$1.50

ham radio magazine

NOVEMBER 1977

third annual receiver issue

This is the amplifier you have been waiting for

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.

- The 2KD-5 is a 2000 watt PEP input (1200 watt PEP nominal output) RF linear amplifier, covering the 80, 40, 20, 15 and 10 meter amateur bands.
- Two Eimac 3-500Z glass envelope triodes operating in a grounded grid circuit.
- Pi-L plate circuit with a rotary silver plated tank coil for greatest efficiency and maximum attenuation of unwanted harmonics.
- Full legal input in all modes. 2000 watts PEP input for SSB. 1000 watts DC input for CW, RTTY and AM.
- Jumper for 115 or 230 VAC, 3 wire single phase.
- 10.5" high x 15" wide x17.5" deep
- Price . . . $895.00

2K-4...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 2K-4. 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 2,000 watts PEP input on SSB or 1,000 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 fine 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.

Model	Drive Power	Output Power	Price
LOW BAND VHF AMPLIFIERS (35 to 75 MHz)			
Tempo 100C30	30W	100W	$159
Tempo 100C02	2W	100W	$179
Tempo 100C10	10W	100W	$149
HIGH BAND VHF AMPLIFIERS (135 to 175 MHz)			
Tempo 130A30	30W	130W	$189
Tempo 130A10	10W	130W	$179
Tempo 130A02	2W	130W	$199
Tempo 80A30	30W	80W	$149
Tempo 80A10	10W	80W	$139
Tempo 80A02	2W	80W	$159
Tempo 50A10	10W	50W	$ 99
Tempo 50A02	2W	50W	$119
Tempo 30A10	10W	30W	$ 69
Tempo 30A02	2W	30W	$ 89
UHF AMPLIFIERS (400 to 512 MHz)			
Tempo 70D30	30W	70W	$210
Tempo 70D10	10W	70W	$240
Tempo 70D02	2W	70W	$270
Tempo 40D10	10W	40W	$145
Tempo 40D02	2W	40W	$165
Tempo 40D01	1W	40W	$185
Tempo 25D02	2W	25W	$125
Tempo 10D02	2W	10W	$ 85
Tempo 10D01	1W	10W	$125

TEMPO 100AL10 VHF LINEAR AMPLIFIER. Com pletely solid state, 144-148 MHz. Power output o 100 watts (nom.) with only 10 watts (nom.) in Reliable and compact ...$199.00
TEMPO 100AL10/B BASE AMPLIFIER ...$349.0

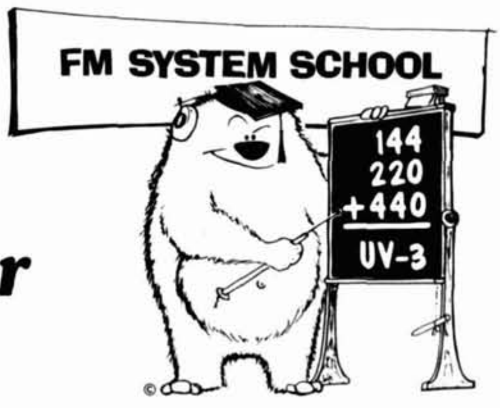
Tempo solid state amplifiers are available at Tempo dealers throughout the U.S.

please call or write for complete information.

Henry Radio

11240 W. Olympic Blvd., Los Angeles, Calif. 90064 213/477-6701
931 N. Euclid, Anaheim, Calif. 92801 714/772-9200
Butler, Missouri 64730 816/679-3127

Prices subject to change without notice.



thoughts to consider about the new

DRAKE UV-3

Optional
Drake 1525EM
Encoding Mike

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	**$1130.00**

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.

R. L. DRAKE COMPANY DRAKE®

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

More Details? CHECK—OFF Page 150

ham radio magazine

NOVEMBER 1977

volume 10, number 11

ham radio magazine
is published monthly by
Communications Technology, Inc
Greenville, New Hampshire 03048
Telephone: 603-878-1441

subscription rates

U.S. and Canada: one year, $12.00
two years, $22.00
three years, $30.00

Europe, Japan, Africa:
(via Air Forwarding Service)
one year, $25.00
two years, $45.00

North America, South America, Australia
and Asia (except *Japan*):
(via Surface Mail)
one year, $18.00
two years, $34.00

foreign subscription agents

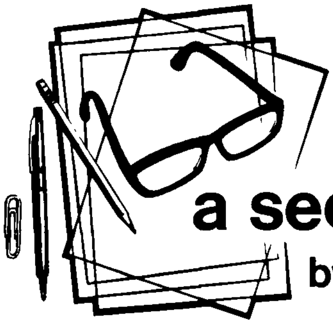
Foreign subscription agents are
listed on page 133

Microfilm copies
are available from
University Microfilms, International
Ann Arbor, Michigan 48106
Order publication number 3076

Cassette tapes of selected articles
from *ham radio* are available to the
blind and physically handicapped
from Recorded Periodicals
919 Walnut Street, 8th Floor
Philadelphia, Pennsylvania 19107

Second-class postage
paid at Greenville, N.H. 03048
and at additional mailing offices
Publication number 23340

contents



a second look

by Jim Fisk

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 1N21 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 magnificient 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.**

VHF/UHF AMATEUR AND MARINE COMMUNICATION EQUIPMENT

Distributed by:

ICOM

ICOM WEST, INC.
Suite 3
13256 Northrup Way
Bellevue, Wash. 98005
(206) 747-9020

ICOM EAST, INC.
Suite 307
3331 Towerwood Drive
Dallas, Texas 75234
(214) 620-2780

ICOM CANADA
7087 Victoria Drive
Vancouver B.C. V5P 3Y9
Canada
(604) 321-1833

presstop

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.

Technicians 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 144.9-145.1 slot for non-channelized 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.

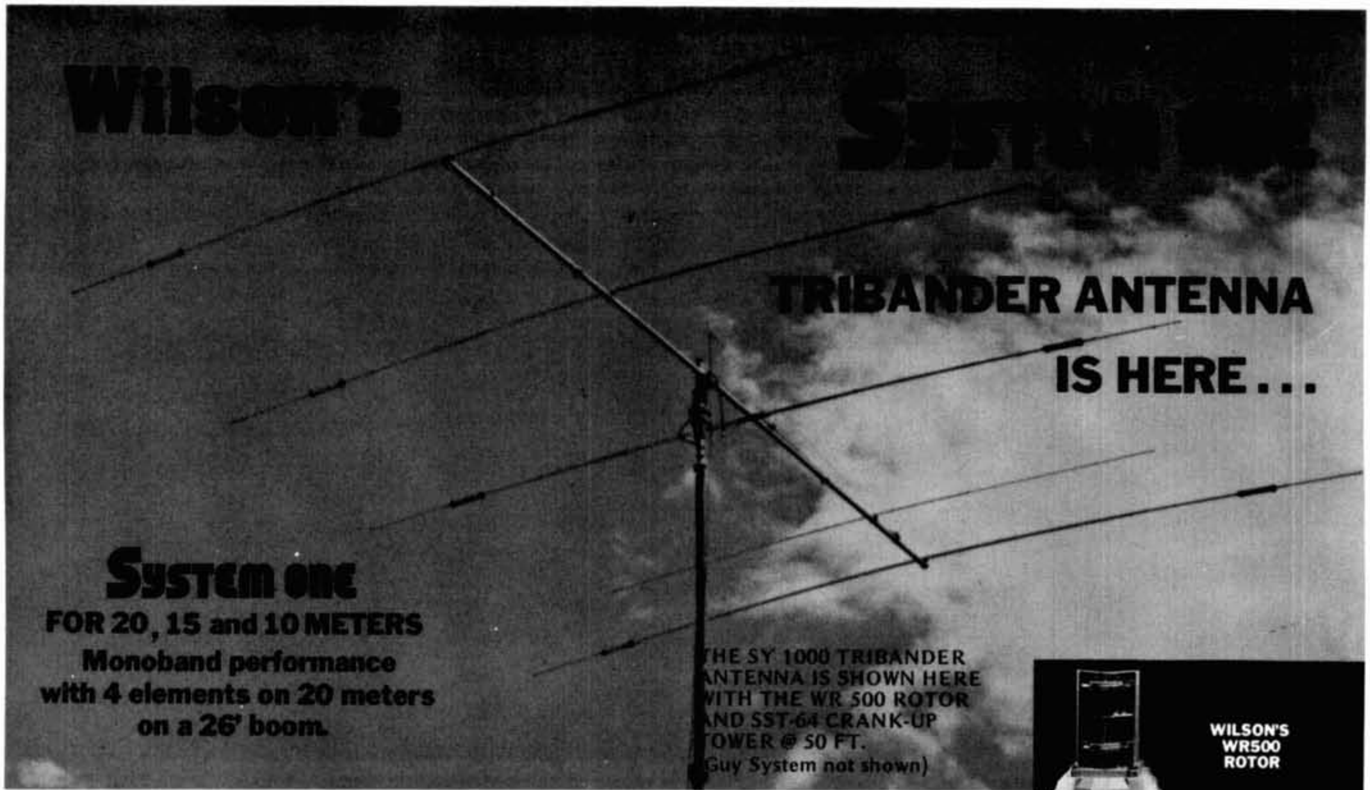
DISTINCTIVE PREFIXES SUCH AS KG6 and KV4 are being discontinued for various Pacific and Caribbean islands. Instead of their present unique prefixes, all Pacific area U.S. Amateurs will be issued KH6 calls while those in the Caribbean will receive KP4 prefixes. Present holders of calls with the discontinued 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 callsigns 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. WBØOAY, 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 Amateur and municipal communications channels. 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.

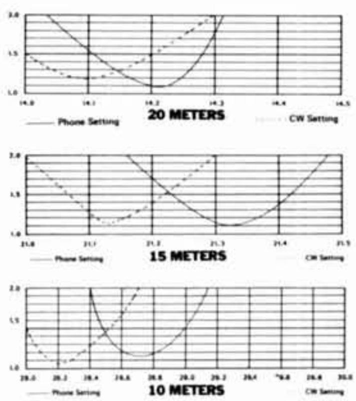
General Class Amateurs licensed before 1933 would be grandfathered to Advanced if a petition filed with the FCC by Paul Halmbacher of Milwaukee were granted. Comments on the petition, RM-2884, may be filed through October 19.

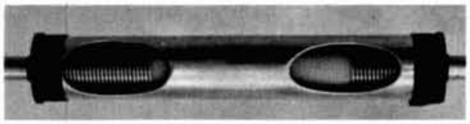


The new standard of performance for Tribanders is the Wilson System One!!! A DX'ers delight operating 20 meters on a full 26' boom with 4 elements, 4 operational elements on 20-15-10, plus separate reflector element on 10 meters for correct monoband spacing. Featured are the large diameter High-Q Traps, 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:

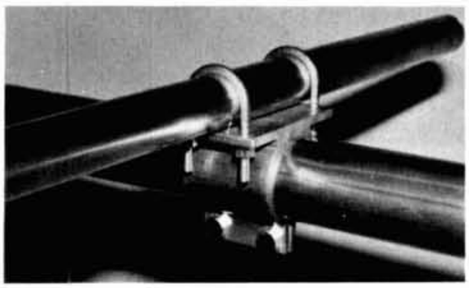
Matching Method:	Beta	F/B Ratio	20-25 dB	Mast Diameter	2" O.D.
Band MHz:	14-21-28	Boom Length	26' (2" O.D.)	Boom Diameter	2" O.D.
Maximum Power Input:	Legal Limit			Surface Area	7.3 sq. ft.
Gain	10 dB	No. of Elements	5	Windload Area	146 lbs.
VSWR (at Resonance)	1.5 to 1	Longest Element	26' 7"	Shipping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





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



HEAVY DUTY BOOM TO ELEMENT EXTRUSION

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

More Details? CHECK — OFF Page 150

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.

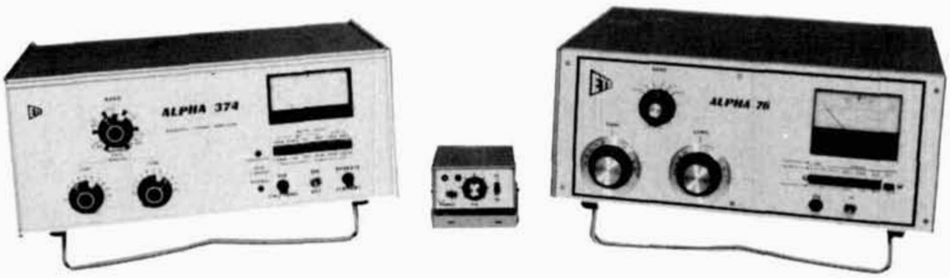
BUT if you buy a linear amplifier on the basis of toothpaste claims — or ambiguous specifications — you may end up with a real turkey!

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?

ETO Ehrhorn Technological Operations, Inc.

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

More Details? CHECK—OFF Page 150

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

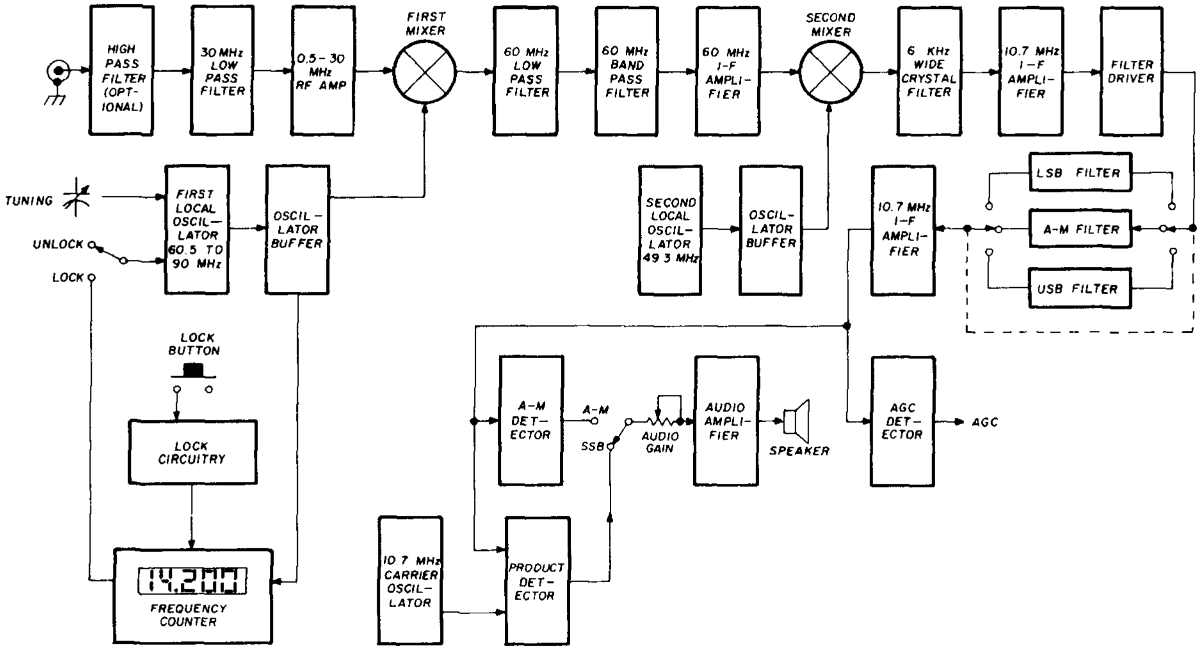


fig. 1. Block diagram of a high-performance communications receiver that tunes from 500 kHz to 30 MHz. The design features digital frequency readout, upconversion to 60 MHz, i-f selectivity at 10.7 MHz, and a unique digital control system to maintain frequency stability.

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 1. Performance specifications of the general-coverage communications receiver designed by W6URH.

Frequency range	500 kHz to 30 MHz continuous change
Sensitivity	1 μV for 10 dB signal-to-noise ratio (6 kHz bandwidth)
Image rejection	−87 dB
I-f rejection	−85 dB
Out-of-band IMD	−35 dB
Cross modulation	−25 dB
Agc range	100 dB for less than 10 dB change in audio
Audio distortion	less than 3 per cent
Audio output	3 watts
Power consumption	approximately 50 watts

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 preceeding 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.

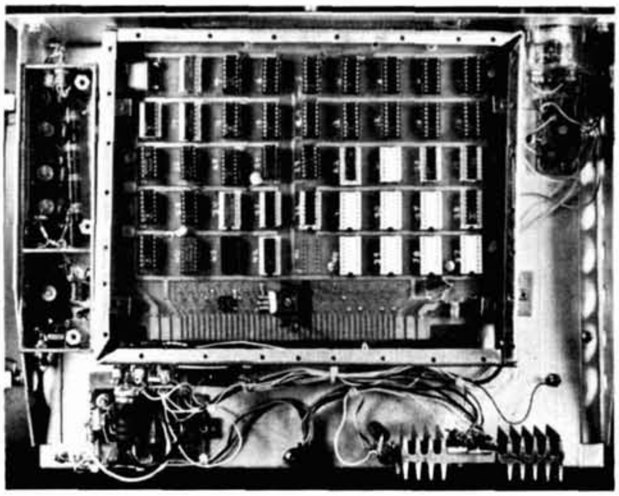
60-MHz amplifier. C401, C402, and L401 transform the 50-ohm output of the 60-MHz bandpass filter to about 1500 ohms. Q401 provides about 10 dB of gain to compensate for loss in the first mixer and the two 60-MHz filters; the gain is set by R401. MX401 combines the 60-MHz i-f with the second local oscillator 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)

S1	S2	Operation
low	low	preset
low	high	count up
high	low	count down
high	high	hold (stop count)

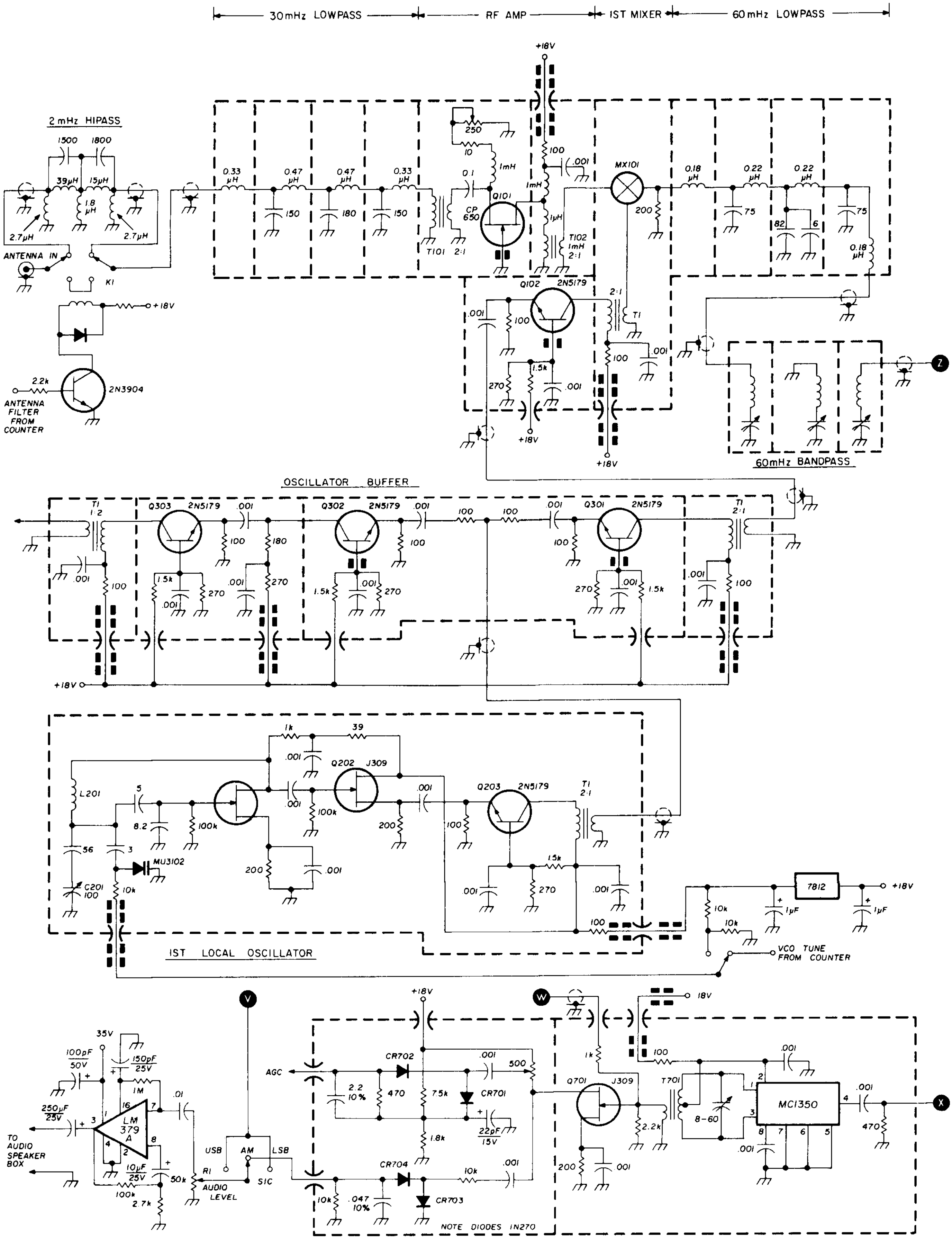
For the 74192 up-down counters to count up, the input signal must be connected to pin 5; for count down the input signal is connected to pin 4. Clear is determined by the level on pin 14; load or preset is determined by the voltage on pin 11.

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


30mHz LOWPASS
RF AMP
1ST MIXER
60mHz LOWPASS
2 mHz HIPASS
ANTENNA IN
K1
+18V
2N3904
ANTENNA FILTER FROM COUNTER
Q101
CP 650
T101 2:1
T102 1mH 2:1
MX101
Q102 2N5179
T1
60mHz BANDPASS
OSCILLATOR BUFFER
Q303 2N5179
Q302 2N5179
Q301 2N5179
Q202 J309
Q203 2N5179
L201
C201 100
MU3102
1ST LOCAL OSCILLATOR
7812
VCO TUNE FROM COUNTER
35V
LM 379 A
TO AUDIO SPEAKER BOX
R1 AUDIO LEVEL
USB
AM
LSB
S1C
AGC
CR702
CR701
CR704
CR703
NOTE DIODES 1N270
Q701 J309
T701
MC1350
18V

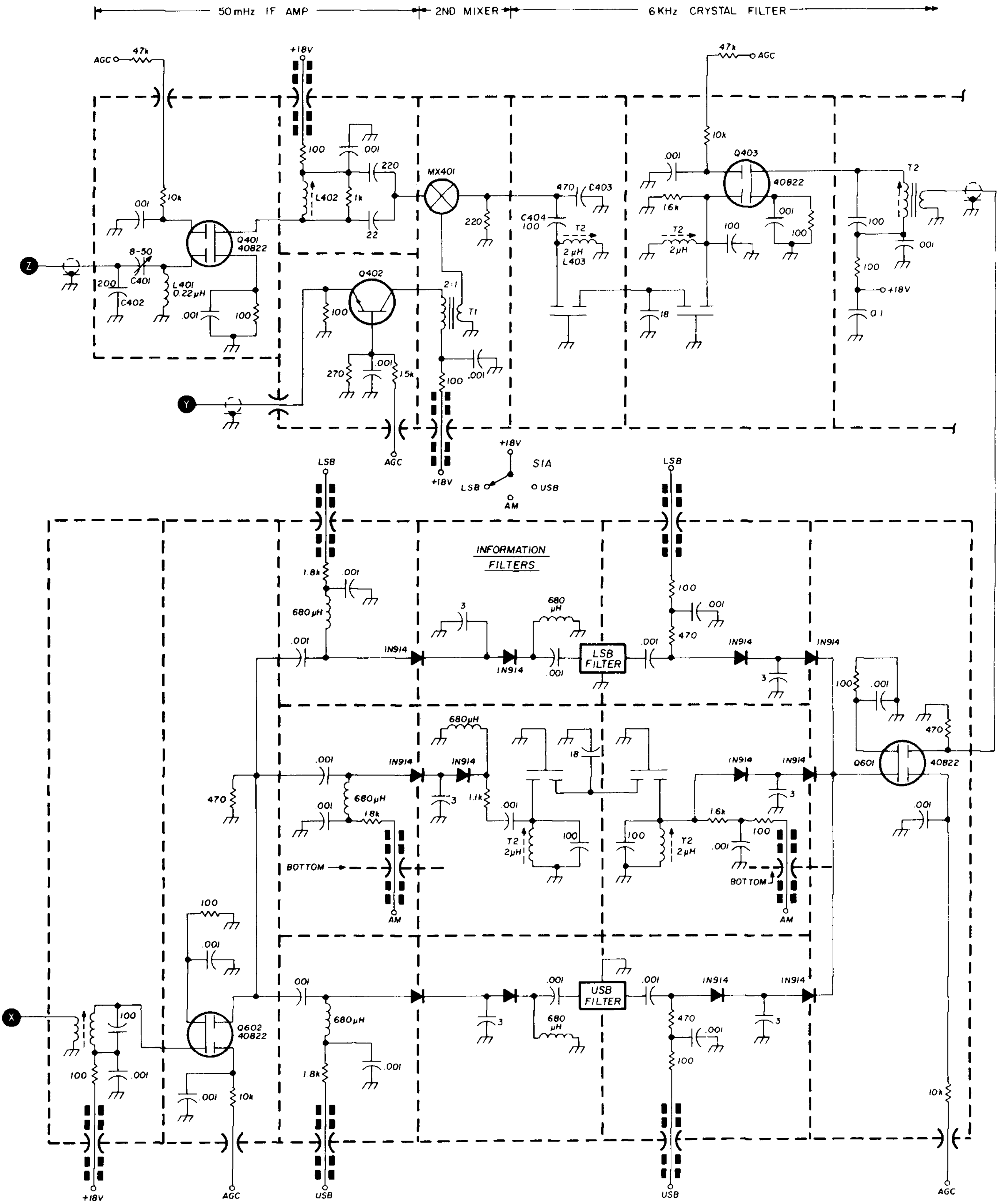
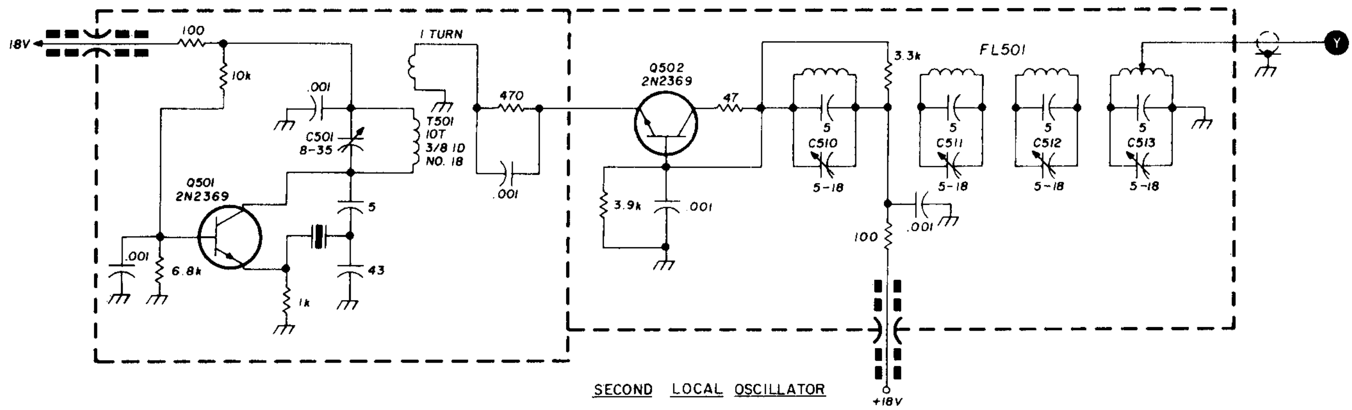
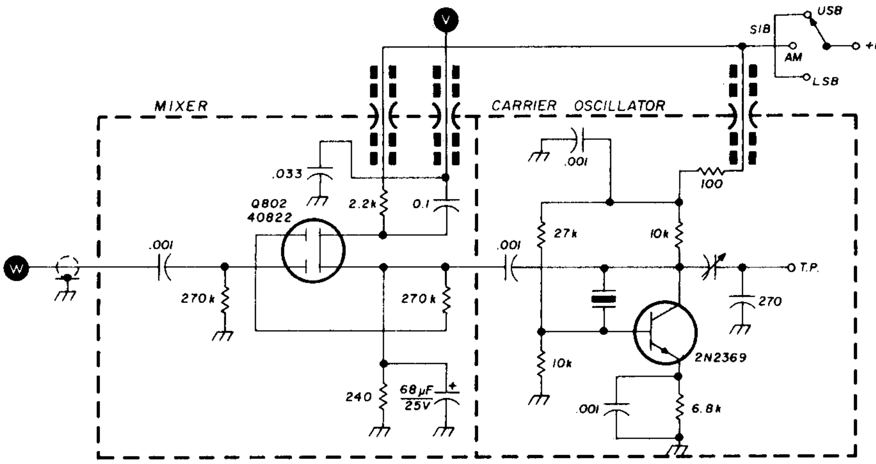


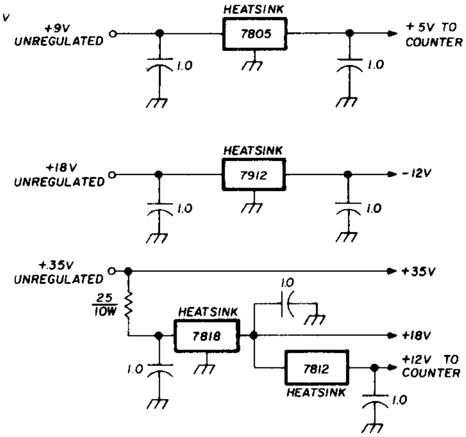
fig. 2. Schematic diagram of the high-performance general-coverage receiver. All feedthrough capacitors are 1000 pF; other capacitors between 1 pF and 2000 pF are silver mica. The 0.001 bypass capacitors are ceramic discs; capacitors marked 0.01 are ceramic discs; capacitors marked 0.01 to 2.2 μF are ceramic, monolithic, or tantalum types; larger value capacitors are electrolytics. All resistors are ¼ watt, 5 per cent, unless otherwise indicated.

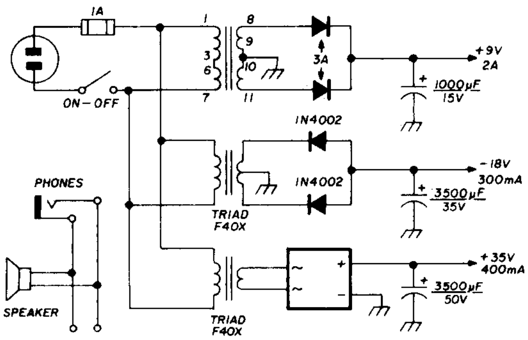


SECOND LOCAL OSCILLATOR

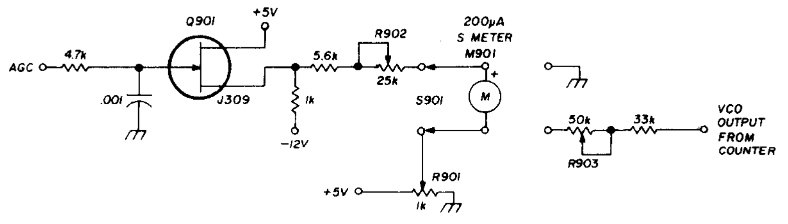


PRODUCT DETECT



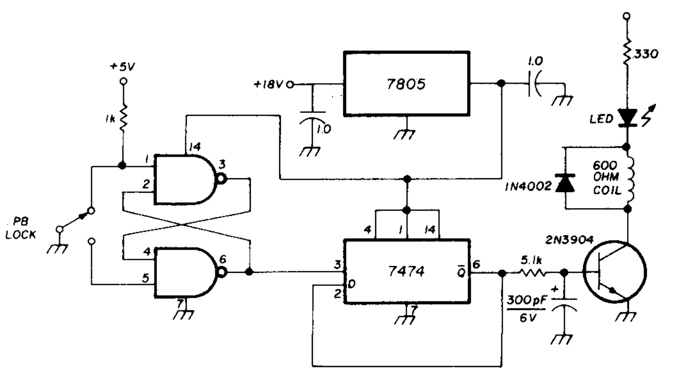


SPEAKER BOX



METER CIRCUIT

FL 501	4 windings no. 24 (0.5mm) wire on 1/2″ (13mm) form, 1/2″ (13mm) between windings
L402	7 turns no. 26 (0.4mm) on a 1/4″ (6.5mm) slug-tuned form
MX101, MX401	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



LOCK CONTROL

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 vco control. The 5.1k and 300 μF 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 $\bar{S}$ 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 $\bar{S}$ 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

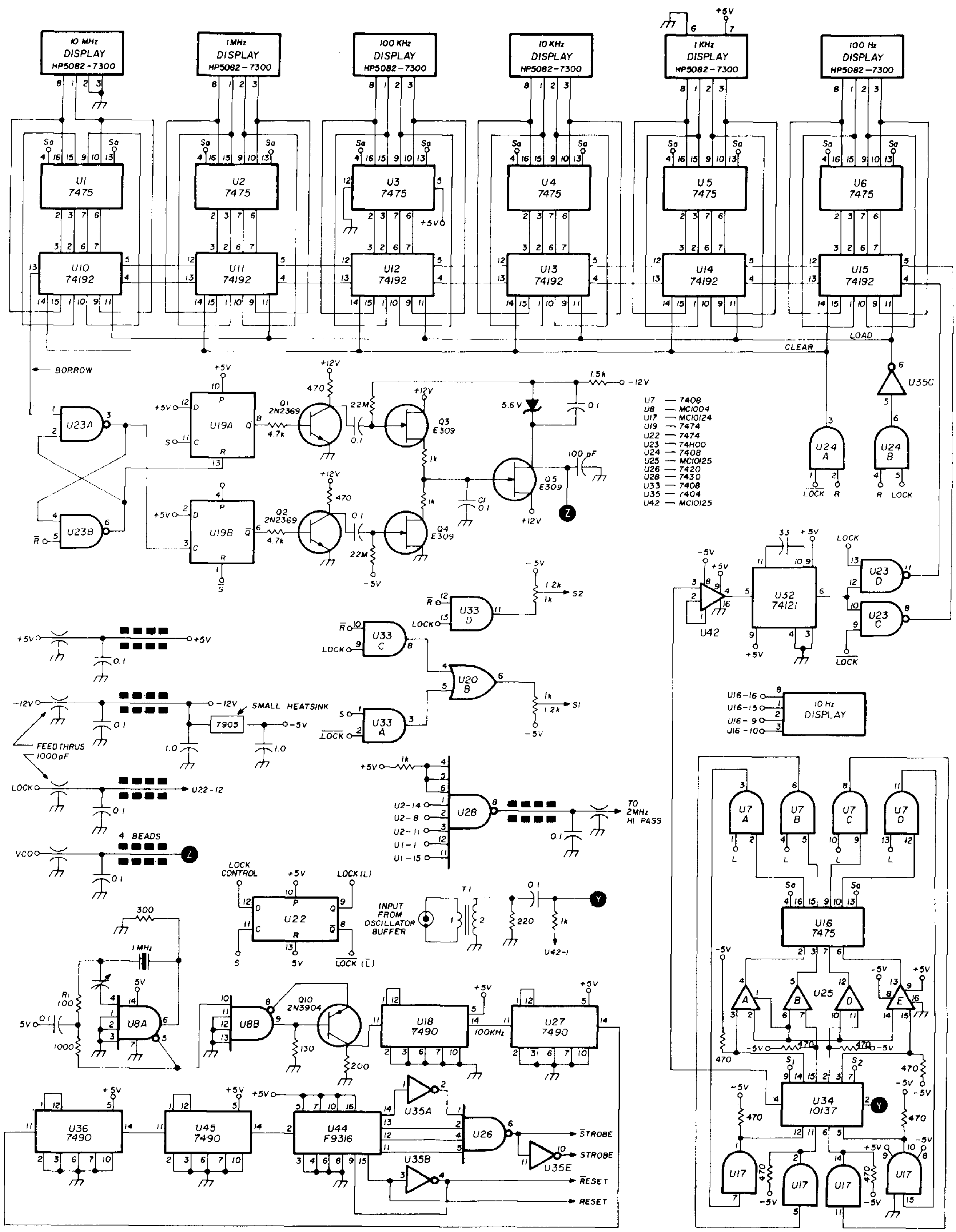


fig. 3. Schematic for the digital frequency readout and digital frequency control system. Although not shown here, install a 0.1 μF bypass capacitor at every fifth IC (+ Vcc to ground). 22 μF, 15 volt bypass capacitors are installed on the +12, −12, +5 and −5 volt supplies. Digital displays are Hewlett-Packard 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 μV. 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 bypassing.

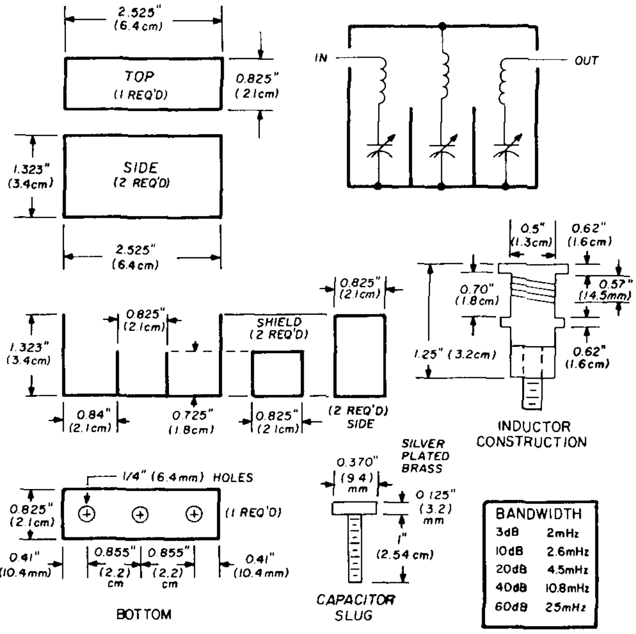


fig. 5. Layout of the 60-MHz bandpass filter. The coil form is a ½" (13mm) slug-tuned National XR50. Tuning capacitance is provided by a slug mounted through the side of the shielded filter enclosure. Winding for each coil is 24 turns no. 30 AWG (0.25mm), spaced one wire diameter.

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 μF 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 (9x5x2.5cm) 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,

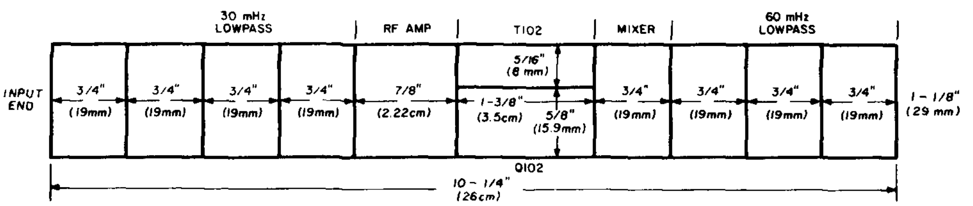


fig. 4. Layout of the rf assembly (30-MHz lowpass filter through the 60-MHz lowpass filter, fig. 2). The unit is 1 inch (25mm) high. The area around the mixer is crowded in this layout; more space should be provided for this circuit.

filter capacitors, and speaker are mounted in a separate box measuring 6 inches (15cm) on a side.

Crystal filters. The a-m filter is a Heath Dynamics A-5100. The ssb filters I used were manufactured by firms which do not sell filters in small quantities. Many of the 9-MHz crystal filters which are advertised for amateur use could be used with a few circuit changes.

Other components. The air variable capacitor used in the first local oscillator, and the coil forms used in the 60-MHz bandpass filter, will probably have to be obtained on the surplus market since these components have not been commercially available for several years. Many of the parts I used in this receiver came from my junkbox and those of other people so the original sources are unknown.

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.

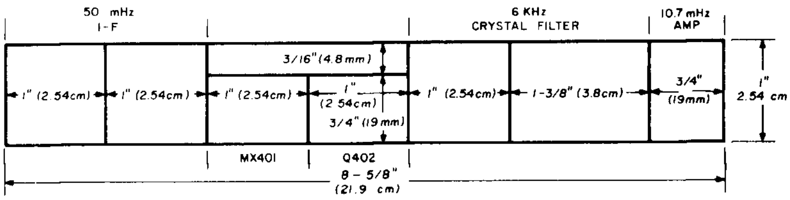


fig. 6. Layout of the first i-f assembly (60-MHz i-f amplifier, second mixer, 6-kHz crystal filter, and 10.7 MHz i-f amplifier; fig. 2). The unit is 1-inch (25mm) high.

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).

3. Vacuum-tube voltmeter.

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.

6. Grid-dip meter.

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 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.

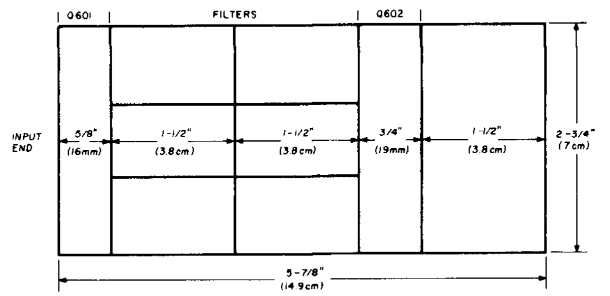


fig. 7. Layout of the information filter assembly. The filters are mounted from the opposite side; standoffs are used to mount this unit to the chassis. The size and shape of this unit may be modified to accommodate filters which are available to the builder. Unit is 1-inch (25mm) high; last compartment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

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 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,

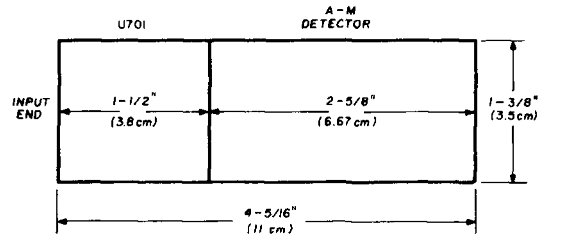


fig. 8. Layout of the assembly containing the second i-f amplifier and product detector. Unit is 1 inch (25mm) high.

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 per cent 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

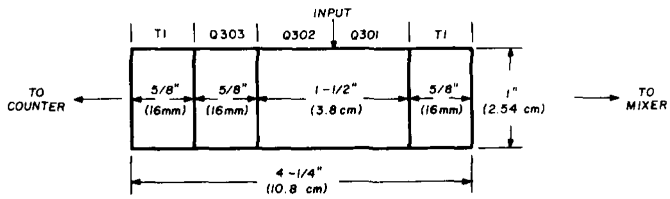


fig. 9. Layout of the oscillator-buffer assembly. Unit is 1 inch (25mm) high.

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.

	logic zero	logic 1
TTL	0 to 0.8 V	2 to 5 V
ECL	−1.5 to −5.0 V	−0.5 to −0.9 V

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.

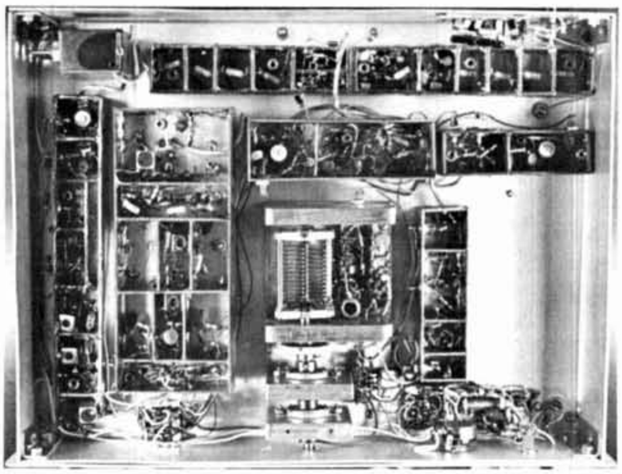
The frequency being counted comes out of U34 as a 20 ns wide pulse and is stretched out to 50 ns by U32. This 50 ns pulse becomes very difficult to see as it is divided down by the counters. Therefore, a low-frequency generator, at 1 MHz for example, makes investigation much easier.

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 T1 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.



Bottom view of the communications receiver, showing the shielded compartments for the major assemblies. The enclosure at the top contains the rf amplifier assembly including the 30-MHz and 60-MHz lowpass filters. The unit in the top left-hand corner contains the 60-MHz bandpass filter. Along the left-hand side of the chassis is the 60-MHz i-f amplifier, mixer MX401, 6-kHz crystal filter, and 10.7-MHz i-f amplifier. The information filters are in the next enclosure to the right. The enclosure on the right-hand side of the vfo contains the buffer circuitry; the second i-f is center top, and the product detector is to its right.

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.

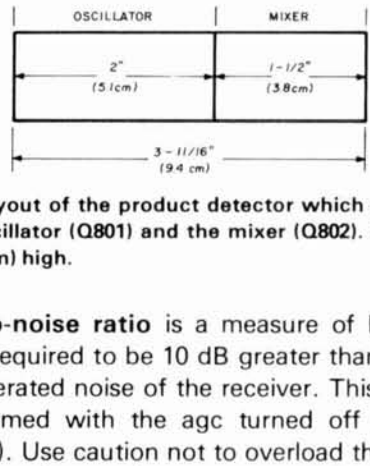


fig. 10. Layout of the product detector which contains the carrier oscillator (Q801) and the mixer (Q802). The unit is 1 inch (25mm) high.

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

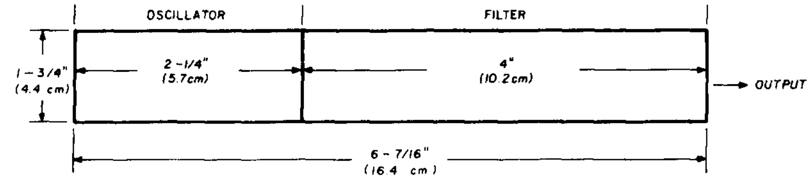


fig. 11. Layout of the assembly containing the second local oscillator and the oscillator filter, FL501. This unit is 1¾ inches (45mm) high; the increased size is needed to minimize detuning of the filter. Holes, ¼ inch (6.5mm) in diameter, are provided in the top for tuning up the oscillator and filter.

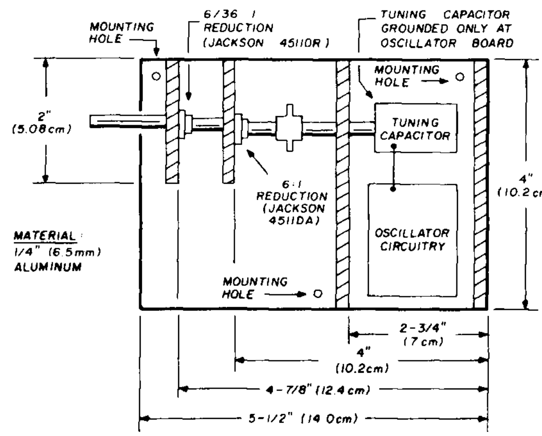


fig. 12. Construction of the first local oscillator. The total height of this unit is 2¼ inches (57mm), including the ¼ inch (6.5mm) thick baseplate; a cover is provided to shield the oscillator circuitry and the tuning capacitor. This assembly is mounted on the main chassis with three 4-40 (M3) screws, 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 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.

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

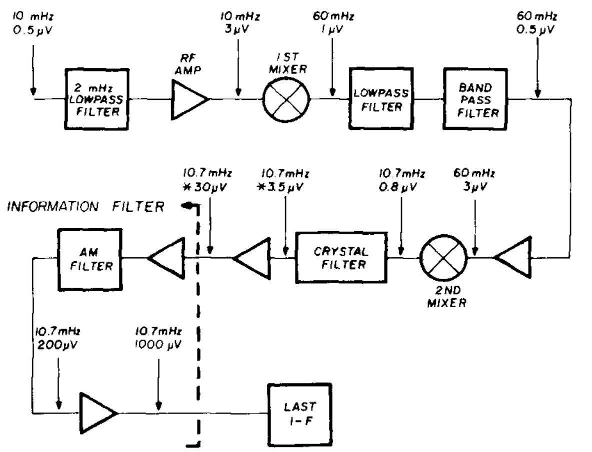


fig. 13. Sensitivity at various points in the general-coverage communications receiver. Alignment can be done one *assembly* at a time, but using this diagram and checking one *stage* at a time provides a comparison of sensitivity. When making tests at the points marked with an asterisk, terminate the generator with a 50-ohm resistor. Turn the agc to minimum for all tests.

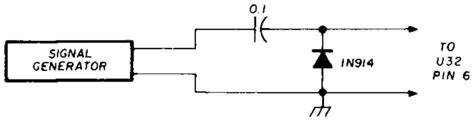


fig. 14. Interface circuit for connecting the signal generator to U32 when troubleshooting the counter circuit.

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

table 3. List of high-power medium- and high-frequency transmitting stations located near W6URH.

station	distance miles	(kilometers)	power (kW)	frequency (MHz)
KGEI I	6	(10)	250 kW	6 - 15 MHz
KGEI II	6	(10)	50 kW	6 - 15 MHz
KNBR	6	(10)	50 kW	680 kHz
KLHI	5	(8)	10 kW	1550 kHz
KFS	3	(5)	3 kW	6348 kHz
KFS	3	(5)	12 kW	6365 kHz
KFS	3	(5)	12 kW	8444 kHz
KFS	3	(5)	12 kW	8558 kHz
KFS	3	(5)	12 kW	12.695 MHz
KFS	3	(5)	12 kW	12.844 MHz
KFS	3	(5)	12 kW	17.026 MHz
KFS	3	(5)	12 kW	17.184 MHz
KFS	3	(5)	12 kW	22.425 MHz
KFS	3	(5)	3 kW	22.515 MHz
KGO	2.5	(4)	50 kW	810 kHz
KDFC	2	(3)	10 kW	1220 kHz

radio station can be heard — hopefully there will be only one. To make this test you have to be within ten miles of a broadcast or short-wave transmitter run-

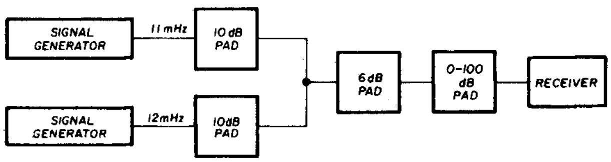


fig. 15. Test set-up for checking intermodulation distortion. See text for test procedure.

ning 1000 watts or more. I have sixteen such transmitters within 6 miles of my home operating between 680 kHz and 22 MHz (see **table 3**). Before I installed the 2-MHz highpass filter in the receiver, a-m broadcast stations could be heard at a low level as I tuned across the short-wave bands. KGEI I (250 kW) and KGEI II (50 kW) cannot be heard on frequencies other than their normal operating frequencies. Station KFS (up to 12 kW) has never been heard on frequencies 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.

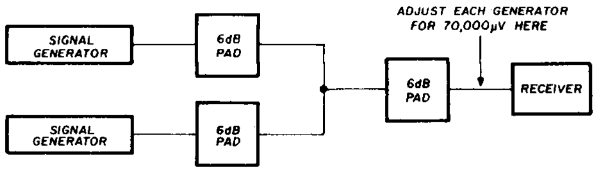


fig. 16. Test set-up for measuring receiver cross-modulation. See text for test procedure.

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, W1DTY, "Receiver Noise Figure, Sensitivity, and Dynamic Range," *ham radio*, October, 1975, page 8.
2. D. DeMaw, "His Eminence, the Receiver," *QST*, June, 1976, page 27; July, 1976, page 14.
3. W. Hayward, W7ZOI, "CER-verters," *QST*, June, 1976, page 31.
4. W. Hayward, W7ZOI, "Defining and Measuring Receiver Dynamic Range," *QST*, July, 1975, page 15.
5. W. Sabin, WØIYH, "The Solid-State Receiver," *QST*, July, 1970, page 35.
6. R. Moore, "Modern RF Amplifiers for Communications Receivers," *ham radio*, September, 1974, page 42.
7. T. Gadwa, W2JO, "Computerized Search for Receiver Birdies," *QST*, February, 1974, page 28.
8. U. Rohde, "Eight Ways to Better Receiver Design," *Electronics*, February, 1975, page 87.
9. "Get the Most from Mixers," Mini-Circuits Laboratory, 837-843 Utica Avenue, Brooklyn, New York 11203.
10. P. Will, "Reactive Loads — The Big Mixer Menace," *Microwaves*, April, 1971, page 38.

ham radio

More Details? CHECK—OFF Page 150

noise blanker design

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[1] 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[2] 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

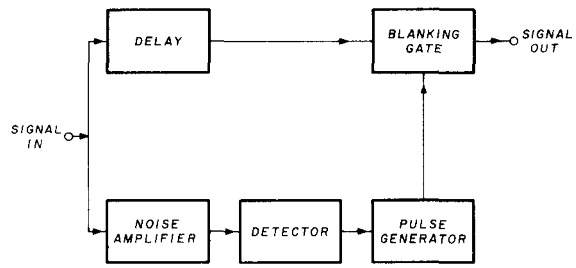


fig. 1. Block diagram of a typical noise blanking circuit. The signal is split into two paths, the noise or control signal plus the original communications signal. The delay is introduced to ensure that the two signals arrive at the blanking gate simultaneously.

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.)

By Wes Stewart, K7CVT, 1801 East Canada Street, Tuscon, Arizona 85706

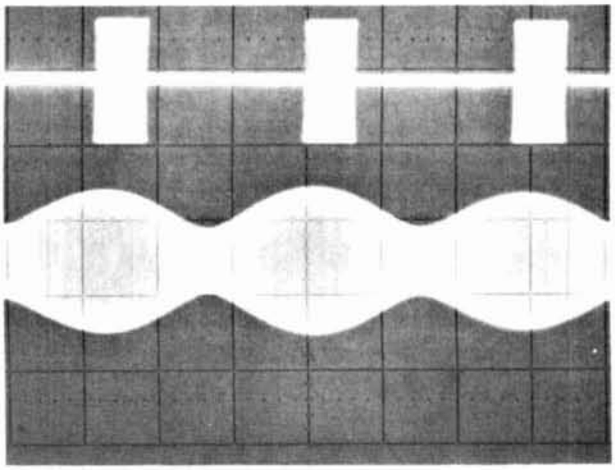


fig. 2. Example of the effects of applying a noise pulse to a relatively narrow i-f filter. The upper trace shows an applied pulse while the bottom shows the output from the filter. Both traces were recorded at identical sweep speeds.

The main channel is sometimes delayed, then passed through a gate and on to the rest of the receiver. In the noise channel, the noise and signal are amplified, and the noise impulses detected with the detector output are used to trigger the pulse generator. The pulse generator forms a signal of proper amplitude and polarity to cut off the gate for the duration of the noise impulse.

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

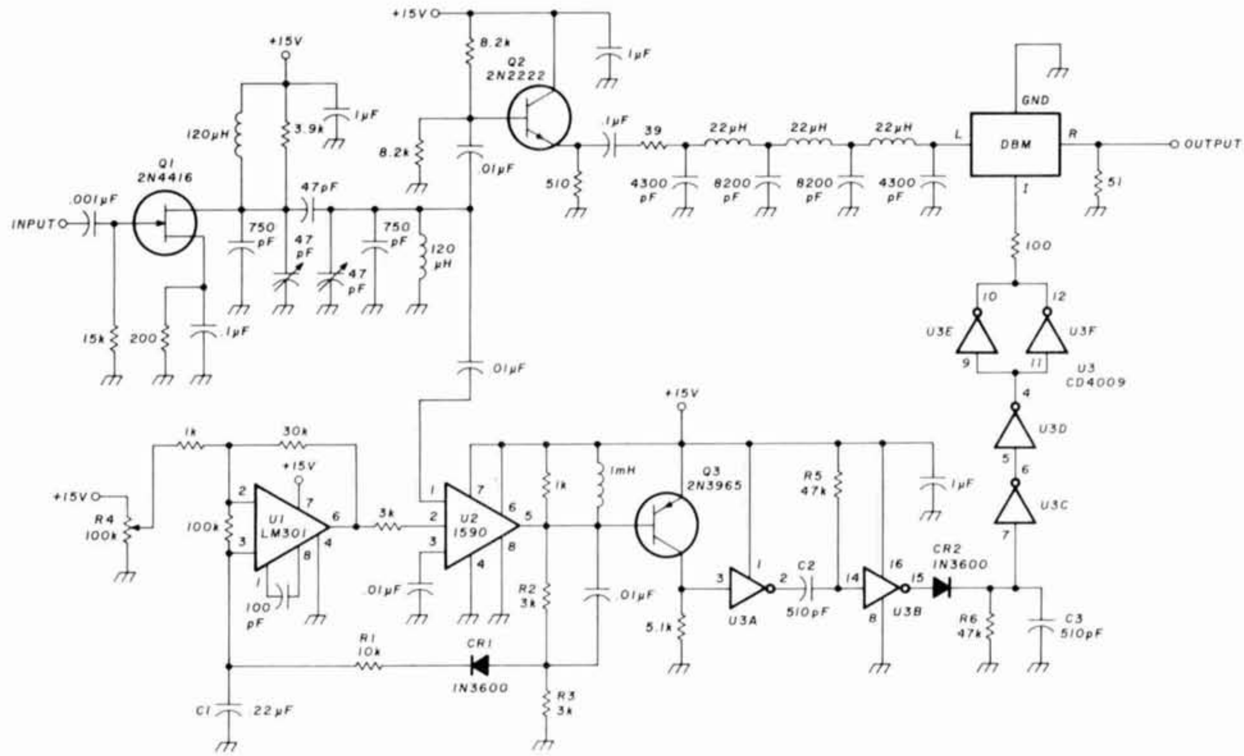


fig. 3. The final design of the noise blanker as applied to the author's receiver.

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 great 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 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.[3] 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.

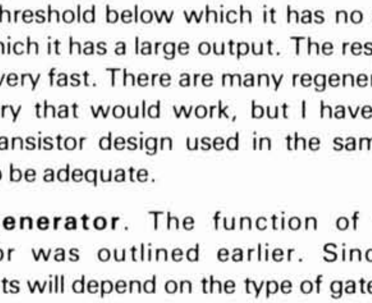


fig. 4. A double-balanced mixer can be used as a current-controlled attenuator. This example shows the required current for two different applied power levels.

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:

$$t_d = \frac{\theta}{360 \cdot f}$$

where

θ = the phase shift in degrees
f = the frequency of operation.

Blanking gate. Last, but perhaps most important, is the selection of a suitable gate. The characteristics of

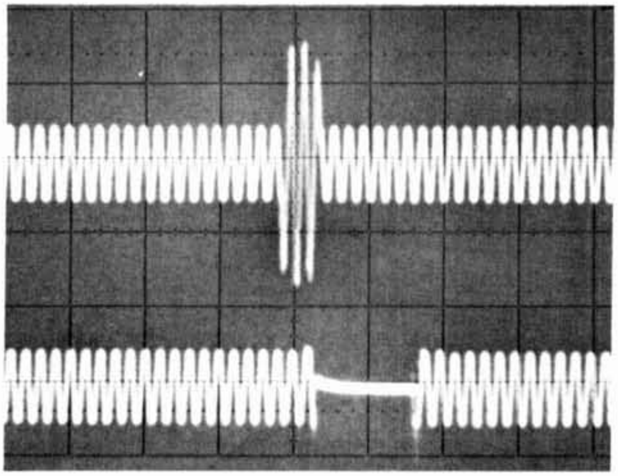


fig. 5. The bottom trace of this photograph shows the output from the gate after a noise pulse has been blanked. The original pulse (top trace) had a 10 dB noise-to-signal ratio.

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

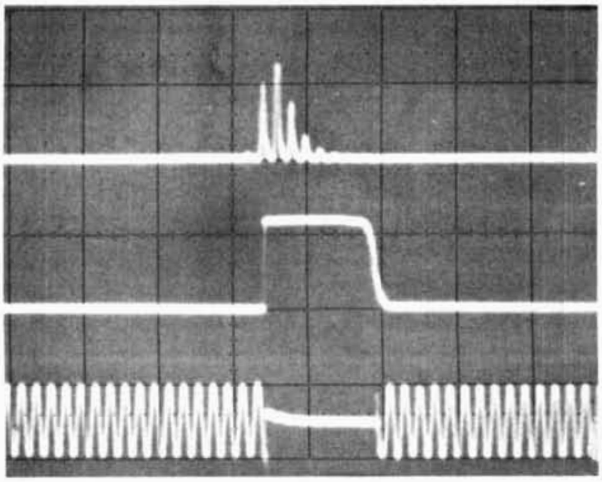


fig. 6. Additional points in the blanker are shown in this photograph. The upper trace is the collector of Q3 while the middle trace is the output of the one-shot multivibrator. The bottom trace is the same input as in fig. 5.

between the plate of the second mixer and the first i-f amplifier. The i-f is at 500 kHz and the signal level is a few millivolts.

In this circuit Q1 and its double-tuned drain circuit comprise a low-gain bandpass amplifier that removes the remaining local oscillator signal while setting the bandwidth at about 50 kHz. At this point, the signal is split into the two channels. In the main channel, Q2, an emitter follower, drives the 50-ohm lowpass delay network. The output from this network passes through the gate (DBM) on to the remainder of the receiver. This particular delay network is a seven-pole Butterworth lowpass filter with a 700-kHz cutoff frequency. The phase shift is about 200 degrees at 500 kHz; therefore, the delay is about 1.1 μs.

In the noise channel, U2, a MC1590 operating as a video amplifier, is the noise amplifier. It drives Q3, the pulse detector, and CR1, the agc detector. The agc time-constant, set by R1 and C1, is long enough to be unaffected by short noise pulses but will follow the average signal level. The anode of CR1 is biased at one half the supply voltage by R2 and R3. An operational amplifier, U1, amplifies the agc and controls the gain of U2. R4 applies an offset voltage to the input of U1. This has the effect of setting the point at which CR1 begins to conduct, since both inputs of the op amp are at the same potential. R4, therefore, becomes the threshold adjustment. Once set, it should not require further adjustment unless it is necessary to disable the blanker in the presence of a strong adjacent channel signal.

Detection takes place in Q3 and the resulting positive pulses are applied to buffer U3A. The output of U3A triggers the one-shot comprised of R5, R6, C2, C3, CR2, and gates U3B and U3C. The remaining 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.

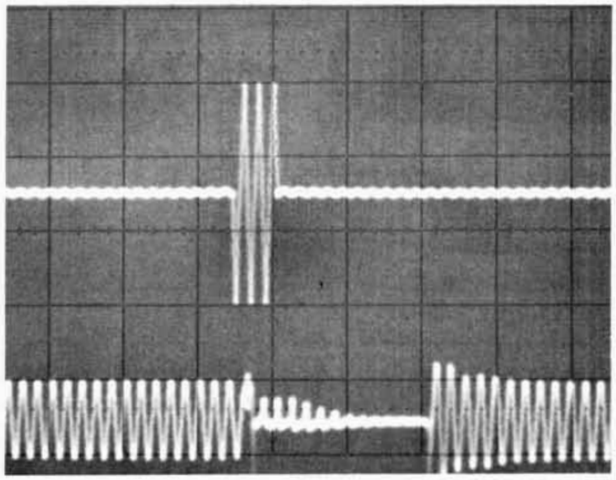


fig. 7. Example where the noise-to-signal ratio has been increased to 40 dB. The bottom trace shows almost complete elimination of the noise pulse at the output of the blanking gate.

problems. It is but one technique among other more sophisticated ones, such as coherent detection, adaptive filtering, and auto-correlation, that should be considered when attempting to communicate in the presence of noise.

references

1. J. J. Lamb, "A Noise Silencing I.F. Circuit for Superhet Receivers," *QST*, February, 1936, page 11.
2. W. R. Nelson, "Electrical Interference," *QST*, April, 1966, page 11; May, 1966, page 39.
3. J. A. Dean and J. P. Rupley, "Astable and Monostable Oscillators Using RCA Cos/Mos Digital Integrated Circuits," *Applications Note ICAN-6267*, RCA Solid State Division, Somerville, New Jersey.

ham radio

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 (480km) 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[1]

$$F_T = F_1 + \frac{(F_2 - 1)}{G1} \qquad \textbf{(1)}$$

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:

$$F\,(ratio) = Antilog\ \frac{NF\,(dB)}{10} \qquad \textbf{(2)}$$

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:

$$F_1 = F_T - \frac{(F_2 - 1)}{G} \tag{3}$$

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

$$F_1 = F_{T'} - \frac{(F_3 - 1)}{G} \tag{4}$$

Since F_T, $F_{T'}$, F_2, and F_3 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.

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

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

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

$$G = \frac{F_2 - F_3}{F_T - F_{T'}} \tag{5}$$

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_T 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 preceeding it with a precision pad for the second measurement to degrade its noise figure by a known amount. NF_3 (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:

$$G = \frac{9F_2}{F_{T'} - F_T} \tag{6}$$

The measurement procedure is relatively straight forward:

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_1 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

*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 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.

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 $F_{T'}$. 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') 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 $F_{T'}$ *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

1. H. T. Friis, "Noise Figures of Radio Receivers," *Proceedings of the IRE*, July, 1944, page 419.

ham radio

effects of noise in receiving systems

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.

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 op-

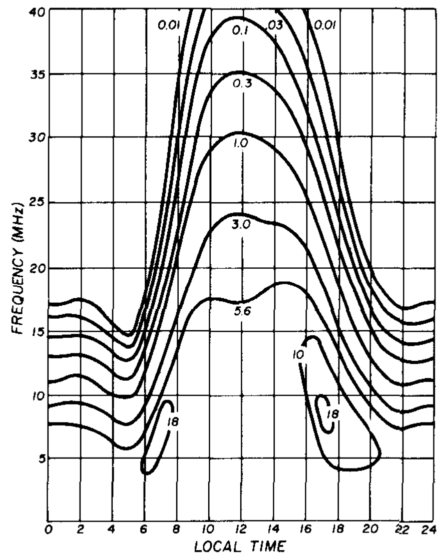


fig. 1. Field strength in microvolts per meter for a 1000-watt transmitter as a function of local time and frequency.

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

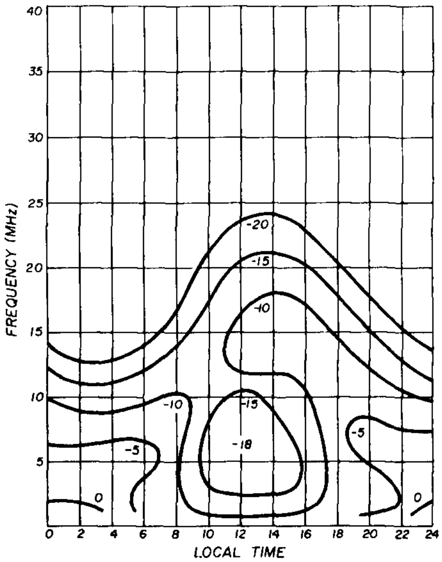


fig. 2. Atmospheric noise field strength in dB above or below 1 μV per meter as a function of time and operating frequency (assumes 1 kHz bandwidth). If this noise chart is placed over the propagation chart in fig. 1, the signal-to-noise ratio can be calculated (S/N = receiving field strength minus noise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

timum frequency until slightly after 0500 (point 1), when 6.3 MHz is the better choice. At 1600 the operator changes frequency to 8.2 MHz (point 2), and at 2000 goes back to 6.3 MHz (point 3). At about 2300 hours local time, 3.6 MHz is again the optimum frequency (point 4) and remains so until the next morning at about 0500.

Precipitation static is produced by wind and rain around the receiving antenna, and is important only below about 10 MHz; it is particularly troublesome for aircraft communications. It can be reduced by

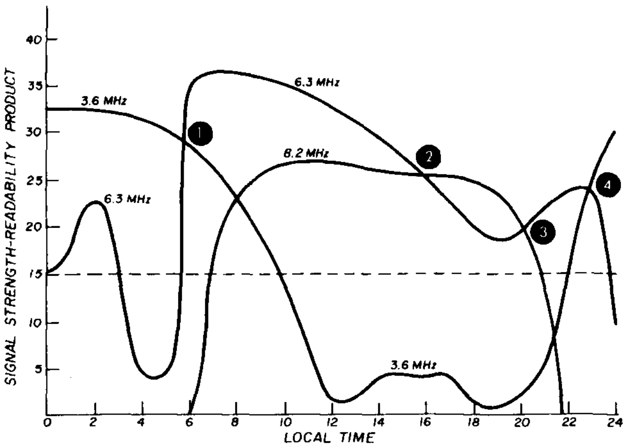


fig. 3. Optimum operating frequencies vs time of day for two man-pack radios operating over a distance of 20 miles (32km). This data was gathered in September, 1969. The dashed line indicates the minimum required signal strength-readability product to understand the transmitting station.

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):

$$P_n = kT_oB \tag{1}$$

where P_n = available noise power

k = Boltzmann's constant = 1.38×10^{-23} joules/°Kelvin

T_o = reference temperature (typically 290°K)

B = effective receiver noise bandwidth, Hz

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

$$e_n^2 = 4kT_oBR \tag{2}$$

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

$$e_n^2 = 4kT_oB\frac{R}{2} \tag{3}$$

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 ($T_o = 290°K$).

$$e_n = \sqrt{4(1.38x10^{-23})(290)(2.4x10^3)(50/2)}$$
$$= 3.1 \times 10^{-8} \text{ volts}$$
$$= 31 \text{ nanovolts } (nV)$$

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,

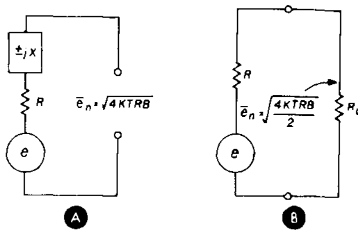


fig. 4. Mean noise voltage depends on temperature, resistance, and noise bandwidth (A); this is the open-circuit noise voltage. Maximum noise power is transferred to the load when the load resistance is matched to the source resistance (B); in the terminated condition only half the available noise power appears across the load (receiver) terminals.

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

$$F = \frac{P_n}{kT_o B} = \frac{T_a}{T_o} \tag{4}$$

where P_n is the available noise power and T_a is the effective noise temperature (°K). If the noise factor

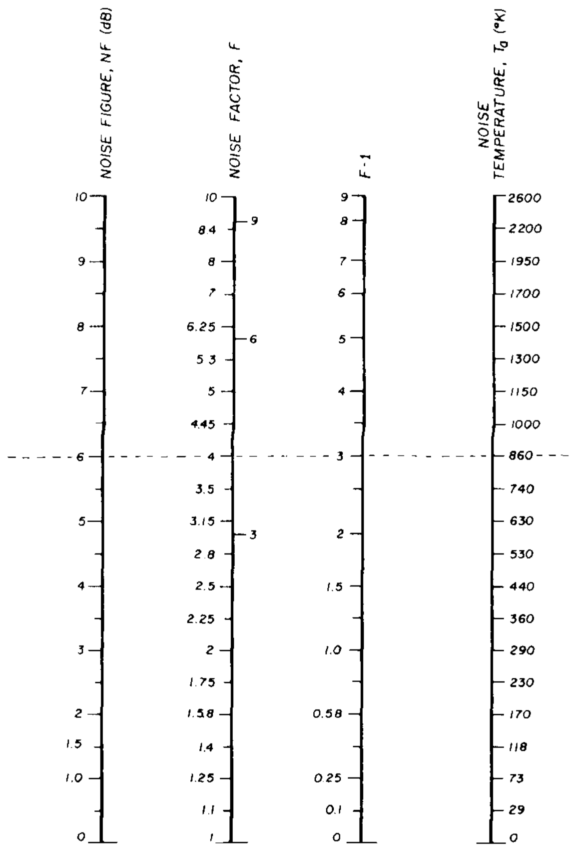


fig. 5. Conversion table for noise figure, noise factor, and effective noise temperature. The dashed line shows a noise factor of 4 is equivalent to a noise figure of 6 dB or an effective noise temperature of 860°K.

of a receiving system is known, the noise voltage for a signal-to-noise ratio of unity ($S/N = 1$) can be calculated from

$$e_n^2 = F(4kT_o BR) \tag{5}$$

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

$$e_n = \sqrt{10 \cdot 4(1.38x10^{-23})(290)(2.4x10^3)(50/2)} = 98\ nV$$

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

$$Noise\ figure = 10\ log\ noise\ factor$$

A simple graph for converting from noise factor, F, to noise figure in dB or effective noise temperature, T_a, 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

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \ldots + \frac{F_n - 1}{G_1 G_2 G_3 \ldots G_{n-1}} \tag{6}$$

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

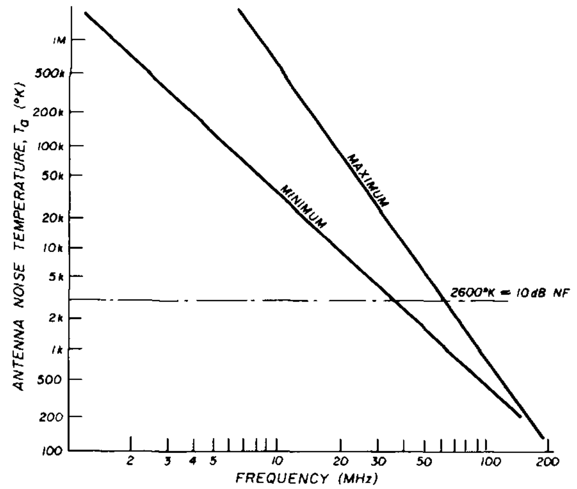


fig. 6. Noise temperature of an antenna (unity gain) as a function of frequency under daytime and nighttime conditions. The dashed line shows that a receiver noise figure of 10 dB is sufficient up to about 36 MHz.

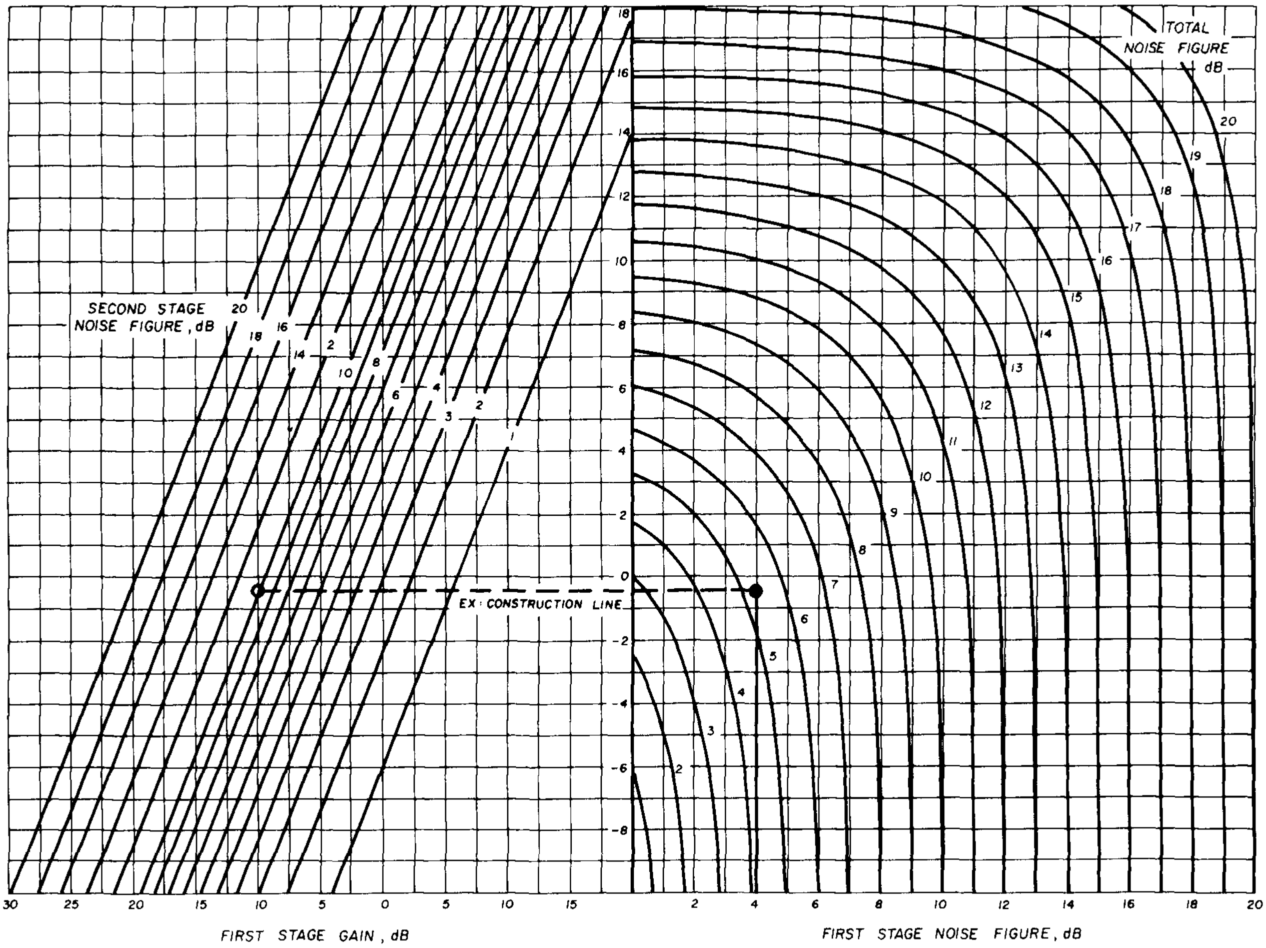


fig. 7. Chart for calculating the overall noise figure of two cascaded stages. In the example shown, a first stage with a noise figure of 4 dB and power gain of 10 dB, is cascaded with a stage having a 10 dB noise figure; the overall noise figure is 5.3 dB.

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

$$F = F_1 + \frac{F_2 - 1}{G_1} \quad (7)$$

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

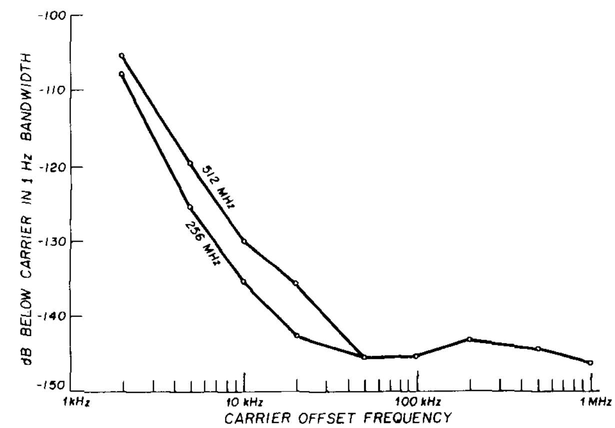


fig. 8. Noise sideband performance of the Hewlett-Packard 8640B signal generator.

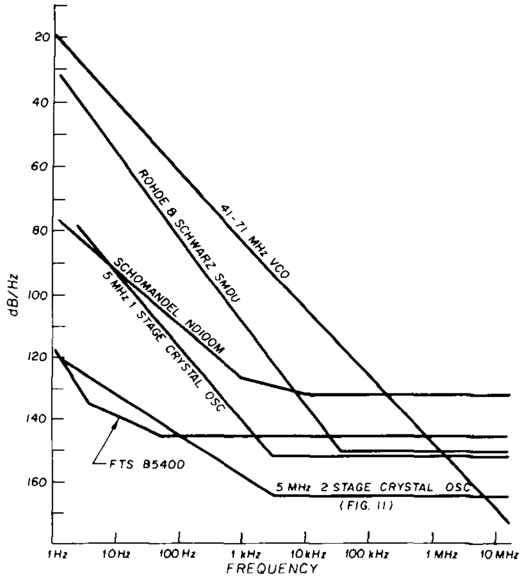


fig. 9. Measured noise sideband performance of a 41-71 MHz vco, Rohde & Schwarz SMDU signal generator, Schomandel ND100M frequency synthesizer. Frequency and Time Services (FTS) B5400 modular 5-MHz crystal oscillator, and single and double stage 5-MHz crystal oscillators.

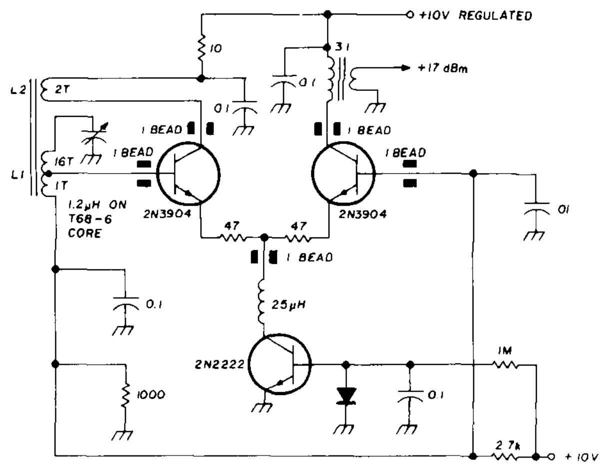


fig. 10. Schematic of a very low noise LC oscillator operating at 5 MHz.

figures, their second-order distortion is much worse (by definition) than that of bipolar transistors (the square-law characteristic of the fet makes it ideally suited as a frequency doubler). Because of their high gain reserve, it's relatively easy to linearize bipolar transistors with suitable feedback circuits (transistors offer higher gain-bandwidth products than fets with slightly higher noise figures).

noise in oscillators

The graph in **fig. 8** shows the sideband noise of an oscillator stage using a high-Q, tuned LC circuit. To 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.

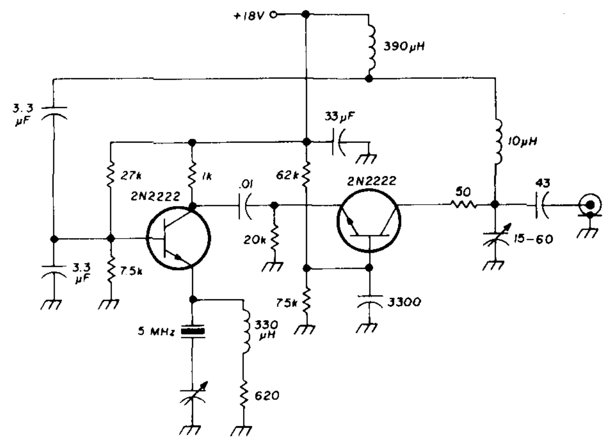


fig. 11. Schematic diagram of an extremely low noise series-mode crystal oscillator, designed for 5 MHz as described in reference 6.

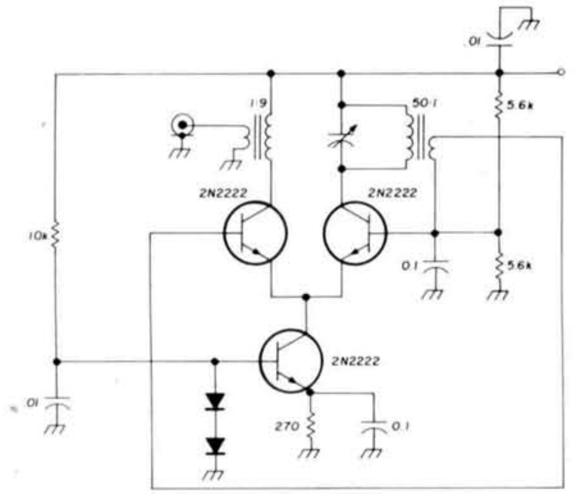


fig. 12. Circuit for a low noise and low distortion LC oscillator. Harmonic distortion is less than 1 per cent.

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

$$\frac{Q_o}{Q_L} = \frac{R_s}{R_s + R_{T1} + R_{T2}} \qquad \textbf{(8)}$$

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

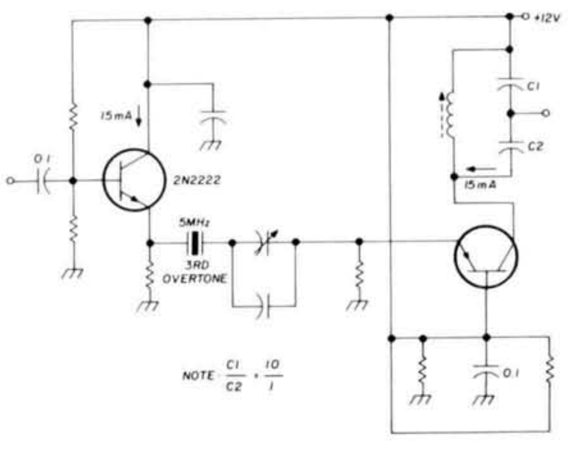


fig. 13. Schematic of a simple crystal filter with only a few Hz bandwidth. Collector current is set at 15 mA to satisfy the relationship between the series-resonant resistance and unloaded Q, as discussed in the test.

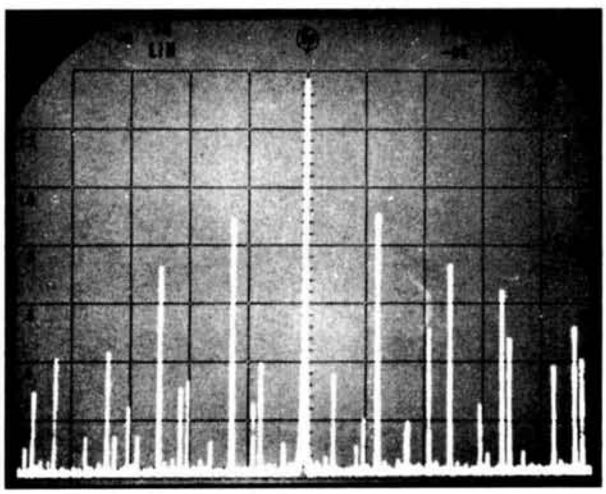


fig. 14. Output of a double-balanced mixer with one strong station and several weaker signals applied. This produces numerous close-in spurs or birdies. The same thing occurs when the LO drive is insufficient.

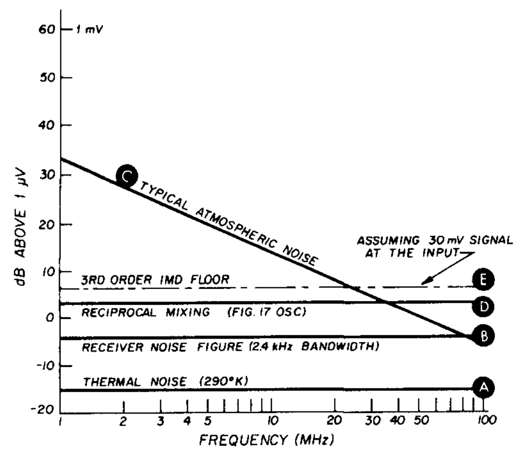


fig. 15. Typical energy distribution. Thermal noise = 31 nV (A), receiver noise = 95 nV (B), typical atmospheric noise (C), effect of reciprocal mixing (D), and third-order IMD (E).

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 recceiving 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 ΔF apart, are applied to the rf port, two mixing products, ΔF above and below the two input signals, will be generated at a level of -60 dBm or 224 μV.

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 μV. Under these conditions no signals below 60 μV 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.[7] 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

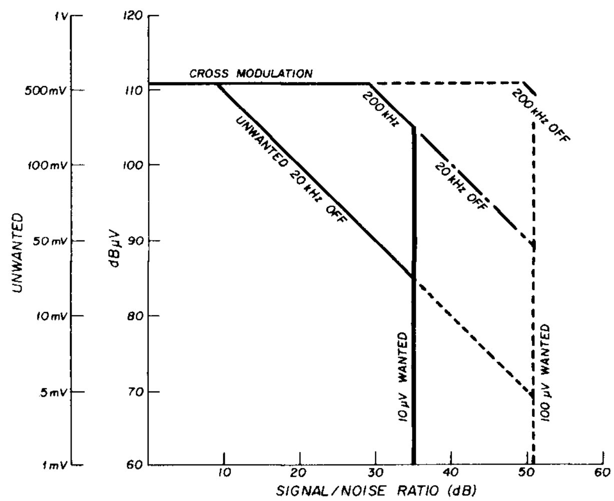
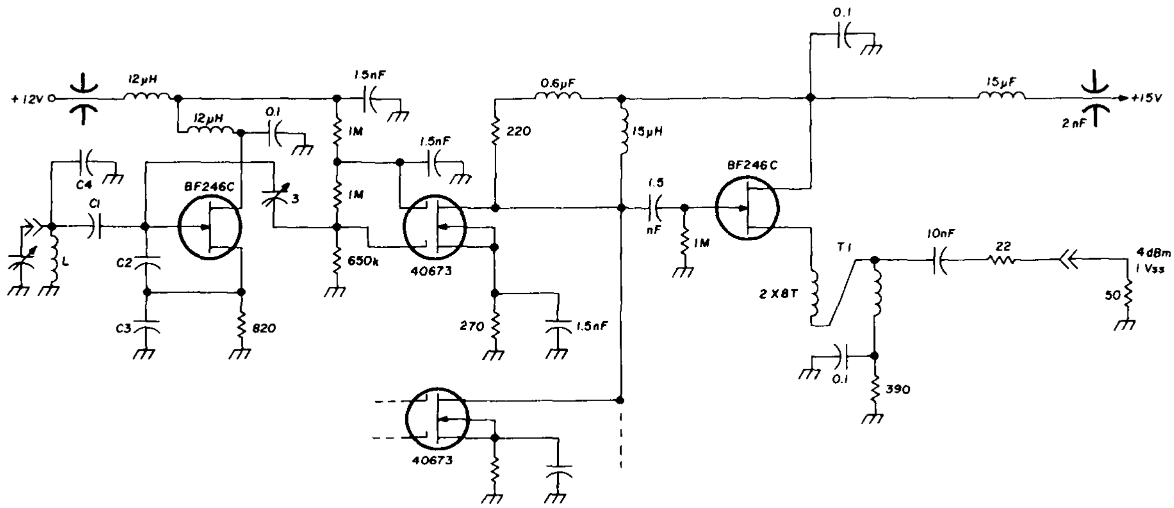


fig. 16. Graph showing the effect of reciprocal mixing and cross modulation, assuming a wanted signal of 10 μV, and one of 100 μV.



band	MHz	C1 pF	C2 pF	C3 pF	C4 pF	L μH	L-Typ Nr. *Fa. Stettner*	ΔC pF
80	11,963-13,076	68NPO 15P100 15P100	100NPO 250N150 15P100 15P100	680N150	0	1,9P30	87-5319/47	10-30
40	15,948-17,049	68NPO 15P100 15P100	100NPO 250N150	470N150	1,5NPO 2N150	1,1P30	87-6023-01	10-26
20	22,951-24,083	56NPO	100NPO 39N150 15N220	330N150	2N150	1,0P30	87-5319/35	5-12
15	29,950-31,060	100NPO 15N220	100NPO 15P100 15P100	330N150	5P100	0,4P30	87-5880e-01	5-18
10	36,980-39,010	56NPO	100NPO 30N470 30N470	250N150	1-5NPO	0,32P30	87-5880d-01	5-12

fig. 17. ***Circuit for a low-noise, five-band LC oscillator for amateur equipment (designed by Michael Martin, DJ7VY). The temperature coefficient of each capacitor is given (P = positive coefficient; N = negative temperature coefficient).***

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 8)

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 μV and 100 μV. It can be clearly seen that reciprocal mixing occurs long before cross modulation saturates the receiver.

references

1. *Reference Data for Radio Engineers*, 5th edition, ITT, Howard Sams and Company, Indianapolis, 1968, page 27-1.
2. James R. Fisk, W1DTY, "Receiver Sensitivity and Dynamic Range," *ham radio*, October, 1975, page 8.
3. Dr. David E. Norton, Technical Notes, Anzac Catalog, Anzac, Woburn, Massachusetts.
4. *Proceedings of the 20th Annual Symposium on Frequency Control*, April, 1968, page 340.
5. Ulrich L. Rohde, DJ2LR, "High Dynamic Range Receiver Input Stages," *ham radio*, October, 1975, page 26.
6. M. M. Driscoll, "Two-Stage Limiting Series-Mode Type Quartz Crystal Oscillator Exhibiting Improved Short-Term Frequency Stability," *Proceedings of the 26th Annual Symposium on Frequency Control*, Ft. Monmouth, New Jersey, 1972, page 43.
7. R.F.A. Winn, "Synthesized Communications Receiver," *Wireless World* (England), October, 1974, page 413.
8. Ulrich L. Rohde, DJ2LR, "Optimum Design for High-Frequency Communications Receivers," *ham radio*, October, 1976, page 10.

ham radio

above & beyond...

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

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:

Model 1346 Drake UV-3 (144-220-440) **$995.00**
Model 1344 Drake UV-3 (144-440) **$795.00**
Model 1343 Drake UV-3 (144-220) **$795.00**
Model 1345 Drake UV-3 (220-440) **$795.00**
Model 1340 Drake UV-3 (144) **$595.00**

(Prices above include factory installed modules for bands as listed, standard dynamic mike, and mobile mounting bracket.)

*144 Add-on Module **$250.00**
*220 Add-on Module **$250.00**
*440 Add-on Module **$250.00**
Model 1504 Drake PS-3 AC Power Supply ..... **$ 89.95**
Model 1525 Drake 1525 EM Encoding Mike ... **$ 49.95**
Model 1330 Drake UMK-3
Remote Trunk-Mount Kit .... **$ 69.95**

*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.

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:"

unwanted signal	superhet	DC receiver
I-f breakthrough	yes	no
Reception on image frequency	yes	no
Reception by mixing with oscillator harmonics	yes	yes
Crossmodulation	yes	yes
Intermodulation	yes	yes
Breakthrough of a-m stations outside passband	no	yes

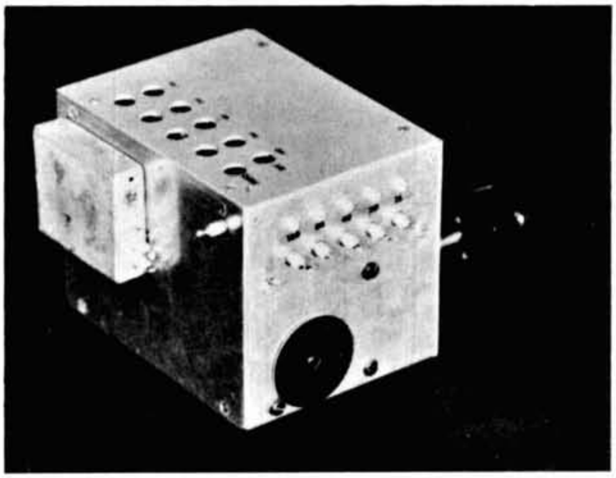
Because the first two unwanted signals don't exist with the DC receiver, preselection can usually be somewhat simpler than with the superhet (more about this aspect later). Whether or not the DC

By Dick Rollema, PA0SE, v.d. Marckstraat 5, Leiderdorp, The Netherlands

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.



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.

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!

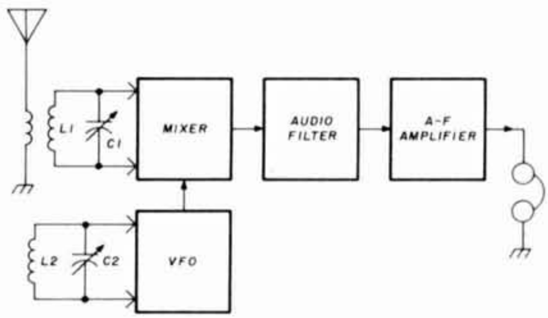


fig. 1. Block diagram of the direct-conversion receiver.

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 ratio at the output. (The ssb filter was in operation for this test). The signal was detuned outside the receiver

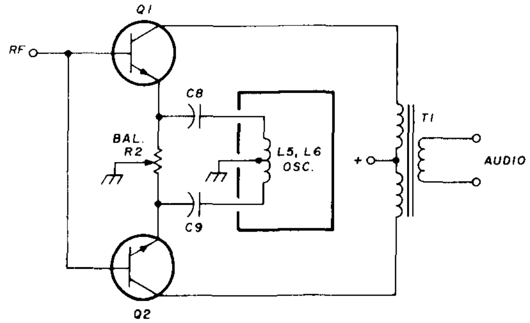


fig. 2. Balanced transistor mixer used by YU2HL (from reference 1).

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 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 $7.00 (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 coourse 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 this 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

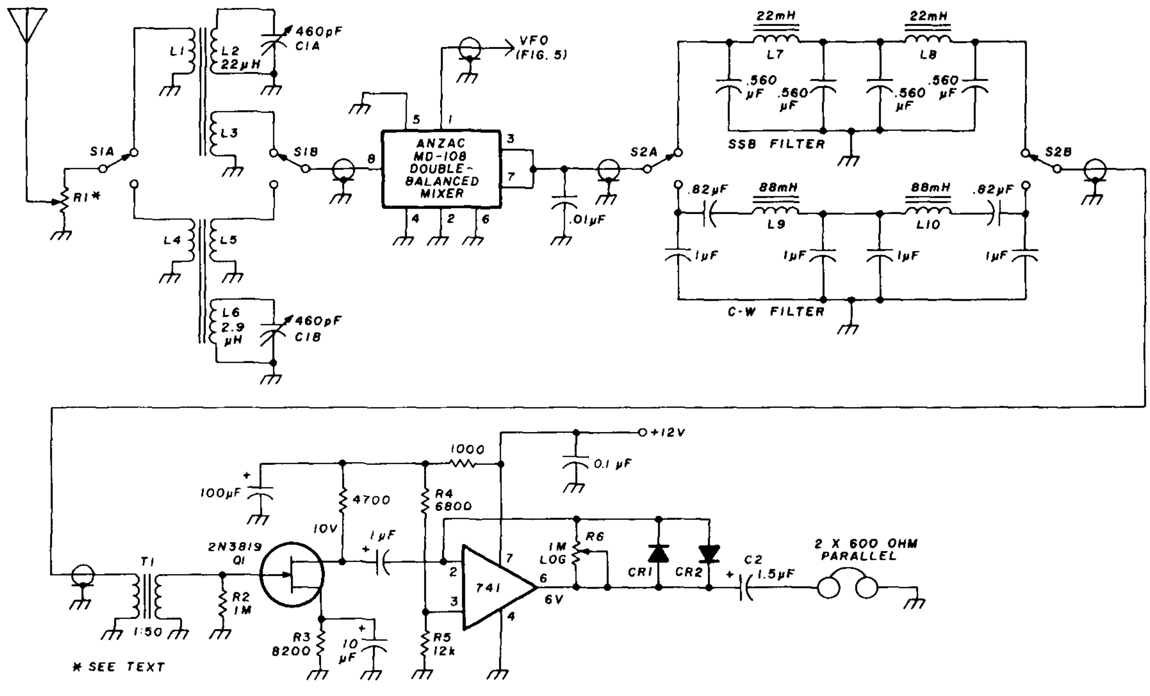


fig. 3. Schematic of the direct-conversion receiver for 1.8-21 MHz less the vfo. Details of L1-L6 are described in the text. L7, L8, 88-mH toroids with windings series connected. S1, S2, dpdt toggle switch of good quality. T1, microphone transformer from tube-type transmitter. R3, selected for a dc drain voltage on Q1 of 10 volts; see text. The MD108 double-balanced mixer is made by Anzac. Pin numbers on the 741 op amp relate to the round (TO-5) package.

table 1. Component values for the vfo.

Band	Range (MHz)	L1 (μH)	C1 (pF)	C2 (pF)	C3 (pF)	C4 (pF)	C5 (pF)	C6 (pF)	R1 (ohms)	R2 (ohms)
160	1.8-2.0	25	70 max	39	390	800	800	390	0	220
80	3.5-3.8	5.7	70 max	100	390	800	800	330	0	150
40	7.0-7.1	2.7	9 max	0	300	800	800	160	120	150
20	14.0-14.35	1.7	9 max	0	100	220	330	82	0	150
15	21.0-21.45	0.58	9 max	0	220	220	330	47	0	150

selectivity will be poor. A few trials will quickly bring a good compromise between these conflicting requirements.

variable-frequency oscillator

Oscillator frequency determines the tuning range of the receiver, so frequency stability is perhaps the most important oscillator requirement. The oscillator signal should have minimum noise modulation. As explained earlier, oscillator noise can become the limiting factor of receiver sensitivity. In my limited experience, an fet produces less noise than a bipolar transistor. Output power is of no consideration in a vfo; this is the job of the following amplifier, which is covered in a later part of the article.

For a multiband, direct-conversion receiver the oscillator signal should be generated directly, without premixing or frequency multiplication. This reduces the risk of spurious signals and noise modulation. It is, of couse, not a simple task to limit frequency drift on the higher-frequency bands, but

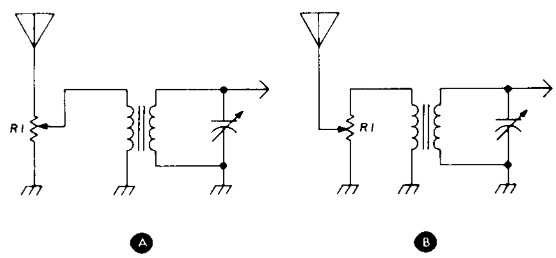


fig. 4. Two ways of connecting a so-called "antenna attenuator." Method in (B) is preferred.

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.

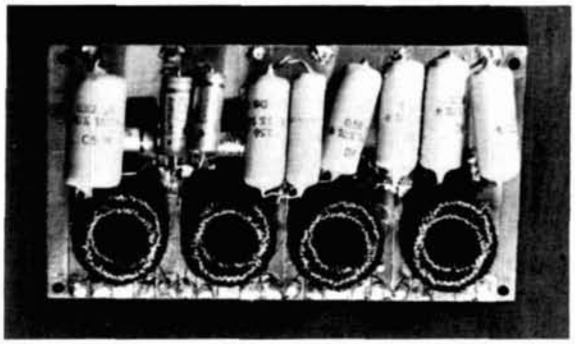
The inductance of L1 is determined by the lowest-frequency in the band desired. L1 should resonate on that frequency with the total capacitance in parallel (C1 set to maximum). Variation of C1 with respect to the total fixed parallel capacitance determines the bandspread. This means fiddling with the 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.



Ssb and CW filter are combined on one piece of epoxy PC board. Toroids were first individually cemented to small pieces of board with epoxy. Copper plating was divided into five wide tracks with a knife. Winding ends were soldered to the ends of the tracks (center one not used), and the external connections were then made to the other ends. Small boards carrying the coils were then epoxied to the mother board.

The oscillator required for a band is activated by connecting the supply volttage 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.[2] 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

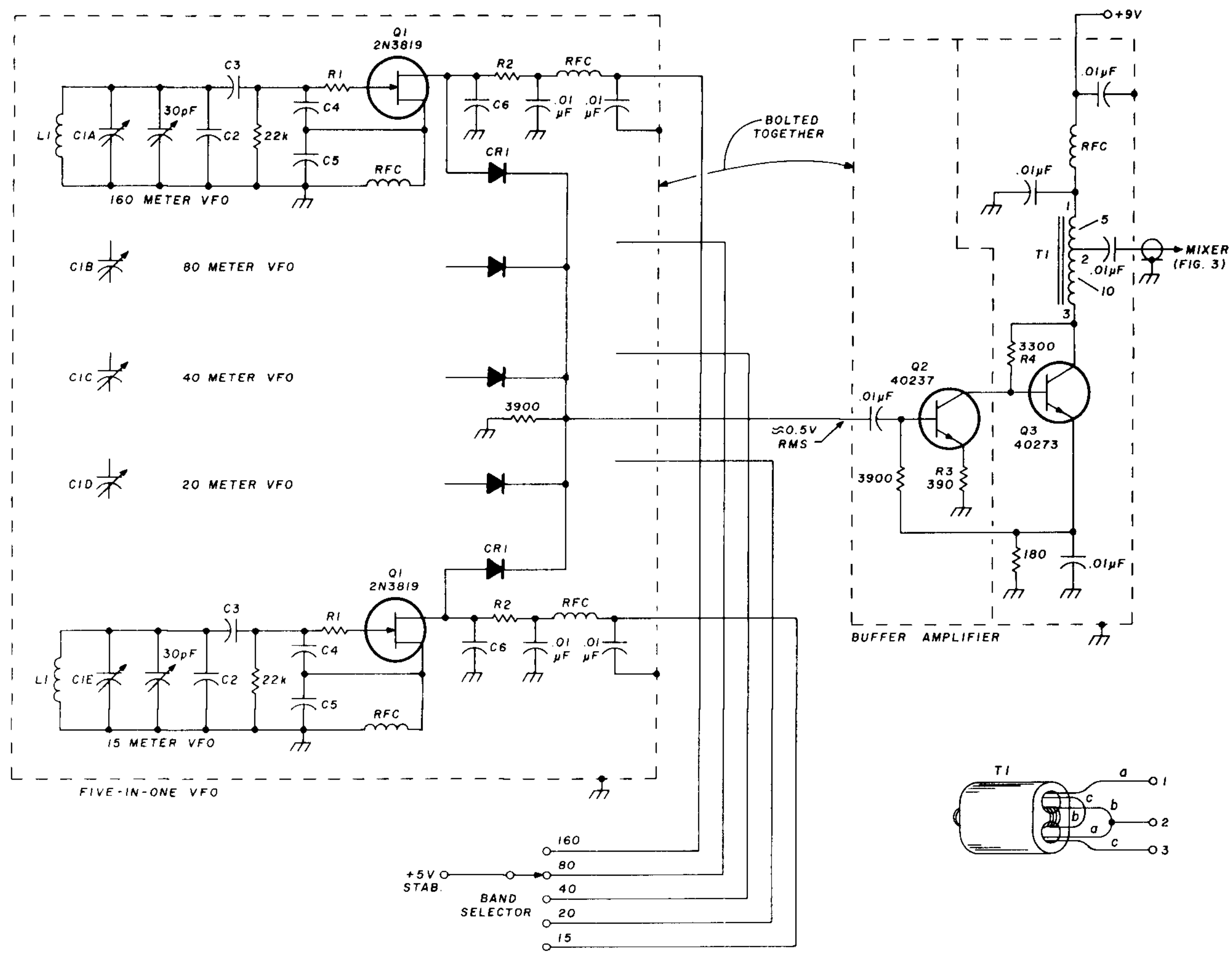


fig. 5. Vfos and buffer amplifier schematic. A separate oscillator is used for each band, which is selected by connection to the supply voltage. C1 is a five-gang capacitor with all but one plate removed in the rotor section for 7, 14, and 21 MHz. CR1 can be any rf silicon diode such as a 1N914. Instead 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.

does not 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 stepdown 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 feedthrough 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 usng an SL640 IC 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

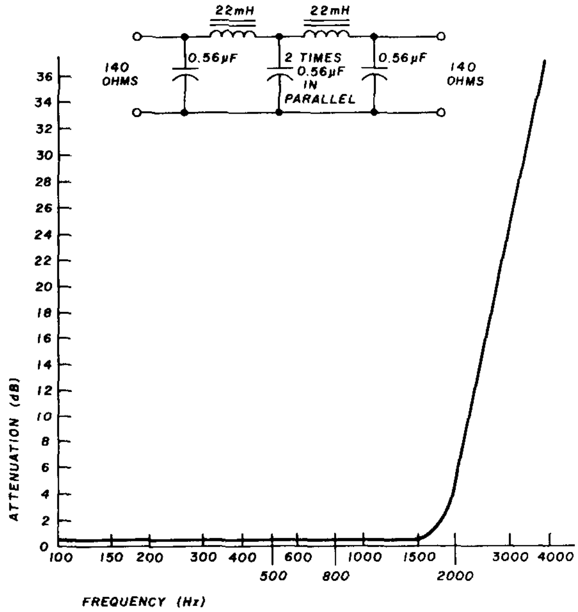


fig. 6. Measured frequency response of ssb filter.

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 o f **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 dections 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 ½ 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

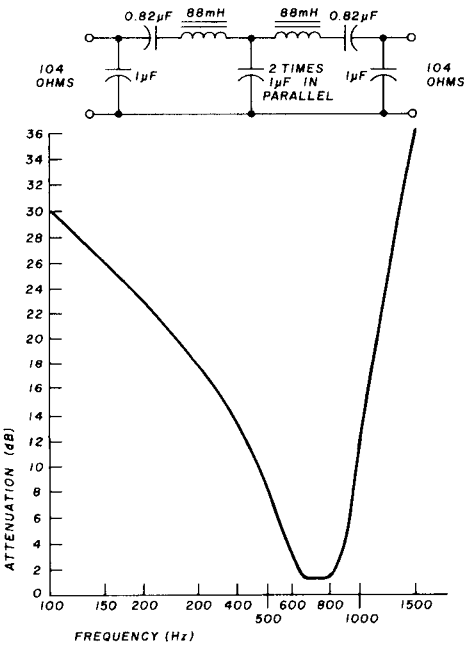


fig. 7. Measured frequency response of CW filter.

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 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 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 underloaded 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

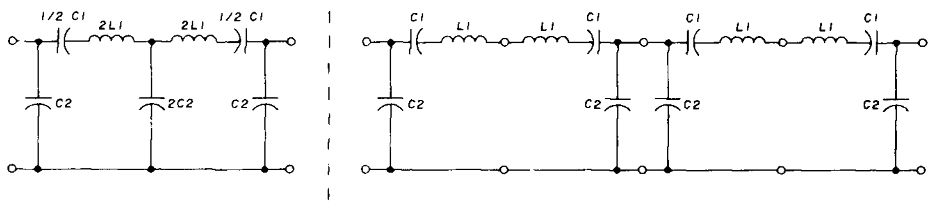


fig. 8. The CW filter is a combination of four half sections, shown to the right of the vertical line. Note how coils and capacitors in the individual sections are combined in the actual filter at the left of the dashed vertical line.

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.

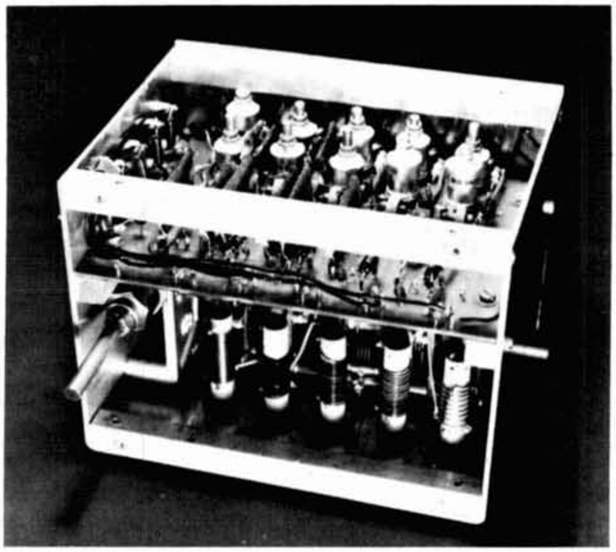
Very suitable for our purpose are microphone transformers from communications equipment using tubes (war-surplus transmitters, obsolete mobile radios). Transformer T1 in **fig. 3** came from Wireless Set type 19, a famous British WW II veteran. The photograph shows the unit in its shielded box. A test 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 providded 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

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



Inside view of the five-in-one vfo.

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 oscillato r 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.

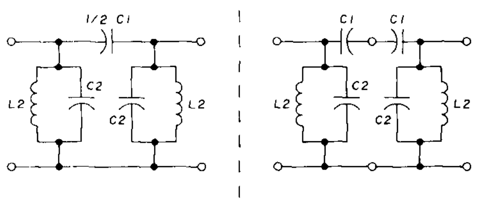


fig. 9. Bandpass filter built from two half sections provides only half as steep a filter slope compared with circuit of fig. 8, although the number of coils is two in each case. The actual filter is to the left of the dotted line.

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 and early thirties, 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 af 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.[5] 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 breakthrough, 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,[6] 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

1. Bozidar Pasaric, YU2HL, "A New Front End for Direct-Conversion Receiver," *QST*, October, 1974, page 11.
2. E. M. Cherry and D.E. Hooper, "The Design of Wideband Transistor Feedback Amplifiers," *Proceedings of the I.E.E.*, Vol. 110, No. 2, February, 1963.
3. Max J. Fuchs, WA1NJG, "88-mH Toroid Coils," (ham notebook), *ham radio*, June, 1976, page 70.
4. *Reference Data for Radio Engineers*, 4th Edition, Howard W. Sams & Co., Indianapolis, Indiana, page 168.
5. James K. Boomer, WØVDC, "Noise Considerations in Receiver Design," *QST*, June, 1965, page 45 (graph on page 48).
6. James R. Fisk, W1HR, "Receiver Noise Figure and Dynamic Range — What the Numbers Mean," *ham radio*, October, 1975, pages 8-25.

ham radio

high performance 20-meter receiver with digital frequency readout

Part two: digital counter, display, and receiver integration

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 abililty 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[1] 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

By M. A. Chapman, K6SDX, 935 Elmview Drive, Encinitas, California 92024

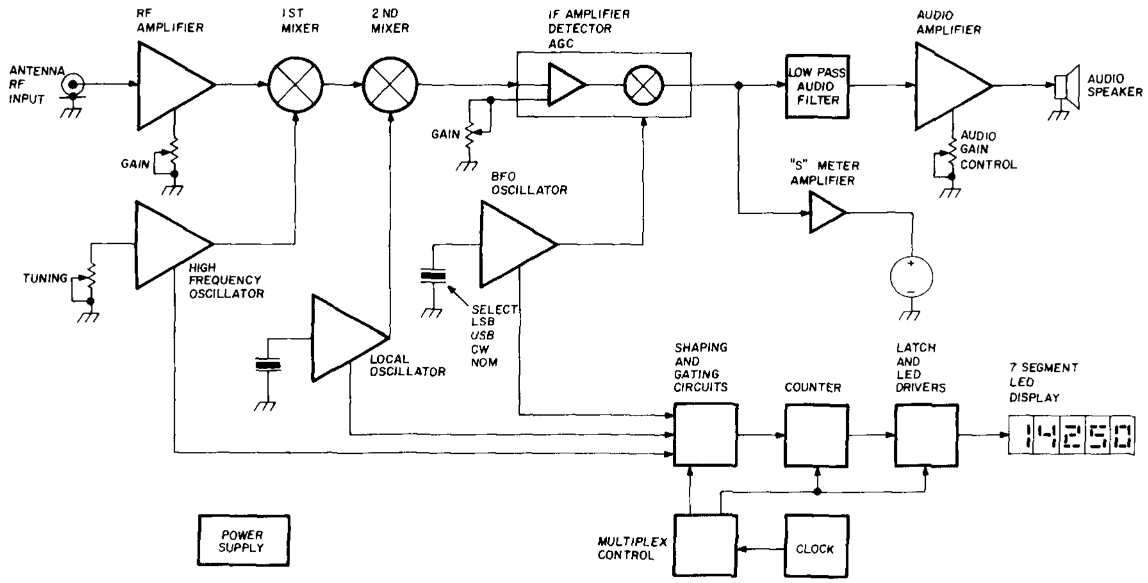


fig. 1. Block diagram of 20-meter high-performance receiver.

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 $\overline{A}B$ 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

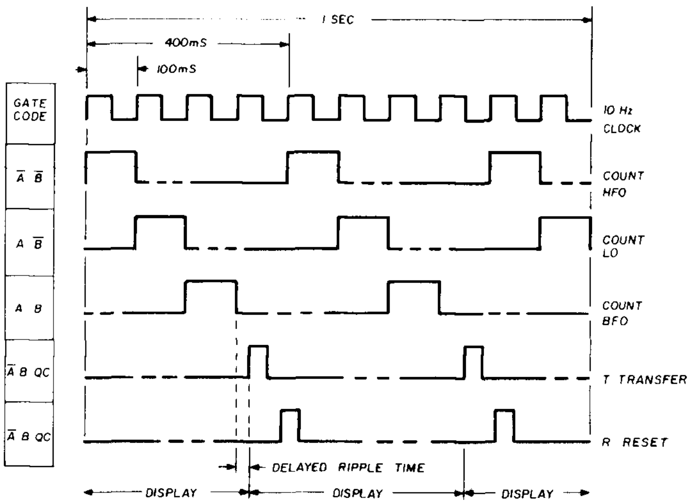


fig. 2. Counter timing diagram for a 2.5 Hz count/display operation.

the multiplex $\overline{A}$ B state. The strobe used in conjunction with the 10-Hz clock is then ganged 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

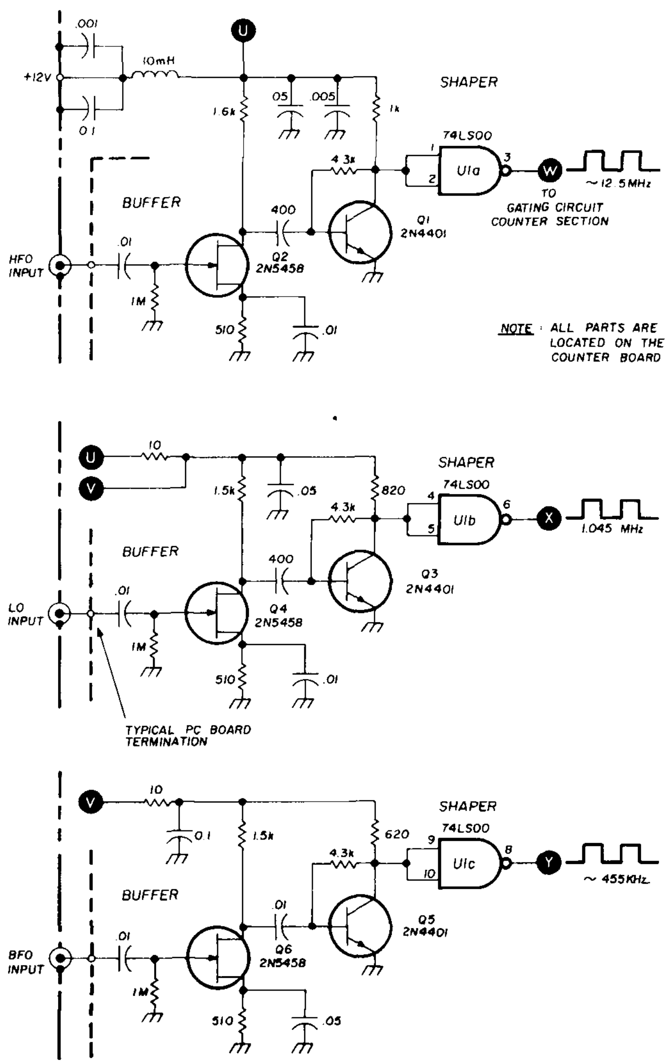


fig. 3. Input buffer and shaping circuits, counter section.

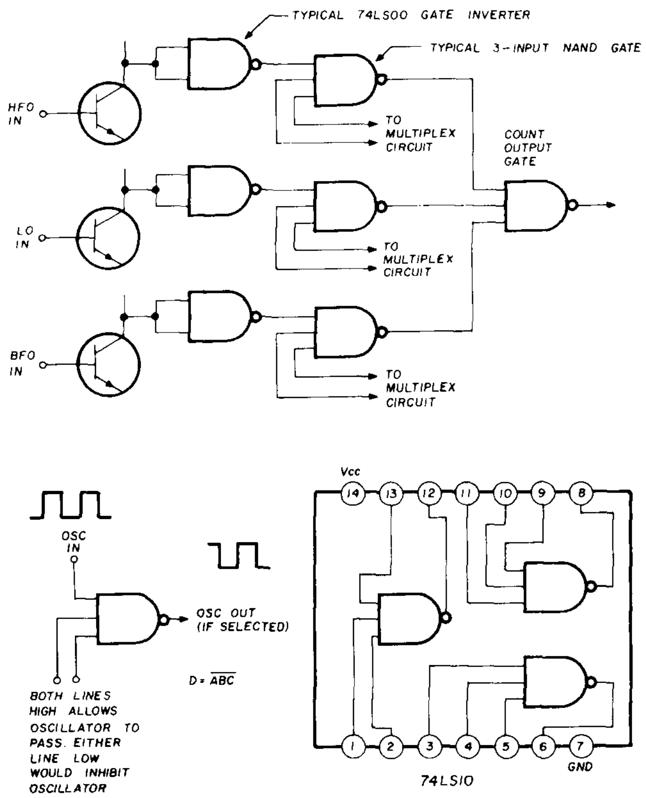


fig. 4. Triple 3-input positive NAND gate function diagram.

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 multiplex 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 multiplex 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 $\overline{A}$ 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

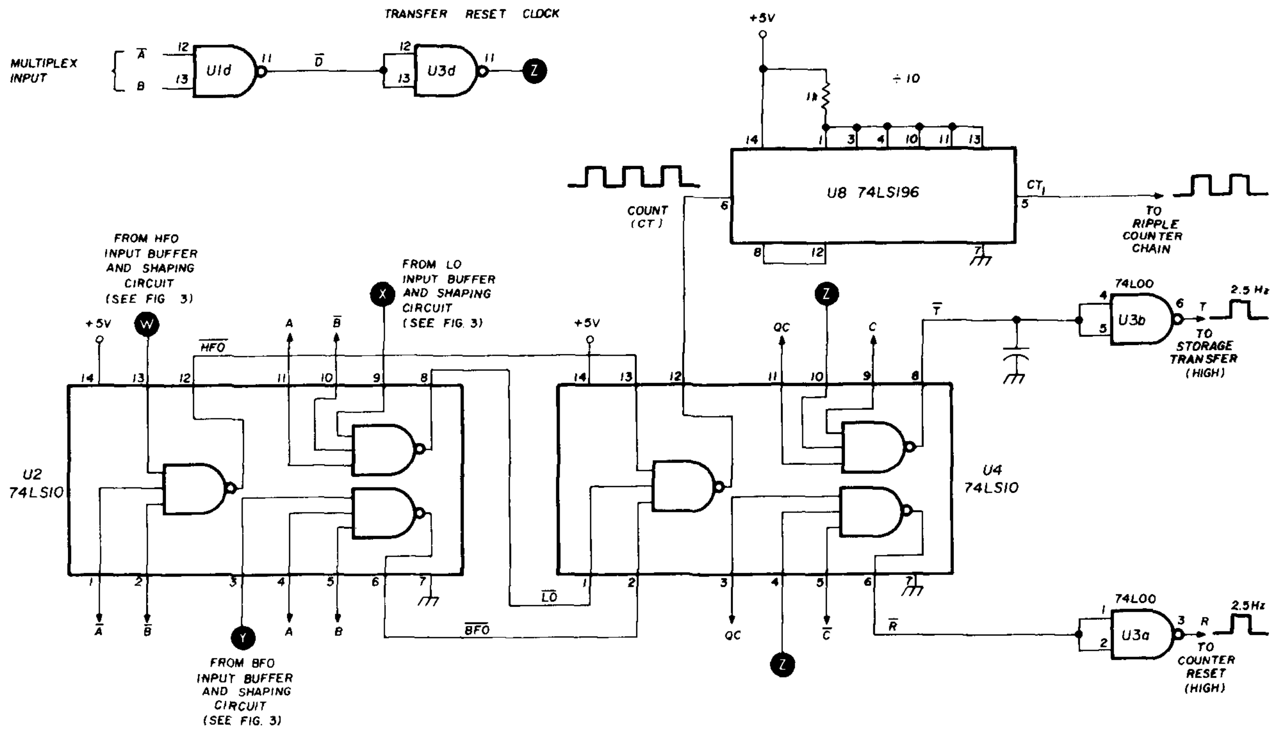


fig. 5. Gating circuits; counter section schematic.

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 $\overline{C}$), 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, . . . 111), so that the various counter states are derived for count, transfer, and reset at specific timing intervals.

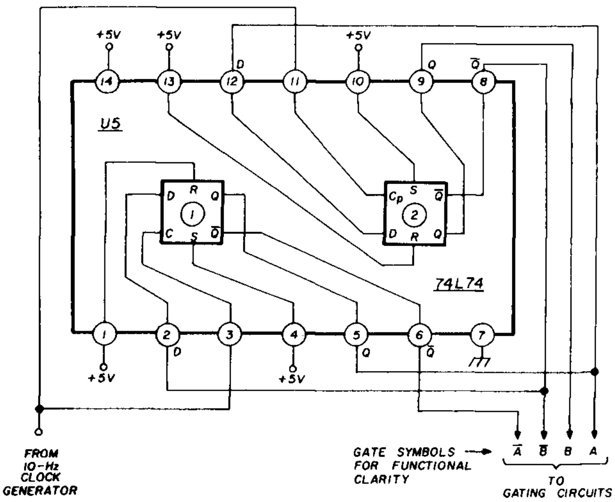


fig. 6. Multiplex gate control generator; counter section schematic.

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 $\overline{C}$. 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.

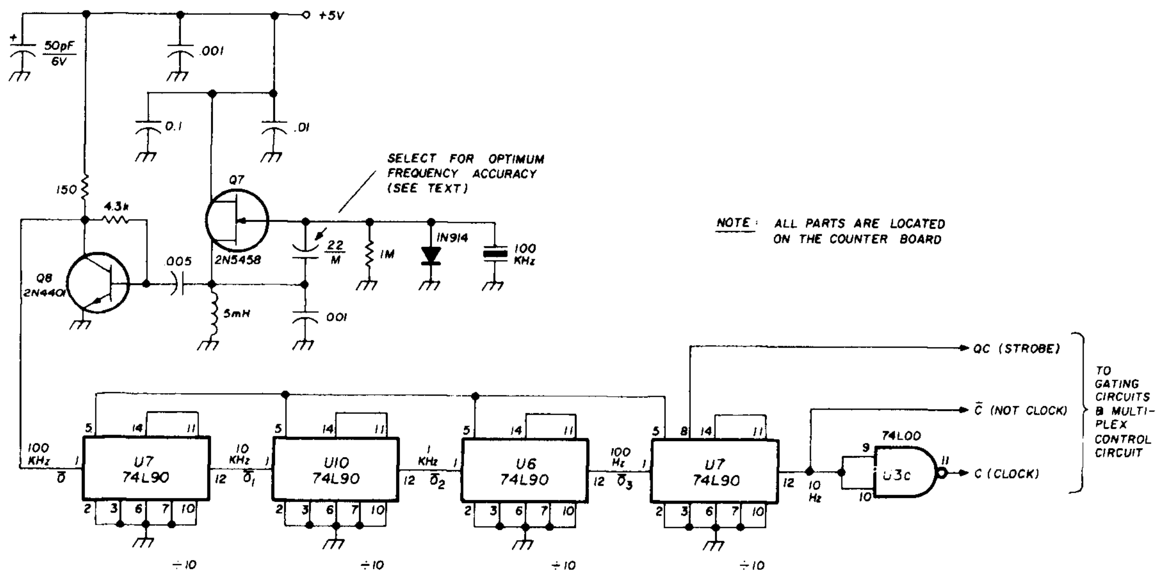


fig. 7. 10-Hz clock and NOT-clock generator schematic.

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 104.5×10^3 pulses respectively. The total accumulated counts after gating is the sum of the 100-millisecond-sampled oscillators, or:

$$\begin{array}{r} 1.2625 \times 10^6 \\ 0.1045 \times 10^6 \\ \underline{0.0455} \times 10^6 \\ 1.4125 \times 10^6 \end{array}$$

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 CT_1. This 141.125 kHz train first passed through an additional decade divider to produce CT_2. 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. CT_1 enters a divide-by-10 stage; its output is CT_2. CT_2 enters a decade divider

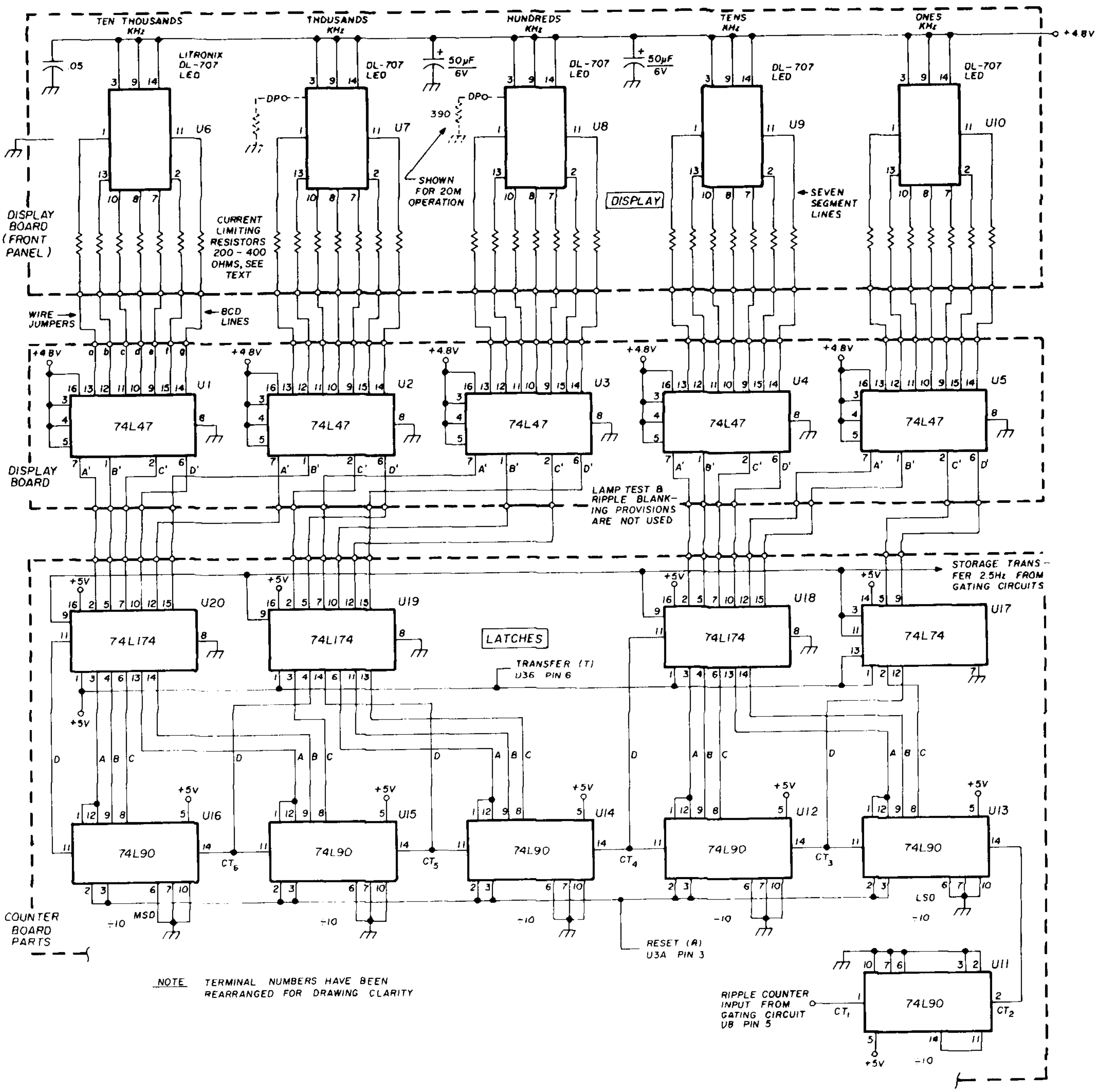


fig. 8. Ripple counter, latch, and segment display schematic.

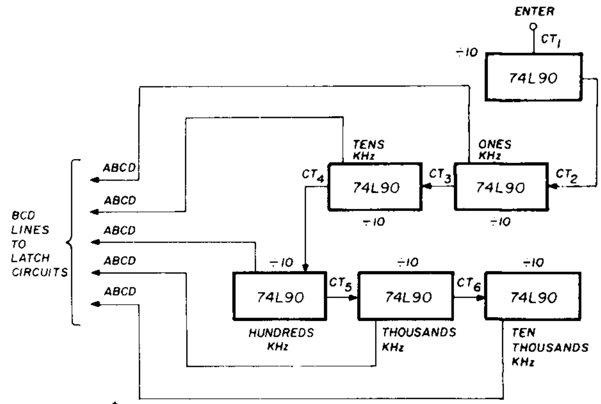


fig. 9. Ripple counter functional diagram.

with BCD ouput lines. Its output, CT_3, 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-

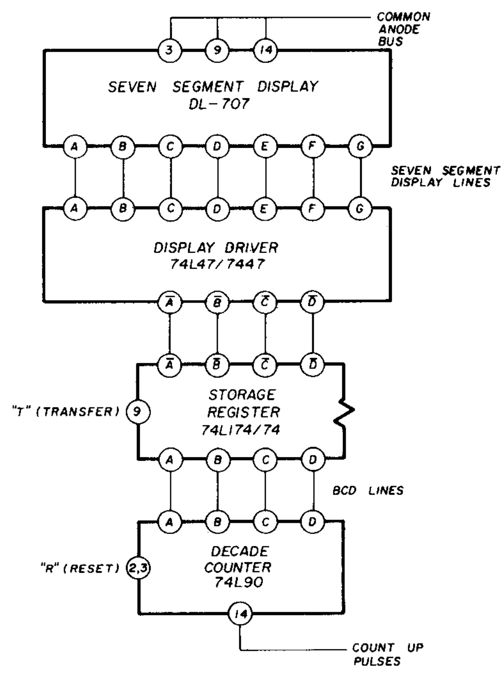
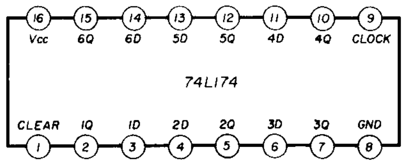


fig. 10. Typical count and display scheme (single digit).

mat 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



INFORMATION ON THE D INPUT LINES IS TRANSFERED TO THE Q OUTPUTS ON THE POSITIVE-GOING EDGE OF THE CLOCK PULSE. CLOCK FREQUENCY ~ 35MHz MAX.

INPUTS			OUTPUTS
CLEAR	CLOCK	D	Q
L	X	X	H
H	↑	H	H
H	↑	L	L
H	L	X	Q_0

fig. 11. HEX D-Type flip-flop with clear (top view).

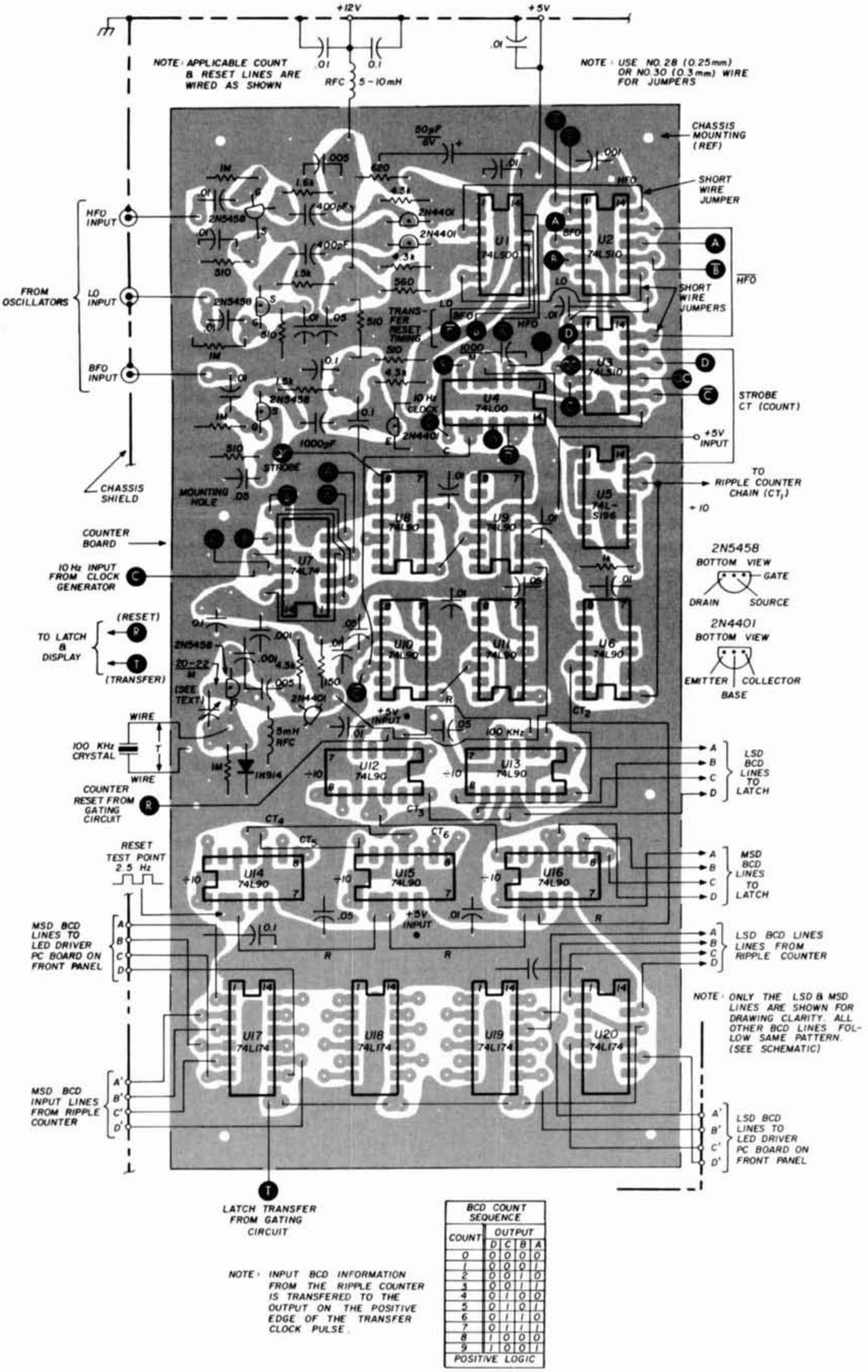
lines and transfer to the output Q lines on the leading edge of the clock, or T pulse in this case. A complete illustration of the latch is shown in **fig. 11**.

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 art work 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



BCD COUNT SEQUENCE

COUNT	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

POSITIVE LOGIC

fig. 12. Component placement diagram for the main counter board.

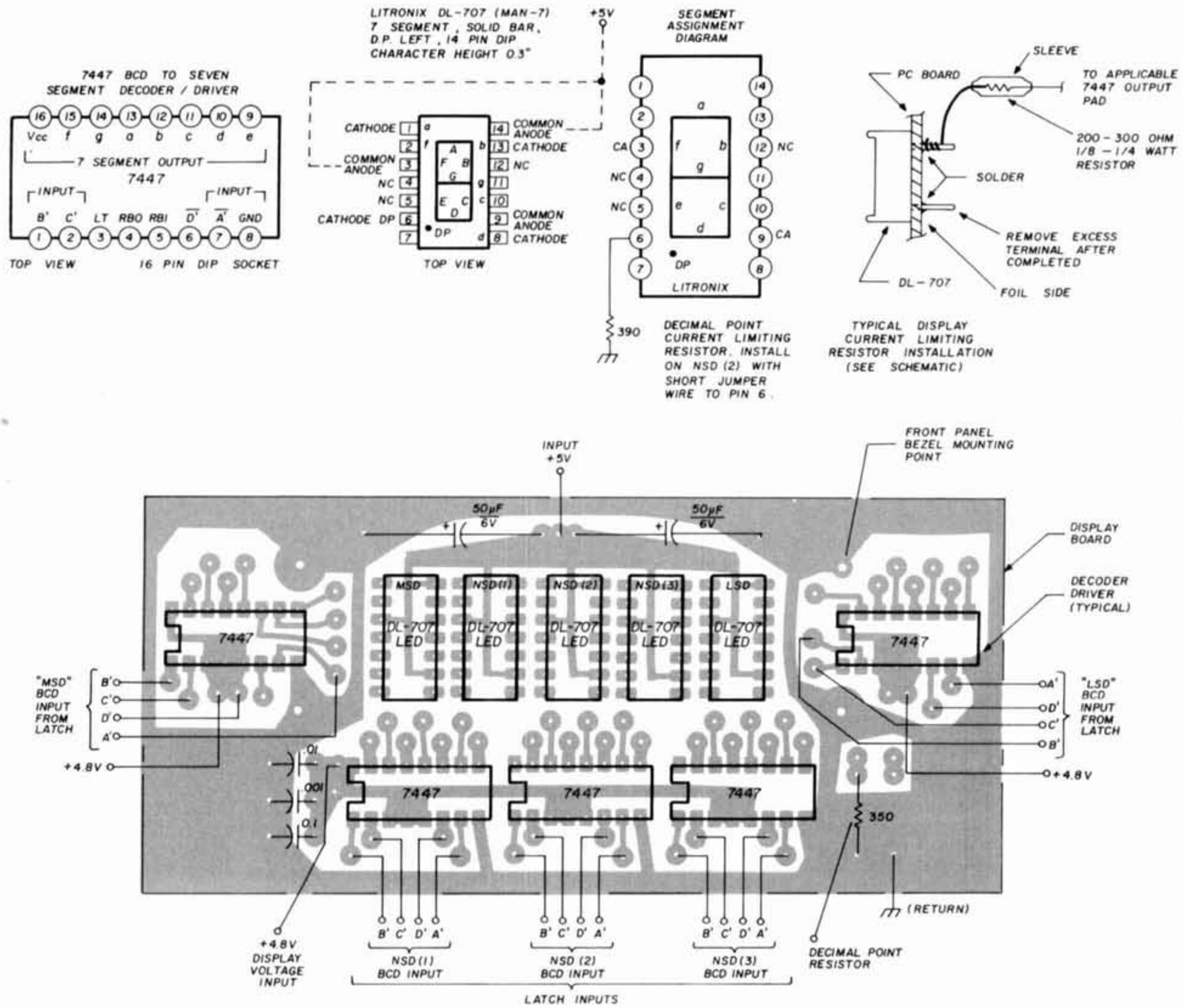


fig. 13. Decoder/driver and LED display PC component installation.

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 accurate 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

1. M. A. Chapman, K6SDX, "High-Performance 20-Meter Receiver with Digital Frequency Readout," Part one, *ham radio*, October, 1977, pages 48.

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_{FV} control potentiometer value is increased by a factor of 10, and

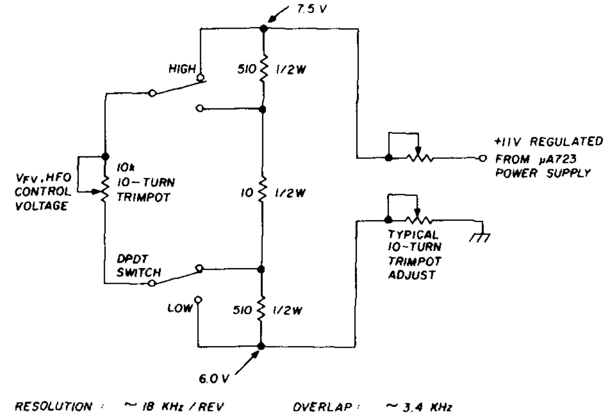


fig. A1. Split bandspread for high-resolution tuning.

a series voltage divider network of three resistors plus a simple dpst switch do the rest. Presuming that the original V_{FV} 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.

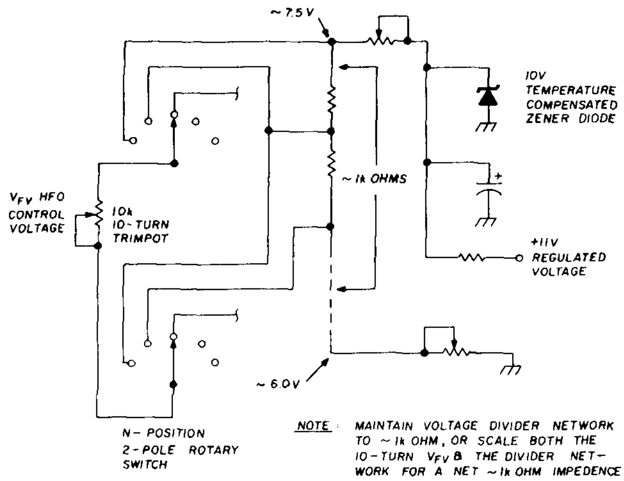


fig. A2. Ultra high-resolution bandspread scheme.

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 parts, equal or unequal. Assuming five equal parts at the previous 360-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

crystal-controlled harmonic generator

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 μL914 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 ¼ 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.

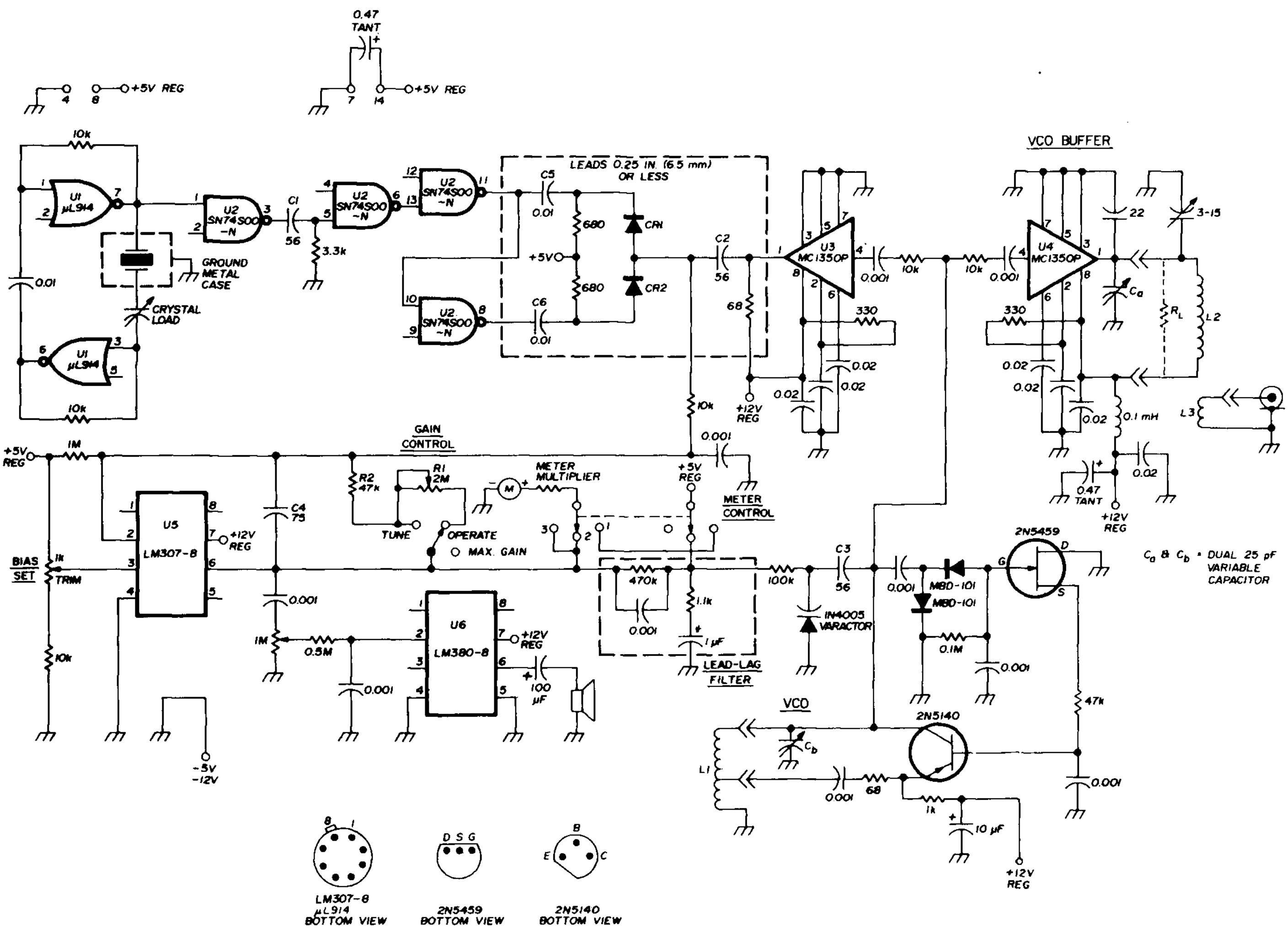


fig. 1. Schematic of the phase-locked loop, crystal-controlled harmonic generator. Circuit provides high-accuracy integer harmonics from a basic crystal-oscillator frequency.

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 a 1N4005 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 1N4005 was about 50%; the 1N4007 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

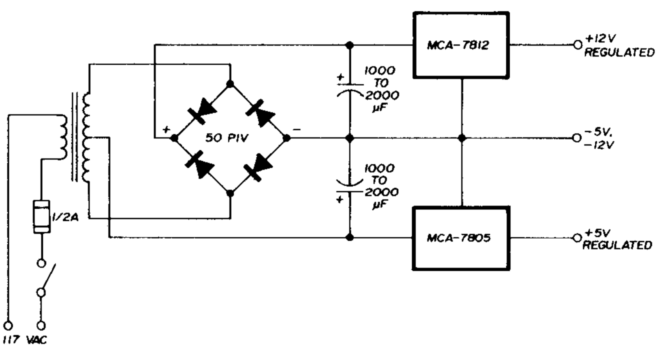


fig. 2. Suggested power-supply circuit, which provides regulated 5 and 12 volts.

and buffer frequencies is much more easily accomplished with a counter. If a counter isn't available, a continuous-coverage communications receiver can be pressed into service.

Assuming the crystal oscillator is working and that the vco is oscillating near one of the required harmonics, use the following steps.

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.

conclusion

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 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

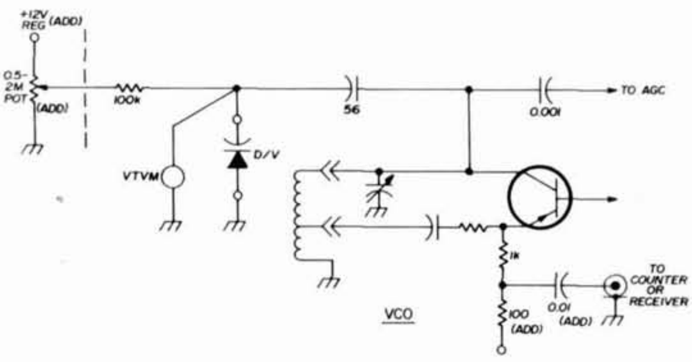


fig. 3. Test setup using the vco to determine suitability of diodes for varactor service.

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 W4OQ 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

1. K. W. Robbins, W1KNI, "Transistors and ICs in a Phase-Locked Local Oscillator," *QST*, January, 1972. (Corrections in QST, February, 1972 and subsequent issues of *The ARRL Handbook*.)
2. K. W. Robbins, W1KNI, "PLL Update," July, 1975 (unpublished).

ham radio

improved receiver selectivity and gain control

An alternative to the manually switched front-end attenuator for hf receivers — a PIN diode attenuator and cascaded i-f 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 i-f 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,[1] 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 i-f 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.[2,3]

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[2] showed that cascading i-f 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[2,3,4,5] 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.

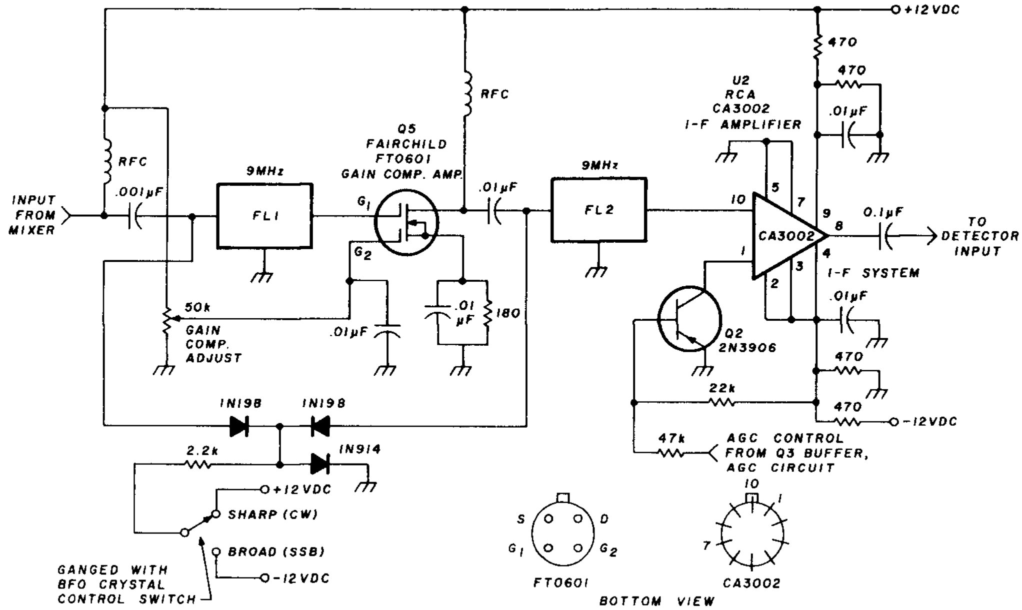
The following circuitry is the end result of these deliberations — another "great leap forward" in the endless quest for the ultimate in homebuilt receivers.

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, this 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

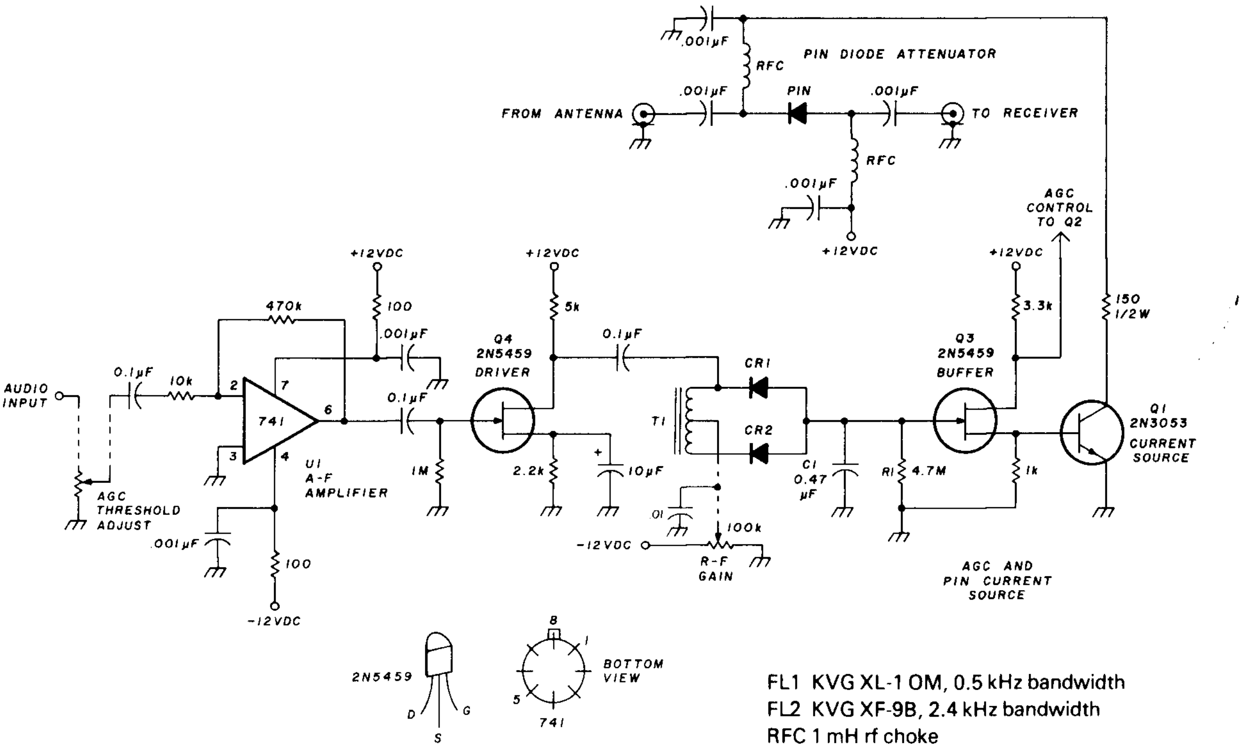


CR1, CR2	Germanium diode	RFC	1 mH, 100 mA rf choke
PIN	Hewlett-Packard 5082-3379	T1	Any small audio transformer

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.

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



FL1 KVG XL-1 OM, 0.5 kHz bandwidth
FL2 KVG XF-9B, 2.4 kHz bandwidth
RFC 1 mH rf choke

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

1. Doug DeMaw, W1FB, "His Eminence — the Receiver," *QST*, June, 1976, page 27.
2. Mike Goldstein, VE3GFN, "A Solid-State 80-meter Receiver," Radio Handbook, 19th edition, Editors and Engineers, page 20.15.
3. Mike Goldstein, VE3GFN, "An Advanced Solid-State Deluxe Amateur-band Receiver," Radio Handbook, 19th edition, Editors and Engineers, page 20.23.
4. Mike Goldstein, VE3GFN "A Portable Amateur Band Receiver," Radio Handbook, 19th edition, Editors and Engineers, page 19.20.
5. Mike Goldstein, VE1ADH and George Cousins, VE1TG, "High Quality Hybrid Receiver," *73*, February, 1968, page 42.

ham radio

KENWOOD

...pacesetter in amateur radio

TS-520S

AND DG-5 DIGITAL FREQUENCY DISPLAY

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 1.8 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 (12BY7A) and the final tubes. Rather than subsitute TV sweep tubes as 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.

HIGHLY EFFECTIVE NOISE BLANKER

An effective noise blanking cricuit developed by Kenwood that virtually eliminates ignition noise is built into the TS-520S.

RF ATTENUATOR

The TS-520S has a built-in 20 dB attentuator that can be activated by a push button swich conveniently located on the front panel.

PROVISION FOR EXTERNAL RECEIVER

A special jack on the rear panel of the TS-520S provides receiver signals to an external receiver for increased station versitility. A switch on the rear panel determines the signal path . . . the receiver in the TS-820 or any external receiver.

VFO-520 — NEW REMOTE VFO

The VFO-520 remote VFO matches the styling of the TS-520S and provides maximum operating flexibility on the band selected on your TS-520S.

AC POWER SUPPLY

The TS-520S is completely self-contained with a rugged AC power supply built-in. The addition of the DS-1A DC-DC converter (optional) allows for mobile operation of the TS-520S.

EASY PHONE PATCH CONNECTION

The TS-520S has 2 convenient RCA phono jacks on the rear panel for PHONE PATCH IN and PHONE PATCH OUT.

CW-520 — CW FILTER (OPTION)

The CW-520-500 Hz filter can be easilly installed and will provide improved operation on CW.

AMPLIFIED TYPE AGC CIRCUIT

The AGC circuit has 3 positions (OFF, FAST, SLOW) to enable the TS-520S to be operated in the optimum condition at all times whether operating CW or SSB.

The TS-520S retains all of the features of the original TS-520 that made it tops in its class: RIT control • 8-pole crystal filter • Built-in 25 KHz calibrator • Front panel carrier level control • Semi-break-in CW with sidetone • VOX/PTT/MOX • TUNE position for low power tune up • Built-in speaker • Built-in Cooling Fan • Provisions for 4 fixed frequency channels • Heater switch.

TS-520 Specifications

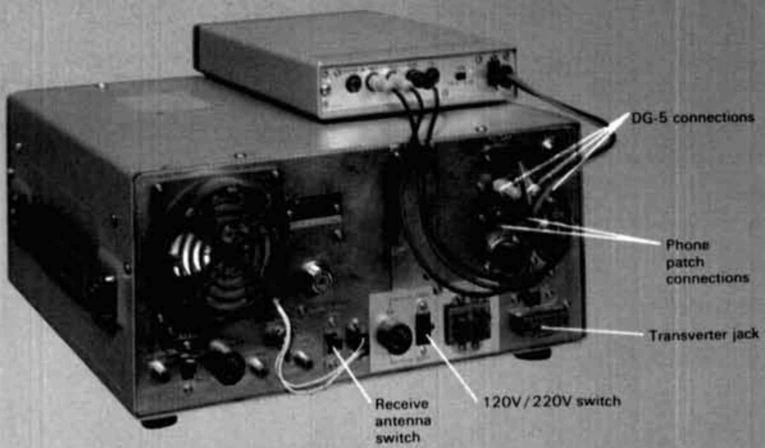
Amateur Bands: 160-10 meters plus WWV (receive only)
Modes: USB, LSB, CW
Antenna Impedance: 50-75 Ohms
Frequency Stability: Within ±1 kHz during one hour after one minute of warm-up, and within 100 Hz during any 30 minute period thereafter
Tubes & Semiconductors:
Tubes 3
(S2001A x 2, 12BY7A)
Transistors. 52
FETs 19
Diodes. 101
Power Requirements: 120/220 V AC, 50/60 Hz, 13.8 V DC (with optional DS-1A)
Power Consumption: Transmit: 280 Watts Receive: 26 Watts (with heater off)
Dimension: 333(13⅛) W x 153 (6-0) H x 335(13-(13-3/16) D mm(inch)
Weight: 16.0 kg(35.2 lbs)

TRANSMITTER
RF Input Power: SSB: 200 Watts PEP 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 uV for 10 dB (S+N)/N
Selectivity: SSB:2.4 kHz/-6 dB, 4.4 kHz/-60 dB
Selectivity: 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

SPECIFICATIONS
Measuring Range: 100 Hz to 40 MHz
Input Impedance: 5 k Ohms
Gate Time: 0.1 Sec.
Input Sensitivity: 100 Hz to 40 MHz . . . 200 mV rms or over, 10 kHz to 10 MHz . . 50 mV or over
Measuring Accuracy: Internal time base accuracy ±0.1 count
Time Base: 10 MHz
Operating Temperature: -10° to 50° C/14° 122° F
Power Requirement: Supplied from TS-520S or 12 to 16 VDC (nominal 13.8 VDC)
Dimensions: 167(6-9/16) W x 43(1-11/16) H x 268(10-9/16) D mm(inch)
Weight: 1.3 kg(2.9 lbs)



DG-5

The luxury of digital readout is available on the TS-520S by connecting the DG-5 readout (option). 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 anyplace in your shack for easy to read operation . . . or set it on the dash board 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-520 adapter kit.

KENWOOD

...pacesetter in amateur radio

TS-820S

WITH DIGITAL FREQUENCY DISPLAY

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.

TS-600

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".

TV-506

An easy way to get on the 6 meter band with your TS-520/520S, TS-820/820S and most other transceivers. Simply plug it in and you're on . . . full band coverage with 10 watts output on SSB and CW.

TR-8300

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 F_3 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.

KENWOOD

...pacesetter in amateur radio

TS-700S

WITH DIGITAL FREQUENCY DISPLAY

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 frequency 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 interferance, 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

. . . pacesetter in amateur radio

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.

R-599D T-599D

R-300

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 anyplace • Automatically switches to battery power in the event of AC power failure.

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 spurs 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.[1-3] One of the very simplest and easiest to use is that of Fisk[4] 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.[5]

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

ratio	spur product	order	difference, terms of lower frequency	zero beat
0.600	$4F_L - 2F_H$	6	$2F_L/3$	682.5 kHz
0.667	$2F_L - F_H$	3	$F_L/2$	910.0 kHz
0.750	$3F_L - 2F_H$	5	$F_L/3$	1365.0 kHz

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

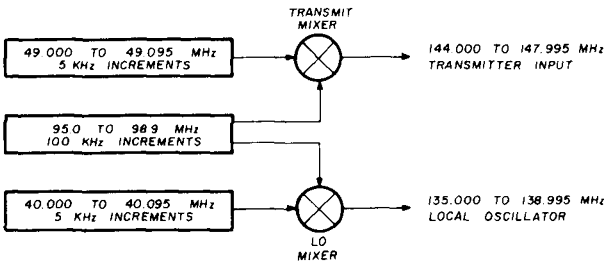


fig. 1. Mixing synthesizer frequency control system for a two-meter transceiver with a 9-MHz i-f. This system has several unwanted spurs, as discussed in the text.

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[5] 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 49.000/98.9 = 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.

F_L/F_H ratio	spur product	spur order	difference output due to spur product in terms of: F_L	F_H
0.143	$6F_L$	6	$6F_L$	$6F_H/7$
0.167	$5F_L$	5	$5F_L$	$5F_H/6$
0.200	$4F_L$	4	$4F_L$	$4F_H/5$
0.250	$3F_L$	3	$3F_L$	$3F_H/4$
0.333	$2F_L$	2	$2F_L$	$2F_H/3$
0.400	$4F_L - F_H$	5	$3F_L/2$	$3F_H/5$
0.500	F_L	1	F_L	$F_H/2$
0.600	$4F_L - 2F_H$	6	$2F_L/3$	$2F_H/5$
0.667	$2F_L - F_H$	3	$F_L/2$	$F_H/3$
0.750	$3F_L - 2F_H$	5	$F_L/3$	$F_H/4$

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 lowpass 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 adapability 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

table 2. Spur identification of sum output. Note that there are two possible spur products for each F_L/F_H ratio.

F_L/F_H ratio	spur products		spur order	sum output due to spur product in terms of: F_L	F_H
0.200	$6F_L$	or $2F_H - 4F_L$	6	$6F_L$	$6F_H/5$
0.250	$5F_L$	or $2F_H - 3F_L$	5	$5F_L$	$5F_H/4$
0.333	$4F_L$	or $2F_H - 2F_L$	4	$4F_L$	$4F_H/3$
0.500	$3F_L$	or $2F_H - F_L$	3	$3F_L$	$3F_H/2$
0.667	$4F_L - F_H$	or $3F_H - 2F_L$	5	$5F_L/2$	$5F_H/3$

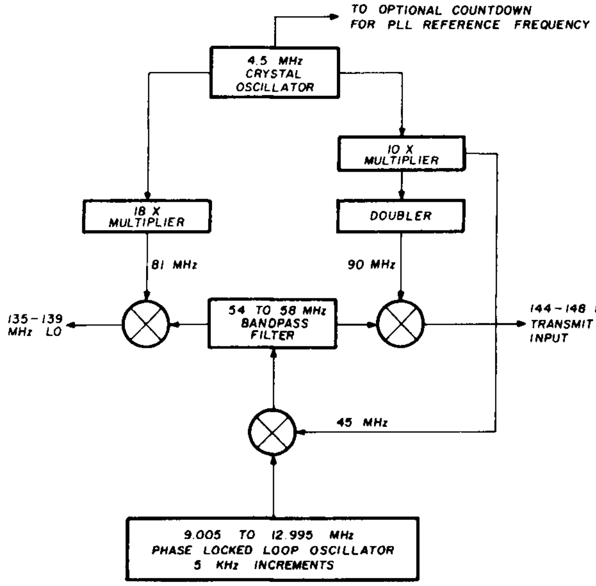


fig. 2. A 144-MHz transceiver frequency control circuit using a phase-locked-loop oscillator and mixing with a crystal oscillator reference.

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

$$e_n = \left[\frac{2A}{n^2\pi^2 F t_r}\right] \left| Sin\ (n\pi F\ t_r)\ Sin\ (n\pi F\ t_w)\right| \quad \textbf{(1)}$$

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_w = 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.[7]

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 ampltude varies between devices and examples may be found in the manufacturer's data books.[8] 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 V_{CC} 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 TLL devices are required at such frequencies. A different frequency set is needed since the spurs at the lower band 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

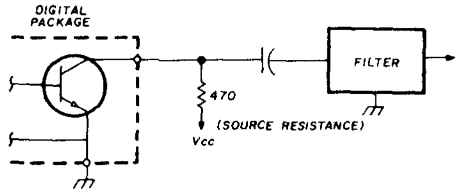


fig. 3. Digital to analog interface through a filter using open-collector outputs.

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 it 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.

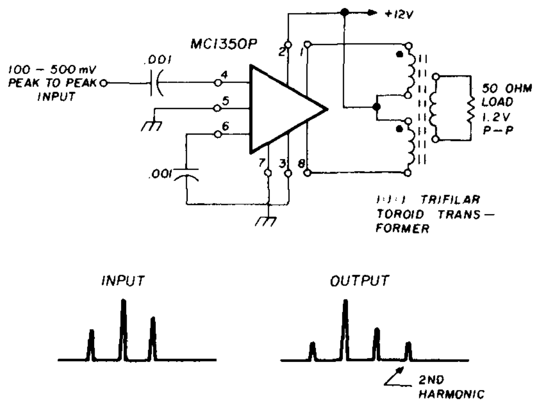


fig. 4. Using an active limiter as a spur suppressor. The input and output signal spectra are shown at the bottom with spurs to either side of the center frequency (logarithmic vertical scale).

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 antennas, 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

1. John R. Coleman, "Programmable Calculator Performs Spur Analaysis," *Electronics*, September 2, 1976, page 108, (for HP-25).
2. M. Y. Huang, R. L. Buskirk, D. E. Carlile, "Select Mixer Frequencies Painlessly," *Electronic Design*, April 12, 1976, page 104, (algorithm for desk calculator).
3. Raymond P. Meixner, "BASIC Computer Algorithm Spots Spurious Responses," *Microwaves*, March, 1977, page 42, (complete BASIC source code, adaptable to microcomputers).
4. James Fisk, WA6BSO, "Choosing I-F and Mixer Frequencies," *73*, April, 1966, page 62.
5. Roger T. Stevens, "Linear Scales Show Mixer Harmonics," *Electronics*, January 10, 1964, page 37.
6. James Fisk, W1DTY, "Receiver Sensitivity, Noise Figure, and Dynamic Range," *ham radio*, October, 1975, page 8.
7. *Reference Data For Radio Engineers*, 4th Edition, ITT, page 1021.
8. *Signetics 1976 Data Book*, Signetics Corporation, Sunnyvale, California, page 4.
9. *Motorola Application Note AN-513*, Motorola Semiconductor Products, Inc., Phoenix, Arizona, (full description of MC1590, applies to MC1350).
10. Aron Levy, "Head Off DC/DC-Converter Problems," *Electronic Design*, August 16, 1976, page 72.
11. Arpad Barna, "On The Transient Response Of Emitter Followers," *IEEE Journal of Solid-State Circuits*, June, 1973, page 233.
12. Michael Chessman, Nathan Sokal, "Prevent Emitter-Follower Oscillation," *Electronic Design*, June 30, 1976, page 110.

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.

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.

Accessories
- VX-2 Vox
- MK-II Linear amplifier
- DD-76 Digital Dial

The 750CW is a CW man's dream come true. What's more there's a long list of accessories you can add later for increased performance.

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
- 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)

Accessories
- VX-2 Vox
- 14A DC Converter
- 1200X linear amplifier

- Crystal Calibrator (350A only)

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

350D. $699.95 with built-in A.C. power supply.

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)

SWAN® ELECTRONICS

A subsidiary of Cubic Corporation

305 Airport Road, Oceanside, CA 92054

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

high-dynamic range active double-balanced mixer

By Ulrich L. Rohde, DJ2LR

During recent years, much research has been done on solid-state mixer design. One important design configuration was described by Rafuse;[1] 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.[2] 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,[3] optimum performance of present-day active mixers can only be

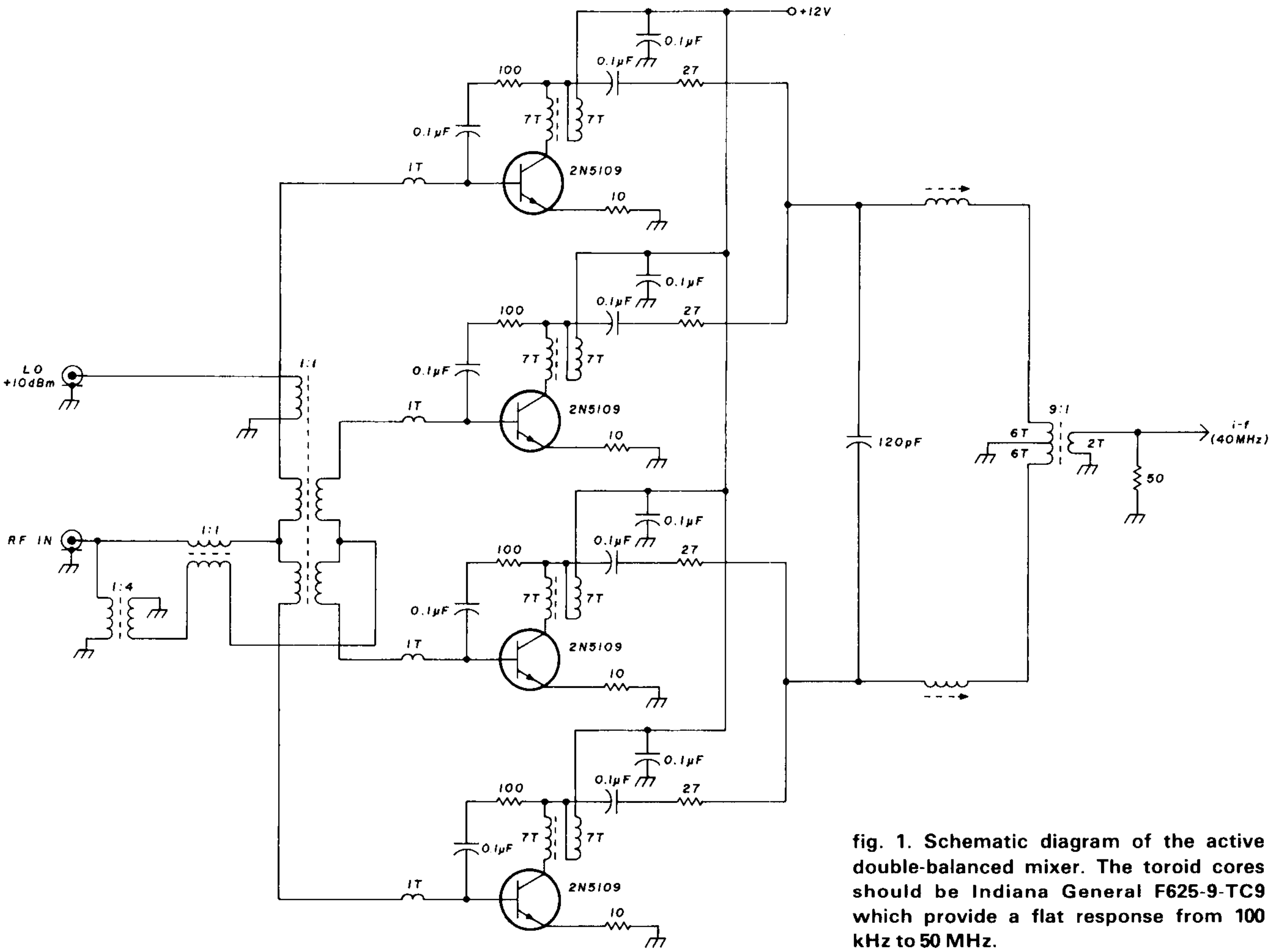
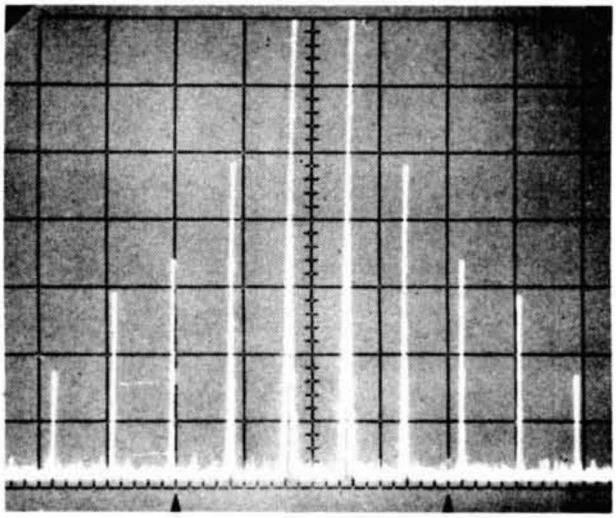
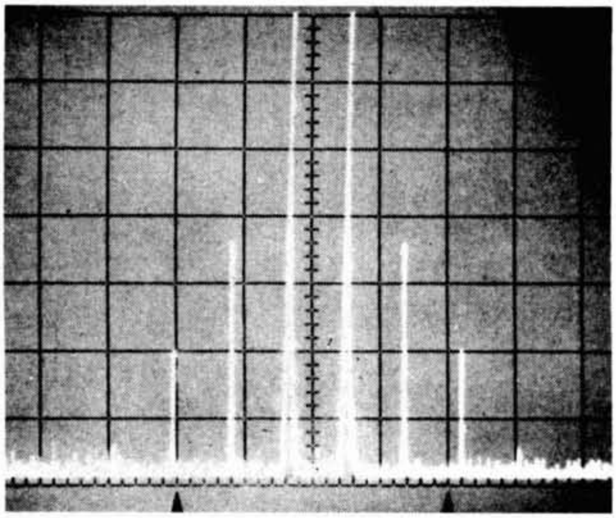
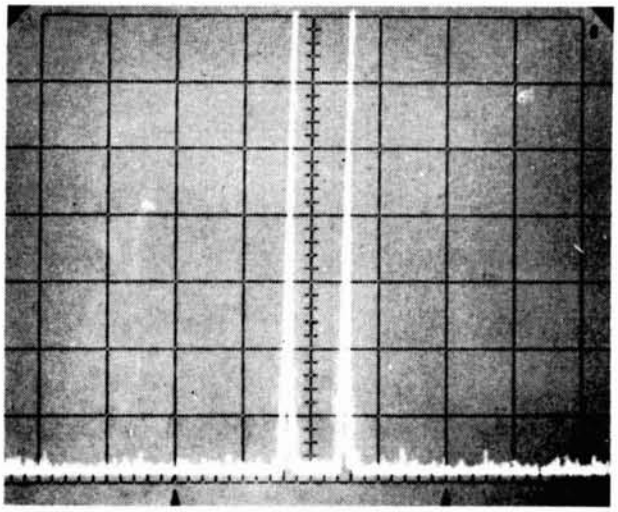


fig. 1. Schematic diagram of the active double-balanced mixer. The toroid cores should be Indiana General F625-9-TC9 which provide a flat response from 100 kHz to 50 MHz.







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.[4] 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.

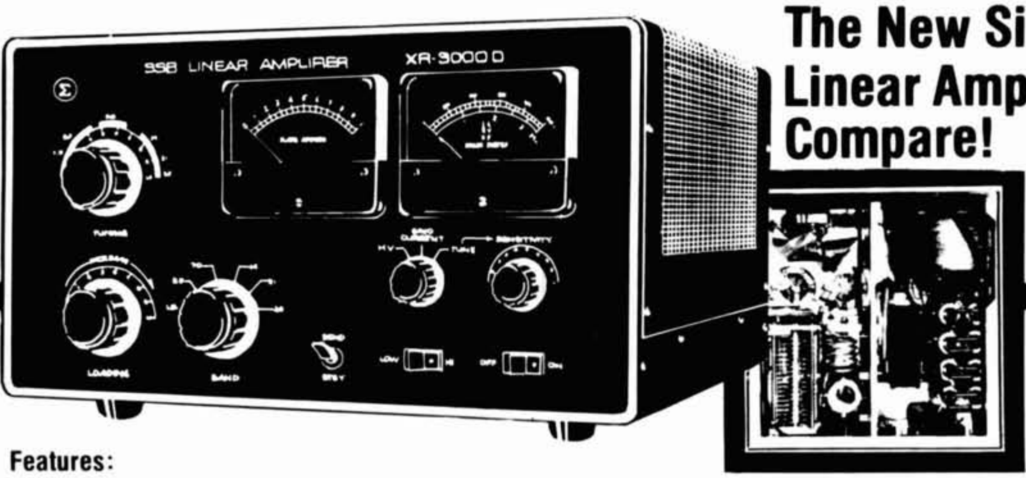
Recent developments in the transistor field have produced a group of CATV transistors that are characterized by low noise figures and high gain-bandwidth products. By applying new types of rf feedback, linear operation can be obtained that will provide superior IMD product performance over previous fet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

1. R. P. Rafuse, "Symmetric Mosfet Mixer of High Dynamic Range," *1968 International Solid State Conference Circuits*, February, 1968, page 122.
2. E. Oxner, "Fets in Balanced Mixers," *Siliconix Applications Note*, Siliconix, Inc., Santa Clara, California, July, 1972.
3. U. L. Rohde, "High Dynamic Range Receiver Input Stages," *ham radio*, October, 1975, page 26.
4. U. L. Rohde, "High-Frequency Receiver Design," *ham radio*, October, 1976, page 10.

ham radio



The New Sigma XR3000D Linear Amplifier Compare!

Introductory price

$789

2 Day Air Shipment
Anywhere in U.S. $35
Alaska and Hawaii Slightly Higher

Features:

Custom computer grade commercial components, capacitors, and tube sockets manufactured especially 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 relative 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.

- Full band coverage 160-10 meters including mars.
- 2000 watts P.E.P. SSB input. 1000 watts input continuous duty, CW, RTTY & SSTV.
- Two Eimac 3-500Z 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).

HOLIDAY INTRODUCTORY SPECIAL!

New! Sigma Model AF250L Deviation/Modulation Meter

Introductory Price

$169

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:

Frequency: 1.8MHZ-520MHZ/3 range select (A, B, C, EXT), A range: 26.5 MHZ-40MHZ, B range: 48MHZ-60MHZ, C range: 140MHZ-156MHZ, EXT. range: 1.8MHZ-520MHZ (Need Signal Generator) • Generous overranges • Input level: (1) Through type input level: IW-200W (RF Input Terminal), (2) Direct input level: More than 80db/50ohm impedance • Amplitude modulation degree: 0-100% • Frequency deviation: 0-20KHZ • Accuracy: +/-3% of full scale • Intermediate frequency: 10.7MHZ • Local input frequency (EXT Range) • Measuring frequency +/-10.7MHZ • RF Attenuator: 0-60db variable • Audio signal oscillator: (1) Audio Frequency—1,000HZ (1 KHZ), (2) Output level—More than 1V RMS • Power Source: AC117V • Dimensions: H-5½" (140mm), W-10¼" (260mm), D-7¼" (184mm) • Weight: 7 lbs.

$29

Introductory Price

NEW CDE HAM III ROTATORS—
Reg. $159.95—$125

Sigma RF-2000 SWR & Power Meter

Cal PWR Scales 200W-2000W Freq Range 3.5-150 MHz Please do not confuse the RF2000 with similar appearing lower priced units. RF2000 is an individually calibrated professional quality instrument. Unequaled at many times the price. Size 7" (w) x 2½" (h) x 2⅓" (d).

KDK **SPECIAL SALE**
FM 144 Accessories

FMPS-4R	Regulated AC PS	$49
FMTP-1	Touch Tone Pad	$59
FMTP-2	Touch Tone Pad with 10 Number Programmable Memory	$99
FMMC-1	Microphone with Built-in Touch Tone Pad	$59
FMTD-1	Private Call Decoder for use with and Programmed by Any Touch Tone Pad	$75
SC-12A	Audible Tone Encoder Decoder	$65
FMSC-1	Scanner—Random, Any Range	$99
FMSC-2	Scanner—Programmable 14 Channels	$65
MARS CAP	Option Kit—Any Frequency, Any Split	$12
FMOF-1	Offset Option Kit—2 Extra Positions, Crystals Required	$10
FMOF-2	+1 MHz Offset Option Kit (No Crystals To Buy)	$10
FMTE-1	Sub Audible Tone (100 Hz Adjustable 67-203 Hz)	$15
FMAT-1	½ Wave Portable Antenna for Hotel, Motel or Apartment	$7.95
	Extra DC Cord & Plug	$3.50
	ACC Socket 5 Pin Din Plug	$1.50
	Owners Manual (Extra)	$5.00
	Service Manual	$2.00
	Mounting Bracket (Extra)	$6.00

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

SRC 146A	$314
4 Xtals 34/94 and 94/94	NC
USA 2 Deluxe Base Charger	$47
PT3644 Leather Case	$12
AT 19 Rubber Ant and Whip	$10
N1-cads	$30
Reg.	$413

NEW!!! Touch Tone pad completely wired and ready to plug in-$69.00

Our Price **$289**

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 variable output capacitor. 10,000 volt fixed capacitors. Silver plated RF conductors. Large precision, easy-to-read dials. 360° readout. Overload protection for SWR meter.

AMATEUR-WHOLESALE ELECTRONICS

8817 S.W. 129th Terrace, Miami, Florida 33176

COURTEOUS PERSONAL SERVICE—SAME DAY SHIPMENT • Prices subject to change without notice.
Telephone: (305) 233-3631 • Telex 51-5628 • Store Hours: 10-5 Mon.-Fri.

BANKAMERICARD master charge

Atlas 210X-215X and 350-XL
Please write for special bonus and package offers.

More Details? CHECK—OFF Page 150

THE FUTURE NOW!

FM 2015 R

KDK ...

All Solid State CMOS PLL digital synthesized - No Crystals to buy! 5KHz steps - 144 - 149 MHz-LED digital readout PLUS MARS-CAP.*
● 5MHzBand 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 Oscilator-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 munted 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 positons A,B,C, provided for installation of optional crystals: EXAMPLE - 1 Mhz offset. Duplex Frequency Offset Built in - 600 Khz plus or minus 5 Khz steps, plus simplex, any frequency.
- **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 2 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.
- **RECEIVE:** 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.

master charge

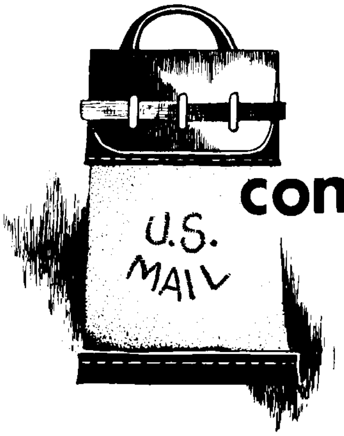
your BANKAMERICARD welcome here

AMATEUR-WHOLESALE ELECTRONICS

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

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

More Details? CHECK—OFF Page 150



comments

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, electrically 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 V_{CC} to V_{SS} 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.

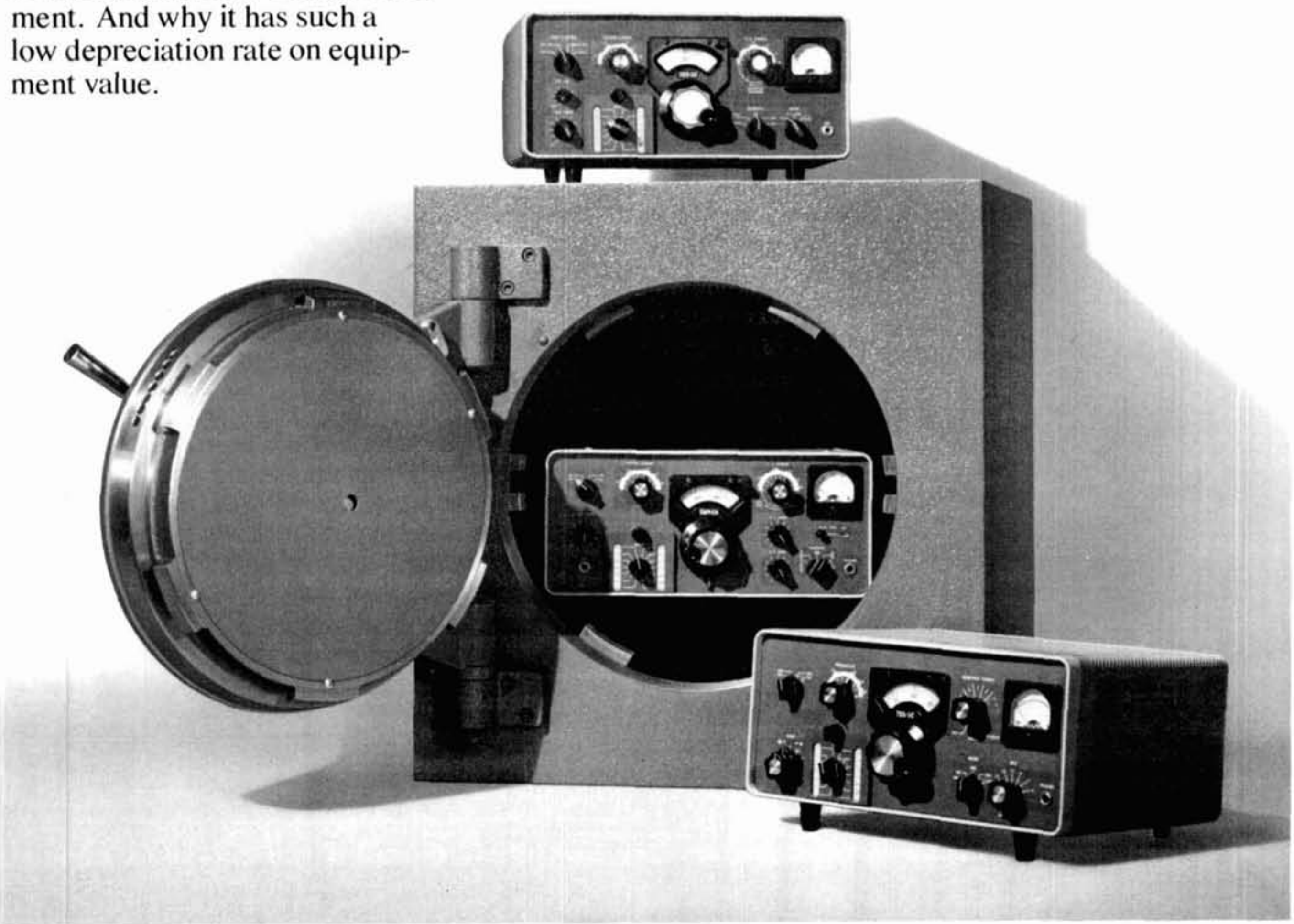
The list is reproduced below for the information of your readers. Several of the meters listed have been discontinued, but the information is included for those who may still have them lying around.

catalog number	scale	internal resistance (ohms)
22-016	0-150 Vac	80
22-017	0-50 μA	1600
22-018	0-1 mA	80
22-019	VU	750
22-020	"S" meter	80
22-036	0-15 Vdc	80
22-037	0-100 μA	1000
22-051	0-50 μA	1600
22-052	0-1 mA	80
22-053	VU	750

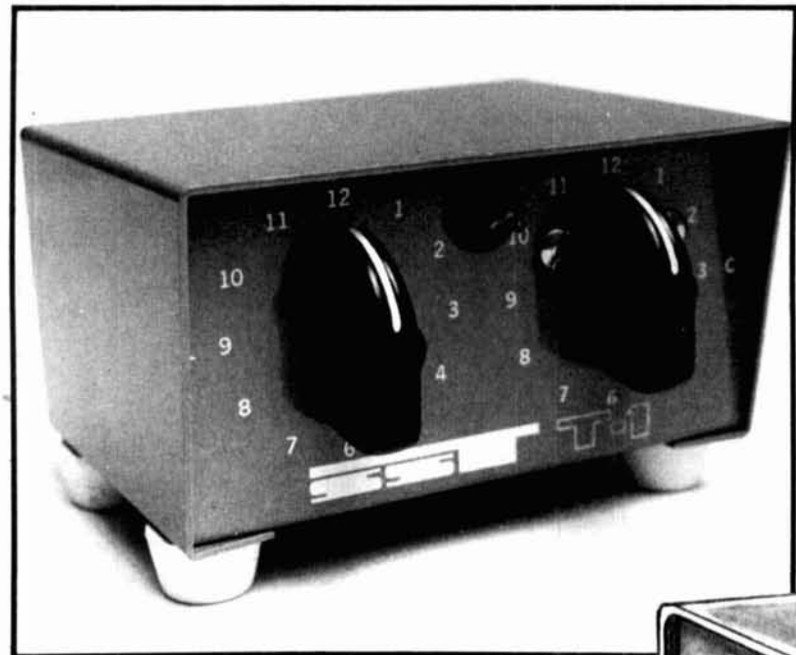
It seems as though W0MAY's calculation of 1600 ohms for his 0-50 μA meter was right on the money! I hope your readers will find this list of use.

G. L. Katzenberger
Troy, Ohio

*David Cheney, W0MAY, "Shirt Pocket Transistor Tester," *ham radio*, July, 1976, page 40.

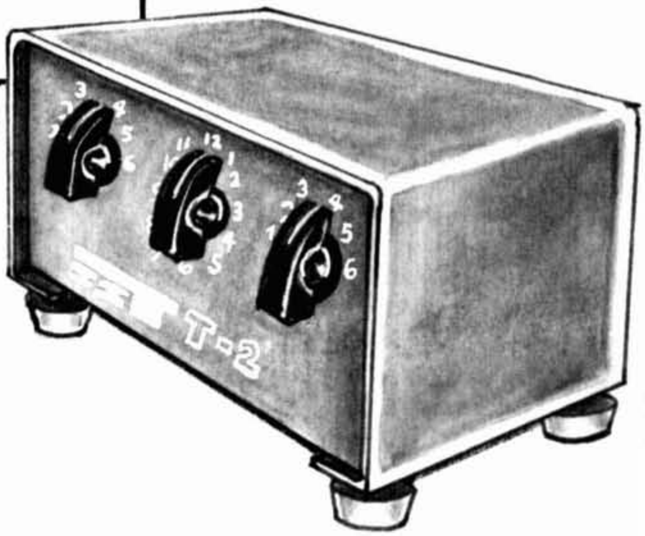


SST T-1 RANDOM WIRE ANTENNA TUNER



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



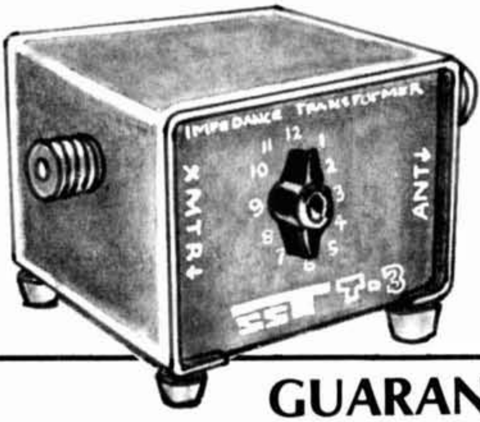
sst t-2 ULTRA TUNER

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: 5¼" x 2¼" x 2½." 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.

SST ELECTRONICS

P.O. BOX 1 LAWNDALE, CALIF. 90260 · (213) 376-5887

More Details? CHECK — OFF Page 150

More Details? CHECK—OFF Page 150

the ham notebook

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.

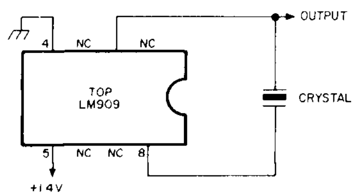


fig. 1. Schematic of the simple crystal oscillator using the National LM3909 integrated circuit. The crystal can be adjusted for its exact frequency by connecting a capacitor in series with pin 8.

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 (fming) 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 fming 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 fming 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 fming, 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

table 1. Data for determining tension in a guy wire.

wire size	breaking strength	initial tension	mass slugs/foot	(kg/m)
1/8 inch (3mm) HS	1330 lbs. (603kg)	150 lbs. (68kg)	9.33×10^{-4}	(45.6×10^{-3})
3/16 inch (5mm) HS	2850 lbs. (1293kg)	300 lbs. (136kg)	2.27×10^{-3}	(110.9×10^{-3})
3/16 inch (5mm) EHS	3990 lbs. (1810kg)	400 lbs. (181kg)	2.27×10^{-3}	(110.9×10^{-3})
1/4 inch (6.5mm) HS	4750 lbs. (2155kg)	500 lbs. (227kg)	3.73×10^{-3}	(182.3×10^{-3})
1/4 inch (6.5mm) EHS	6650 lbs. (3016kg)	700 lbs. (318kg)	3.73×10^{-3}	(182.3×10^{-3})
5/16 inch (8mm) HS	8000 lbs. (3628kg)	800 lbs. (363kg)	6.37×10^{-3}	(311.3×10^{-3})
5/16 inch (8mm) EHS	11200 lbs. (5080kg)	1200 lbs. (544kg)	6.37×10^{-3}	(311.3×10^{-3})
3/8 inch (9.5mm) HS	10800 lbs. (4899kg)	1100 lbs. (499kg)	8.49×10^{-3}	(414.9×10^{-3})
3/8 inch (9.5mm) EHS	15400 lbs. (6985kg)	1600 lbs. (726kg)	8.49×10^{-3}	(414.9×10^{-3})

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:

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

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 lead, (**fig. 1**). By adding the resistor, the grid bias voltage, which is normally developed across a 33-ohm resistor,

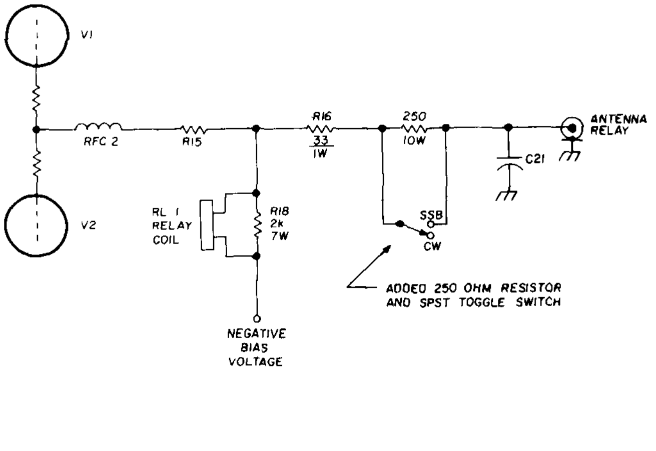


fig. 2. The tubes in the amplifier are held cutoff by the addition of the 250-ohm resistor since bias is developed across the resistor. A toggle switch can be used to short out the resistor for ssb work. If this is not done, excessive distortion will result because the amplifier is operated in class C.

is increased. Fortunately, the resulting reduced current is still adequate to operate the antenna relay, which is in series with the negative grid bias supply output.

When ssb operation is desired, the 250-ohm resistor is simply shorted out. The resistor can be mounted internally, with a small spst toggle switch mounted on the front panel between the meter selector switch and RELATIVE POWER SENSITIVITY control shown in **fig. 2**.

John Abbott, K6YB

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.

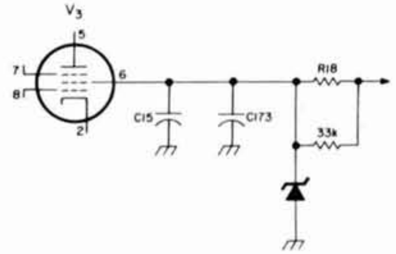


fig. 3. The addition of the zener diode helps stabilize the screen voltage on the i-f amplifier in the Collins S-line, which improves ALC metering. The diode is a 100 volt, 500 mW zener.

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

TEN-TEC CENTURY 21. The Exciting New 70-Watt, 5-Band CW Transceiver That's Surprising Everyone, Beginner and Old Timer, With Its Super Performance and Low Cost.

• 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 μV • 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: 6⅛" × 12½" × 12", 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 QRM. 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 QRM gets 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 TVI. 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.

TEN-TEC, INC.
SEVIERVILLE, TENNESSEE 37862
EXPORT: 5715 LINCOLN AVE., CHICAGO, ILL. 60646

We have been notified that Motorola has been granted registration of the tradename "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.

THE SURPRISE OF THE CENTURY

More Details? CHECK—OFF Page 150

More Details? CHECK—OFF Page 150

THE LEADER
IN THE NORTHWEST!

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.

DenTron

DENTRON MLA-2500
$799.50.

DENTRON 160-10 AT
Super Tuner **$129.50.**

DENTRON MT-3000A
Deluxe Tuner **$349.50.**

KENWOOD

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

KENWOOD Transceiver
TS-520S 160 thru 10M
$649. (less DG-5)

KENWOOD 2M FM
TR-7400A **$399.**

ATLAS RADIO INC.

ATLAS 350-XL Transceiver
160 thru 10M **$895.**

ATLAS Transceiver 210X
80 thru 10M **$679.**

ATLAS Transceiver 215X
160 thru 15M **$679.**

ICOM

ICOM Transceiver 2M FM
SSB IC 211 **$749.**

ICOM Transceiver 2M FM
IC 22S **$299.**

ICOM Transceiver 2M FM
IC 245 **$499.**

YAESU

YAESU HF SSB
FT-101E, 160 thru 10M **$729.**

YAESU FT-221R
2 meter FM-SSB **$595.**

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.

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

Write or call for **SPECIAL** tower, rotor, antenna package! Tri-Ex, Rohn, Wilson Towers

VISA — Shipping info: F.O.B. Seattle via UPS, truck, or parcel post.

BANKAMERICARD

master charge

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

More Details? CHECK—OFF Page 150

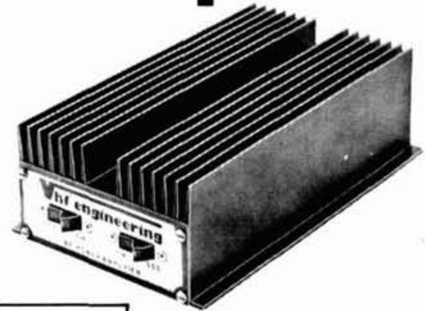
More Details? CHECK—OFF Page 150

More Details? CHECK—OFF Page 150

Vhf engineering

BLUE LINE RF Amplifiers

Don't sacrifice maximum power output and high efficiency for linearazation. 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.



Vhf engineering is the only name you have to remember when it comes to VHF or UHF amplifiers, just look at the variety available.

MODEL	BAND	EMISSION	POWER INPUT	POWER OUTPUT	WIRED AND TESTED PRICE
BLC 10/70	144 MHz	CW-FM-SSB/AM	10W	70W	139.95
BLC 2/70	144 MHz	CW-FM-SSB/AM	2W	70W	159.95
BLC 10/150	144 MHz	CW-FM-SSB/AM	10W	150W	259.95
BLC 30/150	144 MHz	CW-FM-SSB/AM	30W	150W	239.95
BLD 2/60	220 MHz	CW-FM-SSB/AM	2W	60W	159.95
BLD 10/60	220 MHz	CW-FM-SSB/AM	10W	60W	139.95
BLD 10/120	220 MHz	CW-FM-SSB/AM	10W	120W	259.95
BLE 10/40	420 MHz	CW-FM-SSB/AM	10W	40W	139.95
BLE 2/40	420 MHz	CW-FM-SSB/AM	2W	40W	159.95
BLE 30/80	420 MHz	CW-FM-SSB/AM	30W	80W	259.95
BLE 10/80	420 MHz	CW-FM-SSB/AM	10W	80W	289.95

Don't forget our popular PA-2501 and PA-4010 at $74.95 (wired and tested) $59.95 (Kit)

FEATURES

- High efficiency means low current drain.
- Broad band design (no tuning).
- Direct 12 volt DC operation.
- Indicator lamps for On/Off and FM/SSB.
- 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.

WANT TO BRING YOUR AMPLIFIER INDOORS?

LOOK AT THESE POWER SUPPLIES!

- Over-voltage protection crowbar.
- 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.
- Units are factory wired for 115 volt AC, 50/60 cycle power. A simple jumper will reconfigure the input for 220 volt AC, 50/60 cycles.
- Temperature range — operating: 0° to +55° C.
- Black anodized aluminum finish.

PS-25M WITH CURRENT METERS

Recommended for:

BLC 10/70 BLD 2/60 BLE 30/80
BLC 2/70 BLD 10/60 BLE 10/80

Voltage Output: adjustable between 10-15V
Load Regulation: 2% from no load to 20 a
Current Output:
25 amps intermittent (50% duty cycle)
Ripple: 50 mV at 20 amps
Weight: 22-1/2 pounds
Size: 12-1/4" x 6-3/4" x 7-1/2"

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

PS-15C LOW COST

Recommended for:

BLE 10/40 BLE 2/40

Voltage Output: adjustable between 12-14V
Load Regulation: 2% from no load to 10 amps
Current Output:
15 amps intermittent (50% duty cycle)
Ripple: 50 mV at 10 amps
Weight: 13 pounds
Size: 11-1/4" x 5-1/2" x 4-3/4"

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

PS-3012 COMMERCIAL

Recommended for:

BLC 3/150
BLC 30/150
BLD 10/120

Output Voltage: Adjustable, 11-15 VDC
Output Current: 30 amps (50% duty cycle)
Regulation: Better than 2 percent
Output Ripple: 50MV pk-pk maximum
Temperature Range: 0°-60° C operating
Overvoltage Protection: Built in OVP crowbar
Overcurrent Protection: Foldback current limiting at 30 amps
Short Circuit Current: 2 amps maximum
Input Voltage: 105-120 or 208-230 at 50-60Hz
Size: 13-1/4" L x 7-1/8" W x 6-5/8" H
Weight: 25 lbs.
Finish: Black anodized aluminum

PS-3012 Wired & tested . . . $239.95

Export prices are slightly higher. Prices subject to change.

Vhf engineering
DIVISION OF BROWNIAN ELECTRONICS CORP.
BOX H / 320 WATER ST. / BINGHAMTON, N.Y. 13901
Phone 607-723-9574

WE HONOR master charge THE INTERBANK CARD — BANKAMERICARD

More Details? CHECK — OFF Page 150

Calling All Hams...

...All Hams Call Us!

It's Toll Free...So Dial Away!

1-800-325-3636

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*.

master charge

We welcome your Master Charge or Bank Americard

BANKAMERICARD

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

KESTER SOLDER

Handymen! Hobbyists! DO-IT-YOURSELFERS!

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".

Litton **KESTER SOLDER** 4201 WRIGHTWOOD AVENUE/CHICAGO, ILLINOIS 60639

"Right on" with Jan Crystals

for

- **General Communication & Industry**
- **Citizen's Band (Standard & Synthesized)**
- **Two-Meter - Monitor - Scanners**
- **Marine VHF** • **Amateur Bands**

Depend on Jan Crystals made in U. S. A. for

- **Frequency Control** • **Frequency Stability**
- **High Performance**

Send 10¢ for our latest catalog
Write or phone for more details

JAN CRYSTALS

2400 Crystal Drive
Ft. Myers, Florida 33901
all phones (813) 936-2397

More Details? CHECK—OFF Page 150

Great gift ideas from Ham Radio's Bookstore.

☐ **Ham Radio HORIZONS Magazine**
☐ One Year . . . $10.00 (12 issues) ☐ Three Years . . . $24.00 (36 issues)

☐ **HAM RADIO Magazine**
☐ 1 yr. . . . $12.00 (12 issues) ☐ 2 yrs. . . . $22.00 (24 issues) ☐ 3 yrs. . . . $30.00 (36 issues)

*Please enclose names and addresses on all gift subscriptions.

☐ 1978 ARRL RADIO AMATEUR'S HANDBOOK

World's best selling technical reference; a standard for every Radio Amateur's bookshelf. Revised and updated with state of the art technology. Guaranteed to please every ham. Softbound.

(AR-HB) $8.50

☐ AMATEUR SINGLE SIDEBAND

Originally published by Collins Radio Company, reissued 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 1 X 2 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

International suspense and romance in a dynamic novel where Amateur Radio is the hero. A real spellbinder!

(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-80M) $4.50

Yes! Please enter my order as checked on the boxes by each book on this page.

Number of books checked ______ Total amount $______
☐ 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**

More Details? CHECK—OFF Page 150

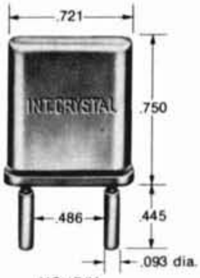
WHERE RELIABILITY & ACCURACY COUNT

INTERNATIONAL CRYSTALS

70 KHz to 160 MHz

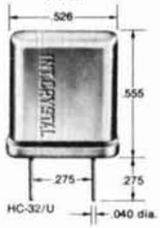
HOLDER TYPES

F-609



HC-17/U

FI-4



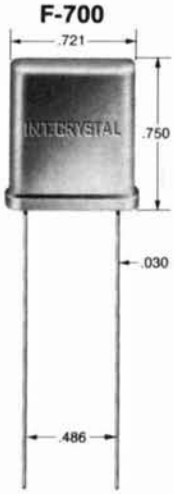
HC-32/U

F-605

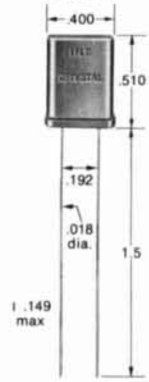
HC-6/U

F605-SL

F-700



FM-1



HC-18/U

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.

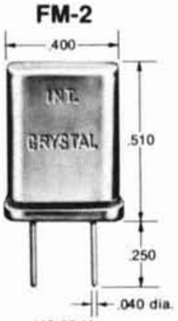
CRYSTAL TYPES

(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.

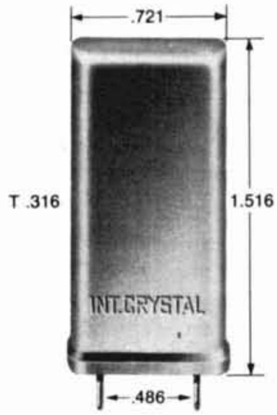
WRITE FOR INFORMATION

FM-2



HC-25/U

F-13



HC-13/U

ICM

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee, Oklahoma City, Oklahoma 73102
405/236-3741

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 useable for manual programming.
- Plugs into 9 pin accessory socket.
- Adjustable scan delay feature.
- 90 day limited warranty.

ONLY 149^95 Amateur Net

Send S.A.S.E. for more SPECSCAN info.

SPECIAL PRE-WIRED PRICE
BRAND NEW IC-22S WITH
SPECSCAN DIGITAL SCANNER
Both for only **$398.00**

NOW AT SPECTRONICS . . . MFJ

Station Accessories for just about any need!

$39^95

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 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-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 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 • 9 V battery • 2-3/16 x 3-1/4 x 4 inches • CWF-2PC, wired PC board, $19.95.

$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 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

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 whips, 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 toroid cores.

$29^95

SBF-2BX SSB Filter

Dramatically improves readability.
• Optimizes your audio to reduce sideband splatter, remove low and high pitched QRM, 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.

Model 43
$120 + shipping

BIRD

. . . If you have been having difficulty locating the Wattmeter or element just right for you. . . . You may have been looking in the wrong places. Our large inventory of most common elements lets you get what you want when you need it. Give us a call first for your BIRD needs.

SPECTRONICS, INC.

1009 GARFIELD
OAK PARK, IL. 60304
312-848-6777
TELEX 72:8310

HOURS

STORE HOURS:
Mon-Thurs 9:30-6:00, Fri. 9:30-8:00
Sat. 9:30-3:00, Closed Sun. & Holidays.

More Details? CHECK—OFF Page 150

Regency
the first name in solid state ®

THE FM LEADER

2 METER **220 MHz**
6 METER **440 MHz**

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

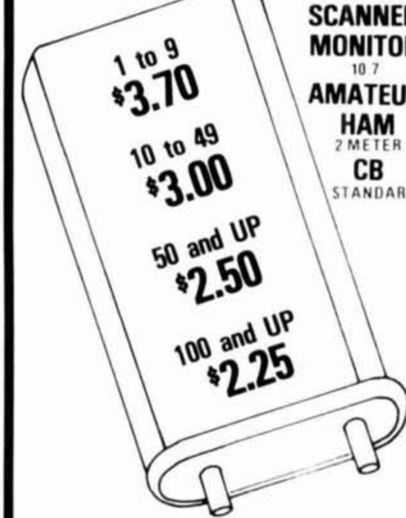
HR-440
UHF—The Ultimate in FM

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 the first name in solid state ® ELECTRONICS, INC. 7707 Records Street
Indianapolis, Indiana 46226

10's OF THOUSANDS OF CRYSTALS IN STOCK!

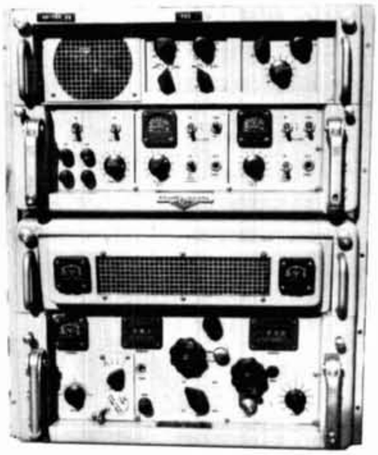


H25C CASE
SCANNER MONITOR
10.7
AMATEUR HAM
2 METER
CB
STANDARD

Immediate delivery on most frequencies!
OTHERS ARE SPECIAL ORDER

CRYSTAL BANKING SERVICE
P.O. BOX 683
LYNNFIELD, MASSACHUSETTS
01940

2-32 MHz RECEIVERS



AN/WRR-2 TRIPLE CONVERSION RECEIVER — 2-32 MHz for reception of SSB; upper and lower sideband separately or simultaneously, AM, MCW, 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^{00}**
AN/FRR-59A — Tunes in 500 Hz increments or continuously; for rack mounting, Used, Reparable. . . . . **$375^{00}**
RECEIVER — Checked, good operation, add **$100^{00}**
MANUAL with purchase of Receiver only. . . . **$20^{00}**

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

Sunspot Cycle 21 takes off... triggers exceptional 6 meter openings!

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 (2.5 W AM).
- Built-in power supply for 115 VAC and 13.8VDC.
- Clarifier.
- Noise blanker.
- Squelch.
- Triple conversion receiver with better than 0.25μV 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.

"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? (Murphys' 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? Rotsaruck 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

C F P COMMUNICATIONS, INC.

211 NORTH MAIN STREET
HORSEHEADS, N.Y. 14845
PHONE: 607-739-0187

Store Hours
Tues. to Fri. 10-6 p.m.
Sat. 10-4 p.m.
Fri. & Sat. subject to Hamfest weekends
Closed Sun. & Mon.

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

BiRD

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!

hrbc
Ham Radio's Communications Bookstore
Greenville, NH 03048

Order HR-SSB Just $4.95

☐ I 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

More Details? CHECK—OFF Page 150

More Details? CHECK—OFF Page 150

VLF CONVERTER

- **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

SELLING/TRADING THINK MONEY!

TOP DOLLAR FOR NEW/USED EQUIPMENT!!!!

COLUMBIA NEEDS AND WILL BUY: AN/ARC-51, -94, -102, -114, -115, -116, -131, -134, -159, -164, AN/PRC-77, AN/URC-9, R-1051/URR, AM-3007/URT, AM-3349/GRC, AN/PRC-74B, C-3866/SRC, RT-524/VRC, RT-662/GRC, RT-834/GRC, T-827/URT, WILCOX 807A

WE ALSO WANT: COLLINS 618-T, -490T-1, -1A.

HAVE YOU ANY OF THE ABOVE? OR SIMILAR GEAR?

Phone us now — collect — at

(213) 764-9030.

If you prefer, fill out and mail coupon below:

COLUMBIA ELECTRONICS

BOX 9266, N. HOLLYWOOD, CA 91609

Dear Paul: Here's what I have to ☐ sell ☐ trade:

ITEM	PRICE WANTED	CONDITION

Name ____________
please print
Address ____________
City ____________
State ____________ Zip ____________

COLUMBIA ELECTRONICS
7360 ATOLL AVE., P.O. BOX 9266
N. HOLLYWOOD, CA 91609

IMPROVES ALL SSB & CW STATIONS
PR-1000 VARIABLE AUDIO FILTER

Greatly improves reception and audio selectivity of even the best ham receiver. Easy to operate and quickly connects between any ham receiver, transceiver or SWL receiver and speaker (or headphone). Provides variable selectivity bandpass of 40 Hertz to 3000 Hertz with selectivity skirts a minimum of 80db! Super sharp 70db variable notch rejects nearby CW stations as close as 100 Hertz! Incorporates the latest electronic audio filtering circuitry. Five (5) integrated circuits with self-contained 110 volt AC power supply and one watt audio amplifier. Attractive low profile eggshell white cabinet with walnut-like sides.

PRIME ELECTRONICS, INC. Dept. HR
221 West Market St. Derby, KS. 67037

☐ Please send me more information
☐ Rush me ______ PR-1000 Variable Audio Filters @ $59.95 each plus $1.50 postage & handling. Check or M.O. enclosed.

Name ____________
Address ____________
City ______ State ______ Zip ______

Distributor and dealer inquiries invited.

More Details? CHECK—OFF Page 150

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

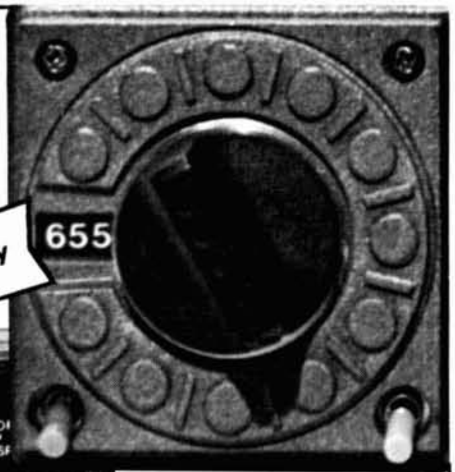
P. O. BOX 153
BREA, CALIFORNIA 92621
(714) 998-3021

K-1 FIELD REPLACEABLE, PLUG-IN, FREQUENCY DETERMINING ELEMENTS

$3.00 each

More Details? CHECK—OFF Page 150

NOW ALL 2-METER FM CHANNELS with your IC-22S



— dash indicating alternate channel means better legibility

VIP-15 option: *provides 15 kHz split channels, 15 kHz above indicated frequency.*

VIP-600 option: *provides simplex operation 600 kHz above the indicated frequency.*

These repeater pairs are programmed in the switch:

146.01-.61	147.60-.00
146.04-.64	147.63-.03
146.07-.67	147.66-.06
146.10-.70	147.69-.09
146.13-.73	147.72-.12
146.16-.76	147.75-.15
146.19-.79	147.78-.18
146.22-.82	147.81-.21
146.25-.85	147.84-.24
146.28-.88	147.87-.27
146.31-.91	147.90-.30
146.34-.94	147.93-.33
146.37-.97	147.96-.36
146.40-.00	147.99-.39

PLUS: The following simplex channels are also programmed in the switch:

146.43	146.55	147.48
146.46	146.58	147.51
146.49	147.42	147.54
146.52	147.45	147.57

PLUS: Two user programmed channels

- **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 preprogrammed 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.**

VIP-42 kit

$29.95

VIP-600 option - $3.50
VIP-15 option - $3.50

Order yours today! Make your fine transceiver even better!

ViP Valley Instrument Products

(312) 741-8820 — P.O. BOX 339 BARTLETT, ILLINOIS 60103

Valley Instrument Products
P.O. Box 339
Bartlett, IL 60103

PLEASE SHIP ______ VIP-42 conversion kit(s) at $29.95 each.

ALSO INCLUDE ______ VIP600 option(s) at $3.50 each.

and ______ VIP15 option(s) at $3.50 each.

BANKAMERICARD

VISA

Name ______ Call ______

☐ I enclose $ ______ check or money order.

Address ______

☐ Please charge my VISA/Bank-Americard $ ______

City ______ Card number ______ Expiration date ______

State ______ ZIP ______ Signature ______

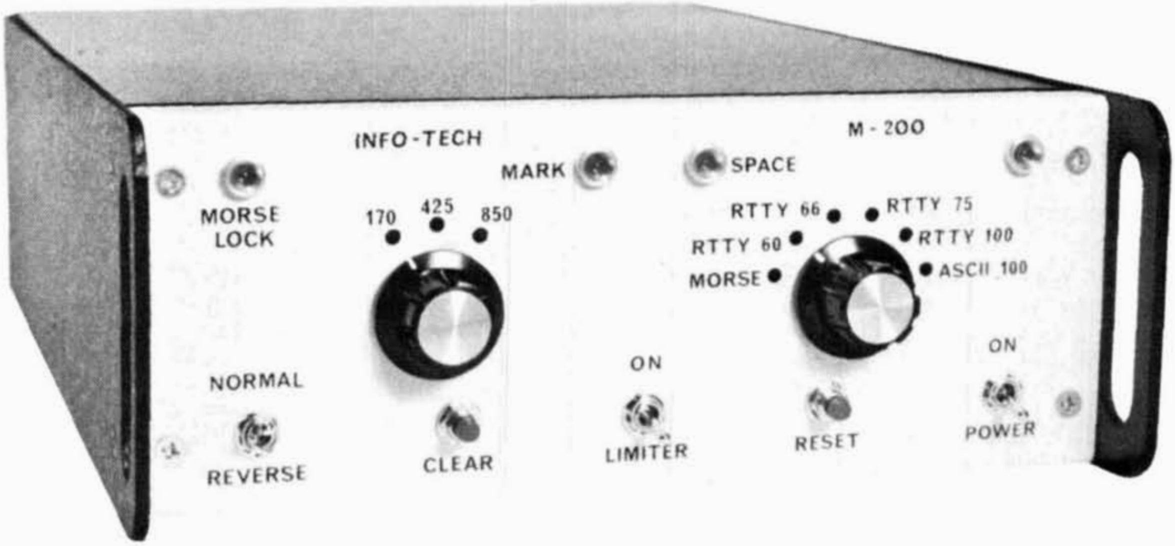
ILLINOIS RESIDENTS ADD 5% SALES TAX

More Details? CHECK—OFF Page 150

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

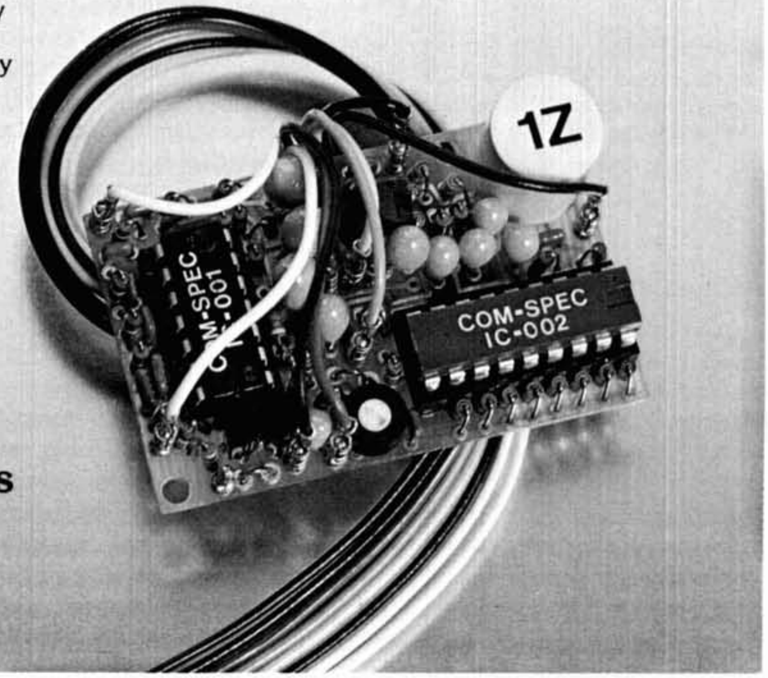
INFO-TECH INCORPORATED *Specializing in Digital Electronic Systems*

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

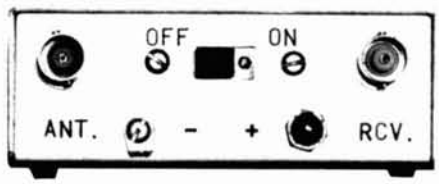
Telrex "Monarch" (Trapped) I.V. Kit
Duo-Band / 4 KWP I.V. Kit $63.50
Post Paid Continental U.S.

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, Omni-directional, 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)

COMMUNICATION SYSTEMS SINCE 1921 telrex Laboratories
ASBURY PARK NEW JERSEY 07712 U.S.A.

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 .005% 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/power switch. Measures 3½" x 2¾" x 1¼"
- Operates 12 Vdc @ 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

WARBLE ALARM CAR-VAN CLOCK WITH HEADLIGHT ALARM

- ELAPSED TIMER
- SECONDS DISPLAY SWITCH
- 9 MINUTE SNOOZE ALARM
- SIMPLE 4 WIRE HOOK UP
- JUMBO ½" LED DISPLAY
- 1 TO 59 MINUTE COUNTDOWN TIMER RUNS SIMULTANEOUSLY WITH CLOCK!
- RUGGED ABS CASE
- QUARTZ CRYSTAL ACCURACY

COMPLETE KIT $35.95
ASSEMBLED $45.95

DIGITAL AUTO INSTRUMENTS
SEVEN MODELS!

- #1 TACHOMETER
- #2 WATER TEMP.
- #3 FUEL LEVEL
- #4 SPEEDOMETER*
- #5 OIL PRESSURE
- #6 OIL TEMP.
- #7 BATTERY MONITOR

KIT INCLUDES:
- CASE & ALL HARDWARE
- PRESSURE & TEMP SENDERS
- ASSEMBLED MAIN PC BOARD

FEATURES:
- 4" ORANGE LED'S
- 4½" x 4" x 2" ABS CASE

*ADD $10 FOR REQUIRED SPEED SENDER. $15 FOR SPEED SENDER ALONE

KIT: $49.95. . . . . . . ASSEMBLED: $59.95

ELECTRONIC 'PENDULUM' CLOCK

- SWING PENDULUM
- 7" HOURS AND MINUTES DISPLAY
- TIME SET PUSH BUTTONS
- ALARM FEATURE

KIT-UNFINISHED CASE $59.95
ASSEMBLED-STAINED CASE $69.95

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

ELAPSED TIMER: HRS, MINS & SECS
SIMPLE PUSHBUTTON RESET &
HOLD TOGGLE SWITCH
KIT INCLUDES EVERYTHING.
NOTHING ELSE TO BUY! 4" LEDS!
INTERNAL BATTERY BACKUP!
NON POLAR INPUT!
12 OR 24 HR MODE
DIMENSIONS: 4" x 4" x 2"

KIT: $27.95. . . . . . . ASSEMBLED: $37.95

NOW WITH ELAPSED TIME!

3½ DIGITAL CLOCK

- 4 DIGIT KIT $49.95
- 6 DIGIT KIT $69.95
- 4 DIGIT ASSEMBLED $59.95
- 6 DIGIT ASSEMBLED $79.95

117 VAC 12 OR 24 HR MODE — KIT COMES COMPLETE!
6 DIGIT VERSION 27" x 5" x 1" — 4 DIGIT VERSION 18" x 5" x 1½"

TV-WALL CLOCK

117 VAC

- 25' VIEWING DISTANCE
- 6" HOURS & MINUTES
- 3" SECONDS
- COMPLETE WITH WOOD CASE

KIT: $34.95. . . . . . . ASSEMBLED: $39.95

ECONOMY CAR CLOCK

- ½" LED MODULE!
- COMPLETE WITH CASE, BRACKET & TIME SET PUSHBUTTONS
- ALARM OPTION

KIT: $19.95. . . . . . . ASSEMBLED: $26.95

PENDULUM

GIVE YOUR DIGITAL CLOCK A PENDULUM SWING
9 TO 12V DC · 60 HZ INPUT
SIMPLE HOOK UP TO ANY CLOCK

$14.95 CASE WITH BRACKET **$3.75**

MARK FOSKETS'
SOLID STATE TIME

P.O. BOX 2159
DUBLIN, CALIF. 94566
ORDERS (415) 828-1923

master charge — 24 HR PHONE — BANKAMERICARD

CALIFORNIA RESIDENTS · ADD 6% SALES TAX

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 .06μV 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.

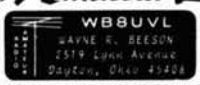
The DF is battery-powered, can be used with accessory antennas, and is 12/24V for use in vehicles or aircraft. It is available in the 140-150 MHz VHF band and/or 220-230 MHz UHF band. This DF has been successful in locating malicious interference sources, as well as hidden transmitters in "T-hunts", 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

Radio Amateur Labels

FOUR DESIGNS



SIX COLORS

FOR SAMPLES AND PRICES WRITE TO:
Artistic Label Co.
P.O. BOX 1662 ENGLEWOOD, COLO. 80150

THE BEVERAGE ANTENNA HANDBOOK

Construct and operate your own Beverage Antenna. Defeat the broadcast stations on 40 meters. Has plans for three band Beverage, 1.8-3.9-7.2 MHz, with steerable null and direction switching. Contains: Theory for single wire Beverage and two wire Beverage; Null steering; Direction switching; Antenna patterns; Effect of height, wave velocity, distributed losses; End terminations; Ground system; Construction diagrams; Circuit diagrams; Impedances; Short Beverage. $5.00 postpaid. Spiral bound, lies flat. Published by Vic Misek, W1WCR, Wason Road, Hudson, N. H. 03051.

NEW!

DAVIS ELECTRONICS

MINI COUNTER

60 MHz
600 MHz
(with optional prescaler)

General Purpose Low Cost Counter Without the Sacrifice of Basic Performance

"Check the features we have that some other low cost counters don't have."

- All Metal Cabinet
- 8 Digit .4" LED Display
- Input Cable Included
- 12V Input Jack
- Push Button Controls
- Gate Light
- Completely Auto Decimal Point
- Selectible Gate Times (1 sec & .1 sec)
- State of the Art LSI Circuitry
- Sensitivity < 10 MV
- Crystal Time Base
- 115V or 12V Operation

ORDER NOW
Call Toll Free
1-800-828-7422

7208 60 MHz Assembled	$169.95
7208A 600 MHz Assembled	$199.95

DAVIS ELECTRONICS 636 Sheridan Dr., Tona., N.Y. 14150 716/874-5848

More Details? CHECK—OFF Page 150

Watch for our supermarket bargains each month!

GOOD NEWS

BARGAINS OF THE MONTH

TRAVELS FAST!

POLY PAKS® IS THE WORLD'S LARGEST ELECTRONIC DISCOUNT SUPERMARKET

NOV. 77 HAM RADIO SPECIALS

RCA High quality "POCKET" VOM

- 1000 ohms per volt

Model WV-539A. Features 1% precision, movements diode protected against burnout. Measures DC volts 0-15-150-1000; AC volts 0-15-150-1000; DC current 0-150ma; resistance X1000. Sensitivity 1000 ohms/volt AC-DC. Uses penlite cell, not included. Size 2 3/8 x 3 1/2 x 1 3/4". Wt. 5 ozs. Cat. No. 11H3921

$8.88

3½ DIGIT OPEN FACE DPM

- Dual Range! 0-2V, 0-200mV

DIGITAL PANEL METER

Kit

LOWEST PRICE ANYWHERE . . . others have 'em at $49.95. Displays DC voltage in 3½ digits, at 0.05% accuracy! Minus sign automatically displays negative input. High input impedance, 100 megohms. Uses the latest MOS-LSI circuitry, (7107), assembles in minutes. Automatic zeroing. Voltage range selectable by changing two components (both sets supplied). Complete kit with PC board, readouts, IC, & all other components. Less case. Requires ±5VDC. Size 3½" x 5".

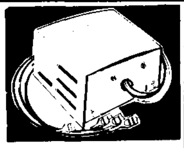
0.4" LED Digits! $29.95

Cat. No.			
11H4041	DPM Kit	Wt. 14 ozs.	$29.95
11H4042	DPM Wired		39.95
11H4038	7107 Chip		15.95

ECC INDUSTRIAL

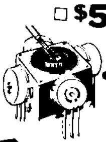
SPEED CONTROL

3 FOR $16. $5.95



A $30 item. Rated at 1200 watts. A very elaborate circuit for controlling many electrical and electronic devices. Easily controls speeds of electric drills, brush type motors, etc. Built with heavy duty aluminum framing. Complete with external pot, for variable speed control. Heavy duty colored wires for 115VAC 60 cycles, and item to be controlled. 10/32 mounting stud. Outperforms our previous sellout. With hookup diagram. Use as temperature controller too. Wt. 2 lbs. Cat. No. 11H3392

$5.50 TV GAME & HI-FI JOY STICK



- Includes four 100K pots

For TV & computer games, and quadrophonic balancing! 1½ x 1½ x 1". With 1" handle. Wt. 6 ozs. Cat. No 11H3808

TOUCH-TONE ENCODER KIT $22.50

Buy 'em separately

Attention 2 meter FM HAMS! Phone from your mobile or portable rig. Kit includes: Chomerics touch tone pad, Motorola MC-14410 chip, & all components necessary, with PC board. 1 mHz crystal. Wt. 8 ozs. Cat. No.11M3385

11H3382	Touch Tone IC MC14410P	$6.95
11H3149	12-Key "feather touch Keyboard	6.88
11H3635	1.00 MHz Crystal	5.95
11H3383	Autopatch PC Board	2.95

Cat. No.11H4011 $5.95

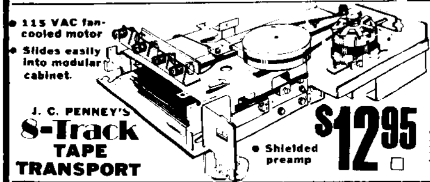
5 GIGAHERTZ MICROWAVE POWER TRANSISTOR

HAMS take note! High frequency, high power NPN. Stud mount TO-128 case. Perfect for UHF and microwave communications gear. ¾" dia. epoxy case, ½" gold plated leads, and ½" stud for heat sinking. Bvceo 30V, Hfe 20-200, fc max 500 mils, power dissipation 5 watts. Two emitter leads. Type SD1043. Wt. 2 ozs.

POLY PAKS "CHIPS" AWAY IC PRICES!

Order Cat. No. 11H4048 and Type No.

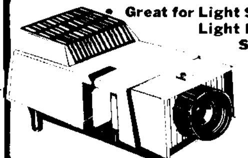
Type		Sale
ICM7205	Stopwatch	$14.95
AY3-8500-1	Six TV Games	9.95
MM5330	4½ Digit DVM	4.95
8038C	Volt Control Osc	4.95
KR2376	Encoder ROM BCD	6.95
95H90DC	350 MHz Prescaler	8.88
MC14410	Touch Tone Encoder	9.95
MK2002P	Char. Gen. (2513 equal)	3.95
7207A/7208	Frequency Counter, pair	29.95
ICM7107	3½ Digit DPM	12.50
MM5316	Alarm Clock	2.95
8080A	Microprocessor	14.95
1702A	Erasable PROM	4.95
2708	8K EPROM	22.88
2102-1	1K RAM	1.39



- 115 VAC fan-cooled motor
- Slides easily into modular cabinet.
- Shielded preamp

J. C. PENNEY'S 8-Track TAPE TRANSPORT $12.95

Excellent replacement or design your own quality tape system! Automatic or manual track selection with program indicator lights. Player shuts off automatically when tape is removed. Built-in low-distortion preamp and wow free motor. With input & output cables. Requires external power supply. With instructions. Size 9 x 6 x 3½". Wt. 4 lbs. Cat. No.11H3010



- Great for Light Shows, Strobes, Light Displays, Slide Projector!
- Worth many times our asking price.
- Wide angle focusing lens!

5 IN 1 PROJECT-ALL SLIDE PROJECTORS 12.50

U.S. maker. Originally designed as a slide projector. Some may be modified for projecting a bar of lite. High quality 3 lens condensing system. Requires standard 100 watt projection bulb. 35mm slides can be inserted and removed manually. Heavy duty bakelite case, grey hammertone finish. Design your own low cost light show. Use a Xenon flash tube and make a strobe light. Many other uses too numerous to mention. Size: 11 x 5½ x 4½". Wt. 5 lbs. Cat. No. 11H3870

69¢ EACH 6 for $2.50 SPECTROL "SKINNY-TRIMS"

3/8" square. Screwdriver shaft. 20% tolerance. ½ watt. Cermet construction. PC leads. Order by Cat. No. and Value. *Available in all types **Available in Cat. No 11H3863 only.

11H3863	25 Turn upright, type 64	
11H3864	25 Turn flat, type 64	
11H3866	Single turn flat, type 63	

OHMS: 10 *, 20 **, 50 *, 100 **, 200 *, 500 *, 1K *, 2K *, 5K *, 10K *, 20K *, 50K **, 100K **, 200K *, 500K **, 1 Meg**

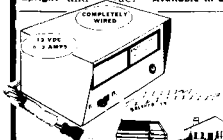
upright — flat

DIP Switches

Reg. $1.69 ea. Your Choice $1.00

Cat. No.	Switches
11H3668	2
11H3669	3
11H3021	4
11H3670	5
11H3671	6
11H2677	7

We've sold 'em as high as $2.98 each. You can mix them when you buy. All SPST, fits 14-pin DIP socket. Wt. 1-oz.



"CB" POWER SUPPLY

3 AMPS $16.88 — 4 AMPS $19.95

Ideal for CB's, Ham rigs, tape decks & more! Modern cabinet, 5 x 4½ x 2¼". With on/off switch, LED lamp, built-in circuit breaker. 115 VAC 60 Hz, Wt. 5 lbs. Cat. No.11H3452

- Completely wired
- 12 VDC @ 3 Amps output
- Regulated, continuous duty

BARREL KITS

TEST 'EM YOURSELF 'N SAVE!

EXCLUSIVE

GUARANTEED 50% YIELD ON UNTESTED......

Buy 10 BARREL KITS AND CHOOSE THE 11TH KIT Free

BARREL KIT #264 PRE-CUT-'N'TINNED HOOKUP WIRE — 200 lengths* $1.98. Breadboarders note. #22 wire, precut into 4" to 8" lengths. Asst. color plastic jackets. Wt. 12 ozs. *200 ft. approx. No. 11H3959

BRIDGES! KIT #270 — 20 for $1.98. We hot 2 tons of 2, 4, 10 and 25 amp full wave bridges. How good, we don't know. Untested and hobby. Wt. 9 ozs. No. 11H4022

BARREL KIT #203 CALCULATOR KEYBOARDS — 10 for $1.98. It's true! 20-key, 4 function keyboards at ridiculous give-away. Wt. 12 ozs. Cat. No. 11H3524

BARREL KIT #253 LINE CORDS — 8 for $1.98. 100's of AC power uses! Heavy-duty, 6-ft. long, 18 gage. White vinyl insulation & molded plug. Wt. 8 ozs. Cat. No. 11H3843

BARREL KIT #200 6 DIGIT READOUT MODULES — 5 for $1.98. Barrels and barrels and no time to test. Calculator and driver chips beneath epoxy on back. Wt. 6 ozs 11H3515

BARREL KIT #244 HOBBY 1702A ROMS — 3 for $1.98. Hobby fallouts of the famous erasable programmable ROM. 2048 bit. Cat. No. 11H3729

BARREL KIT #239 SHIELDED CABLE — 40-ft. $1.98. For mikes, stereos; 1-cond. plus shield, 22 ga. vinyl jacket. Wt. 1 lb. Cat. No. 11H3577

BARREL KIT #230 HALF INCH READOUTS — 15 for $1.98. HOBBY. From factory to you! Includes Fairchild FND-500 & 507's. 11H3629

BARREL KIT #225 SOUND TRIGGERS — 3 for $1.98. "Hand clap" sensitizes crystal mike amplifier, triggers SCR. Use for alarms, etc! Wt. 6 ozs. No. 11H3625

BARREL KIT #221 IC SOCKETS — 8 for $1.98 hobby. Mfr unloads! Four 14-pin, four 18-pin. Solder tail, lo-profile. No. 11H3621

BARREL KIT #205 MINI BLOCK CAPACITORS — 50 for $1.98. Unbelievable! Worth $50. High precision subminii caps for all applications. Wt. 3 ozs. No. 11H3528

BARREL KIT #201 6V INDICATORS w/leads — 15 for $1.98. Test lamp manufacturer dumps inventory! Worth 60¢ ea. Like grain-o-wheat. Cat. No. 11H3526 hobby

BARREL KIT #194 10 AMP INLINE BRIDGES — 20 for $1.98. Factory dumped in barrels. We can't test 'em, but for the price you can't go wrong. Hobby. Wt. 8 ozs. Cat. No. 11H3475

BARREL KIT #192 NYLON GEARS — 40 for $1.98. Wide variety of sizes 1" to 3" gears for the mechanical gear train hobbyists. Wt. 10 ozs. No. 11H3427

BARREL KIT #188 400 PARTS — $1.98. Includes resistors, caps, diodes, IC's, for PC work, some on PC boards. Dumped into barrels by factories, 100% material. Wt. 12 ozs. Cat. No. 11H3401

BARREL KIT #184 ¼-WATT METAL FILM — 150 for $1.98. 100% metal film resistors. Long leads. 11H3413

BARREL KIT #182 JUMBO RED LEDS — 15 for $1.98. 100% material, user cancellation from factory dumps. 3V 10 mils. For 100's of projects, red lens. Cat. No. 11H3369

BARREL KIT #163 MINI TRIM POTS — 30 for $1.98 1 oz. Asst. values 100 to 1 meg. What a buy. Single turn. ¼ W. Wt. 6 oz. 11H3345

BARREL KIT #160 HOBBY VOLTAGE REGULATORS — 10 for $1.98. LM-309K TO-3 barreled, bot by the pound, but who wants to check 'em? Your gain. Wt. 20 ozs. 11H3330

BARREL KIT #138 PANEL SWITCHES — 30 for $1.98 9 ozs. Did you hear of OAK? Another eqpt maker barrelled all types of rotaries, electric, slides, etc. 11H3266

BARREL KIT #128 MINI-DIP IC'S — 100 for $1.98. 741's, LM380, 703, 567, 555, who knows? Factory mixed, you test. Untested and hobby. Wt. 1 lb. Cat. No. 11H3245

BARREL KIT #127 AXIAL ELECTROS — 40 for $1.98. Asst. capacities and voltages. Cat. No.11H3227

BARREL KIT #126 UPRIGHT ELECTROS — 40 for $1.98. 1mf to 300mf in mixture of voltages. 100% marked 'n good. 11H3226

BARREL KIT #115 MOLEX SOCKETS — 150 for $1.98, 100% good. Cat. No. 11H3144. Calculator maker dump! We gut a zillion of 'em.

BARREL KIT #109 TERMINAL STRIPS — 100 for $1.98. Wide asst. of terminal strip connectors, from 1 contact up. Strip manufacturers barrel dump is your gain. Wt. 1 lb. Cat.No11H3136

BARREL KIT #104 SLIDE VOLUME CONTROLS — 10 for $1.98. Cat.No 11H3057

BARREL KIT #101 RESISTOR SPECIAL — 200 for $1.98. Includes: 1/8, ¼, ½, 1, 2-watters, carbon. 8 oz. 100% good. 11H3054

BARREL KIT #99 PHOTO ELECTRIC CELLS — 10 for $1.98. Asst. GE types, CDS types. Mixed by factory. Big job for us to separate. 100% good. Cat.No. 11H3052

BARREL KIT #93 HALF WATTERS — 200 for $1.98. Resistor factory tried to fool us by mixing 100% color-coded resistors in barrel. But value is there. 4 oz. 11H3046 Untested

BARREL KIT #87 NAT. IC BONANZA! — 100 for $1.98. Hobby and untested, factory mixed in barrels. Linears, 7400's, ROMS, DTL'S, registers, clock and calculator chips and more. Wt. 12 ozs. Cat. No. 11H2860

BARREL KIT #86 HOBBY LEDS — 40 for $1.98. WOW! Top U.S.A. maker dumps discretes in barrels. Hobby and untested. Useable yield 50% or better! Wt. 4 ozs. Cat. No.11H2859

BARREL KIT #83 LM-340T VOLTAGE REGULATORS — 15 for $1.98. Factory rejects, hobby, cosmetic rejects May include 5, 6, 12, 15, 18 or 24 volts. TO-220 power tab. Wt. 4 ozs. Cat.11H2635

BARREL KIT #71 CAPACITOR SPECIAL — 100 pcs. $1.98. micas, moldeds, plastics, ceramics, discs, etc. Nifty 100% good Cat.No11H2738

BARREL KIT #68 2 WATTERS — 100 for $1.98, 100% good. Suppliers throw 'em in the barrel. It's a li'l gold mine. All marked Cat.No. 11H2735

BARREL KIT #61 POLYSTYRENE CAPS — 100 for $1.98. Finest caps made. As a gamble we bought 10 barrels from factory, mixed values; all good. Cat.No. 11H2729

BARREL KIT #58 SLIDE SWITCHES — 30 for $1.98. All shapes, sizes, spst, dpdt, momentaries, etc. Tremendous shop pak for 100's of switching projects. Cat.No.11H2726 100% good

BARREL KIT #39 HOBBY NPN POWER TRANSISTORS — 15 for $1.98. Factory fallouts and "off spec" TO-3 powers. 100% hobby, no opens, no shorts. Wt. 1 lb. Cat. No. 11H2617

BARREL KIT #31 METALLIC RESISTORS — 100 for $1.98. Made mostly by Corning, the finest resistor made. Mostly ½ watters, 1% to 5% tol. & a barrel of values. Cat. No. 11H2609

BARREL KIT #30 PREFORMED RESISTORS — 200 for $1.98. We got barrels of ¼ and ½ watters for pc use. 100: ¼, 100 ½ watters. No.11H2608 100% good

BARREL KIT #27 PREFORMED DISCS — 150 for $1.98. Hi-Fi mfr's shelf inventory but he dumped 'em in barrels. Preformed, for PC use. Mixed values too! 11H2605

BARREL KIT #26 PLASTIC TRANSISTORS — 100 for $1.98. Untested and hobby transistors, TO-92 (TO-18), asst. 2N numbers, asst. manufacturers. Wt. 8 ozs. 11H2604

BARREL KIT #20 LONG LEAD DISCS — 100 for $1.98. "auction sale". Prime, marked only. Long leads. Cat. 11H2598 100% good

BARREL KIT #19 DIPPED MYLARS — 60 for $1.98. Finest capacitors made, shiny finish. Imagine factory dumping 'em in barrels. Cat.No.11H2597 100% good

BARREL KIT #14 PRECISION RESISTORS — 200 for $1.98. Marked and unmarked ¼, ½, 2 watts. No11H2428

BARREL KIT #7 VOLUME CONTROL — 30 for $1.98, 100% good. Singles, duals, variety of values, styles, big ones — small ones. Cat. 11H 2421

BARREL KIT #3 1N4148/914 SWITCHING DIODES — 100 for $1.98. Imagine famous switching diodes at these prices! Cat.No.11H2418 Untested.

BARREL KIT #1 SN7400 DIP IC'S — 75 for $1.98. Marked 14 and 16 pin dips, may include gates, flip-flops, registers, counters, who knows? Untested, hobby. Wt. 14 ozs. 11H2415

Terms: Add postage Rated: net 30
Phone: Wakefield, Mass. (617) 245-3829
Retail: 16-18 Del Carmine St., Wakefield.

POLY PAKS

P.O. BOX 942H LYNNFIELD, MA. 01940

SALE — Send for FREE Fall-Winter CATALOG

C.O.D.'s MAY BE PHONED

MINIMUM ORDER — $6.00

More Details? CHECK—OFF Page 150

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-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each 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 93862.

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, FT net, more. Back issues of Newsletter available from 1972. To join, send $5 for calendar year (includes all 1977 issues of Newsletter) or $1 creditable towards dues, for complete information and sample Newsletter. Milton Lowens, WA2AOQ/N4ML, 248 Lake Dora Drive, W. Palm Beach, Fl. 33411.

QRP TRANSMATCH with Preamp for HW7 Ten-Tec. Send stamp for details to Peter Meacham Associates, 19 Lorreta Road, Waltham, Mass. 02154.

WANTED — Manual for Panoramic Electronics Model SPA-4a Spectrum Analyzer — Judson Snyder, K2CBA, Petersburg, N.Y. 12138

CANADIANS 1,000,000 surplus parts. Bargains galore. Free catalog. Etco-HR. Box 741, Montreal, H3c 2v2.

Foreign Subscription Agents for Ham Radio Magazine

Ham Radio Austria
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

Ham Radio Canada
Box 114, Goderich
Ontario, Canada N7A 3Y5

Ham Radio Europe
Box 444
S-194 04 Upplands Vasby
Sweden

Ham Radio France
Christiane Michel
F-89117 Parly
France

Ham Radio Germany
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio Holland
MRL Ectronics
Postbus 88
NL-2204 Delft
Holland

Ham Radio Italy
STE, Via Maniago 15
I-201 34 Milano
Italy

Ham Radio Switzerland
Karin Ueber
Postfach 2454
D-7850 Loerrach
West Germany

Ham Radio UK
P.O. Box 63, Harrow
Middlesex HA3 6HS,
England

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

PORTA PAK the accessory that makes your mobile really portable. $67.50 and $88.00. Dealer inquires invited. P.O. Box 67, Somers, Wisc. 53171.

FOR SALE; One 20A Central Electronics Transmitter; One National 303 Receiver; Both in excellent condition. KØYBC 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, Strobes, LEDS, Transistors, IC's, Unique Components. Chaney's, Box 27038, Denver, Colo. 80227.

QSL — BROWNIE W3CJI — 3035B Lehigh, Allentown, Pa. 18103. Samples with cut catalog 50¢.

TRAVEL PAK QSL KIT — Send call and 25¢; receive your call sample kit in return. Samco, Box 203, Wynantskill, N.Y. 12198.

NATIONAL NC-183 General Coverage receiver complete with manual. Poor condition as is $40. Steven Terhaar, WAØPXQ, 650 Beech, Moorhead, MN. 56560.

MILLEN 90651-A GDO, probe, & tone modulator $75.00; Bell & Howell equipment — #34 oscilloscope $65.00, transistorized meter $20.00, two design consoles $20.00 each.; RCA Institute signal generator and VOM, both $30.00; RCA WV-98C senior voltohmyst $40.00; Sprague TO-6 Tel Ohmike capacitor analyzer $90.00; Eico equipment — 955 in circuit capacitor tester $25.00, 378 Audio Generator $40.00, 565 VOM $15.00, 1030 Regulated Power Supply $50.00, 1064 Battery Eliminator & charger $30.00, 1078 Auto Transformer $40.00; Heath IM-38 AC VTVM $30.00, Heath ID-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 Conner, WA3OBW, 149 Gladstone Street, Phila., Pa. 19148, 215-HO 2-9293.

SELL: ROBOT 70A monitor, 61 viewfinder, 80A camera with 25mm 1.4 lens, 8- and 15-foot camera cables. Original cartons and instruction books. Recently factory calibrated. $500. Gordon Buckner, WØVZK, Box 721, Marshall, MO. 65340.

MOTOROLA HT220, HT200, and Pageboy service and modifications performed at reasonable rates. WA4FRV (804) 320-4439, evenings.

AUTHORIZED DEALER for Dentron, KLM, Larsen, Bearcat, etc., Big Catalog 201-962-4695 Narwid Electronics, 61 Bellot Road, Ringwood, N.J. 07456.

RECONDITIONED TEST EQUIPMENT for sale. Catalog $.50. Walter, 2697 Nickel, San Pablo, Ca. 94806.

PERSONALIZED CODE TAPES Specify: Speed (5-99 WPM), Content (Letters, or Punctuation and Numbers, or Both). 60 minutes for $4.00. TRICOMM, P.O. Box 5036, Aloha, OR 97005.

YOUR CALL on a bumper sticker. Red or Yellow-Green letters on Black — $1.25 postpaid. R. Schweizer, Box 4675, Margate, Florida 33063.

D & V RADIO PARTS — variable & trimmer capacitors, chokes, Miniductors, stocked for immediate shipment. First class stamp for flyer — 12805 W. Sarle Rd., R#2, Freeland, Michigan 48623.

YOUR CALL & HANDLE Engraved on laminated plastic. 5/8" x 2-1/2" Safety Pin Backs. Choice of colors. No C.O.D.'s or Stamps. Badges shipped postpaid. $2.00 each. SASE For Full Line Quotes. Carl Suriano, W7HUL, 8511 19th Ave. N.W., Seattle, WA. 98117.

CASH for your clean ham gear. Beacon Communications — used equipment specialists, 879 Beacon St., Boston, Mass. 02215. 617-267-1975.

TRANSMITTING TUBES, HV and filament xfmrs, rotary inductors, transmitting capacitors. Send stamp for flyer. T.S. Marinich Electronics, 102 Bell St., Weirton, W. Va. 26062.

MODERN CODE PRACTICE. 0-22wpm on four 60 min. cassettes, $10. Royal, P. O. Box 2174, Sandusky, Ohio 44870.

EXCLUSIVELY HAM TELETYPE 23rd year, RTTY Journal, articles, news, DX, VHF, classified ads. Sample 35¢. $3.50 per year. 1155 Arden Drive, Encinitas, Calif. 92024.

FIGHT TVI with the RSO Low Pass Filter. For brochure write: Taylor Communications Manufacturing Company, Box 126, Agincourt, Ontario, Canada MIS 3B4.

RUBBER STAMP, name/call/QTH $2.50 ppd. (CA residents add tax). LWM Press, Box 22161, San Diego, CA 92122.

More Details? CHECK—OFF Page 150

flea market

SELLING: 120 Hz sharpest CW filter for TS-820. New. $95. Yamada, Box 272, FPO, Seattle 98761.

WONDERFUL! Star-Tronics picture flyer of electronic parts and pieces. Cheap. Builders love it. Send 25¢. U.S. only. Star-Tronics, Box 683, McMinnville, OR 97128.

TELETYPE EQUIPMENT for beginners and experienced operators. RTTY machines, parts, supplies. Beginner's special: Model 15 Printer and demodulator $139.00. Dozen black ribbons $6.50; case 40 rolls 11/16 perf. tape $17.50 FOB. Atlantic Surplus Sales, 3730 Nautilus Ave., Brooklyn, N. Y. 11224. Tel: (212) 372-0349.

100 RESISTORS $1.50 ppd. Two pieces G-10 1 Oz. copper clad, 4-1/2 x 6 in. $1.50 ppd. SASE Catalog. OK Electronics, Box 291, Onalaska, WI. 54650.

MOBILE BONDING STRAPS under 50¢ each. Literature. Estes Engineering, 930 Marine Drive, Port Angeles, Wash. 98362.

QSTs, pre-1960 WANTED, also Motorola HT-100 (2m) wanted, state asking prices. Al Blank, W1BL, 727 Pine St., Bristol, Conn. 06010.

FERRITE BEADS: w/specification and application sheet - 10/$1.00. Assorted PC pots - 5/$1.00. Miniature mica trimmers, 3-40 pf. - 5/$1.00. Postpaid. Includes latest catalog. Stamp for catalog alone. CPO Surplus, Box 189, Braintree, MA 02184.

THE "CADILLAC" of QSL's! New! Samples: $1.00 (Refundable) — MAC'S SHACK; Box #1171-D; Garland, Texas 75040.

CASH for any Collins unit, 618T, 490T, modules, parts, accessories. Air Ground Electronics, P.O. Box 416, Kearny, NJ 07032.

HEATHKITS BUILT — 20 years experience. Write for details. K4TO, 1207 Monte Sano, Huntsville, AL 35801.

COMPUTER HOBBYISTS — Classified advertising newsletter. Ads, New Products, etc. Every 3 wks. — Since Jan 76. $3.75/year. Free Sample. ON LINE, 24695 Santa Cruz Hwy., Los Gatos, CA 95030.

LET LaRue BE YOUR VHF GURU! Factory-authorized dealer for: ICOM, Regency, Standard, Cushcraft and CES Touch-Tone pads. Antenna Specialists 2-meter 5/8 wave mobile antennas in stock. Bomar 2-meter crystals for the above radios on most standard ARRL repeater frequencies $4.50 each postpaid. Mastercharge and BankAmericard accepted. For the greatest deal call or write LaRue Electronics, 1112 Grandview St., Scranton, Pennsylvania 18509. (717) 343-2124.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $10.00 per year. HURRY! HURRY! Ham Radio HORIZONS, Greenville, NH 03048.

VERY in-ter-est-ing! Next 4 issues $1 "Ham Trader Yellow Sheets," Sycamore, IL 60178.

POWER SUPPLIES — Brand New 2.5 amp. Less regulator circuit. You add. With circuit plans. $13 PP. Telstar Ent., E. 16109 Longfellow, Spokane, WA 99216.

PC BOARDS Ham Radio articles, Prescaler (11C90) 12/75 $3.00, Capacitor Checker 4/75 $3.50, Tone Encoder 8/77 $3.50, Frequency Standard 8/77 $3.50. Glass, Plated, Drilled, Instructions. RTC Electronics, Box 2514, Lincoln, Nebr. 68502.

BUY-SELL-TRADE. Write for free mailer. Give name, address and call letters. Complete stock of major brands new and reconditioned equipment. Call for best deals. We buy Collins-Drake-Swan etc. SSB & FM. Associated Radio, 8012 Conser, Overland Park, Kansas 66204.

LET'S TRADE. I have new HORNET ANTENNAS. 6-10-15 & 20 meter beams; 10 to 80 element 2-meter antenna systems; stacking kits, antenna hardware, etc. I need good clean transmitters, receivers, transceivers, test equipment. Jack W5AJZ, Box 880, Duncan, OK 73533.

HEATH EQUIPMENT. Wired and tested. Most never used. IM-25 Bench VOM $75. SB-634 Station Console $160. SB-604 Speaker for SB-104 $20. HM-2103 KW Dummy Load/Wattmeter $75. Prices or Best Offer. Will ship FOB. Larry E. Riley, Box 513, APO NY 09194.

ELIMINATE QRM and QRN problems with our superior CW and SSB Filters. Also CW keyers, speech compressors, power supplies, and multiband antennas assembled or in kits. Dealer discounts. Dynamic Electronics, Box 896, Hartselle, AL 35640. (205) 773-2758.

More Details? CHECK—OFF Page 150

More Details? CHECK—OFF Page 150

flea market

PUBLICATIONS for trade: duplicates Rider's Radio & Sams Photofacts, ARRL Handbooks, radio & electronic magazines and books. Need RADEXs, WRTHs, SWL club bulletins, Rider's TV, and magazines, old or new. Donald Erickson, 6059-M Essex Street, Riverside, California 92504. 714-687-5910.

LOCAL RESIDENT PICKUP ONLY, no shipping. Sell one FR-4/U Frequency meter, No handles, like new, original calibration book, no accessories. $30.00. One ARR-41 Receiver, no handles, home made panel, no power supply, operates. Excellent condx, $30.00. One signal generator, no handles, no accessories, TS-413/U. Operates, needs possible alignment. Very good condition, $25.00, or all three $80.00. T. North, 2016 N. Adams St., Apt. 208 Rear, Arlington, VA. Tel: 525-3023.

TELETYPEWRITER PARTS, gears, manuals, supplies, tape, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, FL. 33310. Buy parts, late machines.

STOP LOOKING For a good deal on amateur radio equipment — you've found it here — at your amateur radio headquarters in the heart of the Midwest. We are factory-authorized dealers for Kenwood, Drake, Collins, ICOM, Ten-Tec, Atlas, Regency, Tempo, Swan, Midland, Alpha, Standard, Dentron, Hy-Gain, Mosley, Cushcraft, and CDE, plus accessories. Thousands of thrifty hams from coast to coast already know us and we invite you to join them by writing or calling us today for our low quote and trying our personal and friendly Hoosier service. HOOSIER ELECTRONICS, P. O. Box 2001, Terre Haute, Indiana 47802. (812)-238-1456.

Coming Events

NORTH CAROLINA QSO PARTY, sponsored by the Alamance Amateur Radio Club, Inc., from 1900Z Dec. 2 through 0100Z Dec. 4. Suggested frequencies are plus/minus 10 kHz: cw, 3560 7060 14060 21060 28060; Novice, 3720 7120 21120 28120; ssb, 3900 7270 14290 21390 28590. Out-of-state stations transmit RS(T) and state, province or country. NC stations send RS(T) and NC county. Out-of-state stations count 1 point for each NC contact (same station worked on different band, mode, or in different NC county, counts as new contact); multiply by the total number of NC counties worked for final score. NC stations count 1 point for each contact, multiply by total of states, provinces, foreign countries for final score. NC mobiles use the number of counties operated FROM for additional multiplier. Your log must be signed, none can be returned. Log must show RS(T)s, bands/modes, time (Z), state, province, country or NC county. On a separate sheet please show name, call and mailing address plus your total score and where you operated from. In the case of multi-operator stations, this sheet must also list the call of the operators. Awards. Logs must be postmarked no later than Jan. 10, 1978 and sent to: Alamance ARC Inc., 2822 Westchester Dr., Burlington, NC 27215.

WESTERN MICHIGAN UNIVERSITY will hold its 23rd annual VHF Conference, November 19, 1977. Contact Dr. Glade Wilcox, W9UHF/8, Dept. of Electrical Eng., WMU Kalamazoo, Michigan 49008.

MASSILLON ARC 16th ANNUAL HAMFEST & AUCTION Sun. Nov. 20, 1977 at new location. Towne Plaza Shopping Center, Downtown Massillon, Ohio. Unlimited parking. Starts 9:00 AM. Major prizes given away. Mobile check-in 146.52 simplex. Admission $1.50 at door. For brochure & map write to MARC, P.O. Box 73, MASSILON, Ohio 44646.

PAN AMERICAN HAM JAMBOREE/EXPOSITION. Ft. Lauderdale, FL, October 29 & 30 at the National Guard Armory (State Road 84). Hours: Saturday, Noon to 10 PM; Sunday, 9 AM to 5 PM. Talk-in on 31/91 or 52 simplex. Additional info from WA4ZRW (305) 581-2718.

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 Hotel, contact: F.G.C.A.R.C. Convention, P.O. Box 157, Clearwater, FL 33517.

RADIO AND ELECTRONIC SWAP AND SHOP, sponsored by the Marshall County Amateur Radio Club, will be held on Sunday, October 30, 1977, at the Plymouth, Indiana National Guard Armory, located at 1220 West Madison Street, from 8 AM to 5 PM. Free tables, no charge for set-up. Tickets $2.00 at the door. Food, drink, and door prizes. Talk-in on 146.07-67 and 146.52 simplex. For further information contact Wayne Zehner, WA9INM, Rt. 3, Box 526, Plymouth, Indiana 46563.

More Details? CHECK—OFF Page 150

7400N TTL

SN7400N	.16	SN7472N	.39	SN74160N	1.25
SN7401N	.18	SN7473N	.39	SN74161N	.99
SN7402N	.20	SN7474N	.35	SN74162N	1.95
SN7403N	.20	SN7475N	.50	SN74163N	.99
SN7404N	.20	SN7476N	.35	SN74164N	.99
SN7405N	.20	SN7479N	5.00	SN74165N	.99
SN7406N	.35	SN7480N	.50	SN74166N	1.25
SN7407N	.35	SN7482N	.99	SN74167N	3.25
SN7408N	.20	SN7483N	.70	SN74170N	2.10
SN7409N	.25	SN7485N	.89	SN74172N	6.00
SN7410N	.20	SN7486N	.39	SN74173N	1.50
SN7411N	.30	SN7488N	3.50	SN74174N	1.25
SN7412N	.35	SN7489N	2.49	SN74175N	.99
SN7413N	.69	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.75	SN74177N	.79
SN7416N	.35	SN7492N	.49	SN74179N	2.49
SN7417N	.35	SN7493N	.49	SN74180N	.99
SN7420N	.20	SN7494N	.79	SN74181N	2.49
SN7421N	.39	SN7495N	.79	SN74182N	.95
SN7422N	.49	SN7496N	.79	SN74184N	1.95
SN7423N	.37	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	1.25	SN74186N	15.00
SN7426N	.29	SN74107N	.39	SN74187N	6.00
SN7427N	.37	SN74109N	.95	SN74188N	3.95
SN7429N	.42	SN74116N	1.95	SN74190N	1.79
SN7430N	.25	SN74121N	.39	SN74191N	1.25
SN7432N	.25	SN74122N	.39	SN74192N	.89
SN7437N	.35	SN74123N	.50	SN74193N	.89
SN7438N	.35	SN74125N	.60	SN74194N	1.25
SN7439N	.25	SN74126N	.60	SN74195N	.75
SN7440N	.21	SN74132N	1.25	SN74196N	1.00
SN7441N	.89	SN74136N	.95	SN74197N	1.00
SN7442N	.69	SN74141N	1.15	SN74198N	1.75
SN7443N	.75	SN74142N	2.95	SN74199N	1.75
SN7444N	.75	SN74143N	3.25	SN74200N	5.59
SN7445N	.75	SN74144N	3.00	SN74251N	1.79
SN7446N	.89	SN74145N	1.15	SN74279N	.90
SN7447N	.69	SN74147N	2.35	SN74283N	2.25
SN7448N	.89	SN74148N	2.00	SN74284N	6.00
SN7450N	.25	SN74150N	1.25	SN74285N	6.00
SN7451N	.25	SN74151N	.79	SN74365N	.75
SN7453N	.25	SN74153N	.89	SN74366N	.75
SN7454N	.25	SN74154N	1.25	SN74367N	.75
SN7459A	.25	SN74155N	.89	SN74368N	.75
SN7460N	.25	SN74156N	.89	SN74390N	2.25
SN7470N	.45	SN74157N	.89	SN74393N	2.25

20% Discount for 100 Combined 7400's

CMOS

CD4000	.23	CD4044	.89	MC14562	14.50
CD4001	.23	CD4046	1.79	CD4566	2.25
CD4002	.23	CD4047	2.50	MC14583	3.50
CD4006	1.19	CD4048	1.35	**74C00 Series**	
CD4007	.25	CD4049	.49	74C00	.39
CD4009	.49	CD4050	.49	74C02	.55
CD4010	.49	CD4051	1.19	74C04	.75
CD4011	.23	CD4053	1.19	74C10	.65
CD4012	.25	CD4056	1.49	74C14	3.00
CD4013	.39	CD4059	9.95	74C20	.65
CD4014	1.39	CD4060	1.49	74C30	.65
CD4015	1.19	CD4066	.79	74C42	2.15
CD4016	.49	CD4068	.39	74C73	1.50
CD4017	1.19	CD4069	.45	74C74	1.15
CD4018	.99	CD4070	.55	74C89	4.00
CD4019	.49	CD4071	.23	74C90	3.00
CD4020	1.19	CD4076	1.39	74C93	2.00
CD4021	1.39	CD4081	.23	74C95	2.00
CD4022	1.19	CD4082	.23	74C107	1.25
CD4023	.23	MC14409	14.95	74C151	2.90
CD4024	.79	MC14410	14.95	74C154	3.00
CD4025	.23	MC14419	4.95	74C157	2.15
CD4026	2.25	MC14506	.75	74C160	3.25
CD4027	.69	MC14507	.99	74C161	3.25
CD4028	.89	CD4508	3.95	74C163	3.00
CD4029	1.19	CD4510	1.39	74C164	3.25
CD4030	.49	CD4511	1.29	74C173	2.60
CD4035	.99	CD4515	2.95	74C193	2.75
CD4040	1.19	CD4518	1.29	74C195	2.75
CD4041	1.25	CD4520	1.29	80C95	1.50
CD4042	.99			80C97	1.50
CD4043	.89				

LINEAR

LM300H	.80	LM340T-8	1.25	LM723N	.55
LM301H	.35	LM340T-12	1.25	LM733N	1.00
LM301CN	.35	LM340T-15	1.25	LM739N	1.19
LM302H	.75	LM340T-18	1.25	LM741CH	.35
LM304H	1.00	LM340T-24	1.25	LM741CN	.35
LM305H	.60	LM350N	1.00	LM741-14N	.39
LM307CN	.35	LM351CN	.65	LM747H	.79
LM308H	1.00	78MG	1.75	LM747N	.79
LM308CN	1.00	LM370N	1.15	LM748H	.39
LM309H	1.10	LM373N	3.25	LM748N	.39
LM309K	1.25	LM377N	4.00	LM1303N	.90
LM310CN	1.15	LM380N	1.25	LM1304N	1.19
LM311H	.90	LM380CN	.99	LM1305N	1.40
LM311N	.90	LM381N	1.79	LM1307N	.85
LM317K	6.50	LM382N	1.79	LM1310N	2.95
LM318CN	1.50	NE501K	8.00	LM1351N	1.65
LM319N	1.30	NE510A	6.00	LM1414N	1.75
LM320K-5	1.35	NE529A	4.95	LM1458CN	.59
LM320K-5.2	1.35	NE531H	3.00	LM1496N	.95
LM320K-12	1.35	NE536T	6.00	LM1556V	1.75
LM320K-15	1.35	NE540L	6.00	LM2111N	1.95
LM320T-5	1.25	NE550N	1.30	LM2901N	2.95
LM320T-5.2	1.25	NE555V	.39	LM3053	1.50
LM320T-8	1.25	NE560B	5.00	LM3065N	.69
LM320T-12	1.25	NE561B	5.00	LM3900N(3401)	.49
LM320T-15	1.25	NE562B	5.00	LM3905N	.89
LM320T-18	1.25	NE565H	1.75	LM3909	1.25
LM320T-24	1.25	NE565N	1.25	LM5556N	1.85
LM323K-5	5.95	NE566CN	1.75	MC5558V	1.00
LM324N	1.80	NE567H	1.95	LM7525N	.90
LM339N	.99	NE567V	1.49	LM7534N	.75
LM340K-5	1.35	LM703CN	.45	80388	4.95
LM340K-6	1.35	LM709H	.29	LM75450	.49
LM340K-8	1.35	LM709N	.29	75451CN	.39
LM340K-12	1.35	LM710N	.79	75452CN	.39
LM340K-15	1.35	LM711N	.39	75453CN	.39
LM340K-18	1.35	LM723H	.55	75454CN	.39
LM340K-24	1.35			75491CN	.79
LM340T-5	1.25			75492CN	.89
LM340T-6	1.25			75494CN	.89

74LS00 TTL

74LS00	.29	74LS76	.49	74LS153	1.25
74LS02	.29	74LS83	1.75	74LS155	1.25
74LS03	.29	74LS85	2.49	74LS157	1.50
74LS04	.35	74LS86	.49	74LS160	1.95
74LS05	.35	74LS90	.89	74LS161	1.95
74LS08	.29	74LS92	.89	74LS162	1.95
74LS10	.29	74LS93	.89	74LS163	1.95
74LS13	.69	74LS95	1.50	74LS164	1.95
74LS14	1.75	74LS96	1.89	74LS175	1.95
74LS20	.29	74LS107	.59	74LS181	3.69
74LS26	.39	74LS109	.59	74LS190	2.49
74LS27	.39	74LS112	.59	74LS191	2.49
74LS28	.39	74LS123	1.25	74LS192	2.49
74LS30	.29	74LS132	1.25	74LS193	2.49
74LS32	.39	74LS136	.59	74LS194	1.89
74LS33	.39	74LS138	1.25	74LS195	1.89
74LS40	.39	74LS139	1.25	74LS253	1.75
74LS42	1.25	74LS151	1.25	74LS257	1.75
74LS47	1.25			74LS260	.55
74LS51	.29			74LS279	.79
74LS55	.29			74LS367	.99
74LS73	.49			74LS368	1.99
74LS74	.49			74LS670	3.95
74LS75	.69				

Grab Bag Specials

CAPACITORS

GB100	100 ea. Ceramic Disc	$2.00/lot
GB101	60 ea. Mylar	4.00/lot
GB102	60 ea. Electrolytics	4.00/lot
GB103	40 ea. Tantalum (tubular)	4.00/lot
GB104	20 ea. Ceramic Trimmers (marked)	6.00/lot
GB105	20 ea. Ceramic Trimmers (house # or unmarked)	3.00/lot

DIODES

GB106	100 ea. Germanium	2.00/lot
GB107	100 ea. Silicon	2.00/lot

INTEGRATED CIRCUITS

GB108	50 ea. Marked TTL Series	4.00/lot
GB109	30 ea. Marked Linear	4.00/lot

LEDS LAMPS - Readouts

GB110	100 ea. ASST LEDS	6.00/lot
GB111	40 ea. NE2 Type Lamps	3.00/lot
GB112	20 ea. Multiple Readouts, Calculators, Watches, Timers, Leds to Panaplex New — Used — Rejects	6.00/lot

RESISTORS

GB116	200 ea. ¼ watt Assortment	$2.00
GB117	200 ea. ½ watt Assortment	2.00
GB118	40 ea. Wirewound 3-10 watt 1-100 ohm	5.50
GB119	40 ea. Wirewound 3-10 watt 100ω-25K	5.00

SWITCHES

GB120	25 ea. Miniature Slide	3.00
GB121	12 ea. Rocker	3.00
GB122	20 ea. Reed-Coil & Magnetic	5.00

MISC.

GB123	30 ea. Heat Sinks Asst. Sizes	2.50
GB124	6 ea. Calculator Type Keyboards	5.00
GB125	300 ea. Molex Pins (8,9,14 sections)	3.00
GB126	50 ea. Opto Isolators IL-1 Series (untested)	2.00
GB127	100 ea. Transistors Plastic & Power	3.00
GB128	30 ea. Toroids Cores Iron & Tape	4.00
GB129	50 ea. Photo Transistors	4.00
GB130	1 ea. Tape Drive - 6 volt Motor with Erase Head & 2 Cassette Tapes (no amplifier)	5.00
GB131	30 ea. 6" Shrinktubing Asst. Sizes & Colors	4.00
GB132	Wire Asst. Sizes & Colors — 1lb.	2.95

POTENTIOMETERS

GB113	30 ea. Minature Trimmers 100ω-1meg	4.00
GB114	10 ea. 10 Turn P.C. Mount (rectangular marked)	4.00
GB115	10 ea. 10 Turn P.C. Mount (rectangular mismarked)	2.00
GB133	15 ea. ¾" sqaure Single Turn P.C. Mount (mismarked)	3.00

DISCRETE LEDS

.125" dia.			.200" dia.			.185" dia.			.200" dia.			.190" dia.		
XC209	Red	10/$1	XC22	Red	10/$1	XC526	Red	5/$1	XC556	Red	5/$1	XC111	Red	10/$1
XC209	Green	4/$1	XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1	XC111	Green	4/$1
XC209	Orange	4/$1	XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1	XC111	Yellow	4/$1
XC209	Yellow	4/$1	XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1	XC111	Orange	4/$1
			SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	7/$1			

.085" dia. MV50 - Red - 6/$1

INFRA-RED LED ¼" x ¼" x 1/16" Flat 5/$1.00

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode	.270	2.95
MAN 2	5 x 7 Dot Matrix	.300	4.95
MAN 3	Common Cathode	.125	.39
MAN 4	Common Cathode	.187	1.95
MAN 7	Common Anode	.270	1.25
MAN 7G	Common Anode-green	.270	1.95
MAN 7Y	Common Anode-yellow	.270	1.95
MAN 52	Common Anode-green	.300	1.00
MAN 71	Common Anode	.300	1.25
MAN 72	Common Anode	.300	1.25
MAN 74	Common Cathode	.300	1.50
MAN 81	Common Anode-yellow	.300	1.00
MAN 82	Common Anode-yellow	.300	1.00
MAN 84	Common Cathode-yellow	.300	1.00
MAN 3620	Commmon Anode-orange	.300	1.00
MAN 3640	Common Cathode-orange	.300	1.75
MAN 4610	Common Anode-orange	.300	1.00
MAN 4640	Common Cathode-orange	.400	1.00
MAN 4710	Common Anode-red	.400	1.00
MAN 4730	Common Anode-red	.400	1.00
MAN 4740	Common Cathode-red	.400	1.00
MAN 4830	Common Anode-yellow	.400	1.00
MAN 6610	Common Anode-Double Digit-orange	.560	1.25
MAN 6630	Common Anode-orange	.560	1.25
MAN 6640	Common Cathode-Double Digit-orange	.560	1.25
MAN 6650	Common Cathode	.560	1.25
MAN 6660	Common Anode	.560	1.25
MAN 6680	Common Cathode	.560	1.25
MAN 6710	Common Anode-Double Digit-red	.560	1.25
MAN 6730	Common Anode-Double Digit-red	.560	1.25
MAN 6740	Common Cathode-Double Digit-red	.560	1.25
MAN 6750	Common Cathode	.560	1.25
MAN 6760	Common Anode-red	.560	1.25
MAN 6780	Common Cathode-red	.560	1.25
DL701	Common Anode-red ± 1	.300	1.00
DL702	Common Cathode-red	.300	1.25
DL704	Common Cathode	.300	1.50
DL707	Common Anode	.300	1.50
DL728	Common Cathode	.500	2.95
DL741	Common Anode	.600	1.95
DL746	Common Anode	.630	1.95
DL747	Common Anode	.600	2.25
DL749	Common Cathode	.630	1.95
DL750	Common Cathode	.600	2.49
DL338	Common Cathode	.110	.69
FND70	Common Cathode (FND359)	.250	.75
FND503	Common Cathode (FND500)	.500	1.29
FND507	Common Anode (FND510)	.500	1.29

RCA LINEAR

CA3013	2.15	CA3083	1.60
CA3023	2.56	CA3086	.85
CA3035	2.48	CA3089	3.75
CA3039	1.35	CA3091	10.20
CA3046	1.30	CA3102	2.95
CA3053	1.50	CA3123	2.15
CA3059	3.25	CA3130	1.39
CA3060	3.25	CA3140	1.75
CA3080	.85	CA3401	.49
CA3081	2.00	CA3600	1.75
CA3082	2.00	RC4194	5.95
		RC4195	3.25

HP 5082-7400 Series — Multi-Digit

- ⅛" ht. • Common Cathode Red
- 3-5 volts @ 5 mils/second
- 7 segment Monolithic
- Dip Package

		10 or more
2 Digit	$ .79	.69
3 Digit	.89	.79
4 Digit	.99	.89
5 Digit	1.19	.99

TV GAME CHIP SET — $9.95

Includes AY-3-8500-1 Chip and 2.010 mhz crystal (2.010 crystal — $1.95 ea/AY-3-8500-1 chip — $8.95 ea.)

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	16	15	24 pin	$.38	37	36
14 pin	20	19	18	28 pin	45	44	43
16 pin	22	21	20	36 pin	60	59	58
18 pin	29	28	27	40 pin	63	62	61
22 pin	37	36	35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	25	24	28 pin	$ .99	90	81
16 pin	30	27	25	36 pin	1.39	1.26	1.15
18 pin	35	32	30	40 pin	1.59	1.45	1.30
24 pin	49	45	42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	27	24	24 pin	$ .70	63	57
14 pin	35	32	29	28 pin	1.10	1.00	90
16 pin	38	35	32	36 pin	1.75	1.40	1.26
18 pin	52	47	43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	41	37	24 pin	$1.05	95	85
14 pin	39	38	37	28 pin	1.40	1.25	1.10
16 pin	43	42	41	36 pin	1.59	1.45	1.30
18 pin	75	68	62	40 pin	1.75	1.55	1.40
22 pin	95	85	75				

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5% - 50 PCS.
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5% - 50 PCS.
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5% - 50 PCS.
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5% - 50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5% - 50 PCS.
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5% - 50 PCS.
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5% - 50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$10.95 ea.**

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1978 Catalog
Dealer Information Available

NOW OPEN SATURDAYS

James ELECTRONICS

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru November

WIRE WRAP CENTER

HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)

Complete with built-in bit and sleeve

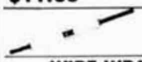
$34.95 (batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP

- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire.

$11.95



WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

WIRE DISPENSER — WD-30

- 50 ft. roll 30 AWG KYNAR wire wrap wire **$3.45 ea.**
- Cuts wire to desired length
- Strips 1" of insulation **Specify** — Blue-Yellow-White-Red

B&K PRECISION **New**

3½-Digit Portable DMM

Comes with test leads, operating manual and spare fuse.

- Overload Protected • .3" high LED Display
- Battery or AC operation • Auto Zeroing
- 1mv, 1Va, 0.1 ohm resolution • Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC Voltage: ±0-1000V/AC Voltage: 0-1000V
Freq. Response: 50-400 HZ/DC-AC Current: 0-1000mA
Resistance: 0-10 meg ohm
Size: 6.4" x 4.4" x 2"

Model 2800	**$99.95**
AC Adapter BC-28	**8.00**
Rechargeable Batteries BP-28	**20.00**
Carrying Case LC-28	**6.00**

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
Linear	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	28	1N4734	5.6	1w	28
1N5234	6.2	500m	28	1N4735	6.2	1w	28
1N5235	6.8	500m	28	1N4736	6.8	1w	28
1N5236	7.5	500m	28	1N4738	8.2	1w	28
1N456	25	40m	6/1.00	1N4742	12	1w	28
1N458	150	7m	6/1.00	1N4744	15	1w	28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

MPS A05	5/$1.00	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00	2N3724	$ .65	2N5087	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3055	$ .89	2N3905	4/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N3906	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N4013	3/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4123	10/$1.00	C106B1SCR	2/$1.00
				2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

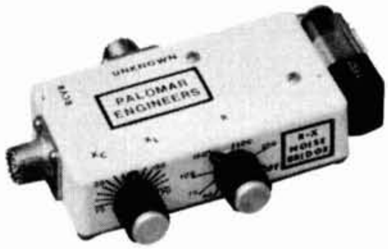
+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

R-X NOISE BRIDGE



√ 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 i2VTT, P.O. Box 37, 22063 Cantu. 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!

PALOMAR ENGINEERS
BOX 455, ESCONDIDO, CA 92025
Phone: (714) 747-3343

ALL-MODE VHF amplifiers

FOR BASE STATION & REPEATER USE

MODEL	INPUT	OUTPUT	PRICE
V70	10-20W	60-70W	$298
V71	1-5W	60-70W	$329
V130	25-40W	110-130W	$389
V131	1-5W	110-130W	$419
V135	5-10W	110-130W	$419
V180	10-15W	180-200W	$525
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
- ☆ 115 or 230V AC
- ☆ 60dB Spurious
- ☆ Fully Protected Output
- ☆ Internal T/R Switch
- ☆ U.S. Manufactured
- ☆ 19" Rack Panel Option
- ☆ Size 8-1/2 x 13 x 7" H

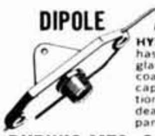
Only two things are needed to put this power house on the air with your handy-talky or mobile transceiver: a two foot piece of coaxial cable and a 115 or 230 volt AC outlet. That's all. You do not need anything else. The mobile transceiver can be powered directly from the accessory socket located in 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.

VISA

DEALER INQUIRIES INVITED

RF POWER LABS, INC.
11013-118th Place N.E. • Kirkland, Washington 98033 • Telephone: (206) 822-1251 • TELEX No. 32-1042

DIPOLE ANTENNA CONNECTOR



HYE-QUE (HQ-1) dipole connector has coax SO-239 socket molded into glass filled plastic body to accept coax PL-259 plug on feedline. Drip-cap keeps coax fittings dry. Instructions included. Guaranteed. At your dealers or **$3.95 postpaid.** Companion insulators **2/$.99.**

BUDWIG MFG. Co. PO Box 97H, Ramona, CA 92065

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.

JENSEN TOOLS & ALLOYS
1230 SOUTH PRIEST DRIVE TEMPE AZ 85281

CURTIS KEYER CHIP $24.95

8043; IC only, 50-up group rate .... $ 7.95
8043-1; IC, PCB, Manual .... $ 24.95
8043-2; Semi-kit .... $ 49.95
Add for air postage and handling ... $ 1.50
(See Feb 75 CQ, Apr 75 HR, Feb 76 QST, Radio Handbook 75)
KB4200 Keyboard Keyer (Oct 74 QST) ... $549.95
EK420/KM420 Keyer/Memory (Oct 73 QST) $439.90
EK430 CMOS Keyer (Feb 76 QST) $124.95
IK440 Instructokeyer (Mar 76 QST) $224.95

Curtis Electro Devices Inc.
(415) 964 3136
Box 4090, Mountain View, CA 94040

master charge — Your BANKAMERICARD welcome here

RECEIVER MODULE KIT

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

ORDER FROM
DIRECT CONVERSION TECHNIQUE
3132 North Lowell Avenue
Chicago, Illinois 60641

More Details? CHECK—OFF Page 150

SEND FOR FREE COMPLETE MAIL ORDER CATALOG

SST T-1 RANDOM WIRE ANTENNA TUNER

All band operation (160-10 meters with most any random length wire. 200 Watt power capability. Ideal for portable or home operation. A must for Field Day. Size 2 x 4-1/4 x 2-3/8. Built-in neon tune-up indicator. Guaranteed for 90 days. Compact — easy to use. Only $29.95.

Larsen Antennas
to fit Any Mobile Unit

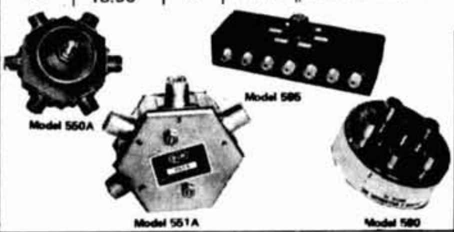
Larsen Antennas

Magnetic Mount or Gutter Clamp 5/8 wave – $38.50
Specify, 2 meters, 220, 450. 1/4 wave – $18.50

3/8" single hole mount 5/8 wave $31.50
1/4 wave 11.50

COAXIAL SWITCH SELECTOR CHART – BARKER & WILLIAMSON, INC.

Model	PRICE	Outputs	Connector Placement	Remarks
375	18.95	6	Axial	PROTAX switch. Grounds all except selected output circuit.
376	18.95	5	Radial	PROTAX switch. Grounds all except selected output circuit. Sixth switch position grounds *all* outputs.
550A	14.00	5	Radial	
550A-2	12.50	2	Radial	
551A	17.50	2	Radial	Special 2-pole, 2-position switch used to switch any RF device in or out of series connection in a coaxial line. See figure (over).
556	.95	–	–	Bracket only, for wall mounting of radial connector switches.
590	17.95	5	Axial	
590G	17.95	5	Axial	Grounds all except selected output circuit.
592	16.50	2	Axial	
595	18.50	6	In-line	Grounds all except selected output circuit.



MODEL 104R

NPC 6 Amp Power Supply Regulated.
Solid State. Dual Overload Protection.

Converts 115 volts AC to 13.6 volts DC ±200 millivolts. Handles 4 amps continuous and 6 amps max. Ideally suited for applications where excellent DC stability is important, such as CB transmission, small Ham radio transmitter, and high quality eight-track car stereos. Can be used to trickle-charge 12 volt car batteries.

	MAXIMUM	TYPICAL
Output Voltage	13.6 ± 2 VDC	13.6 ± 3 VDC
Line/Load Regulation	20 mV	50 mV
Ripple/Noise	2 mV RMS	5 mV RMS
Transient Response	20 uSec	
Current Continuous	4 Amp	
Current Limit	6 Amp	
Current Foldback	2 Amp	

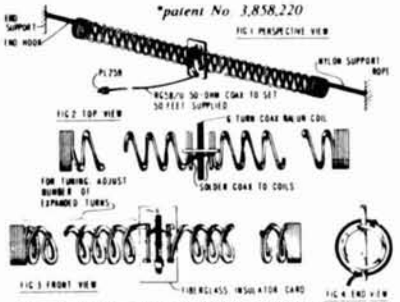
$49.95

Case: 3½" (H) x 5½" (W) x 6½" (D). Shipping Weight: 6 lbs.

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!

**patent No. 3,858,220*



• This electrically small 80/75, 40, & 20 meter antenna operates at any length from 24 to 70 feet • no extra balun or transmatch needed • portable—erects & stores in minutes • small enough to fit in attic or apartment • full legal power • low SWR over complete 80/75, 40, & 20 meter bands • much lower atmospheric noise pickup than a vertical and needs no radials • kit includes a pair of **specially-made 4-inch dia. by 4-inch long coils,** containing 335 feet of radiating conductor, balun, 50 ft RG58/U coax, PL259 connector, nylon rope & instruction manual • now in use by US Dept. of State, US Army, radio schools, plus thousands of hams the world over

talk power by TPL

TPL for an Economy Price?
THAT'S RIGHT!
introducing the ECONO-LINE

Model	Input	Output	Typical	Frequency	Price
702	5-20W	50-90W	10 in/70 out	143-149 MHz	$139.00
702B	1-4W	60-80W	1 in/70 out	143-149 MHz	$169.00

Now get TPL COMMUNICATIONS quality and reliability at an economy price. The new Econo-Line gives you everything that you've come to expect from TPL at a real cost reduction. The latest mechanical and electronic construction techniques combine to make the Econo-Line your best amplifier value. Unique broad-band circuitry requires no tuning throughout the entire 2-meter band and adjacent MARS channels. See these great new additions to the TPL COMMUNICATIONS product line at your favorite amateur radio dealer.

For prices and specifications please write for our Amateur Products Summary! FCC type accepted power amplifiers also available. Please call or write for a copy of TPL's Commercial Products Summary.

DENTRON

160-10AT SUPERTUNER™
Want an antenna tuner to match everything between 160 and 10 through balanced line, coax line and random line. Supertuner™ is the one for you at just $129.50

160-10AT-3K SUPER SUPERTUNER™
Designed and engineered to be compatible with the full-power highly efficient modern amplifiers now available to the amateur. In our opinion the finest tuner on the market today. $229.50

80-10AT SKYMATCHER™
Here's an antenna tuner for 80 through 10 meters, handles full legal power and matches your 52 ohm transceiver to a random wire antenna. 80-10AT is yours for only $59.50

BOMAR Crystal Company

TWO METER CRYSTALS IN STOCK

Standard • Icom • Heathkit • Ken • Clegg • Regency • Wilson • VHF Eng • Drake • And Others!

$4.50 @ Lifetime Guarantee

Novice Crystals (Specify Band Only)

NOW! Motorola HT 220 Crystals In Stock!

Make/Model	Xmit Freq.	Rec. Freq.

TUFTS

209 Mystic Ave.
Medford MA 02155
(617) 395-8280

New England's Friendliest Ham Store

Ask about our Dealer Program

Master Charge & BankAmericard accepted on most orders.

Name ________________ Call __________

Address __________________________

City ______________ State ______ Zip ______

Order: __________________________

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.

FREE Gift With Every Order! master charge **ALL SALES FINAL!** BANKAMERICARD

BULLET ELECTRONICS

P. O. BOX 19442
DALLAS, TEXAS 75219
(214) 823-3240

PHONE ORDERS ON MASTERCHARGE OR VISA CARDS

New! PS-14 HIGH CURRENT REGULATED POWER SUPPLY KIT

A low cost, no frills, heavy duty power supply. Designed for use and abuse!

12V @ 15A

Less Case, meters & jacks

* Better than 200MV load & line regulation
* Foldback Current Limiting
* Short Circuit Protected
* Thermal Shutdown
* Adjustable Current Limiting
* Less than 1% ripple.
* 15 amps 11.5 to 14.5V
* All parts supplied including heavy duty transformer.
* Quality plated fiberglass PC board.

$39.95
UPS SHIPPING PAID!

PS–12: SAME AS ABOVE BUT VARIABLE OVER 3–30 VDC IN 2 RANGES. $49.95
(without thermal shutdown)

SPECIAL! METERS

LARGE, QUALITY 3½ RECTANGULAR METERS AVAILABLE FOR USE WITH OUR POWER SUPPLIES. DIAL CAN BE BACK LIGHTED. INDIVIDUALLY PACKAGED WITH MOUNTING HARDWARE. NEW DESIGN REQUIRES MUCH SMALLER CUTOUT THAN STANDARD METERS.

0–15V DC 7.16	0–15 ADC 7.16
0–25V DC 7.05	0–25 ADC 7.05

DEDUCT 10% IF ORDERED WITH PS 14 OR PS 12 POWER SUPPLY.

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!

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

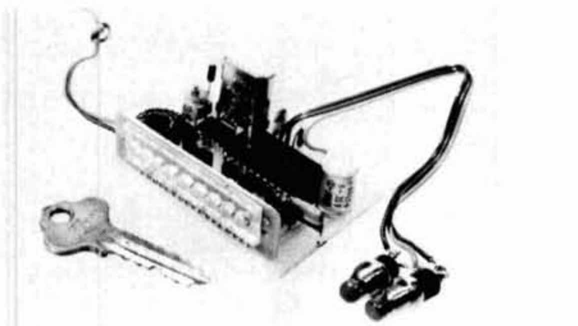
2N6283 MOTOROLA HOUSE # DEVICE

$1.00

20amp NPN Darlington with Hfe of over 5,000! VCE of 80V. Outperforms MJ3001 and MJ1000 devices. TO-3. Limited Qty.!

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).
* Top quality drilled and plated PC boards. Clock board: 2.6" x 2" Readout board: 2 3/8" x .75"

$12.95

With punched front aluminum case – $15.95

Small enough to mount in the instrument panel!

Free Money $$ Free Money

Starting October 1, 1977, each Bullet catalog will be stamped with a different special code number that will be placed in a monthly drawing. The monthly prize will be **$100.00 in cash!** The winning number will be announced each month in this ad and the winner will have until the 20th of the month to claim the money. *No purchase necessary. Catalogs are available free upon request. All orders receive a catalog.* **Watch for your Lucky Number!**

Ribbon Cable

Multi Colored Standard

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.
* Large 4 digit .5" LED readout
* All CMOS construction
* Complete electronics including transformer & speaker; drilled and plated PC boards measure 4.5" x 6.5"

$39.95

BEAUTIFUL SOLID WALNUT

Custom case for above kit. Over 9¾" tall. **$19.95**

* No COD'S.
* Send check or MO
* MasterCharge or VISA accepted.
* Texas Residents add 5% sales tax.
* Foreign orders add 10% (20% airmail)
* Catalog included with each order
* Orders over $50, take 10% discount.

SPECIAL — All phone orders over $10. from this ad will receive a FREE Warble Alarm Kit ($2.50 value). **PHONE ORDERS ONLY!**

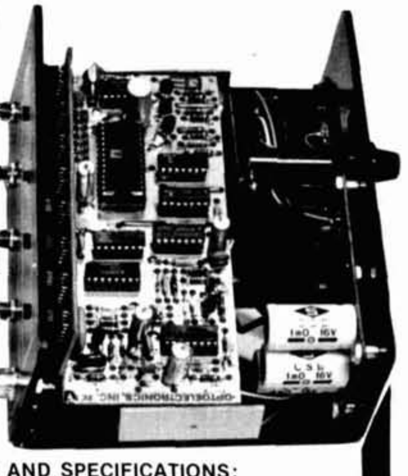
More Details? CHECK—OFF Page 150

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-50 C	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 WIRED, TESTED & CAL.	165.95
MODEL #FC-50/600 WT	600 MHZ	COUNTER WIRED, TESTED & CAL.	199.95



SIZE:
3" High
6" Wide
5½" Deep

FEATURES AND SPECIFICATIONS:

DISPLAY: 8 RED LED DIGITS .4" CHARACTER 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 HZ TO 60 MHZ. [65 MHZ TYPICAL].
SENSITIVITY: 10 MV RMS TO 50 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 [± .0001%]; AFTER CALIBRATION TYPICAL.
STABILITY: WITHIN 1 PPM PER HOUR AFTER WARM UP [.001% XTAL]
IC PACKAGE COUNT: 8 [ALL SOCKETED]
INTERNAL POWER SUPPLY: 5 V DC REGULATED.
INPUT POWER REQUIRED: 8-12 VDC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS

KIT #FC-50C IS COMPLETE WITH PREDRILLED CHASSIS ALL HARDWARE AND STEP-BY-STEP INSTRUCTIONS. WIRED & TESTED UNITS ARE CALIBRATED AND GUARANTEED.

PLEXIGLAS CABINETS

Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H,6¼"W,5½"D
CABINET II 2½"H,5"W,4"D
Black, White or Clear Cover
\$6.50 ea.

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS
3"x6"x1/8" 95¢ ea. 4/\$3

SEE THE WORKS Clock Kit Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled
Kit #850-4 CP
Size: 6"H,4⅓"W,3"D
\$23.50 ea. 2/\$45. Assembled \$29.95

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC.
1"x2" PC Board
Power Req: 5-15V (2.5 MA. TYP.)
Easy 3 wire hookup
Accuracy: ± 2PPM
#TB-1 (Adjustable) Complete Kit \$4.95
Wir & Cal \$9.95

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	\$1.75 ea.	100-199	\$1.45 ea.
25-99	1.60 ea.	200-999	1.39 ea.

1000 AND OVER \$1.29 ea.

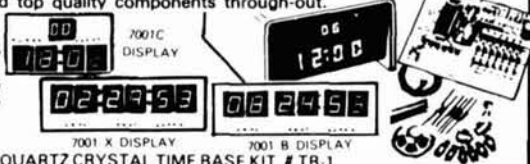
6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 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 battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT - 7001B WITH 6 - .5" DIGITS \$39.95
KIT - 7001C WITH 4 - .6" DIGITS & 2 - .3" DIGITS FOR SECONDS \$42.95
KIT - 7001X WITH 6 - .6" DIGITS \$45.95



KITS ARE COMPLETE (LESS CABINET)
ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC 12/24 Hr. time, PC Boards, Transformer, Line Cord, Switches and all Parts. Ideal Fit in Cabinet II

Kit #5314-5 \$19.95 2/\$38.

JUMBO DIGIT CONVERSTION KIT \$9.95 ea.

Convert small digit LED clock to large .5" displays. Kit includes 6 - LED's, Multiplex PC Board & Hook up info.
Kit #JD-1CC For Common Cathode
Kit #JD-1CA For Common Anode

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.
Specify for 7001
B, C or X - \$7.95

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND. KEYLESS ALARM HAS PROVISION FOR POS & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD. UNIT MOUNTS UNDER DASH - REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED. CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM. DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED.

KIT #ALR-1 \$9.95
#ALR-1WT WIRED & TESTED \$19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

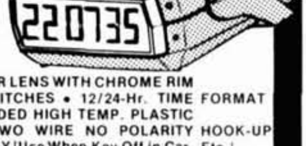
KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 \$8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. \$3.50

MOBILE LED CLOCK

12/24 HR .4" DIGITS!

MODEL #2001 12 VOLT AC or DC POWERED



- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY [Use When Key Off in Car, Etc.]
- TOP QUALITY PC BOARDS & COMPONENTS - INSTRUCTIONS.
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT \$27.95 EA. 3 OR MORE \$25.95 ea. 115 VAC Power Pack #AC-1 \$2.50 EA.

ASSEMBLED UNITS WIRED & TESTED ORDER #2001 WT [LESS 9V. BATTERY] Wired for 12-Hr. Op. if not otherwise specified. \$37.95 EA 3 OR MORE \$35.95 ea.

OPTOELECTRONICS, INC.

BOX 219 HOLLYWOOD, FLA. 33022
PHONE [305] 921-2056 / 921-4425

ORDER BY PHONE OR MAIL
COD ORDERS WELCOME

ORDERS TO USA & CANADA ADD 5% FOR SHIPPING, HANDLING & INSURANCE. ALL OTHERS ADD 10%. ADDITIONAL \$1.00 CHARGE FOR ORDERS UNDER \$15.00 - COD FEE \$1.00. FLA. RES. ADD 4% STATE TAX.

master charge THE INTERBANK CARD
BANKAMERICARD welcome here

HAM MART

Ham Radio's guide to help you find your loc

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
408-998-5900
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 KØLT.

Florida

AGL ELECTRONICS, INC.
1800-B DREW ST.
CLEARWATER, FL 33515
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 33516
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
Amateur Radio's Top Dealer. Buy — Sell — Trade.

Kentucky

COHOON AMATEUR SUPPLY
HIGHWAY 475
TRENTON, KY 42286
502-886-4535
Yaesu, Ten-Tec, 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. 198
LAUREL, MD 20810
301-792-0600
New & Used Amateur Equipment. Wilson, Ten-Tec, R. L. Drake, Tempo

Dealers - You should be here too! Contact Ham Radio today for complete details.

PROFESSIONAL ELECTRONICS CO., INC.
1710 JOAN AVENUE
BALTIMORE, MD 21234
301-661-2123
A professional place for amateurs.
Service-sales-design.

Massachusetts

TUFTS RADIO ELECTRONICS
386 MAIN STREET
MEDFORD, MA 02155
617-395-8280
New England's friendliest ham store.

Michigan

RADIO SUPPLY & ENGINEERING
1207 WEST 14 MILE ROAD
CLAWSON, MI 48017
313-435-5660
10001 Chalmers, Detroit, MI 48213, 313-371-9050.

Minnesota

ELECTRONIC CENTER, INC.
127 THIRD AVENUE NORTH
MINNEAPOLIS, MN 55401
612-371-5240
ECI is still your best buy.

Missouri

HAM RADIO CENTER, INC.
8340-42 OLIVE BLVD.
ST. LOUIS, MO 63132
800-325-3636
See Our Ads In This Issue.

MIDCOM ELECTRONICS, INC.
2506 SO. BRENTWOOD BLVD.
ST. LOUIS, MO 63144
314-961-9990
At Midcom you can try before you buy!

Nebraska

COMMUNICATIONS CENTER, INC.
2226 NORTH 48 ST.
LINCOLN, NE 68504
800-228-4097
Yaesu, Drake, Tempo, Swan, HyGain - call Toll Free

New Hampshire

EVANS RADIO, INC.
BOX 893, RT. 3A BOW JUNCTION
CONCORD, NH 03301
603-224-9961
Icom, Dentron & Yaesu dealer.
We service what we sell.

New Jersey

ATKINSON & SMITH, INC.
17 LEWIS ST.
EATONTOWN, NJ 07724
201-542-2447
Ham supplies since "55".

New Mexico

ELECTRONIC MODULE
601 N. TURNER
HOBBS, NM 88240
505-397-3012
Yaesu, Kenwood, Swan, Dentron, Tempo, Atlas, Wilson, Cushcraft

New York

ADIRONDACK RADIO SUPPLY, INC.
185 W. MAIN STREET
AMSTERDAM, NY 12010
518-842-8350
Yaesu dealer for the Northeast.

CFP COMMUNICATIONS
211 NORTH MAIN STREET
HORSEHEADS, NY 12010
607-739-0187
Jim Beckett, WA2KTJ, Manager
Bryant Hozempa, WB2LVW, Sales

GRAND CENTRAL RADIO
124 EAST 44 STREET
NEW YORK, NY 10017
212-682-3869
Drake, Atlas, Ten-Tec, Midland, Hy-Gain, Mosley in stock

HARRISON "HAM HEADQUARTERS, USA"
ROUTE 110 & SMITH STREET
FARMINGDALE, L. I., N. Y. 11735
516-293-7990
Since 1925 . . . Service, Satisfaction, Savings. Try Us!

RADIO WORLD
ONEIDA COUNTY AIRPORT
TERMINAL BLDG.
ORISKANY, NY 13424
315-337-2622
New & used ham equipment.
See Warren K2IXN or Joe WB2GJR

Ohio

UNIVERSAL SERVICE
114 N. THIRD STREET
COLUMBUS, OH 43215
614-221-2335
Give U.S. a try when ready to buy.

Oklahoma

RADIO STORE, INC.
2102 SOUTHWEST 59th ST.
(AT 59th & S. PENNSYLVANIA)
OKLAHOMA CITY, OK 73119
405-682-2929
New and used equipment — parts and supply.

Oregon

PORTLAND RADIO SUPPLY CO.
1234 S.W. STARK STREET
PORTLAND, OREGON 97205
503-228-8647
Second location, 1133 S. Riverside Avenue, Medford, OR 97501.

Pennsylvania

ELECTRONIC EXCHANGE
136 N. MAIN STREET
SOUDERTON, PA 18964
215-723-1200
New & Used Amateur Radio sales and service.

"HAM" BUERGER, INC.
68 N. YORK ROAD
WILLOW GROVE, PA 19090
215-659-5900
Communications specialists.
Sales and service.

HAMTRONICS, DIV. OF TREVOSE ELECT.
4033 BROWNSVILLE ROAD
TREVOSE, PA 19047
215-357-1400
Same location for 25 years.

South Carolina

AMATEUR RADIO ELECTRONICS
100 STATE ST.
WEST COLUMBIA, SC 29169
803-796-7957
Featuring Swan Equipment

Tennessee

GERMANTOWN AMATEUR SUPPLY
3203 SUMMER AVE.
MEMPHIS, TN 38112
800-238-6168
No monkey business. Call Toll Free.

J-TRON ELECTRONICS
505 MEMORIAL BLVD.
SPRINGFIELD, TN 37172
615-384-3501
Ten-Tec dealer — call or write for best trade.

HAM MART

Texas

AGL ELECTRONICS
3068 FOREST LANE, SUITE 309
DALLAS, TX 75234
214-241-6414 (within Texas)
Out-of-State, Call our toll-free number 800-527-7418.

HARDIN ELECTRONICS
5635 E. ROSEDALE
FT. WORTH, TX 76112
817-461-9761
Your Full Line Authorized Yaesu Dealer.

Wisconsin

AMATEUR ELECTRONIC SUPPLY, INC.
4828 WEST FOND du LAC AVENUE
MILWAUKEE, WI 53216
414-442-4200
Open Mon & Fri 9-9, Tues, Wed, Thurs, 9-5:30, Sat, 9-3.

Washington

AMATEUR RADIO SUPPLY CO.
6213 13TH AVENUE SOUTH
SEATTLE, WA 98108
206-767-3222
First in Ham Radio in Washington
Northwest Bird Distributor

Wyoming

DENCO COMMUNICATIONS CENTER
1728 EAST 2nd STREET
CASPER, WY 82601
307-234-9197
Sales, Service to Wyoming and the Northern Rockies.

Dealers -

you should be here too!

Contact Ham Radio today

for complete details.

(TOLL FREE)
800-258-5353

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, Leesburg, 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 allocations - 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.

OSCAR

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 softbound book.

Order RS-O *JUST $8.50*

Ham Radio's Communications Bookstore
Greenville, NH 03048
Order RS-O *Just $8.50*

☐ I enclose 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

THE PERSONAL COMMUNICATIONS FOUNDATION

Legal research for the amateur radio and citizens band services.

The Personal Communications Foundation is a non-profit, tax-exempt California corporation established in November, 1976. Its Board of Trustees, Officers and Advisors consist of lawyers, judges and law school professors with substantial experience in the representation of users who have encountered communications related legal problems.

The Foundation has been organized expressly for the purpose of creating a comprehensive personal communications law library. The Foundation continues to collect available court decisions, briefs and legal memoranda relating to personal communications.

The Foundation has already expended thousands of dollars in funding special studies. One study on the issue of Federal Pre-emption has already been incorporated into a brief before the California Court of Appeals.

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.

NAME (first, middle initial, last) or COMPANY NAME

STREET ADDRESS

CITY

STATE

ZIP

PCF use only

MEMBERSHIP CLASS (check one)

- ☐ LIFE MEMBER ($250)
- ☐ CONTRIBUTING MEMBER ($100)
- ☐ FULL MEMBER ($25)
- ☐ ASSOCIATE MEMBER ($10)

AMOUNT ENCLOSED

DATE

SIGNATURE

SEND CHECK PAYABLE TO:

PERSONAL COMMUNICATIONS FOUNDATION
10960 Wilshire Boulevard, Suite 1504
Los Angeles, California 90024

More Details? CHECK—OFF Page 150

Advertisers check-off

...for literature, in a hurry — we'll rush your name to the companies whose names you **"check-off"**

Place your check mark in the space between name and number. **Ex: Ham Radio ✓ 234**

INDEX

ABC ____ 571
AGL ____ 558
ARRL *
Aldelco ____ 347
Alkan *
Am. Wholesale
  Elect. ____ 003
Amidon ____ 005
Antler ____ 547
Artistic Label ____ 326
Atlas ____ 198
Atronics ____ 382
Bencher ____ 629
Beverage Ant. *
Budwig ____ 233
Bullet ____ 328
CFP ____ 022
CIR ____ 548
Cal-Com ____ 282
Cleng ____ 465
Columbia Elect. ____ 633
Comm Center ____ 634
Comm. Elect. ____ 489
Comm. Spec. ____ 330
Crystal Banking
  Service ____ 573
Curtis ____ 034
Cushcraft ____ 035
Cygnus-Quasar ____ 549
Dames Comm. ____ 551
Dames ____ 324
Data Signal ____ 270
Davis ____ 332
Dentron ____ 259
Direct Conv. Tech. *
Disc-Cap ____ 449
Drake ____ 039
E. T. O. *
Elect. Distr. ____ 044
Elect. Equip.
  Bank ____ 288
Electrospace ____ 407
Epsilon ____ 046
Erickson ____ 047
Excel ____ 535
Fair ____ 048
GLB ____ 552
Gilfer ____ 207
Gray ____ 055
Gregory *
Gull Elect. ____ 635
Hal ____ 057
Hal-Tronix ____ 254
H. R. C. B. ____ 150
Ham Center ____ 491
Hamtronics ____ 246
Heath ____ 060
Heights ____ 061
Henry ____ 062
Icom ____ 065
Info-Tech ____ 351
Int. Circuits ____ 518
Int. Crystal ____ 066
James ____ 333
Jan ____ 067
Jensen ____ 293
Jones ____ 626
KLM Electronics ____ 073
K-Enterprises ____ 071
KE Electronics ____ 072
Kenwood *
Kester Solder ____ 492
L-Tronics ____ 576
Lafayette ____ 598
Larsen ____ 078
Long's ____ 468
Lunar ____ 577
Lyle ____ 373
MFJ ____ 082
Madison *
Masters ____ 555
NuData ____ 455
Optoelectronics ____ 352
Palomar ____ 093
Partridge ____ 439
Personal Comm. *
Pipo ____ 481
Poly Paks ____ 096
Prime ____ 627
RF Power
  Comp. ____ 542
RF Power Labs ____ 602
Callbook ____ 100
Radio World ____ 592
Ramsey ____ 442
Regency ____ 102
Rockwell, Collins ____ 258
Ross Dist. ____ 581
SST ____ 375
SAROC *
Securitron ____ 461
Solid State Time ____ 636
Space ____ 107
Spectronics ____ 191
Spectrum Comm. ____ 336
Spectrum Int. ____ 108
Swan ____ 111
Tee/Ax ____ 615
Telephone Equip. ____ 496
Telrex ____ 377
Ten-Tec *
Trevor Ind. ____ 474
Tri-Ex ____ 116
Tristao ____ 118
Tufts ____ 321
VHF Engineering ____ 121
Valley Instr. ____ 583
Vanguard *
Varian ____ 043
Webster Comm. ____ 423
Weinschenker ____ 122
Western Elect. ____ 601
Whitehouse ____ 378
Wilson ____ 123
Yaesu ____ 127

*Please contact this advertiser directly.

Limit 15 inquiries per request.

November 1977

Please use before December 31, 1977

Tear off and mail to

HAM RADIO MAGAZINE — "check off"
Greenville, N. H. 03048

NAME..

CALL..................

STREET.......................................

CITY..

STATE.................. **ZIP**..................

Advertisers iNdex

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!

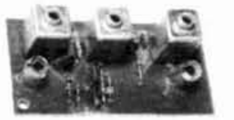
P8 KIT $7.95 **P16 W/T 16.95**

Recommended for mounting inside transceivers — only 1/2 x 2-3/8 inches

MODEL	RANGE
P8-30	20-83MHz
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!

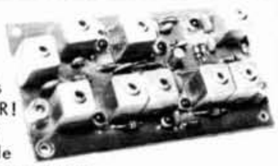


MODEL	RANGE
P9-30	26-88 MHz
P9-150	88-172 MHz
P9-220	172-230 MHz
P14 (W/T)	Give exact freq.

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, 6M, 10M, 220 MHz, aircraft, com'l, etc. • Stable cascode rf 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 fm, aircraft, com'l, etc. • Economy converter • Use with P15 Preamp for optimum performance • Any i-f 10-160 MHz

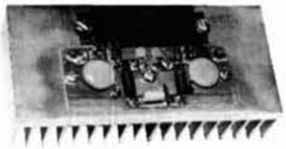
XTAL (either of above) $5.50

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 2M input, 200 mW 450 MHz output $19.95



RF POWER AMPLIFIER MODULES

- NO TUNING • VSWR PROTECTED
- 150 MW DRIVE • COMPLETELY STABLE

T80-150, 140-175 MHz, 20-25W output, wired and tested, simply connect your cables...................... $79.95
T80-450, 430-470 MHz, 13-15W 79.95

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

Larsen Antennas

We have a large stock of these popular whips. Pick the mount and whip which are right for you! All whips and mounts are interchangeable. Request catalog for more information.

LM-150	5/8 wave 2meter whip	$23.85
LM-220	5/8 wave 220 MHz whip...	23.85
LM-440	Colinear 450 MHz whip....	23.85
Q	1/4 wave whip 144-450 MHz	2.65
MM-LM-K	Magnet Mount.........	$14.60
LM-K	3/4" Blind Hole Mount..	6.35
GC-LM-K	Gutter Clip Mount......	14.60
TLM-LM-K	Trunk Lip Mount........	14.05
AMB-K	Trunk Gutter Mount.....	9.10

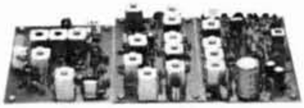
cushcraft CORPORATION

We have large stock of popular antennas. Call or write for quote or more information.

VHF/UHF FM RCVR KITS

VHF MODELS FOR ANY BAND 28-240 MHz

R60-( ), 0.5-1 uV sens, incl VHF Converter and IF/Audio Boards............ $64.95
R69-( ), 0.2-0.4 uV sens, incl P9 Preamp, VHF Converter, and IF/Audio ... $69.95
Crystals (We stock common freq and will gladly order specials)........... $5.50



UHF MODELS FOR ANY BAND 380-520 MHz

R60-450, 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 Preamp, UHF Conv, VHF Conv, and IF-Audio Boards........................ $94.95

FAMOUS ANTENNAS STOCKED IN DEPTH **hy-gain**

REQUEST CATALOG FOR MORE DETAILS

14AVQ	10-40M Vertical	$67.00
18AVT	10-80M Vertical	97.00
18HT	10-80M Hy-Tower Vert	279.95
TH3-MK3	Tribander	199.95
TH3-JR	Tribander	144.50
TH6-DXX	Tribander, 6 element	249.95
2BDQ	80-40M Trap Dipole	49.95
5BDQ	80-10M Trap Dipole	79.95
263	2M 5/8 wave Trunk Lip	28.95
265	2M 5/8 wave Mag Mt	29.95
214	14 el 2M Beam	26.95

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

Model	Price	Intermittent	Cont
12CB4	$29.95	2.5A	1.5A
103R	39.95	4A	2.5A
104R	49.95	6A	4A
108RA	79.95	12A	8A
108RM*	99.95	12A	8A
109R*	149.95	25A	10A

*Indicates model which has panel meter(s)

hamtronics, inc.

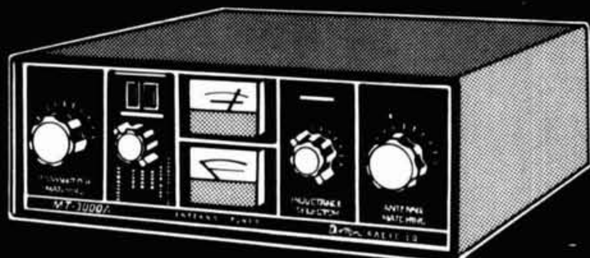
182H BELMONT RD., ROCHESTER, NY 14612

- 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.

More Details? CHECK—OFF Page 150

Call 1-800-633-3410 for Dentron*

*KENWOOD, YAESU, ICOM, CDE, HYGAIN, CUSHCRAFT, NPC, TPL, TRISTAO, NEWTRONICS, REGENCY, ROHN, WILSON, TEN-TEC, B&W, DRAKE, & MFJ.



DENTRON MLA-2500 linear amplifier

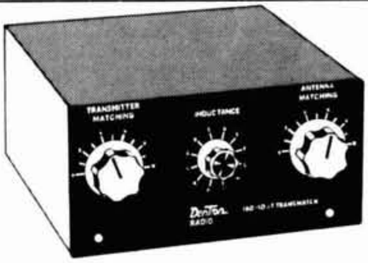
• Contunuous duty power supply • 160 thru 10 meter coverage • 2000 + watts PEP input on SSB • 1000 watts DC input on CW, RTTY, SSTV • Two external-anode ceramic/metal triodes operating in grounded grid • Covers MARS w/o modifications • 50 ohm input/output impedance • Built-in RF watt meter.

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 - 3 0 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.

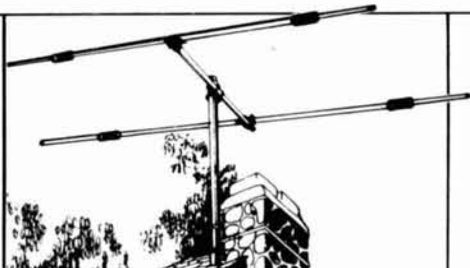
349.50 is list price. Call Toll-Free for quote.



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.

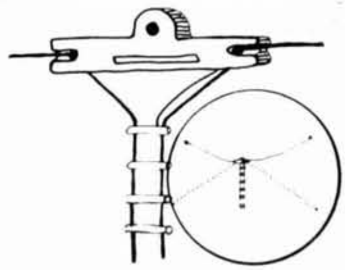
129.50 list price. Call for quote.



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.

Your BANKAMERICARD welcome here

Long's Electronics

master charge THE INTERBANK CARD

MAIL ORDERS: P.O. BOX 11347 BIRMINGHAM, AL 35202 • STREET ADDRESS: 3521 10TH AVENUE NORTH BIRMINGHAM, ALABAMA 35234

More Details? CHECK—OFF Page 150

Years Ahead With Yaesu!

Introducing . . .

THE ALL-NEW YAESU FT-227R 144-148 MHZ 800 CHANNEL "MEMORIZER"!

1980's RADIO TODAY!

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

YAESU
The radio.

1177