JUNE 1978

- Oscar 8 preamplifier 20
- Touch-Tone decoder 26
- vfo design 36
- pi network design 52
- voltmeter calibrator 94
- and much more . . .
Fifty years ago in 1928, Henry Radio first offered to help amateur radio operators solve their communications problems. Today Amateurs, not only in the United States but throughout the free world, still look to Henry Radio as their pre-eminent supplier of fine communications equipment. Fifty years is a long time in the life of an individual. It is a long time in the history of amateur radio. So we are proud to be celebrating our fiftieth anniversary of service to Amateur Radio. We believe it says something important about Henry Radio and about the pioneering contributions we have made to our industry.

From the beginning, we offered personalized service. Service that recognized that every person's needs were as individual as each person is unique.

We were the first to offer low cost time sales of Amateur equipment. We were among the first to trade for used equipment.

From the beginning, we offered personalized service. Service that recognized that every person's needs were as individual as each person is unique.

We were the first to offer low cost time sales of Amateur equipment. We were among the first to trade for used equipment.

At Henry Radio we don't know any other way of doing business. Since we have been active amateurs for all these years, we know the correct answers when we ask ourselves, "Is this the way I would want to be served if I were a customer of Henry Radio?"

Looking back, 50 years seems a long time. Looking ahead we feel like eager youngsters impatient to know the exciting new experiences that the next 50 years will bring. Eager to help our amateur friends all over the world share the unique communication thrills that only amateur radio can provide.

May we help you?
THE NEW INDUSTRY STANDARD
OF PERFORMANCE ... 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 current 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! Additional features: * SWR less than 1.5 to 1 on all bands * 10 dB Gain * 20-25 dB Front-to-Back Ratio.

- Full 4 Elements on 20 Meters with a Long 26' Boom
- 4 Element Monoband Performance
- Separate 10 Meter Reflector

The mechanically superior construction uses heavy duty boom to element extrusion.

Advanced design large diameter High-Q Traps for minimum loss and maximum power capacity

**SPECIFICATIONS: SY-1**

Matching Method ........ Beta
Band MHz .................. 14-21-28
Maximum Power Input Legal Limit VSWR (at Resonance) 1.5 to 1
Impedance ................. 50 ohms
Gain ....................... 10 dB

Boom Length ... 26'
Boom Diameter .... 2" O.D.
No. of Elements .... 5
Longest Element .... 26' 7"
Turning Radius .... 18' 6"
F/B Ratio .......... 20-25 dB

Required
Mast Diameter .... 2" O.D.
Surface Area ...... 8.6 sq. ft.
Windload at 78 mph .... 215 lbs.
Shipping Weight .... 65 lbs.
UPS Shipment in 2 Cartons

Model Antenna — not to scale.

**Wilson Electronics Corp.**

4288 So. Polaris • P. O. Box 19000 • Las Vegas, Nevada 89119
Phone (702) 339-1331 • Telex 684-522
This NEW MFJ Versa Tuner II . . .

has SWR and dual range wattmeter, antenna switch, efficient air wound inductor, built in balun. Up to 300 watts RF output. Matches everything from 160 thru 10 Meters: dipoles, inverted vee, random wires, verticals, mobile whips, beams, balance lines, coax lines.

Antenna matching capacitor. 208 pF. 1000 volt spacing.

Sets power range. 300 and 30 watts. Pull for SWR.

Meter reads SWR and RF watts in 2 ranges. Efficient air wound inductor gives more watts out and less losses.

Transmitter matching capacitor. 208 pF. 1000 volt spacing.

Only MFJ gives you this. MFJ-941 Versa Tuner II with all these features at this price:

A SWR and dual range wattmeter (300 and 30 watts full scale) lets you measure RF power output for simplified tuning.

An antenna switch lets you select 2 coax fed antennas, random wire or balance line, and tuner bypass.

A new efficient air wound inductor (12 positions) gives you less losses than a tapped toroid for more watts out.

A 1:4 balun or balance lines. 1000 volt capacitor spacing. Mounting brackets for mobile installations (not shown).

With the NEW MFJ Versa Tuner II you can run your full transceiver power output — up to 300 watts RF power output — and match your one existing antenna. No need to put up separate antennas for each band.

Increase the usable bandwidth of your mobile whip by tuning out the SWR from inside your car. Works great with all solid state rigs (like the Atlas) and with all tube type rigs.

It travels well, too. Its ultra compact size 8x2x6 inches fits easily in a small corner of your suitcase.

This beautiful little tuner is housed in a deluxe eggshell white Ten Tec enclosure with walnut grain sides.

SO-239 coax connectors are provided for transmitter input and coax fed antennas. Quality low wave binding posts are used for the balance line inputs (2), random wire input (1), and ground (1).

For Orders Call toll-free 800-647-8660

For technical information, order and repair status, and in Mississippi, please call 601-323-5869.

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

MFJ ENTERPRISES P. O. BOX 494 MISSISSIPPI STATE, MISSISSIPPI 39762

More Details? CHECK — OFF Page 142
magazine

JUNE 1978
volume 11, number 6

T. H. Tenney, Jr., W1NLB
publisher
James R. Fisk, W1HR
editor-in-chief

editorial staff
Martin Hart, WB1CHQ
administrative editor
Charles J. Carroll, K1XX
Patrick A. Hawes, WA1WPM
Alfred Wilson, W8AF
assistant editors
Thomas F. McMullen, Jr., W1SL
Joseph J. Schroeder, WSUUV
associate editors
Wayne T. Pierce, K3SUK
cover

publishing staff
C. Edward Bufflington, WB1AMU
assistant publisher
Fred D. Muller, Jr., WA1USO
advertising manager
James H. Gray, W1XU
assistant advertising manager
Theresa R. Bourgault
circulation manager

ham radio magazine
is published monthly by
Communications Technology, Inc.
Greenville, New Hampshire 03048
Telephone: 603-678-1441

subscription rates
U.S. and Canada: one year, $12.00
two years, $22.00
Three years, $30.00
Europe, Japan, Africa:
via Air Forwarding Services:
one year, $25.00
North America, South America, Australia,
and Asia (except Japan):
via Surface Mail:
one year, $18.00

foreign subscription agents
Foreign subscription agents are
listed on page 117

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

copies types of selected articles
from ham radio are available to
the blind and physically handicapped
from Recorded Periodicals
1919 Walnut Street, 8th Floor
Philadelphia, Pennsylvania 19103
Copyright 1978 by
Communications Technology, Inc.
Title registered at U.S. Patent Office
Second-class postage paid at Greenville, N. H. 03048
and at additional mailing offices
Publication number 23330

10 RTTY SELCOM
Robert C. Clark, K9HVW
Archie C. Clark, WB4KUR
Fred R. Scaife, K4EID

20 Oscar 8 receiving preamplifier
Mark S. Pride, K1RX
Kenneth V. Puglia

26 single IC Touch-Tone decoder
Lawrence Nickel, W30G

33 antenna guying
Marchal H. Caldwell, Sr., W6RTK

36 Colpitts vfo design
Maurizio Gramigni, IZBVZ

40 rf choke performance
Courtney Hall, WASSNZ

44 preventing transmitter rf leakage
John E. Becker, K9MM

48 vertical antenna
for portable communications
John S. Jolly, WA7NWW

52 pi network design
Irvin M. Hoff, W6FFC

68 satellite tracking equations
for Texas Instruments calculators
Charles F. Milazzo, KP4MD

74 protecting solid-state devices
William J. Prudhomme, WB5DEP

81 instantaneous shutdown
for high current power supplies
Alan S. Nusbaum, W6GB

84 command debugging circuit
J. Thomas Norman, WA7FHY

87 grid-dip meter
William A. Wildenhain, W8YFB

92 vhf prescaler packaging
Alan Smith, W8CHK

94 precision voltmeter calibrator
Hubert Woods

96 the gyrator: synthetic inductor
John M. Lowthmiller, W89ATW

98 ham notebook

102 letters

104 new products

142 reader service

142 stop press

142 advertisers index

117 flea market

132 ham mart

132 ham notebook

june 1978
A group of atomic physicists at Western Washington University has predicted that sometime this year the first message through the earth, rather than around it by way of the ionosphere, will be transmitted along a beam of neutrino particles from a particle accelerator. The neutrino is one of the fundamental subatomic particles, but one of the more elusive ones — Wolfgang Pauli first proposed its existence on theoretical grounds in 1930; Enrico Fermi christened the new particle the neutrino (for “little neutral one”), but it wasn’t until 26 years later, in 1956, that it was first detected by scientists.

The interaction of neutrinos with ordinary matter is so weak that, according to classical theory, a neutrino could pass through a block of lead that stretched from here to the nearest star without disturbing any of the atoms in its path. Since the neutrino carries no charge and has no mass (or nearly no mass, scientists aren’t sure), it evaded traditional particle detection methods simply by passing through them without affecting them in any way. Billions of neutrinos from the sun pass through your body every second, day and night, but it’s estimated that a neutrino interacts with one of the atoms in your body only about once every ten years. It’s no wonder it took 26 years to detect the neutrino’s presence!

While the average neutrino is capable of passing through most of the matter of the universe without slowing down or losing any of its energy, it’s been found that neutrinos fired in eight-second bursts from a high-energy particle accelerator occasionally collide with other particles, at the rate of about one collision for every 17 tons of matter that the beam penetrates. Although neutrinos cannot be detected directly, the particle debris, light, and noise generated by their collisions can be. When a beam of neutrinos is passed through a large volume of water, all along its path some of the collision products emit a forward cone of Cerenkov photons which can be detected by a light collector-phototube system. Prototype experiments using Cerenkov detectors to intercept cosmic neutrinos 1000 meters below the ocean’s surface have already been carried out.

In experiments at the 400-billion-electron-volt proton accelerator of the Fermi National Accelerator Laboratory in Illinois, a 20-microsecond pulse of protons is directed into a bar of aluminum — the resulting atomic collisions produce about 10-billion neutrinos per pulse. The beam of neutrinos generates about one reaction per pulse in a bubble chamber containing 25 tons of liquid neon one kilometer away. With a grid of Cerenkov detectors in a large body of water it’s predicted that a greater number of reactions per pulse would be detected. If information could be encoded into pulses of the neutrino beam, theoretically a message could be received and decoded virtually any distance away.

In the experiment suggested by the group in Washington, a pulsed neutrino beam from the Fermi Lab accelerator would be directed downward at an angle of about 12 degrees so the beam would pass through the earth and emerge in Puget Sound, nearly 3000 kilometers away. The detector-target would consist of the approximately one-million tons of water in Puget Sound where showers of particles would be recorded with each neutrino collision. The tiny flashes of light from the Cerenkov photons would be recorded and translated into the original message. Funding for the experiment is being considered by a number of government agencies, including the Navy, which is interested in applications of the technique for deep-water communications with nuclear submarines.

An analysis by the Naval Research Laboratory has shown that, if the energy level of the Fermi accelerator was increased to 1000-billion electron volts, with improved beam focusing, the neutrino event rates could be increased by a factor of 10. By using synchronous detection techniques and Cerenkov photo detectors 3000 meters below the surface of the ocean (where they’re not bothered by ambient light), it is expected that one 15-bit message per pulse could be transmitted with very low error rates. With one neutrino pulse every 8 seconds, this represents a message rate of 6750 bits per hour. Compared with other methods of communications, this is slow, but unlike radio communications, neutrino beams can’t be blocked, they’re not affected by solar storms nor dependent on the ionosphere, and they travel great distances with no loss of power.

Jim Fisk, W1HR
editor-in-chief
ICOM's **IC-211** maximizes band coverage, speed, performance and convenience like no other transceiver in the 2 meter world. This Maximizer's single-knob dial provides all 4 MHz in a flash, right to your single fingertip! The **IC-211** maximizes read-out speed with positively no time lag or backlash in display stability, even in modes using 100 Hz steps. The **IC-211**'s freewheeling dial, with its superb inertia clutch, is instantly coordinated with the high speed, computer circuitry controlled synthesizer's seven digit read-out using an optical chopper. There is absolutely no mechanical connection between the smooth, bearing mounted flywheel knob and the two dual-tracking VFO's, which come built into your **IC-211**.

- **Single knob frequency selection:** The **IC-211** is synthesized with convenient single knob frequency selection over the entire 4 MHz. No more fumbling with two or more knobs just to check what is going on around the band. One easy spin of the dial does it all.
- **Two VFO's built in:** The second VFO, which is an optional tack-on with most other transceivers, is an integral feature in every **IC-211**.
- **Variable offset:** Any offset from 10 KHz through 4 MHz, in multiples of 10 KHz, can be programmed with the LSI synthesizer.

**Remote programming:** The **IC-211** LSI chip provides for input of touch tone and programing data from an external source, such as the microprocessor controlled accessory which will also provide scan and other functions (available summer '78). Computer control from a PIA interface is also possible (data available on request).

**FM stability on SSB and CW:** The **IC-211** synthesis of 100 Hz steps makes SSB as stable as FM. This extended range of operation is attracting many FM'ers who have been operating on the direct channels and have now discovered SSB.

The **IC-211** is the very best and most versatile 2 meter transceiver made: that's all. For more information and your own hands-on demonstration, see your ICOM dealer. While maximizing performance, the **IC-211** minimizes impatience: yours is ready for delivery now.

**Specifications:**
- Frequency Coverage: 144.00 to 146.00 MHz
- Modes: SSB (ASI), FM (21) CW (21)
- Supply Voltage: DC, 13.8 V (5 V, 12 V or 24 V)
- Output Power: 2 W minimum
- Sensitivity: 0.5 microvolts 10 dB S/N
- Spurious Emissions: 60 dB below carrier
- Harmonic Distortion: 3 dB
- Frequency Stability: 50 ppm or better
- Synthesizer Frequency Range: 144.00 MHz to 146.00 MHz
- Synthesizer Step Size: 100 Hz or 500 Hz for SSB, 500 Hz for FM
- Supplied with: Programming cable, AC cord, DC cord, DC cord, and owner's manual

All ICOM radios significantly exceed FCC specifications limiting spurious emissions.

**Maximize the new repeater band:** Both the **IC-211** and the **IC-245/SSB** operate the new FCC repeater spectrum with no modification.

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

- **ICOM EAST, INC.**
  - Suite 30
  - 3331 Towerwood Drive
  - Dallas, Texas 75234
  - (214) 620-2780

- **ICOM CANADA**
  - 7087 Victoria Drive
  - Vancouver B.C. V5P 3Y9
  - Canada
  - (604) 321-1833
SERIOUS QUESTIONS ABOUT AUTOPATCHES and the apparent increase of business-type communications on the Amateur bands were raised in an April FCC release, which likened "telephone interconnection at Amateur stations" with "the situation in the Personal and Business Radio Services." Though there were some text problems with the release as issued — the Personal Radio Division has requested that it be corrected and re-released — it strongly points up growing Commission concern with this area of Amateur Radio.

Autopatches And Reverse Autopatches in particular were discussed at some length in the FCC document. For example, it pointed out that the regulations require a control operator to be on duty whenever autopatching or reverse autopatching occurs, effectively prohibiting autopatch use when a repeater is operating in "automatic control." It further stated that "all calls not initiated at an amateur station had to be screened by the control operator before being placed on the air." Though a revised release is to be issued shortly, it's obvious that autopatch operators and users should start now to tighten up their operations.

Autopatch Financing could raise still another sticky question with respect to ITT tariffs, WMMKZ points out in Boulder QSP, if money is collected from users specifically for their use of the autopatch. It appears clubs or other groups with autopatch repeaters would be on firmer ground if autopatch costs were to be covered as just another expense item financed from club revenues.

THE FCC'S COMPUTER has mistakenly issued duplicate licenses to approximately 3000 new amateurs. Some of those who received the dual licenses received two call signs, others received two licenses with the same call letters. To end the confusion, the FCC has ruled that amateurs with two tickets are to use the license with the later date, and set aside the one with the earlier date until informed by the FCC what is to be done with it. Two Sets Of "Doubles" were mailed out. The first sets are dated February 28 and March 3, the second pairs are dated March 17 and 21. The FCC should have been in touch by letter with all amateurs who received two licenses.

THE 3-CM AMATEUR BAND IS THREATENED by "Amateur Radio" manufacturers who are planning to make and market police-radar jammers under the "Amateur Radio" label. The March issue of Communications Retailing described one such unit being sold as a "radar calibrator," quotes a company official as saying they may designate their jammer as amateur equipment to escape FCC's controls on such items and it should be on the market in May. Whatever The Result of all this, amateurs seem likely (as with the 10-meter linear ban) to be the losers in the end. Even the radar detector manufacturers oppose the jammers, according to Communications Retailing, on the grounds that they're almost certain to generate legal sanctions that would include detectors.

NEW CHIEF OF THE FCC'S Safety and Special Services Bureau is Carlos Roberts, replacing Charley Higginbothar whose retirement became official April 7. Roberts comes to Safety and Special Services from the FCC's Office of Plans and Policy, where he's been Chief since July, 1975. He's been with the FCC since graduating from college in 1970, starting with the Field Operations Bureau. In 1973 he supervised a Special Enforcement Facility for CB rules, so he's no stranger to either CB or Amateur Radio.

R. L. DRAKE HAS OPPOSED FCC'S ban on 10-meter linears with a Petition for Reconsideration filed near the end of April. The thrust of Drake's objection to the ban is that compliance with the Type Acceptance requirements will effectively prevent an amateur amplifier's use by a CBer, so the ban unnecessarily penalizes Amateurs and those who serve the Amateur market. Several other major amplifier manufacturers were actively considering similar action, with ETO also filing a Petition for Reconsideration.

HY-GAIN HAS BEEN PURCHASED BY TELEX and planned to be back in production May 1 as a division of the Telex Corporation. The product lines will include amateur antennas and electronics, marine antennas and gear, government and commercial antennas, and CB antennas. Notably lacking will be the CB electronics that caused so many of their problems in recent months.

FIRST 2-METER E-M-E contact between North and South America was logged the end of March by W4WDC and YV5Z2. Fine signals were reported at both ends. K1WHS worked YV5Z2 an hour later.

Near States On 70 cm E-M-E (ND, SD, WY, MT, ID) will be provided by K2UVH during a mid-June cross-country trek. Arl will appreciate set-up and operating help — write Dr. Allen Katz, Department of Engineering Technology, Trenton State College, Trenton, New Jersey 08625.

THE SMITH CHART ARTICLE in the March ham radio quoted an incorrect price for packages of 100 charts. The correct price is $6.50 per hundred from Analog Instruments Company, Post Office Box 808, New Providence, New Jersey 07974.
Look closely at the new MT-3000A. You've never seen anything like it.

Times have changed since DenTron introduced its first tuner. With rapid growth in condominiums and housing developments, we have new problems that require new solutions.

DenTron decided to rethink the tuner and what its total capabilities should be.

The MT-3000A is a capsulized solution to many problems. It incorporates 4 unique features to give you the most versatile antenna tuner ever built.

First, as a rugged antenna tuner the MT-3000A easily handles a full 3KW pep. It is continuous tuning 1.8-30mc. It matches everything between 160 and 10 meters.

Second, the MT-3000A has built-in dual watt meters.

Third, it has a built-in 50 ohm dummy load for proper exciter adjustment.

Fourth, the antenna selector switch; (a) enables you to by-pass the tuner direct; (b) select the dummy load or 5 other antenna systems, including random wire or balanced feed.

The compact size alone of the MT-3000A (5½" x 14") makes it revolutionary. Combine that with its four built-in accessories and we're sure you'll agree that the MT-3000A is one of the most innovative and exciting instruments offered for amateur use.

At $349.50 the MT-3000A is not inexpensive. But it is less than you'd expect to pay for each of these accessories separately.

As unique as this tuner is, there are many things it shares with all DenTron products. It is built with the same meticulous attention to detail and American craftsmanship that is synonymous with DenTron.

After seeing the outstanding MT-3000A, wouldn't you rather have your problems solved by DenTron?
Kenwood offers this totally unique unit as a perfect compliment to your TS-820S or TS-520S station. The SM-220, based on a wideband oscilloscope (2 Hz to 10 MHz), permits you to monitor your transmitted signals, thus assuring optimum linearity and maximum performance. With the addition of the BS-5 or BS-8 Pan Display option you will be able to determine visually the location and strength of adjacent signals without tuning your receiver off frequency. The choice of options allows you to adapt the SM-220 to either the TS-820S or TS-520S.

The SM-220 has a built-in two-tone audio generator with full provisions for tuning your exciter and linear amplifier (160 m through 2 m). All this costs little more than a general-purpose oscilloscope. And, of course, it's pure Kenwood quality.

'SWith BS-5 or BS-8 option
**For other models check with appropriate manufacturer for compatibility.**
The TS-520S transceiver provides full transmit and receive coverage of all Amateur bands from 160 through 10 meters. It also receives 15.0 (WWV) to 16.5 MHz and another 500-kHz range of your choice in the auxiliary band position. With the optional DG-5, you have a large digital frequency readout when transmitting and receiving, and the DG-5 also doubles as a 40-MHz frequency counter. The TS-520S includes a built-in AC power supply, and, with the addition of the optional DS-1A DC-DC converter, it can function as a mobile rig. It features a very effective noise blanker, RIT, eight-pole crystal filter, 25-kHz calibrator, front-panel carrier level control, semi-break-in CW with sidetone, built-in speaker, heater switch, 20-dB RF attenuator and easy phone-patch connection. RF input power is 200 W PEP on SSB and 160 W DC on CW. Carrier suppression is better than -40 dB and sideband suppression is better than -50 dB. Spurious radiation is less than -40 dB. Receiver sensitivity is 0.25 μV for 10 dB (S+N)/N. Selectivity is 2.4 kHz at -6 dB/4.4 kHz at -60 dB and, with the optional CW-520 CW filter, is 0.5 kHz at -6dB/1.5 kHz at -60 dB.

See your local Authorized Kenwood Dealer for more information, and a super deal!

The TS-520S is the most popular Amateur Radio transceiver in the world... provides a foundation for an expanding series of accessories designed to please any ham... from Novice to Amateur Extra.
RTTY SELCOM

Discussion of the RTTY SELCOM — an advanced TTL design, providing selective character recognition

One of the first applications of digital logic to RTTY was the RTL SELCAL described by Lamb.1 Capable of recognizing a single sequence of four characters, it proved very laborious and costly, since there were over 300 wired connections to be made in the basic unit. This concept, however, was expanded and translated into TTL form in the TTL SELCAL described by Branscome.2 Although this unit was constructionally simpler, even with expanded capabilities, it still did not overcome the cumbersome decoding process, or provide for easy expandability.

Shortly after the TTL SELCAL was introduced, the CATC group3 tackled the problem of sequential character recognition, hoping to overcome the two main problems presented by the TTL SELCAL. By 1972 the objectives had been met, and circuit boards were fabricated for what was known as SELCOM I. This unit dramatically expanded the flexibility to decode all 32 Baudot characters and could recognize nearly unlimited strings of characters. Many of the sequences were to be used as selective station control commands, hence the name.

Probably the most powerful discrete logic sequential decoder ever developed, the SELCOM was also far easier to program than the earlier SELCALs since only one connection, instead of five, was required per character. This ease in decoding had been achieved by the use of a 1-of-32 decoder. In this manner, the Baudot character set was decoded, providing access to characters, rather than the bits as in the SELCAL versions. And, to provide expandability, a 32-character bus was connected to every sequential decoder board. This bus could be expanded as desired since each line of the bus was capable of handling up to 500 TTL loads.

In May, 1973, the discrete bus drivers were replaced with TTL buffers, lowering the drive to 30 instead of 500 loads. Even with this change, SELCOM II still retained the versatile bus structure of the original version.

Version III of the SELCOM incorporated a MOS UAR/T. This chip, a natural for the SELCOM, had already been in use for several years by various computer manufacturers, but the single quantity price was prohibitively high for amateur work until about December, 1973. Offering significant simplification, the UAR/T provided all functions except those of the clock and character decoders, and in addition, offered new functions not available in earlier versions of the SELCAL or SELCOM. They included regeneration of the received RTTY signal, speed conversion, and the ability to handle any code of 5 through 8 bits with only a simple jumper change.

By Robert C. Clark, K9HWV, Archie Lamb, WB4KUR, and Fred R. Scalf, K4EID. Mr. Clark may be reached at 930 Chestwood Avenue, Tallahassee, Florida 32303.
fig. 1. Schematic diagram of the DU-200 Universal UART module. The jumper placement is explained in the text and also Table 1. The UART is available from either Texas Instruments or General Instruments. The buffers for the receiver output and flag lines can be eliminated if the lines are used for feeding only one TTL load.
In early 1974, an attempt was made to eliminate the mechanical problems presented by the double-width cards used in earlier SELCOMs. To do this, the versatile bus structure was abandoned in favor of a functional module approach. These modules provided a versatility not possible in the earlier versions of the SELCOM. With the change to single-width cards, SELCOM IV may be used with 5, 6, 7 or 8 bit codes at speeds up to 9600 bits per second. The following description is for the five-bit Baudot code used for amateur RTTY at 45.45 and 74.2 baud, but the unit is designed for expansion to the full 64-character ASCII code group.

**SELCOM features**

**DU-200 Universal UAR/T.** The DU-200 (fig. 1) is not only the heart of the SELCOM system, but also provides a powerful functional module for many other applications as well. It may be used for teleprinter signal regeneration, speed conversion, serial-to-parallel data conversion, parallel-to-serial data conversion, code conversion (Baudot to ASCII, ASCII to Baudot, Baudot to Morse, etc.), and many other ways. All the features of the UAR/T have been made available in the DU-200, either through hard-wired jumpers or through external control. In this way, the same board may be configured as a Baudot or ASCII regenerator, an interface between a serial RTTY station and a parallel I/O port of a microprocessor, a SELCOM, or a wide variety of other applications.

The DU-200 consists of the UAR/T, interface (buffering), control, and clock functions. The UAR/T IC (U1) functions as two nearly independent circuits, a digital receiver and a digital transmitter. The receiver accepts serial data in a particular format (selected by the user), checks for format errors (parity error, missing stop bit, etc.), and outputs the data in a parallel form. The transmitter accepts parallel data, adds start, stop, and parity bits, and sends the data in a serial format at the data rate selected. If the parallel output of the receiver is connected to the parallel input of the transmitter, the unit functions as a regenerator. The two sections may be used independently, but the data format for both sections must be the same. That is, both the receiver and transmitter must operate with the same code, parity, and so on. Under certain conditions they may operate at different speeds.

The UAR/T is capable of accepting data with up to 43 per cent distortion (more in some cases) and resending it with less than 1 per cent distortion. Typical teleprinters are capable of accepting less than 30 per cent distortion, while many keyboards and transmitter distributors generate signals with large amounts of distortion. As machines age, their ability to accept distortion is diminished and their ability to produce it is increased. The use of the DU-200 as a regenerative repeater offers improvements to all mechanical teleprinters, keyboards, and transmitter distributors.

Under marginal conditions several undesirable situations may exist with the mechanical teleprinter. Typically, high-frequency propagation phenomena tend to add distortion to that which already exists on the transmitted signal. For this reason, it is highly de-
sirable that the transmitted signal have a minimum of
distortion. If the DU-200 is used to process the trans-
mittted signal, then this criteria will be met. Even if
the transmitted signal is perfect, distortion will be
added by the time the signal reaches the receiver.

Another problem that exists with a mechanical
teleprinter is that a short noise pulse may be read as a
start. When this happens, a clutch is released, begin-
ing the sequence of events which decode and print a
character. The teleprinter shaft must complete one
full revolution before it can recover from this prema-
ture start. If the real start bit is received during this
revolution, the printer will not be able to get back in
synchronization with the sending station. In such a
situation, the printer may print garbage for several
characters. Most brands of the UAR/T though, after
receiving what appears to be a start bit, recheck to
determine that the start bit is still at the appropriate
level in the middle of the bit. If the start bit is not
valid, then the UAR/T is immediately reset. Thus, the
probability of the receiving station staying in syn-
chronization with the sending station is greatly im-
proved.

Another undesirable condition exists when the
received signal drops below the noise level and gar-
bage is printed. If the signal is not capable of providing
the necessary information for character recognition,
then it is quite likely that the appropriate level will not
be maintained during the stop bit. This is termed a
Framing Error and the UAR/T provides a flag to indi-
cate this error. The flag may be used to suppress the
transfer of the character to the transmitter section. If
this feature is selected, the mutilated character will
not be printed. A similar feature is available for parity
errors on received characters.

The UAR/T will respond only to those characters
that appear to be valid RTTY. It will not respond to a
steady space (a single blank character will be trans-
ferred to the transmitter section unless the Framing
Error flag has been used to suppress the transfer)
while most noise and CW will transfer fewer charac-
ters to the printer than if the UAR/T were not pres-
ent. With the DU-200 on-line, the appearance of the
page is dramatically improved, with any
demodulator.

If the clock applied to the transmitter and receiver
sections of the UAR/T are set for different rates, the
UAR/T will function as a speed converter. For exam-
ple, if a 100 wpm (74.2 baud) printer is used, it's pos-
sible to receive any speed up to 100 wpm without
expensive and noisy gear shifts. By providing a buf-
fer memory between the receiver and transmitter
sections, the DU-200 can function as a down con-
verter. Of course, if the size of the buffer is finite,
then the UAR/T receiver will deliver characters to the
buffer faster than the transmitter section clears
them, causing the buffer to overflow. In the case of
overflow, the UAR/T provides an Overrun Error flag
which may be used to signal an external device to
withhold further characters.

**DU-210 Character Decoder.** The DU-210 (fig. 2)
recognizes which one of 32 possible characters has
actually been received by the UAR/T in the DU-200.
Several DU-210 boards may be used to recognize
characters from larger character sets. Two DU-210
boards may be used to recognize the 64 characters of
the ASCII-6 subset and four may be used to recog-
nize the 128 characters of the full ASCII set. In fact,
the DU-210 may be used in many applications where
one particular binary code must be recognized.

**Sequential Decoder.** The DU-220 (fig. 3) works
with the DU-200 and DU-210 to recognize sequences
of characters. It might be wired to recognize the sta-
tion call, setting a latch when the call is received.
This latch could be used to prevent the station printer
from operating until the call was received. In fact, the
DU-220 is capable of detecting a number of sequen-
ces, each of which may control some event such as:

1. Turn on reperforator.
2. Turn off reperforator.
4. Turn transmitter on.
5. Turn transmitter off.

If necessary, these control sequences may be configured so that they will be recognized only when the source is the local keyboard.

The DU-220 is quite versatile in that it may be used to detect a sequence of events independent from the SELCOM system. For instance, the DU-220 might be used to recognize a sequence of digits from a Touch-Tone* decoder. Certain sequences could be prevented from reaching the telephone lines, with others being used to control repeater functions. In addition, the DU-220 could also be used to recognize a sequence of switch closures in an electronic lock.

circuit description

DU-200 UART Board. Serial data for the UART is first applied to pin 5 of U2A. The input to pin 20 (Serial Data Input) of U1 is jumpered to either pin 4 or pin 6 of U2 depending on the sense of the data (mark low or mark high). The UART is programmed, by either hard wiring or external devices, as shown in table 1.

The speed of the received data is selected by an external clock set to sixteen times the baud rate. For 60 wpm, the clock would be set to $45.45 \text{ Hz} \times 16 = 727.27 \text{ Hz}$. On the first mark to space transition, an internal counter is reset and allowed to count clock pulses. Each brand of UART has some provisions for verifying that the mark to space transition was a valid start bit. If the start is verified, the counter continues, in turn controlling a serial-shift register, so that each received bit is stored in the shift register. At the time of the expected stop bit, another check is performed. If the stop (a mark) is not present at the required time, the Framing Error (FE) flag is raised to indicate an invalid condition. In the same manner, if a parity check has been requested, and the proper parity is not verified, the Parity Error (PE) flag is raised. The Overrun Error (OE) flag is available to indicate that one character has not been removed from the receiver holding register before the next character took its place. These flags may be used to control indicators, keep the character from being printed, or control error-correction schemes.

When a complete character has been received and transferred to the receiver-holding register (only complete characters appear at the receiver holding register output), pin 19 of the UART (Data Ready) goes high to indicate that the character is available in parallel form on pins 5 through 12 of U1. U5 is a two-stage shift register clocked by the receiver clock. The high from pin 19 of U1 (DR) is transferred through U5 after the next two successive clock pulses. The out-

*Touch-Tone is a registered trademark of the American Telephone and Telegraph Company.
By using this fail-safe timer, the transmitter will be turned off if an identification is not sent every 10 minutes. As with all other diagrams, the power supply connections have not been shown. If the return line from the identification unit is low when the ID is running, J1 should be connected; if high, J2 is connected.

The character transferred to the transmitter holding register will in turn be transferred to the transmitter register when empty. Notice that the UAR/T may be simultaneously processing 3 characters, sending one character, holding a second character, and receiving a third character. The status of the transmitter registers is indicated by pins 22 (Transmitter Holding Register Empty) and 24 (Transmitter Register Empty) of U1. When a character reaches the transmitter register it is clocked out in serial form (at pin 25 of U1, Serial Data Out) according to the format previously selected, at a speed determined by the transmitter-register clock. If this clock is the same one used for the receiver, then the unit operates as a regenerative repeater. If the clocks are of different frequencies, then the DU-200 operates as a speed converter. If the receiver speed is higher than the transmitter speed, the characters may arrive at the transmitter holding register faster than they may be accepted and a buffer memory must be provided to avoid overrun.

Two clocks are installed on the DU-200 board. In addition, jumpers are provided so that one clock may be used to operate both the receiver and transmitter, or a separate clock may be provided for each. It is also possible to supply clock signals from an external source. A crystal-controlled clock, supplying multiple baud rates, has been designed as part of the CATC line. The 555 IC (U3 and U4) has proven to be adequate as a clock, as long as the ambient temperature is relatively stable. Wide frequency excursions can be expected with wide temperature variations. Most of this frequency shift can be attributed to the thermal characteristics of the resistors and the capacitor which form the RC timing portion of the oscillator. Choice of components, to minimize this shift, will improve the drift characteristics of the oscillator. A polystyrene capacitor is recommended. Also, metal-film resistors will show a significant improvement over the carbon composition types. The configuration of the timing resistors (R4, R5, and R6 for U3) was chosen for stability and is superior to most shown in other articles.

Oscillator frequency is the only adjustment required for the DU-200. The frequency should be set in accordance with table 2, while measuring at pin 3 of the 555.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Baud Rate</th>
<th>Clock Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 wpm</td>
<td>45.45</td>
<td>727.273 Hz</td>
</tr>
<tr>
<td>European</td>
<td>50.00</td>
<td>800.00 Hz</td>
</tr>
<tr>
<td>75 wpm</td>
<td>56.83</td>
<td>909.280 Hz</td>
</tr>
<tr>
<td>100 wpm</td>
<td>74.18</td>
<td>1186.880 Hz</td>
</tr>
</tbody>
</table>

Since the UAR/T is only capable of sinking one TTL load, buffering has been provided on the output and flag lines. If only one load is to be connected to any

---

**table 2. Oscillator frequency of the 555 timer.**
UAR/T output, and none of the flags or control signals are to be used externally, then U6 and U7 may be eliminated and a jumper used to complete the circuit.

The UAR/T is available from a number of manufacturers. The Texas Instruments TMS-6011NC, General Instrument AY-5-1013, and the Western Digital TR-1602A have all been tested in the DU-200. Difficulties have been experienced with the TR-1602A.

The DU-220 Sequential Decoder. As shown in fig. 3, selected character lines from the DU-210 are connected to the inputs of the DU-220. Suppose that the enable line of the DU-220 is low and that characters A, B, C, and D from the DU-210 have been connected to CH1, CH2, CH3, and CH4 respectively of the DU-220. When the DU-200 receives an A, it is recognized by the DU-210, and the CH1 line of the DU-220 pulled low. Only when both inputs of U1A are pulled low does the output go low. This low is presented to the D input of U2A. Shortly after the character is recognized, the DU-200 DR line goes high, indicating that a character has been received and is stable in the receiver holding register. The leading edge of the DR line pulse clocks the D level through to the Q output of the flip flop. Since the other character lines are not low, all other flip flops in the chain will be reset producing a 1 on the Q output. The high from the output of the first D flip flop is used to enable U1B. If the next character is a B, then the other input of U1B is pulled low (the output of U1A will not change until the next DR pulse is received). This output is applied to the D input of U2B and is transferred to the output when the DR line goes high. If the next two characters are C and D, this sequence is continued through to U2D. The low on the output of U2D indicates that A, B, C, and D have been received in that order. If at any time a different character is received, or the characters are not in the right order, the sequential decoder is reset. It will respond only to the right characters in the right order. The output of this sequential decoder may then be used to control a number of station control functions.

Station Control

Power-up Circuity. When digital equipment is first turned on, latches and flip flops come up in random
states. The portion of the station control logic shown in fig. 4 is a power-up reset which resets all control functions when the power is first turned on. It also guarantees that automatic features are enabled only when desired by the operator.

The latch formed by U1A and U1B is used to enable any automatic functions. The operator may set or reset this latch with S1 and S2. Q1 and U3A form the power-on clear portion of the circuit. As the five-volt supply starts up from zero, the base of Q1 is held low by the 47\mu F capacitor. The capacitor begins to charge slowly through R1, but the voltage on the capacitor will not turn on Q1 for several seconds. By this time the five-volt supply has stabilized and the U1A latch is reset. The R output is low any time the latch is reset, and is used to disable or reset other circuits in the station control. The 7405 open collector hex inverter allows the output of the enable latch to be "OR tied" with other resets, in this case from U3F. U3E and U3F provide an additional reset from the DU-220, resetting all latches.

Fig. 4 also shows the transmit/receive latch. In addition to being set or reset manually by S3 and S4, the latch is reset from the reset line. This means that the transmitter will be turned off by the power-up reset, a manual reset of the enable latch, or by the reset function (figures, blank, space). The provision for a reset function allows the transmitter to be turned off by a code typed on paper tape. Thus, the operator may cut a tape (concluding with the reset sequence) and then look for something more interesting to do than sit and watch the tape play. At the end of the tape, the reset sequence will turn the transmitter off.

Identification and fail-safe timer. The fail-safe timer (fig. 5) guarantees that the transmitter does not stay on the air for an unintentional extended period of time (as when the tape tangles and tears). U1 is another 555 which is enabled only when the transmitter is on the air. The timing components have been chosen so that the period of the oscillator is 1.25 minutes. The pulses from the 555 are applied to the input of U2, a 7493 four-stage binary counter. When the 7493 has counted eight clock pulses (10 minutes) the D output goes high. This high is inverted by U3A and the resulting low is used to pull the reset line down, resetting the transmit/receive latch.

The counter may be reset to zero at any time by starting the CW identification device. A line from the identification device resets the 7493 when the ID starts. Options are provided so that the CW run line may be active low or active high.

If the 7493 reaches a count of seven without being reset, then pins 12, 9, and 8 are all high. When the next line feed is received, U5A is enabled, and if the transmitter is on, U3B provides a low, starting the CW identification device. The keyboard and transmitter distributor must be inhibited though while the CW device is running.

It should also be possible for the operator to start a CW identification earlier than 8 minutes and 45 seconds into the transmission. In my case, the sequence figures, line feed is used to insert a CW identification at any time the transmitter is on. The outputs of U3B and U3C are OR tied to provide both automatic and semi-automatic identification. A manual push button is also provided to start the identification.

Printer control. The call latch (fig. 6) is mainly used to prevent the station printer from operating until the correct sequence is received. When the DU-220 has recognized the four-character sequence (in my case letters H, V, W) the call latch is set. It may be reset in any of the three different ways: by the sequence N, N, N, N, by a lack of activity on the serial data line, and by the enable latch.

The four N counter (U2) counts DR pulses as long as the N line from the DU-210 is low. When the counter reaches four it is forced to a count of nine. The resultant high on pin 11 is inverted and used to reset the call latch. A unique feature of this counter is that it will automatically reset on the first character after the fourth N.

As all stations have not developed the procedure
of sending four Ns at the end of each transmission (or they might be sent, but not received) another method of resetting the call latch is desired. The method chosen is to monitor the serial data line for mark/space transitions. If no transitions are detected for thirty seconds, the call latch will be reset by the action of U4. This 555 is configured as a monostable with a period of thirty seconds. Each time the serial data line goes to the space level, the 47 µF capacitor is discharged through Q1 and the sequence begins again. Pin 3 of the 555 goes low after thirty seconds of no transitions and resets the call latch.

Another latch (U1C and U5A) is used to control a reperforator. The sequence letters, H, V, W, letters, blank, S sets the latch and turns the reperforator on (the call and reperforator latches are used to enable and disable the DD-350 selector magnet driver and motor control). The reperforator latch is reset by the sequence letters, H, V, W, letters, blank, D or any sequence or event that resets the call latch.

At times it is helpful to control machine functions to save wear and tear both on the operator and machine. One function that is not always valuable is the bell. The operation of the bell on random noise is irritating and the excess use of the bell by some operators is infuriating. Fig. 7 shows one method of controlling the bell function. Initially, the printer bell is disabled and replaced by a Mallory Sonalert. U1A and U1B form a 2-bit shift register. The first stage is enabled by a figures function and the count is allowed to continue if the next character is an S. The output of U1B goes high when the sequence figures, S has been received, triggering U3A which controls the time the Sonalert is on. The reset input of U1A may be used to inhibit the operation of the bell. One way to use this would be to connect the disable pin to the output of the call latch in Fig. 6. In this way, the bell will ring only when the station call has been sent and then the sequence figures, S is received. This should eliminate all bells directed at someone else and the repeated ringing of the bell.

In a similar manner, the machine may be prevented from responding to a sequence of line feeds. U4A and U4B count DR pulses as long as the received character is a line feed. When two consecutive line feeds are received, the output of U4B goes high, is inverted, and the character suppression input of the DU-200 is pulled low, preventing the character from being transferred to the printer. As long as line feeds are sent, no characters will reach the printer. If the operator wishes to double space, a sequence of carriage return, line feed, letters, line feed, letters will circumvent the line feed counter and allow two lines to be turned up.

Many other station control functions may be provided for with the SELCOM system. Another possibility would be to establish two frequencies within the same band, one for general calling and the other for third-party traffic. Station A may call station B on the general calling frequency and send a code to switch station B to the traffic frequency. Station A then sends traffic to station B on the second frequency, resetting station A to the calling frequency at the termination of the traffic. The SELCOM can control almost any function that the operator can dream of.

**summary**

The SELCOM is a powerful digital building block which may be used to implement a wide range of station control applications. In a subsequent article, the DU-300 will be presented. The DU-300 Mini-SELCOM is a single board which provides many of the functions of the DU-200, 210, 220, and the station control board. The DU-300 provides regeneration, speed conversion, call-letter recognition, four N turn-off, printer control, and two other (user defined) functions for station control. Also, the trade-offs between the SELCOM and the Mini-SELCOM will be discussed.

All correspondence should be addressed to Robert Clark at the address indicated at the beginning of this article. All inquiries with a self-addressed stamped envelope will be acknowledged.

**acknowledgements**

WØROI, K40AH, and W6DNT were very helpful in the design of the early versions of the SELCOM. WA4SNL did the layout for versions II, III, and IV. WB8IDJ assisted in preparing tables and parts lists. K4TKU was instrumental in the preparation of high-quality drawings as he has done for other CATC project efforts. WA5IAT was particularly helpful with his work on the control section of the DU-200 and in providing comments on the draft article. We extend our appreciation to each of these who have helped, hoping we have not overlooked anyone.

**references**

Full Features and Superior Performance

ST-6000 RTTY DEMODULATOR

Select Rx & Tx Shifts
Accurately Tuned Rx Filters
Crystal Controlled Tx Tones
True Transceive Operation

Invert Both Rx Demod., and Tx Tones

Data Status Indicators
Loop 1
Post-Autostart
Pre-Autostart

Hard-Limiting [FM]
or
Non-Limiting [AM]
Reception

Correct for Bias Distortion
Correct for Multi-Path Distortion
Local Loop Operation

Tuning Oscilloscope
[Front Panel Controls]
Meter Indicator Option
Also Available

Automatic Tx/Rx Station
Control with Keyboard
Operated Switch [KOS]

Why not have the best?
The HAL ST-6000 Demodulator offers outstanding performance, versatility, and ease of operation. The Receive Demodulator features multiple-pole active filters available for "high" or "low" tones. These filters are frequency-matched to the transmit tone crystals for true transceive operation. Input bandpass filters, discriminator filters, and post-detection filters are carefully designed and tested for optimum weak-signal recovery. The ST-6000 has an internal loop power supply, 2 loop keyers, RS-232, MIL-188C, and CMOS data I/O, and rear panel connections to data and control circuits for connection to UART and computer devices. Use it with the HAL DS-3000 KSR for the best in RTTY performance.

$595.00

Write today for HAL's latest RTTY catalog.

HAL COMMUNICATIONS CORP.
Box 365
Urbana, Illinois 61801
217-367-7373

For our Overseas customers:
see HAL equipment at:
Richter & Co.; Hannover
I.E.C. Intereleco; Bissone
Vicom Imports; Auburn, Vic., Australia
receiving preamplifier
for OSCAR 8 Mode J

Amateurs who have designed and built vhf and uhf transistor circuits in the past are well aware of the fact that high performance often seems to be more art than science; however, the "art" involved in the design of vhf/uhf amplifiers is rapidly giving way to science with the utilization of $S$ parameters and computer optimization. Using these techniques, an engineer can design a multi-stage vhf or uhf amplifier in a few hours with the aid of a computer and be highly confident of the results. The low-noise 435-MHz preamplifier described in this article is a good example of the combination of the manufacturer's transistor $S$-parameter data, engineering judgment, and computer optimization.

design approach

Virtually all manufacturers of transistors intended for vhf, uhf, and microwave applications now utilize $S$ parameters to characterize the performance of their high-frequency transistors. This fact alone attests to the usefulness of this parameter set in the design of high-frequency amplifiers. In conjunction with specific noise figure data and bias point considerations, the addition of a computer analysis and optimization program, and sound engineering judgment, you have all the ingredients necessary for a successful design.

This article describes the design of a low-noise 435-MHz receiving preamplifier which is intended for the reception of the downlink communications channel of the OSCAR 8; the preamplifier also provides excellent performance for communications on 432 MHz. Basically, the design approach is developed as outlined below:

1. Selection of the appropriate transistor.
2. Determination of the terminal impedances (both input and output) required to obtain the specific performance objectives.
3. Synthesis of the appropriate matching networks to present the desired terminal impedances.
5. Stability analysis over a broad band of frequencies.

transistor selection

The main criteria in the selection of a transistor for this application is low noise figure coupled with sufficient gain to minimize the second stage contribution to the system noise figure. The intended device should also be completely specified and characterized in terms of $S$ parameters and noise figure data. In the absence of such data, extensive analysis of the amplifier circuit is impossible unless, of course, the designer is willing to perform the transistor evaluation and characterization himself.

The Microwave Associates 42140 series of uhf transistors is ideally suited for this application. The devices are completely specified and characterized over a broad range of frequencies. At optimum bias, or dc operating point which results in minimum noise figure ($V_{CE} = 8$ volts, $I_C = 5$ mA), the MA42141 has the following characteristics:

\[
\begin{align*}
S_{11} &= 0.64 L - 112^\circ \\
S_{21} &= 7.70 L 111^\circ \\
S_{12} &= 0.046 L 41^\circ \\
S_{22} &= 0.72 L - 35^\circ \\
\Gamma_{in} &= 0.32 L 38^\circ \\
NF_{min} &= 1.80 \text{ dB}
\end{align*}
\]

where $\Gamma_{in}$ is the source reflection coefficient required for minimum noise figure.

transformation networks

From this data, the design task is to synthesize matching networks which present $\Gamma_{in}$ to the input of

By Mark Pride, K1RX, and Kenneth V. Puglia, Microwave Associates, Inc., Burlington, Massachusetts 01803

The 435-MHz preamp using the Microwave Associates 42141 transistor. The extra chip capacitor, on the collector lead of the bias transistor, is used to ensure a good ac ground. Note the extensive grounding between the two sides of the printed circuit board.
studying fig. 1 which illustrates, in a block diagram form, a cascade of the input network, the transistor, and the output network. Fig. 2 is a Smith chart plot showing the locations of the various impedance points. The Smith chart will aid in the synthesis of the transforming networks. (Note that a 150-ohm resistor has been added in shunt across the output of the transistor to provide a margin of stability to the amplifier since the initial analysis in determining the complex conjugate of the output impedance indicated that the transistor was potentially unstable when terminated with these impedances.)

The networks required to transform the 50-ohm source and load to the desired impedances may be designed with the Smith chart. Smith charts are an indispensable tool in the design of impedance transforming networks which use reactive circuit elements and transmission lines. References 3 and 4 provide a clear understanding of Smith charts and their applications.

Figs. 3 and 4 may now be used to determine "ballpark" values for the transformation networks. Variable capacitors have been employed at the input to allow for normal transistor manufacturing variations as well as to extract the absolute minimum noise figure available from the transistor. A single variable capacitor at the output allows you to peak the gain and to minimize the output impedance mismatch.

Variable capacitors are recommended for this
application because it's doubtful that either the antenna or the receiver used with the preamplifier will provide the desired 50-ohm impedances; in military and commercial designs where the source and termination impedances are known to be 50 ohms, fixed capacitors are usually installed.

![Diagram](image)

fig. 4. Design of the output matching network with a Smith chart. Component values are optimized with a computer program.

**input matching network**

At the input of the preamplifier it is necessary to transform the 50-ohm input impedance to the source reflection coefficient required for minimum noise figure ($\Gamma_{in}$). This can be accomplished with a T network consisting of a series capacitance, shunt inductance, and series inductance. Beginning at the 50-ohm point at the center of the Smith chart (which has been normalized to 1.0) at point A, the series capacitance moves the impedance to $1.0 - j1.0$ (point B); the shunt inductance rotates the impedance to $1.5 - j0.9$ (point C); the series inductance transforms this to the source reflection coefficient $\Gamma_{in}$ at $1.5 + j0.66$.

The required reactance values for each of the components in the matching network can be read directly away from the Smith chart. Note that the series capacitance rotates the input impedance from $1.0 \pm j0$ at the center of the chart to $1.0 - j1.0$ at point B. Therefore, the required capacitive reactance is $-j1.0(50)$ or $-j50$ ohms; at 435 MHz this is represented by 7.3 pF.

To determine the reactance of the shunt inductor it's necessary to first convert to admittance (lower case letters designate normalized values).

**Point B** $z = 1.0 - j1.0$ $y = 0.5 + j0.5$

**Point C** $z = 1.5 - j0.9$ $y = 0.5 + j0.3$

The desired transformation requires a normalized susceptance of $-j0.2$; in a 50-ohm system this represents $0.004$ Siemens ($0.004$ mho) or +250 ohms. In this circuit this is provided by $37$ nH in parallel with $2.2$ pF (a 5 pF variable allows adjustment within the limits indicated by the arrows at point C on the Smith chart plot).

The series inductance transforms the impedance of $1.5 - j0.9$ at point C to $1.5 + j0.66$ at $\Gamma_{in}$. This requires a normalized reactance of $+j1.56$ or 78 ohms (28.5 nH at 435 MHz).

**output matching network**

The design procedure for the output matching network is similar to that used for the input network. Working from the 50-ohm load back to the collector of the transistor, the series capacitor transforms the load at A ($1.0 \pm j0$) to point B ($1.0 - j0.58$); the shunt inductor rotates the impedance to $1.23 - j0.35$ at point C. The series inductor then provides the desired reflection coefficient for the load ($\Gamma_{L} = 0.35 \angle 54^\circ$) at point D ($1.23 + j0.80$).

For the desired transformation the series capacitor must present a reactance of $0.58 \times 50$ or 29 ohms; at 435 MHz this is provided by 12.6 pF. To calculate the value of the shunt inductor, the impedance points are converted to admittance:

**Point B** $z = 1.0 - j0.58$ $y = 0.75 + j0.43$

**Point C** $z = 1.23 - j0.35$ $y = 0.75 + j0.21$

To move from $j0.43$ to $j0.21$ requires a negative susceptance of $-j0.22$ or 4.5 milliSiemens. This is equivalent to 223 ohms of inductive reactance of 82 nH at 435 MHz.

The series inductor required to transform $1.23 - j0.35$ at point C to $1.23 + j0.80$ at $\Gamma_{L}$ has an inductive reactance of $1.15 \times 50$ or 57.5 ohms (21 nH at 435 MHz). A preliminary schematic of the amplifier is shown in fig. 5.

Note that it is necessary only to determine approximate component values for the matching networks because, in this case, a computer program will be

![Diagram](image)

fig. 5. Basic 435-MHz low-noise preamplifier circuit with component values determined with the aid of a Smith chart (figs. 3 and 4).
used to adjust the values for optimum performance. However, values which are close to optimum will result in the usage of less computer time and, hence, lower cost.

Rather than winding inductors which could be lossy and cause stray coupling from unwanted radiation, it is better to use lengths of etched transmission lines for the inductive elements. This can be done providing the line lengths are less than $\lambda/8$ and preferably less than $\lambda/16$. This is more easily seen if you examine the input impedance of a lossless short-circuited transmission line:

$$Z_{in} = + jZ_o \tan \frac{2\pi l}{\lambda} = + jZ_o \tan \Theta$$

Where:

- $Z_{in}$ = input impedance to the transmission line
- $Z_o$ = characteristic impedance of the line
- $l$ = length of the transmission line
- $\lambda$ = wavelength
- $\Theta$ = electrical length of the line in degrees

Note that this expression represents a pure reactance which varies almost linearly with the electrical length $\Theta$, provided that $\Theta$ is small. Therefore, by varying the characteristic impedance $Z_o$ and the electrical length $\Theta$ it’s possible to synthesize inductive elements which are very accurate and highly repeatable when printed-circuit techniques are employed.

**computer optimization**

The next step in the design of the low-noise preamplifier is to select an appropriate computer program to execute the calculations and optimize the component values. The COMPACT* Computer Program is used extensively for this purpose because it has broad capability in terms of network elements and interconnections and is modest in cost when used within certain guidelines.

![fig. 7. Active bias circuit is used in the low-noise preamplifier to allow direct grounding of the emitter lead. The collector-to-emitter voltage of the MA42141 is determined by voltage divider resistors R1 and R2 (see text).](image)

The information for the computer is written in the form of a data file. Once the data file is written, the computer will vary the network elements and attempt to minimize the error between the desired circuit performance and the actual circuit performance. Specific performance parameters may be weighted so that their attainment carries more importance than other performance parameters. For example, if noise figure is the most important design goal, input impedance match or gain may be sacrificed so that the lowest noise figure may be achieved; the computer will adjust the variable elements in a direction which minimizes noise figure but not necessarily maximizing gain or lowering the input impedance mismatch.

In this case the computer analyzed the circuit and optimized it for operation at one frequency, 435 MHz. Additional or broader optimization could be performed by altering the data file, but this would increase computer time (and cost) because of the larger number of variables. After optimizing the component values, the computer predicted the following preamplifier performance at 435 MHz:

- Noise figure 1.81 dB
- Power gain 16 dB
- Output vswr 1.22:1

The noise figure might be somewhat optimistic since no allowance has been made for circuit losses associated with the variable capacitors and high input vswr.

A complete schematic of the optimized preamplifier circuit is shown in fig. 7. The synthesized induct,
Table 1. Comparison of computer predicted performance with measured performance.

<table>
<thead>
<tr>
<th></th>
<th>predicted</th>
<th>measured performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>unit 1</td>
<td>unit 2</td>
</tr>
<tr>
<td>Noise figure</td>
<td>1.8 dB</td>
<td>1.9 dB</td>
</tr>
<tr>
<td>Gain</td>
<td>16.1 dB</td>
<td>16.0 dB</td>
</tr>
<tr>
<td>Output vswr</td>
<td>1.22:1</td>
<td>1.15:1</td>
</tr>
</tbody>
</table>

The parasitic element which is most sensitive to performance degradation is the emitter lead inductance, which, if not kept to a minimum, will both reduce gain and alter the source impedance required for minimum noise figure. It may also introduce instabilities within the circuit which, under certain conditions, could result in oscillations. For these reasons an active bias circuit has been utilized in this amplifier. The active bias circuit will provide the proper collector-to-emitter voltage and collector current, while allowing direct grounding of the emitter lead to minimize the introduction of any parasitic impedance into the circuit. A schematic of the active bias circuit is shown in fig. 7.

![fig. 7. A schematic of the active bias circuit.](image)

The active bias circuit is actually a feedback loop which senses the collector current of the rf transistor and adjusts the base current to hold that collector current fixed. The collector-to-emitter voltage of the rf transistor is held at a fixed potential determined by the voltage divider R1 and R2. The current through resistor R3 becomes the collector current of the rf transistor under the assumption (a good one) that both the 2N2907 and the MA42141 have moderate dc current gain.

**references**

5. COMPACT Version 4.5, Compact Engineering, Los Altos, California.
6. Computer Aided Microwave Circuit Design with COMPACT, Application Note 1, Compact Engineering, Los Altos, California.
In choosing the SB-104A you join a pretty select fraternity of fellow Amateurs. They're individuals whose imaginations were fired by the looks, feel, and reputation for outstanding performance that, since its inception, has become the trademark of Heath's entire line of famous SB series Amateur equipment. You've joined a group of people who want state-of-the-art perfection, still insist on building their own to insure handcrafted quality, prefer to do their own maintenance and service, and above all want a rig that's good enough to measure up to their abilities, standards, and the reputations they've built for themselves. Heath's SB-104A, it's the only choice when you're ready for a transceiver that's good enough to measure up...to you!

Heath Amateur Radio Gear.... ....the quality that measures up!

**FREE Heathkit Catalog**

Catalogs also available at the 50 Heathkit Electronic Centers coast-to-coast units of Schlumberger Products Corp. where Heathkit products are displayed, sold, and serviced. Retail prices on some products may be slightly higher. See your white pages.

---

**Heath** Schlumberger
Heath Company,
Dept. 122-420
Benton Harbor,
Mi. 49022

Gentlemen, please send me my free Heathkit Catalog
I am not on your mailing list.

Name ____________________________
Address __________________________

City ____________________________ State _______
Zip ____________________________

Price is mail order. F.B.O. Benton Harbor. Mi.
Prices and specifications subject to change without notice.
A new integrated circuit and high performance active filter are combined into an extremely reliable Touch-Tone decoder.
group. In addition, when decoding tones from an FM receiver, signal strength and deviation are two more variables. An effective decoding scheme must incorporate an audio ALC system. If the decoder circuitry is sensitive to twist, then separate ALC control could be necessary for the high and low groups.

**Bounce And Noise.** A Touch-Tone source may not present a clean, stable leading edge. Secondly, noise, music, or speech may momentarily produce coincident tones at the proper frequencies, which could be recognized as a legitimate Touch-Tone pair. What is required is a delay, of perhaps 40 milliseconds, before a valid tone pair is acknowledged. Then the decoder output must turn on and stay on until the signal disappears, with no bounce. It has been my experience that achieving good noise rejection, fast response without false tripping, and freedom from bounce is not practical with PLL techniques.

**Frequency Stability.** Tone generation schemes which depend on RC time constants for frequency stability are not reliable, especially at temperature extremes. This is why the Motorola MC14410 and Mostek MK5087 crystal-controlled encoder chips were developed. The same is true of decoding circuitry. Crystal control is a must!

**new generation integrated circuits**

Within the last two years, several manufacturers have introduced some very sophisticated tone-decoder ICs. The first entry was Rockwell International's Collins CRC8030 dual tone multi-frequency (DTMF — another name for tone control) receiver. It is an MOS decoder chip in a 28-pin dual-in-line package which uses a standard 3.579545 MHz TV color-burst crystal for its reference. This ceramic IC was originally priced at $49 in unit quantities, but a plastic case (CRC8030-3-31) now sells for $42. An ALC system, a filter (which separates high and low group tones), and two voltage comparators are required to complete the decoder. General Instrument also produces a decoder selection designated the AY59800 series. One or more of these chips use a 1 MHz crystal and require dual power supplies.

**table 1. Data output from the MK5102 decoder.**

<table>
<thead>
<tr>
<th>digit</th>
<th>D0</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The newest entry into the tone-decoder field is the Mostek MK5102. It's a CMOS chip in a 16-pin package, with a typical power dissipation of only 25 mW, at 5 V dc. Available in either a ceramic (MK5102P-5) or plastic case (MK5102N-5), unit quantity prices start at $34.50. Even though this is a large sum of money to pay for an IC, at this time it is the only way to build a complete, top-quality decoder without spending more than $60.

A pinout diagram for the MK5102 is shown in fig. 1. Compared to the 28-pin CRC8030, this is sheer simplicity. The 5 V dc and ground connections, pins 1 and 6 respectively, are self-explanatory. An inexpensive 3.579545-MHz TV-color burst crystal is connected between pins 2 and 3. Pin 5 is used to control the output format of pins 7 through 10 (D1 through D4). This tri-state input line selects a four-bit binary code.
fig. 2. Block diagram of a complete tone decoding system using the new single IC tone decoder.

(input high), a dual two-bit row/column code (input floating), or high-impedance output (input low) for use with bus-structured circuitry.

Pins 7 through 10 are the data out lines. The outputs are CMOS loads when enabled, and open circuited (high impedance) when disabled by the control pin. The output data formats are shown in table 1. The two output codes allow the user to obtain either 1-of-16 or 2-of-8 output data by only using a single additional package.

Pin 4, the strobe output, goes high after 40 ms of a valid tone pair, and remains high for a minimum of 10 ms after the input ceases. The output information is valid when the strobe signal goes high and will remain unchanged until the next DTMF digit is detected.

The low- and high-group tones are filtered, separated, and applied to pins 11 and 12, respectively. The MK5102 can detect capacitively-coupled, square-wave signals as small as 1.2 volts pk-pk. The tones are detected, after band splitting, using the digital-counter method. The zero crossings of the incoming tones are counted over a longer period. When a minimum of 40 milliseconds of a valid signal is detected, the proper data is latched into the outputs and the output strobe goes high. When a valid digit is no longer detected, the strobe will return low and the data will remain latched into the outputs. The minimum interdigit time is 35 milliseconds.

A block diagram of a complete Touch-Tone decoding system using the MK5102 is shown in fig. 2. The ALC reduces any amplitude variations from the signal source.

The low-group tones, the rows on your Touch-Tone pad, and the high group tones, the columns, are separated in the tone-separation filter. Its outputs are two sine waves which are squared up in comparators and applied to the MK5102.

active filter

Design Considerations. An active filter for a 1-kHz frequency range is generally of low cost, small, has gain, high-input impedance, low-output impedance, and is easy to design. My intention here is not to make the reader a filter expert but to give a little of the philosophy behind the design of this one. My criteria were:

1. It must be inexpensive.
2. It must use readily available components.
3. It must be easily constructed.
4. It must provide adequate out-of-band rejection.

For the bandwidth and Q required, a staggered circuit is necessary. After examining sample response curves for 2-section filters, I felt that at least 3-sections would be required to achieve adequate out-of-band rejection. One section is tuned to the center frequency, another is tuned to $s$ (the "staggering value") times the center frequency, and

fig. 3. Passband response as a result of varying $s$ in equation 1. A shows a single-peaked response when $s = 1$. For large values of $s$, B shows the dual-peaked response. In C, a response is obtained that has a minimum passband ripple, yet adequate bandwidth ($s = 1.16$).
the third \(1/s\) times the center frequency. For \(s = 1\), the response has one peak and a very-narrow bandwidth (fig. 3A). For a large value of \(s\), 1.5 for instance, there are two separate distinct passbands (fig. 3B). By selecting the best value of \(s\) for two- or three-section filters, a suitable bandwidth with minimum ripple can be achieved, as shown in fig. 3C. Each of the three sections is designed for a particular \(Q\). Usually, it is best for the center section to have a lower \(Q\) than the outside sections which have identical higher \(Qs\). This makes for a flatter passband and a steeper slope beyond the passband (if the \(Q\) is too high the ripple in the passband will be excessive).

The transfer function for a three-section filter is:

\[
\frac{E_{\text{out}}}{E_{\text{in}}} = 20 \log_{10} \left( A \cdot B \cdot C \right) \quad \text{eq. 1}
\]

where

\[
A = \sqrt{1 + Q^2 \left( \frac{f^2/s^2 - 1}{f/s} \right)^2}
\]

\[
B = \sqrt{1 + Q^2 \left( \frac{f^2/s^2 - 1}{f/s} \right)^2}
\]

\[
C = \sqrt{1 + \left( \frac{Q}{2} \right)^2 \left( \frac{f^2 - 1}{f} \right)^2}
\]

\(s = \text{staggering value}\)

\(f = \text{normalized center frequency, with two outside sections of } Q \text{ selectivity and one center section of } Q/2 \text{ selectivity.}\)

Various values of \(s\) and \(Q\) were calculated and plotted. Using \(s = 1.16\) and \(Q = 10\) and 20 for the center and outside sections, produced a passband ripple of 3 dB and 32 dB of rejection for the other tone group. With the \(s\) and \(Q\) values determined, it only remained to select a suitable circuit.

Many designs, using 1, 2, 3, and 4 amplifiers per section, have been published, but the disadvantage of the 1- and 2-op amp versions is that they are not generally suitable for high \(Q\) applications, especially with inexpensive ICs which have low gain-bandwidth products. Since low-cost quad op amps are available, and in many pin compatible packages, a 3- or 4-op amp design is preferable; any circuit configuration would be acceptable, especially if one per cent tolerance resistor and capacitors are used, but I did not wish to use precision components, and therefore, expended the additional labor to ensure that standard parts can be used.

Filter Selection. The BIQUAD filter section (see fig. 4) was chosen because the center frequency and \(Q\) can easily be adjusted by trimming just one resistor for each function. The principle of operation of the

BIQUAD is as follows. Since the integral of a sine wave is a cosine wave, or a 90-degree phase shift, U1 is an integrator, giving a 90-degree shift. U2 is an inverter yielding 180-degree shift, for a subtotal of 270 degrees. U3 is another integrator giving an additional 90 degrees, for a grand total of 360 degrees. Positive feedback may then be provided from input to output.

Without the \(Q\) setting resistor, the gain and \(Q\) of the BIQUAD would be excessively high, causing the circuit to oscillate at the frequency where the phase shift is 360 degrees (the integrator and inverter do not have exactly 90 degrees and 180 degrees shift respectively at more than one frequency). This resistor introduces enough loss so that the \(Q\) is controlled and the BIQUAD does not oscillate. The actual frequency response curve for the complete filter is shown in fig. 5 and its schematic is presented in fig. 6.

Filter Operation. The tonal input is simultaneously applied to both sides of the filter, passing through the 686 Hz, 809 Hz, and 955 Hz sections of the low-group filter as well as the 1191 Hz, 1404 Hz, and 1657 Hz sections of the high-group filter. Resistive dividers R19/R20 and R41/R42 reduce the outputs of the 686 Hz and 1191 Hz sections so that these sections may be driven farther toward cutoff and saturation without overloading the following stages. Since a single 12-volt supply is used, R39 and R40 divide 12 volts down to 6 volts, establishing the dc bias so that the output may swing equally about 6 V dc. C13 ensures that the 6 V dc bias line is at ac ground.

filter construction

My filter was built using wire-wrap techniques. I used standard, wire-wrap IC sockets with a phenolic...
FREQUENCY

the generator does not cause a dc-bias problem with
the filter; you may want to include a 0.01 µF capaci-
tor in series with the filter input.

Tune the generator from approximately 600 Hz to
1200 Hz with the scope connected to the low group
output. Notice where the three filter sections are
peaking. Don’t expect the peaks to be the same
amplitude since the Q has not been tuned yet. If you
have chosen to use pots, tune the center frequency
of each section to the correct value, using R6, R12,
and R18.

If you are using individual resistors, divide the ac-
tual center frequency of each section by the desired
frequency for that section. Square this fraction and
multiply it times the existing resistor value. This will
give you the approximate value for a resistor which
will put you very close to the desired frequency. Set
the center frequency for the three high group sec-
tions in a similar manner by tuning the generator
from approximately 1000 Hz to 2000 Hz.

To tune the Q, each BIQUAD could be driven and
monitored separately and adjusted to the desired Q.
An easier method is as follows. The Q of the first low
group section is 20; the frequency is 686 Hz; the
bandwidth is 686/20 or 34 Hz. Hook the oscilloscope
to U3 pin 7. Adjust the generator to the center fre-
quency and note the amplitude. Find the two fre-
quencies where the output is 3 dB (0.707 times) less
than at the center. Is the bandwidth more or less
than 34 Hz? Adjust R2 upward to increase Q or down
to decrease Q. Once this value equals 20, connect
the scope to the output of the low group filter.

Set the generator for the center frequency of the
686 Hz section. If, for instance, the output is 500 mV
peak-to-peak, tune the generator to the center of the
809-Hz section and adjust R8 for 500 mV, then tune
the generator to the center of the 955-Hz section and
adjust R14 for 500 mV.

The high-group filter may now be tuned in a similar
manner at its respective frequencies, first adjusting
the 1191-Hz section, via R22 for a Q of 20 and a 60-
Hz bandwidth with your scope on U3 pin 8. Then,

**tuning and alignment**

For checkout, you will need a sine-wave audio
source and an oscilloscope. It would be helpful if the
sine-wave source does not change in amplitude as it
is tuned from one frequency to another, but if
necessary its output can be readjusted with the
scope.

You should now install the ICs and apply power.
Set the generator for approximately 50 mV peak-to-
peak. Beware, a larger value may reduce the Q
and/or drive the op amps into nonlinearity. Be sure

**fig. 4. Diagram of the basic BIQUAD active filter. The two integ-
trators produce a 90-degree phase shift and the inverter
provides 180 degrees of shift. With proper feedback, this
filter will pass a single frequency.**

board and Vector wire-wrap terminals to mount the
resistors and capacitors. This method has one very
attractive advantage (though it is slightly more
expensive), it's very fast, especially compared to
point-to-point soldered connections.

Drop the Vector pins into place, seating them by
pulling from the bottom of the board. Epoxy the
sockets into position. The board can be wired using
an inexpensive, hand wire-wrap tool. The use of pre-
cut and stripped no. AWG 30 (0.25mm) wire further
speeds assembly. Use an ohmmeter to check all
wiring for errors. This is extremely important since it will
prevent damaging components and could save con-
siderable time later.

Temporarily install the final 12 resistors using the
nominal values shown in the schematic. Miniature
potentiometers set to these values are highly recom-

**fig. 5. Filter response for the high and low tone separation
filter.**
with your scope on pin 1 of U5, adjust R28 and R34 at 1404 Hz and 1657 Hz respectively as you did for the low-group sections. Finally, check to ensure that 1209 Hz is really 30 dB down from 941 Hz in the low-group filter, and vice versa.

A voltmeter may be substituted for an oscilloscope for every filter test, but it will not allow you to see nonlinearities, oscillations, and hum. Also, a Touch-Tone pad can be used as a frequency standard to calibrate the generator by setting up a Lissajous pattern. On most pads, pressing two row or column buttons will produce only the sine wave for that row or column.

If your filter oscillates, the problem may be:

1. The Q of one or more stages is too high.
2. The power supply is not adequately bypassed.
3. The ground circuit is not adequate.

The filters I have constructed have not had these problems. Should you decide to use a substitute op amp be aware that if it has poor power supply rejection or insufficient phase margin, it could cause oscillation.

**Comparator and Decoder Circuitry**

Fig. 7 is the schematic for the comparator and decoder. The two sections of the comparator U1 are used to square up the filter outputs. The resistive dividers on the output of the comparators allow adjustment of the drive to the MK5102, although this does not seem critical; you may choose to replace the pots with fixed dividers.

In this circuit, the decoder’s data control pin is tied to 5 V dc to constantly enable the proper format. A 74154 separates the twelve subsequent commands. The 74154 outputs are active low, so if you require active high signals include hex inverters U5 and U6. If the digit 1 is received, then pin 2 of the 74154 will stay low just as long as the 1 is being received.

The filter, decoder, and ALC circuitry has been in operation for many hours. It’s presently connected to the output of a 2-meter fm receiver tuned to a noisy, busy, repeater channel, and is used every day for selective call and remote control. The circuit does not trigger on false signals. In fact, it has proven to be stable and reliable, sufficiently so that it has permanently replaced an earlier sophisticated 567 PLL decoder system which was in use here for over a year and a half.

Incidentally, there is a minor limitation of which you should be aware. Because of the ALC used with this system, a signal with somewhat low deviation will not be a problem. However, a signal with excessive deviation will be wider than your receiver’s passband and will not be decoded. This is not a fault of the decoder, but must be corrected at the transmitter.

Soon the MK5102, with its tri-state outputs, will be connected to a MOS-Technology 6502 microprocessor system so that more complex functions may be performed. I welcome and solicit any and all comments and improvements to this Touch-Tone decoder.
Amateurs with free-standing antenna towers are fortunate indeed: no need to worry about guy wires, anchors, and supports. But if your antenna tower must be guyed, how do you ensure that your guying system will withstand the forces of high winds? What about your soil conditions? Can your soil hold guy anchors?

This article gives some guidelines on how to handle the problem of guying antenna towers erected on various types of soil (from hard rock through loose sand and gravel). Also included are some tips on guying materials and how to use them. The author has had some 30 years of experience in the engineering and construction of antenna systems in locations where wind velocity often exceeds 185 km/hr (100 knots).

**guy-anchor placement**

Starting at ground level and going up, the location of each guy anchor is our first consideration. Ideally, guy anchors should be placed the same distance from the tower or mast base as the guy attachment to the structure, a 1:1 ratio. A minimum of three guys, spaced 120 degrees apart are considered while four guys spaced 90 degrees apart is most desirable. When real estate is not available to maintain the desired 1:1 ratio, consideration should be given to an acceptable ratio of 6:4.

**anchors**

Table 1 shows how we may expect our anchors to accept the strain when installed in various soils. Considering the load that an average guy will put on the anchor and rod, the stamped 152-mm (6-inch) anchor with a 13 mm (1/2 inch) by 1.5-meter (5 foot) rod will perform satisfactorily in most locations (fig. 1).

In my case anchor holes were drilled with a power-driven post-hole digger leased from a local equipment rental agency. Angle the anchor hole so that guy tension is in a straight line with the anchor rod. The holding ability of this type of construction is shown in table 2. Before placing the anchor and rod, dress the rod threads to prevent the nut from backing off.

These units will survive for many years if the soil composition is not corrosive. A test with litmus table 2. Holding power of a 152 mm (6 inch) cone anchor in several soil types (courtesy Graybar Electric).

<table>
<thead>
<tr>
<th>soil classification</th>
<th>soil description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>hard rock, solid</td>
</tr>
<tr>
<td>2</td>
<td>shale or sandstone, solid or layered</td>
</tr>
<tr>
<td>3</td>
<td>hard, dry, hardpan</td>
</tr>
<tr>
<td>4</td>
<td>crumbly, damp</td>
</tr>
<tr>
<td>5</td>
<td>firm, moist</td>
</tr>
<tr>
<td>6</td>
<td>plastic, wet</td>
</tr>
<tr>
<td>7</td>
<td>loose dry sand, gravel</td>
</tr>
</tbody>
</table>

By Marchal H. Caldwell, Sr., W6RTK, 4620 Greenholme Drive, No. 4, Sacramento, California 95842
paper will reveal the presence of any contaminants. Coat the rod and anchor with thinned roofing mastic before back filling.

**guy wire material**

Consider the actual guy wire. There are probably more different guy wire types than vacuum tubes, and most will survive for a long time. Since an antenna and its supporting structure represent a considerable investment, the proper selection and use of guying materials is a must. Table 3 lists some of the available solid and stranded guy wire.

**attaching the guys**

Guy-wire attachment to the anchor rod eye is usually by a clevis-and-eye turnbuckle, with the clevis end attached to the rod and the guy strand attached to the eye by wire rope clamps. At least two clamps must be used spaced six times the diameter of the wire. The wire dead-end should be served around the wire adjacent to the outer clamp. Turn-buckles should be safety-wired. A thimble should be used under the wire and inside the eye (fig. 2).

Towers and masts are sometimes provided with a guy attachment bracket. Terminate the guy wire in the same manner as used at the turnbuckle (fig. 3). When no guy bracket is provided, wrap the guy around the tower leg above a cross brace.

Proper guy tension has always presented a problem. The only sure and safe method is to use a strand dynamometer, which is expensive and normally not available. However, most amateurs use the eyeballing method — keeping too much tension out and not too much sag.

**strain insulators**

Some antenna structures will require the guy wires to be broken with strain insulators while others won’t need this treatment. Fig. 4 shows how to connect strain insulators in the guy wires. Note the recommended method of serving the loose ends of the wires, which is extremely important. At amateur frequencies, the most desirable maximum distance between guy-wire insulators is 3 meters (10 feet). Your
fig. 4. How to connect strain insulators to your guys. Serv- ing the loose ends of the guys follows the rule: 7 turns, 7 times.

pocketbook will be the deciding factor since the insulators and guy wire clamps could cost about $5 at each point.

Reasonably corrosion-proof materials should be used in your antenna construction. Hot-galvanized materials are among the best. An excellent source of supplies is your local electrical contractor. Exploration of surplus and salvage agencies often produces items at a considerable saving — but again, don’t compromise on quality!

Personal safety during construction is a most important consideration, which must be practiced and observed. Have an adequate supply of strong hands and backs available when erecting any type of supporting structure. Ground-crew members should be equipped with hard hats, safety shoes, work gloves, and a knowledge of your construction plans. Climbers should be similarly equipped and have a good safety belt.

If you're considering constant experimental work at the top of your structure, fall-safe units are available, which will prevent a disastrous fall. (This stuff is expensive, but so is a hospital bed!)

Table 3. Guy-wire strength in terms of size, breaking strength, and maximum load (courtesy Graybar Electric).

<table>
<thead>
<tr>
<th>Size, Insulator</th>
<th>Breaking Strength, kg (lb)</th>
<th>Maximum Load, kg (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanized telephone &amp; telegraph</td>
<td>2.6 (10)</td>
<td>293 (655)</td>
</tr>
<tr>
<td>2.1 (12)</td>
<td>193 (425)</td>
<td>91 (200)</td>
</tr>
<tr>
<td>1.6 (14)</td>
<td>112 (247)</td>
<td>52 (115)</td>
</tr>
<tr>
<td>Diameter, mm (in)</td>
<td>Breaking Strength, kg (lb)</td>
<td>Maximum Load, kg (lb)</td>
</tr>
<tr>
<td>5.0 (3/16)</td>
<td>522 (1150)</td>
<td>250 (550)</td>
</tr>
<tr>
<td>6.5 (1/4)</td>
<td>863 (1900)</td>
<td>409 (900)</td>
</tr>
<tr>
<td>8.0 (5/16)</td>
<td>660 (2200)</td>
<td>300 (600)</td>
</tr>
<tr>
<td>Seven wires twisted into 1 strand (common grade)</td>
<td>5.0 (3/16)</td>
<td>999 (2200)</td>
</tr>
<tr>
<td>6.5 (1/4)</td>
<td>1816 (4000)</td>
<td>908 (2000)</td>
</tr>
<tr>
<td>8.0 (5/16)</td>
<td>2724 (6000)</td>
<td>1362 (3000)</td>
</tr>
</tbody>
</table>

Finally, but by no means of less importance, remember that erecting a supporting structure near high-voltage power lines could cause you to miss out on the Quarter Century Wireless Club.

Ham radio
vfo design

using characteristic curves

Graphical aid to help you choose vfo component values on the basis of working-frequency range and scale linearization

This article will help you design a vfo using what I call the “universal characteristics” of the Colpitts oscillator. The hard work has already been done with the aid of a computer. The result is a family of parametric curves that allow you to choose frequency determining values of critical components precisely and without guesswork.

background

Several months ago I started the project with an ssb transceiver using ICs, following the new and well-known concept of concentrating all common circuits that don’t depend on reception-transmission frequency in a single printed circuit. An external vfo and a tuned amplifier in the input-output circuit defined the transceiver operating frequency. Several IC manufacturers have developed exclusive ICs for the common parts of the transceiver mentioned above by standardization and by reducing the number of discrete components.

the external vfo

The first problem I met was designing the external vfo. I needed a vfo in the 5 to 5.5-MHz frequency range with good stability and linearity. Because of the chosen frequency and the oscillator characteristics, I chose the Colpitts oscillator. I first tried to find articles that already described vfos working in my desired frequency range. I found a couple of circuits, and despite the different component values shown, I started construction following the scheme in fig. 1. First of all I used a capacitor, \( C_v = 80 \, \text{pF} \) with an inductance of approximately \( L = 5 \, \mu\text{H} \), using different values for \( C_1 \) and \( C_2 \). I immediately realized the dif-

![fig. 1. Typical vfo Colpitts oscillator circuit used in the text example. Components \( L \), \( C_v \), \( C_1 \), \( C_2 \) define the oscillation frequency, for which parametric curves have been derived and are shown in fig. 3.](image)

By Maurizio Gramigni, I2BVZ, 1621 16th Avenue NW, Rochester, Minnesota 55901
ficulties ahead; in fact, when turning $C_1$ 180 degrees, the frequency range was around 1.6 MHz, which was not the desired range. After this failure I decided to face the problem from a technical point of view, starting from these assumptions:

1. Determine frequency stability vs temperature variation.
2. Calculate circuit-component values on the basis of the chosen working frequency range and scale linearization.*

Regarding point 1, the use of an fet is highly recommended compared with bipolar transistors or vacuum tubes. The advantages are listed below:

1. An fet, with its high input impedance, can amplify signals with very low current level. As a result the power dissipation will be less than with bipolar transistors and vacuum tubes.
2. As a consequence of point 1 above, the heat dissipated and transferred to the oscillator components is lower, resulting in better thermal stability.
3. Since the power used is very low and the fet mass is very small and compact, the thermal equilibrium will be reached in a very short time — 30-40 seconds.

Using components such as silver mica capacitors helped to provide an oscillator with a very good frequency stability.

Calculating component values as a function of frequency range and scale linearization is the subject of this article. Fig. 1 shows our vfo circuit. Let’s say, first of all, that $L$, $C_v$, and $C_a$ define oscillation frequency,

fig. 2. At the resonant frequency the oscillator impedance will equal zero. The network $L$, $C_v$, $C_a$ formed the basis of the FORTRAN program, which resulted in the universal characteristic curves for determining vfo values as shown in fig. 3.

while $C_1$ and $C_2$ are the positive feedback network, which provides self starting and maintains oscillation. Distortion due to the nonlinear elements is limited by the proper choice of resistor $R$.

Generally it’s easy to design an oscillator working at one predetermined frequency. In fact, this occurs when the capacitive reactance of the oscillator circuit equals its inductive reactance. If a variable frequency oscillator is needed, however, a different approach to the problem is required. In this case, once the frequency range is chosen we need to know $L$, $C_v$, and $C_a$ values.

universal characteristics

To reach our goal we start by calculating the transfer function of the complete oscillatory circuit. Then if we indicate

\[ \omega = 2\pi f \]

\[ C = \frac{C_1 \cdot C_2}{C_1 + C_2} \]

\[ X_L = j\omega L \]

\[ X_v = -j \frac{1}{\omega C_v} \]

\[ X_a = -j \frac{1}{\omega C_a} \]

\[ X_C = -j \frac{1}{\omega C} \]

the final equation is

\[ Z = \left( \frac{X_L \cdot X_v}{X_L + X_v} + X_a \right) \cdot \left( \frac{R \cdot X_C}{R + X_C} \right) \]

\[ = \left( \frac{X_L \cdot X_v}{X_L + X_v} + X_a \right) + \frac{R \cdot X_C}{R + X_C} \]

Because of the quantity of calculations I used a computer to solve for $Z$.

As mentioned previously the real oscillator circuit consists of $L$, $C_v$, $C_a$ components (see fig. 2). At the resonant frequency, its impedance will equal zero, therefore our complex impedance, $Z'$, must also equal zero. The program, in FORTRAN language, was based on the observation above. In fact, the computer printout directly supplied $C_a$ values for that particular frequency value where $Z'$ equals zero.

parametric curves

Starting from frequency values of 2.5 MHz, and for fixed values of $L$, $C$, $C_a$, and $R$, we obtained from the computer the $C_v$ values for $Z' = 0$. The results are summarized in the curves of fig. 3.

Fig. 3A shows the universal characteristics family for $L = 7.5\mu H$. $C_a$ values vary from 150 to 400 pF in 50-pF
Fig. 3. A family of parametric curves for determining component values for the Colpitts vfo in fig. 1. Operating frequency as a function of variable capacitance, $C_v$, is shown as a function of oscillator frequency with values of $C_a$ as a parameter. The three sets of curves are for various values of inductance, $L$.

steps. Fig. 3B shows the universal characteristics for $L = 4.5 \mu F$. Seven curves for $C_a$ values between 250 and 550 pF have been calculated.

Fig. 3C refers to the universal characteristics for $L = 2 \mu F$. These curves show that the effect of decreasing $L$ causes an extension of the frequency range of interest by universal characteristics. For the characteristics of figs. 3A and 3B it was not possible to calculate other $C_a$ values because of the unstable conditions I found. Therefore, only 12 curves for $C_a$, from 250 to 800 pF, have been calculated.

**how to use the universal characteristics**

I call these characteristics ‘universal’ because they are valid for all vfos (Colpitts) as shown in fig. 1. With these characteristic features you can determine directly the values of all vfo components, as shown in the following example.

Assume you want a variable oscillator covering 3.5-3.9 MHz. Choose two curves, the first from fig. 3B with $C_a = 300$ pF and the second one from fig. 3C with $C_a = 800$ pF. In the first case, the linearity ratio value is $\Delta f/\Delta C_a = 4.4 \text{ kHz/pF}$; while in the second case it is $\Delta f/\Delta C_a = 2.1 \text{ kHz/pF}$. To obtain $C_v$ (which in this case is 90 pF instead of 190 pF as in the second case) the curve of fig. 3B could be used. From this figure it’s possible to get all the other values, which are:

$$C_a = 300 \text{ pF} \quad C_v = 90 \text{ pF}$$

$$L = 4.5 \text{ pF} \quad R = 22 \text{ K}$$

$$C1 = C2 = 600 \text{ pF}$$

Usually $C1$ and $C2$ have the same values to guarantee self-starting oscillations.

**in conclusion**

Once the working frequency range is chosen, it’s possible to satisfy, through the universal characteristics of fig. 3, the following points:

1. Dial linearization; that is, keeping the $\Delta f/\Delta C_v$ ratio constant within the chosen range.

2. Definition of minimum and maximum $C_v$ values.

In any case, for about 200 kHz of frequency range, the linearity error is very low for each curve of the families. On the contrary, for a wider frequency range, the choice of the curve is much more limited and depends on the desired $\Delta f/\Delta C_v$ ratio; that is the derivative value of the curve. Generally, for the $\Delta f/\Delta C_v$ ratio, it’s advisable not to select very high values, around $4 \text{ kHz/pF}$.
EXPERIENCE. There’s no substitute for it. And TEN-TEC has it. More experience in solid-state HF technology than any other amateur radio manufacturer. Because TEN-TEC produced the first all-solid-state HF transceiver for amateur radio. So, it stands to reason that the latest generations (the 540/544 models) benefit the most from that experience — in features, reliability, and operating ease. They are the “voices of experience.”

TAKE MECHANICAL DESIGN. Experience tells us: make it rugged. So, like all fine solid-state devices such as computers and good test equipment, the 540/544 transceivers have their strength built into the chassis — the case is merely a cover. Ruggedness is carried over into the circuit boards as well. Component leads are “clinched,” not just inserted, to give additional strength and to prevent annoying intermittents.

TAKE PHYSICAL APPEARANCE. Experience tells us: keep it simple. WWII is over, so is its technology, so why should your transceiver look like war surplus? The 540/544 transceivers look like tomorrow — small because technology makes it possible — few controls for the same reason. And they’re elegantly handsome with black cases and brushed aluminum front panels.

TAKE ELECTRICAL DESIGN. Experience tells us: push the state-of-the-art. Example: we pioneered high power solid-state design for HF amateur radio gear. The advantages are numerous: efficient, small size, no lethal voltages, less heat, longer life, greater reliability. Example: broadband design. The advantages: easier operation for everyone, rag-chewers, DX chasers, even net operators. No out of reasonance danger, no need for a dummy load to prevent tune-up QRM, no boring, time-consuming “tune-up” procedures. Another example: computer aid. In circuit design, in manufacturing, for speed and optimization. Example: computer compensating oscillator drift to achieve rock-like stability.

TAKE SERVICING. Experience tells us: make it easy, for everyone. So the 540/544 transceivers have modular design with plug-in circuit boards. And trouble-shooting (if it’s ever needed) can be done by you with ordinary test equipment. (Of course, Ten-Tec service people are ready to help).

TAKE OPERATING CONVENIENCE. Experience tells us: everyone wants it. Examples: high sensitivity with low internal noise makes the 540/544 transceivers great for DX, especially during poor band conditions. Full break-in on CW turns conventional QSOs into interesting conversations. Pre-selectable ALC gives automatic level control at various input powers (40-200 watts) plus optimized input power for linear amplifiers. “Semi-hard” keying effectively penetrates pileups, QRM, and QRN, yet is highly articulate and pleasant to copy. Pulsed calibrators are easy to identify. VOX that eliminates “anti-VOX” by triggering on a tone present in your voice but not in the transceiver speaker. (There are even more conveniences in the following “features” list.)

FEATURES — • Instant Band Change (no transceiver tune-up) • Covers 3.5 to 30 MHz (plus One-Sixty with option) • 200 Watts Input — all bands • Receiver Sensitivity 0.3 uV • VFO changes less than 15 Hz per F0 after 30 min. warm-up • 8-pole Crystal IF Filter • Direct Readouts — choose LED digital model or 1 kHz dial model • Optional 150 Hz CW filter • Optional Noise Blanker • Offset Tuning • WWV at 10 & 15 MHz • Separate Receiver Capability • Automatic Sideband Selection, Reversible • Sidetone Level and Pitch control • Pre-Settable ALC • 100% Duty Cycle • S Meter and SWR Bridge • LED indicators for ALC and OFFSET • Modular Plug-In Circuit Boards • Broad Accessory Line

544 Digital — $869 540 Non-Digital — $699
Give your voice the Ten-Tec “Voice of Experience” treatment. See the 540/544 transceivers at your Ten-Tec dealer or write for full details.
rf chokes

their performance above and below resonance

An investigation into the properties of rf chokes over wide frequency ranges

For years I've heard various electronics engineers quote a simple rule-of-thumb about rf chokes: "Never use an rf choke above its self-resonant frequency because it's capacitive!" The inference is, I think, that above its self-resonant frequency, the rf choke will have a very low reactance, which is the opposite effect usually desired from an rf choke. After all, capacitors are used for bypass and coupling functions, and an rf choke does show capacitive reactance above its self-resonant frequency.

This rule-of-thumb is a very safe and conservative way to apply rf chokes in circuit design, I suppose, but sometimes it makes it difficult to get the impedance you want over a desired frequency range; in general, the larger the inductance of an rf choke, the lower will be its self-resonant frequency.

A frequent application of rf chokes by amateurs is the use of a 2.5 millihenry choke in a circuit which operates up to 30 MHz. Such use is in direct conflict with the stated rule-of-thumb, because the self-resonant frequency of these chokes is usually on the order of 3 MHz! In the paragraphs which follow, I have attempted to resolve this conflict by mathematical analysis.

Mathematical analysis of the rf choke

To evaluate the performance of rf chokes at different frequencies, I felt it necessary to develop a general mathematical expression for impedance as a function of self-resonant frequency. Starting with the mythical ideal rf choke, we have a pure inductor as shown in fig. 1. The equation for its impedance in ohms is

\[ Z = j2\pi fL \]  

where \( Z \) is the impedance, \( f \) is frequency in Hertz, and \( L \) is inductance in henries. The \( j \) is simply a notation which indicates that the phase angle of the impedance is +90º with respect to a pure resistance. To simplify the following equations a little, I will substitute \( \omega \) for \( 2\pi f \)

\[ \omega = 2\pi f \]  

where \( \omega \) is frequency in radians-per-second. You can always get back to frequency in Hertz by a rearrangement of eq. 2.

\[ f = \frac{\omega}{2\pi} \]  

The solid line on the graph of fig. 2 shows how the impedance of a pure inductor, having an inductance of 1 henry, rises linearly with increasing frequency, according to eq. 1. The linear relationship will continue to any frequency.

fig. 1. The ideal rf choke is a pure inductance.

Practical rf chokes, however, are not pure inductors; stray capacitance between turns of the coil is effectively in parallel with the ideal inductor. For the purpose of this discussion all of the stray capacitance may be lumped into one equivalent parallel capacitor, as shown in fig. 3. The rf choke now has a self-resonant frequency whose value is determined by the values of \( L \) and \( C \). The equation for the impedance of this parallel circuit is

\[ Z = -\frac{(j\omega L) - \frac{1}{j\omega C}}{j\omega L + \frac{1}{-j\omega C}} = \frac{j\omega L}{1 - \omega^2 LC} \]  

The self-resonant frequency of the circuit will be
designated \( \omega_o \), and its value is
\[
\omega_o = \frac{1}{\sqrt{LC}} \tag{5}
\]

If \( \omega_o \) is substituted for \( \omega \) in eq. 4, we obtain the value of the choke's impedance at the self-resonant frequency.
\[
Z_o = \frac{j \omega_o L}{1 - \omega_o^2 LC} = \frac{j \omega_o L}{1 - \left(\frac{1}{LC}\right)LC} = \frac{j \omega_o L}{1 - 1}
\]

The denominator in eq. 6 is equal to zero, so the impedance, \( Z_o \), must be infinitely large (remember, we don't have any losses in our mathematical model, yet).

To solve for the choke's impedance at one octave below and above the self-resonant frequency, substitute \( \frac{\omega_o}{2} \) and \( 2\omega_o \), respectively, for \( \omega \) in eq. 4
\[
Z_{\frac{\omega_o}{2}} = \frac{j \left(\frac{\omega_o}{2}\right) L}{1 - \frac{\omega_o^2}{4} LC} = \frac{j \left(\frac{\omega_o}{2}\right) L}{1 - \frac{LC}{4LC}} = \frac{2}{3} \left(j \omega_o L\right) \tag{7}
\]
\[
Z_{2\omega_o} = \frac{j(2\omega_o) L}{1 - 4\omega_o^2 LC} = \frac{j(2\omega_o) L}{1 - 4LC} = -\frac{2}{3} \left(j \omega_o L\right)
\]

Let's closely examine these two results. Notice that the quantity \( (j \omega_o L) \) in each answer is the reactance a pure inductor would have at \( \omega_o \), the frequency at which the practical choke is self-resonant. Notice too that the magnitudes of the two answers are equal; the choke has as much impedance one octave above the self-resonant frequency as it does one octave below. The minus sign of the impedance one octave above self-resonance indicates the impedance has a phase angle of \(-90^\circ\) with respect to a pure resistance, and this means it is a capacitive reactance.

fig. 3. Practical rf choke has stray capacitance, creating a resonant circuit.

To explore this a little further, let's find the choke's impedance one decade below and above self-resonance
\[
Z_{\frac{\omega_o}{10}} = \frac{j \left(\frac{\omega_o}{10}\right) L}{1 - \frac{\omega_o^2}{100} LC} = \frac{j \left(\frac{\omega_o}{10}\right) L}{1 - \frac{LC}{100LC}} = \frac{10}{99} \left(j \omega_o L\right) \tag{9}
\]
\[
Z_{10\omega_o} = \frac{j (10\omega_o) L}{1 - 100\omega_o^2 LC} = \frac{j (10\omega_o) L}{1 - 100LC} = -\frac{10}{99} \left(j \omega_o L\right)
\]

Again, both answers have the same magnitude, and the impedance is inductive below self-resonance and capacitive above self-resonance. I have solved for the choke's impedance at several more frequencies and plotted the curve shown in fig. 4. Although the choke's impedance is capacitive above self-resonance, it doesn't fall off any faster than it does below self-resonance.

fig. 4. Relative frequency response of a lossless, but self-resonant rf choke. The frequency of resonance is at \( \omega_o \).
We must add an equivalent parallel resistance, \( R_p \), as shown in fig. 5, to make the mathematical choke completely realistic. Another way to show this is pictured in fig. 6, where \( R_p \) is connected in parallel with the impedance, \( Z \), solved for above. \( R_p \) accounts for losses in the choke; at the self-resonant frequency, the impedance of the choke will be equal to \( R_p \).

The value of \( R_p \) does not stay constant as frequency changes because losses tend to increase at higher frequencies. A major contributor to this characteristic is the skin effect in the wire of the coil, which causes \( R_p \) to decrease as a function of the square-root of frequency. Solving for the exact impedance of the rf choke with \( R_p \) present is a little tedious and will not be dealt with here. It is assumed, however, that \( R_p \) will be large enough so that the calculations above may be taken as rough approximations at frequencies at least one octave away from self-resonance. Thus the value of \( R_p \) at 25 MHz is estimated to be

\[
\frac{215,985}{\sqrt{25 \text{ MHz}}} = \frac{215,985}{\sqrt{10^2}} = 215,985 \text{ ohms}
\]

so it won’t cause too large an error in the result of eq. 16. Notice that the impedance at 25 MHz, one decade above self-resonance, is nearly the same as the impedance at 250 kHz, one decade below self-resonance (see eq. 11).

One final calculation of interest is the value of capacitance the choke represents at 25 MHz

\[
C = \frac{1}{2\pi(2.5 \times 10^6) (39,270)} = 1.6 \text{ pF}
\]

Well, how about that? The same value as at self-resonance. Obviously, the equivalent parallel capacitance of the choke is totally dominating the value of reactance at 25 MHz. But then, it should.

**Conclusion**

After going through the exercise above, it is evident that an rf choke behaves like any parallel tuned circuit. But since an rf choke has a self-resonant frequency, we knew it was just a parallel tuned circuit all along, didn’t we? If we can use an rf choke below its self-resonant frequency, I see no reason not to use it above its self-resonant frequency, so long as it will provide the required impedance. An rf choke does look like a capacitor above self-resonance, but as we saw with the 2.5 mH choke, it can be a very small capacitor.
techniques for preventing rf leakage from your transmitter

We are all aware of the increasing incidence of RFI problems caused by solid-state home entertainment products which are not designed to function normally in the presence of a strong RF field. These kinds of problems can be cured only by adding filtering and/or shielding to the affected device.

At the same time it behooves us all not to forget to be sure that our own transmitters are clean. This means using a good lowpass filter and making sure that the only path out of the transmitter for rf energy is through that lowpass filter. If you have any RFI problems, this is the first thing that should be checked.

Run your transmitter into a shielded dummy load. If the RFI is still present, you have rf leakage which should be eliminated. If it is harmonic interference, no lowpass filter will do any good if the harmonics are leaking out ahead of it. If it is overload interference, it may be possible to eliminate it by curing the leakage, depending on the amount of leakage to begin with and the relative distances from the equipment and the antenna to the device suffering the interference.

Three areas need to be addressed to solve rf leakage problems: filtering of power, audio, and control leads; shielding effectiveness of coaxial cable; and leakage at joints in shielded enclosures. Techniques

By John E. Becker, K9MM, 201 East Marion Street, Prospect Heights, Illinois 60070
for filtering of power, audio, and control leads has been thoroughly discussed in many amateur publications so that topic will not be addressed here. Instead, I will concentrate on the other two areas.

There is considerable difference in the shielding efficiencies of different types of coaxial cable. The numbers to be quoted are from manufacturers’ literature, and while different manufacturers do not necessarily agree on the shielding efficiency of a particular type of cable, there is no doubt about the significant difference in the shielding efficiency afforded by the different types of cable construction to be discussed, and the numbers should be considered with that in mind. The most commonly used type of coax, that having a single shield braid of stranded copper wire, has a shielding efficiency of –48 dB at 100 MHz for a 30 cm (1 foot) length of cable. That is, the total power radiated by that 30 cm of cable is 48 dB down from the signal level in the cable. This assumes 95 percent shield coverage. This shielding efficiency increases only slightly with decreasing frequency, to –52 dB at 10 MHz according to data published by the Times Wire and Cable Company.

The shielding efficiency is significantly reduced by lower shield coverage, and 85-90 percent is more typical. This means that if you have 30 cm of coax between your transmitter and lowpass filter, harmonics radiating from that piece of coax are 48 dB down from their level at the transmitter output. Under these conditions, a lowpass filter with 100 dB harmonic attenuation is no better than one with 48 dB attenuation as far as nearby interference problems are concerned. The filter will keep the harmonics from getting to the antenna to be radiated for long distances, but the TVI problem next door is just as likely to be due to the radiation from the cable.

While we’re still on the subject of single shielded coax, be especially wary of bargain priced coax that is not made to military specifications. Some manufacturers have drastically reduced shield coverage in the last few years to keep costs down.

There are more sophisticated types of coaxial cable with much better shielding efficiencies. The most often encountered construction is double shielded coax. This type of cable uses two shield layers with no dielectric between them. Shielding efficiency is typically –87 dB at 100 MHz for a 30 cm (1 foot) length, and since this is a premium cable designed for excellent shielding you can be sure that the shield coverage is as great as possible.

A still better type of construction for shielding efficiency is triaxial cable. This cable has two shield layers with a dielectric layer between them. Shielding efficiency is further improved to –97 dB at 100 MHz for a 30 cm length.

The ultimate in shielding efficiency is the solid jacketed type of cable. Radiation from this type of cable is below measurable limits, and system shielding efficiency is limited only by leakage at a connector interface.

The use of one of these improved types of cable for all station interconnections up to the lowpass filter will ensure that you are getting all the harmonic protection the filter is capable of. Double-shielded substitutes for RG-8A/U or RG-213/U are RG-9B/U or RG-214/U. The double-shielded substitute for RG-58C/U is RG-58A/U or RG-223/U. A triaxial substitute for RG-8A/U or RG-213/U is Times TRF-8. A triaxial substitute for RG-58C/U is Times TRF-58 or Essex 21-204.

Whatever kind of cable is used, be sure the connectors are properly installed. An improperly attached shield will seriously degrade shielding effectiveness. With double-shielded and triaxial cables, both shields should be attached to the connector shell at both ends of each cable run. Assembly instructions for UHF, N, and BNC connectors can be found in both the ARRL Handbook and Antenna Book.

For sealing joints of shielded enclosures, the 3M company has two products that are hard to beat for effectiveness and ease of application. They are copper foil tapes with conductive adhesives, especially designed for RFI shielding. Type X-1181 is a smooth tape, and type X-1245 is embossed with a grid pattern for more reliable electrical contact with the surface on which it is applied. Both are available in widths from 6 to 25 mm (1/4 to 1 inch). Shielding efficiency of up to –65 dB is claimed by 3M, depending on the type of metal the tape is applied to. If desired, it is possible to solder to the tape without damaging it.

I have applied this tape to the edges of all shield enclosures in my equipment, to the seams of lowpass filter boxes, and over the edges of coax connectors. The same piece has been removed and re-applied on my linear amplifier cover shield several times with no apparent loss of adhesion. If the metal surface is clean to begin with, the adhesion is excellent. This type of tape may also be spirally wound over a length of conventional single shielded coax to obtain improved shielding efficiency. Each turn should overlap the previous turn by half the width of the tape, and the tape should extend over the shell of the connector at each end.

ham radio

june 1978
Cushcraft engineers have incorporated more than 30 years of design experience into the best 3 band HF beam available today. ATB-34 has superb performance with three active elements on each band, the convenience of easy assembly and modest dimensions. Value through heavy duty all aluminum construction and a price complete with 1-1 balun.

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

**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Gain</td>
<td>7.5 dBd</td>
</tr>
<tr>
<td>F/B Ratio</td>
<td>30 dB</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.5-1</td>
</tr>
<tr>
<td>Power Handling</td>
<td>2000 Watts PEP</td>
</tr>
<tr>
<td>Boom Length/ Dia</td>
<td>18' x 2 1/8&quot;</td>
</tr>
<tr>
<td>Longest Element</td>
<td>32'&quot;</td>
</tr>
<tr>
<td>Turning Radius</td>
<td>18'9&quot;</td>
</tr>
<tr>
<td>Wind SFC</td>
<td>5.4 Sq Ft.</td>
</tr>
<tr>
<td>Weight</td>
<td>42 Lbs.</td>
</tr>
<tr>
<td>Wind Survival</td>
<td>90 MPH.</td>
</tr>
<tr>
<td>Complete UPS Shippable</td>
<td></td>
</tr>
<tr>
<td>No Extras to Buy</td>
<td></td>
</tr>
<tr>
<td>In Stock with Distributors</td>
<td></td>
</tr>
</tbody>
</table>

**UPS SHIPPABLE**

**COMPLETE**

**NO EXTRAS TO BUY**

**IN STOCK WITH DISTRIBUTORS WORLDWIDE**
HF VERTICALS BY CUSHCRAFT

Cushcraft's new multiband vertical antenna systems have been optimized for wide operating bandwidth and provide the low angle of radiation which is essential for long-haul DX communications on the high-frequency amateur bands. The high Q traps which were designed especially for these verticals use large diameter enameled copper wire and solid aluminum air-dielectric capacitors; the trap forms are manufactured from filament-wound fiberglass for minimum dielectric loss and high structural strength. High strength 6063-T632 aluminum tubing with 0.056" (1.5 mm) walls is used for the vertical radiator. The massive 2 inch (50 mm) OD double-walled base section and heavy-duty phenolic base insulator ensure long life and durability. For maximum performance with limited space, choose a Cushcraft multiband vertical; all models may be roof or ground mounted on a 1 1/2" - 1 1/4" (32 - 48 mm) mast.

ATV-3 Cushcraft's ATV-3 multiband vertical provides low VSWR operation for both SSB and CW on 10, 15, and 20 meters. Matched to 50 ohms, built-in connectors mates with standard PL-259. Stainless-steel hardware is used for all electrical connections. The ATV-3 is a compact 166 inches (4.2 meters) tall. Rated at 2000 watts PEP.

ATV-4 The Cushcraft ATV-4 four-band vertical antenna has been optimized for wide operating bandwidth on 10, 15, 20, and 40 meters. SWR is less than 2.1 over the CW and SSB segments of 10, 15, and 20. The 2:1 SWR bandwidth on 40 meters is approximately 240 kHz, may be quickly and easily adjusted to favor any part of the band. Coaxial fitting takes 50 ohm transmission line with PL-259 connector. Overall height: 233 inches (5.9 meters). Rated at 2000 watts PEP.

ATV-5 The ATV-5 trapped vertical antenna system has been engineered for five-band operation on 80 through 10 meters. The high Q traps are carefully optimized for wide operating bandwidth: 2:1 SWR bandwidth with 50 ohm feedline is 1 MHz on 10 meters, more than 500 kHz on 15 and 20 meters, 160 kHz on 40 meters, and 75 kHz on 80 meters. Instructions are provided for adjusting resonance to your preferred part of the band. CW or SSB. Built-in coaxial connector takes PL-259. Nominal height: 293 inches (7.4 meters). Rated at 2000 watts PEP on all bands.

THE ANTENNA COMPANY
IN STOCK WITH DEALERS WORLDWIDE
P.O. BOX 4680, MANCHESTER, NH 03108

June 1978
simple and effective vertical antenna for portable communications

How to build a simple vertical antenna mount that can be set up quickly for emergency radio communications

One of the important aspects of amateur radio is the provision for efficient and timely communications in emergency or disaster situations. Having been a ham for several years I have found it interesting that, in the various ham-oriented magazines, there is substantial coverage given for proper procedures to follow during disaster or emergency communications but little mention or suggestion for effective and simple antenna systems. The following presents an idea which fulfills both the "simple" as well as "effective" aspects of an emergency antenna set-up and is easy and inexpensive to make. The secret to success is in the use of a vertical antenna (for the bands you intend to operate) with ground radials, and a homebrew base section which mounts in the spare tire from your vehicle (see fig. 1).

construction

The materials required to build the base section are a short length of mast or pipe and a front wheel hub that will bolt into your vehicle’s spare tire (the wheel hub can be obtained from a local junk yard for a few dollars). You will also need a set of lug nuts that will fit the bolts on the hub.

The outside diameter of the mast should be as close to the inside diameter of the outside grease-seal surface of the hub as possible to make it easier to position the mast perpendicular to the hub. The mast must be welded to the hub.

Clean the hub of all oil or grease. Place it on a hard surface (that will not burn) with the lug-bolts facing up, stand the mast in the hub, and weld the mast and hub together as pictured in fig. 2. Be sure to position the mast perpendicular to the hub so the antenna will be straight and not tilted to one side or the other.

field use

To use the antenna set-up for emergency or portable operation (such as Field Day or a camping trip)

By John S. Jolly, WA7NW L, 1840 North 64th Lane, Phoenix, Arizona 85035

fig. 1. Portable vertical antenna mount consists of a junk-yard hub bolted to the spare tire from your car. In high wind conditions you may want to weight the tire down with rocks, but in most cases this isn’t necessary. Construction of the hub section is shown in fig. 2.

all you need to do is remove the spare tire from your automobile, bolt in the base-section, lay the spare on the ground so the mast points up, and mount the antenna on the mast. If the vertical leans to one side, remove some dirt from under the high side of the tire or place some dirt, rocks, or a board under the low side to correct it. If you wish, you can place several
fig. 2. Stub mast for the portable antenna base consists of a front hub from the junkyard which fits your car, and a short steel mast which is welded to the hub. The outside diameter of the short mast should be very close to the inside diameter of the hub's grease-seal surface so the mast is perpendicular to the stub.

The stub mast for the portable antenna base is made from a hub and a short steel mast welded to it. It is designed to be portable and effective for use when conditions necessitate it. In addition to emergency and portable use, this setup could be used by those hams living in apartments or townhouses which forbid permanent fixture on their roofs.

 cleanup tips for amateur equipment

Being in a position that would be considered enviable among some amateur radio operators (this was written during my fifth year in the R.L. Drake Company Customer Service Department; I now work for ETO), I've been able to pick up on some tips and hints on routine maintenance for amateur equipment. Even though I work for one of the manufacturers, don't wrinkle your nose and flip the page in favor of the ads on the latest offerings from your local dealer. What I'm going to talk about is directly applicable to any amateur equipment.

The item I want to deal with is cleaning the exterior of your gear. The benefits here are numerous; you can operate without having an air-sick bag handy, most technicians would rather spend an hour giving the gear a little extra tweaking instead of cleaning it, and it keeps the wife from nagging you about operating a home for wayward cockroaches.

For those of you who smoke, the gear really gets coated with tobacco stains in a hurry. The primary reason for this fact is that most of us get so wrapped up in a hot contest that we wind up with two cigarettes between the lips and three burning in the ashtray without realizing it. In time, the panel markings get dim and blurred and you find yourself shading the vfo with one hand while squinting your eyes trying to read the numbers and keying with the other.

There are only two cures for this condition that I know of. One is to stop smoking (if you have the willpower — I don't), the other is a couple of products called Sani-Wax and Fantastik along with about two hours work. Even if you decide to quit smoking, you still have the gear to clean up or trade in, and clean equipment almost always brings a few extra bucks when you trade.

Sani-Wax is a white liquid that comes in a handy-dandy plastic quart container and retails for a dollar ninety-nine in my neck of the woods. The things it does for metal panels and cabinet borders is magnificent. It's the only product I've used that will cut through smoke, grease, oil, and coffee stains while leaving a nice shine behind. The best part is that it goes on easy and wipes off easier.

Fantastik is a spray cleaner from Texize Chemicals Company that will totally fascinate you with what it does for meters, vfo dials and windows, and especially knobs. It knocks the skin oils and accumulated dirt out of the little grooves in those plastic knobs like crazy and it doesn't scratch or discolor them. An old toothbrush makes the job easier and a lot faster. Just make sure you get it back in the rack before your mother-in-law shows up for her weekly overnight visit.

A word of caution before you start. It's a good idea to remove all knobs before beginning and to mark down what position your knobs are in BEFORE removing them. A lot of the controls, particularly bfo, audi/rf gain, passband tuning, and veniers, don't have flatted or keyed shafts to realign the pointers.

If you can't find Fantastik at your local supermarket or electronics surplus store, try writing to the Consumer Relations Department, Texize Chemicals Company — Division of Morton-Norwich Products, Inc., Greenville, South Carolina 29602. They can put you hot on the heels of a local distributor. The people at Sani-Wax can be contacted by writing to Roger Solem, Market Mechanics, 1900 East Randoll Mill Road, Suite 106, Arlington, Texas 76011.

By using Sani-Wax on all the metal parts, and Fantastik on all the plastic parts, your amateur equipment will shine like new with a minimum of work.

William D. Fisher

june 1978
The age of tone control has come to Amateur Radio. What better way to utilize our ever diminishing resource of frequency spectrum? Sub-audible tone control allows several repeaters to share the same channel with minimal geographic separation. It allows protection from intermod and interference for repeaters, remote base stations, and autopatches. It even allows silent monitoring of our crowded simplex channels.

We make the most reliable and complete line of tone products available. All are totally immune to RF, use plug-in, field replaceable, frequency determining elements for low cost and the most accurate and stable frequency control possible. Our impeccable 1 day delivery is unmatched in the industry and you are protected by a full 1 year warranty when our products are returned to the factory for repair. Isn't it time for you to get into the New Age of tone control?
TS-1  Sub-Audible Encoder-Decoder • Microminiature in size: 1.25” x 2.0” x 0.65” • Encodes and decodes simultaneously • $59.95 complete with K-1 element.

TS-1JR  Sub-Audible Encoder-Decoder • Microminiature version of the TS-1 measuring just 1.0” x 1.25” x 0.65”, for hand-held units • $79.95 complete with K-1 element.

ME-3  Sub-Audible Encoder • Microminiature in size, measures .45” x 1.1” x .6” • Instant start-up • $29.95 complete with K-1 element.

TE-8  Eight-Tone Sub-Audible Encoder • Measures 2.6” x 2.0” x .7” • Frequency selection made by either a pull to ground or to supply • $69.95 with 8 K-1 elements.

PE-2  Two-Tone Sequential Encoder for paging • Two call unit • Measures 1.25” x 2.0” x .65” • $49.95 with 2 K-2 elements.

SD-1  Two-Tone Sequential Decoder • Frequency range is 268.5 - 2109.4 Hz • Measures 1.2” x 1.67” x .65” • Momentary output for horn relay, latched output for call light and receiver muting built-in • $59.95 with 2 K-2 elements.

TE-12  Twelve-Tone Sub-Audible or Burst-Tone Encoder • Frequency range is 67.0 - 263.0 Hz sub-audible or 1650 - 4200 Hz burst-tone • Measures 4.25” x 2.5” x 1.5” • $79.95 with 12 K-1 elements.

ST-1  Burst-Tone Encoder • Measures .95” x .5” x .5” plus K-1 measurements • Frequency range is 1650 – 4200 Hz • $29.95 with K-1 element.

COMMUNICATIONS SPECIALISTS
426 W. Tait Ave., Orange, CA 92667
(714) 998-3021
pi network design
for high-frequency power amplifiers

A complete discussion of pi and pi-L networks with computer derived component values for a wide range of operating conditions

The design of rf power amplifiers has always fascinated the typical radio amateur, and it remains one of the few fields in which a person of modest technical capability can still actively participate. Although the number of home-built transmitters has steadily diminished as more commercial companies have entered the market, many amateurs still like to design and build their own final amplifier. The information contained in this article should greatly assist those so inclined. Many interesting comparisons will be presented between amplifiers running at different power levels as well as pertinent computer-derived data for the proper selection of component values.

With single sideband and its legal 2-kW PEP maximum input power, certain problems crop up which many amateurs overlook or are unable to handle. This is because the operator wants to run the amplifier at one power level for ssb and another for CW. The problems are compounded when the operator also wants to run RTTY, which is 100 per cent keydown continuous-carrier operation.

There is also a growing tendency to build power amplifiers with higher plate voltages than were common a few years ago. Part of this trend is due to the fact that the newer power tubes provide maximum performance at high plate voltages. Many of the pi-network design charts previously published have not been extended to include these higher operating voltages.

**pi networks**

The pi network is so named because of its resemblance to the Greek letter pi as shown in fig. 1. The same network in its electrical form with input and output impedances is shown in fig. 2. Since most amateurs use 50-ohm coaxial transmission line, the output load impedance of the pi network is usually 50 ohms.

When the pi network is used in a power amplifier, the circuit looks like that shown in fig. 3. The antenna provides the output load impedance, $Z_L$, and the power tube provides the input load impedance, $Z_p$. Since the plate load impedance usually falls into the range from 1200 to 5000 ohms, the pi network transforms the high impedance of the vacuum tube into the 50-ohm antenna load. It performs this job quite efficiently, and with predictable results.

Actually, the pi network is a basic form of a three-pole lowpass filter. With proper care in design it will attenuate the second harmonic by 35 dB or more. This would be for a loaded $Q$ of 12; if the $Q$ is doubled, attenuation is increased by approximately 6 dB.

The pi-L network shown in fig. 4 consists of a standard pi network with an additional inductor. Since the pi-L network is a four-pole lowpass filter, second harmonic attenuation is increased to approximately 50 dB. This is particularly important if you want maximum suppression of TVI.

In addition to increased harmonic suppression, the pi-L network offers greater bandwidth for a given variation in operating $Q$, requires less output capacitance, and is able to operate efficiently with lower $Q$ at very high plate load impedances. These advantages will become more apparent later.

By Irvin M. Hoff, W6FFC (reprinted from the September, 1972, issue of *ham radio*)
The dc plate resistance of a vacuum tube, at a given input power level, can be calculated with Ohm's law: \( R = \frac{E}{I} \), where \( E \) is the dc plate voltage and \( I \) is the dc plate current. However, since we are dealing with an ac circuit, this is of little value. What we need to know is the plate load impedance. This is given approximately by the following equation which has been derived from the complex functions of a vacuum tube operating in class B.

\[
Z_p = \frac{E}{1.57I} \tag{1}
\]

where \( Z_p \) is the plate load impedance, \( I \) is the indicated plate current, and \( E \) is the dc plate voltage.

When the vacuum tube is operated in class C, as for CW, the plate load impedance is approximated by

\[
Z_p = \frac{E}{2I} \tag{2}
\]

If you are using a linear amplifier that runs with very high idling current, and approaches class A, the following approximation for plate load impedance would be more appropriate.

\[
Z_p = \frac{E}{1.3I} \tag{3}
\]

Zero-bias grounded-grid linears are usually thought of as being class B, but there is no hard and fast rule in this regard. A number of articles has been written on this subject, and you are likely to have already formed some opinions of your own.

Consider the case of a class-B rf power amplifier with a 2100-volt plate power supply and indicated plate current of 476 mA (1kW input). As calculated from eq. 2, the plate load impedance is 2800 ohms:

\[
Z_p = \frac{2100}{1.57 \times 0.476} = 2800 \text{ ohms}
\]

Typical plate load impedances for various power levels and different operating voltages and currents are shown in table 1. It can be seen from this data that the plate load impedance rises to very high levels when the plate voltage is increased above 4000 volts. More amateurs than might be expected use 4000 to 6000 volt power supplies, and many of the associated problems have not been adequately discussed in the past.

**circuit Q**

The letter \( Q \) stands for quality factor, and is used to describe, in simple numerical terms, the efficiency and performance of capacitors and inductors. Actually, there are two types of \( Q - \) loaded \( Q \) and unloaded \( Q \). The unloaded \( Q \) is the inherent quality factor of the component itself; loaded \( Q \) is the quality factor of the component when it is used (and loaded down) by the circuit.

The unloaded \( Q \) of a component is given by

\[
Q_u = Q(\text{unloaded}) = \frac{X}{r} \tag{4}
\]

where \( X \) is reactance and \( r \) is ac resistance. The unloaded \( Q \) of a high-quality capacitor might be 1000 or more, and a silver-plated inductor might have an unloaded \( Q \) of more than 500.

The loaded \( Q \) of a pi network is usually on the order of 10 to 20 for maximum harmonic attenuation, and is given by:

\[
Q_l = Q(\text{loaded}) = \sqrt{\frac{Z_p - Z_L}{Z_L}} \tag{5}
\]

where \( Z_p \) is the input impedance to the network, and \( Z_L \) is the output impedance.

When designing pi networks a value of loaded \( Q \) is chosen on the basis of harmonic attenuation, and is used in the design equations to determine the inductance and capacitance values for a given operating frequency.

**L-networks**

A typical step-down L-network is shown in fig. 5. This network is used to transform its input impedance to a lower output impedance. The \( Q \) of this circuit is entirely dependent upon the ratio of the input and output impedances as given in eq. 5.

For example, if the input impedance to an L-network is 2500 ohms, and the output impedance is 50 ohms, the loaded \( Q \) of the network is 7:

\[
Q_l = Q(\text{loaded}) = \sqrt{\frac{2500 - 50}{50}} = \sqrt{49} = 7
\]

However, a loaded \( Q \) of 7 is much too low for good harmonic suppression. To determine the L-network input impedance required to provide a desired value of loaded \( Q \), eq. 5 is rearranged as shown below:

\[
Z_p = Z_L(Q_l^2 + 1) \tag{6}
\]
For example, with an output load impedance of 50 ohms, and a desired loaded Q of 12 (for good harmonic suppression), the required input impedance is 7250 ohms. This is very restrictive and does not allow the designer sufficient latitude. So, although the L network is extremely efficient (98 per cent, typical), a pi network is usually used in transmitter output circuits.

![fig. 3. Pi network used in the output of an rf power amplifier is coupled to the power tube through a dc blocking capacitor (C3). C1 is the tuning capacitor, C2 is the loading capacitor, and L1 is the tank inductor.](image)

**pi network analysis**

You can think of the pi network as being two L networks in tandem as shown in [fig. 6](image). The first L network is a step-down type while the second L network is reversed for impedance step up. As an example, consider the case where the input impedance to the dissected pi network in [fig. 6](image) is 2900 ohms. With a Q of 12, the first L network would step the input impedance down to 20 ohms. This is often called the virtual impedance. The second L network would then be designed to raise this virtual impedance of 20 ohms to 50 ohms to match the antenna. The Q of the second section would be quite low, on the order of 1.5.

As the input impedance is increased with Q held constant, the virtual impedance increases, and when the virtual impedance is equal to the desired output impedance, the pi network reverts to an L network. For example, with a plate load impedance of 7250 ohms and a Q of 12, the virtual impedance is 50 ohms. This is the maximum possible impedance transformation for a Q of 12 and an output impedance of 50 ohms.

Normally, about 70 per cent of the maximum possible impedance transformation is used in a practical circuit. For a Q of 12 and an antenna load of 50 ohms, this would represent a plate load resistance of 5075 ohms. If the plate load resistance in an rf power amplifier is higher than 5075 ohms, a Q of more than 12 is required to retain the same level of harmonic suppression. This problem is circumvented by the use of the pi-L network, as discussed below.

**pi-L network design**

Another L network may be added to the pi network as shown in [fig. 7](image) for additional harmonic attenuation. In actual practice C2 and C3 are combined into one capacitor so the circuit used in the transmitter is like that shown in [fig. 4](image).

In the pi-L network, the input pi section transforms the plate load impedance to some lower figure, such as 300 ohms; this is often called the image impedance. The final L network transforms the image impedance down to 50 ohms to match the antenna.

From eq. 6 it can be seen that with an image impedance of 300 ohms and a Q of 12, the pi network has a maximum transformation of 43500 ohms.

![fig. 5. Typical step-down L network is highly efficient but very restrictive as far as acceptable Q is concerned.](image)

Using 70 per cent of the maximum possible transformation as a practical maximum, as noted before, results in a maximum practical input impedance of 30500 ohms with a Q of 12. This is far in excess of what you will ever need in a power amplifier designed for amateur service.

The image impedance usually falls in the range between 200 and 400 ohms. It is selected for good harmonic attenuation, as well as balance in the T section of the pi-L network, and reasonable component values for the capacitors and inductors. If the image impedance is too high, the tuning capacitor (C1) will be too small on 10 and 15 meters, and the two inductors will be very large. Large inductors, of course, increase circulating currents which result in higher losses due to heat.

**Q vs frequency**

The loaded Q of a pi network (or any tank circuit, for that matter) is equal to its parallel-resonant impedance divided by either the inductive or capacitive reactance of the network.

\[
Q_p = \frac{Z_p}{X_p}\tag{8}
\]

The reactance of any inductor is directly proportional to frequency, increasing as the frequency in-
creases. Therefore, from eq. 8 it can be seen that if a particular inductor is used, loaded Q will vary inversely with frequency. As the frequency is lowered, for example, Q is raised a proportionate amount. With this in mind, it is easy to determine the Q for a given network on a different frequency from the following formula:

\[ \frac{f_1}{f_2} = \frac{Q_2}{Q_1} \]  (9)

Where \( f_1 \) and \( Q_1 \) are the frequency and Q at one frequency, and \( f_2 \) and \( Q_2 \) are at the second, different frequency.

For example, if an 80-meter pi network has a Q of 12 at 4.0 MHz, what is the Q at 3.5 MHz?

\[ \frac{4.0}{3.5} = \frac{Q_2}{12} \]  
\[ Q_2 = 13.7 \]

Although the actual loaded Q is somewhat dependent upon the value of plate load impedance used in the circuit, this approximation is accurate within 1 per cent. In the above example, with a plate load impedance of 3000 ohms, \( Q_2 \) would actually be 13.84.

![fig. 6. Pi network is basically two L networks in tandem.](image)

Since the Q of the network goes up as the frequency goes down, it's a good idea to design the pi network for the highest frequency that is to be used.2 With this approach, when the same inductor is used at lower frequencies within an amateur band, Q increases somewhat, improving harmonic attenuation.

Table 2 shows how Q varies as a pi network is retuned to a different frequency (same inductor). Table 2A shows a pi network designed for 4.0 MHz which is retuned to 3.5 MHz; Q increases from 12 at 4.0 MHz to 13.8 at 3.5 MHz. The values of the tuning and loading capacitors are shown for comparison.

Table 2B shows the case where a pi network is designed for 3.5 MHz with a Q of 12 and retuned to 4.0 MHz (same inductor). The Q drops to 10.4, well below the selected minimum of 12.

network efficiency

As the loaded Q of a network is increased, efficiency goes down because of higher circulating currents and higher losses in the components. Approximate efficiency is given by

\[ \text{efficiency} = 100 \left( 1 - \frac{Q_o}{Q_u} \right) \]  (10)

where \( Q_o \) is the loaded circuit Q and \( Q_u \) is the unloaded component Q. The graph in fig. 8 shows that efficiency is a linear function of loaded Q. For minimum loss, the loaded Q should be as low as convenient, while still providing adequate harmonic attenuation. This figure has arbitrarily been chosen as 12.

When the pi network is designed, the minimum Q of 12 can only be obtained at the upper frequency of each amateur band, and then only at the maximum input power level. For other frequencies or lower input powers, the loaded Q is higher than 12.

pi network design

Usually, when you are trying to design a pi network for your transmitter or linear amplifier, you must refer to graphs shown in reference books such as the ARRL “Radio Amateur’s Handbook.”3 These graphs are often somewhat confusing because you must first determine the plate load impedance, select a value of Q and then find the reactance of each of the components. Then you must locate yet another graph to convert these reactance values into actual values of inductance and capacitance.

Few of these charts and graphs are extended above plate load impedances of 5000 ohms, and most give vague reference to the fact that if the plate load impedance is greater than about 5000 ohms, the Q should be increased.

The charts in table 3 and table 4 are computer derived and offer all the required information to build
a practical pi network. The pi networks in table 3 for plate load impedances above 5000 ohms have increasing Q so that the transformation ratio never exceeds the 70 per cent maximum. In addition, the inductors chosen for each of these designs are calculated for the highest frequency in the band.

The Q of the network at the highest frequency is 12 except when the plate load impedance is greater than 5075 ohms. The chart shows the capacitance values required to resonate the network to the lowest frequency in the band (maximum capacitance), as well as the operating Q at that frequency. In table 4, the image impedance (R3) at the lower frequency is also given.

You will notice that the Q of the pi-L network does not go up as fast when frequency is lowered as it does with the pi network. Also, the Q remains the same for the pi-L for higher plate loads.

In both table 3 and table 4 the values for ten meters are for 29.7 MHz, the highest frequency in the band. This is because you need to know minimum capacitance values to reach this frequency in a five-band transmitter.

**effect of swr**

A standing-wave ratio of 4:1 will affect the capacitance required at C1 by ±10 per cent and at C2 by ±25 per cent. If the swr is caused by capacitive reactance, the tuning and loading capacitors are on the smaller side, and if the swr is the result of inductive reactance, the loading and tuning capacitors must be larger. Keep this in mind when selecting component values for a transmitter so you will be able to compensate for an antenna that is not exactly matched to your transmission line.

**ssb and CW operation**

Table 1 shows that for a given plate supply voltage, the plate load impedance is inversely proportional to the input power level. That is, 1000 watts at 2800 volts represents 5000 ohms, while 2 kW at the same supply voltage is 2500 ohms. Pi network values for a Q of 12 for each of these impedances are shown below (capacitance in pF, inductance in μH):

<table>
<thead>
<tr>
<th>f (MHz)</th>
<th>R1</th>
<th>C1</th>
<th>L1</th>
<th>C2</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>250</td>
<td>191</td>
<td>9.18</td>
<td>1097</td>
<td>12.0</td>
</tr>
<tr>
<td>4.0</td>
<td>500</td>
<td>95</td>
<td>17.38</td>
<td>534</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Note that the required inductance values are quite different.

As an example of what you may expect under actual operating conditions, consider the 2-kW design above (9.18 μH inductor). At 3.5 MHz with 2 kW input, C1 is 252 pF, C2 is 1536 pF, and Q is 13.8; not too bad. However, if the input power is reduced to 1000 watts at 3.5 MHz, C1 is 246 pF, C2 is 2287 pF, and Q reaches 27.0, increasing the circulating currents and heat losses in the network.

These figures point out the problems you can run into when you use the same operating voltage and same inductor at different power levels. Fortunately, there are several things which the designer can do to minimize these problems.

**variable inductors**

There are various variable rotary inductors available on the market which allow the operator to select the proper inductance for 1000 watts CW at the bottom of a band as well as 2000 watts PEP ssb at the top. When compared to fixed inductors, these variable units are fairly expensive, and require a turns counter, further increasing cost. However, they are available in various inductance and current-carrying abilities, so they encompass practically any design requirement. Also, using a variable inductor eliminates the need for a bandswitch.

**bandswitch**

The primary purpose of the bandswitch is to change the tap on the tank-circuit inductor to one better suited for the band in use. However, there are several other important functions for the bandswitch:

1. Used to switch input networks to match the 50-ohm output of the exciter.
2. Changes taps on the second inductor in a pi-L network.

3. Sometimes used to switch in additional tuning/loading capacitance on the 80-meter band so smaller variable capacitors may be used in the circuit.

Since you may wish to use a bandswitch in your power amplifier because of these additional uses, the variable inductor may lose some of its appeal.

In a novel approach to this problem a ten-position bandswitch has been used in one design to select different amounts of inductance for the CW and ssb ends of the band. However, the additional switch leads and the large number of inductor taps make this approach seem impractical for the typical home builder.

Table 5 compares the performance of 1000- and 2000-watt transmitters, as well as a 2000-watt transmitter run at 1000 watts input. In the latter case some additional losses are evident, but they're hardly large enough to cause much excitement. The same comparison shows that the 2-kW transmitter with a Q of 12 at 4 MHz, has a Q of 16.2 at 3.0 MHz. However, considerably more capacitance is required at C1 and C2. The pi-L network will alleviate this problem to some extent, as the Q of the pi-L does not increase as rapidly as frequency is lowered as does with the straight pi network.

Since the 80-meter band is proportionally wider than any other high-frequency amateur band, there is some merit in using an extra bandswitch position for 80 meters. While I have shown previously that this is not required, it would be beneficial because you could select the 75-meter inductor for 4 MHz and 2-kW input, with the 80-meter inductor chosen for 3.7 MHz and 1-kW input.

The primary advantage in such an arrangement would be the ability to add a second input network to match the exciter. Since the input networks have low Q (typically 2 to 3), they are quite broadband and are usually set to a frequency in the middle of the band. However, it would be literally impossible for the same input network to work equally well on both 3.5 and 4.0 MHz, so it would be desirable to have one for each end of the band. From a practical standpoint, this might not be necessary because most operators have ample drive on CW if they are able to push the final to 2000 watts PEP on ssb.

**Power Supply Voltage**

Since, as I just mentioned, most exciters have more than ample drive for 1000-watts input on CW if they are capable of driving the final to 2000-watts PEP on ssb, it's desirable to include some sort of automatic swamping so the exciter can be run in a normal manner for both ssb and CW. Lowering the plate supply voltage on the final-amplifier tubes decreases the plate load impedance required for a given input power level, therefore requiring more drive to reach this input power level.

<table>
<thead>
<tr>
<th>Table 2. Variations in Q as the resonant frequency of the pi network is changed (same inductor).</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>A. Decreasing</td>
</tr>
<tr>
<td>frequency</td>
</tr>
<tr>
<td>B. Increasing</td>
</tr>
<tr>
<td>frequency</td>
</tr>
</tbody>
</table>

For example, if it takes 70 watts drive with 3000 volts on the plate to reach 2000-watts input, then, depending upon the tubes used, it would take 70 to 80 watts drive to reach 1000-watts input with a substantially lower plate supply voltage. At the same time, the voltage-current relationship has changed, lowering the plate load impedance to something much closer to that which would give a Q of 12 with the same inductor.

Also, the plate voltage must be lowered to retain the same Q with the same inductor at the same operating frequency. This voltage reduction can be determined from

\[
E2 = 0.71 \times (E1)
\]

where \( E1 \) is the original plate voltage for 2000-watts input and \( E2 \) is the lowered plate voltage for 1000-watts input. For example, a plate supply of 2800 volts for 2000-watts input must be changed to 2000 volts for 1000 watts input at the same operating frequency and circuit Q. Actually, on 3.5 MHz, this would be perhaps 1800 to 1900 volts to provide a Q of 12 at 3.5 MHz (1000 watts input) using a 2-kW transmitter designed for a Q of 12 at 4.0 MHz. However, it is unlikely that you could get 1000-watts input at this plate voltage, even with 100 watts drive on a cathode-driven grounded-grid amplifier.

**Tuning Capacitance**

Table 3 and Table 4 show that the C1 tuning capacitance becomes quite small on 10 and 15 meters as the plate load impedance is raised. A typical 2000-watt transmitter might use 2800 volts on the plate,
### Table 3A: Pi network component values for matching a 50-ohm antenna load. Values have been chosen for a Q of 12 at the top edge of each amateur band. For plate load impedances greater than 5000 ohms, the Q of the network has been adjusted upward to compensate for the maximum transformation ratio, as discussed in the text. RI is the plate load impedance.

<table>
<thead>
<tr>
<th>RI</th>
<th>F</th>
<th>C</th>
<th>I4LT</th>
<th>R1</th>
<th>F</th>
<th>C</th>
<th>I4AA</th>
<th>R1</th>
<th>F</th>
<th>C</th>
<th>I41P</th>
<th>R1</th>
<th>F</th>
<th>C</th>
<th>I4Rq</th>
</tr>
</thead>
<tbody>
<tr>
<td>3A</td>
<td>5.5</td>
<td>5147</td>
<td>6.9k</td>
<td>6244</td>
<td>5.8</td>
<td>15.8</td>
<td>13.8</td>
<td>15.5</td>
<td>5.5</td>
<td>457</td>
<td>5.58</td>
<td>2285</td>
<td>50</td>
<td>15.5</td>
<td>5.5</td>
</tr>
<tr>
<td>7A</td>
<td>7.4</td>
<td>1046</td>
<td>20.7</td>
<td>1170</td>
<td>7</td>
<td>109</td>
<td>10.9</td>
<td>11.2</td>
<td>7.4</td>
<td>674</td>
<td>7.79</td>
<td>4616</td>
<td>70</td>
<td>11.4</td>
<td>7.4</td>
</tr>
<tr>
<td>10A</td>
<td>10.4</td>
<td>1510</td>
<td>20.7</td>
<td>1450</td>
<td>10.4</td>
<td>180</td>
<td>12.3</td>
<td>12.5</td>
<td>10.4</td>
<td>1510</td>
<td>10.83</td>
<td>10.51</td>
<td>100</td>
<td>12.5</td>
<td>10.4</td>
</tr>
<tr>
<td>14A</td>
<td>14.0</td>
<td>2110</td>
<td>20.7</td>
<td>1870</td>
<td>14.0</td>
<td>180</td>
<td>12.5</td>
<td>12.6</td>
<td>14.0</td>
<td>2110</td>
<td>18.20</td>
<td>12.92</td>
<td>170</td>
<td>13.5</td>
<td>14.0</td>
</tr>
<tr>
<td>21A</td>
<td>21.0</td>
<td>3180</td>
<td>20.7</td>
<td>2740</td>
<td>21.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>21.0</td>
<td>3180</td>
<td>27.69</td>
<td>13.39</td>
<td>240</td>
<td>14.0</td>
<td>21.0</td>
</tr>
<tr>
<td>29.7</td>
<td>29.7</td>
<td>4680</td>
<td>20.7</td>
<td>3950</td>
<td>29.7</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>29.7</td>
<td>4680</td>
<td>39.26</td>
<td>13.87</td>
<td>300</td>
<td>14.0</td>
<td>29.7</td>
</tr>
<tr>
<td>33.5</td>
<td>29.7</td>
<td>5280</td>
<td>20.7</td>
<td>4500</td>
<td>33.5</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>33.5</td>
<td>5280</td>
<td>45.90</td>
<td>14.36</td>
<td>350</td>
<td>14.0</td>
<td>33.5</td>
</tr>
<tr>
<td>37.0</td>
<td>37.0</td>
<td>5880</td>
<td>20.7</td>
<td>5050</td>
<td>37.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>37.0</td>
<td>5880</td>
<td>51.54</td>
<td>14.85</td>
<td>400</td>
<td>14.0</td>
<td>37.0</td>
</tr>
<tr>
<td>41.0</td>
<td>41.0</td>
<td>6480</td>
<td>20.7</td>
<td>5500</td>
<td>41.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>41.0</td>
<td>6480</td>
<td>54.18</td>
<td>15.34</td>
<td>450</td>
<td>14.0</td>
<td>41.0</td>
</tr>
<tr>
<td>47.0</td>
<td>47.0</td>
<td>7080</td>
<td>20.7</td>
<td>6050</td>
<td>47.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>47.0</td>
<td>7080</td>
<td>60.82</td>
<td>15.83</td>
<td>500</td>
<td>14.0</td>
<td>47.0</td>
</tr>
<tr>
<td>53.0</td>
<td>53.0</td>
<td>7680</td>
<td>20.7</td>
<td>6500</td>
<td>53.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>53.0</td>
<td>7680</td>
<td>63.46</td>
<td>16.32</td>
<td>550</td>
<td>14.0</td>
<td>53.0</td>
</tr>
<tr>
<td>59.0</td>
<td>59.0</td>
<td>8280</td>
<td>20.7</td>
<td>6950</td>
<td>59.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>59.0</td>
<td>8280</td>
<td>66.10</td>
<td>16.81</td>
<td>600</td>
<td>14.0</td>
<td>59.0</td>
</tr>
<tr>
<td>66.0</td>
<td>66.0</td>
<td>8880</td>
<td>20.7</td>
<td>7400</td>
<td>66.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>66.0</td>
<td>8880</td>
<td>68.74</td>
<td>17.30</td>
<td>650</td>
<td>14.0</td>
<td>66.0</td>
</tr>
<tr>
<td>74.0</td>
<td>74.0</td>
<td>9480</td>
<td>20.7</td>
<td>7850</td>
<td>74.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>74.0</td>
<td>9480</td>
<td>71.38</td>
<td>17.79</td>
<td>700</td>
<td>14.0</td>
<td>74.0</td>
</tr>
<tr>
<td>84.0</td>
<td>84.0</td>
<td>10080</td>
<td>20.7</td>
<td>8300</td>
<td>84.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>84.0</td>
<td>10080</td>
<td>74.02</td>
<td>18.28</td>
<td>750</td>
<td>14.0</td>
<td>84.0</td>
</tr>
<tr>
<td>95.0</td>
<td>95.0</td>
<td>10680</td>
<td>20.7</td>
<td>8750</td>
<td>95.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>95.0</td>
<td>10680</td>
<td>76.66</td>
<td>18.77</td>
<td>800</td>
<td>14.0</td>
<td>95.0</td>
</tr>
<tr>
<td>108.0</td>
<td>108.0</td>
<td>11280</td>
<td>20.7</td>
<td>9200</td>
<td>108.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>108.0</td>
<td>11280</td>
<td>79.30</td>
<td>19.26</td>
<td>850</td>
<td>14.0</td>
<td>108.0</td>
</tr>
<tr>
<td>124.0</td>
<td>124.0</td>
<td>12880</td>
<td>20.7</td>
<td>9650</td>
<td>124.0</td>
<td>180</td>
<td>12.5</td>
<td>12.5</td>
<td>124.0</td>
<td>12880</td>
<td>81.94</td>
<td>19.75</td>
<td>900</td>
<td>14.0</td>
<td>124.0</td>
</tr>
</tbody>
</table>

- **R1**: Plate load impedance.
- **R2**: 0 ohms.
- **RQ**: Power tube plate supply impedance.
- **C1**: Tuning capacitance.

Providing a plate load impedance of approximately 2500 ohms. This transmitter would require only 26 pF tuning capacitance to reach the top end of the 10-meter band.

Unfortunately, most modern rf power tubes designed for the 2000-watt level have output capacitances of under 10 pF — this leaves about 16 pF for tuning, including stray circuit capacitance. If you study the various air-variable capacitors available you will find that it is virtually impossible to find a variable capacitor that will provide the necessary spacing for this operating voltage as well as tune the capacitance range needed for both 10 and 80 meters. Also, you must keep in mind that 10% leeway should be provided to compensate for any swr on the transmission line.

As the plate load impedance increases, the situation becomes even more acute. A 1000-watt transmitter with a plate supply of 2800 volts has a plate load impedance of 5000 ohms — on ten meters this means the tuning capacitor C1 is a total of 13 pF. In this case you would probably have to delete C1 entirely from the circuit and let the capacitance of the power tube supply the necessary tuning capacitance. However, this is not practical.

Fortunately, there are several things you can do to help alleviate this situation. You can use a smaller capacitor and add fixed capacitance on 40 and 80 meters, or use two variable capacitors, switching in the larger one on the lower bands. The vacuum capacitor is another possibility because of its low minimum capacitance, often as low as 3 pF. You can also blunder ahead and use a too-large capacitor, allowing the Q to be higher than normal.
Oddly enough, each of these different techniques is currently being used in commercial amateur-band power amplifiers. The vacuum variable provides the best answer to this problem, but it is also the most expensive (by a wide margin). However, the vacuum variable has many advantages worth considering if you are more interested in performance than in total cost.

From table 6 you can see that the Q on ten meters goes up quite rapidly if too much capacitance is used at C1. One currently available commercial amplifier uses 2800 volts at 2-kW input (plate impedance, 2500 ohms). For ten meters this calls for an input capacitor of about 15 pF, after the output capacitance of the tubes has been subtracted. However, this amplifier uses two 20-150 pF capacitors in parallel which are tuned in tandem with a geared arrangement. Thus, their minimum capacitance is about 40 pF, plus 10 pF added by the power tubes, providing a minimum input capacitance of more than 50 pF without any allowance for strays.

Table 6 shows that this gives a minimum Q of 24.0 at the top end of the ten-meter band (around 25.5 at the bottom end). If the amplifier were used at 1000-watts input, the Q would be nearly 48 at the top band edge and over 50 at the bottom!

This amplifier would obviously lose substantial power output in the form of heat in the tank inductor, and proper tuning would be very critical. It would also have to be retuned more often as frequency was changed.

This design is what I call the blunder-ahead method. In my mind, it would have been relatively simple for the manufacturer to use only one of the two tuning capacitors on 10, 15, and 20 meters, switching in the second tuning capacitor on 40 and 80.

Another manufacturer does precisely this. He uses a dual-section capacitor — half is used for the three upper bands and the other half is added in parallel on 40 and 80 meters. This provides normal Q for 2000-watts input on 10 meters. It still gives Q in excess of 20 with 1000-watts input, but that's really not too bad. This tuning system gives more than twice the vernier of the other system since the maximum capacitance on 20 meters, for example, is 120 pF. On the previous amplifier there is 300 pF available, even on 20 meters. The unit with the lower capacitance is far easier to tune on the upper three bands.
<table>
<thead>
<tr>
<th>R1</th>
<th>F</th>
<th>C1</th>
<th>L1</th>
<th>C2</th>
<th>L2</th>
<th>R1</th>
<th>‘Q’</th>
<th>R1</th>
<th>F</th>
<th>C1</th>
<th>L1</th>
<th>C2</th>
<th>L2</th>
<th>R1</th>
<th>‘Q’</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>1.5</td>
<td>129</td>
<td>2.85</td>
<td>2119</td>
<td>4.45</td>
<td>241</td>
<td>58</td>
<td>13.4</td>
<td>4000</td>
<td>1.5</td>
<td>155</td>
<td>18.55</td>
<td>924</td>
<td>4.45</td>
<td>241</td>
</tr>
<tr>
<td>500</td>
<td>1.8</td>
<td>159</td>
<td>5.99</td>
<td>627</td>
<td>2.44</td>
<td>269</td>
<td>90</td>
<td>12.4</td>
<td>4000</td>
<td>1.8</td>
<td>85</td>
<td>18.16</td>
<td>415</td>
<td>2.44</td>
<td>269</td>
</tr>
<tr>
<td>500</td>
<td>2.4</td>
<td>178</td>
<td>1.23</td>
<td>572</td>
<td>1.42</td>
<td>299</td>
<td>122</td>
<td>12.2</td>
<td>4000</td>
<td>2.4</td>
<td>65</td>
<td>18.06</td>
<td>279</td>
<td>1.42</td>
<td>299</td>
</tr>
<tr>
<td>500</td>
<td>2.1</td>
<td>188</td>
<td>1.04</td>
<td>498</td>
<td>0.85</td>
<td>328</td>
<td>122</td>
<td>12.5</td>
<td>4000</td>
<td>2.1</td>
<td>45</td>
<td>21.08</td>
<td>194</td>
<td>0.85</td>
<td>328</td>
</tr>
<tr>
<td>500</td>
<td>2.9</td>
<td>187</td>
<td>0.85</td>
<td>491</td>
<td>0.68</td>
<td>368</td>
<td>122</td>
<td>12.8</td>
<td>4000</td>
<td>2.9</td>
<td>27</td>
<td>24.99</td>
<td>93</td>
<td>0.68</td>
<td>368</td>
</tr>
<tr>
<td>600</td>
<td>3.5</td>
<td>185</td>
<td>5.29</td>
<td>1965</td>
<td>4.45</td>
<td>241</td>
<td>58</td>
<td>13.4</td>
<td>4000</td>
<td>3.5</td>
<td>122</td>
<td>28.57</td>
<td>992</td>
<td>4.45</td>
<td>241</td>
</tr>
<tr>
<td>600</td>
<td>2.9</td>
<td>186</td>
<td>1.15</td>
<td>561</td>
<td>1.42</td>
<td>299</td>
<td>122</td>
<td>12.2</td>
<td>4000</td>
<td>2.9</td>
<td>65</td>
<td>18.06</td>
<td>279</td>
<td>1.42</td>
<td>299</td>
</tr>
<tr>
<td>600</td>
<td>3.5</td>
<td>186</td>
<td>1.04</td>
<td>489</td>
<td>0.85</td>
<td>328</td>
<td>122</td>
<td>12.5</td>
<td>4000</td>
<td>3.5</td>
<td>45</td>
<td>21.08</td>
<td>194</td>
<td>0.85</td>
<td>328</td>
</tr>
<tr>
<td>600</td>
<td>3.5</td>
<td>188</td>
<td>0.85</td>
<td>489</td>
<td>0.68</td>
<td>368</td>
<td>122</td>
<td>12.8</td>
<td>4000</td>
<td>3.5</td>
<td>27</td>
<td>24.99</td>
<td>93</td>
<td>0.68</td>
<td>368</td>
</tr>
<tr>
<td>700</td>
<td>3.5</td>
<td>270</td>
<td>3.74</td>
<td>1943</td>
<td>4.45</td>
<td>241</td>
<td>58</td>
<td>13.4</td>
<td>7000</td>
<td>3.5</td>
<td>111</td>
<td>22.71</td>
<td>764</td>
<td>4.45</td>
<td>241</td>
</tr>
<tr>
<td>700</td>
<td>3.5</td>
<td>248</td>
<td>2.87</td>
<td>693</td>
<td>2.44</td>
<td>269</td>
<td>90</td>
<td>12.4</td>
<td>7000</td>
<td>3.5</td>
<td>70</td>
<td>12.12</td>
<td>384</td>
<td>2.44</td>
<td>269</td>
</tr>
<tr>
<td>700</td>
<td>4.0</td>
<td>198</td>
<td>1.86</td>
<td>354</td>
<td>1.22</td>
<td>299</td>
<td>122</td>
<td>12.2</td>
<td>7000</td>
<td>4.0</td>
<td>40</td>
<td>14.08</td>
<td>179</td>
<td>1.22</td>
<td>299</td>
</tr>
<tr>
<td>700</td>
<td>4.0</td>
<td>213</td>
<td>1.67</td>
<td>501</td>
<td>0.83</td>
<td>328</td>
<td>122</td>
<td>12.5</td>
<td>7000</td>
<td>4.0</td>
<td>27</td>
<td>14.52</td>
<td>183</td>
<td>0.83</td>
<td>328</td>
</tr>
<tr>
<td>700</td>
<td>4.0</td>
<td>232</td>
<td>1.32</td>
<td>682</td>
<td>0.63</td>
<td>368</td>
<td>122</td>
<td>12.8</td>
<td>7000</td>
<td>4.0</td>
<td>24</td>
<td>15.8</td>
<td>92</td>
<td>0.63</td>
<td>368</td>
</tr>
<tr>
<td>900</td>
<td>3.5</td>
<td>277</td>
<td>5.5</td>
<td>188</td>
<td>1.7</td>
<td>299</td>
<td>122</td>
<td>12.2</td>
<td>9000</td>
<td>3.5</td>
<td>111</td>
<td>22.71</td>
<td>764</td>
<td>1.7</td>
<td>299</td>
</tr>
<tr>
<td>900</td>
<td>3.5</td>
<td>248</td>
<td>2.87</td>
<td>693</td>
<td>2.44</td>
<td>269</td>
<td>90</td>
<td>12.4</td>
<td>9000</td>
<td>3.5</td>
<td>70</td>
<td>12.12</td>
<td>384</td>
<td>2.44</td>
<td>269</td>
</tr>
<tr>
<td>900</td>
<td>4.0</td>
<td>198</td>
<td>1.86</td>
<td>354</td>
<td>1.22</td>
<td>299</td>
<td>122</td>
<td>12.2</td>
<td>9000</td>
<td>4.0</td>
<td>40</td>
<td>14.08</td>
<td>179</td>
<td>1.22</td>
<td>299</td>
</tr>
<tr>
<td>900</td>
<td>4.0</td>
<td>213</td>
<td>1.67</td>
<td>501</td>
<td>0.83</td>
<td>328</td>
<td>122</td>
<td>12.5</td>
<td>9000</td>
<td>4.0</td>
<td>27</td>
<td>14.52</td>
<td>183</td>
<td>0.83</td>
<td>328</td>
</tr>
<tr>
<td>900</td>
<td>4.0</td>
<td>232</td>
<td>1.32</td>
<td>682</td>
<td>0.63</td>
<td>368</td>
<td>122</td>
<td>12.8</td>
<td>9000</td>
<td>4.0</td>
<td>24</td>
<td>15.8</td>
<td>92</td>
<td>0.63</td>
<td>368</td>
</tr>
</tbody>
</table>

Note: The table represents the impedance components for matching a 50-ohm antenna load. Values have been chosen for a Q of 12 at the top edge of each amateur band. The image impedance (R3) has been chosen to provide a balanced transformation in the T section of the pi-L network. R1 is the plate load impedance.
One other circuit trick which can be used quite successfully is to use a dual-section variable, placing the two sections in series rather than parallel. This reduces the minimum capacitance to 10 pF or less.

**broadband power amplifier**

Many operators need special frequencies outside the five amateur bands for MARS or other purposes, and need a power amplifier which can be tuned up at any frequency in the range from 3.0 to 30 MHz. Table 7 shows a pi-network design that gives continuous frequency coverage in five switch positions. A pi-L network for similar use is shown in table 8. The pi-L is more broadband for a given Q variation, and requires substantially less output capacitance. Both designs are for 2000-watts input with a 2800-volt plate supply, or 1000-watts input at 2000 volts.

**component ratings**

To determine the peak voltage across C1 you can use the maximum dc plate voltage. This is not precisely correct, but it’s close enough. Normally, you would increase the voltage by at least 30 per cent when selecting a capacitor to prevent arcing if the tank circuit is not perfectly resonated, and to allow for some oxidation if you use an air variable.

There are several ways to determine peak voltage. If the power output is known at this point you can use eq. 12 to determine peak voltage:

$$E_{pk} = \sqrt{2PZ}$$

where $E_{pk}$ is the peak rf voltage, $P$ is output power, and $Z$ is plate load impedance. For example, in a 1-kW transmitter with 2800 volts on the plate, the peak voltage across C1 and L1 is 2646 volts. (The power output of class-B stages may be estimated at 70 per cent of the input power as this gives some margin of protection and is suitable for this purpose).

The peak voltage across C2 can also be figured in a similar manner, except that $Z$ in eq. 12 is the antenna load impedance. Power output may be estimated at 65 per cent of the input. For example, if the output power is 650 watts (for a 1-kW amplifier), and the antenna load is 50 ohms, this represents approximately 254 peak volts across C2. Thus, for a 1000-watt transmitter, a 350-volt, 365-pF broadcast receiver type capacitor could be used successfully. For 2000 watts input at 2800 volts, the peak voltage across C2 would be 367 volts, and the broadcast-tuning capacitor would be too marginal.

In the pi-L network the image impedance must be used when calculating the peak voltage across capacitor C2, and the voltage rating must be substantially higher than for the same capacitor in the pi network. For example, in a 1-kW transmitter, the peak voltage across C2 is about 635 volts; for a 2000-watt amplifier the peak voltage is about 895 volts.

The peak voltage across C1 has already been determined, but to find the current through C1, rms voltage is more useful. This can be found from eq. 13:

$$E_{rms} = \sqrt{PZ}$$

where $E_{rms}$ is the rms voltage, $P$ is the output power, and $Z$ is the plate load impedance. In the previous example of the 1000-watt transmitter with a 2800-volt plate supply, the rms voltage across C1 is nearly 1870 volts.

To calculate the current through C1 you must first determine the reactance of C1 (eq. 14) and calculate its impedance (eq. 15). The current is found from eq. 16:

$$X_C = \frac{Z_P}{Q}$$

$$Z_{CI} = \sqrt{R^2 + X_C^2}$$

$$I = \frac{E_{rms}}{Z_{CI}}$$

---

**Table 5. Comparisons between a 1-kW transmitter, a 2-kW transmitter, and a 2-kW transmitter operated at 1-kW input.**

<table>
<thead>
<tr>
<th>Component</th>
<th>1 kW</th>
<th>2 kW</th>
<th>1 kW on 2-kW transmitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate voltage</td>
<td>2800</td>
<td>2800</td>
<td>2800</td>
</tr>
<tr>
<td>Plate current</td>
<td>357</td>
<td>714</td>
<td>357</td>
</tr>
<tr>
<td>Plate load impedance</td>
<td>5000</td>
<td>2500</td>
<td>5000</td>
</tr>
<tr>
<td>Power input</td>
<td>1000</td>
<td>2000</td>
<td>1000</td>
</tr>
<tr>
<td>Tube output (typical)</td>
<td>700</td>
<td>1400</td>
<td>700</td>
</tr>
<tr>
<td>Power at antenna</td>
<td>672</td>
<td>1343</td>
<td>647</td>
</tr>
<tr>
<td>Antenna load</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Network efficiency</td>
<td>96</td>
<td>95.9</td>
<td>92.5</td>
</tr>
<tr>
<td>Lost in L1 (heat)</td>
<td>27.9</td>
<td>56.9</td>
<td>52.6</td>
</tr>
<tr>
<td>Circuit Q</td>
<td>12</td>
<td>12</td>
<td>23.6</td>
</tr>
<tr>
<td>Inductor Q (typical)</td>
<td>380</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Frequency</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Antenna load</td>
<td>45.5</td>
<td>91.0</td>
<td>187.8</td>
</tr>
<tr>
<td>L1 inductor</td>
<td>17.38</td>
<td>9.18</td>
<td>9.18</td>
</tr>
<tr>
<td>L2 loading capacitor</td>
<td>538.3</td>
<td>1096.9</td>
<td>1703.0</td>
</tr>
<tr>
<td>C1 tuning capacitor</td>
<td>416.7</td>
<td>208.3</td>
<td>211.9</td>
</tr>
<tr>
<td>C1 reactance</td>
<td>439.9</td>
<td>230.7</td>
<td>230.7</td>
</tr>
<tr>
<td>C2 reactance</td>
<td>74.5</td>
<td>36.3</td>
<td>23.4</td>
</tr>
<tr>
<td>Current in C1</td>
<td>4.49</td>
<td>8.98</td>
<td>8.83</td>
</tr>
<tr>
<td>Current in L1</td>
<td>4.73</td>
<td>9.29</td>
<td>8.93</td>
</tr>
<tr>
<td>Current in L2</td>
<td>4.26</td>
<td>7.14</td>
<td>7.70</td>
</tr>
<tr>
<td>Voltage across C1</td>
<td>2645.8</td>
<td>2645.8</td>
<td>2645.8</td>
</tr>
<tr>
<td>Voltage across C2</td>
<td>259.2</td>
<td>366.5</td>
<td>254.4</td>
</tr>
<tr>
<td>Voltage on antenna</td>
<td>183.3</td>
<td>291.1</td>
<td>179.9</td>
</tr>
<tr>
<td>Current in antenna</td>
<td>3.67</td>
<td>5.18</td>
<td>3.60</td>
</tr>
</tbody>
</table>
However, since the resistance of a high-quality air-variable capacitor is very small, less than 1 ohm, for all practical purposes the impedance of the capacitor is equal to its reactance. Therefore, the current can be found from

\[ I = \frac{E_{\text{rms}}}{X_{C1}} \quad (17) \]

As you can see in table 5, the current through C1 is much higher than you might think, with nearly 4.5 amperes flowing through C1 in the 1000-watt transmitter with 2800 volts on the plate. Most air variables and vacuum capacitors can handle this current easily, but you must be careful when selecting fixed capacitors to pad the variables. Transmitting-type capacitors with high Q and good current-carrying capability are required (such as the Centralab 850 series).

The current through C2 can also be determined with eq. 17. However, when calculating the rms voltage across C2 the antenna load impedance must be used in eq. 13. Again, there is substantial current flowing through C2 — nearly 2.5 amperes in the 1000-watt transmitter.

For all practical purposes, the current through inductor L1 is equal to that through C1. It is actually a little higher, and the following formula is reasonably correct for class B:

\[ I_{cc} = 1.05 \times Q \times I_p \quad (18) \]

where \( I_{cc} \) is the circulating current, \( Q \) is loaded circuit Q, and \( I_p \) is the indicated plate current. Eq. 18 is a close approximation that compares favorably with answers derived from using complex vector analysis of reactive components used in rf circuits at resonance.

### inductor power loss

To determine heat losses in the inductor, it is necessary to know the rf resistance of the inductor.

<table>
<thead>
<tr>
<th>f (MHz)</th>
<th>R1</th>
<th>C1 (pF)</th>
<th>L1 (\mu H)</th>
<th>C2 (pF)</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.7</td>
<td>2500</td>
<td>26</td>
<td>1.24</td>
<td>148</td>
<td>12.0</td>
</tr>
<tr>
<td>29.7</td>
<td>2500</td>
<td>32</td>
<td>1.00</td>
<td>210</td>
<td>15.0</td>
</tr>
<tr>
<td>29.7</td>
<td>2500</td>
<td>39</td>
<td>0.84</td>
<td>251</td>
<td>18.0</td>
</tr>
<tr>
<td>29.7</td>
<td>2500</td>
<td>45</td>
<td>0.72</td>
<td>300</td>
<td>21.0</td>
</tr>
<tr>
<td>29.7</td>
<td>2500</td>
<td>51</td>
<td>0.63</td>
<td>348</td>
<td>24.0</td>
</tr>
<tr>
<td>29.7</td>
<td>5000</td>
<td>26</td>
<td>1.24</td>
<td>234</td>
<td>24.0</td>
</tr>
<tr>
<td>29.7</td>
<td>5000</td>
<td>32</td>
<td>0.98</td>
<td>303</td>
<td>30.0</td>
</tr>
<tr>
<td>29.7</td>
<td>5000</td>
<td>45</td>
<td>0.70</td>
<td>437</td>
<td>42.0</td>
</tr>
<tr>
<td>29.7</td>
<td>5000</td>
<td>51</td>
<td>0.61</td>
<td>503</td>
<td>48.0</td>
</tr>
</tbody>
</table>

Then you can use eq. 19 to find power loss.

\[ P = I^2 r \quad (19) \]

where \( I \) is the circulating current and \( r \) is the rf resistance.

To minimize these losses, the inductor should be silver plated, as should all leads to the bandswitch. Power losses on the order of 30 to 100 watts are not unusual, even with low standing-wave ratios. The use of tubing is encouraged, particularly on the higher frequencies to provide better unloaded Q.

It may come as a surprise to find that the conductivity of silver is only slightly superior to that of copper. In fact, a silver-plated coil is little more efficient than a new tank coil made of copper. Copper, however, oxidizes, and the outer rf-current-carrying layer becomes less effective. On the other hand, silver develops a form of silver sulfide on its outer surface which barely affects its conductivity. Over a period of years the silver-plated coil will retain most of its original conductivity.

### safety

An rf choke should be used at the antenna output of any pi or pi-L network. This choke should be large enough to blow the overload relay (or fuse) in the high-voltage power supply if the dc blocking capacitor should short out. This is the only backup protection you have to keep high dc voltage off the pi-network components if the blocking capacitor

### table 7. Pi-network component values for a broadband 3-30 MHz rf power amplifier matching a 50-ohm antenna load.

This is accomplished in five bands: 3.0-5.0 MHz, 5.0-8.5 MHz, 8.5-14.4 MHz, 13.5-22.0 MHz and 20.0-30.0 MHz. The Q is set for a minimum of 12 at the top of each band. The 2500-ohm plate load impedance corresponds to a grounded-grid amplifier running 2000 watts at 2800 volts, or a 1000-watt amplifier with 2000 volts on the plate.

<table>
<thead>
<tr>
<th>f (MHz)</th>
<th>R1</th>
<th>C1 (pF)</th>
<th>L1 (\mu H)</th>
<th>C2 (pF)</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.0</td>
<td>5.0</td>
<td>435</td>
<td>7.34</td>
<td>2878</td>
<td>50 29.4</td>
</tr>
<tr>
<td>25.0</td>
<td>5.5</td>
<td>317</td>
<td>7.34</td>
<td>2855</td>
<td>50 17.4</td>
</tr>
<tr>
<td>25.0</td>
<td>4.8</td>
<td>242</td>
<td>7.34</td>
<td>1517</td>
<td>50 17.2</td>
</tr>
<tr>
<td>25.0</td>
<td>5.8</td>
<td>155</td>
<td>7.14</td>
<td>874</td>
<td>50 12.8</td>
</tr>
<tr>
<td>25.0</td>
<td>5.0</td>
<td>265</td>
<td>4.12</td>
<td>1764</td>
<td>50 29.4</td>
</tr>
<tr>
<td>25.0</td>
<td>7.8</td>
<td>154</td>
<td>4.12</td>
<td>854</td>
<td>50 14.7</td>
</tr>
<tr>
<td>25.0</td>
<td>7.1</td>
<td>123</td>
<td>4.12</td>
<td>755</td>
<td>50 14.4</td>
</tr>
<tr>
<td>25.0</td>
<td>2.6</td>
<td>96</td>
<td>4.12</td>
<td>516</td>
<td>50 12.9</td>
</tr>
<tr>
<td>25.0</td>
<td>8.5</td>
<td>155</td>
<td>2.55</td>
<td>1354</td>
<td>50 29.5</td>
</tr>
<tr>
<td>25.0</td>
<td>14.0</td>
<td>56</td>
<td>2.55</td>
<td>127</td>
<td>50 12.4</td>
</tr>
<tr>
<td>25.0</td>
<td>14.35</td>
<td>54</td>
<td>2.55</td>
<td>308</td>
<td>50 12.1</td>
</tr>
<tr>
<td>25.0</td>
<td>14.4</td>
<td>55</td>
<td>2.55</td>
<td>308</td>
<td>50 12.0</td>
</tr>
<tr>
<td>25.0</td>
<td>15.5</td>
<td>94</td>
<td>1.67</td>
<td>621</td>
<td>50 19.9</td>
</tr>
<tr>
<td>25.0</td>
<td>21.4</td>
<td>38</td>
<td>1.67</td>
<td>225</td>
<td>50 12.6</td>
</tr>
<tr>
<td>25.0</td>
<td>21.45</td>
<td>37</td>
<td>1.67</td>
<td>212</td>
<td>50 12.5</td>
</tr>
<tr>
<td>25.0</td>
<td>22.0</td>
<td>35</td>
<td>1.67</td>
<td>199</td>
<td>50 12.0</td>
</tr>
<tr>
<td>25.0</td>
<td>29.0</td>
<td>59</td>
<td>1.22</td>
<td>338</td>
<td>50 18.4</td>
</tr>
<tr>
<td>25.0</td>
<td>28.0</td>
<td>59</td>
<td>1.22</td>
<td>176</td>
<td>50 15.9</td>
</tr>
<tr>
<td>25.0</td>
<td>29.7</td>
<td>26</td>
<td>1.22</td>
<td>151</td>
<td>50 12.2</td>
</tr>
<tr>
<td>25.0</td>
<td>30.3</td>
<td>25</td>
<td>1.22</td>
<td>146</td>
<td>50 12.0</td>
</tr>
</tbody>
</table>

then you can use eq. 19 to find power loss.

\[ P = I^2 r \]

where \( I \) is the circulating current and \( r \) is the rf resistance.

To minimize these losses, the inductor should be silver plated, as should all leads to the bandswitch. Power losses on the order of 30 to 100 watts are not unusual, even with low standing-wave ratios. The use of tubing is encouraged, particularly on the higher frequencies to provide better unloaded Q.

It may come as a surprise to find that the conductivity of silver is only slightly superior to that of copper. In fact, a silver-plated coil is little more efficient than a new tank coil made of copper. Copper, however, oxidizes, and the outer rf-current-carrying layer becomes less effective. On the other hand, silver develops a form of silver sulfide on its outer surface which barely affects its conductivity. Over a period of years the silver-plated coil will retain most of its original conductivity.
table 8. Pi-L network component values for a broadband 3-30 MHz rf power amplifier matching a 50-ohm antenna load. This is accomplished in five bands: 3.0-5.0 MHz, 5.0-8.5 MHz, 8.5-14.4 MHz, 13.5-22.0 MHz and 20.0-30.0 MHz. The Q is set for a minimum of 12 at the top of each band. The 2600-ohm plate load impedance corresponds to a grounded-grid amplifier running 2000 watts at 2800 volts, or a 1000-watt amplifier with 2000 volts on the plate.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Number of Turns</th>
<th>Inductance (uH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0-5.0 MHz</td>
<td>10.00</td>
<td>3.90</td>
</tr>
<tr>
<td>5.0-8.5 MHz</td>
<td>6.75</td>
<td>2.25</td>
</tr>
<tr>
<td>8.5-14.4 MHz</td>
<td>4.75</td>
<td>1.33</td>
</tr>
<tr>
<td>12.5-22.0 MHz</td>
<td>3.50</td>
<td>0.83</td>
</tr>
<tr>
<td>20.0-30.0 MHz</td>
<td>3.00</td>
<td>0.65</td>
</tr>
</tbody>
</table>

A suitable inductor for the L-section of the pi-L network consists of 5 cm (2 inches) of Air-Dux 1606T (6 turns-per-inch (2.5cm), no. 14, 5 cm (2 inches) diameter). It should be placed at right angles to the main pi inductor to avoid mutual inductance.

RTTY and ssb

Many amateurs are interested in RTTY as well as CW and ssb. Since RTTY is essentially 100 per cent key-down, it's quite hard on the various components in the transmitter. On ssb, the typical duty factor is 30 to 50 per cent, depending on how much ALC and other compression you use. Typically, however, the average circulating current in the network is perhaps one-third of that for key-down operation.

Table 5 shows that 2000-watts key-down gives comparable circulating currents to that of the same transmitter run at 1000-watts key-down with the same plate voltage and same inductor. This is due to the higher Q that is being used. Because of the lower duty cycle of ssb, running a 2000-watt transmitter key-down at 1000 watts for RTTY is three times as hard on the transmitter as running 2000-watts PEP! This is rather startling, and indicates why some rf power amplifiers should not be used on RTTY, although they are perfectly suitable for ssb at higher input power levels.

Conversely, it follows that if a manufacturer guarantees his unit to run indefinitely at 1000-watts key-down RTTY, that same transmitter should last forever at 2000-watts PEP ssb. Some manufacturers hedge if this specific question is posed to them.

Using a 2000-watt rf power amplifier at the 1000-watt level for RTTY or CW poses certain inherent problems regarding heat and efficiency. High plate supply voltages raise the plate load impedance to the point where it may be difficult to get the minimum capacitance required for resonance on 10 and 15 meters.

When building a high-power final amplifier, consideration must be given to selecting components which will handle the voltage and currents encountered in the circuit. The formulas given in this article should make it relatively easy for the builder to predict what these voltages and circulating currents will be before he actually builds the amplifier.

Computer-derived tables provide much data for the builder, and clarify many design points only hinted at in previous articles. I hope that the information presented here will be of benefit to anyone who builds or buys a final rf power amplifier.

Acknowledgements

Many people are interested in pi and pi-L networks, and have been of direct assistance. Providing particular assistance was Bob Sutherland, W6UOV, or EIMAC. I also spent a great deal of time reading articles written by George Grammer, W1DF, former Technical Editor of QST. His work in this field, and his series of three articles in QST5 represent an outstanding contribution. Bill Craig, WB4FPK, was most helpful, as was Garey Barrell, K4OH. Bill Carver, K6OLG, also provided stimulating comments.

The Computer Terminal Corporation of San Antonio, Texas, provided over 100 hours of computer terminal time which was invaluable in this project.

References

Incredible...
FOØXA-H
CLIPPERTON '78

GREATEST DXpedition OF THEM ALL!

WA9INK W6SQ WA4WME N6IC W6QKI W6HVN

F6AQD HB9AHL F6AOI F9IE HB9(SWL) F6ARC
HB9AEE F5II F6BFH F9JS F6BBJ
If you were one of the fortunate 29,069 hams who worked Clipperton Island in March of 1978, you’ve worked an Atlas 350-XL transceiver. The 350-XL was selected by the DXpedition logistics team, headed by Don Bostrom, N6IC, because it had all of the necessary features required for the operation contained in one compact package. This included primary and auxiliary VFO’s for split frequency operation, digital frequency display with accuracy of ± 50 Hz, VOX for SSB and full break-in for CW, sidetone, more than 200 watts output (twice that of most other transceivers), all solid state design permitting efficient operation from a storage battery if necessary. And above all, rugged design and construction that permits hour after hour of continuous operation without failure.

"The 350-XL is a fine, rugged transceiver... even works after a salt water bath..." Willy, HB9AHL

One very important point we want to make clear... the Clipperton DXpedition was financed by the 16 operators who went there, and by many generous donations from DX clubs, radio clubs, individual hams, and others. Atlas Radio was not a financial sponsor, except to the extent of loaning equipment. Other manufacturers provided similar support.

"As equipment logistics manager, my selection of the Atlas 350-XL proved to be the perfect choice..." Don, N6IC

Needless to say, we at Atlas Radio were very pleased when the team chose the 350-XL as the transceiver for all 3 stations. At that point, how could I (W6QKI) turn down the invitation to join the team, and to share in a tremendous adventure? Did I go along to keep our radios working? Well, truthfully I brought along a box full of spare parts and pieces. Happily I can report that the box could have stayed at home. And there are 15 witnesses who will verify this. Their unanimous and wholehearted endorsement of the 350-XL is most gratifying.

Many of you will be interested in how the 3 stations were organized. Number 1 station was up in the metal Quonset-type building which the French put up in 1957 during the IGY scientific work conducted on the island. This station worked strictly 20 meters round the clock for 7 days, SSB and CW. It included a Dentron MLA-2500 Linear which was used much of the time to break through to Europe and other distant points. The antenna was a Wilson 4 element monobander about 30 feet high. Power was supplied by a 2500 watt Honda gasoline generator. This station ran continuously for 7 days, and made 11,158 contacts! Problems, zero!

Incidentally, we took one box ashore which contained 3 fans. They were intended for blowing air on the transceiver heat sinks. The box is still on the island, unopened! Ambient temperature outside was 85 degrees F. Inside the metal building? Up to 95 degrees!

"Unbelievable performance and reliability under extremely adverse portable conditions and constant use by DXpedition multi-operators..." Hugh, WA4WME

Station Number 2 was located about 200 feet from Number 1, and was set up in a tent. It worked 10 meters daytime, 80 and 160 meters at night. A Dentron MLA-2500 Linear was used, mainly on 80 and 160, some of the time on 10 meters. A 3 element Wilson monobander was used on 10. A doublet was used on 80 meters, later changed to a Delta loop by 6ARC, a KLM vertical with ground radials worked very well on 160 meters. A Dentron MT-3000 antenna tuner was used on 80 and 160. Power was supplied by a Sears 2200 watt generator. This station averaged 21 to 22 hours operation each of the 7 days. Problems? The digital frequency display made signs of acting up. One of the IC’s was replaced. A 5 minute job. The rig had been liberally sprayed with salt water on the trip in through the surf, as also was the Dentron linear. Total contacts from Station Number 2 were 6401 on 10 meters, 1644 on 80 meters, and 202 on 160 meters.


Station Number 3 was located in a tent about 300 feet (and 5000 crabs) from Number 2. It operated on 15 and 40 meters. Foreign broadcast QRM was very rough on 40, so most operating time was on 15 using a Wilson 3 element monobander. No linear was used at this station because the generator would not provide enough power.

So, if you heard Clipperton on 15 or 40 meters, it was strictly barefoot. A Dentron MT-3000 tuner was used with a KLM vertical on 40 meters. Station Number 3 ran all week on a generator that delivered 155 volts AC when receiving... and only 75 to 90 volts during transmit! We were unable to adjust the problem, so simply let it go. Didn’t bother the rig. Total contacts on 15 meters numbered 7194, second only to 20 meters. 40 meters netted 2450 contacts.

This report hardly is complete if we don’t mention 6 meters and Oscar. N61C and W6SO were the Oscar specialists. Unfortunately, some equipment difficulty (not Atlas) limited Oscar contacts to only 20. Rather disappointing, but the best we could do, and the guys really tried. 6 meters just never produced an opening. We monitored every day without ever hearing a signal.

"I cannot say enough about the excellent performance of the Atlas equipment. Under the most trying conditions of operation the gear came through with flying colors. With 16 operators pushing switches and twisting knobs 24 hours a day for 7 days, the equipment never faltered. Truly remarkable. The success of the DXpedition was due in large to the faultless operation of the 350-XL..." Hoppy, W6SO

All in all, we feel the performance record on the HF bands is something to brag about, and hope you’ll pardon us for indulging. One final thing to boast about was really unexpected. The ride through the surf back to the ship was quite a ride. Everyone, and everything thoroughly soaked. Much of the gear was full submerged. But all 3 of the 350-XL’s worked normally after drying out! Being very low on fresh water we could not afford to wash the gear down. All we could do was dry them out in the sun. Obviously, as soon as we got back we had to wash out the salt and clean the sets up. But, they were used “maritime-mobile” on the trip back to San Diego.

The Clipperton ‘78 DXpedition was undoubtedly the biggest expedition and adventure of its kind ever put together, and turned out to be a smashing success in all respects. All the gang at Atlas is mighty proud at how well the 350-XL proved itself, truly a great performer, a real classic that will set the pace for years to come.

73. Herb Johnson, W6QKI

ATLAS RADIO INC.
417 Via Del Monte, Oceanside, CA 92054
(714) 433-1983
Special Customer Service Direct Line (714) 433-9591
TWX 910-322-1397
Following the lead of Ball in February *ham radio*, author Milazzo has also derived the equations for tracking Oscar — emphasis in this case has been placed on developing a program suitable for use with the Texas Instruments calculators which use algebraic notation.

Of primary importance in satellite communication is the required antenna orientation and the time during which the satellite is available from the ground station. Such information increases the dependability and efficiency of satellite use. Presently, the means of obtaining this data is widely available due to the increased popularity of low-cost programmable calculators and minicomputers.

Previous articles have dealt with the prediction of equatorial crossings.¹² These offer few advantages since such information is published monthly and interpolation of this data is easily accomplished. Other articles do offer more useful information but require the use of slide-rule type devices which are imprecise and incapable of being interfaced with station equipment.³⁴

This article presents a series of equations for deter-

**By Charles F. Milazzo, KP4MD**, University of Puerto Rico School of Medicine, Apartado 2-2, GPO Box 5067, San Juan, Puerto Rico 00936.
mining the exact position of any earth satellite that approximates a circular orbit, at any given time. The calculations are useful for manually or automatically tracking a satellite, for preparing tables for future reference, or for alerting the operator when a satellite is approaching. This algorithm has been used to prepare programs for the Texas Instruments SR-52 calculator, but can be programmed for other calculators and computers as well.

**theory**

The theoretical model considers the earth as a stationary sphere with the satellite travelling in a circular orbit moving from east to west. Thus, the coordinates of the ground station remain constant while those of the satellite vary as a function of time. Solving this problem involves the application of spherical trigonometry which implies that the computer must be supplied subroutines for trigonometric functions. Algebraic methods for evaluating these functions are found in various references.\(^5,6\)

The main equations are derived from the law of cosines of spherical trigonometry (see fig. 1).

\[
\cos a = \cos b \cos c + \sin b \sin c \cos A
\]

To calculate the latitude and longitude of the satellite, the angle labelled \(A\) is placed at the equator crossing point of a reference orbit, angle \(B\) is at the satellite's position at time \(T\), and angle \(C\) is at the North Pole. Thus, \(A\) is equal to \(360^\circ - \alpha_{eq}\), and \(C\) is equal to longitudinal displacement of the satellite from the reference crossing \(C = \lambda - \lambda_{eq}\). Side \(a\) is the complement of the satellite's latitude \(a = 90^\circ - \psi_s\), side \(b\) is a function of the orbital period \(P_s\) and of the time elapsed from the reference crossing \(b = 360^\circ(T - T_{eq})/P_s\), and side \(c\) is \(90^\circ\).

Substituting known values into the equation for the law of cosines results in:

\[
\cos (90^\circ - \psi_s) = \cos[360^\circ(T - T_{eq})/P_s] \cos 90^\circ + \\
\sin[360^\circ(T - T_{eq})/P_s] \sin 90^\circ \\
\cos (360^\circ - \alpha_{eq})
\]

The result is used again in the same equation to calculate angle \(C\)

\[
\cos[360^\circ(T - T_{eq})/P_s] = \cos(90^\circ - \psi_s) \cos 90^\circ + \\
\sin(90^\circ - \psi_s) \sin 90^\circ \cos C
\]

which rearranges to give

\[
C = \arccos(\cos[360^\circ(T - T_{eq})/P_s] \cos \psi_s)
\]

The true longitude of the satellite is calculated by adding the longitude of the equator crossing reference point \(\lambda_{eq}\), changing the sign of \(C\) when the satellite is in the Southern Hemisphere, adding the displacement due to the earth's rotation \((0.25^\circ/\text{min})\), and compensating for a constant orbital drift factor \(D\) if necessary.

\[
\lambda = \frac{|\psi_s|}{\psi_s} \arccos \left[ \frac{\cos[360^\circ(T - T_{eq})/P_s]}{\cos \psi_s} \right] \\
+ \lambda_{eq} + (T - T_{eq})(0.25 + D)
\]

Again referring to fig. 1, angle \(A\) is now placed at the location of the ground station and is equal to \(360^\circ\) minus the correct antenna azimuth \((A = 360^\circ - \alpha_{gs})\). Angle \(C\) is the difference between the longitudes of the satellite and the ground station \((C = \lambda - \lambda_g)\). If \(C\) is greater than zero, then the true azimuth is \(360^\circ\) minus \(\alpha_{eq}\). Side \(b\) is the complement of the ground station's latitude \((b = 90^\circ - \psi_g)\), and side \(c\) is the distance from the ground station to the satellite in great circle degrees \((c = \theta)\). Side \(c\) is calculated using the law of cosines.

\[
\cos \theta = \cos(90^\circ - \psi_g) \cos(90^\circ - \psi_g) + \\
\sin(90^\circ - \psi_g) \sin(90^\circ - \psi_g) \cos(\lambda - \lambda_g)
\]

which simplifies to give the degrees distance

\[
\theta = \arccos[\sin \psi_s \sin \psi_g + \cos \psi_s \cos \psi_g \cos(\lambda - \lambda_g)]
\]

This value is used to calculate the azimuth

\[
\cos(90^\circ - \psi_g) = \cos(90^\circ - \psi_g) \cos \theta + \\
\sin(90^\circ - \psi_g) \sin \theta \cos \alpha_{gs}
\]

which rearranges to give

\[
\alpha_{gs} = \arccos[(\sin \psi_s - \sin \psi_g \cos \theta)/\cos \psi_g \sin \theta]
\]

---

**fig. 2. Calculation of the antenna elevation is based on this plane geometric figure.** \(R_s\) is the orbital radius, referenced to the center of the earth.
The antenna elevation is calculated using a plane geometric model as shown in fig. 2. $R_e$ is the earth’s radius (6371.315km) and $R_s$ is the orbital radius. According to Newton’s law of gravitation, the radius of a circular orbit is a function of the orbital period. For any satellite in such an orbit, the centrifugal force ($F = m \omega^2/R_s$) is equal to the gravitational force ($F = GM_e m/R_s^2$). The velocity of the satellite is equal to the orbital circumference divided by the orbital period in seconds ($v = 2\pi R_e/60P_s$), when $P_s$ is in minutes. $GM_e$ is the earth’s gravitational constant (398603km³/s²). Thus, we can calculate the orbital radius by equating the centrifugal and gravitational forces

$$m(2\pi R_e/60P_s)^2/R_s = GM_e m/R_s^2$$

or

$$R_s = \sqrt[3]{GM_e (30P_s/\pi)^2}$$

Fig. 3 shows the trigonometric relationships which result when a perpendicular is drawn from the ground station to the $R_s$ line. Solving for the angle whose apex is at the satellite’s position yields

$$90^\circ - \theta - \phi = \arctan \left[ R_s \sin \theta / (R_s - R_c \cos \theta) \right]$$

which rearranges to give the antenna elevation

$$\phi = \arctan \left[ (R_s - R_c \cos \theta) / R_c \sin \theta \right] - \theta$$

If the satellite is below the horizon, the antenna elevation will be a negative number. This is useful as a conditional test to determine if the satellite is within range.

Ground distance is directly proportional to the arc distance and can be found by $D = k\theta$, where $k$ is 111.14 for kilometers, or 69.06 for statute miles.

Direct line-of-sight distance can also be determined by the law of cosines (fig. 4).

$$D = \sqrt{R_e^2 + R_s^2 - 2R_eR_s \cos \theta}$$

The constants for the Oscar 6 and 7 satellites are as follows:

<table>
<thead>
<tr>
<th>Satellite</th>
<th>$\alpha_{eqx}$</th>
<th>$P_s$</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscar 6</td>
<td>351.0100°</td>
<td>103.23162 min</td>
<td>0</td>
</tr>
<tr>
<td>Oscar 7</td>
<td>348.2900°</td>
<td>114.94483 min</td>
<td>0</td>
</tr>
</tbody>
</table>

the SR-52 program

Due to the complexity of the calculations required, the program is divided into two modules.* The first module enters the appropriate reference and constant information into the data memory, while the second module computes the satellite’s position and direction in terms of azimuth and elevation from a specified ground location. In the second module, the desired time is entered from which the calculator displays the elevation angle, indicating if the satellite is within range. The azimuth and arc distance can then be called from the calculator. To facilitate the tabulation of the results, one key has been programmed to advance or reverse the position of the satellite by a desired number of minutes. The following example demonstrates the use of the program.

The antenna aiming data for the first Oscar 7 pass of August 1, 1977 is desired. The first program card is read into the calculator, and the R/D switch is placed in the degrees mode. A reference orbit from January 1, 1977 is available. The satellite is found to cross the equator at 77.0° west longitude at 0148:49 on January 1. The station coordinates are 18°25’ north latitude and 65°58’ west longitude. Therefore, the following key sequence is executed:

<table>
<thead>
<tr>
<th>enter</th>
<th>press</th>
<th>display</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>A</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>B'</td>
<td>2400</td>
</tr>
<tr>
<td>148.49</td>
<td>B</td>
<td>1548.82</td>
</tr>
<tr>
<td>77.0</td>
<td>C</td>
<td>77.1</td>
</tr>
<tr>
<td>18.25</td>
<td>D</td>
<td>18.42</td>
</tr>
<tr>
<td>65.58</td>
<td>E</td>
<td>65.97</td>
</tr>
</tbody>
</table>

The second card is now read into the calculator. Since the exact time of acquisition is not known, a rough estimate can be made based on the fact that the satellite travels at about 3 degrees per minute and

*A copy of the program is available by sending a self-addressed, stamped envelope to ham radio, Greenville, New Hampshire 03048.
it must be within 36 degrees of the station to be heard. First, determine if the satellite is within range at 0000 GMT on August 1 (213th day of 1977).

<table>
<thead>
<tr>
<th>enter</th>
<th>press</th>
<th>display</th>
</tr>
</thead>
<tbody>
<tr>
<td>213</td>
<td>A</td>
<td>511200</td>
</tr>
<tr>
<td>0</td>
<td>A</td>
<td>-9.23</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>45.8</td>
</tr>
</tbody>
</table>

The negative value for elevation showed that the satellite is below the horizon at 0000 GMT, while pressing C showed that it is about 10 degrees beyond the 36 degree range limit. If the satellite is approaching, it will take about four minutes to come within range. Advancing the satellite four minutes produces:

<table>
<thead>
<tr>
<th>enter</th>
<th>press</th>
<th>display</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>E</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>147.8</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>33.4</td>
</tr>
</tbody>
</table>

The user instructions for the program are straightforward, but the following hints are useful. A date need not be entered if the reference and unknown orbits occur within the same day. When entering a date, it must always be entered before the time. The dates of the reference and unknown orbits must be either within the same month, or else each day of the year must be assigned a consecutive number.

The satellite can be advanced at one minute intervals to produce a listing for this pass.

<table>
<thead>
<tr>
<th>time</th>
<th>elevation</th>
<th>azimuth</th>
<th>distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0004</td>
<td>2.2</td>
<td>147.8</td>
<td>33.4</td>
</tr>
<tr>
<td>0005</td>
<td>5.7</td>
<td>146.2</td>
<td>30.3</td>
</tr>
<tr>
<td>0006</td>
<td>9.4</td>
<td>144.3</td>
<td>27.2</td>
</tr>
<tr>
<td>0007</td>
<td>13.5</td>
<td>142.0</td>
<td>24.2</td>
</tr>
<tr>
<td>0008</td>
<td>18.1</td>
<td>139.0</td>
<td>21.2</td>
</tr>
<tr>
<td>0009</td>
<td>23.4</td>
<td>135.1</td>
<td>18.3</td>
</tr>
<tr>
<td>0100</td>
<td>29.3</td>
<td>129.8</td>
<td>15.5</td>
</tr>
<tr>
<td>0111</td>
<td>35.9</td>
<td>122.4</td>
<td>12.9</td>
</tr>
<tr>
<td>0112</td>
<td>42.7</td>
<td>111.5</td>
<td>10.6</td>
</tr>
<tr>
<td>0113</td>
<td>48.7</td>
<td>95.5</td>
<td>8.8</td>
</tr>
<tr>
<td>0114</td>
<td>51.6</td>
<td>74.3</td>
<td>8.0</td>
</tr>
<tr>
<td>0115</td>
<td>50.1</td>
<td>52.1</td>
<td>8.5</td>
</tr>
<tr>
<td>0116</td>
<td>44.8</td>
<td>34.3</td>
<td>9.9</td>
</tr>
<tr>
<td>0117</td>
<td>38.1</td>
<td>22.0</td>
<td>12.1</td>
</tr>
<tr>
<td>0118</td>
<td>31.3</td>
<td>13.6</td>
<td>14.6</td>
</tr>
<tr>
<td>0119</td>
<td>25.2</td>
<td>7.8</td>
<td>17.4</td>
</tr>
<tr>
<td>0200</td>
<td>19.7</td>
<td>3.7</td>
<td>20.3</td>
</tr>
<tr>
<td>0211</td>
<td>14.9</td>
<td>0.6</td>
<td>23.3</td>
</tr>
<tr>
<td>0222</td>
<td>10.6</td>
<td>358.1</td>
<td>26.3</td>
</tr>
<tr>
<td>0233</td>
<td>6.7</td>
<td>396.2</td>
<td>29.4</td>
</tr>
<tr>
<td>0244</td>
<td>3.2</td>
<td>364.7</td>
<td>32.4</td>
</tr>
<tr>
<td>0255</td>
<td>0.0</td>
<td>353.5</td>
<td>35.6</td>
</tr>
</tbody>
</table>

Results from this program have been compared with published equatorial crossing data, with the predicted coordinates accurate to within one tenth of one degree for both Oscar 6 and Oscar 7. This, for one year from a single reference orbit.

The conclusion is that by using the preceding equations, any person can build his own computerized satellite tracking station by interfacing a digital clock and station controls to a microcomputer. Even without a computer, this program offers valuable, accurate information for any satellite operator.

references

ham radio
The TR-7400A 2-meter FM transceiver provides fully synthesized operation, including 600-kHz repeater offsets, over the entire 144-148-MHz range. It can operate on any of 800 channels, spaced 5 kHz apart. RF output is at least 25 W, and typically 30 W. A low power position produces 5-15 W (adjustable). Included is a dual frequency readout with large six-digit LED display plus a dial readout. The subaudible CTCSS signaling feature may be used on transmit and receive, or transmit only. Optional tone-burst modules are available. Receiver sensitivity is better than 0.4 μV for 20 dB quieting. Large, high-Q, helical resonators minimize interference from outside the band. A two-pole 10.7-MHz monolithic crystal filter provides excellent selectivity. Optional active filters are available for 15-kHz "split" operation. Intermodulation distortion is down more than 66 dB, spurious rejection is better than —60 dB, and image rejection is better than —70 dB.

See your local Authorized Kenwood Dealer today, for a demonstration of the fantastic TR-7400A.

The fully-synthesized TR-7400A 2-meter FM transceiver operates on 800 channels and features a repeater offset over the entire 144-148-MHz range, dual frequency readout, six-digit display, and subaudible tone encoder and decoder. RF output is at least 25 watts!

The PS-8 AC power supply matches the TR-7400A 2-meter FM transceiver, and produces 13.8 VDC at 8 A intermittent (50% duty cycle) and 5 A continuous. It can also be used with other Kenwood VHF and UHF mobile transceivers. It is well-regulated (less than ±4% fluctuation), has low ripple (less than 10 mV rms), and features current limiting (less than 3 A short circuit).

The MC-30S and MC-35S dynamic mobile microphones provide 150-5000 Hz frequency response (150-4000 Hz when operated as noise-cancelling microphones). The MC-30S impedance is 500 Ω and the MC-35S is 50 kΩ.
INTRODUCING THE ULTIMATE IN RECEIVER DESIGN ... THE KENWOOD R-820

With more features than ever before available in a ham-band receiver. This triple-conversion (8.33 MHz, 455 kHz, and 50 kHz IFs) receiver, covering all Amateur bands from 160 through 10 meters, as well as several shortwave broadcast bands, features digital as well as analog frequency readouts, notch filter, IF shift, variable bandwidth tuning, sharp IF filters, noise blanker, stepped RF attenuator, 25 kHz IF shift, variable bandwidth tuning, and many other features, providing more operating conveniences than any other ham-band receiver. The R-820 may be used in conjunction with the Kenwood TS-820 series transceiver, providing full transceive frequency control.

R-820 PERFORMANCE SPECIFICATIONS

Frequency Range:
- 160 meters (1.8-2.0 MHz)
- 80 meters (3.5-4.0 MHz)
- 40 meters (7.0-7.5 MHz)
- 20 meters (14.0-14.5 MHz)
- 15 meters (21.0-21.5 MHz)
- 10 meters (28.0-28.5 MHz)
- 10 meters (35.0-35.5 MHz)
- 10 meters (42.0-42.5 MHz)
- 9 meters (50.0-50.5 MHz)
- 8 meters (56.0-56.5 MHz)
- 7 meters (63.0-63.5 MHz)
- 6 meters (70.0-70.5 MHz)
- 5 meters (75.0-75.5 MHz)
- 4 meters (80.0-80.5 MHz)
- 3 meters (87.0-87.5 MHz)
- 2 meters (100.0-100.5 MHz)
- 1.5 meters (107.0-107.5 MHz)
- 1 meter (114.0-114.5 MHz)
- 0.75 meter (117.0-117.5 MHz)
- 0.5 meter (120.0-120.5 MHz)
- 0.25 meter (123.0-123.5 MHz)

Modes: AM, CW, USB, LSB, RTTY

Sensitivity: 160-10 meters: 10 dB µV at 10 dB SNR
49.3125, 31.25, 16.0 meters: 10 dB µV at 10 dB SNR

Power Requirements: 100/120/220/240 VAC, 50/60 Hz or 12-15 VDC

Dimensions: 13.1/8" x 333 mm (W x 6")
Weight: 26.4 lbs (12 kg)
protecting solid-state devices from voltage transients

There has been a great deal of discussion lately about solid-state equipment failing "for no apparent reason." If you have experienced such an occurrence and you can't explain it, chances are your solid-state gear has been zapped by a voltage transient. These are the little "gremlins" that can appear at any time, unannounced, and proceed to do their dirty work on your favorite electronic device (even when it is turned off).

While this problem may appear at first to be a recent phenomenon, it may surprise many of you to learn that voltage transients have been around for a long, long time. Why, then, have we begun to experience solid-state equipment failures (traceable to transients) only in the last few years?

The key to answering this question begins with an examination of the way equipment is built today as compared to 10 or 15 years ago. The one major and obvious difference is the use of solid-state devices in place of vacuum tubes. While transients have been around for a long time, they never bothered vacuum tubes, which can withstand momentary abuses without damage. Consequently, we have never paid much attention to the elusive voltage transient. To summarize our present situation, we know that:

1. High energy voltage transients can destroy solid-state devices.
2. We must design circuits more conservatively or add protective devices to suppress the transients.
3. We must try to eliminate some of the man-made causes of voltage transients.

In this article, I hope to provide you with some information on what voltage transients are, what causes them, why protection is necessary, and how to detect and suppress transients.

what are voltage transients?

To begin with, voltage transients are generally considered to be abnormally high voltages, occurring in a place where they don't belong, for an extremely short period of time (usually in the nanosecond range). These transients can be generated by a device within the electronic gear (relays or SCRs) or they may come from a number of external sources such as lightning or power line switching.

For example, if an electric current is made to increase or decrease rapidly in an inductive circuit, an extremely high voltage will be generated (directly proportional to the amount of inductance and the rate at which the current is attempting to change). While this all happens very fast, there is a possibility that enough energy will be generated to exceed the breakdown characteristics of the solid-state components in the conduit.

Another problem area exists with transients caused by outside sources that find their way into solid-state equipment through power connections, antenna lead-ins, and other signal inputs to the equipment. This type of transient is much harder to control than the internal transient, and yet can produce just as much damage.

sources of voltage transients

As discussed earlier, transients may be generated under all types of conditions, and may occur on an ac line as well as dc bus. An example of the generation of an internal transient is one that occurs in the windings of the transformer in a power supply. If the line switch on the primary side of the transformer is opened at the exact instant that the transformer core is beginning a downward swing of magnetization current (fig. 1A), a voltage spike is developed on the secondary winding of the transformer. The same thing can happen when the power supply is first turned on (fig. 1B). In this example, we are causing a rapid increase of current in an inductive circuit (the transformer winding) and the result is a momentary spike on the secondary circuit.

While the previous two examples involve ac circuits, the same phenomenon can occur with the interruption of dc circuits that supply inductive loads. A diode connected across the coil of a dc relay is a good example (fig. 1C). When power is interrupted, this circuit is designed to conduct and thereby clip any high-voltage transients that may be developed.

By W. J. Prudhomme, WB5DEP, 6419 Rosalie Court, Metairie, Louisiana 70003
As far as outside sources of voltage transients, one of the most common is lightning striking a power line during a storm. Even when the strike is several kilometers away, it can readily travel through the utility's power lines and play havoc with solid-state equipment. Also, lightning in the area can generate voltage spikes on your antenna that easily find their way into the sensitive rf stages of receivers and transceivers. Here again, the actual lightning may be kilometers away and still generate enough transient energy to damage unprotected equipment.

When I was younger and didn't know better, I used to connect an NE-2 neon lamp across the lead-in of an unused antenna to detect these occurrences. Even when an electrical storm was far away (and although the NE-2 requires about 90 volts to ignite), it would flash with almost every lightning strike. Naturally, for safety reasons, I don't recommend that anyone try this experiment. However, it should give you some idea of the amount of energy an antenna system can absorb and what can happen if you don't protect sensitive circuits.

Other forms of ac voltage transients may come from arcing contactors, incandescent lighting dimmers, electric drills, appliance motors with brushes, power-line switching, and many more. Also, air conditioning motor-starting contactors can produce damaging transients, as well as relays in the control circuits.

**why is protection required?**

To further illustrate the fact that sensitive solid-state equipment should be properly protected, refer to a study conducted by the General Electric Company in 1969. In this study, which took two years to complete, surge voltages in both residential and industrial circuits were measured at 400 different locations in twenty cities.

Surprisingly, higher surge levels were recorded in the residential circuits than in the industrial areas. In addition, the results showed a peak as high as 2500 volts generated by a motor contactor within a residence, and nearby lightning generated a 5600-volt peak on a 120-volt residential service. There were also a significant number of surges in excess of 2000 volts occurring in homes on a repetitive basis.

The GE study proved conclusively that residential lighting circuits are subjected to severe transients, as well as any electronic equipment connected to those circuits. As a result, the solid-state equipment in your home is subject to damage from voltage spikes if not properly protected.

**suppression of transients**

There are several ways to suppress voltage transients, and depending on the circuit application,
some devices are better than others. Some of the devices available for you to choose from include metal-oxide varistors, power zeners, and short-circuiting devices such as spark gaps and electronic crowbar circuits.

**Metal-Oxide Varistors.** These dynamic resistance devices feature both low cost and small size, and are capable of dissipating a considerable amount of energy for a short period of time. One source for metal-oxide varistors is the General Electric Company; their registered trade name for these devices is GE-MOV. These varistors are available from most electronics supply houses.

If you are going to use these devices, I would recommend that you obtain a copy of GE’s “Transient Voltage Suppression Manual,” ($2.50 from GE, Semiconductor Products Department, Electronics Park, Syracuse, New York 13201). This manual is a complete guide to the proper application of varistors.

Since varistors are bi-lateral devices, they may be used in both ac and dc applications. In low-voltage dc applications, however, they may not provide adequate protection due to their soft clamping characteristics. They are generally more suitable for ac line voltages, and consequently are excellent in suppressing transients on the line side of equipment power supplies. An example is shown in fig. 2.

**Power Zener.** While varistors may exhibit soft characteristics at low dc voltages, power zeners can clamp very hard and fast at those voltages. Also, high transient currents do little to raise the clipping level of most zeners, provided ratings are not exceeded. The most effective way to apply zeners is with some amount of series resistance to safely limit the current. Two schemes for protecting both ac and dc circuits are shown in fig. 3.

**Short Circuit Methods.** At first, this approach may seem contrary to normal applications. After all, a short circuit in most cases is a very undesirable situation. However, if it is properly controlled and occurs for very short periods of time (microseconds), the end result can be very beneficial in suppressing transients.

The two most commonly used devices in this category are spark gaps (both open and sealed units) and electronic crowbar circuits. The first is often used by amateurs for antenna applications, while the second is usually too complex for most hobby applications. The spark gap is adjusted to arc at a voltage above a certain level, effectively grounding the transient energy. Which method or combination of methods you choose, will depend on the application and what you are attempting to protect.

The best approach is to buy transient suppressors only in component form and apply them yourself using the guidelines in this article. Only then can you be assured of applying these useful devices for their intended purpose — protecting solid-state devices from voltage transients.

**Reference**


**Ham Radio**
WHERE RELIABILITY & ACCURACY COUNT

INTERNATIONAL CRYSTALS

70 KHz to 160 MHz

HOLDER TYPES

F-609
F-605
F605-SL

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

INTERNATIONAL CRYSTAL MANUFACTURING CO., INC. guarantees every crystal against defective materials and workmanship for an unlimited time, when used in equipment for which they were specifically made.

CRYSTAL TYPES

(GP) for "General Purpose" applications
(CS) for "Commercial" equipment
(HA) for "High Accuracy" close temperature tolerance requirements

International Crystals are available from 70 KHz to 160 MHz in a wide variety of holders. WRITE FOR INFORMATION

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee, Oklahoma City, Oklahoma 73102
405/236-3741
The Drake TR-7 System significantly advances the technology of worldwide radio communications and unfolds an entirely new state of the art.
solid state synthesized hf system

In 1963 Drake led the way by producing the first commercially available transceiver that employed the now widely copied 9 MHz i-f frequency. Even today, 15 years later, many major competitive transceivers are still being introduced using i-f's in this range.

In 1978 Drake led the way again by developing the first commercially available amateur transceiver that uses a 48 MHz i-f, through the technique of "Up-Conversion." This system greatly improves image and general coverage performance, and will be copied in the years to come. With Drake, you can join the new state of the art today!

The design philosophy behind the new Drake "7 system" has created a most sophisticated system concept, extending from engineering to the visual appearance of the system and each of its parts.

The TR-7 System is the result of one of the most extensive engineering and development programs in the history of the R. L. Drake Company, and provides the user with many innovative design features.

With the excellent design of its front panel and controls, the system is simple and straightforward to operate—makes state of the art performance a pleasure.

Broadband, Solid State Design—100% solid state throughout. All circuits are broadbanded so there is no need for preselection tuning or transmitter adjustments of any kind.

Synthesized/PTO Frequency Control—A Drake exclusive: Special high performance synthesizer, combined with the famous Drake PTO, provides smooth, linear tuning with 1 kHz dial and 100 Hz digital readout. 500 kHz up/down range switching is pushbutton controlled.

Continuous, Wide Range Frequency Coverage—The TR-7/DR-7 provides reception from 1.5 thru 30 MHz—continuously, and zero thru 30 MHz continuously with the optional Aux-7 Range Program Board. The highly advanced Drake Synthesizer makes this possible, and is an industry first. The TR-7/DR-7 provides transmit coverage for all Amateur Bands 160 thru 10 meters. With the optional Aux-7 Range Program Board, diode-programmable out-of-band transmit coverage is available for MARS.

State of the Art Receiver Design—The Drake TR-7 introduces another industry first for amateur transceivers: "Up-Conversion," in combination with a special uhf high level double balanced mixer for superior strong signal handling, spurious and image response performance. The first i-f of 48.05 MHz places images well outside the receiver passband, and provides for true general coverage operation without i-f gaps.

True Passband Tuning—The TR-7 employs the famous Drake Full Passband Tuning instead of the limited range "i-f shift" found in some other units. The Drake System tunes from the top edge of one sideband, through center, to the bottom edge of the other sideband. In fact, the range is even wider to accommodate RTTY. Full passband tuning greatly improves receiving performance in heavy QRM.

(Note: Out-of-band transmitter coverage for MARS, Government, and future band expansions in the range 1.5 thru 30 MHz. The Aux-7 Board provides 0 thru 1.5 MHz receive coverage and crystal-controlled fixed channel operation for Government, Amateur, or semi-commercial applications anywhere in the hf range. The TR-7 w/o DR-7 and Aux-7 provides coverage of the Amateur Bands 160 thru 15 meters and the 28.5-29.0 MHz range of 10 meters. The Aux-7 Range Program Board is also useable in the standard TR-7 for extra range coverage as noted.)
DRAKE TR-7 solid state
continuous coverage synthesized hf system

Unique Independent Receive Selectivity — Optional receiving selectivity filters can be installed internally and pushbutton-selected from the front panel. These may be selected independently of transmit mode and provide optimum response for various conditions of ssb, cw, RTTY, and a-m. You may also transmit cw while receiving ssb, or vice versa, or even transmit one sideband while receiving the other. The standard filter is 2.3 kHz for ssb. You may choose from optional 300 Hz, 500 Hz, a special 1.8 kHz for crowded ssb, or 6 kHz filter for a-m.

Effective Noise Blanker — This accessory is custom engineered to provide true blanking performance.

Special High Power Solid State PA — A Drake custom-designed diagonal heat sink provides for an internally mounted power amplifier with nothing mounted outboard subject to physical damage. The unique air ducting effect of this amplifier allows an optional rear-mounted fan to provide continuous duty on SSTV/RTTY. Continuous ssb/cw operation is available without the fan, due to the excellent heat sink design. The optional Drake PS-7 Ac Supply is rugged, rated for continuous duty, and will easily handle power requirements. The System is rated 250 watts input—in any of its modes. Fully VSWR protected.

TR-7 Internal Test Facilities — As well as the standard “S” meter function, the TR-7 metering includes a built-in rf Wattmeter/VSWR Bridge. Also, the DR-7 digital counter reads frequencies to 150 MHz for test purposes. Access to the counter is from the rear panel.

Receiver Incremental Tuning (RIT) — Complete RIT flexibility is provided for both the TR-7 and RV-7 remote VFO for maximum convenience. The RV-7 also includes a special “spot” function for easy zero beating.

Model 1337 Drake TR-7 Transceiver ............... $886.00
Model 1530 Drake DR-7 General Coverage/ Digital Readout Board ............. 186.00
Model 1336 Drake TR-7/DR-7 General Coverage Digital R/O Transceiver .......... 1072.00
Model 1338 Drake RV-7 Remote VFO ................ 156.00
Model 1502 Drake PS-7 120/240V Ac Supply includes special wide range voltage and frequency capability. Operates from any nominal line voltage (90-132 V/ 180-264 V; 50-60 Hz) ideal for overseas $166.00
Model 1536 Drake Aux-7 Range Program Board .... 38.00
Model 1531 Drake MS-7 Matching Speaker .......... 33.00
Model 1537 Drake NB-7 Noise Blanker .............. 74.00
Model 1529 Drake FA-7 Fan .......................... 24.00
Model 7021 Drake SL-300 Cw Filter, 300 Hz .......... 49.00
Model 7022 Drake SL-500 Cw Filter, 500 Hz ........... 49.00
Model 7023 Drake SL-1800 Ssb/RTTY Filter, 1.8 kHz 49.00
Model 7024 Drake SL-6000 A-m Filter, 6.0 kHz ........ 49.00
Model 1335 Drake MMK-7 Mobile Mounting Kit .... to be announced
Model 1538 Drake MN-7 250 Watt 160-10 Meter Antenna Tuner with Rf Wattmeter and complete switching functions .... 165.00
Model 1514 Drake WH-7 Hf Wattmeter/VSWR Bridge 89.00

The Drake State of the Art unfolds an entirely NEW Art of the States!

To receive a FREE Drake Full Line Catalog, please send name and date of this publication to:
R. L. DRAKE COMPANY
540 Richard St., Miamisburg, Ohio 45342
Phone: (513) 866-2421 • Telex: 288-017
Western Sales and Service Center, 2020 Western Street, Las Vegas, Nevada 89102 • 702/382-9470

80 June 1978

More Details? CHECK-OFF Page 142
Protect both the new circuit and power supply by using this high-current instantaneous shutdown power supply.

Anybody who builds a semiconductor circuit is faced with a potentially disastrous problem — what will happen when power is applied to the circuit? A short circuit could be catastrophic, for both the power supply and the newly-built circuit.

A high-current regulated power supply will continue to supply power, even with a short circuit, until one of the following events takes place.

1. The short circuit clears itself.
2. A semiconductor failure occurs (either the silicon or metal leads melts).
3. The power supply is damaged.

By Alan Nusbaum, W6GB, Dalmo Victor Operations, Bell Aerospace Textron, Division of Textron, Inc., 1515 Industrial Way, Belmont, California 94002
4. A fuse is blown, but usually too late to protect the circuit.

5. The power supply contains an extremely fast over-current sensing circuit that will cut off the current in less than 200 nanoseconds.

This article will describe just such an over-current shut-down circuit.

Over the past few years, there have been some new and novel voltage-regulator devices which will tolerate shorts or over-current loads by application of current fold-back circuits or thermal shutdown. Other versions which use a crow-bar device rely on blowing a fuse in the power supply primary. This method, however, is rather brutal treatment, and is often fatal to the pass transistor. I feel that a "graceful" but high-speed shutdown circuit is necessary to protect both the newly developed circuit and the power supply. Essentially, it must shutdown and not

As seen in fig. 1, a PNP pass transistor is driven by a complimentary NPN monolithic Darlington. The Darlington in turn is current driven by a medium-gain transistor which acts as a voltage error detector. This form of regulator has proven to be very sensitive and reliable in that it will hold to within 30 mV from no load to a 15 ampere load, with less than 10 mV ripple at full load.

The shutdown portion of the circuit uses an SCR to rob the base current from the Darlington pair. When the SCR is triggered from the voltage comparator, the point between the 470-ohm resistor and CR2 is effectively grounded, reducing the output voltage to zero. U1, a µA311 voltage comparator, is used to sense the voltage drop caused by over-current across the two 0.1-ohm resistors. The noninverting input of the comparator is fed from a separately regulated source (U2). The inverting input is the actual output voltage, after it has been appro-

![Fig. 1. Schematic diagram of the high-current power supply. The separate 5-volt regulator is used to bias one input of the voltage comparator. The SCR is fired when the second leg of the voltage comparator detects a drop across the 0.1 ohm resistors. S1 is a normally-closed momentary type switch. Q1 must have an adequate heatsink (see text).](image)

be allowed to restart after some pre-determined current level has been exceeded.

This power supply contains a high-gain error voltage control circuit and a voltage comparator that functions as a high-speed switch.
condition. The green and red LEDs are used to indicate the status of the regulator, with red indicating that the SCR has been fired.

### construction

The actual construction of the power supply is straightforward. However, the pass transistor must have an adequate heatsink. The power dissipated is

\[ W_{\text{diss}} = (V_{\text{in}} - V_{\text{out}}) + V_{\text{CEsat}} \times I_{\text{CE}}. \]

To setup and adjust the supply, all components are connected with the exception of the SCR, Q6. A 100-ohm, 100-watt adjustable resistor can be used as a load. With the load resistor set for maximum resistance, the power supply is energized and R1 is adjusted for the desired output voltage (13.6 volts). An oscilloscope can also be connected to determine if there are any oscillations on the output waveform. If so, a 27-pF capacitor connected from collector to emitter of Q3 should eliminate the problem.

With a high-impedance voltmeter connected to the wiper arm, R2 should be adjusted to provide 2 volts to the comparator. This is the reference set point and should not be disturbed once set. After moving the voltmeter to the wiper of R3, this potentiometer should be set for a reading of 2.5 volts. With the meter still connected to R3, change the tap on the load resistor to the 50-ohm point. The 2.5 volt reading should not change.

The final step consists of checking the action of Q6. With the power supply switched off, connect the SCR. Also disconnect the load resistor and set the slider for a resistance of 1 ohm, but do not reconnect the resistor at this time. After re-energizing the supply, the red LED should be on; pressing the arm switch will turn on the green LED while extinguishing the red. If the LEDs do not function as indicated, remove the SCR and check the voltage on R3 to ensure that it’s no lower than 2.5 volts. Also, check the voltage on the output of the comparator; it should be less than 100 millivolts. With the SCR installed and the circuit armed, the gate of Q6 should also measure less than 100 millivolts.

To test the circuit, momentarily connect the 1-ohm load resistor to the supply output. The shutdown circuit should operate instantaneously, and the red LED should come on. You should test this action several times to verify consistent shutdown.

At one ohm, the load current is 13.6 amps, but you can adjust R3 to actuate the shutdown at any current you desire. However, the voltage from R3 must not be lower than R2’s voltage or the circuit will lock up in the fired mode. This system has been in use for over a year and has operated flawlessly during the entire time, even when powering tube-type mobile transmitters.

---

**ham radio**

---

**DISC-CAP, 1434 REYNOLDS ST. AUGUSTA, GA. 30902 404-722-1121**

Ga. Residents add State Sales Tax. Unfortunately, Disc-Cap can only service U. S. customers.
command function debugging circuit

This device takes command information from standard PLL function decoders and applies a short time delay to provide debugged control commands.

Our club had just finished installing an autopatch, exhausting all available funds, when the need for a better command decoder became evident. Each of the users had noted voice falsing of the decoder, and it was enough of an annoyance to be serious. More than once a telephone conversation had been terminated by a voice peak.

The investigation of causes and cures ran the gamut, until we finally decided that a fraction of a second delay on the command-function decoders would probably solve the problem. A number of designs were passed around and considered, and a few almost built, but the one described here was finally implemented — for three reasons: one, it works; two, it costs nothing to build; and three, it was built before any of the others. The design was based on the available components, and on the assumption that it might be necessary to drive a number of different types of loads. These considerations led to the use of transistor switches and reed relays to provide the outputs.

circuit description

The output circuitry from the tone decoder is shown in fig. 1. In our repeater, the debugging circuit was added without making any modifications to the autopatch. As shown in fig. 2, the debugging circuit consists of two portions, the transistor switches are wired to provide $V_{cc}$ to their respective reed relays and the delay circuit which provides the ground return for the relay coils. Since only one relay

By J. Thomas Norman, WA7HFY, 1002 South 8th Street, Laramie, Wyoming 82070
is actuated at a time, only a single delay circuit is required. The diodes at the input of the delay timer form a multiple-input OR gate to actuate the delay after any digit has been decoded.

The timer itself is not very critical, especially since four different transistor types were used (even an unidentified NPN transistor). In its quiescent state, Q1 is biased on, charging C1 to approximately 8 volts. This level maintains Q2 and Q3 on, and Q4 off. When a function is decoded, Q1's base is effectively grounded back through the two diodes and QA. With the transistor now cut off, C1 will discharge through R3.

The value of this resistor can be adjusted for the desired amount of time delay, in our case approximately 0.1 second. When the voltage on the base of Q2 drops below about 1.2 volt, Q2 and Q3 are cut off and Q4 is turned on. With Q4 on, the reed relay is actuated, but when a noise spike is decoded as a pulse, the 2N3644 is turned on; since most noise pulses are very short in duration, they do not allow the timer to complete the circuit to actuate the relay.

ham radio

fig. 2. Schematic diagram of the add-on debugging circuit. Instead of the commands being controlled by transistor switches, they are controlled by reed relays. The delay portion of the circuit prevents the relays from picking up on noise spikes. The transistors can be almost any NPN type. R3 should be adjusted for the desired delay.

The value of this resistor can be adjusted for the desired amount of time delay, in our case approximately 0.1 second. When the voltage on the base of Q2 drops below about 1.2 volt, Q2 and Q3 are cut off and Q4 is turned on. With Q4 on, the reed relay is actuated, but when a noise spike is decoded as a pulse, the 2N3644 is turned on; since most noise pulses are very short in duration, they do not allow the timer to complete the circuit to actuate the relay.

ham radio
ALDA 103 is completely manufactured in the U.S.A.
How to use no-cost parts salvaged from an old broadcast radio to build a grid dipper that tunes from 1 to 90 MHz.

In these days of shortages and skyrocketing prices it seems improbable that anything could be free. However, except for a little spray paint, the instrument described here can, in truth, be free. Originally it was built for novice use to enable them to prune antenna systems, and to serve as an absorption wavemeter to assure output was on the correct band. It has proven so stable and reliable, however, that it can also serve a more experienced ham as a rugged instrument for general purpose work, and where considerably more output is needed than is available from solid-state dippers.

The frequency range is limited to approximately 1-90 MHz due to the variable capacitor I used for tuning. If a fairly clean capacitor is used — one which is not corroded and has good wipers — tuning will be unusually smooth and free from spurious dips. From the photographs it is obvious that it is more bulky than most commercial dippers. The vacuum tube protruding from the end may not be pretty, but this arrangement contributes substantially to frequency stability.

The schematic, fig. 1, shows the basic circuit. The tuning capacitor is the type commonly used in older five-tube ac-dc broadcast sets. If you have no 150-volt supply easily available, you can add a series resistor in the B+ line. This resistor should be about 50k for each 100 volts higher than the desired 150-volt supply. For instance, if the dipper is to be run from a 350-volt supply, the supply voltage is 200 volts too high, so a 100k dropping resistor would be chosen. It can be any value from 82k to 120k, and should be rated at 2 watts. The heater voltage can probably be picked off the same supply.

If you don’t have a milliammeter available, you can use a 1000 ohms-per-volt multimeter on the 1.0- or 1.5-volt scale, or you can install a 2.2k resistor in place of the meter and read across this resistor with a 20,000 ohms-per-volt multimeter or vtvm on a 1.0- to 1.5-volt scale. This hookup is shown in fig. 2.

If you want to modulate the dipper, you can add the simple circuit shown in fig. 3. This transistor oscillator is powered by the dipper grid current and grid modulates the dipper. This makes it easier to locate the dipper signal during calibration, and allows the dipper to be used as a temporary signal generator for alignment work.

By Bill Wildenhein, W8YFB, 41230 Butternut Ridge, Elyria, Ohio 44035.
The dipper can also be used to check that your rig is tuned to the correct band. Switch off the B + voltage to the dipper, but leave the heater voltage on. Poke the dipper into the rig near the output tank coil after you have tuned the rig, and tune the dipper for a peak instead of a dip. The peak will indicate which band you are actually on. Be careful of the high voltage!

**plug-in coils**

All the coils are wound on bases of defunct octal tubes. For those of you who have never smashed tubes, it can be done safely by holding the tube by the base with the glass envelope against the inside of a wastebasket. Give the glass a sharp rap with a hammer and the tube breaks without showering glass around as you would expect. Normally, the glass part cemented into the base remains relatively intact. This part of the glass can be broken up by punching it with a screwdriver. The remaining cement can easily be scratched out with a jackknife. Remove the leads from the pins by applying a soldering iron to the tips of the base pins while you pull on the leads with a pair of pliers.

Line up the tube bases after they are cleaned and select a pair of pins roughly opposite from each other (different tubes may have different base arrangements with some pins missing). Adjacent to one pin drill about a 1.5 mm (1/16 inch) hole as close to the bottom of the base as possible. Adjacent to the other pin, drill a 1.5 mm (1/16 inch) hole 14 mm (9/16 inch) higher up on the socket from the first hole. Be sure the desired pins are cleaned of solder. It sometimes helps to run a piece of enameled wire down through the pin hole while heating the pin with a soldering iron. The wire sizes listed on the schematic need not be exactly as shown. Those are the wire sizes I used, but coils 2, 3 and 4 could use the wire commonly used in the yoke windings of TV sets. The first coil could use either number-34 or -36. This size range is often found in audio interstage transformers. If you are unwinding a transformer, it is easy to find out whether a particular wire size will fit. From the loose end of the transformer winding, measure 14 mm (9/16 inch) and place a bit of masking tape there as a marker. As you unwind to this point, count the turns. If there are at least 80 turns to that point, the wire is small enough for the job.

As a last resort, if you can’t find wire that small, you can find a size that allows perhaps, 60 turns in the total length. Wind the 60 turns, then continue winding over the first layer to get a smooth layer of about 15 turns. Then wind up over that second layer with a third layer totaling, perhaps, 10 turns. If you have never hand wound coils, here are some of the basics: First, carefully scrape the enamel insulation from one end of the wire. Poke the end through the hole in the base nearest the pin end. Now poke the wire down through the proper pin and solder it into the pin. Carefully pull the excess wire back through
The finished grid-dip oscillator with the coils for different tuning ranges.

stand it on the open end of the form as the cement slowly tries to run off the form. When it sets sufficiently that it stops running, leave it overnight. The next day add a second heavy coat. This will form a protective coating that will securely hold the turns in place when inserting or removing the coil, assuring that your calibration remains accurate.

Several of the coils are space-wound. After the winding of these coils is completed, the turns can be adjusted slightly until they are uniformly spaced.

**enclosure construction**

The photograph of the disassembled dipper shows the method of forming the sheet metal case. It was made of galvanized iron of the type used for furnace ducts. To form the sheetmetal box you need a couple lengths of angle iron about one foot long, and one piece about 5.7 cm (2-1/4 inch) long. Cold-rolled steel barstock is even better. Stock about 13x19 mm (1/2 by 3/4 inch) is good. In case you have neither, pick up some scraps of oak flooring and have a friend cut off the tongue and groove to give you a nice sharp corner. You also need a vise and a fairly husky C-clamp. Be sure to lay out and bend up the main chassis first. Fig. 4 shows the layout I used. If your tuning capacitor is larger, make your box slightly larger. Take pains to make the layout very accurate. It saves headaches later when you bend up the lid.

Fig. 5A shows a cross-section if the bends are made correctly. Notice that the overall width is 6 cm (2-3/8 inch) plus two metal thicknesses. The reason for this is quite obvious if you look at fig. 5B. If the bending bar is placed exactly on the line, the outside edge of the metal extends one metal thickness beyond the line. Now look at fig. 6A: the metal is clamped differently than in fig. 5B. If you make one bend as in fig. 5B and the other bend as in fig. 6A, you will end up with the lopsided, inaccurate cross section shown in fig. 6B. Compare the dimensions with those in fig. 5A; to get these dimensions, you must clamp the bending bars as shown in fig. 7.

This leads to a simple sheet-metal rule: if you want the inside dimension of a U-shaped bend held to a
size marked on a layout, the bending bars must also be on the inside, as shown in fig. 7.

For this first piece, the outside dimension is relatively unimportant. The lid is the really important piece because it must fit around this first box, and the inside measurement of the lid must be accurate. After this first piece is bent up, carefully measure the width at all points, then lay out and bend the lid. Next, lay out the holes in the lid and drill them with about a 5 mm (3/16 inch) drill. After removing the burrs, place the two sections together and carefully mark the hole locations on the inner box. These can be drilled with a number 36 (2.5 mm) drill. Then the box can be assembled with number 6 (about 3.5-mm diameter) sheet-metal screws salvaged from scrap TV sets.

![fig. 5. Proper method of bending the sheet metal used for the chassis (see text).](image)

Locate and drill all socket holes, mounting holes and check the fit, then thoroughly clean both pieces with household cleanser. After they are dry they can be sprayed inside and out with grey primer paint before assembly and wiring is begun. The dial is made from a piece of card stock glued to the outer box. This is covered with a piece of clear plastic (small pieces are often available as scrap from hardware stores or glass shops). The "unbreakable" window panes are usually Plexiglass or Lexan, and they have very good rf insulating properties. For using a dial bezel, it is masked, then the layout drawn on the masking tape. With a sharp knife, cut away the part to be painted and spray with acrylic lacquer.

Your first homemade enclosure may take time and may be less than a professional job, but if you practice, using scraps of metal that can be picked up free, you will soon find it possible to do a fast, accurate job the first time. I usually spend less than a half-hour to make this sort of enclosure. The result is that you are no longer limited to standard box sizes or costs. Your dollar savings will pay for any investment in tools many times over. For example, you can get a combination square at a discount store for as little as a dollar, but in most cases they are anything but square! The aluminum or pot metal die-cast head may warp still more. For about $5.00 you can get one with a steel or cast-iron head that will be acceptably accurate for sheet metal work. With just a little care it will last you the rest of your life, and will guarantee a lifetime of accurate boxes.

If you have a very limited budget and can't afford anything but that discount store square, here is a way to check the square in the store, and pick the one that is square (see fig. 8). Take along a piece of sheet metal that has one edge sheared true and straight. If the square isn't a true 90 degrees, it will show up immediately as shown in the drawing. Just place it on the metal as shown in position A and scribe a line on the metal. Swing it around to position B and see if it falls exactly on the previously scribed line. Watch out for a head with a crooked edge, as in fig. 9. Strive for an accuracy of about 0.5 mm in 25 mm (1/64 inch in 10 inches), or better. It will make your work far easier.

**calibration**

Finally, let's cover calibration of the grid dipper. Up to about 30 MHz it can be checked against a general-coverage receiver. Above that frequency you may have to find a friend with a calibrated vhf dipper. Begin calibration at the lowest frequency and work toward the high end because general-coverage receivers commonly use a 455-kHz i-f which leads to poor image response at the higher frequencies. Starting at the low end, your calibration points will be accurate. If you are in doubt about one point, you can return to the last point to be sure you are correct, then carefully proceed higher in frequency. Another check is to watch the receiver's S-meter. The image signal is usually noticeably lower on the S-meter.

![fig. 6. If bend bars are not used properly, one side of the chassis will have a different dimension than the other due to metal thickness (see text). Proper setup is shown in fig. 7.](image)
fig. 8. Simple method for checking the accuracy of a low-cost square.

Since the power output of this dipper will probably be as high as 200 milliwatts, it is inadvisable to attempt to use it to dip circuits connected to solid-state devices. You can easily blow a transistor. Remove the transistor before checking a circuit, but realize that the transistor itself adds capacitance to the circuit. I usually dip tank circuits before installing them, and include a small fixed capacitor to represent the capacitance of the transistor.

In conclusion, although this device is a homely looking gadget built from junk, it is still worth the effort to do the job right. I find it so stable and reliable that it has become one of the hardest working tools on my bench. I hope you enjoy the same benefits.

ham radio

fig. 9. Beware of low-cost squares that are not perfectly flat—they should not rock against the test piece as shown here.

SAY Electronic Power Supplies

Completely Regulated 13.8 to 20 volts dc, variable. Separate volt and amp meters. Dual protection against over voltage and over current.

<table>
<thead>
<tr>
<th>Model</th>
<th>Current</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 amp</td>
<td></td>
<td>$59.95</td>
</tr>
<tr>
<td>8 amp</td>
<td></td>
<td>$109.95</td>
</tr>
<tr>
<td>20 amp</td>
<td></td>
<td>$159.95</td>
</tr>
</tbody>
</table>


CALL FOR QUOTES ON ITEMS NOT LISTED. THIS MONTH'S SPECIAL: BEARCAT 210 SCANNER $249. BEARCAT 250 WRITE OR CALL.

CALL FOR FAST QUOTES SPECIAL ORDERS WELCOME

TERMS: All prices FOB Houston. Prices subject to change without notice. All items Guaranteed. Some items subject to prior sale. Send a letterhead for Authorized dealers price list. Texas Residents add 5.5% tax. Please add postage to estimate.

MADISON ELECTRONICS SUPPLY, INC.

1508 McKINNEY HOUSTON, TEXAS 77002
713/658-0268
Nites 713/497-5683

june 1978
neat packaging for vhf prescalers

Novel packaging for K4GOK's prescaler uses readily available parts

At least one thing is quite apparent from the popularity of technical literature in amateur radio circles. A large part of the hamming community is putting certain minimums of time into electronic gear construction. To a big segment of talented do-it-yourselfers in hamdom, this kind of involvement is necessary to get maximum enjoyment from the hobby. It's not easy. Even those who live for the smell of hot rosin and solder soon learn that workbench time is a scarce luxury. One result of the paucity of time is that we get only the highest priority stuff to the bench and quite simply, lean on the stories others tell (or write) to learn about out-of-reach or lower priority items.

It is pretty well known that not being in a position to build a super hot new receiver doesn't spoil the fun of reading about how the author did it. The buzz word for this, of course, is vicarious and we'd be in rough shape without being able to enjoy things vicariously.

Even with the best intentions, many construction projects find their way into a file cabinet to await future action. Occasionally one may be pulled from the file and placed on the workbench for further thought, but every now and then lightning strikes and a construction article comes along to absolutely ruin your peace of mind until you can translate that writer's words into reality.

K4GOK's prescaler, as detailed in *ham radio* for February, 1976,* was just such a bolt for me. It turned out so well and so easy to assemble that I thought it deserved a little extra mention in all the shacks where it is filed under projects — future.

There is probably a great number of frequency counters in use which conk out at 50 MHz — or less. The need, however, for accurate frequency measurement in today's hamshack is in the order of 300 MHz, and if not a requirement for 2-meter fm, it is certainly a great convenience.


By Alan Smith, W8CHK, 3213 Barth Street, Flint, Michigan 48504
There is no problem if you are in a position to select your needs from a supplier’s shelf, but if you are in the more common position and want to soup up a flea market special or your old reliable Heath 1101, this prescaler is for you.

The construction approach recommended here is to build the prescaler as a separate unit. It will be easy on time and gentle on your pocketbook. You can even get several parts at your local Radio Shack store.

The unit in the photograph was built by my son, WB8YO6, and is a self-contained copy of the circuit described by K4GOK. As shown in the photo, it is set up to prescale two-meter signals with a rubber duck antenna as the coupling element.

The case is an Archer 270-250 ($2.98 from Radio Shack). You can get the transistors at Radio Shack by substituting 2N706 for 2N5179 and MPS-6533 for 2N5771. Otherwise the circuit can be assembled exactly as described in the original article.

The power supply is conventional. It requires a circuit-board transformer with an output voltage of 5.5 volts or more up to a maximum of 12 volts at 300 mA, a standard 500 mA bridge rectifier, one 1000 µF electrolytic capacitor, and an LM309K IC voltage regulator. The LM309K will keep the supply voltage at the required 5 volts.

These parts can be neatly fastened to a square of perf board and secured to the case, or the transformer can be fastened to the base and the remaining components simply hard wired. Add an on-off switch and a miniature red indicator light and you’ll be ready to start prescaling.

HAM RADIO

In the past when your YAESU or KENWOOD dealer said the CW crystal filter for your set was optional you had a choice. Buy one of his standard units or do without.

NO LONGER!
Now FOX-TANGO not only offers filters similar in bandwidth to those supplied by your set’s manufacturer, but also sharp eight-pole, 250 Hz bandwidth filters with superior shape factors at an unbeatable price — some similar units are being advertised for $100! And even so, they are not as sharp.

BUT THAT’S NOT ALL
Yaesu’s CW filters for the FT-101, FR-101 and FT-301 Series have a bandwidth of 600 Hz. Most hams feel 600 Hz is too wide for today’s conditions but that’s not the only reason they find the going rough when the band is crowded. Yaesu’s filters are only six-pole. Ours are eight-pole — with a superior shape factor and 500 Hz bandwidth. Wide enough for tuning ease, yet sharp and selective enough to cut through all but the heaviest QRM. And for the competitive DXer the FOX-TANGO now offers, in addition to the sharp eight-pole 250 Hz units for the TS-520, R-599, and the TS-820 Series, new eight-pole 400 Hz filters with characteristics superior to those of the regular Kenwood 500 Hz units.

SOME REAL OPTIONS
But talk about FREEDOM OF CHOICE! Inexpensive, easily installed diode-switching boards are now available for all the above sets which permit the addition of up to two crystal filters in addition to those for which the manufacturer provides space. For example, if you have no CW filter at present or are just buying your set (which never comes with the filter factory-installed) you can select either of our superior units, secure in the knowledge that you can add the other later if you wish. Or if your rig already has a standard CW filter installed, you can add our sharp unit so that either can be switched selected often using existing front panel controls. Just imagine! Nail your rare DX with the standard-type filter and cut out the crud and crowd with the flip of a switch. Now that’s OPERATING!

HOW WE DO IT
Some hams have wondered how we can offer superior filters at such a low price. And they are superior, not only on the basis of laboratory tests but according to members of the International Fox-Tango Club who have used them in their rigs for many months. The answer to the “low price” question is that these filters are made for us in Japan by a concern with almost a quarter-century of experience in the design and production of these units, among others, for use in the best-known and most respected brands of both amateur and commercial gear. In the past their filters were sold exclusively to set manufacturers. Now they are being offered at retail for the first time — and at introductory prices — through our organization only.

GET YOURS NOW AND BEAT THE INFLATIONARY SPIRAL!
Our filters are sold on a Money-Back Guarantee Basis.

FOX-TANGO CORP.
Box 15944, W. Palm Beach, FL 33406

DIODE SWITCHING BOARDS permit easy mounting (without drilling) of up to two crystal filters of any type in addition to those for which the manufacturer provides space. These boards will accommodate any of the filters listed below and other types planned for the future. They include one stage of amplification to compensate for filter insertion losses. Complete instructions. SPECIFY Set with which board is to be used. $15 with purchase of any filter. $20 without filter. Airmail Pkt US & Canada. Overseas add $3.

ALL TYPES

Only $50
Circle type desired.

I enclose $  

□ Check  
□ Money Order  
□ VISA
□ Master Charge

I prefer to charge my

[ ] Name

Account No.  

□ Address

Expiration date:  

□ City

MC 4 digit no:  

□ State

Florida residents add 4% Sales Tax

june 1978
precision voltmeter calibrator

It's always nice to have a high-accuracy, digital voltmeter around, but unfortunately they're very expensive. To solve this problem, I decided to build a variable voltage source to accurately calibrate the dc voltmeters I had on hand. There have been many precision ten-volt sources described in current literature;\textsuperscript{1, 2, 3} I have used the circuit shown in reference 1 as the basis for my design.

\textbf{circuit details}

The circuit shown in fig. 1 will produce from 0 to 10 volts with an error of less than 20 millivolts. In addition, it's also accurate with meter movements that have an internal resistance as low as a few thousand ohms. The 10 volts developed by the LM308 appears across R4. In my case, I used a ten-turn potentiometer and a suitably accurate ten-turn dial. The output from this potentiometer is fed into a 741 op amp connected for unity gain. In this way the op amp's high-input impedance will have negligible loading on the voltage source and its low output impedance will allow the calibration of meters with low internal resistance.

It will be necessary to null out the small dc offset error which appears at the output of the 741 op amp. This is accomplished by the 10k potentiometer, R5; ground the input of the 741 and adjust R5 for zero volt output. The nulling procedure must be completed before final calibration is attempted. Table 1 shows the results of calibration against a known voltage source.

For operation, this calibrator requires plus and minus 15 volts, at less than 50 mA. The normally closed switch shown in fig. 1 is used to start the calibrator by creating a transient through the 560 pF capacitor. If the power supply for the calibrator is already running, this switch can be eliminated. Finally, you should realize that this calibrator can not be used as a substitute for a variable voltage power supply.

\textbf{table 1. Calibration results for the 0 to 10 volt standard.}

<table>
<thead>
<tr>
<th>nominal voltage as read on R4</th>
<th>laboratory potentiometer reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td>8.00</td>
<td>7.99</td>
</tr>
<tr>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>5.00</td>
<td>5.01</td>
</tr>
<tr>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>3.00</td>
<td>3.60</td>
</tr>
<tr>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\textbf{references}


\textbf{By Hubert Woods, Calle Las Nubes, 1760, Guadalajara 5, Jalisco, Mexico}
This new instrument has taken a giant step in front of the multitude of counters now available. The Opto-8000.1 boasts a combination of features and specifications not found in units costing several times its price. Accuracy of ±0.1 PPM or better—Guaranteed—with a factory-adjusted, sealed TCXO (Temperature Compensated Xtal Oscillator). Even kits require no adjustment for guaranteed accuracy! Built-in, selectable-step attenuator, rugged and attractive, black anodized aluminum case (.090” thick aluminum) with tilt bail. 50 Ohm and 1 Meghm inputs, both with amplifier circuits for super sensitivity and both diode/overload protected. Front panel includes “Lead Zero Blanking Control” and a gate period indicator LED. AC and DC power cords with plugs included.

SPECIFICATIONS:
- Time Base—TCXO ±0.1 PPM GUARANTEED!
- Frequency Range—10 Hz to 600 MHz
- Resolution—1 Hz to 60 MHz; 10 Hz to 600 MHz
- Decimal Point—Automatic
- All IC’s socketed (kits and factory-wired)
- Display—8 digit LED
- Gate Times—1 second and 1/10 second
- Selectable Input Attenuation—X1, X10, X100
- Input Connectors Type—BNC
- Approximate Size—3” x 7½” w x 6½” d
- Approximate Weight—2½ pounds
- Cabinet—black anodized aluminum (.090” thickness)
- Input Power—9-15 VDC, 115 VAC 50/60 Hz or internal batteries

OPTO-8000.1 Factory Wired $299.95
OPTO-8000.1K Kit $249.95

ACCESSORIES:
- Battery-Pack Option—Internal Ni-Cad Batteries and charging unit $19.95
- Probes: P-100—DC Probe, may also be used with scope $13.95
- P-101—LO-Pass Probe, very useful at audio frequencies $16.95
- P-102—High Impedance Probe, ideal general purpose usage $16.95
- VHF RF Pick-Up Antenna—Rubber Duck w/BNC #Duck-4H $12.50
- Right Angle BNC adapter #RA-BNC 2.95

FC-50 — Opto-8000 Conversion Kits:
- Owners of FC-50 counters with #PSL-650 Prescaler can use this kit to convert their units to the Opto-8000 style case, including most of the features.
- FC-50 — Opto-8000 Kit $59.95
- FC-50 — Opto-8000F Factory Update $99.95
- FC-50 — Opto-8000.1 (w/TCXO) Kit $109.95
- FC-50 — Opto-8000.1F Factory Update $149.95

FC-50 — Opto-8000 Conversion Kits:
- Owners of FC-50 counters with #PSL-650 Prescaler can use this kit to convert their units to the Opto-8000 style case, including most of the features.
- FC-50 — Opto-8000 Kit $59.95
- FC-50 — Opto-8000F Factory Update $99.95
- FC-50 — Opto-8000.1 (w/TCXO) Kit $109.95
- FC-50 — Opto-8000.1F Factory Update $149.95

Units returned for factory update must be completely assembled and operational.

TERMS: Orders to U.S. and Canada, add 5% to maximum of $10.00 per order for shipping, handling and insurance. To all other countries, add 10% of total order. Florida residents add 4% state tax. C.O.D. fee: $10.00. Personal checks must clear before merchandise is shipped.
the gyu\-rator:  
a synthetic inductor

Using operational amplifiers 
you can 
simulate inductors 
in LC filter design

The Gyru\-rator \is an electronic device that inverts 
the impedance of a capacitor and therefore makes it 
take on the characteristics of an inductor. Through 
the use of such a device, some of the shortcomings 
of inductors can be eliminated. These shortcomings 
are large physical size, low \(Q\), nonlinearity, and inter-
winding capacitance.

A properly designed Gyru\-rator will provide a synthet-
ic inductor with high \(Q\), wide bandwidth, inductance 
value independent of frequency, and good stability. 
Filters for frequencies up to 50 kHz can be designed 
using Gyru\-rators.

LC filters

Since a Gyru\-rator can be inserted directly into an LC 
filter in place of an inductor, let’s first review how an 
LC filter works. An LC filter is a reactive, two-port, 
doubly-terminated device that reflects power back to 
the source in frequencies that fall outside its band-
pass. As the number of individual elements making 
up the filter is increased, the ability of any one com-
ponent to greatly change the resonant frequency 
decreases. It can be said, therefore, that a coupled

---

By John Loughmiller, WB9ATW, Route 1, 
Box 480C, Borden, Indiana 47106
designing a Gyrator filter

To implement an LC filter without an inductor, first calculate the required inductive and capacitive impedance for the filter you have in mind. If desired, the filter can be built using standard inductances to check your calculations before actually building the Gyrator.

Next, using the circuit in fig. 1, construct a Gyrator replacement for the inductor. This circuit will simulate an inductor with the value of \( KC \), where \( K \) is a constant derived from the resistors: \( K = (R_1 \times R_3 \times R_4) / R_2 \), and \( C \) is the capacitor whose impedance is being inverted (\( C_1 \) in the circuit).

The resultant number so derived can be treated as if it were the value of impedance of an inductor, and the actual inductor can be removed and replaced with the synthesized inductor just created.

A simpler approach is to make all four resistors the same value and use the formula \( R^2 C \). (The impedance presented to the input of the Gyrator is very nearly \( joR^2 C \), hence the formula \( R^2 C \)). Use a value of \( R \) large enough that the op amps won’t be loaded, yet slightly lower than the differential input impedance.

The Gyrator circuit appears to be just another active filter circuit; however, there’s a significant difference: in other active filter circuits amplifier phase shift degrades circuit Q. In Gyrators, the Q is enhanced. When the phase shift is greater than 90 degrees, the Q is actually higher than that of the capacitor itself.

Speaking of capacitors, table 1 indicates the Q to be expected (at 1 kHz reference) for various types of capacitors. You can see that a high-Q inductor can be synthesized by using one of the high-Q capacitors, since the Gyrator inverts its capacitive impedance into an inductive-type impedance.

With regard to temperature, the NPO ceramic is least affected by changes of this variable. Higher stability could therefore be expected if NPO-type capacitors were used; however, there would be a tradeoff in Q. For high Q the choice is polystyrene or polypropylene, with the latter perhaps a better choice as it has a better temperature coefficient.

floating inductors

Perhaps the principal drawback to Gyrators is the fact that a floating (ungrounded) inductor can’t be simulated by a single Gyrator. It’s possible, however, to use two Gyrators as in fig. 2 and successfully simulate such an inductor.

The formula is \( L = [(R_1 \times R_3 \times C) / R_2] R_4 \), and \( R_4 \) is a shared resistor between Gyrator A and B, as in fig. 2. \( R_4 \) is the resistor that determines the simulated inductance. So if \( R_4 \) becomes a loaded port, the simulated inductance will be dependent on the value of resistance connected to the port. This being the case, resistor \( R_4 \) could (if desired) be divided into sections and T or pi filters simulated, such as shown in fig. 3. Here, a T filter is created synthetically, which would perform as if it were constructed in the manner shown in fig. 4.

When building multisection filters, a quad op-amp is recommended. A 4136 is the choice of Mr. Thomas Lynch, from whom much of the information in this article was obtained.

---

**table 1. Typical Q of various types of capacitors at 1 kHz.**

<table>
<thead>
<tr>
<th>Capacitor Type</th>
<th>Q at 1 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mica</td>
<td>600</td>
</tr>
<tr>
<td>NPO ceramic</td>
<td>1500</td>
</tr>
<tr>
<td>Glass</td>
<td>1500</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>2000</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>3000</td>
</tr>
</tbody>
</table>

---

**bibliography**

pi-network rf choke

The great majority of pi-network rf amplifiers use shunt feed for the high voltage dc to the plate. Therefore, great dependence is placed on the isolation properties of the rf choke. Most chokes are not suitable for this purpose due to resonances, especially when the amplifier is a multiband unit.

The most successful shunt feed rf chokes are single layer solenoid wound, preferably using resistance wire to lower the $Q$ and damp out potential resonant frequencies. One of the best chokes was the one made by Collins for the ART-13 transmitter. Ceramic capacitors are recommended.

Gary Legel, W6KNE

calculating feedline loss with a single measurement at the transmitter

Much has been written about the amount of insertion loss of various types of feedline and connectors, and about how the loss in some types of coax increases sharply with age and exposure to the elements. What is not widely known in amateur circles is that the loss in any run of cable can be determined with only an swr bridge or wattmeter, a transmitter or other drive source, and a shorted connector.

If a piece of cable is terminated with a short or an open circuit, the vswr measured at the transmitter will be infinite if the cable has zero insertion loss. In the real world, any cable has some loss, and this loss will cause the vswr measured at the transmitter to be less than infinity. The greater the cable loss, the lower the vswr.

To determine the cable loss, disconnect the antenna from the feedline and replace it with a shorted connector. This produces the infinite vswr at the transmitter end of the cable more reliably than simply leaving the cable unterminated. Connect the swr bridge or wattmeter at the transmitter and measure the vswr of both forward and reflected power, using the lowest possible transmitter power to avoid possible damage to the final amplifier. The reflection coefficient, $\rho$, is found by using one of the following formulas:

$$\rho = \sqrt{\frac{P_{\text{reflected}}}{P_{\text{forward}}}} \quad \text{or} \quad \rho = \frac{\text{SWR} - 1}{\text{SWR} + 1}$$

This reflection coefficient is a numerical ratio which must then be converted to decibels:

$$\rho(dB) = 20 \log_{10} \left| \frac{1}{\rho} \right|$$

Note that a vswr of $\infty$ corresponds to $\rho = 1$ or $\rho(dB) = 0 \, \text{dB}$, and a vswr of $1.0$ corresponds to $\rho = 0$ or $\rho(dB) = \infty \, \text{dB}$. The cable loss is determined by using the general equation:

$$\rho(dB)_L = \rho(dB)_C + 2A_o$$

where $\rho(dB)_C$ is the reflection coefficient at the transmitter, $\rho(dB)_L$ is the reflection coefficient at the load, and $A_o$ is the cable loss in decibels. Since $\rho(dB)_L = 0$ in this case,

$$A_o = \frac{\rho(dB)_C}{2}$$

This same general formula can also be applied if vswr or wattmeter readings are taken at both ends of the cable with the antenna connected instead of the shorted termination. The
advantage of using the shorted termination is that it eliminates the need to take readings at the antenna, which is usually a two-man job.

Once the feedline loss is known, the antenna is reconnected, and it is now possible to accurately determine the VSWR at the antenna based on the reading taken at the transmitter:

\[ \rho(dB)_{L} = \rho(dB)_{G} - 2A_{0} \]

\[ \rho_{L} = \frac{1}{\text{antilog}_{10} \frac{\rho(dB)_{L}}{20}} \]

\[ \text{SWR} = \frac{1 + \rho}{1 - \rho} \]

For most accurate results with multiband antennas, a feedline loss calculation should be made for each band.

John E. Becker, K9MM

**RM terminal modification**

After using the Mini Micro Mart RM Terminal Unit for a number of months, some deficiencies were noted which made it a little unwieldy to use, and sometimes downright difficult! I decided to pull all the guts out of it, because I didn’t know how it worked, and if it broke, about all I could do is use it for weight in the back of my car in the winter. This modification is used to convert the parallel output of the original keyboard into special data for insertion into the loop of a RTTY system. In addition to this, it gives you end of line (EOL), letters, and figures indications through the use of an LED. The EOL feature is especially nice if you are using a video display which has less than the 66 characters necessary for a complete line of hard copy. In this instance we are counting up to 64, which is close to the 66 count maximum. Fortunately, the CD4020 is also equipped with a reset, and when the carriage return key on the keyboard is struck, a positive pulse resets the chip, and the process starts all over again. The output from the 4020 is used to drive a flip-flop made from a 74121 to make it. The UART is clocked with a NE555, which can be set at any speed. The required frequency for various speeds is:

<table>
<thead>
<tr>
<th>speed</th>
<th>baud</th>
<th>clock frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>45.45</td>
<td>728 Hz</td>
</tr>
<tr>
<td>66</td>
<td>50.00</td>
<td>800 Hz</td>
</tr>
<tr>
<td>75</td>
<td>57.00</td>
<td>912 Hz</td>
</tr>
<tr>
<td>100</td>
<td>73.70</td>
<td>1179 Hz</td>
</tr>
</tbody>
</table>

It can be seen that the clock speed necessary for the UART is the baud rate times 16.

Coming out of the UART is the serial data, which is fed into a transistor driver, which keys an optical isolator. These devices are good for more than 20 mA, so if used in an application shown is used for indication of which shift you are in.

This modification can be made quite easily, and the additional circuitry can be put on perf board or a separate printed-circuit board. I built the unit on a wire-wrap card because it was incorporated into another system.

Tim Ahrens, WA5VQK

**switching inductive loads with solid-state devices**

Recently, while attempting to interface my 8080A microprocessor to a model 26 Teletype machine, I destroyed the 8080A and a 2N2222 transistor. The following suggestions may help others from encountering problems when trying to switch inductive loads with solid-state devices. My first attempt at a switching circuit is shown in fig. 1. What happens is this:

1. Assume that the 2N2222 is conducting, the collector of the transistor is at 0.2 volt (it is saturated).

```
fig. 1. Initial circuit used by WA6ROC to interface an 8080A microprocessor with a teleprinter. This arrangement destroyed both the expensive 8080A and the 2N2222.
```

where the loop is less than this, no problems should be noted. Please note the polarity.

Also coming out of the UART from pin 24 is a terminal which says in effect, “one character is finished;” this is normally high, and when the character is complete, it goes low for a moment. This pulse is fed into a CD4020 binary counter, which can be set up for any count up to 214. In this instance we are counting up to 64, which is close to the 66 count maximum. Fortunately, the CD4020 is also equipped with a reset, and when the carriage return key on the keyboard is struck, a positive pulse resets the chip, and the process starts all over again. The output from the 4020 is used to drive a flip-flop made from a 7400, but in the configuration shown, another section is used to drive a LED or audible alarm to show that the end of line has arrived. The other flip-flop

```
fig. 2. Basic opto-isolator circuit used by WA6ROC to provide protection to the delicate microprocessor.
```
2. The gate tries to turn off the 2N2222.

3. The inductor tries to maintain its current of 60 mA, thus the collector voltage of the 2N2222 rises, as it turns off.

4. When the collector reaches 12.7 volts the 1N914 starts to conduct. The +12 volt regulator, however, will not clamp its output at +12 volts (indeed most series-regulated power supplies will allow the output voltage to climb if you try to force current into the output).

5. Thus, the collector voltage of the 2N2222 climbs very high, and it experiences secondary voltage breakdown (fatal). Also, the +12 volt line follows the collector voltage (but it is one diode drop less). Thus the large spike on the +12 volt line destroys the microprocessor (and maybe other devices).

It was at this point that I decided to use an opto isolator — to provide a means of protection of the delicate microprocessor (or other solid-state parts). I tried the circuit which appeared in the November, 1976, issue of *ham radio* (see fig. 2).

This circuit is optically isolated, but it has one problem: it will not key low voltages. Since all I had at the time was a low-voltage power supply, a simple modification was made to allow this circuit to key a considerable amount of current, over a wide range of voltages.

The reason that this circuit will not key low voltage loops is that an appreciable voltage will exist from the collector to the emitter of the HEP244 when it is turned on. Suppose the HEP244 is supposed to key a 60 mA loop, let us further suppose it has a current gain of 60. Therefore, to key the loop, the collector current will be 60 mA and the base current must be

$$I_B = \frac{60}{60} = 1 \text{ mA}$$

(actually $I_c = 59 \text{ mA}$, $I_B = 1 \text{ mA}$, $\beta = 59$)

To sustain conduction, the collector to emitter voltage must be

$$V_{BE2} + V_{CESAT} = 0.7 + 0.7 + 0.3 + 0.55 = 2.25 \text{ volts (versus 33.0 volts before). This circuit will satisfactorily key both low and high voltage loops, and will handle quite a bit more current than 60 milliamperes.}

Now, as to the matter of protecting the keying transistor from secondary voltage breakdown. The common trick is to clamp the collector of the keying transistor to the magnet supply. If you do this, be sure to follow these two precautions:

1. Use a diode capable of carrying several amps, as the current through the suppressing diode can be several orders of magnitude greater than the magnet current, and small signal diodes (such as the 1N914) will often be destroyed by the large surge.

2. Make sure the magnet supply has sufficient capacitance to adequately absorb the energy of the spike without allowing the voltage to climb. Sometimes, however, the clamping diode will slow down the release time of the magnets (because the diode allows the current flow to continue for some time). In a case where this is important, an RC filter across the keying transistor will usually solve the problem. Thus the final configuration (fig. 4) is the circuit I now use to key my teleprinter magnets.

FREQ OUT. FOR LESS.

Introducing CSC's new Mini-Max. It brings down the cost of counting up the frequency for CB-ers, hams, computer enthusiasts, audiophiles...just about any engineer, technician or hobbyist will find it indispensable.

It's mini-sized, too—a pocketable 3 x 6 x 1½ inches.

But when it comes to performance, Mini-Max means maximum value. Measuring signals as low as 30 mV from 100 Hz to a guaranteed 50 MHz, with ± 3 ppm timebase accuracy and better than 0.2 ppm/°C stability from 0 to 50°C. Completely automatically. Advanced LSI circuitry with a crystal controlled timebase provides precise frequency readings on a bright, six-digit LED display, with automatic KHz/MHz indications. Mini-Max is versatile, too. You can connect it directly to the circuit under test, or use its matching mini antenna for easy RF checking. Either way, the input is protected against overload to 50V (100V below 1 KHz).

Mini-Max is as inexpensive to use as it is to own. An ordinary 9 volt alkaline battery gives up to 8 hours of intermittent operation, and you have the flexibility of a battery eliminator for AC operation. For increased versatility, there's a complete line of accessories, including standard clip-lead cable and mini antenna—eliminator and carrying case are optional.

CSC's new, all-American made Mini-Max is everything you need for highly-accurate checking of frequencies up to 50 MHz. At a price that will Freq you out. Order today. Call 203-624-3103. 9 a.m. - 5 p.m. Eastern Standard Time. Major credit cards accepted. Or see your CSC dealer. Prices slightly higher outside U.S.A.

100 Hz to 50 MHz.

$89.95*

CONTINENTAL SPECIALTIES CORPORATION

*Manufacturer's suggested retail price
© 1978 Continental Specialties Corporation
satellite tracking

Dear HR:
The article in your September issue, "Tracking Oscar Satellites," was especially interesting, and I might make some comments regarding the nautical mile. Most Maritime nations, including the United States, have adopted the International Nautical Mile, which is exactly 1852 meters, or 6076.10333... U.S. feet.

For most navigational purposes, the nautical mile is one minute of latitude or any other great circle. On the Clarke spheroid of 1866, used for mapping North America, the nautical mile varies from 6046 feet at the equator to 6108 feet at the poles. The length of one minute of a great circle of a sphere having an area equal to that of the earth is 6080.2 U.S. feet. This was the U.S. standard nautical mile prior to the adoption of the International Mile of 1852 meters.

One of the first attempts to establish a standard of length was made by the Greeks, who used the length of their Olympic stadium as a unit and called it, naturally, the stadium. It was 600 Greek feet (607.9 U.S. feet), or almost exactly one-tenth of the International Mile of 1852 meters.

I have written several navigational programs for my HP-97 calculator, and, in great-circle distances and bearing calculations, I use the 1852-meter International Nautical Mile.

I. L. McNally, K6WX
Sun City, California

active filters

Dear HR:
I would like to compliment W41YB on the fine article concerning active RC filters in the October 1976, ham radio. He has presented three basic filter configurations, each with different adaptations. Personally I prefer the second configuration; I have used it in thousands of modems sold to users of the telephone network. I ran off a computer tracing of the band-pass characteristics of the filters, both single and 4-unit combinations, based on a Q of 6. My curves come quite close to what is shown in W41YB's fig. 2. I should mention however, that the equations you presented are difficult for the average ham radio reader. I use the following simpler equations:

\[ R_1 = \frac{Q}{C \cdot f \cdot g \cdot 2\pi} \]
\[ R_2 = \frac{1}{2 \cdot (Q - 9/Q) \cdot C \cdot f \cdot 2\pi} \]
\[ R_3 = \frac{2 \cdot Q}{C \cdot 2\pi \cdot f} \]

where \( C = C_1 = C_2 \)

\( g \) = gain from input to output (usually set to 1 or 0.5)

\( Q \) = not more than 10 or 20 for 741s in the audio range

\( f \) = frequency in the audio range

Robert H. Weitbrecht, W6NRM
Redwood City, California

noise interference

Dear HR:
I ran across an unexpected source of interference not long ago. A noise sounding like a machine gun was creating tremendous interference. It covered up to 900 kHz, and with multiples of 900 kHz, up to 30 MHz. The source of the noise was finally found to be originating from the telephone lines, with faulty battery chargers at the substations being the cause. The intensity of the interference was great enough to cover local broadcast stations, even though I live more than 6 miles (9km) from the substation. Even after locating the source, it is very difficult to solve the problem because the telephone company is very reluctant to admit blame.

Keith Olson, W7FS
Belfair, Washington
$1.00 per pair

QUALITY CRYSTALS FOR 2 METERS and 220 MHz

We are now stocking crystals for most 2-meter pairs and the most popular 220 MHz pairs. If you need crystals for use in any radios listed below, we can normally ship from stock the same day your order is received. These are quality crystals, built to exacting specifications to provide trouble-free operation.

146 MHz PAIRS
Transmit/Receive
146.01/146.61
146.04/146.64
146.07/146.67
146.10/146.70
146.13/146.73
146.16/146.76*
146.19/146.79
146.22/146.82
146.25/146.85
146.28/146.88*
146.31/146.91
146.34/146.94
146.34/146.94*
146.46/146.46
146.49/146.49
146.55/146.55

Note: Items marked * stocked for Wilson only; # stocked for ICOM only.

147 MHz PAIRS
Transmit/Receive
147.99/147.39
147.96/147.36
147.93/147.33
147.67/147.27
147.84/147.24
147.81/147.21
147.78/147.18
147.75/147.15
147.72/147.12
147.69/147.09
147.66/147.06
147.63/147.03
147.30/147.30
147.42/147.42
147.48/147.48
147.51/147.51
147.54/147.54
147.57/147.57

220 MHz CRYSTAL PAIRS
Transmit/Receive
222.22/223.82 MHz
222.34/223.94 MHz
222.50/224.10 MHz
222.54/224.14 MHz
222.94/224.54 MHz
223.06/224.66 MHz
223.18/224.78 MHz
223.22/224.82 MHz
223.26/224.86 MHz
223.34/224.94 MHz
223.38/224.98 MHz

SIMPLEX
Transmit/Receive
223.46/223.46 MHz
223.54/223.54 MHz

220 MHz CRYSTALS
146.01/146.61
146.04/146.64
146.07/146.67
146.10/146.70
146.13/146.73
146.16/146.76*
146.19/146.79
146.22/146.82
146.25/146.85
146.28/146.88*
146.31/146.91
146.34/146.94
146.34/146.94*
146.46/146.46
146.49/146.49
146.55/146.55

Note: Items marked * stocked for Wilson only; # stocked for ICOM only.

THE BIG DUMMY

$29.50 Full kW Dummy Load

Low-cost dummy load covers the full range from 1.8 to 300 MHz with flat SWR. Ventilated container; comes with one gallon of high quality industrial-grade, long-life, transformer-type cooling oil. Power capability: 1 kW continuous carrier, 10 minutes; 2 kW PEP, 20 minutes. Duty cycle: 50%. Impedance: 50 ohms non-inductive. VSWr: 1.05:1 or better. Size: 6-5/8" dia. x 7¾" high. Wt.: 10 lbs.

ORDERING INFORMATION

1. State Brand and model number of transceiver.
2. State frequency pair wanted, indicating transmit frequency first, then receive.

MOSTEK AUTO-PATCH TONE GENERATOR

DIGITRAN KEYBOARD

LOW PROFILE YET ALMOST STROKE 1/16th

A star value at the Dayton Hamvention. Incorporates the ideal "tactile feel" leaving no doubt that contact has been made. These new keyboards are manufactured by the Digitran Company and are furnished with instructions for combining with a Mostek or Motorola chip and a crystal (plus several small components) to become a Tone Encoder.

12 Key (2 of 7 Masts) x 2.77 x 5/16".................. $8.00
16 Key (2 of 8 Masts) x 2.5 x 2.77 x 5/16"........ $10.00

WHEN ORDERING FROM SPECTRONICS, REMEMBER:

C.O.D. ORDERS require payment to be made by cash, certified check, or money order only. We will gladly quote you the exact amount that the delivery man will ask for.

SHIPPING CHARGES must be added to your order.

ALL ORDERS sent F.O.B. Oak Park, Illinois.

Economical DTMF generating system combines CMOS logic, D-to-A converter, an operational amplifier and bipolar transistors on a single IC chip. Uses inexpensive 3.58 MHz crystal. Dual tones mix internally. Tones are 16-step synthesized sine waves for low distortion. Compatible with Digitran keyboard. Common key function outputs. For 5-10 V.

FOR 5-70 V.

Model MK 5088. Interfaces to either 2-of-8 keyboard or other electronic systems.$9.00

FAMOUS HAM-KEYS... POPULAR FAVORITES FOR CW!

Model HK-1 Dual-lever squeeze paddle. Can be used with any electronic keyer. Heavy base has non-slip rubber feet. Pedals are reversible for wide-finger or close-finger spacing.$29.95

Model HK-2. Same as HK-1 less base. For incorporation in own keyer............................................ $19.95

Model HK-3. Deluxe straight key. Heavy base so there's no need to attach to desk. Velvet smooth action.$16.95

Model HK-3A. Same as HK-3, less base.$9.95

Navy type knob only ........................................ $2.75

Model HK-4. Combines models HK-1 and HK-3. On heavy base with non-slip rubber feet.$44.95

Base only, with rubber feet. Heavy........................................ $12.00

Terminals. Red or black................................. Each $ .75

Model HK-1
Model HK-2
Model HK-3
Model HK-3A
Model HK-4

More Details? CHECK—OFF Page 142

june 1978
new Drake transceiver

The new TR-7 transceiver from the R.L. Drake Company is the first commercially available amateur transceiver that uses a 48-MHz i-f. This concept allows great flexibility in frequency coverage as well as providing greatly improved image rejection.

Reception through the entire range of 1.5 through 30 MHz is provided by the TR-7, and, with the use of an Aux-7 Range-Program board, the range can be expanded to cover from 0 to 30 MHz. The up-conversion technique, along with the synthesized/PTO frequency control, makes this extended frequency coverage possible.

Full passband tuning is another feature of the receiver portion of the unit. It is possible to tune from the top edge of one sideband, through zero, to the bottom edge of the other sideband. The range is also wide enough to allow tuning through RTTY signals. This ability to place a wanted signal at the proper spot in the filter passband is a great aid when working on the crowded amateur bands.

Further improved reception can be obtained by installing optional receiving-selectivity filters in the rig; you can select the desired filter by pushbutton switches on the front panel. Also, a unique system permits you to select the receiving filter independently of the transmitter mode or function. Thus you can transmit on CW but receive with an ssb filter, or even transmit on one sideband while receiving the other. Optional filter widths include 300 Hz, 500 Hz, 1.8 kHz, or 6 kHz.

On the transmit side of the unit, optional programmable coverage for nonamateur-band parts of the spectrum are available. Proof of license for operation out of the amateur bands must be submitted to the R.L. Drake Company before obtaining these options, however. This feature also takes care of any possible later expansion of the amateur frequencies.

The all-solid-state design and broadband tuned circuits means that there are no preselector or peaking circuits to contend with in the TR-7. The power amplifier is designed for continuous-duty ssb and CW operation. The efficient, internal heatsink provides enough dissipation in free air for full power on all modes except SSTV or RTTY; these high-duty-cycle transmissions are provided for by an optional fan for extra cooling. The transmitter is rated at 250 watts input on all modes, and the PS-7 ac power supply is designed to provide continuous-duty power for any mode. This supply also accepts input voltages of 90-132 Vac, 180-264 Vac, at 50 to 60 Hz, which makes it ideal for overseas locations. The TR-7 transceiver may also be operated from any nominal 13.6 Vdc supply capable of providing 3 Amps on receive and 25 Amps on transmit.

Additional features of the TR-7 include a digital frequency readout, which will provide accuracy of \pm 100 Hz, or an analog readout with \pm 1 kHz accuracy when properly calibrated. The digital frequency display can be used as a test instrument with frequency capability of up to 150 MHz, with access to the counter input through a rear panel connector. Power-output metering is obtained by making the standard S-meter double as a built-in wattmeter/swr indicator.

Here are some of the specifications from the TR-7 brochure:

- **Dimensions (height, width, depth):** 11.6 x 34.6 x 31.7 cm (4.6 x 13.6 x 12.5 in.).
- **Receiver sensitivity:** less than 0.5 \mu V for 10 dB S + N/N ratio.
- **Image and i-f rejection:** greater than 80 dB.
- **Power input:** 250 watts PEP 1 ssb; 250 watts CW.
- **Spurious output:** greater than 50 dB down.
- **Harmonic output:** greater than 45 dB down.
- **Intermodulation distortion:** 30 dB below PEP.
- **Undesired sideband suppression:** greater than 60 dB at 1 kHz.

A wide range of optional features are available, including a noise blanker, mobile mounting kit, and crystal filters. A speaker in a matching cabinet, and a similarly matching remote vfo, will combine with the TR-7 transceiver to make a complete, attractive, and state-of-the-art amateur station that will set the pattern for years to come.

For more information, see your authorized Drake dealer, or write R.L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342.

**prime components purchasing guide**

A new components catalog has just been released by Prime Components Corporation of Hauppauge, New York.

The 36-page illustrated booklet lists many of the small parts often
needed by hobbyists, experimenters, and small development laboratories.

A partial list of items that can be purchased from Prime Components Corporation includes cleaning and servicing chemicals, test equipment, tools, integrated circuits, diodes, transistors, capacitors, resistors, LEDs and LED displays, lamps, and fuses. All of the parts are brand-name manufactured, and are available from stock. The catalog is free, and there is a minimum order requirement of $25.

To receive your free catalog, write to Prime Components Corporation, 65 Engineers Road, Hauppauge, New York 11787.

tandy computers catalog

A microcomputer mail-order catalog has just been issued by Tandy Computers, the newly created retail division of Tandy Corporation, parent company of the nationwide Radio Shack electronics store chain. The 52-page, four-color catalog details a full line of popular brand microcomputers and accessories, software packages, parts, and literature currently in stock. Both kits and fully assembled microcomputer systems are listed in the catalog, at prices that range from several hundred dollars to more than $20,000.

Among the nationally known

- 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 singles 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
Box 455, Escondido, CA. 92025 • Phone: [714] 747-3343
ALL-MODE VHF amplifiers

FOR BASE STATION & REPEATER USE

<table>
<thead>
<tr>
<th>MODEL</th>
<th>INPUT</th>
<th>OUTPUT</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V70</td>
<td>10-20W</td>
<td>70-90W</td>
<td>$298</td>
</tr>
<tr>
<td>V71</td>
<td>1.5W</td>
<td>60-70W</td>
<td>$329</td>
</tr>
<tr>
<td>V130</td>
<td>25-40W</td>
<td>110-130W</td>
<td>$389</td>
</tr>
<tr>
<td>V131</td>
<td>1.5W</td>
<td>110-130W</td>
<td>$419</td>
</tr>
<tr>
<td>V135</td>
<td>5-10W</td>
<td>110-130W</td>
<td>$419</td>
</tr>
<tr>
<td>V190</td>
<td>8-15W</td>
<td>160-200W</td>
<td>$525</td>
</tr>
</tbody>
</table>

* All units: Harmonics exceed - 60 dB specification of FCC R&O 20777

- 143-149 MHz No Tuning
- AM - FM - CW - SSB
- Low Harmonics
- Heavy Duty
- No Power Supply Needed
- Illuminated Panel Meter
- + 13.5V/3 Amp Socket

Only two things are needed to put this power house on the air with your handy-dandy 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.

DEALER INQUIRIES INVITED

RF POWER LABS, INC.
11013-118th Place N.E. • Kirkland, Washington 98033 • Telephone: (206) 822-1251 • TELEX No. 32 1102

DIPole ANTEnna CONNECTor

HY-QUI (MO) dipole connector has coax 50-399 socket molded into glass tube. Plastic body. Ideal panel use. No tuning. No coax fittings or instructions needed. Guaranteed. All your dealers. $2.50 each. Call 273-399.

K-ENTERPRISES

Frequency Counters  \ Power Supplies
Prescalers          Amplifiers
Meter & Peaking   Frequency Standards
Generators

Write for Gratis Catalog
Box 410 (Pump St., Rd.) - Fairland, OK 74343
Phone: (918)-676-3752

ALL BAND TRAP ANTENNAS!

ALL 5 BAND OPERATION - ONLY ONE TRAP Antenna!!

FOR ALL MAKES AMATEUR HF TRANSMITTERS - TRANSCEIVERS - GUARANTEED FOR 2000 WATTS. PEP POWER FOR NOVICE AND ALL CLASS AMATEURS! COMPLETE Ready to put up with 30 ft. Dacron. For below 100 ft. Dacron. Hand support cord. Wt. 3 lbs. 1" 3/4 MOLDED RESONANT TRAPS - just switch your transmitter to desired band for EXCELLENT PERFORMANCE! NO TUNERS OR BALUNS NEEDED! CAN BE USED IN ANY OTHER TRANSCEIVER. TOPS OF BUILDINGS, INVERTED V, IN MINIMUM SPACE! NO CENTER SUPPORT NEEDED! NO HAYWIRE HOUSE APPEARANCE COMPLETELY ASSEMBLED NO TRAPS - cutting - soldering - measuring - JUST HANG IT AND USE IT! SWR is 1.2 at resonance. THOUSANDS IN USE - EASIEST INSTALLATION! 80-20-15-10-5 meters bands---102 ft. with 90 ft. RG 58U coax connector - Model 900 BU . . . $49.95 40-20-15-10 meter bands---54 ft. with 90 ft. RG 58U coax connector - Model 99 BU . . . . $49.95 20-15-10-5 meter bands---26 ft. with 90 ft. RG 58U coax connector - Model 100 BU . . . . . . . $47.95

Send only $5.00 (cash, ck, mo) and pay postman balance plus COD postage OR SEND FULL PRICE FOR POST PAID DEL. IN USA (Canada is $5.00 extra) or order by MAIL or PHONE with Bank of America VISA - MASTER CHARGE - OR AM EXP. Give number and exp. date. Ph 1-306-238-5333

Weekly. We ship in 3-5 days. INFLATION? PRICES MAY INCREASE - SAVE - ORDER NOW! INFO AVAILABLE FROM WESTERN ELECTRONICS Dept. AH-4 Kearney, Nebraska 68847

A new Ampenofl in-line UHF coax cable jack that can be installed in seconds without special tools or solder has been announced by the RF Operations of Ampenofl North America Division, Bunker Ramo Corporation. Developed as a follow-up to last year's introduction of the Ampenofl no-solder PL-259 connector for RG-58/U, the new companion in-line splice jack also uses the innovative FCP termination approach, resulting in an extremely fast cable termination — less than 20 seconds.

Whenever an in-line antenna or hookup coax cable splice is needed, the user has only to strip the cable,
insert the center conductor into the back of the connector, and slide the ferrule into place. Once accomplished, termination is complete. The result is a handy, in-line SO-239 receptacle that will directly accept any PL-259 plug. All need for a second PL-259 connector plus PL-259 to PL-259 adapter has been eliminated.

Called the Amphenol UHF Cable Jack 83-58FCJ, the new device easily handles all power levels up to maximum ratings of the RG-58/U coax cable itself. The 83-58FCJ connector adapters have a frequency range of 0-300 MHz, and a voltage rating of 500 volts peak. And, unlike conventional solder connection techniques, the 83-58FCJ can be easily disassembled and reused. It also has standard 5/8-24 threads for simple, screw-on mating with conventional UHF plugs.

Manufactured by Amphenol exclusively in the United States, the new jacks are machined from brass rod stock and plated with Astroplate®, lustrous, non-tarnish finish. For more information, contact Bunker Ramo Corporation, 33 East Franklin Street, Danbury, Connecticut 06810.

turner personal communications catalog

The Turner Division of Conrac Corporation now has available a newly revised personal communications catalog. The catalog is all inclusive, containing Turner's entire personal communications product line. Twenty-eight pages in size, the new catalog has sections on microphones, stainless steel antennas, fiberglass antennas and accessories. Previously, Turner had separate catalogs for each product line.

The four-color catalog features a section on Turner's new no-solder microphone connector program, "The Turner Connection." The catalog contains general information and engineering specs to aid the distribution of information.
TR-7 SYSTEM:
The new TR-7 System is an addition to the Drake line. The Drake C-Line with its accessories is continuing to be produced.

The TR-7/DR-7 features continuous reception from 1.5 thru 30 MHz and transceive 160 thru 10 meter Amateur Bands. For reception from 0 thru 1.5 MHz use the optional ALX-7 Range Program Board and an RRM-7 Receive Module for each 500 kHz segment to be covered. Each RRM-7 plugs directly into the ALX-7 board and is selected from the front panel.

Out-of-band transmit for MARS, etc., is accomplished by plugging an RTM-7 Transceive Module into the ALX-7 for each 500 kHz segment to be covered. Proof of license is necessary to purchase transceive modules.

The MN-7 Antenna Matching Network covers the Amateur Bands from 160 thru 10 meters; matches balanced lines, long wires, and coax-fed antennas; features a built-in RF Wattmeter/VSWR Bridge; and has complete switching functions.

The MN-4C Antenna Matching Network offers the same features, but is styled to match the 4-Line/C-Line.

UV-3 SYSTEM:
The UV-3 System is fully synthesized to 5 kHz on each of the bands it covers. Among other firsts, it is presently the only rig in the world synthesized on 440 MHz fm.

There is a separate SO-239 Coax Connector for each band, so a choice of antennas may be used.

Extra fixed channels and special offsets are diode-programmable, so crystals are not necessary at all.

These thoughts of interest are provided by Drake, "The Newsmakers"

To receive a FREE Drake Full Line Catalog, please send name and date of this publication to:

R. L. DRAKE COMPANY
540 Richard Street, Miamisburg, Ohio 45342 • Phone (513) 866-2421 • Telex 288-017
Western Sales and Service Center, 2020 Western Street, Las Vegas, Nevada 89102 • 702/892-2478
weatherproofed PVC-wrapped loading coil, and 17 feet of coaxial cable with a soldered PL-259-type connector.

The 200 watt two-meter antennas also feature Antenna Incorporated's new high-power coaxial cable. While the 150 watt high-band and 200 watt low-band antennas include RG/58/U cable, this cable cannot safely handle 200 watts of power on two meters. Antenna Incorporated's high-power cable has performance characteristics similar to RG-8/U, but in a smaller size, thus eliminating the problems of using the larger cable in mobile applications.

“These antennas also are part of Antenna Incorporated's professional land mobile line and have been designed to meet the needs of high power communications users,” sales manager Randall Friedberg said. “They offer the amateur the best in antenna quality and dependability.”

For further information on the company's complete line of communications antennas and accessories, contact Randall J. Friedberg, Antenna Incorporated, 23850 Commerce Park Road, Cleveland, Ohio 44122. Phone (216) 464-7075.

hallicrafters H2M-1000 two-meter transceiver

Hallicrafters Company, a long-time manufacturer of amateur radio equipment and systems, has announced the introduction of its new two-meter PLL frequency synthesized multimode transceiver. Hallicrafters’ new H2M-1000 is designed to operate in fm, usb, lsb, and CW modes. In the fm mode, the H2M-1000 provides 800-channel coverage (5 kHz steps) and a vxo variation of ±7 kHz in the ssb/CW modes. The H2M-1000 also features simplex and repeater offsetts of ±600 kHz and ±1 MHz for fm.

The H2M-1000 provides easy readout with a six-digit, seven-segment, light-emitting diode (LED) frequency display in the fm mode and five-digit display in single sideband (ssb) mode.
MFJ ENTERPRISES brings you a new 24 hour digital alarm clock with HUGE 1-5/8 inch orange 7 segment digits that you can see clear across the room.

This one is strictly for your ham shack, one that you can leave set to GMT. No more mental calculations to get GMT.

Use the alarm to remind you of a SKED or with the snooze function as an ID timer to buzz you in 8 minute intervals.

A constantly changing kaleidoscopic pattern indicates continuous operation.

Beige. 2 1/4 x 4 1/8 x 8-3/4 inches. UL listed. Requires 120VAC, 60Hz.

Order from MFJ and try it — no obligation. If not delighted, return it within 30 days for a refund (less shipping). One year limited warranty by MFJ Enterprises.

To order, simply call us toll free 800-647-8660 and charge it on your VISA or Master Charge or mail us a check or money order for $29.95 plus $2.00 for shipping and handling.

Don’t wait any longer to enjoy the convenience of a “Hams Only” clock. Order today.

MFJ ENTERPRISES
P. O. Box 494
Mississippi State, MS 39762
Call Toll Free . . . . 800-647-8660
For order status and repair status and in Mississippi, call 601-323-5869.

The SEVEN-SYSTEM is all you need!

DRAKE TR-7
An Engineering Breakthrough for the finest in Solid-State Transceiver performance.

Covers 10 - 160 meters* Frequency Counter to 150 MHz with digital option

Broadband, solid-state design Designed & manufactured in U.S.A.

Programmable auxiliary coverage 250-watt input with full VSWR protection

Synthesized PTO CW 558 RTTY AM capability

Up-conversion receiver for superior dynamic range True passband tuning

Matching Accessories:

AM filter
RTTY filter
2 CW filters, 300 Hz, 500 Hz
Fan (for RTTY)
Noise blanker

Mobile mount
Antenna tuner/wattmeter
Wattmeter/VSWR bridge
Aux-2 Expanded receive capability

*Includes capability for MARS, Embassy, and Government frequencies, and possible future amateur-band expansion. Receiver coverage continues from 1.5 - 30 MHz, and 0.5 - 5 MHz with Aux-2.

Call Now to find out how easy it is to put a new DRAKE TR-7 in your shack.

Hams Serving Hams Since 1939

ELECTRONIC DISTRIBUTORS, INC.
1960 PECK STREET
MUSKEGON, MICHIGAN 49441
TELEPHONE (616) 726-3196
TELEX 22-8411

The H2M-1000 can be operated on either ac or dc and has two panel meters; a combination S and rf power output plus a discriminator meter. The rf power output is in excess of 10 watts in the high-power mode and one watt in low-power mode. Other features include a noise blanker switch, an agc recovery switch (standard and slow agc), mike gain control, a built-in vox, and receiver incremental tuning (RIT). For additional information, contact the Hallicrafters Company, 2501 Arkansas Lane, Grand Prairie, Texas 75051.

Hammond diecast utility boxes

Hammond Manufacturing has introduced two new water and corrosion-resistant utility boxes, 12.5 x 7.9 x 5.6 cm (4.9 x 3.1 x 2.2 inches) and 22 x 12 x 7.9 cm (8.7 x 4.7 x 3.1 inches). Diecast in an aluminum alloy, they have an exceptionally good finish, unmarrred by closure screws which have been recessed into the lid. The color is baked on Hammerstone Grey enamel.

Sealing is facilitated by an interlocking flange and neoprene rubber ring inset in the lid. Both models come with two bolt holes outside of the sealing ring and concealed beneath the lid for attractive and secure mounting of the box. Electrical, rf shielding, and environment protection are some of the many applications for these products. For more information, contact Larry Humphries, Hammond Manufacturing Company, Inc., 385 Nagel Drive, Buffalo, New York 14225.

More Details? CHECK — OFF Page 142
Braced against the elements as only Swan can do it! Even hurricane winds to 100 MPH can't lower the boom on your operations.

**The Swan TB3HA Tri-Bander:** a really heavy-duty 20-15-10 meter beam. 3 solid elements, all working on all bands. With a VSWR of 1.5:1 or better at resonance, plus a full 2000-watt PEP rating, our TB3HA is built to work up a storm!

**Strongest fittings available:** this you've got to see. Exclusive cast-aluminium braces grasp tubes at every joint, spreading stress over an 11% span. Compared to slipshod U-bolt plates—no contest!

**Reinforced by super specs,** TB3HA's one tough competitor:
- 8dBd average forward gain.
- 20-22 dB front to back ratio.
- 16' turning radius.
- longest element: 28'2"
- 16' boom, optimum spacing.
- direct 52 Ohm coaxial feed.
- wind load @ 80 mph: 110 lbs.
- 44 lbs. net weight.
- $199.95 complete, Swan Credit Card accepted.

For $199.95 at your local Swan dealer you can start operating tri-band from a position of real strength—because TB3HA is Swan-engineered to work under pressure!

Please rush full information on Swan's Heavy Duty Tri-Band Beam Antennas:
- 3-element TB3HA
- 4-element TB4HA

Name______________
Address__________________________
City__________________ State________ Zip________

**FREE! Personalized call-letter plaque** 2½ x 4" with stand, no charge.
- Please send my plaque engraved with my station call

ELECTRONICS
305 Airport Road, Oceanside, CA 92054
Swan's continuing commitment to product improvement may affect specifications and prices without notice.
8 POLE 350 Hz FILTER for SIGNAL/ONE TRANSCEIVER $129.00

Finally! Superior 8-Pole CW Selectivity for Drake TR-4, TR-4C, TR-4G

185 Hz at 0 dB, 300 Hz at 0 dB, Cost SAVVY. More selective than Drake CW filter in new TR-4Gw which is 500 Hz at 0 dB, and 1000 Hz at 0 dB. GT-3500: $100.00. Switch and resetting kit: $35.00

At Last! Superior 8-Pole CW Selectivity for Kenwood TS-820

MINIMUM LOSS IN SET. GOOD SIGNAL TO NOISE 185 Hz at 0 dB, 300 Hz at 0 dB. Cost SAVVY. More selective than standard YG350C Drake CW filter which is 500 Hz at 0 dB, and 1000 Hz at 0 dB. CE-3570: $125.00

600 Hz 6-Pole First-IF Filter for Drake R4C

When the selectivity is critical... Electronic phase high-passed fifth order filters are built around the switchable second IF filter. Minimize the chance of failing missing contacts in the switch. Choice of intermediate and discriminator. Both the existing filter and new filter are mounted on a printed circuit board and switch in to foam frequency capacitors. CE-RAV: $65.00. Reset switch kit: $12.00

125 Hz 8-Pole Second-IF Filter for Drake R4C

500 sharp points available. 300 Hz at 0 dB. 500 Hz at 0 dB. Cost SAVVY. Ideal for DX and contest work. Uncompromising under critical band conditions. Uses what ratio selectivity is. No more selectivity than audio only. It is 8 poles in the first stage and 6 poles in the second stage. Of course the bandpass filter is critical. Comes complete with audio filter to improve receiver performance. Price depends on an accessory filter. CE-2575: $125.00

GO WITH "THE FORCE!"

Rohn is the TOWER FORCE when it comes to building towers — look at the BX Towers and you’ll see why...

- HDBX Towers will hold up to 18 sq. ft. antenna capacity.
- Due to design, BX Towers hold greater antenna loads than competitive models.
- Can be assembled on the ground and hinged up or built vertically, section upon section.
- Shipped nested
- Fabricated in the U.S.A.

Check out the ROHN TOWER FORCE, you’ll be glad you did!

Unarco-Rohn
Division of Unarco Industries, Inc.
6118 West Flash Road, P.O. Box 2000
Perrysburg, Ohio 43551

VIDEO TERMINAL
MODEL 795 VIDEO DISPLAY TERMINAL

With 7 x 10" magnetically-deflected CRT. With internal DC-to-DC converter, 10 VDC supply, horiz. and vert. deflection amps, and internal multi-fan control. For intensity, vert. and horizon control. Requires 115 VAC 60 Hz. Power cord supplied. 15V x 17" x 21", Sh. Wt: 100 lbs. Used. Reg. 59.50

KSR-33 TELETYPEWRITER and KEYBOARD - 100 WPM, 500 operations per sec. Utilizes ASCII code with parity bit. 8½" x 11" paper. 115 VAC 60 Hz. 1 lb x 18½” x 11½”, Sh. Wt: 5 lbs. Used, operational, but may require some adjustment. Less cover $250. Used. $300.

SPDT ANTENNA CHANGEOVER RELAY
Heavy silver contacts good for at least 500 watts. Coil: 5 V 60 Hz 1 ohm. Requires three "N" connectors. 3x3½x1, 2 lbs. sh. $9.95

R-390A RECEIVER
0.5-32 Mhz digitally-tuned; 95 lbs. sh. Reconditioned $695.00

NEMS-CLARKE 1502 RECEIVER
50-260 Mhz AM, FM, CW; 50 lbs. sh. Used, reparable $275.00

Write for New Catalog WS-78 - Government and Commercial Electronic Surplus All Prices F.O.B., Lima, Ohio

Please make allowance for shipping charges! Use your VISA, RAC or Master Charge card.

Address: Dept HR * Phone: 419-227-6573

FAIR RADIO SALES
1015 E. EUREKA • Box 1105 • LIMA, OHIO • 45802

PCP "TYPE-R"

SEE POPULAR ELECTRONICS
FEB '78 ISSUE!

If you've got a calling for far-reaching action, have we got a number for you!

**Swan's 4010V:** precision engineered for 40-20-15-10 meters.

With slim-line traps, this 4-band vertical offers advanced light-weight construction with heavy weight performance.

4010V's fine-tuned to handle 2000 PEP. With a typical VSWR of 1.5:1 at resonance.

Powerfully designed — yet powerfully simple to set up.

**No-hassle installation.** The 21' vertical comes in short, easy to assemble lengths. Complete with mounting hardware. You're up and running in record time.

**Expandable too.** No trick at all to stretch your reach into 75 meters, with the optional Swan 75 AK Kit.

**Just $74.95** for an outstanding 4-band trap vertical, the 4010V (and $39.95 for the 75-meter add-on kit), at your Swan dealer. And by all means, use your Swan Credit Card.

Please rush full specs for Swan's

- 4010V 4-band trap vertical antenna
- 75 AK 75-meter Kit

Name: ____________________________
Address: __________________________
City: ____________________ State: ______ Zip: ________

FREE! Personalized call-letter plaque

2½" x 4" with stand, no charge

☐ Please send my plaque imprinted with my station call

305 Airport Road, Oceanside, CA 92054

Swan's continuing commitment to product improvement may affect specifications and prices without notice.
CRYSTAL FILTERS and DISCRIMINATORS

9.0 MHz FILTERS

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Frequency</th>
<th>Desc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF9-A</td>
<td>2.5 kHz</td>
<td>SSB TX</td>
</tr>
<tr>
<td>XF9-B</td>
<td>2.4 kHz</td>
<td>SSB RX/TX</td>
</tr>
<tr>
<td>XF9-C</td>
<td>3.75 kHz</td>
<td>AM</td>
</tr>
<tr>
<td>XF9-D</td>
<td>5.0 kHz</td>
<td>AM</td>
</tr>
<tr>
<td>XF9-E</td>
<td>12.0 kHz</td>
<td>NBFM</td>
</tr>
<tr>
<td>XF9-M</td>
<td>0.5 kHz</td>
<td>CW (4 pole)</td>
</tr>
<tr>
<td>XF9-NB</td>
<td>0.5 kHz</td>
<td>CW (8 pole)</td>
</tr>
</tbody>
</table>

9.0 MHz CRYSTALS (Hc25/u)

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Frequency</th>
<th>Desc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>XF900</td>
<td>9000.0 kHz</td>
<td>Carrier</td>
</tr>
<tr>
<td>XF901</td>
<td>8998.5 kHz</td>
<td>USB</td>
</tr>
<tr>
<td>XF902</td>
<td>9001.5 kHz</td>
<td>LSB</td>
</tr>
<tr>
<td>XF903</td>
<td>8999.0 kHz</td>
<td>BFO</td>
</tr>
</tbody>
</table>

F-05: Hc25/u Socket Chassis | $50.00
F-06: Hc25/u Socket P.C. Board | $50.00

ALSO AVAILABLE FROM KVG

10.7 MHz CRYSTAL FILTERS AND XTAL DISCRIMINATORS

Oscillator Crystals 50 kHz to 150 MHz

Write for Details

PRE-SELECTOR FILTERS

Eliminate IMD "BIRDIES" from your receiver.
Clean up your transmitter output. Very low loss, 0.15 dB typical.

432 MHz PSF432 | $39.95
1296 MHz PSF1296 | $139.95
1691 MHz PSF1691 | $52.45

Shipping: $3.50 per filter

RECEIVE CONVERTERS

Models for all bands 50 MHz thru 1296 MHz. Low noise options at 432 MHz.

Standard I.F., 10 M. If options 6M & 2M

Power 12V D.C.

Shipping: $2.50

MMc144: N. F. 2.8 dB typ. | $49.95
MMc432: N. F. 3.8 dB typ. | $59.95
MMc438/ATV: Ch2 or Ch3 IF | $79.95
MMc1296: N. F. 8.5 dB typ. | $69.95

ANTENNAS (FOB Concord, Via UPS)

144-148 MHz J-SLOTS

8 over 8 Horizontal Pol. +12.3 dBd | $45.95
8 by 8 Vertical Pol. | D8/2M | $53.95
8 + 8 Twist | D8/2M-Vert. | $47.65

420-450 MHz MULTIBEAMS

48 EL. | Gain +15.7 dBd 70/MM48 | $49.95
88 EL. | Gain +18.5 dBd 70/MM88 | $73.50

UHF LOOP YAGIS

26 Loops | Gain +20 dbi | $56.95
1250-1340 MHz | 1296-LY | $63.95
1650-1750 MHz | 1691-LY | $63.95

Send 26¢ (2 stamps) for full line catalogue of KVG crystal products and all your VHF & UHF equipment requirements.

Pre-Selector Filters | Amplifiers | SSB Transmitters
Varactor Triggers | Crystal Filters | FM Transmitters
Decade Pre-Scalers | Frequency Meters | VHF Converters
Antennas | Oscillator Crystals | UHF Converters

The TPL 1/4 KILOWATT LINEAR AMPLIFIER

TPL proudly presents the first true power 1/4KW SSB/AM, FM or CW solid state 2 meter linear amplifier.

A remote control plug allows you to operate with the amplifier on or off, or in SSB/AM, FM or CW from the dashboard.

The 2002 utilizes the latest state of the art engineering including microstrip circuitry and modular construction. The three final transistors combine to produce 250W when driven by 15W or more at 13.8VDC.

Power Input:

200-250W carrier FM or CW
300W PEP SSB or AM

Harmonic Attenuation:

5-20W Carrier FM or CW All Harmonics Attenuated
20W PEP maximum

5-20W Carrier FM or CW All Harmonics Attenuated

Power Output:

200-250W carrier FM or CW
300W PEP SSB or AM

Duty Cycle:

FM 50% @ 1MW
FM-40 Amps @ 250W

60% @ 150W
FM-30 Amps @ 300W

50% @ 250W
FM-30 Amps @ 300W

Frequency Range:

144 to 148 MHz

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:

FM 50% @ 150W
SSB 60% @ 150W 50% @ 250W

Model 2002 | $479.00

Duty Cycle:
Before you take off for the wide open spaces, close in on the top performer in the field:

**Swan's 5-band Mobile 45**, loaded with high-engineering specs unavailable from any other antenna source today.

Wait till you see how we've got band-switching in hand. This has got to turn you on!

**No more coil changing.** At the flick of the positive-stop switch, skip across all 5 bands freely using our High-Q tapped coil. Nine positions to shift to:

- one each for 10, 15, 20 and 40 meters
- five settings on 75 meters

And gold smooths the way. Only Mobile 45’s rods slide through switch contacts that we’ve *gold-plated*, to deliver a swan-song to corrosion.

All for $119.95, with 1000 watts PEP, and the same extra rugged, heavy duty construction you always count on from Swan.

Check out Mobile 45’s exclusive strong points at your Swan dealer, where—your Swan Credit Card’s good anytime.

Please rush full details for the Swan 5-band Mobile 45 with manual band-switching.

Name: ________________________________
Address: ______________________________
City: __________________ State: _______ Zip: _______

FREE! Personalized call-letter plaque

2½" x 4" with stand, no charge

☐ Please send my plaque imprinted with my station call _______________________

Swan's continuing commitment to product improvement may affect specifications and prices without notice.

305 Airport Road, Oceanside, CA 92054
ITS WHAT YOU CAN'T HEAR THAT MAKES YOUR QSO Q5

The Frequency-Agile FL-1 is totally unique in that it will automatically scan the 280 - 3,000 Hz audio spectrum, and when sensing interfering heterodynes, CW or RTTY signals, rejects them up to 40 dB.

NOTCH-MODE OPERATION
During your SSB/SSTV operations, the Frequency-Agile FL-1 AUTOMATICALLY scans, locks, and tracks interference within the 280-3000 Hz spectrum, and in a second or two reduces QRM up to 40 dB! For CW/RTTY usage, fully INDEPENDENT control of bandwidth and center frequency provide rejection of interfering signals up to, or greater than 40 dB.

PEAK-MODE OPERATION
The SSB/SSTV operator, using the fully INDEPENDENT controls of the FL-1, can precisely tailor the audio response, reducing or eliminating adjacent channel splatter or SSTV QRM.

For CW/RTTY operation, the FL-1 can adjust bandwidth down to 25 Hz rejecting virtually all interference to the desired signal. Often, the AUTOMATIC and AFC features of the FL-1 are desirable when in this mode.

$179.95
 Including Pre-Paid shipping & full insurance

GENERAL SPECIFICATIONS
• Size: 8"W x 1"H x 5.5"D
• Requires 16 VDC from either internal battery or external supply (not included)
• Installs easily in your audio line between your receiver and speaker
• Highest quality construction - 2 glass circuit boards, 8 I.C.s, 6 Transistors, 8 Diodes, 2 LEDs

Dedicated to Excellence
Technical Products Corp.

Box 62 Birmingham, Michigan 48010 Telephone 313/588-2288

NEW TOUCH-O-MATIC TOUCH TONE ENCODER

ONLY $39.95

AT YOUR LOCAL HAM DEALER

• Digitran positive touch keyboard
• New lower price results from applying latest integrated circuit technology
• Automatic transmitter keying when you dial. Complete with built-in keying and delay circuitry
• Great for hand-helds and mobiles
• Crystal Stable
• Quality and performance comparable to encoders selling for $20 to $30 more.

FOR DEALER INFORMATION WRITE
T/T Communications
1344 N. Scottsdale Road
Tempe, AZ 85281

THE COMM CENTER
LAUREL PLAZA — RTE. 198
LAUREL, MD 20810
301-792-0600

DRAKE • ICOM • TEN-TEC • TEMPO • WILSON

!! JUST IN TIME FOR FIELD-DAY !!

The HF BANTAM DIPOLE is a truly portable all-band miniature dipole complete with its own carrying case and mast/hardware to mount on a camera tripod (3/8" x 24 adaptor available). High performance is obtained on 80-10 meters at its normal 13 foot length or the same antenna may be shortened to 7 feet for 75-10 meter coverage. Polarization is quickly interchangeable from horizontal to vertical. No ground system necessary. The BANTAM DIPOLE is ideal for camping, traveling, mountain-topping, apartment living, or if you're stuck with building code restrictions. Construction is of high quality 6061-T6 aluminum and stainless steel hardware. 30-day money back guarantee.

$59.95

LAUREL PLAZA — RTE. 198
LAUREL, MD 20810
301-792-0600

Send S.A.E. for spec sheet
U.S. Patent pending
Dealer inquiries invited
I HAVE A BEAUTIFUL KENWOOD TS-920S transceiver that is about to be surplus to my present needs. It is like new, has all cables, manual, warranty card (not filled in) and is in perfect condition, inside and out. I will include a new MC-50 matching microphone with the rig, I prefer not to ship, but will ship, if you insist, in original factory carton and protective cover. This rig has the CW filter installed. You will never regret buying this rig — especially at my rock-bottom price of $650 plus shipping. First casher's check or Money Order takes it. W1XU. Tel. (603) 924-5795. Do not call before June 2nd, and no collect calls, please.

HAM RADIO HORIZONS, a super new magazine for the Ham Radio, new, has all cables, manual, warranty card (not filled in). Guaranteed new, 8-1/2 x 11 x .50, 32 pages. SASE, SASE for info. KWSWE, Box 20-A, San Antonio, Texas 78201. (512) 699-9260.

TELETYPewriter PARTS, gears, manuals, supplies, tools, toroids. SASE list. Teleprinter Corp., Box 8673, Ft. Lauderdale, FL 33310. Buy parts, late models, too.

VHF-UHF TRANSVERTERS: Extend frequency range of your rig. VHF gear. Send for info. UHF-VHF COMMUNICATIONS, 53 St. Andrew, Ridge City, SD 57701.

FOR SALE: Pair of 1977 call books; $6.00. Late issues of QST and Ham Radio $2.50 per year; plus shipping all items. Ham Radio, with dues balun, BMC clamp, $11.50. Please pick up: Clark W2HZ.

CERTIFICATE for proven two-way radio contacts with Amateurs in all ten USA call areas. Award suitable to frame and proven achievements added on request. SASE brings TAD data sheet from W5LS, 2841 Empire, Burbank, CA 91504.

FREE CATALOG of new merchandise. Resistors, capacitors, IC's, semiconductors, and more. Send to: Key Electronics, Box 35066N, Schenectady, New York 12303.

WANTED: Measurements 35 grid dipper. Also interested in HF and UHF tuning heads. Jim Fisk, W1HR, Ham Radio, Greenville, NH 03048.


SEE OUR AD in this issue. Pyramid Data, Page 000.


MOTOROLA HT220, HT290, and Pageboy service and modifications performed at reasonable rates. WA4FIV (804) 320-4439, evenings.

AUTHORIZED DEALER for DenTron, KLM, Larsen, Bear- cat, etc., Big Catalog 201-962-4695, Narwed Electronics, 61 Beil Road, Ringwood, NJ 07456.


TELETYPewriter PARTS WANTED: for all machines manufactured by: Kienzschmidt Corp., Teletype Corp. and Mite. Any quantity, top prices paid send list for my quote. Phil Ricken, WA4LW, Rt. 9, Box 116202, Brookville, FL 33952.


QLS CARDS 5000/4.00 illustrations, sample. Bowman Printing, Dept. HR, 747 Harvard, St. Louis, MO 63130.

HOMEBREWERS: Stamp brings component list. GPO Surplus, Box 189, Braintree, Mass. 02184.

CHANNEL ELEMENTS NEEDED KKN1024A. Motorola for Micor Radio. Need several. WA6GOA, 4 Ajax, Berkeley, CA. 94704. (415)543-8525.

ATLAS 2100 $50, 220 CS $95, 10X $30, DMK $25. All new, unused, in original cartons. Package deal $700. Have two of each. Reid W6MFT, 2701 Durant 9, Berkeley, CA. 94704. 415-549-0518.

ORP ACCU-KEYER PC board, G-10 drilled. See QST Jan. 76; $5.00. UC Engineering, 1903 Gambela Quais, Austin, Texas 78756, KPX.


RTTY — NS-1A PDL demodulator. Board $3.50; Parts $1.50; W7 $24.95, all postpaid. SASE for info. Nat Stinehette Electronics, Taurus, Ft. 32778.

NEED — IC-22S or better ZM Transceiver, Atlas 1800122125, R.F. Sensitive SSB, TO (or sale) TV Camera with zoom lens — $179 for VTR. SSTV/TWAT, Security uses. Data Precision $245 DIMM (4 x digits) with nicads, manuals. W50017 Majoura CI., San Jose, California 95120. (408) 997-0312.

HONEYBEE, a super new magazine for the Ham Radio. new, has all cables, manual, warranty card (not filled in). Guaranteed new, 8-1/2 x 11 x .50, 32 pages. SASE, SASE for info. KWSWE, Box 20-A, San Antonio, Texas 78201. (512) 699-9260.

HONEYBEE, a super new magazine for the Ham Radio. new, has all cables, manual, warranty card (not filled in). Guaranteed new, 8-1/2 x 11 x .50, 32 pages. SASE, SASE for info. KWSWE, Box 20-A, San Antonio, Texas 78201. (512) 699-9260.

HONEYBEE, a super new magazine for the Ham Radio. new, has all cables, manual, warranty card (not filled in). Guaranteed new, 8-1/2 x 11 x .50, 32 pages. SASE, SASE for info. KWSWE, Box 20-A, San Antonio, Texas 78201. (512) 699-9260.

HONEYBEE, a super new magazine for the Ham Radio. new, has all cables, manual, warranty card (not filled in). Guaranteed new, 8-1/2 x 11 x .50, 32 pages. SASE, SASE for info. KWSWE, Box 20-A, San Antonio, Texas 78201. (512) 699-9260.

IF YOU SELL A BEAUTIFUL NEW Radio, you 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.

SMOKE DETECTOR

- PL55 patch cord — a full 20 feet long with a molded PL55 one end. Real nice. A low — 75c ea. ppd.

- 4-400 relay, VDC coil, Potter Brumfield, 3 amp contacts, factory new of course, a beauty $1.99 ea.

- Mini-Toggle, DPDT Cutler-Hammer wire-wrap terminals but can also be soldered. Gold plated. A very high quality unit. Hardware supplied. $1.50 ea. ppd.

- Computer Grade Capacitor. 5100 mfd @ 50 volts. Size: 2 x 1-1/4 high. $1.90 ea. ppd.

- 1000 volt PIV 2 amp dIodes .10 ea.

- ALL ITEMS PPD USA SEND STAMP FOR LIST OF BARGAINS PA RESIDENTS ADD 6% SALES TAX FONE 412-883-7006

SUPER-BUY — 5000 mfd. @ 48 volt electrolytic cap, factory new and complete w/ all hardware. $1.35 ea. ppd.
flea market

WANTED: AN PRC-70, 74 and/or parts and accessories. Send details and price to Strch 6301 Glad Ave., K200 Woodland Hills, CA 91367.

SELL or trade for VHF rig; novice rigs, surplus gear, tele-type parts, tubes, components. SASE for list. KBUP Mike Reed, Rt. 1, Box 200, Wobdbach, Nebraska 68882.


RELAY CHANGEOVER ANTENNA

Others available:

With your DSI Counter... save the shop cost of tweaking xtals... know your frequency... from 160 meters through 450 MHz. Now DSI offers the most counter for your dollar. Latest state-of-the-art technology... DSI advanced LSI design far exceeds outdated TTL. Go with the leader... buy a DSI FREQUENCY counter and SAVE TIME & MONEY!!

MODEL 3500 $139.95
Includes TCXO ± 1 PPM

- MADE IN USA—Factory assembled—2 Hr. Burn-in Test & Calibration
- Built in 600MHz Prescaler with RF Preamp—Not an add-on
- Large Bright—1½ inch LED Readouts
- Resolution—10Hz Non-Prescaled 100Hz Prescaled, 1 sec Gate
- ACCURACY ± 1 PPM ± one count ± 1 PPM per six months from 65°F to 85°F
- SENSITIVITY—50 MHzrms 150 to 250MHz 100mV @ 450MHz
- Gate Time Light—Automatic Decimal Point Placement
- Automatic Leading Zero Blankling When No Input Signal is Present
- No RF Connection Required with Supplied Antenna
- 50238 Connectors Supplied for Direct Probe Input
- AC or DC Operation—115 VAC 50/60 Hz 8.5V to 13.5 VDC @ 300mA
- Comprehensive Owners Manual with Complete Schematics
- Size 2 7/8"H x 8"W x 5" Deep

MODEL 3600A $189.95
Includes oven timebase ± .5 PPM

- MADE IN USA—Factory Assembled—8 Hr. Burn-in Test & Calibration
- Built in 600MHz Prescaler & RF Preamp—Not and add-on
- 8 Large Bright—1½ inch LED Readouts
- Two Selectable Clock Times—1 sec. & 1 sec. 10Hz to 600Hz
- ACCURACY ± .5 PPM ± one count ± 1 PPM per six months from 50°F to 100°F
- SENSITIVITY—10MHzrms 100 to 250MHz 50mV @ 500MHz
- Gate-time & Oven Light—Automatic Decimal Point Placement
- Automatic Leading Zero Blankling When No Input Signal is present
- No Direct RF Connection Required—With Supplied Antenna
- 50238 Hz input 50Hz to 75MHz—50239 Low ± 10Hz to 600MHz
- AC or DC Operation 115 VAC 50/60 Hz, 8.5V to 13.5 VDC @ 400mA
- 50Hz to 600MHz Sine or Square Wave Input
- FCC Certified—Designed for the Professional Service Technician
- Resolution 1 Hz Non-Prescaled 10Hz Prescaled @ 1 sec. Gate

PERFORMANCE YOU CAN COUNT ON

1. PPM OVER TEMPERATURE RANGE With a spec. of ± 1 PPM over 50°F to 100°F, your worst error over temperature would be ± 145Hz, when measuring 145 MHz. This is the most important specification for any frequency counter because temperature variation of only a few degrees could have a drastic effect on the accuracy of your counter.

2. PPM LONG TERM With a spec. of ± 1 PPM per six months, your additional error would only be 145Hz when measuring 145MHz, six months after calibration.

3. LAST DIGIT ERROR All counters have an error in the last digit. If the last digit should read a 5 it could be a 4, 5 or 6. When you have 10 Hz resolution (last digit represents tens of Hz) your additional error will be ± 10 Hz.

4. TOTAL ERROR The overall error of a counter is the sum of the error due to temperature variation, last digit error and long term error. A simple ± 1 PPM spec, with no mention of temperature or ageing could conceal a much larger overall inaccuracy. Example: ± 1 PPM at 75°F is ± 145Hz at 145MHz, but the same counter might be in error 1 kHz or more at only 85°F.

VISIT US AT YOUR NEXT HAMVENTION

Dayton, Ohio 28, 29, 30 April • Baton Rouge, LA 5, 6, 7 May • Birmingham, ALA 13, 14 May • L.E.R.C., L.A., CA 20, 21 May

See Your Local Dealer

Call Toll Free (800) 854-2049 DSI instruments Inc.

Name
Address
City State Zip Code

☐ Please send more information on your full line of instruments
☐ Check Enclosed ☐ C.O.D.

Please charge my: ☐ Bank American ☐ Visa ☐ Master Charge ☐ AE

Card # Exp. Date

Signature

California Residents add 5% State Sales Tax and Call Collect (714) 565-8402

7914 Ronson Road No. G, San Diego, CA 92111

June 1978
RHONDA SCAMMELL, REGENCY SCANNER
BRINGS YOU THE NEWS WHILE ITS HAPPENING

10 channels covering all 5 bands. AC/DC operation.

SAVE $40 LIST-$129.95

1,000's OF CRYSTALS

- H25C Case Scanner Monitor
- 10.7 Amateur Ham
- 2 Meter, CB, Standard
1 to 9 10 to 49 $3.70
50 and UP $3.00

CRYSTAL BANKING SERVICE
P.O. Box 683
LYNNFIELD, MASS. 01940

TECH MANUALS for Govt. surplus gear - $6.50 each:
SP-500UX, URM-252, GS-64U, TS-173UR. Thousands more available. Send 50c (coin) for 22-page list. W3HID, 7216 Roanne Drive, Washington, DC 20021.

RECEIVE PARTS LISTS regularly for $4yr. Surplus Parts, P.O. Box 7057, Norfolk, VA 23509.


I have the best! Try me and see for yourselves. I'm easy handling, I'm easy to work, and I'm easy to keep up. Call me, see or write W2E3. Bob Smith Electronics, RDF 3, Hwy 169 & 7, Fort Dodge, IA 50501. (515) 576-3866.

TRAVEL-PAK QSL KIT - Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMERICAN ELECTRONICS, 212 Pennsylvania Avenue, Linden, NJ 07038.

NEW NORTH ELECTRIC COMPUTER POWER supplies,骗子, high receivertransceiver, variable scan rate, manual advance, discriminator, more. Free literature.

In Amateur Ham Radio... What it's all about, How to get started, The Beginner, the Novice and anyone else who wants to know us and we invite you to join them by writing or calling.

TEC-MARK TECHNOLOGY LTD

For the home and the office, a phone system that offers high quality sound through a speakerphone. TEC-MARK TECHNOLOGY LTD, 2200 W. 140th Street, Chicago, IL 60628.

Eiad market

TECHNICAL MANUALS for Govt. surplus gear—$6.50 each: SP-500UX, URM-252, GS-64U, TS-173UR. Thousands more available. Send 50c (coin) for 22-page list. W3HID, 7216 Roanne Drive, Washington, DC 20021.

QSL FORWARDING SERVICE — 30 cards per dollar. Write: QSL Express, 30 Lockwood Lane, West Chester, PA 19380.

RECEIVE PARTS LISTS regularly for $4 yr. Surplus Parts, P.O. Box 7057, Norfolk, VA 23509.


EZ deals are the best! Try me and see for yourselves. I'm easy handling, I'm easy to work, and I'm easy to keep up. Call me, see or write W2E3. Bob Smith Electronics, RDF 3, Hwy 169 & 7, Fort Dodge, IA 50501. (515) 576-3866.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

THE MEASUREMENT SHOP has used/reconditioned test equipment at sensible prices; catalog. 2 West 22nd St., Baltimore, MD 21218.

RADIO MUSEUM NOW OPEN. Free admission, 15,000 pieces of equipment from 1850 telegraph instruments to amateur and commercial transmitters of the 1920s. Amateur station W2AN. Write for information: Antique Wireless Assn., Main St., Holcomb, NY 14469.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.

AMATEUR MICROPROCESSOR EXPERIMENTERS: 10 MHz, 12 MHz, 20 MHz, 24 MHz, 28 MHz. Off the shelf, in a rack, expansion bus, and ready to test.

TRAVEL-PAK QSL KIT — Send call and 25c, receive your call sample kit in return. Samco, Box 203, Wyanetkill, NY 12198.
**Frequency Schemes Available:**

**VX2-4** 28-30 = 144-146
**VX2-5** 28-29 = 145-146
**VX2-6** 26-28 = 144-146

**Other frequency ranges available on special order**

---

**2M LINEAR POWER AMPLIFIERS:**

- **LPA 2-15** Kit 15 W p.e.p. $69.95
- **LPA 2-70** Kit 70 W p.e.p. $139.95

---

**New VHF & UHF Converter Kits**

**Features:**
- Linear Converter for SSB, CW, FM, etc.
- Use low power tap on exciter or attenuator pad
- Easy to align with built-in test points

**P9 Kit** $12.95
**P14 Wired** $24.95

**P8 Kit** $10.95
**P16 Wired** $21.95

**P15 Kit** $18.95
**P35 Wired** $34.95

**T40** 11 Channel 200 MW Exciter Kit for 2M or 6M band $39.95

**T20** Tripler/Driver Kit. Use with T40 for operation on 432-450 MHz band $19.95

**T80** NF Power Amplifier Modules for Above
- No tuning
- WSWR Protected
- Wired and Tested
- Rated for Continuous Duty - Great for Repeaters

**R70** 6 Channel VHF Exciter Receiver Kit for 2M, 6M, 10M, 220 MHz, or any band $69.95
- Optional VHF filter for 100 dB adjacent channel

**R90** UHF Receiver Kit for any 2 MHz segment of 380-520 MHz band $89.95

---

**FREE 1978 CATALOG**

40 PAGE CATALOG IS YOURS FOR THE ASKING!

**IT'S EASY TO ORDER!**

- **CALL OR WRITE NOW FOR FREE CATALOG OR TO PLACE ORDER!**
- **PHONE 716-653-9254**. (Answering service evenings and weekends for your convenience. Personal service 9-5 eastern time.)
- **Use credit card, c.o.d., check, m.o.**
- **Add $2.00 shipping & handling.**

IN CANADA, send to Comtelg, 5605 Westlake Ave, Montreal, Que H4W 2N3 or phone 514-482-2640. Add 28% to cover duty, tax, and exchange rate.

**Hamtronics, Inc.**
182-C Belmont Rd; Rochester, NY 14612
STEREO CW FILTER

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

Now an audio filter that really works. Connect to your receiver phone jack, plug your phones into the filter and hear the difference a stable 8-pole active filter can make. Does not ring or sound "tinny". Multiple low Q filters add up to sharp skirt selectivity without ringing.

Switch position 1 gives "wide band" filtering (300 Hz bandwidth, wide skirts). Removes hum and splitter, peaks the signal, but lets off-frequency signals come through.

Switch position 2 gives "narrow-band" filtering (80 Hz bandwidth, steep skirts). Selects the signal you want, eliminates the rest. Greatly improves reception in heavy QRM.

FT-1011 ICOM IC-211
RF DIRECTIONAL WATTMETER
with VARIABLE RF SIGNAL SAMPLER — BUILT IN
AUTHORIZED DISTRIBUTOR

CENTRAL NEW YORK'S FASTEST GROWING HAM DEALER

Black Hills A.R.C. Prize Drawing. Flea market.


KENTUCKY: JEFFERSON DAVIS MONUMENT AWARD sponsored by the Pennyma R.S., Hopkinsville, Ky., in memory of Jefferson Davis, President of the Confederacy, who was born in Fairview, Ky. The Pennyma R.S. will be operating from Jefferson Davis Memorial Park June 3rd, and this certified sequential award will be presented to the amateur who presents written confirmation of contact with any PARS member during the QSO period; or any ten Kentucky amateurs during the year; QSO Party begins 1400 UTC June 3rd and ends 0500 UTC June 4th. Frequencies are: 3.740, 21.140, 28.140 for Novice, and 3.970, 7.270, 14.310, 21.370, and 28.610 for General and higher licensees.

THE SIXTH DISTRICT DX QSL Bureau is for receiving INCOMING DX-QSLs for Sixth District Amateur Radio Operators. Send a minimum of 5, (12 Maximum) self-addressed stamped 5"x7" envelopes to the QRM in only one by. The almost magic action of the ears and the brain, the interference is rejected. Yet off-frequency calls can be heard. Great for contest operators, cw nets.

Send for free brochure.
Order direct. $39.95 in U.S. and Canada. Add $2.00 shipping/handling. California residents add sales tax.
<table>
<thead>
<tr>
<th>DIODES/ZENERS</th>
<th>SOCKETS/BRIDGES</th>
<th>TRANSISTORS, LEDS, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1N914 100v 10mA</td>
<td>8-pin pcb .25 ww</td>
<td>2N2222A NPN (2N2222 Plastic, 10) .15</td>
</tr>
<tr>
<td>1N4005 600v 1A</td>
<td>14-pin pcb .25 ww</td>
<td>2N2907A PNP             .15</td>
</tr>
<tr>
<td>1N4007 1000v 1A</td>
<td>16-pin pcb .25 ww</td>
<td>2N3906 PNP (Plastic)    .10</td>
</tr>
<tr>
<td>1N4148 75v 10mA</td>
<td>18-pin pcb .25 ww</td>
<td>2N3904 PNP (Plastic)    .15</td>
</tr>
<tr>
<td>1N753A 6.2v z</td>
<td>22-pin pcb .45 ww</td>
<td>2N3054 PNP              .35</td>
</tr>
<tr>
<td>1N758A 10v z</td>
<td>24-pin pcb .35 ww</td>
<td>2N3055 PNP 15A 60v .60</td>
</tr>
<tr>
<td>1N759A 12v z</td>
<td>28-pin pcb .35 ww</td>
<td>TIP125 NPN PNP Darlington .15</td>
</tr>
<tr>
<td>1N4733 5.1v z</td>
<td>40-pin pcb .50 ww</td>
<td>LED Green, Red, Clear, Yellow .15</td>
</tr>
<tr>
<td>1N5243 13v z</td>
<td>4042 .95</td>
<td>D.L. 747 7 seg 5/8&quot; High com-anode .125</td>
</tr>
<tr>
<td>1N5244B 14v z</td>
<td>401 5 .90</td>
<td>XAN72 7 seg com-anode (Red) .125</td>
</tr>
<tr>
<td>1N5245B 15v z</td>
<td>4066 .95</td>
<td>MAN71 7 seg com-anode (Red) .125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAN3610 7 seg com-anode (Orange) .125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAN82 7 seg com-anode (Yellow) .125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MAN74A 7 seg com-cathode (Red) .15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FNQ359 7 seg com-cathode (Red) .125</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C MOS</th>
<th>T T L</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000 .15</td>
<td>7400 .15</td>
</tr>
<tr>
<td>4001 .15</td>
<td>7401 .15</td>
</tr>
<tr>
<td>4002 .20</td>
<td>7402 .20</td>
</tr>
<tr>
<td>4004 .95</td>
<td>7403 .20</td>
</tr>
<tr>
<td>4006 .95</td>
<td>7404 .15</td>
</tr>
<tr>
<td>4007 .35</td>
<td>7405 .25</td>
</tr>
<tr>
<td>4008 .95</td>
<td>7406 .55</td>
</tr>
<tr>
<td>4009 .45</td>
<td>7407 .55</td>
</tr>
<tr>
<td>4010 .45</td>
<td>7408 .25</td>
</tr>
<tr>
<td>4011 .20</td>
<td>7409 .15</td>
</tr>
<tr>
<td>4012 .20</td>
<td>7410 .10</td>
</tr>
<tr>
<td>4013 .45</td>
<td>7411 .25</td>
</tr>
<tr>
<td>4014 .95</td>
<td>7412 .30</td>
</tr>
<tr>
<td>4015 .90</td>
<td>7413 .35</td>
</tr>
<tr>
<td>4016 .35</td>
<td>7414 1.10</td>
</tr>
<tr>
<td>4017 1.10</td>
<td>7415 .60</td>
</tr>
<tr>
<td>4018 1.10</td>
<td>7417 .40</td>
</tr>
<tr>
<td>4019 .50</td>
<td>7420 1.15</td>
</tr>
<tr>
<td>4020 .85</td>
<td>7421 .30</td>
</tr>
<tr>
<td>4021 1.00</td>
<td>7422 .45</td>
</tr>
<tr>
<td>4022 .85</td>
<td>7430 .15</td>
</tr>
<tr>
<td>4023 .25</td>
<td>7432 .30</td>
</tr>
<tr>
<td>4024 .75</td>
<td>7437 .30</td>
</tr>
<tr>
<td>4025 .30</td>
<td>7438 .35</td>
</tr>
<tr>
<td>4026 1.95</td>
<td>7440 .25</td>
</tr>
<tr>
<td>4027 .50</td>
<td>7441 1.15</td>
</tr>
<tr>
<td>4028 .95</td>
<td>7443 .45</td>
</tr>
<tr>
<td>4030 .35</td>
<td>7444 .45</td>
</tr>
<tr>
<td>4032 .15</td>
<td>7445 .45</td>
</tr>
<tr>
<td>4033 2.45</td>
<td>7446 .95</td>
</tr>
<tr>
<td>4035 1.25</td>
<td>7447 .95</td>
</tr>
<tr>
<td>4040 1.35</td>
<td>7448 .95</td>
</tr>
<tr>
<td>4041 1.69</td>
<td>7449 .65</td>
</tr>
<tr>
<td>4042 .95</td>
<td>7450 .25</td>
</tr>
<tr>
<td>4043 .95</td>
<td>7451 .25</td>
</tr>
<tr>
<td>4044 .95</td>
<td>7452 .25</td>
</tr>
<tr>
<td>4046 1.75</td>
<td>7454 .25</td>
</tr>
<tr>
<td>4049 .45</td>
<td>7460 .45</td>
</tr>
<tr>
<td>4050 .45</td>
<td>7470 .45</td>
</tr>
<tr>
<td>4066 .95</td>
<td>7472 .40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MICRO'S, RAMS, CPU'S, ETC.</th>
<th>LINEAR'S, REGULATORS, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>745188 3.00</td>
<td>LM320T5 1.65</td>
</tr>
<tr>
<td>1702A 4.50</td>
<td>LM320T12 1.65</td>
</tr>
<tr>
<td>MM5314 3.00</td>
<td>LM320T15 1.65</td>
</tr>
<tr>
<td>MM516 3.50</td>
<td>LM324N 9.50</td>
</tr>
<tr>
<td>2102-1 1.45</td>
<td>LM339 9.50</td>
</tr>
<tr>
<td>2102L-1 1.75</td>
<td>7805 (340T) .95</td>
</tr>
<tr>
<td>TR16028 4.50</td>
<td>7805 (340T) .95</td>
</tr>
<tr>
<td>TMS 4044-45NL 14.50</td>
<td>7805 (340T) .95</td>
</tr>
<tr>
<td>8T80AD 12.00</td>
<td>LM304T12 1.00</td>
</tr>
<tr>
<td>8T13 1.50</td>
<td>LM304T15 1.00</td>
</tr>
<tr>
<td>8T23 1.50</td>
<td>LM304T18 1.00</td>
</tr>
<tr>
<td>8T24 2.00</td>
<td>LM304T24 1.00</td>
</tr>
<tr>
<td>8T7 1.00</td>
<td>LM47 1.45</td>
</tr>
</tbody>
</table>

INTTEGRATED CIRCUITS UNLIMITED

7899 Clairemont Mesa Boulevard, San Diego, California 92111
(714) 278-4394 (Calif. Res.)

All orders shipped prepaid No minimum
Open accounts invited COD orders accepted
Discounts available at OEM Quantities California Residents add 6% Sales Tax
All IC's Prime/Guaranteed. All orders shipped same day received.

24 Hour Toll Free Phone 1-800-854-2211 American Express / BankAmericard / Visa / MasterCharge

SPECIAL DISCOUNTS
Total Order Deduct
$35  - $99  5%  
$100 - $300  10%  
$301 - $1000  15%  
$1000  - Up  20%

20%
WE’VE DONE IT AGAIN!

Announcing the new “SCANICOM”™ 245/211 scanner, the ultimate accessory for your new ICOM radio.

“SCANICOM”:
- Will scan the entire 2-meter band in 5 kHz steps (the radio’s display tells you the frequency)
- Has a built-in delay that allows you to remain on frequency for a few seconds after the signal goes away
- Employs a connector that simply plugs into the back of your unit
- Requires only one wire to be added to your unit, and
- Comes complete with a fully illustrated instruction manual for fast, simple, installation
- Proper installation will not void warranty

$39.95

Units available directly from ESSARY ENTERPRISES or from your local ICOM dealer. Call or write for details NOW.

EASARY ENTERPRISES
P.O. Box 1731
Richardson, TX 75080
Tel: (214) 231-5866

flea market

THE TRI-STATE AMATEUR RADIO ASSN. (TARA) 18th Annual Hamfest, Sunday, June 4, 1978 11:00 AM Camden Park, Rte. 60 West Huntington. Talk-in: WYAB, 0464, 1676, 3494. For information and tickets write: TARA, P.O. Box 1295, Huntington, W.Va. 25755.

ROME HAM FAMILY DAY will be held on June 4, 1978. For information write Rome Radio Club, PO Box 721, Rome NY 13440. (Dealer inquiries invited).

ILLINOIS: Egyptian Radio Club Annual Hamfest, Sunday, June 11, at club grounds, Granite City.


MICHIGAN S.P.A.R.K. Activities. Weekend, June 10th and 11th. Newberry, Michigan, Saturday; Fish Fry, Toonerville Trolley and River Trip; Sunday, Annual Swap and Shop. Fun and enjoyment for all — hams, CBers, YLs, XYLs; children. Donations $2 for registration and drawings; Tables $1.50 and $2.50. Talk-in on 01/81, 31/91, and 52 simplex. Contact W6GGR, Box 67, Newberry, MI 49868. Tel. 906-263-8805.

“TIN LIZZY” INTERNATIONAL QSL PARTY — Saturday and Sunday, June 17 and 18 — commemorating the 75th anniversary of the Ford “Tin Lizzy” and sponsored by the Ford Amateur Radio League, an employee organization of the Ford Motor Company. Open to all amateurs throughout the world, on all bands 160 through 10 meters, the contest will run from 2400 UTC Friday, June 16th through 2400 UTC Sunday, June 18th. Stations once per band, per mode — CW or ssb only. Call “CG Tin Lizzy” on SSB, and “CG TLC” on CW. For details of logs, exchanges, etc. contact The Tin Lizzy Goof, P.O. Box 932, Dearborn, Michigan 48121. Be sure to include a $10 SAPE with postage (U.S.) or an I.R.C. For other questions, contact K882TH, 14468 Bassett Ave., Livonia, MI 48154; tel. (313) 454-9149 at home, or (313) 594-1779 at work.

MICHIGAN Monroe County A.R.C. Annual Swap & Shop 800 AM to 4:00 PM Sunday, June 4th at Monroe County Community College, Raisinville Road (off M-50); Monroe, Michigan. Talk-in: 1373. Donation $1 at gate. FREE tables and trunk sales. Details W8BI4T, 3473 Vermont Court, Monroe, MI 48161.

INDIANA — Fifth Annual “Dad’s Day” Hamfest, sponsored by Lake County A.R.C., 8:00 AM to 5:00 PM Sunday, June 11th, at the Izaak Walton Leagien Picnic Grounds, Portage, Indiana. Take I-94 to Indiana 249 — Portage exit — then North 1/2 mile. Picnic facilities, no hookups. Talk-in: 146.57 or 6424. Tickets $2 donation at gate or $1.50 advance. Details from TICKETS, Box 348, Griffith, Indiana 46319.

PONY EXPRESS CERTIFICATE — Available from the Missouri Valley A.R.C. to any ham who works the HF bands. Work 5 MVARC members, send 5 QSLs confirming QSOs and include two 10 stamp (U.S. Hams); or 3 MVARC members and 2 confirming QSLs, plus one I.R.C. (DX hams) to W5KBR, P.O. Box 141, Station E, St. Joseph, MO 64805. Also, list of MVARC stations from same address.

OHIO — The Goodyear A.R.C. 11th Annual Hamfest and Family Picnic, Sunday, June 11th, 10:00 AM to 8:00 PM at Wingfoot Lake Park, Akron, Ohio on county road 87 near Route 43. Many prizes, ample parking, shelters, picnic facilities, play areas for children, refreshments. Flea market and display space $5.00 to ticket holders. Family donation $2.50 advance, $3.00 gate. Details from W6BASX, 161 So. Hawkins Ave., Akron, OH 44313; tel. (216) 964-3666.

THE WEST WASHETNAW SWAP & SHOP sponsored by the Dexter Amateur Radio Club — Chelsea Communications Club, at the Chelsea Fairgrounds, June 4th, 8:00 AM to 3:00 PM. Donations $1.50 advance, $2.00 gate. Table space $20 per foot, trunk sales $1.00 per space.


Practical experience with Superior Quality Materials and Construction that’s...

TOWER POWER by TISTAO

Tristao isn’t just a trade name... it’s a man called Lou, and he’s been designing towers for hams all his life... the pioneer. That’s why Tristao towers above all. And because he knows hams, he engineers quality at a price you can afford. For the Mini-Mast to the giants, it’s TOWER POWER all the way with Tristao.

WRITE RIGHT NOW FOR FULL SPECS and dealer nearest you. PROMPT DELIVERY.

TRISTAO TOWER
Division of Palmer Industries, Inc.
415 E. 5th St. P.O. Box 115
Hannaford, CA 93230 / Ph. (209)582-9016

SYNTHESIZERS

We have the worlds largest selection of synthesizers for receivers, transmitters and transceivers. For complete details see our 1/3 page ad in the April 1979 issue of this magazine or call for additional information. Phone orders accepted between 9 AM and 4 PM EDT. (212) 468-2720.

VANGUARD LABS
196-23 JAMAICA AVENUE
HOLLIS, N. Y. 11423

BIRD WATCHERS
Don’t be absurd, buy a BIRD!... from your Bird distributor

MODEL 43
$120

ALL ITEMS AND ELEMENTS ORINARILY IN STOCK
Prepaid Shipment in Continental USA Only

MADISON ELECTRONICS SUPPLY, INC.
1508 McKinney Houston, Texas 77002
713/658-0258
Nites 713/497-5683
**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 anywhere available. Efficient toroid inductor for small size: 4-1/4" x 2-3/8" x 3", and negligible loss. Built-in neon tune-up indicator. SO-239 connector. Attractive bronze finished enclosure.

only **$29.95**

THE ORIGINAL Random Wire Antenna Tuner... in use by amateurs for 6 years.

---

**SST T-2 ULTRA TUNER**

Tunes out SWR on any coax fed antenna as well as random wires. Works great on all bands (80-10 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 efficient toroid inductor and specially made capacitors for small size: 6-1/4" x 2-1/4" x 2-1/2". Rugged, yet compact. Negligible line loss. 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 **$39.95**

---

**SST T-3**

Mobile Impedance Transformer

Matches 50 ohm coax to the lower impedance of a mobile whip or vertical. 12-position switch with taps spread between 3 and 82 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**

---

**SST A-1 VHF Amplifier Kit**

1 watt input gives you 15 watts output across the entire 2 meter band without re-tuning. This easy-to-build kit (approx. 1/2 hr. assembly) includes everything you need for a complete amplifier. All top quality components. Compatible with all 1-3 watt 2-meter transceivers. Short and open protected—not damaged by high SWR.

Kit includes:
- Etched and drilled 1-10 epoxy solder plated board.
- Heat sink and mounting hardware. All components—including pre-wound coils.
- Top quality TRW RF power transistor.
- Complete assembly instruction with details on a carrier operated T/R switch.

only **$29.95**

$49.95 wire and tested

---

**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 82 for shipping and handling. Calif. residents, please add sales tax. COD orders OK by phone.

---

**ELECTRONICS**

P.O. BOX 1 LAWNDALE, CALIF.
90260 (213) 376-5867

June 1978 125

More Details? CHECK — OFF Page 142
flea market

JUNE 4, 1978, STARVED ROCK RADIO CLUB HAMFEST, Bureau County Fairgrounds, Princeton, Illinois. Advance registrations $1.50 before May 25, after $2.00. Large SASE please for registrations, map, information, etc. W9KWW/AF/GB/HR, RFD #1, Box 171, Oglesby, Illinois 61346. 815-667-4614.


WIMU (Wyoming, Idaho, Montana, Utah) The 46th Annual WIMU Hamfest is scheduled for August 4, 5, and 6, 1978 at Mack’s Inn, Idaho. 25 miles South of West Yellowstone, Montana. Talk-in 146.349/4 and 3935. Advance registration: $6.00 for adults and $2.00 for children, before July 25th. Lastminute registration: $7.00 and $2.50. SPECIAL PRICE DRAWING FOR PRE-REGISTRATION. Please pre-register to: WIMU Hamfest, 3645 Vaughn Street, Idaho Falls, Idaho 83401. Phone: (208) 522-9566.

CENTRAL MICHIGAN Amateur Repeater Association Fourth Annual Swap & Shop in Midland, Michigan, June 3rd at the Midland County Fairgrounds. Camping & Program: Friday evening. Demonstrations, Door Prizes. Donation: $2.00 at door. $1.50 in advance. Talk-in: 146.07/146.67 WBRAN, 146.13/146.73 WBAHM and 146.52 Simplex. Info: Tickets, SASE to Don Zahn, WB6DSQ, 3871 Monroe Rd, Midland, MI 48640.

ANNUAL TEXAS VHFS-FM SOCIETY SUMMER CONVENTION, hosted by the Houston Echo Society, August 4, 5, 6, 1978 at the Galeria Plaza Hotel off interstate loop 610 at Westheimer Road. Microprocessors/microcomputers, hidden transmitter hunt, OSCAR communications, VHFS-FM activities. ARRL & FCC forums, open hospitality suite, ladies' activities. Astronomical-astrofandom tour of the kids, Exhibitors, and prizes. Saturday night banquet featuring Bill Tynan, W5XO, editor of QST's "World Above 50 MHz", as guest speaker. For information and reservations write FM Society Summer Convention, P.O. Box 717, Tomball, Texas 77375.

MANASSAS HAMFEST SPONSORED BY The "Old Virginia Hams" A.R.C. June 4, 1978 at the Prince William County Fairgrounds one half mile south of Manassas, Virginia on Rt. 234. Gates open 7 AM for tailgating. 8 AM for general admission. Fantastic Prizes. Admission: $3.00 adult; under 12 free. Tailgating $10.00 per vehicle, over 300 spaces available. Refreshments, YL Program, Children's entertainment. FM Clinic, CQ Bureaus: learn how they work. CW Proficiency awards: 5 wpm up. In door exhibit space available for Dealers: for info contact Sam Lewbach, KY12, Sydney Manor Dr., Manassas, VA 22110. Talk-in on 146.349/47, 147.84/147.24 and CB Ch. 1. Accommodations: Old Towne Inn in Manassas, Holiday Inn at 1-60 and Rt. 154. Camping at Prince William County Forest (on Rt. 234 near the intersection of 234 and 1-66).

HAMFESTERS 44TH ANNUAL PICNIC AND HAMFEST, Sunday, August 13, 1978 at Santa Fe Park, 191st and Wolf Road, Willowbrook, Illinois, Southwest suburb of Chicago. Exhibits for OM's and YLF's. FAMOUS SWAP-PERS ROW. Tickets at gate $2.00. Advance $1.50. For Hamlects info or advance tickets (send check or money order — SASE appreciated) to Bob Haynes W9KWX, 18031 Cedar Ave., Country Club Hills, IL 60447.

SATELLITE AMATEUR RADIO CLUB Annual Swap-Fun fest and Santa Maria BBQ on Sunday, June 18. Best steak and biggest hamfest in the west. Fantastic prizes! Swap tables available. All you can eat dinner — $6.00 adults; $3.00 children under 12. Contact W2KVA at (808) 925-0396, or write SWAPFEST, P.O. Box 2551, Orcutt, CA 93454.

Stolen Equipment

STOLEN FROM AIRLINE BAGGAGE, probably either in Minneapolis/St. Paul or San Francisco, Wilson WE-8000, s/n 12521821 with 10 white "no brand" Nic-cad batteries inside, flex antenna with UHF ell connector and UHF to BNC connector. Also homebuilt battery charger with 723 IC. Mint NOS dacker, WATTF, Box 2932, Piscataco, ID 83201.

STOLEN EQUIPMENT: 1. KLM 160 watt amplifier, no I.D. 2. Black Heath 2036 with Micoled and several obvious modifications: hi low power selector on squelch knob, variable power on internal potentiometer, RCA plug replaced with SO-239, Social Security No. 350137771 etched in foil on transmitter board. Darrel Dorssett, KI9ZK, Kankakee Area Career Center, Rt. 2, Road 100-W, Bourbonnais, IL 60914.

There's nothing !
like it

RADIO AMATEUR
callbook

Respected worldwide as the only legal authority for radio amateur QSL and QTH information.

The U.S. Callbook has over 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 300,000 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.

COPY MORSE CODE with the new MVD-1000 MORSE VIDEO DISPLAY

- Enjoy Morse Code copy on your TV screen
- Displays letters, numbers, and punctuation
- 16 lines of 32 characters per page
- 2 page display with Recall feature
- Automatic scrolling
- Automatic or Manual speed control
- Copy Morse Code from E-60 WPM
- Easily connects between receiver and TV set
Write for more information

DGM ELECTRONICS
787 BRIAR LANE, BELMONT, WIS. 53511

GOING 2 OR 220?
GET ON WITH THE BEST:

Midland 13-510
- Synthesized
- 144-148 MHz
- 1 or 2 watts
Reg. $99.95
Our Price $438*

Midland 13-513
- Synthesized
- 220-225 MHz
- 1, 10, 20 watts
Reg. $99.95
Our Price $438*

*Master Charge and VISA welcome.

Details? CHECK—OFF Page 142
### VHF-FM RECEIVER

**Model: 44.5**  
**ACCESSORIES**
- Crystal filter provides better than 75dB channel rejection
- Alumínium Case
- Speaker/Amplifier Kit 2.35 x 4" board

**Price:** $59.95

**Specifications:**
- 5 channels, remote switchable
- 6 pole channel filter
- 75dB channel rejection
- 100dB all other spurious
- Audio and video output
- Operates from 8-20 VDC
- 15mA nominal drain, squelched
- Electronic Signal Products, Inc.
- 2250 G Landmeier Rd., Elk Grove, IL 60007 (312) 364-0080

### AMATEUR RADIO EQUIPMENT DIRECTORY

The most complete directory of Amateur Radio Equipment ever published. The all new 1978 Edition includes specifications, pictures, and prices of transmitters, receivers, amplifiers, power supplies, antennas, and more. No ham library will be complete without a COPY of the 1978 Edition.  

**Price:** $4.00 Postpaid (U.S.)

**Canada:** $5.00 Postpaid

**Kendall Park, N.J. 08824**

### NEW 1978 EDITION

**Marlin J. Jones & Associates**

**PO Box 923**

**Rivera Beach, Florida 33404**

**Phone:** (305) 941-8296

**Price:** $5.00, Foreign (Air). $7.00

**VISA - Master Charge and American Express Accepted**
CALL TOLL FREE
1-800-228-4097

Antenna Sale!

MOSLEY

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Regular</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic 33</td>
<td>3 ele. 10, 15, 20 Mtr. beam</td>
<td>$232.50</td>
<td>$189.95</td>
</tr>
<tr>
<td>Classic 36</td>
<td>6 ele. 10, 15, 20 Mtr. beam</td>
<td>$310.65</td>
<td>$149.95</td>
</tr>
<tr>
<td>TA-33</td>
<td>3 ele. 10, 15, 20 Mtr. beam</td>
<td>$206.50</td>
<td>$159.95</td>
</tr>
<tr>
<td>TA-36</td>
<td>6 ele. 10, 15, 20 Mtr. beam</td>
<td>$335.25</td>
<td>$219.95</td>
</tr>
<tr>
<td>TA-33 Jr.</td>
<td>3 ele. 10, 15, 20 Mtr. beam</td>
<td>$151.85</td>
<td>$129.95</td>
</tr>
<tr>
<td>TA-40KR</td>
<td>40 Mtr. add on</td>
<td>$92.25</td>
<td>$74.95</td>
</tr>
</tbody>
</table>

CUSHCRAFT

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Regular</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATB-34</td>
<td>4 ele. 10, 15, 20 Mtr. beam</td>
<td>$239.95</td>
<td>$199.95</td>
</tr>
<tr>
<td>ARX-2</td>
<td>2 Mtr. Ringo Ranger</td>
<td>$32.95</td>
<td>$29.95</td>
</tr>
<tr>
<td>A147-20T</td>
<td>2 Mtr. Twist</td>
<td>$54.95</td>
<td>$47.95</td>
</tr>
<tr>
<td>A144-10T</td>
<td>10 ele. Twist 2 Mtr.</td>
<td>$34.95</td>
<td>$31.95</td>
</tr>
<tr>
<td>A144-20T</td>
<td>20 ele. Twist 2 Mtr.</td>
<td>$54.95</td>
<td>$47.95</td>
</tr>
<tr>
<td>A14T-MB</td>
<td>Mounting Boom</td>
<td>$15.95</td>
<td>$14.95</td>
</tr>
</tbody>
</table>

HUSTLER

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Regular</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>4BTV</td>
<td>10-40 Mtr. Trap Vertical</td>
<td>$99.95</td>
<td>$82.95</td>
</tr>
<tr>
<td>RM-75</td>
<td>75 Meter Resonator</td>
<td>$15.50</td>
<td>$13.50</td>
</tr>
<tr>
<td>RM-75s</td>
<td>75 Meter Super Resonator</td>
<td>$30.00</td>
<td>$26.50</td>
</tr>
<tr>
<td>G6-144-A</td>
<td>6 db. 2 Mtr. Base Colinear</td>
<td>$67.55</td>
<td>$57.95</td>
</tr>
</tbody>
</table>

HY-GAIN

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Regular</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH6-DXX</td>
<td>Super Thunderbird</td>
<td>$249.95</td>
<td>$209.95</td>
</tr>
<tr>
<td>TH3-MK3</td>
<td>3 ele. 10, 15, 20 Mtr. beam</td>
<td>$199.95</td>
<td>$169.95</td>
</tr>
<tr>
<td>Hy-Quad</td>
<td>2 ele. Quad 10, 15, 20 Mtr.</td>
<td>$219.95</td>
<td>$189.95</td>
</tr>
<tr>
<td>TH3-Jr.</td>
<td>3 ele. 10, 15, 20 Mtr. beam</td>
<td>$144.50</td>
<td>$129.95</td>
</tr>
<tr>
<td>18 HT</td>
<td>Hy-Tower 10-80 Mtr. Vertical</td>
<td>$279.95</td>
<td>$239.95</td>
</tr>
<tr>
<td>14AVQ/WB</td>
<td>10-40 Mtr. Trap Vertical</td>
<td>$67.00</td>
<td>$57.00</td>
</tr>
<tr>
<td>18AVT/WB</td>
<td>10-80 Mtr. Trap Vertical</td>
<td>$97.00</td>
<td>$84.95</td>
</tr>
<tr>
<td>203</td>
<td>3 ele. 2 Mtr. beam</td>
<td>$12.95</td>
<td>$12.95</td>
</tr>
<tr>
<td>205</td>
<td>5 ele. 2 Mtr. beam</td>
<td>$16.95</td>
<td>$16.95</td>
</tr>
<tr>
<td>208</td>
<td>8 ele. 2 Mtr. beam</td>
<td>$19.95</td>
<td>$19.95</td>
</tr>
<tr>
<td>214</td>
<td>14 ele. 2 Mtr. beam</td>
<td>$26.95</td>
<td>$26.95</td>
</tr>
</tbody>
</table>

WILSON

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Regular</th>
<th>Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>System One</td>
<td>5 ele. 10, 15, 20 Mtr. beam</td>
<td>$259.95</td>
<td>$239.95</td>
</tr>
<tr>
<td>System Two</td>
<td>4 ele. 10, 15, 20 Mtr. beam</td>
<td>$199.95</td>
<td>$185.00</td>
</tr>
</tbody>
</table>

CDE ROTORS

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ham III</td>
<td>$125.00</td>
<td></td>
</tr>
<tr>
<td>T2X Tail Twister</td>
<td>$249.00</td>
<td></td>
</tr>
<tr>
<td>CD-44</td>
<td>$105.00</td>
<td></td>
</tr>
</tbody>
</table>

Call for SUPER price on Consolidated Tower and Berk-Tec Coax Cable

Open seven days a week

Communications Center
The Radio Store
443 N. 48th, Lincoln, Nebraska 68504
In Nebraska Call (402)466-8402

June 1978
ALUMA TOWERS
60 ft
Ham Crank-Up
Model T-50-H

Ham Model T-140
HIGHEST QUALITY

MANY MODELS MFG.

EXCELLENT FOR HAM COMMUNICATIONS

Towers to 100 feet. Specials designed & made. See dealer or send for free catalog.

ALUMA TOWER CO.
P.O. BOX 3999
VERO BEACH, FLA. 32960
PHONE (305) 567-3423

ALUMA TOWERS
60 ft
Ham Crank-Up
Model T-50-H

Ham Model T-140
HIGHEST QUALITY

MANY MODELS MFG.

EXCELLENT FOR HAM COMMUNICATIONS

Towers to 100 feet. Specials designed & made. See dealer or send for free catalog.

ALUMA TOWER CO.
P.O. BOX 3999
VERO BEACH, FLA. 32960
PHONE (305) 567-3423

Radio Amateurs
Reference Library
Of Maps and Atlas

WORLD PREFIX MAP — Full color. 40" x 28", shows prefixes on each country . . . DX zones, time zones, cities, cross referenced tables $1.25

MOBILE CLOCK CALENDAR KIT

Quality 3"/8" Meters for PS-14 (0-25A; 0-15 VDC)
Individually Packaged. Not Surplus $12.95/set

POWER SUPPLY ACCESSORIES

Quality 3"/8" Meters for PS-14 (0-25A; 0-15 VDC)
Individually Packaged. Not Surplus $12.95/set

BULLET ELECTRONICS
P. O. BOX 19442
DALLAS, TEXAS 75219
PHONE ORDERS (214/823-3240) ON MASTERCHARGE & VISA

PS-14 HIGH CURRENT REGULATED POWER SUPPLY KIT
A low cost, no frills, heavy duty power supply. Designed for use and abused!

12V @ 15A CONTINUOUS Less Case, meters & jacks

MC1498R |4A positive Voltage Reg. House . . . 1.25
MC1499 |4A negative Voltage Reg. House . . . 1.25
MC383B |FM, AM and Sound System . . . 1.25
CA3011 |Wideband RF Amp IC House . . . 1.25
MB8376 |6 Digit Alarm Clock Chip . . . 1.25
555 |Timer & Dual Slot Chip . . . 1.25
741 |Op-amp 6 pin MINI DIP . . . 1.25
LM3000 |Quad ON/OFF . . . 1.25
722 |Pass Voltage Reg. Dip . . . 2.50
752 |Ultra low noise high gain House . . . 1.25
NF606A |P LL DIP . . . 2.50
TC4150 |Quad Audio Oscillator Dip . . . 2.50
MG2120 |Maslow M-1000, 2000 B Cartridges . . . 2.50
IN4148 |V Pack 100 . . . 1.25
2N3712 |NPN Small Signal . . . 1.25
2N3904 |NPN Power Transistor . . . 1.25
2N5668 |Programmable Unijunction . . . 1.25
2N611 |PNP Power Transistor . . . 1.25

More Details? CHECK-OFF Page 142 June 1978 131
Alabama

LONG'S ELECTRONICS
2808 7TH AVENUE SOUTH
BIRMINGHAM, AL 35202
800-633-3410
Call us Toll Free to place your order

Alaska

RELIABLE ELECTRONICS
3306 COPE STREET
ANCHORAGE, AK 99503
907-279-5100
Kenwood, Yaesu, DenTren, Wilson, Atlas, ICOM, Rohn, Tri-Ex.

Arizona

HAM SHACK
4506 A NORTH 16TH STREET
PHOENIX, AZ 85016
602-279-9200
Serving all amateurs from beginner to expert.

KRYDER ELECTRONICS
5520 NORTH 7TH AVENUE
NORTH 7TH AVE. SHOPPING CTR.
PHOENIX, AZ 85013
602-249-3739
We service what we sell.

POWER COMMUNICATIONS
6012 NORTH 27th AVE.
PHOENIX, AZ 85017
602-242-6030
Arizona's #1 Ham Store. Kenwood, Drake, ICOM & more.

QSA 599 AMATEUR RADIO CENTER
11 SOUTH MORRIS STREET
MESA, AZ 85202
602-833-8051
Eimac Distributor. New & Used Equipment, Parts - Surplus too!

California

C & A ELECTRONIC ENTERPRISES
2529 EAST CARSON ST.
P. O. BOX 5223
CARSON, CA 90745
213-834-5868
Not the Biggest, but the Best — since 1962.

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

MILE-HI COMMUNICATIONS, INC.
1970 SOUTH NAVAO
DENVER, CO 80223
303-936-7108
Rocky Mountain's newest ham store. Lee Tingle KC4LT.

CONNECTICUT

ARCOMM ELECTRONICS
2865 MAIN STREET
BRIDGEPORT, CT 06606
203-335-9850
Featuring Ten-Tec and DenTron.

AUDITRONICS INC.
18 ISAAC STREET
NORWALK, CT 06850
203-838-4877
The Northeast's fastest growing Ham Dept. dedicated to service.

Florida

AGL ELECTRONICS, INC.
1800-B DREW ST.
CLEARWATER, FL 33751
813-461-HAMS
West Coast's only full service Amateur Radio Store.

MARC'S CENTRAL EQUIPMENT CO., INC.
18451 W. DIXIE HIGHWAY
NORTH MIAMI BEACH, FL 33160
305-932-1818
See Marc, WD4AAS, for complete Amateur Sales & Service.

RAY'S AMATEUR RADIO
1590 US HIGHWAY 19 SO.
CLEARWATER, FL 33716
813-535-1416
West coast's only dealer: Drake, Icom, Cushcraft, Hustler.

Illinois

ERICKSON COMMUNICATIONS, INC.
5935 NORTH MILWAUKEE AVE.
CHICAGO, IL 60646
312-631-5181
Hours: 9:30-5:30 Mon, Tues, Wed, Fri; 9:30-9:00 Thurs; 9:00-3:00 Sat.

KLAUS RADIO, INC.
8400 NORTH PIONEER PARKWAY
PEORIA, IL 61614
309-691-4840
Let us quote your Amateur need's.

SPECTRONICS, INC.
1009 GARFIELD STREET
OAK PARK, IL 60304
312-848-6777
Chicagoland's Amateur Radio leader.

Indiana

HOOSIER ELECTRONICS, INC.
P. O. BOX 2001
TERRE HAUTE, IN 47802
812-238-1456
Ham Headquarters of the Midwest. Store in Meadows Shopping Center.

KRYDER ELECTRONICS
2810 MAPLECREST RD.
FORT WAYNE, IN 46815
219-484-4946
We service what we sell. 10-9 T, TH, F; 10-5 W, SAT.

Iowa

BOB SMITH ELECTRONICS
RFD #3, HIGHWAY 169 and 7
FT. DODGE, IA 50501
515-576-3886
For an EZ deal.

Kansas

ASSOCIATED RADIO
8012 CONSER P. O. BOX 4327
OVERLAND PARK, KS 66204
913-381-5901
Amateur Radio's Top Dealer. Buy - Sell - Trade

dealers. you should be here too! contact Ham Radio today for complete details.
### Amateur Radio Dealer

<table>
<thead>
<tr>
<th>State</th>
<th>Dealer Name</th>
<th>Address Details</th>
<th>Contact Information</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky</td>
<td>COHOON AMATEUR SUPPLY</td>
<td>HIGHWAY 475, TRENTON, KY 42286</td>
<td>502-886-4535</td>
<td>Yaesu, Ten-Tec, Tempo, DenTron. Our service is the BEST.</td>
</tr>
<tr>
<td>Kentucky</td>
<td>COMM CENTER, INC.</td>
<td>9624 FT. MEADE ROAD, LAUREL PLAZA RT. 198</td>
<td>301-792-0600</td>
<td>New &amp; Used Amateur Equipment. Wilson, Ten-Tec, R. L. Drake, Tempo</td>
</tr>
<tr>
<td>Kentucky</td>
<td>PROFESSIONAL ELECTRONICS CO., INC.</td>
<td>1710 JOAN AVENUE, BALTIMORE, MD 21234</td>
<td>301-661-2123</td>
<td>A professional place for amateurs. Service-sales-design.</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>TUFFS RADIO ELECTRONICS</td>
<td>209 MYSTIC AVENUE, MEDFORD, MA 02155</td>
<td>617-395-8280</td>
<td>New England's friendliest ham store.</td>
</tr>
<tr>
<td>Michigan</td>
<td>ELETRONIC DISTRIBUTORS</td>
<td>1960 PECK STREET, MUSKEGON, MI 49441</td>
<td>616-726-3196</td>
<td>Dealer for all major amateur radio product lines.</td>
</tr>
<tr>
<td>Michigan</td>
<td>RADIO SUPPLY &amp; ENGINEERING</td>
<td>1207 WEST 14 MILE ROAD, CLAWSON, MI 48017</td>
<td>313-435-5660</td>
<td>New and used equipment - parts and supply.</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>ELECTRONIC CENTER, INC.</td>
<td>127 THIRD AVENUE NORTH, MINNEAPOLIS, MN 55401</td>
<td>612-371-5240</td>
<td>ECI is still your best buy.</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>PAL ELECTRONICS INC.</td>
<td>3452 FREMONT AVE. NORTH, MINNEAPOLIS, MN 55412</td>
<td>612-521-4662</td>
<td>The Midwest's Fastest Growing Ham Dealer.</td>
</tr>
<tr>
<td>Missouri</td>
<td>HAM RADIO CENTER, INC.</td>
<td>8340-42 OLIVE BLVD. ST. LOUIS, MO 63132</td>
<td>314-961-9990</td>
<td>At Midcom you can try before you buy!</td>
</tr>
<tr>
<td>Missouri</td>
<td>MIDCOM ELECTRONICS, INC.</td>
<td>2506 SO. BRENTWOOD BLVD. ST. LOUIS, MO 63144</td>
<td>314-961-9990</td>
<td>Kenwood, Yaesu, Drake and more at discount prices.</td>
</tr>
<tr>
<td>Missouri</td>
<td>EVANS RADIO, INC.</td>
<td>BOX 893, RT. 3A BOW JUNCTION, CONCORD, NH 03301</td>
<td>603-224-9961</td>
<td>Icom, DenTron &amp; Yaesu dealer. We service what we sell.</td>
</tr>
<tr>
<td>Missouri</td>
<td>ATKINSON &amp; SMITH, INC.</td>
<td>17 LEWIS ST., EATONTOWN, NJ 07724</td>
<td>201-542-2447</td>
<td>Ham supplies since &quot;55&quot;.</td>
</tr>
<tr>
<td>Missouri</td>
<td>RADIOS UNLIMITED</td>
<td>1760 EASTON AVENUE, SOMERSET, NJ 08873</td>
<td>201-469-4599</td>
<td>New Jersey's newest complete Amateur Radio center</td>
</tr>
<tr>
<td>Missouri</td>
<td>THE BARGAIN BROTHERS</td>
<td>216 SCOTCH ROAD, GLEN ROC SHOPPING CTR., WEST TRENTON, NJ 08828</td>
<td>609-883-2050</td>
<td>A million parts - lowest prices anywhere. Call us!</td>
</tr>
<tr>
<td>New Mexico</td>
<td>ARTCO ELECTRONICS</td>
<td>302 WYOMING AVENUE, KINGSTON, PA 18704</td>
<td>717-283-8985</td>
<td>The largest variety of semiconductors in Northeastern Pennsylvania</td>
</tr>
</tbody>
</table>
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.”

KESTER SOLDER
Litton
4201 Wrightwood Avenue/Chicago, Illinois 60639

R F ENGINEER

An immediate opportunity exists with our well-established, growing electronics firm, located in beautiful San Diego.

Requires a BSEE with a minimum of 5 years experience in HF, VHF, and UHF RF design. Candidates must be comfortable with independent state-of-the-art transceiver design and PLL servo theory. Licensed amateur operator desired.

Our offer includes excellent salary and a full range of company sponsored benefits.

CALL WILL GORDON (714) 277-6780, Ext. 245
or send resume to:
SWAN ELECTRONICS
A Division of Cubic Corporation
9233 Balboa Ave., San Diego, Ca., 92123
An Equal Opportunity Employer

CFP COMMUNICATIONS, INC.

THE BEST of BOTH WORLDS
Open Tuesday-Friday 10-6; Saturday 12-4

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

More Details? CHECK — OFF Page 142
SLEEP ELECTRONICS
SHIPPING ANTENNAS AND ACCESSORIES

SWAN
TBH1A 4EL 20/15/10 BEAM
TBH1B 3EL 20/15/10 BEAM
TBZ1 2EL 20/15/10 BEAM
MBL89 50 MOBILE BEAM
MBL98 10/40 GOLDEN SWAN TRAP VERTICAL
75MK ADD 75M TO 1040V
40IV1 10/40 SLIM LINE TRAP VERTICAL
75AK ADD 75M TO 40IV1
45 MOBILE ANTENNA 75/40/20/15/10, 1000W PEP,
GOLD PLATED CONTACTS, MANUAL BAND SWITCHING
742 MOBILE ANTENNA 75/40/20, 500W PEP,
AUTOMATIC SWITCHING
SWR 1A POWERRED wire 1 KW, 3.5-150MHz,
SO-239 IN LINE
SWR 3 MEASURE SWR 1:1 TO 3, 1-750MHz
SO-239 IN LINE
WM-2000 IN LINE WATTMETER 3 SCALES TO 2KW,
POWERSW 3.5-30MHz
WM-2000 A TRUE PEP SS IN LINE PEAK RMS WATTMETER/SWR
TO 2 KW PMS ON PEAK BY SWITCHING
WM-6000 VHF IN LINE WATTMETER/SWR 2 SCALES TO 200 WATT
MOSLEY
CJ 36 CLASSIC 6EL 10/15/20 BEAM
CL-33 CLASSIC 3EL 10/15/20 BEAM
TA-33 JR 3EL 10/15/20 BEAM
TA-32 CL 10/15/20 BEAM
TA-20K CONVERSION KIT ADD 40M TO TA-33
MINI-PRODUCTS
HC-1 HYBRID QUAD MINI BEAM, 6, 10, 15, 20 ELEMENT LENGTH
11 FT, 2000W PEP, Turnover Radii 6 1/2” - 1200W PEP,
50 ohm input, 100W PEP, 15 ft. LINES TOOL
WT. 15 LBS.
FINCO
A1-4 BEAM 10/4EL
A5-6 BEAM 6/3EL
A2-6 BEAM 6 AND 2M COMBO
A2-10 BEAM 2M 10EL
A2-5 BEAM 2M 5EL
A2 & 2 BEAM 10/4EL DUAL POLARIZATION 2M DESIGNED FOR OSCAR
OR CHANGING FROM VERTICAL TO HORIZ POLARIZATION

TAYLOR
2M 64L MOBILE 2 METER 5/8 TRUNK LIP MOUNT
2M 64RT MOBILE 2 METER 5/8 ROOF OR DECK MOUNT
2M 64L-5 MOBILE 2 METER 5/8 MAGNETIC MOUNT
2M64GC MOBILE 2 METER 5/8 GUTTER CLIP MOUNT
2M M-1/4 MOBILE 2 METER 1/4 WAVE MAGNETIC MOUNT

CABRER & WILLIAMSON
257 - ANTENNA PROTAX SWITCH 6 OUTPUTS SO-239
REAR W/GROUND FOR LIGHTING PROTECTION
376 - SAME AS ABOVE EXCEPT 5 OUTPUTS, AND SIDE SO-239
CONNECTORS
377 - COAXIAL ANTENNA CHANGE OVER RELAY, GROUNDS
RECEIVER WHEN RELAY IS IN TRANSMIT POSITION,
115V 60Hz 25W PEP

CUSHCRAFT
ATB-34 BEAM 4EL 10/15/20
ARK-2 RINGO RANGER 135-170 MHz
ARK-20 RINGO RANGER 220-225 MHz
ARK-450 RINGO RANGE 435-450 MHz
DX-130 DX ARRAY 20EL 144-146 MHz
KA142x4 BEAM 4EL 146-154 MHz
KA142 1111 BEAM 1111 146-148 MHz
KA142 2111 BEAM 2111 144-146 MHz
KA144 101111 OSCAR 145 MHZ
KA144 201111 OSCAR 145 MHZ
KA142 201111 OSCAR 430-436 MHz
KA144 111111 BEAM MOUNT BOOM AND BRACKET
A560 111111 5 METER
WE PAY SHIPING VIA U.P.S. OR BEST WAY ON ALL ADVERTISED ITEMS TO 56 STATES
AND TO PROSAP ON MAILABLE ITEMS. EXPEDITED SHIPING EXTRA. WE ACCEPT MASTER
CHARGE OR VISA. NORTH CAROLINA RESIDENTS ADDED% N.C. SALES TAX PHONE BILL
SLEEP (704) 524-7519.

NEW!
16K ECONORAM IV” KIT
S-100 compatible 16K x 8 memory. Static design,
current under 2000 ma, manual wire protect switch
for 4-kilocycle clock, can be used on any bottom, line
and it actually costs less than dynamic equivalences!

SLEEP ELECTRONICS
P.O. BOX 100, HWY. 441, DEPT. HR-6
OTTO, NORTH CAROLINA 28763

BEST BUYS

TAYLOR
2M 64L MOBILE 2 METER 5/8 TRUNK LIP MOUNT
2M 64RT MOBILE 2 METER 5/8 ROOF OR DECK MOUNT
2M 64L-5 MOBILE 2 METER 5/8 MAGNETIC MOUNT
2M64GC MOBILE 2 METER 5/8 GUTTER CLIP MOUNT
2M M-1/4 MOBILE 2 METER 1/4 WAVE MAGNETIC MOUNT

COMING SOON:
24K ECONORAM VII” KIT
Just around the corner for the S-100 buss... we
think you'll like it. All the regular features of our static
Econorams, plus a few extras. It's static, it's 24K, it's an
Econoram... watch for it!

PLUG FROM BILL: There are no more of the
above items to be had now. Our collection of
Econoram parts was accumulated over many years of
building and now we are down to the last few items.
Please allow up to 5% for shipping, extra included.
JAN/TECH magazine add tax. COD orders accepted with
check address for UPS. For VISA/Master Charge orders call
us at (415) 570-0235. We accept COD orders by phone.

FREE FLYER: Please allow up to 5% for shipping, extra included.
Package includes lead form of conductors, passive
elements and more! Each pack contains double
quantity of each part. We will gladly send you a flyer
describing our products upon receipt of your name and address.

JAN CRYSTALS
HOLD THE FREQUENCY

S-100 compatible 8K x 8 in a cost-effective
package. All lines buffered, fast, low power, unique
configuration as two 4K blocks, handles D/A, and
many other features... packed on a high quality
board and using high quality parts (all sockets in-
cluded). Totally static design...

See the +/1/8 issue of Kibobaud for an in-depth
evaluation, or send SASE to "KB Printout" and we’ll
send you a copy... or better yet, talk to somebody
who owns one.
Kit: $135.00; 3 kits: $375.00; Assembled: $155.00

SLEEP ELECTRONICS
P.O. BOX 100, HWY. 441, DEPT. HR-6
OTTO, NORTH CAROLINA 28763

H8 COMPATIBLE
ECONORAM VI” KIT
12K x 8 for the HR, with the same features that
have made Econoram the name in S-100 buss
memory. Static design, built-in D/A plus all sockets and
bypass caps are already soldered in place so you can
get right into the best part of kit building.
Kit form: $235.00

NEW!
16K ECONORAM IV” KIT
S-100 compatible 16K x 8 memory. Static design,
current under 2000 ma, manual wire protect switch
for 4-kilocycle clock, can be used on any bottom, line
and it actually costs less than dynamic equivalences!

COMING SOON:
24K ECONORAM VII” KIT
Just around the corner for the S-100 buss... we
think you'll like it. All the regular features of our static
Econorams, plus a few extras. It's static, it's 24K, it's an
Econoram... watch for it!

PLUG FROM BILL: There are no more of the
above items to be had now. Our collection of
Econoram parts was accumulated over many years of
building and now we are down to the last few items.
Please allow up to 5% for shipping, extra included.
JAN/TECH magazine add tax. COD orders accepted with
check address for UPS. For VISA/Master Charge orders call
us at (415) 570-0235. We accept COD orders by phone.

FREE FLYER: Please allow up to 5% for shipping, extra included.
Package includes lead form of conductors, passive
elements and more! Each pack contains double
quantity of each part. We will gladly send you a flyer
describing our products upon receipt of your name and address.
Come to Dallas!!
Join thousands of Ham Radio & Computer Enthusiasts gathering for the Southwest's top Ham & Hacker Huddle. With a giant flea market on a paved lot, timely seminars, top trade exhibits, family field trips, ladies' programs, great prizes, and a big barbeque, Ham-Com/78 will be too much to miss.

HAM-COM '78 REGISTRATION:

PREREGISTRATION DEADLINE: JUNE 13, 1978

<table>
<thead>
<tr>
<th>Name</th>
<th>$_00 each person for... people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>$_00 each person for... people</td>
</tr>
<tr>
<td>City</td>
<td>$_00 each person for... people</td>
</tr>
<tr>
<td>State ZIP</td>
<td>$_00 each person for... people</td>
</tr>
</tbody>
</table>

Send check or money order to:
Ham-Com/78, 3321 Towerwood Drive, Suite 101, Dallas, Texas 75234

For Additional Information call (214) 621-2775

MILITARY SURPLUS WANTED
Space buys more and pays more. Highest prices ever on U.S. Military surplus, especially on Collins equipment or parts. We pay freight! Call collect now for our high offer. 201 440-8787
SPACE ELECTRONICS CO.
div. of Military Electronics Corp.
35 Ruta Court, S. Hackensack, N. J. 07606

WANT TO KNOW WHY?
Send for Descriptive Brochure and Complete Dealers List
P.O. Box 3435, Dept. B, Hollywood, CA 90028

Pipo Communications

We'll see you there!
- HAM RADIO Magazine
- Ham Radio HORIZONS
- HR Report
- Ham Radio's Communications
Bookstore
The Ham Radio Publishing Group
Greenville, NH 03048
The New Yaesu FT-901

CALL OR WRITE
FOR INFORMATION
ON PRICE
AND OPTIONS

OTHER YAESU MODELS ALSO AVAILABLE...

Summer Specials:
(PREPAID SHIPMENT TO AREAS SERVED BY UPS BROWN LABEL)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Description</th>
<th>Reg.</th>
<th>Sale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CUSHCRAFT ATB-34</td>
<td>TRI-BAND BEAM w/ BALUN</td>
<td>239.95</td>
<td>199.95</td>
</tr>
<tr>
<td>CDE</td>
<td>HAM III ROTATOR</td>
<td>129.95</td>
<td></td>
</tr>
<tr>
<td>CDE</td>
<td>T2X ROTATOR</td>
<td>249.95</td>
<td></td>
</tr>
<tr>
<td>WILSON SY1</td>
<td>TRI-BAND BEAM</td>
<td>274.95</td>
<td>239.95</td>
</tr>
</tbody>
</table>

ABOVE SPECIALS EXPIRE JULY 31, 1978 AND ARE SUBJECT TO STOCK ON HAND.

MASTER CHARGE & VISA ACCEPTED SAME DAY SHIPMENT ON MOST ITEMS

STORE HOURS: MON. thru SAT. 9:30 a.m. to 6:00 p.m.

The NEW Yaesu FT-901

Call or write for information on price and options.

Oak Hill Academy
Amateur Radio Session
19th Year – July 29 thru August 11, 1978

We have moved our location just 15 miles from our previous site to the Oak Hill Academy, Mouth of Wilson, Virginia. Our accommodations are now the finest one could hope for, suites in a beautiful dorm with bath for each four students. Lovely spacious lobby and fine recreation room in the lower level of the dorm.

Oak Hill Academy in the Appalachian Mountains of Virginia offers an intensive two week Radio Session in code and theory starting at your level. Expert instructors, some of whom have been on the staff for the past 15 years are the same. Only the location has been changed.

Close association with fellow amateurs offers an opportunity for Saturation Learning that has been very successful since its conception. Novice upgrade to General, Tech to General & Advanced, and Advanced become Extras. Golf privileges, canoeing on the New River & many other recreation activities are offered. Make your vacation a “Vacation with a Purpose” and upgrade your license at a beautiful school in the cool mountains of Virginia.

Formerly Glade Valley School Radio Session

C. L. Peters, K4DNJ, Director

Oak Hill Academy Amateur Radio Session
Mouth of Wilson, Virginia 24363

Name: ___________________ Call: _____________
Address: ________________________________
City/State/Zip: ____________________________

RTTY for ALL Systems

ELECTROCOM® “SERIES 400” FREQUENCY SHIFT CONVERTERS

Professionally engineered for outstanding performance, stability, and reliability, the Electrocom® Models 400 and 402 add new dimensions of compatibility between radio and teleprinter systems. Manufactured to highest quality standards—an Electrocom tradition for nearly two decades—these units are ideal for military, government, commercial, civil defense, and amateur applications. The Model 400 front panel digital knob accurately selects shifts up to 1000 Hz. while two such knobs on the Model 402 independently set the mark and space frequencies. Both systems are assured by matched filters, precision linear detectors, baud rate selector, bias compensation, and semi-diversity cir- cuitry. Operation is enhanced by a CRT monitor, autostart with solid-state motor switching, antispace, markhold, EIA/MIL output voltages, and a constant current loop supply. In addition, various options are available including rack mounting and polar current output.

Write or call us for complete product de- tails and specifications. Learn why Electrocom® “400” Converters are designed not only for today’s communication environment, but ultimately to fulfill RTTY requirements for years to come.

Electrocom® INDUSTRIES
1105 N. IRONWOOD DRIVE, SOUTH BEND, INDIANA 46615

Telephone: (219) 232-2743

June 1978 \( \frac{137}{137} \)
 WORK MEXICO in the JUNE VHF CONTEST!

A special expedition to Punta Banda, Baja California, will be active for this contest on the following bands:

- 50 MHz—50.100, or 50.155 calling frequency.
- 144 MHz—144.012 for EME and 144.200 and FM simplex calling.
- 220 MHz—222.005 and FM simplex calling.
- 432-1296 and 2304 MHz upon request.

Station call is XE2BC headed by XE2IO, XE2S1, XE2AZR with an assist from the Lunar gang; Chip NGCA and Louis WB6NMT. For skeds contact Lunar.

LUNAR'S COMPLETE LINE OF AMATEUR EQUIPMENT!

LUNAR'S Linearized Amplifier
$95.95

LUNAR'S Linearized Oscillating Amplifier
$149.95

LUNAR'S New Oscillating Amplifier
Get on Oscar 8!

LUNAR's equipment includes Transmitters.

FREE BACK ISSUE CATALOG

Get yours now! Ham Radio's FREE back issue catalog will help you find that special article, complete your series, replace lost issues and discover new ones. Check your magazine library to see what you’re missing and send now for your FREE back issue catalog to:

HAM RADIO Magazine
Greensville, NH 03048

NEW!

600 MHz Mini Counter

- Completely Portable
- With Ni Cad Batteries
- Crystal Oscillator Available

"Check the features we have that other low cost counters don’t have!"

- All Metal Cabinet
- Sensitivity 10 MV at 60 MHz
- Completely Auto Decimal Point
- 8 Digit 4.5" LCD Display
- 115V or 12V Operation
- Selectable Gate Times (1 sec & 1 sec)
- 12V Input Jack
- Gate Light
- Built-in Prepamps (optional)
- Crystal Time Base (1 ppm after cal)

Options:
- Portable w/ Ni Cad Battery (Built in Charger) $39.95
- Crystal Oven (1 ppm to 60PPM) $39.95
- Handle $10.00
- Built-in Prepam 10 MV @ 150 MHz $49.95

C. W. KEYBOARD MODULE

BY WB2DFA. SEE JAN '78 HR, PG 81-87
- DOUBLE SIDED, PLATED THRU BOARD
- USES POWERFUL 6504 MICROPROCESSOR
- 256 CHARACTER BUFFER INCLUDING 64 CHARACTER RECALLABLE BUFFER FOR CO'S. HERE IS... ETC. 5 TO 99 W.P.M. SPEED RANGE X16 CONTROLLED EXPANDABLE MORSE CHARACTER SET AUTO XMTR SWITCH OPERATIONS FOR YOUR RIG (KEYBOARD VOX). BUFFER OVERFLOW WARNING LAMP DRIVERS USE WITH ASCHI ENCODED KEYBOARD $25.00 BARE BOARD LESS PARTS, PPD USA $1000 KITS AVAILABLE

PYRAMID DATA SYSTEMS
8 TERRACE AVE., NEW EGYPT, N.J. • 908-758-7468

FACSIMILE

COPY SATELLITE PHOTOS, WEATHER MAPS, PRESS.

The Fax Are Clear — on our full size (18-1/2" wide) recorders. These commercial/military units now available at surplus prices. Learn how to copy with our FREE Fax Guide. Tel: (212) 372-0349

ATLANTIC SURPLUS SALES
1730 NAUTILUS
BROOKLYN, N.Y. 11224

BUILD YOUR OWN TV CAMERA!

Ideal for home & business

WESTERN ELECTRONICS
P.O. Box 941, Monroe, Mich. 48161

TEST EQUIPMENT

All equipment listed is operational and unconditionally guaranteed. Money back if not satisfied. Prices listed are FOB Monroe:

- HP1020 4050 Hz gen pur scope $215
- HP1050 (USM1050) 15mHz scope with reg horiz, dual trace vert plugs $375
- HP1058 (M4150) Delay sweep for above $130
- HP1076 (USM140) 30mHz scope with reg horiz, dual trace vert plugs $475
- HP1075 50mHz scope with reg horiz, dual trace vert plugs $565
- Tek560 Dual beam 10mHz scope less plug ins (3 series) $625
- Tek560 80mHz gen pur scope less plug ins $645

For complete list of all the test equipment card stock will be sent. Ask about free catalog.

GRAY Electronics
P.O. Box 941, Monroe, Mich. 48161
Specializing in used test equipment.
REPEATER USERS — Stay in Touch — with DSI

UNIVERSAL

The Data Signal TTP Series of keyboard encoders is used to generate the standard 12 or 16 DTMF digits. The encoders provide fully automatic transmitter keying and feature a delayed Transmit Ready light, an interdigit timer, and a built-in audio monitor. Features also include all solid-state, crystal-controlled, digitally-synthesized tones and an optional internal mount Automatic Number Identifier (ANI).

TTP-1 (12-digit) $59.00
TTP-2 (16-digit) $69.00


*Touch-Tone is a registered trade name of AT&T.

TOUCH-TONE® ENCODERS

SUB-MINIATURE ENCODERS

MODEL SME — Smallest available Touch Tone Encoder. Thin, only .05" thick, keyboard mounts directly to front of hand-held portable, while sub-miniature tone module fits inside. This keyboard allows use of battery chargers. Price SME (less keyboard) $24.00

AUTOPATCH — Ready to go!

A Complete Autopatch facility that requires only a repeater and a telephone line. Features include single-digit access, disconnect, direct dialing from mobile or hand-held radios, adjustable amplifiers for transmitter and telephone audio, and tone-burst transponder for acknowledgement of patch disconnect.

RAP-200 P. C. Card $199.50
RAP-200R Rack Mount $249.50

DATA SIGNAL, INC.

2403 COMMERCE LANE
ALBANY, GEORGIA 31707, 912-883-4703

Be sure to ask about our new keyers and CW memory for CW buffs.

FREE!

NEW '78 AMATEUR RADIO CATALOG

Choose from the top names in selected ham equipment. Plus — get the full details on Clegg's unique purchase plans for Drake/Yaesu/ KLM/Dentron/Alpha/Microwave modules/Atlas and other quality products.

Phone toll-free today for your new Clegg catalog!
1-800-233-0250
In Pennsylvania call collect
717-299-7221

Clegg Communications Corp., 1911 Old Homestead Lane, Greenfield Industrial Park East, Lancaster, PA 17601.

FREE! RF SPEECH PROCESSOR

Models Now Available
Collins 325, KWM-2, $98.50 ea.
Drake TR-5, TR-4, TR-6, TR-4C,
T-4, T-4X, T-4X8, T-4XC $128.50 ea.
Postpaid — Calif. Residents add 6% Tax

Watch for other models later!

DX Engineering
1050 East Walnut, Pasadena, Calif. 91106

More Details? CHECK — OFF Page 142

may 1978 139
The all new AR model M100 PL unit, unlike the other type, insures against physical damage and inadvertent short-circuits because of its complete encapsulation in resilient epoxy. Furthermore, the M100 PL uniquely offers your choice of high and low impedance outputs to facilitate finding a suitable injection point. Should for any reason other than physical abuse the M100 PL unit fail within 2 years, AR will replace it on an exchange basis for only $6.50 handling, freight, and insurance charges.

Dedicated to Excellence
Technical Products Corp.
Bohemia, NY 11716 Phone (313) 588-2286

PARTS!!

AIR VARIABLE CAPACITORS
40-310pf Dual, 7.5KV $27.00
27-300pf Dual, 4.5KV $25.00
40-310pf Single, 7.5KV $17.50
27-300pf Single, 4.5KV $16.75
40-190pf Single, 5.5KV $16.25
Many, Many More Types. Send SASE for free list.

JUNE-JULY SPECIALS
"While They Last"
TUBES- Many Types In stock
6356C $5.50 6146A $6.25
572B $29.00 6146B $6.75

EIMAC POWER TUBES IN STOCK
Send SASE for free list of tubes.

AMPHENOL CONNECTORS PL259(UHF) 79c
UG218J(N) $1.99 UG88(U)/BNC)99c

HILSON WR500 ROTOR -- $99.95
HILSON WR500 ROTOR -- $99.95
MUFFIN FANS - $7.50 ea.

TELECHPAPER/TAPE --$10.00/case

NEW ELECTRONIC PARTS
ICs - TRANSISTORS - PHOTOBOARDS - RESISTORS - CAPACITORS - DIODES - SWITCHES - CONNECTORS - VOLTAGE REGULATORS - GAIN ENHANCERS - COOLERS - HEAT SINKS - MUXES & MUCH MORE - STAMP BRINGS CATALOGUE

SPECIALS
KEYBOARD ENCLOSURES
FREE SHIP. WHITE OR BLACK TOP

BREADBOARD KIT $10.75

Please allow for shipping charges.
AZ residents add 5% sales tax.

Amateur Radio Center
11 S. Morris, Mesa, AZ 85202
(602) 833-8051

More Details? CHECK—OFF Page 142
COLLINS & MORE
Ham Gear
Collins 18051, Antenna tuner $325
Collins 5134 w/SBB Mod, like new $795
Collins 312B4, SSB, Cbl., rd., exc. $795
Collins 312B5, Vfo, available, vy gd $495
Collins 312B5, Vfo Console, new, orig. box $795
Collins 3253, Transmitter, rnd., exc. $850
Collins 7653A, Ham receiver, vy gd $475
Collins 7553B, Ham receiver, vy gd $695
Collins 54A4, Ham receiver, vy gd $425
Collins 5813, 2.30MHz new $995
Collins 5813, 2.30MHz new $795
Collins R-38B/513J receiver, vy gd $425
Hammarlund SP-6001X, 5.50MHz rev. $250
Collins CP-1 Crystal Pack $195

New Coils
T-1005 An excellent do-it-yourself guide to building and operating a solar flare detection station for serious Radio Amateurs, shortwave listeners and communications experimenters. Learn to build or (how to inexpensively acquire) and use the antennas, receivers and recorders needed to monitor and record the fascinating solar flare. Just $6.95

THE HANDBOOK OF SOLAR FLARE MONITORING & PROPAGATION FORECASTING
by Carl M. Chernen, WA3UER

THE ZAPPING OF AMERICA
by Paul Brodeur

AMATEUR TV IN A NUTSHELL
by Henry Ruhl, W8BWM

QS0 CODE PRACTICE TAPE
by H. L. Gibson, G2BUP

TEST EQUIPMENT FOR THE RADIO AMATEUR
by H. L. Gibson, G2BUP

HOME-BREW HF/VHF ANTENNA HANDBOOK
by William Hood, W2FEZ

Get the most from your antenna!

With the Omega-t Antenna Noise Bridge you can test for resonant frequency and impedance - adjust and retest - until your antenna performs at its optimum. Use the Noise Bridge to trim RF lines for best performance, too.

This patented design uses your sensitive receiver as a bridge detector, outputting more, metrology equipment.

Reduce power loss due to mismatch now! See more details or order today.

Model TE-01...100 MHz range: $34.95
Model TE-02...100 MHz range: $44.95

Check below to order:

T-1005 The Handbook of Solar Flare $6.95
T-963 Home-Brew HF/VHF Antenna $5.95
RS-TRA Test Equipment for the Radio Amateur $9.50
NZ-A The Zapping of America $11.95
R-ATV Amateur TV in a Nutshell $5.00
QS0-T 7/4, 10, 13, 15 wpm tape $4.95
QS0-110 20, 23, 26 wpm tape $4.95

Can't wait? Call TOLL FREE
800-258-5353

Total Book Cost
Total Postage
(Apr. 35 ea. for 1-3 books, 4 or more HCIB pays postage)

Final Total

Check or Money Enclosed
VISA Master Charge

Exp. date MC Bank #

Name ____________________________
Address ____________________________
City __________________ State ______ Zip ______

Hardbound $11.95

Clip Coupon and Mail Now!

Ham Gear's Communications Bookstore
Greenville, N. H. 03048

ELECTROSPACE SYSTEMS, INC.
P.O. BOX 1359
RICHARDSON, TEXAS 75080
TELEPHONE (214) 231-9303

Sold at Amateur Radio Dealers
or Direct from ElectroSpace Systems, Inc.

june 1978 / 141

More Details? CHECK — OFF Page 142
**AGL would like you to know that we're now a YAESU dealer with a big stock of their latest and best gear!**

Have you thought about YAESU's FT-901D series of competition grade HF transceivers? Take the FT-901DM for example, an all-mode transceiver designed to give you the competitive edge either at home or on a DX-pedition. Look at these features: rejection tuning, variable IF bandwidth tuning, and auto peak frequency tuning. Add digital and analog frequency display, a built-in Curtis 6034 keyer chip, and much, much more! Come in — call — or write TODAY, and make your dream come true.

AGL also takes great pride in stocking these other great lines of Amateur radio equipment.

---

**INDEX**

<table>
<thead>
<tr>
<th>Index</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL Electronic Corp.</td>
<td>116, 140</td>
</tr>
<tr>
<td>AGL Electronics</td>
<td>142</td>
</tr>
<tr>
<td>ALDA Communications</td>
<td>68</td>
</tr>
<tr>
<td>ATV Research</td>
<td>138</td>
</tr>
<tr>
<td>Advanced Electronic Application</td>
<td>108</td>
</tr>
<tr>
<td>Alumina Tower Co.</td>
<td>131</td>
</tr>
<tr>
<td>Atlantic Surplus Sales</td>
<td>138</td>
</tr>
<tr>
<td>Atlas Radio</td>
<td>66, 67</td>
</tr>
<tr>
<td>R.H. Bauman Sales Co.</td>
<td>112</td>
</tr>
<tr>
<td>Bird Mfg. Co.</td>
<td>116</td>
</tr>
<tr>
<td>Bullet</td>
<td>131</td>
</tr>
<tr>
<td>Burbank Electronics</td>
<td>128</td>
</tr>
<tr>
<td>C.C. Communication</td>
<td>137</td>
</tr>
<tr>
<td>C.F. Communications</td>
<td>134</td>
</tr>
<tr>
<td>CW Electronic Sales Company</td>
<td>35</td>
</tr>
<tr>
<td>Clegg</td>
<td>139</td>
</tr>
<tr>
<td>Communications Center</td>
<td>129</td>
</tr>
<tr>
<td>Communications Specialists</td>
<td>50, 51</td>
</tr>
<tr>
<td>Continental Specialties</td>
<td>101</td>
</tr>
<tr>
<td>Crystal Bank Service</td>
<td>120</td>
</tr>
<tr>
<td>Cushcraft</td>
<td>46, 47</td>
</tr>
<tr>
<td>DGM Electronics</td>
<td>126</td>
</tr>
<tr>
<td>DSI Instruments</td>
<td>119</td>
</tr>
<tr>
<td>DX Engineering</td>
<td>136</td>
</tr>
<tr>
<td>Dames Communications Systems</td>
<td>141</td>
</tr>
<tr>
<td>Daniels, Ted</td>
<td>124</td>
</tr>
<tr>
<td>Data Signal, Inc.</td>
<td>139</td>
</tr>
<tr>
<td>Dale Electronics</td>
<td>130, 138</td>
</tr>
<tr>
<td>Denton Radio Company</td>
<td>83</td>
</tr>
<tr>
<td>Disc Cap</td>
<td>75, 76, 80, 108</td>
</tr>
<tr>
<td>Drake Co</td>
<td>104</td>
</tr>
<tr>
<td>Ehrman Technical Operations</td>
<td>143</td>
</tr>
<tr>
<td>Electromagnetic Industries</td>
<td>137</td>
</tr>
<tr>
<td>Electronic Distributors</td>
<td>110</td>
</tr>
<tr>
<td>Electronic Equipment Bank</td>
<td>118</td>
</tr>
<tr>
<td>Electronic Signal Products</td>
<td>128</td>
</tr>
<tr>
<td>Electronic Space Products</td>
<td>141</td>
</tr>
<tr>
<td>Erickson Communications</td>
<td>120</td>
</tr>
<tr>
<td>ESB Inc.</td>
<td>134</td>
</tr>
<tr>
<td>Fast Radio Sales</td>
<td>112</td>
</tr>
<tr>
<td>Fox Tango Corporation</td>
<td>90</td>
</tr>
<tr>
<td>GB Electronics</td>
<td>140</td>
</tr>
<tr>
<td>Goodfellow Electronics</td>
<td>135</td>
</tr>
<tr>
<td>Gray Electronics</td>
<td>135</td>
</tr>
<tr>
<td>Gregory Electronics</td>
<td>114</td>
</tr>
<tr>
<td>Gulf Electronics</td>
<td>140</td>
</tr>
<tr>
<td>Hal Communications Corp.</td>
<td>121</td>
</tr>
<tr>
<td>Hall Trons</td>
<td>86</td>
</tr>
<tr>
<td>Ham-Com '78</td>
<td>136</td>
</tr>
<tr>
<td>Ham Radio Center</td>
<td>130</td>
</tr>
<tr>
<td>Ham Radio Center's Bookstore</td>
<td>140, 141</td>
</tr>
<tr>
<td>Hamcom, Inc.</td>
<td>137</td>
</tr>
<tr>
<td>Hancom Company</td>
<td>126</td>
</tr>
<tr>
<td>Henry Radio Stores</td>
<td>135</td>
</tr>
<tr>
<td>Icon</td>
<td>5</td>
</tr>
<tr>
<td>Integrated Circuits Unlimited</td>
<td>70</td>
</tr>
<tr>
<td>International Crystal</td>
<td>77</td>
</tr>
<tr>
<td>Jan Crystals</td>
<td>136</td>
</tr>
<tr>
<td>Jones, Martin P. &amp; Associates</td>
<td>106</td>
</tr>
<tr>
<td>K Enterprises</td>
<td>106</td>
</tr>
<tr>
<td>Kenwood Corp.</td>
<td>129</td>
</tr>
<tr>
<td>Kenwood Communications, Inc.</td>
<td>83, 72, 73</td>
</tr>
<tr>
<td>Kester Soldor</td>
<td>134</td>
</tr>
<tr>
<td>Lafayette Radio Electronics</td>
<td>126</td>
</tr>
<tr>
<td>Lang's Electronics</td>
<td>133</td>
</tr>
<tr>
<td>Lunar Electronics</td>
<td>136</td>
</tr>
<tr>
<td>Lyle Products</td>
<td>118</td>
</tr>
<tr>
<td>MFJ Enterprises</td>
<td>210</td>
</tr>
<tr>
<td>Madison Electronic Supply</td>
<td>211, 124</td>
</tr>
<tr>
<td>MAE Electronics</td>
<td>140</td>
</tr>
<tr>
<td>Oak Hill Academy Amateur Radio Service</td>
<td>140</td>
</tr>
<tr>
<td>Optoelectronics</td>
<td>85</td>
</tr>
<tr>
<td>Palomar Engineering</td>
<td>336</td>
</tr>
<tr>
<td>Panbridge (HI) Electronics</td>
<td>120</td>
</tr>
<tr>
<td>Pico Communications</td>
<td>136</td>
</tr>
<tr>
<td>Printed Circuit Boards</td>
<td>112</td>
</tr>
<tr>
<td>Pyramid Electronics</td>
<td>138</td>
</tr>
<tr>
<td>QST Radio</td>
<td>141</td>
</tr>
<tr>
<td>QST Telecommunications Center</td>
<td>140</td>
</tr>
<tr>
<td>RF Power Labs</td>
<td>106</td>
</tr>
<tr>
<td>R.I. V. Products</td>
<td>126</td>
</tr>
<tr>
<td>Radio Amateur Callbook</td>
<td>126, 131</td>
</tr>
<tr>
<td>Radio Systems Technology, Inc.</td>
<td>119</td>
</tr>
<tr>
<td>Radio World</td>
<td>122</td>
</tr>
<tr>
<td>Ramsey Electronics</td>
<td>65</td>
</tr>
<tr>
<td>Regency Electronics</td>
<td>107</td>
</tr>
<tr>
<td>Unarco Rohn</td>
<td>112</td>
</tr>
<tr>
<td>SST 1 Electronic Co.</td>
<td>125</td>
</tr>
<tr>
<td>Sherwood Engineering</td>
<td>112</td>
</tr>
<tr>
<td>Sigu Electronics</td>
<td>135</td>
</tr>
<tr>
<td>Space Electronics</td>
<td>136</td>
</tr>
<tr>
<td>Spectronics</td>
<td>103</td>
</tr>
<tr>
<td>Spectrum International</td>
<td>114</td>
</tr>
<tr>
<td>Swan Electronics</td>
<td>111, 113, 115, 124</td>
</tr>
<tr>
<td>TPI Communications</td>
<td>116</td>
</tr>
<tr>
<td>T/T Communications</td>
<td>116</td>
</tr>
<tr>
<td>Tandy Computers</td>
<td>135</td>
</tr>
<tr>
<td>Ten-Tec</td>
<td>39</td>
</tr>
<tr>
<td>Texas Towers</td>
<td>120</td>
</tr>
<tr>
<td>The Comm Center</td>
<td>134</td>
</tr>
<tr>
<td>Tristar Tower</td>
<td>124</td>
</tr>
<tr>
<td>VRH Engineering, Div of Brownco</td>
<td>43</td>
</tr>
<tr>
<td>Varga Land</td>
<td>124</td>
</tr>
<tr>
<td>Vanan, Ecco Division</td>
<td>140</td>
</tr>
<tr>
<td>Vines, James K</td>
<td>140</td>
</tr>
<tr>
<td>Webster Associates</td>
<td>122</td>
</tr>
<tr>
<td>Weinschenker</td>
<td>122</td>
</tr>
<tr>
<td>Western Electronics</td>
<td>156</td>
</tr>
<tr>
<td>Whittaker, G. E. &amp; Co.</td>
<td>156</td>
</tr>
<tr>
<td>Wilson Electronics</td>
<td>1</td>
</tr>
<tr>
<td>YAESU Electronics Corp.</td>
<td>1</td>
</tr>
</tbody>
</table>

---

**AGL Electronics**

3068 FOREST LANE, SUITE 309
DALLAS, TEXAS 75234

---

**June 1978**

Please use before July 31, 1978.

**CALL 214-241-6414 (in Texas)**

**ART KSTRG**
**MIKE NSFL**
**MIKE NSMP**
**TOM KSTM**

We service and repair all major lines of Amateur Radio equipment.

---

**Advertisers**

**check-off**

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

Place your check mark in the space between name and number, Ext: Ham Radio . 234
There are lots of so-called “Maximum Legal Power” linear amplifiers on the market. Why is it that so many knowledgeable amateurs, after checking out (and often owning) the others, ultimately choose an ALPHA?

For one thing, “maximum legal power” doesn’t begin to tell the whole story. Nearly all manufacturers’ ratings implicitly assume an amateur service duty cycle much less than 100%. Even the terms “continuous” and “100%” duty have been so debased in recent years as to be meaningless unless explicitly defined. The consequence, too often, is a power transformer or tube going up in smoke during a long operating period.

Every ALPHA amplifier is unequivocally rated to run a full 1000 watts of continuous, average d-c power input, in any mode, with No Time Limit (NTL). You could leave your ALPHA (ANY ALPHA) all day with a brick on the key, at a kilowatt input (or at 2 KW PEP input, two-tone SSB) without hurting it. In fact, you could leave it for weeks: last year we ran a standard ALPHA 76 keydown at a kilowatt for 18 days without ill effect. That's ALPHA POWER. To top it off, your new ALPHA is protected by ETO's exclusive 18 MONTH factory warranty — SIX TIMES AS LONG as the industry-standard 90 days! Now that DOES pretty much tell the whole story.

These new ALPHA's are even better than their famed ALPHA 76/374 Series predecessors... Believe it or not!

The pleasure of owning and using a new ALPHA is enhanced by the ruggedly handsome new metal work... refined metering and pushbutton control systems... improved bandpass circuits in the no-tune-up models. One version combines the great conveniences of no-tune-up operation AND full CW break-in. Another brings ALPHA POWER to 6 meters.

We've retained the robust components and basic circuitry that compiled such an amazing record of freedom from major failures in the ALPHA 76 and '374. Why tamper with success?

We think the new ALPHA's set a standard for style. But the real beauty of every ALPHA linear amplifier is INSIDE the cabinet — where engineering and craftsmanship tell the whole story of ALPHA superiority.

For detailed descriptive literature and fast service on an even-greater new ALPHA, contact your dealer or ETO direct.

ALPHA: Sure you can buy a cheaper linear...

But is that REALLY what you want?
DRAKE TR-4CW transceiver

TR-4CW covers 80 thru 10 meters. Modes SSB, AM, CW • 300 watts PEP input on SSB, 260 watts on CW; AM • 500 Hz CW filter included • Transceive or separate PTO • Wide range receiving AGC • Constant calibration mode to mode • Solid-state VFO • Shifted-carrier CW • VOX or PTT • Output impedance is adjustable • CW semi-break-in • Audio output: 3 watts • Receiver Incremental Tuning.

799.00 list price. Call Toll-Free for quote.

DRAKE MN-2000 matching network

The MN-2000 is a worthwhile addition to any amateur station where peak performance is desired • Frequency coverage: 3.5 to 4.0 MHz, 7.0 to 7.3 MHz, 14.0 to 14.35 MHz, 21.0 to 21.45 MHz, 28.0 to 29.7 MHz • Input impedance: 50 ohms resistive • Insertion loss: 0.5 dB or less • Wattmeter accuracy ±5% of reading • 1000 watts RF continuous, 2000 W PEP.

250.00 list price. Call Toll-Free for quote.

DRAKE MN-4C matching network

New MN-4C features: 160 thru 10 meters coverage • Matches coax FED, long wire, or balanced line antennas with optional 4:1 balun (24.35) • Handles 250 watts continuous RF output • Built-in RF watt meter/VSWM bridge • Unique "low-pass filter" design provides significant harmonic reduction to fight TVI.

165.00 list price. Call for quote.

DRAKE 1525 EM microphone

The auto-patch encoder and microphone are a single unit, fully wired and ready to use • High accuracy IC tone generator, no frequency adjustments • High reliability Digitran® keyboard • Power for tone encoder from transceiver via mic cable • Encoder audio level adjustable from 1 mV to 5 mV with internal potentiometer • Low output impedance • 4-pin plug.

49.95 Call for quote today.

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. Store hours: 9:00 AM to 5:30 PM, Monday thru Friday.
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
The first three of a new family of power tubes are available today from EIMAC. These ceramic-metal triodes provide the high power, gain and efficiency of tetrodes, along with long life and reliability up into the UHF spectrum.

EIMAC can supply cavity or cavity design guidance for these tubes in CW as well as pulse service. Because of the circuit simplicity of triodes, this EIMAC family allows the circuit designer to take full advantage of simple cavity design. No tricky screen bypass capacitors or critical isolation circuits are required.

<table>
<thead>
<tr>
<th>EIMAC Type</th>
<th>Typical CW Performance Data</th>
<th>Maximum Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gain</td>
<td>Power Output</td>
</tr>
<tr>
<td>3CX400U7</td>
<td>13.0dB</td>
<td>225W</td>
</tr>
<tr>
<td>3CX600U7</td>
<td>14.0dB</td>
<td>445W</td>
</tr>
<tr>
<td>8938</td>
<td>12.8dB</td>
<td>1570W</td>
</tr>
</tbody>
</table>

For full information, contact Varian, EIMAC Division, 301 Industrial Way, San Carlos, California 94070. Telephone (415) 592-1221. Or call any of the more than 30 Varian Electron Device Group Sales Offices throughout the world.

EIMAC delivers triode simplicity with tetrode performance at UHF.
Send for your copy of the world's largest selection of quality electronic products in easy-to-build, money-saving kit form! Nearly 400 kits in all — all with Heath's world-famous assembly manuals that take you step-by-step from unpacking to final plug-in.

fill in card and mail today

Please rush me my personal copy of the new Heathkit catalog.

I am not on your mailing list.

Name: ____________________________
Address: _________________________
City: _______ State: ___________
PC-126 Zip: ___________
HAM RADIO Dept. 122-420
Send for your FREE HEATHKIT CATALOG

Complete descriptions and specifications of nearly 400 electronic kits including:
- stereo components
- auto, marine and aircraft accessories
- digital clocks and weather instruments
- Amateur Radio
- color TV
- personal computers
and lots more!

HEATH COMPANY
Benton Harbor MI 49022

PLACE STAMP HERE