERIOR QUALITY and CONSTRUCTION at a price
packages
beams to 8 sq. ft. Takes CDR HAM II and similar rotors. Complete installation packages available.

NEW SIZES — VERTICAL MOUNT
cable
BOARD POTENTIOMETERS
American made (CRL) Cartridge sizes:
25K, 100K ohms, 5/$1.30 ppd.
CTS Blue wheel. Values: 75K, 1K, 1.5K, 50K, 300K ohms. 5/$1.25 ppd.

ENERGY CRISIS SOLVED!

Personal energy crisis? Get precious RF or DX signal with World Record Breaking antenna that won W6VY/T3 the CPE ARC 1,000,000 award 1969
THE JOYSTICK VFA
Variable freq. and gain to give wide angle, omnidirectional, harmonics free radiation on all bands! 100-120, 1 CL, 10W, 10K, 100 and receiver on all RC & SW.
100% of glowing reports in our files of the VFA in use in poor QTH and curb power, surfboard etc.

SYSTEM A $75.00
250W P.E. & 6K Receiver Only

SYSTEM J $99.00
500W P.E. And Improved 5 Factor Receiver
Air Mail cost included. (Each system 3 sections required to make up 7’ long Matching ATU.) Not sure you will save space but you will save $$$ at present fuel exhorbant and by having direct UK manuf. Wash your order Mastercharge or check or ask for brochure.

PARTRIDGE (HR)
ELECTRONICS LTD.
2670 BONAVENTURA DR., SAN JOSE, CA 95134

MILITARY SURPLUS, GOOD CITED
Space buys more and pays more. Highest prices ever on U.S. Military surplus, especially on Collins equipment or parts. We pay freight. Call collect now for our high offer 201-440-4878.
SPACE ELECTRONICS CO.
div. of Military Electronics Corp.
35 Ruta Court, Hackensack, N.J. 07606

CASH FOR 2-WAY FM RADIO MOTOROLA, GE, RCA, ETC. EQUIPMENT MOBILES, BASES, PORTABLES, MOBILE-TELEPHONES, RECEIVERS, REMOTE CONTROLS, TONE EQUIPMENT, 2-WAY TEST EQUIPMENT Operational Units, Antennas, Telescopes, Monolmatch, Commissions/Finders Fees

CALL-COM SYSTEMS, INC.
2670 BONAVENTURA DR., CA 95134
408/262-7200 Outside Cal. toll free 800/536-9388

FOR A BETTER DEAL SEE ROSS THE COUNTRY HAM
$500 TRADE-IN ALLOWANCE FOR TS-520 OR FT-101 IN GOOD CONDITION TOWARD ASTRO 200, FT-3010, OR ICOM 701
Midland 13-510 (2m). new. $349.96
Yaesu FR101S, like new. $349.00
Yaesu 2215 (HF). new. $299.00
Write icom 211, new. $250.00
icom 226, new. $250.00
Call or write for quote on Astro 200, Dentron MT-300A, Yaesu FT-3010.

ROSS DISTRIBUTING CO.
208-852-0830 Preston, Idaho 83853
Established 1957
Dealer for Yaesu, Atlas, Drake, Icom, CIR, Dentron, Swan, Radio, KLM, Cushcraft, Hy-Gain, Tempo, Midland, MFJ, Mosley, Covercraft.

m. weinichenker
specialty electronics BOX 353, IRWIN, PA 15642

144 November 1977

More Details? CHECK — OFF Page 150
NEW LSI TECHNOLOGY

FREQUENCY COUNTER

TAKE ADVANTAGE OF THIS NEW STATE-OF-THE-ART COUNTER FEATURING THE MANY BENEFITS OF CUSTOM LSI CIRCUITRY. THIS NEW TECHNOLOGY APPROACH TO INSTRUMENTATION YIELDS ENHANCED PERFORMANCE, SMALLER PHYSICAL SIZE, DRASTICALLY REDUCED POWER CONSUMPTION (PORTABLE BATTERY OPERATION IS NOW PRACTICAL), DEPENDABILITY, EASY ASSEMBLY AND REVOLUTIONARY LOWER PRICING!

KIT #FC-50C ............................................... 60 MHz COUNTER WITH CABINET & P.S. ......... $119.95 COMPLETE!
KIT #PSL-650 ............................................ 650 MHz PRESCALER (NOT SHOWN) ............. 29.95
MODEL #FC-50WT ..................................... 60 MHz COUNTER WIRE, TESTED & CAL. .... 165.95
MODEL #FC-50/600WT .................. 600 MHz COUNTER WIRE, TESTED & CAL .......... 199.95

SIZE:
3" High
5 1/2" Deep

FEATURES AND SPECIFICATIONS:
DISPLAY: 8 RED LED DIGITS, 4" CHARACTERS HEIGHT
GATE TIMES: 1 SECOND AND 1/10 SECOND
PRESCALER WILL FIT INSIDE COUNTER CABINET.
RESOLUTION: 1 Hz AT 1 SECOND, 10 Hz AT 1/10 SECOND.
FREQUENCY RANGE: 10 KHz TO 60 MHz, 100 MHz TYPICAL.
SENSITIVITY: 10 MV RMS TO 60 MHZ. 20 MV RMS TO 60 MHZ TYP.
INPUT IMPEDANCE: 1 MEGOHM AND 20 PF.
(DIODE PROTECTED INPUT FOR OVER VOLTAGE PROTECTION)
ACCURACY: ± 1 ppm (± 0.05%) AT 25°C CALIBRATION TYPICAL.
STABILITY: WITHIN ± 1 PPM PER HOUR AFTER WARM UP (100% XTAL)
IC PACKAGE COUNT: 8 ALL SOCKETED.
INTERNAL POWER SUPPLY: 5 V DC REGULATED.
INPUT POWER REQUIREMENTS: 120 VAC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS

7-DIGIT LED CLOCK CALENDAR KIT
DATE-TIME-SNOOZE ALARM & MORE... KIT 700!

FOR THE BUILDER THAT WANTS THE BEST FEATURING 12 OR 24 HOUR TIME,
2-30-31 DAY CALENDAR, ALARM, SNOOZE AND AUX. TIMER CIRCUITS
Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only
with other functions on demand. Has built-in oscillator for backup battery. A loud 24 hour alarm
with a selectable 10 minute snooze alarm, alarm set & timer indicators. Includes
100 VAC/60Hz power pack with cord and plug components throughout.

KIT #7001 WITH 5-7 DIGITS $39.95
KIT #7001C WITH 4-6 DIGITS & 2.3 DIGITS FOR SECONDS $42.95
KIT #7001X WITH 6-8 DIGITS $45.95

KITS ARE COMPLETE (LESS CABINET)
ALL KITS FIT CABS CABI & ACCEPT QUARTZ CRYSTAL BASE KIT #71B

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are
drilled Fiberglass, solder plated and screened with component layout.

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE ANTI-TheFT DEVICES FOR HOME OR OFFICE USE. A.Day
NORMALLY OPEN REED SWITCHES OR SENSORS WILL ACTIVATE THE RELAY, AND A.
BUILT-IN SIREN WILL BE HEARD DURING THE ROBBERY. CAN BE Mounted ON ANY
ENTRY OR ALARM RECORD-UP Ports.

KIT #ALR-1 $9.95
#ALR-1WT WIRE & TESTED $19.95

MOBILE LED CLOCK

12 VOLT AC or DC POWERED

MODEL #2001

$279.95 COME EURE

ORDER BY PHONE OR MAIL
COD OR WIRE WELCOME

OPTOELECTRONICS, INC.
BOX 179 HOLLYWOOD, FLA. 33302
PHONE [305] 921-2056 / 921-4425

More Details? CHECK-OFF Page 150
Ham Radio's guide to help you find your loci

Alabama
LONG'S ELECTRONICS
3521 TENTH AVE. NORTH
BIRMINGHAM, AL 35234
800-633-3410
Call us Toll Free to place your order.

Arizona
MASTERS COMMUNICATIONS
7025 N. 57th DRIVE
GLENDALE, AZ 85301
602-939-8356
Rohn tower distributor, Atlas, Icom, Tempo, HyGain & service.

POWER COMMUNICATIONS
6012 NORTH 27TH AVE.
PHOENIX, AZ 85017
602-242-8990
Arizona's #1 Ham Store.

California
C & A ELECTRONICS
2529 EAST CARSON ST.
P. O. BOX 5232
CARSON, CA 90745
213-834-5868
Not the biggest, but the best — since 1962.

CARSON ELECTRONICS
12010 EAST CARSON ST.
HAWAIIAN GARDENS, CA 90716
213-421-3786
Dealing exclusively in ICOM communications equipment.

COMMUNICATIONS CENTER
705 AMADOR STREET
VALLEJO, CA 94590
707-642-7223
Who else has a Spectrum Analyzer?

HAM RADIO OUTLET
999 HOWARD AVENUE
BURLINGAME, CA 94010
415-342-5757
Visit our stores in Van Nuys and Anaheim.

QUEMENT ELECTRONICS
1000 SO. BASCOM AVENUE
SAN JOSE, CA 95128
408-996-5900
Serving the world’s Radio Amateurs since 1933.

TOWER ELECTRONICS CORP.
24001 ALICIA PARKWAY
MISSION VIEJO, CA 92675
714-768-8900
Authorized Yaesu Sales & Service. Mail orders welcome.

Colorado
C W ELECTRONIC SALES CO.
1401 BLAKE ST.
DENVER, CO 80202
303-573-1386
Rocky Mountain area's complete ham radio distributor.

MILE-HI COMMUNICATIONS, INC.
1970 SOUTH NAVAJO
DENVER, CO 80223
303-936-7108
Rocky Mountain's newest ham store. Lee Tingle Kc7L.

Florida
AGL ELECTRONICS, INC.
1800-B DREW ST.
CLEARWATER, FL 33715
813-461-HAMS
West Coast’s only full service Amateur Radio Store.

CENTRAL EQUIPMENT CO.
18451 W. DIXIE HIGHWAY
NORTH MIAMI BEACH, FL. 33160
305-932-1818
Specializing in Amateur, CB & Marine Equipment.

RAY’S AMATEUR RADIO
1590 US HIGHWAY 19 SO.
CLEARWATER, FL 33716
813-535-1416
West coast's only dealer: Drake, Icom, Cushcraft, Hustler.

Illinois
ERICKSON COMMUNICATIONS, INC.
5935 NORTH MILWAUKEE AVE.
CHICAGO, IL 60646
312-631-5181
Hours: 9:30-9 Mon. & Thurs. 9:30-5 Tues., Wed., Fri. 9-3 Sat.

KLAUS RADIO, INC.
8400 NORTH PIONEER PARKWAY
PEORIA, IL 61614
309-691-4840
Let us quote your Amateur needs.

SPECTRONICS, INC.
1009 GARFIELD STREET
OAK PARK, IL 60304
312-848-6777
Chicagoland's Amateur Radio leader.

Indiana
HOOSIER ELECTRONICS
P. O. BOX 2001
TERRE HAUTE, IN 47802
812-238-1456
Ham Headquarters of the Midwest. Store in Meadow Shopping Center.

KRYDER ELECTRONICS
GEORGETOWN NORTH SHOPPING CENTER
2810 MAPLECREST RD.
FORT WAYNE, IN 46815
219-484-4846
We service what we sell. 10-9 T, TH, F; 10-5 W, SAT.

Iowa
BOB SMITH ELECTRONICS
12 SOUTH 21ST STREET
FT. DODGE, IA 50501
515-576-3886
For an EZ deal.

Kansas
ASSOCIATED RADIO
8012 CONSER P.O.B. 4327
OVERLAND PARK, KS 66204
913-381-5901

Kentucky
COHOON AMATEUR SUPPLY
HIGHWAY 475
TRENTON, KY 42286
502-886-4535
Yaesu, en-ec, Tempo, Dentron.

Our service is the BEST.

Louisiana
DIGITAL ELECTRONICS, INC.
BOX 30566
NEW ORLEANS, LA 70190
800-535-9598 Toll-free out of state Louisiana residents may call collect: 504-568-9879.

Maryland
COMM CENTER, INC.
9624 FT. MEADE ROAD
LAUREL PLAZA RT. 196
LAUREL, MD 20810
301-792-0600

Dealers — You should be here too! Contact Ham Radio today for complete details.
<table>
<thead>
<tr>
<th>State</th>
<th>Address</th>
<th>City, State</th>
<th>Phone</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>TUFTS RADIO ELECTRONICS 386 MAIN STREET</td>
<td>MEDFORD, MA 02155</td>
<td>617-395-8280</td>
<td>New England’s friendliest ham store.</td>
</tr>
<tr>
<td>Michigan</td>
<td>RADIO SUPPLY &amp; ENGINEERING 1207 WEST 14 MILE ROAD</td>
<td>CLAWSON, MI 48017</td>
<td>313-439-5660</td>
<td>10001 Chalmers, Detroit, MI 48213, 313-371-9050</td>
</tr>
<tr>
<td>Minnesota</td>
<td>ELECTRONIC CENTER, INC. 127 THIRD AVENUE NORTH</td>
<td>MINNEAPOLIS, MN 55401</td>
<td>612-371-5240</td>
<td>Yaesu dealer for the Northeast.</td>
</tr>
<tr>
<td>Nebraska</td>
<td>COMMUNICATIONS CENTER, INC. 2226 NORTH 48 ST.</td>
<td>LINCOLN, NE 68504</td>
<td>800-226-4097</td>
<td>Yaesu, Drake, Tempo, Swan, HyGain - call Toll Free.</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>EVANS RADIO, INC. BOX 893, RT. 3A BOW JUNCTION</td>
<td>CONCORD, NH 03301</td>
<td>603-224-9961</td>
<td>Icon, Dentron &amp; Yaesu dealer. We service what we sell.</td>
</tr>
<tr>
<td>New Jersey</td>
<td>ATKINSON &amp; SMITH, INC. 17 LEWIS ST.</td>
<td>EATONTOWN, NJ 07724</td>
<td>201-542-2447</td>
<td>Ham supplies since &quot;55&quot;.</td>
</tr>
<tr>
<td>New Mexico</td>
<td>ELECTRONIC MODULE 601 N. TURNER</td>
<td>HOBBS, NM 88240</td>
<td>505-397-3012</td>
<td>Yaesu, Kenwood, Swan, Dentron, Tempo, Atlas, Wilson, Cushcraft.</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>RADIO STORE, INC. 2102 SOUTHWEST 59th ST.</td>
<td>OKLAHOMA CITY, OK 73119</td>
<td>405-682-2929</td>
<td>New and used equipment — parts and supply.</td>
</tr>
<tr>
<td>Oregon</td>
<td>PORTLAND RADIO SUPPLY CO. 1234 S.W. STARKE STREET</td>
<td>PORTLAND, OREGON 97205</td>
<td>503-228-8647</td>
<td>Second location, 1133 S. Riverside Avenue, Medford, OR 97501.</td>
</tr>
<tr>
<td>South Carolina</td>
<td>AMATEUR RADIO ELECTRONICS 100 STATE ST.</td>
<td>WEST COLUMBIA, SC 29169</td>
<td>803-796-7957</td>
<td>Featuring Swan Equipment.</td>
</tr>
<tr>
<td>Tennessee</td>
<td>GERMTOWN AMATEUR SUPPLY 3203 SUMMER AVE.</td>
<td>MEMPHIS, TN 38112</td>
<td>800-236-5168</td>
<td>No monkey business. Call Toll Free.</td>
</tr>
<tr>
<td></td>
<td>J-TRON ELECTRONICS 505 MEMORIAL BLVD.</td>
<td>SPRINGFIELD, TN 37172</td>
<td>615-384-3501</td>
<td>Ten-Tec dealer — call or write for best trade.</td>
</tr>
</tbody>
</table>

november 1977
There's nothing like it

RADIO AMATEUR callbook

Respected worldwide as the only complete authority for radio amateur QSL and QTH information.

The U.S. Callbook has nearly 300,000 W & K listings. It lists calls, license classes, names and addresses plus the many valuable back-up charts and references you come to expect from the Callbook.

Specialize in DX? Then you're looking for the Foreign Callbook with almost 235,000 calls, names and addresses of amateurs outside of the USA.

U.S. Callbook  $14.95
Foreign Callbook  $13.95

Order from your favorite electronics dealer or direct from the publisher. All direct orders add $1.50 for shipping. Illinois residents add 5% Sales Tax.

RADIO AMATEUR callbook INC.
Dept. A  925 Sherwood Drive
Lake Bluff, Ill. 60044

12 Button Touch Tone Encoder, 90 day guarantee $14.00
Plastic Mounting Box for ITT, S/C, WECO, or A.E. pads, Black, Gray, or Beige $4.75
Complete System with cable (battery not included) $24.95
Complete System as above but with speaker, amplifier, and battery $39.95
Transmitter keying circuit (100 ma max) with delay drop out feature installed in each system $7.50

Florida Residents add 4% Sales Tax. Orders under $20, add $1.00 for shipping and handling.

TELEPHONE EQUIPMENT COMPANY
Post Office Box 596, Largo, Florida 32748
(904) 728-2730

1978 Ham's Almanac
Wall calendar format — monthly cartoon — propagation forecasts — contest & convention dates — DX prefix/country/zone beam heading list — puzzles — frequency allocation — OSCAR data — memorable events — & more useful reference data. $3.30 4th class mail, $3.80 1st class. December shipment. Order now!
Almanac, Box 3494, Scottsdale, AZ 85257

Already a best-seller in the German edition! Translated into English for this RSGB edition! Absolutely the best look at OSCAR available.

Want to understand the principles of communications satellites, specifically OSCAR? This book is the most in-depth examination available on the market. You'll get a basic understanding of the principles, explore OSCAR from concept to launching and from locating to methods and equipment necessary to work the bird. A handsome 200 page soft-bound book.
Order RS-O  JUST $8.50

Ham Radio's Communications Bookstore
Greenville, NH 03048
Order RS-O  Just $8.50

Order RS-O

[Box for check or M.O.]

[On my VISA  acc. no.  exp. date]
[On my Mastercharge  bank no./acc. no. exp. date]

name

address

city

state  zip

More Details? CHECK — OFF Page 150
Why you, the user, need the Personal Communications Foundation...

1. In 1976 there were over 7,000 legal matters involving all aspects of non-profit personal communications. In 1956 there were only 200.

2. **If you have an outdoor antenna**, you may be the subject of a criminal action for violating a zoning ordinance. If you are not now in violation of a zoning ordinance, be advised that they are being changed all over the country with the purpose of eliminating towers and outdoor antennas. You can be the subject of a civil action for violation of private deed restrictions.

3. **If you use a transmitter**, you may be sued if you interfere with a neighbor’s TV or stereo, even if the interference is due to the inadequate designing of the TV or stereo.

4. Litigation of this nature can cost $10,000 or more. It is estimated that 40% of that amount represents time expended in research. By providing your attorney with our research material, the Personal Communications Foundation can save you thousands of dollars in addition to helping your attorney better represent you.

...and why the Personal Communications Foundation needs you.

The Personal Communications Foundation is a membership corporation. Four classes of membership have been established, known as Associate Membership, for a yearly contribution of $10.00, Full Membership, for a yearly contribution of $25.00, Contributing Membership, for a yearly contribution of $100.00, and Life Sustaining Membership, for a single contribution of $250.00 or more. All contributions are completely tax deductible. All members of the Foundation will receive the newsletter.
AGL wants you to begin with the best

As you develop your skills, increase your participation in Ham Radio activities, and add hardware for ever-increasing flexibility of operations, you'll come to know ICOM. Just ask any old Ham. ICOM is the quality name in VHF/UFH Amateur Radio equipment because it is simply the best. ICOM is the line you'll want to move up to for unequaled quality and features.

AGL has developed a new piece of hardware for your IC-211 and IC-245, the "AGL SCANNER II." It will allow you to use your transceiver to scan all 4 MHz in 5-kHz steps as the digital display in the radio tells you what frequency you are listening to. The "AGL SCANNER II" can be mounted inside or outside of your unit and has adjustable scan rate.

Don't delay in moving up. BEGIN WITH THE BEST: ICOM and AGL's "AGL SCANNER II"... $29.95

Both the IC-211 and IC-245 are available with SCANNER installed. Call or write for our quote.
EVER WISH YOUR RECEIVER
COULD HEAR THE WEAK ONES?
Almost every amateur and commercial VHF UHF receiver can be more sensitive
with these popular preamps. Over 7000 in
use throughout the world.

P8 KIT $7.95
P16 W/T 16.95
Recommended for mounting inside transceivers
— only 1/2 x 2-3/8 inches

MODEL RANGE
P8-30 20-83 MHz
P8-150 83-190 MHz
P8-220 220-230 MHz
P16 (W/T) Give exact freq.

P9 KIT $9.95
P14 W/T $19.95
Premium model where space permits —
1-1/2 x 3 inches. Ideal for OSCAR!

MODEL RANGE
P9-30 26-88 MHz
P9-150 88-172 MHz
P9-220 172-230 MHz
P14 (W/T) Give exact freq.

P15 KIT $15.95
P35 W/T $34.95

- Available for any band
- 380-520 MHz
- 20 dB gain

VHF AND UHF CONVERTERS

- Low noise FET
- Front end
- All common i-f's
- Great for OSCAR!
- Low power drain
- Crystals available for any desired freq scheme

MODEL C25 VHF CONVERTER KIT (shown) $25.95
- Models for 2M, 4M, 10M, 220 MHz, aircraft, com't, etc.
- Stable cascade i-f stage
- 0.3-0.5 uV sensitivity
- 10-20 dB gain
- Compact 2-1/2 x 4-1/2" pcb
- Any I-f 10-50 MHz
- Featured in HR mag article

MODEL U20-450 UHF CONVERTER $19.95
- For 432-435 MHz ssb, atv, OSCAR, 450 MHz
- fMHz, aircraft, com't, etc.
- Economy converter
- Use with P15 Preamp for optimum performance
- Any I-f 10-160 MHz

XTAL (either of above) $5.50

FM/CW TRANSMITTER KITS

200 MW EXCITER MODULE KITS
T40-11 Eleven Channel Exciter for 2M, 6M, or 220 MHz $39.95
T40-1 One Channel Exciter...... 34.95
T20 Tripler/Driver Module Kit, 150 mW $19.95

RF POWER AMPLIFIER MODULES
- NO TUNING eVSWR PROTECTED
- 150 MW DRIVE COMPLETELY STABLE

TEST PROBE KITS

ONLY $7.95/ea.

TE-3 RF Detector Probe for VTVM, good from
100 kHz to over 500 MHz
TE-4 Direct Probe for ac/ohms, etc.
TE-5 DC Probe w/res for 11 meg input VTVM
TE-6 Blocking Capacitor Probe for counter,
signal generator, etc.
TE-7 Wideband Detector Probe for scopes
TE-8 High Z/ Low Capacitance scope probe

Famous Antennas
STOCKED IN DEPTH

UHF MODELS FOR ANY BAND 380-520 MHz
R60-500, 5-10 uV economy rcvr, incl UHF
Conv & IF/Audio Boards only.... $59.95
R80-450, 2-5 uV sens monitor rcvr, incl UHF
Conv, VHF Conv, and IF/Audio... $84.95
R95-450, 0.4-1 uV sens rcvr, incl P15 Pre-
amp, UHF Conv, VHF Conv, and IF/Audio
Boards................................ $94.95

SUPERIOR QUALITY —
Yet only $189.95

IF YOU'VE HEARD THE NEW
HY-GAIN 2M HT, YOU ALREADY
KNOW IT'S FANTASTIC! WE
HAVE THEM IN STOCK COMPLETE
WITH CRYSTALS AND ACCY'S

Inexpensive DC Power Supplies

- CALL OR WRITE NOW FOR FREE CATALOG OR
- TO PLACE YOUR ORDER!
- PHONE 716-663-9254, 9AM-9PM EST DAILY.
- Use your credit card or C.O.D.
- Specify operating freq • Add $1 shipping and handling.

hamtronics, inc.
182H BELMONT RD., ROCHESTER, NY 14612
More Details? CHECK — OFF Page 150

november 1977 151
DENTRON MLA-2500 linear amplifier
- Continuous duty power supply
- 160 thru 10 meter coverage
- 2000 watts PEP input on SSB
- 1000 watts DC input on CW, RTTY, SSTV
- Two external-anode ceramic/metal triodes operating in grounded grid
- Covers MARS w/o modifications
- 50 ohm input/output impedance
- Built-in dual watt meters
- Built-in RTTY, SSTV
- Two external-anode ceramic/metal triodes in 50 ohm dummy load for proper exciter adjustment
- Antenna operating in grounded grid
- Covers MARS w/o modifications
- Selector switch enables you to by-pass the tuner direct or select the dummy load or 5 other antenna systems.

799.50 is list price. Call Toll-Free for quote.

DENTRON MT-3000A antenna tuner
- 160 thru 10 meter coverage
- Handles a full 3KW PEP
- Continuous tuning 1.8-30 mc
- Built-in dual watt meters
- Built-in 50 ohm dummy load for proper exciter adjustment
- Antenna selector switch enables you to by-pass the tuner direct or select the dummy load or 5 other antenna systems.

349.50 is list price. Call Toll-Free for quote.

DENTRON 160-10AT super tuner
- Balanced line, coax cable, random, or long wire antennas, the 160-10AT will match it—160 thru 10 meters
- Continuous tuning, 1.8-30 mc
- 3 inputs
- Handles 500 watts DC, 1000 watts PEP
- Heavy duty, 2-core Balun (3½" dia. x 3" H)
- Tapped inductor #12 ga. wire.

129.50 list price. Call for quote.

DENTRON Trim Tenna 20 meter beam
- For the amateur who wants fantastic performance with good looks!
- Front element: 16' driver with H-Q coils fed directly with 52 ohm coax
- Reflector element: 17' with 15 dB F/B ratio
- 8½ turning radius
- 4 dB forward gain over dipole
- Elements 7 feet apart
- Weight: 14 lbs.

129.50 list price. Call for quote.

DENTRON all band doublet antenna
- This all band doublet or inverted antenna covers 160 thru 10 meters.
- Has total length of 130 ft. of 14 ga. stranded copper wire.
- The doublet is tuned & center fed thru 100 ft. of 470 ohm PVC covered transmission line.
- Assembly is complete.

24.50 is Long's low price.

Remember, you can call TOLL-FREE: 1-800-633-3410 in U.S.A. or call 1-800-292-8668 in Alabama for our low price quote. Hours: 9:00 AM til 5:30 PM, Monday thru Friday.

Long's Electronics
MAIL ORDERS: P.O. BOX 11347 BIRMINGHAM, AL 35202 • STREET ADDRESS: 3521 10TH AVENUE NORTH BIRMINGHAM, ALABAMA 35234

More Details? CHECK-OFF Page 150
Introducing . . .

THE ALL-NEW YAESU FT-227R
144-148 MHZ 800 CHANNEL

"MEMORIZER"!

Compare These Features And You’ll Know What We Mean When We Say “Years Ahead With Yaesu”

- one knob channel selection using optical sensing to select 800 channels
- memory circuit that allows instant return to any frequency selected between 144-148 MHz
- large 4 digit LED frequency readout
- fully synthesized frequency control, using PLL techniques in 5 KHz steps
- built-in tone burst, plus optional tone squelch encoder/decoder
- spurious well below minus 60dB requirement—superior cross modulation, overload and image rejection
- standard 600 KHz offsets plus any split within the band using the memory circuit
- automatic final protection, PLL “unlock” protection and busy channel indicator
- selectable 10 watt/1 watt output

See this sensational new two meter transceiver at your YAESU DEALER now!

Yaesu Electronics Corp., 15954 Downey Ave., Paramount, CA 90723 • (213) 633-4007
Eastern Service Ctr., 613 Redna Terrace
Cincinnati, OH 45215

UNDER $300!
Look over DenTron's low profile, styled MLA-2500 amplifier. Two EIMAC high-mu 8875 power triodes are the heart of the modularized design. The combination of DenTron's cathode-driven circuitry and EIMAC's 8875s provides simplicity, economy and high power all in one compact package.

Unexcelled for rugged amateur service, the 8875 is a natural choice for DenTron, just as it and other EIMAC power tubes are the choice of most principal manufacturers of amateur, commercial and military communication equipment.

Whether you build or buy your equipment—go EIMAC. The EIMAC name is your assurance of power, dependability and quality. Send today for your free copy of the EIMAC Quick Reference Catalog which provides information on all popular EIMAC products. Write Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. Telephone (415) 592-1221. Or contact any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.

EIMAC 8875s Power DenTron's MLA-2500 Linear Amplifier.