$1.50

ham radio magazine

JANUARY 1978

- microstrip design 28
- microwave path evaluation 40
- RTTY test generator 64
- GaAs fets 74
- microprocessors 81
- and much more . . .

This is the amplifier you have been waiting for

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

At Henry Radio, we know how to build only one kind of amplifier ... the best. We want you to compare the 2KD-5 with any other desk model at any price.

Remember, the 2KD-5 is only one model in the world's broadest line of amplifiers ... both vacuum tube and solid state ... for HF, VHF and UHF ... fixed station and mobile ... low power and high power.

Never before has any one company offered such a cornucopia of high power RF amplifiers.

Remember also that Henry Radio offers a broad line of commercial and FCC type accepted amplifiers covering the range of 3 MHz to 500 MHz. Henry amplifiers are in use all around the world. Commercial and export inquiries are invited.

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

2K-4...LINEAR AMPLIFIER. Offers engineering, construction and features second to none. Provides a long life of reliable service, while its heavy duty components allow it to loaf along even at full legal power. Operates on all amateur bands, 80 thru 10 meters. If you want to put that strong clear signal on the air that you've probably heard from other 2K users, now is the time. Move up to the 2K-4. Floor console...$995.00

TEMPO 6N2 brings the same high standards to the 6 and 2 meter bands. A pair of advanced design Eimac 8874 tubes provide 2,000 watts PEP input on SSB or 1,000 watts on FM or CW. Complete with self-contained solid state power supply, blower and RF relative power indicator. ...$895.00

TEMPO 2002. The same fine specs and features as the 6N2, but for 2 meter operation only. ...$745.00

TEMPO 2006. Like the 2002, but for 6 meter operation. ...$795.00

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

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

TEMPO 100AL10 VHF LINEAR AMPLIFIER. Corr pletely solid state, 144-148 MHz. Power output c 100 watts (nom.) with only 10 watts (nom.) ir Reliable and compact ...$199.00

TEMPO 100AL10/B BASE AMPLIFIER ...$349.0

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

please call or write for complete information.

Henry Radi

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

Prices subject to change without notice.

TEN-TEC 540/544—the transceivers that almost seem like an extension of yourself. Following your every command, easily, simply — because we did our homework. They are designed with the same out-front thinking that characterizes all Ten-Tec equipment — super-sophisticated to make things simple for you.

TAKE BAND CHANGING. IT'S SIMPLE! No more peak and dip, peak and dip. Just snap a switch and there you are. Anywhere you want to be, in any part of a band segment—and always at full efficiency without danger of out-of resonance damage to the final amplifier. Thanks to the Ten-Tec broadband design, and thanks to the leadership of Ten-Tec engineers in solid-state high power HF design.

FREQUENCY READOUT. IT'S SIMPLE! The 544 has big easy-to-read numerals with significant figures in red for instant recognition. No more studying a dial or misreading, and no more lag in readout — you instantly know where you are on the band. Even the 540 has an optional add-on digital readout, in case you change your mind later. More of life's operating simplicity, from Ten-Tec.

THE SMART "S"-METER. IT MAKES THINGS SIMPLE FOR YOU. It's electronically switched to read SWR when you are transmitting so that without throwing switches you know at a glance that the correct antenna is in use. Simple for you, extra effort for us.

SIGNAL HANDLING OF ALL SIZES. IT'S SIMPLE! From the "down under" DX to the KW next door, the 540/544 series has excellent dynamic range that goes a long way in minimizing front-end overload. And that's important in today's growing amateur radio population. So is the 8-pole i-f filter. It gives you State-of-the-Art signal separation in those crowded bands — to make your operating simpler, more enjoyable.

SUPERIOR SPEECH QUALITY. IT'S SIMPLE! Ten-Tec rigs are known for their crisp articulation — the kind that brings compliments and satisfaction. Articulated, shaped speech for maximum penetration, yet smooth and clean, with less than 2% distortion to reduce fatigue and enhance the quality of both transmitted and received signals. The signal that's easy to listen to is the one everyone wants to work. And it's yours in the sophisticated simplicity of the 540/544.

CW CONVERSATION. IT'S SIMPLE! The CW buffs used to speak in monologs. Now they carry on conversations, thanks to Ten-Tec's *full* break-in. It provides a constant window on the band to check for QRM, to save useless calling, to allow conversations that are natural, easier, and a lot more fun. And no more clattering relays! Simply sophisticated.

FAST, EASY, LOW-COST SERVICING. IT'S SIMPLE! The thoughtful modular design of the 540/544 makes any trouble-shooting simple and fast, resolving itself down to one of 22 circuit boards, any of which are readily replaced or serviced in the field! Or give the Ten-Tec service people a shout — they will have an exchange on its way to you the same day.

But, best of all, little if any service will be needed because while your 540/544 is sophisticated, complex equipment, it also is designed to conservative ratings with high standards of American craftmanship. Simply durable.

FEATURES — • Instant Band Change (no xmtr. 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 F° after 30 min. warm-up • 8-pole Crystal IF Filter • Direct Readouts — choose LED digital model or 1 kHz dial model • 150 Hz CW filter • Offset Tuning • WWV at 10 & 15 MHz • Separate Receive Capability • Automatic Sideband Selection, Reversible • Sidetone Level and Pitch control • Pre-Setable 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

To make your operating simple, simply see your Ten-Tec dealer, or write for full details.

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

SIMPLICITY OF OPERATION, SOPHISTICATION OF DESIGN

This NEW MFJ Versa Tuner II . . .

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

BRAND NEW

$79^{95}

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 airwound 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:

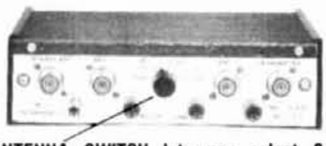
A SWR and dual range wattmeter (300 and 30 watts full scale) lets you measure RF power output for simplified tuning.

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

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

A 1:4 balun for 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 transmitter to **any** feedline from 160 thru 10 Meters whether you have coax cable, balance line, or random wire.



ANTENNA SWITCH lets you select 2 coax fed antennas, random wire or balance line, and tuner bypass.

You can tune out the SWR on your dipole, inverted vee, random wire, vertical, mobile whip, beam, quad, or whatever you have.

You can even operate all bands with just 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 5x2x6 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 five way binding posts are used for the balance line inputs (2), random wire input (1), and ground (1).

$59^{95}

BRAND NEW

MFJ-901 VERSA TUNER

New efficient air wound coil for more watts out.

Only MFJ uses an efficient air wound inductor (12 positions) in this class of tuners to give you more watts out and less losses than a tapped toroid. Matches everything from 160 thru 10 Meters: dipoles, inverted vees, random wires, verticals, mobile whips, beams, balance lines, coax lines. Up to 200 watts RF output. 1:4 balun for balance lines. Tune out the SWR of your mobile whip **from inside your car.** Works with all rigs. Ultra compact 5x2x6 inches. SO-239 connectors. 5 way binding posts. Ten Tec enclosure.

$49^{95}

BRAND NEW

MFJ-900 ECONO TUNER

Same as MFJ-901 Versa Tuner, but does not have built-in balun for balance lines. Tunes coax lines and random lines.

$39^{95}

MFJ-16010 RANDOM WIRE TUNER

Operate 160 thru 10 Meters. Up to 200 watts RF output. Matches high and low impedances. 12 position inductor. SO-239 connectors. 2x3x4 inches. Matches 25 to 200 ohms at 1.8 MHz.

$49^{95}

BRAND NEW

MFJ-202 RF NOISE BRIDGE

This MFJ RF Noise Bridge lets you adjust your antenna quickly for maximum performance. Measure resonant frequency, radiation resistance and reactance. Exclusive range extender and expanded capacitance range (± 150 pf) gives you much extended measuring range.

Tells resonant frequency and whether to shorten or lengthen your antenna for minimum SWR. Adjust your single or multiband dipole, inverted vee, beam, vertical, mobile whip or random system for maximum performance. 1 to 100 MHz. SO-239 connectors. 2x3x4 inches. 9 volt battery.

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 VISA master charge

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

ham radio magazine

JANUARY 1978

volume 11, number 1

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

subscription rates

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

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

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

foreign subscription agents

Foreign subscription agents are
listed on page 117

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

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

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

ham radio magazine

contents

10 broadcast-quality television camera
Arthur C. Towslee, WA8RMC

28 microstrip transmission lines
James R. Fisk, W1HR

40 microwave path evaluation
Dennis L. Haarsager, N7DH

46 low-band antenna solution
William A. Wildenhein, W8YFB

52 ssb phasing techniques
Roger L. Harrison, VK2ZTB

64 test generator for RTTY
John M. Loughmiller, WB9ATW

68 microwave bibliography
Clifford C. Buttschardt, W6HDO

74 GaAs field-effect transistors
Paul C. Wade, WA2ZZF

76 new operational amplifier challenges the 741
Courtney Hall, WA5SNZ

81 microprocessors: a microprocessor controlled CW keyboard
James W. Pollock, WB2DFA

4 a second look
142 advertisers index
117 flea market
132 ham mart
94 ham notebook
90 letters
81 microprocessors
6 presstop
142 reader service

a second look

by Jim Fisk

Seventy-five years ago this month, on January 19th, 1903, the first two-way radio transmission was completed between the United States and England when President Theodore Roosevelt exchanged greetings with King Edward VII of England through the Marconi wireless station at South Wellfleet on Cape Cod. Only ten years earlier it was an achievement which would have seemed impossible, even to the most foresighted scientists; they were delighted when their crude laboratory apparatus could be made to span a few meters – to transmit a radio signal across 5000 kilometers of ocean was beyond their wildest imagination. Young Guglielmo Marconi, not yet 30 years old when he accomplished the feat, was not restrained by such learned skepticism, but from the viewpoint of his first attic laboratory in 1894, even he would have been surprised by his great successes of the future.

The son of a well-to-do land owner, Marconi had little formal technical training, but through his family's friendship with Professor Righi at the University of Bologna he was allowed to audit the professor's physics classes. It was there that Marconi was first exposed to the radio experiments of Heinrich Hertz, Oliver Lodge, and others. He soon set up a small lab in the attic of his father's large estate and began to experiment with electromagnetic phenomena. With Righi's spark gap mounted in the center of a short dipole and Lodge's coherer (a glass tube filled with metal filings) for his receiver, he was able to transmit radio signals that rang a bell at the other end of the attic.

Guglielmo moved his equipment out into the yard and was soon working over distances of 50 meters or more. He found that he could extend his range by increasing the height of his antenna, but with greater heights it became more and more impractical to install the spark gap at the center of the antenna. When he installed the spark gap at ground level and connected it between the antenna and ground, his range increased dramatically. What was happening, of course, was that greater antenna heights meant lower operating frequencies since the dipole was the only resonant circuit in the transmitter, and the longer wavelengths provided greater range (Marconi's earliest experiments were at about 300 MHz, which limited transmissions to line of sight).

In 1896 Marconi took his apparatus to England where some friends had arranged a meeting with William Preece, chief engineer of the British Post Office, the governmental department which had jurisdiction over all electrical communication in Great Britain. Preece was apparently impressed by the young Italian because arrangements were quickly made for a practical demonstration of the equipment for various British officials. By the autumn of 1896 Marconi had transmitted and received signals over a distance of 3 kilometers at Salisbury; in the spring of 1897 he transmitted signals across the Bristol Channel (14km); and later that year he communicated between two ships at sea 16 km apart.

Although Marconi was enjoying the full support of Preece at the Post Office, apparently the bureaucracy moved too cautiously (or released funds too slowly), for he formed his own firm, the Wireless Signal and Telegraph Company in July, 1897 (in 1900 the name of the company was changed to Marconi's Wireless Telegraph Company).

In the late 1890s Marconi continued to improve his equipment, and, in 1899, at the invitation of the French government, he bridged the English Channel, a distance of more than 50 km. By 1900 science had progressed to the point where signalling over distances of 300 km was possible, and Marconi began hinting that even the wide expanse of the Atlantic was not a barrier to wireless. In October the Marconi Company began construction of what was to be the most powerful wireless station in the world, at Poldhu Point in southwest England; by November, 1901, all was in readiness and Marconi sailed for St. John's, Newfoundland, the point in North America which was nearest to Poldhu. On December 12th, he and his assistants were successful in copying the Morse letter S transmitted from Poldhu – thirteen months later two-way wireless communications across the Atlantic were accomplished and the era of long-distance radio had begun.

Marconi had a great deal of respect for the radio amateurs, for it was amateurs who showed that the short waves were not a "vast wasteland," as many scientists of the day believed, but were more valuable to long-distance radio than the lower frequencies favored by the commercial interests. In his later years Marconi often referred to himself as an "amateur" – it's only fitting that the 75th anniversary of his two-way radio transmission across the Atlantic will be celebrated this month on the amateur bands by KM1CC, a special events station operated by amateurs on Cape Cod. Look for them on 160 through 10 meters the week of January 14th. During the same period amateur stations will also be operating from the original Marconi transmitting sites at Poldhu and Clifden, Ireland.

Jim Fisk, W1HR
editor-in-chief

presstop

"REPEATER DEREGULATION is being delayed" reported FCC Safety and Special Services Chief Charley Higginbotham. Enough serious questions about some provisions of the Docket 21033 Report and Order were raised by concerned Amateurs — and particularly the ARRL in its petition for reconsideration — to justify staying its effective date pending further review. Charley expects the Commission to move quickly in its reconsideration, probably before January 1st.

Individual Secondary Station licenses will be on their way out when the Commission announces a decision on Docket 21135, but military recreation, club, and RACES station licenses will be continued. Charley also predicted that by sometime this year Amateurs will no longer need to change callsigns when moving from one call area to another. Call areas will continue, but having a prefix corresponding to your call area will become optional. He also predicted a "lifetime" Amateur operator's license will be adoptec. In addition, he expects we'll soon be able to claim credit for "elements passed" in an Amateur license exam — take the whole test even if you fail the CW, then return for only the failed portion next time.

Autopatch Abuses, Charley warned, continued to jeopardize interconnects for the Amateur Service. "It's your decision!" he said, and if we don't clean up our act we'll end up with formal Commission proceedings that will severely curtail, if not eliminate, Amateur ability to tie into the phone system.

A PIRATE 220-MHZ REPEATER operating in Chicago as a "commercial telephone service" was shut down in early November by the FCC's Chicago Field Office after a two-week-long investigation. No Amateur Callsigns were ever heard and it's probable that most of the "subscribers" (including a tire wholesaler and a medical clinic) thought they were perfectly legal.

TWO NEW ORLEANS AMATEURS PLEADED GUILTY in U.S. District Court to three counts of an eight-count bill charging them with transmitting obscene language and maliciously interfering with a New Orleans repeater during this last summer. The problem had been going on for over a year, but the two Amateurs — K5NY and WB5AWN — had avoided getting caught by the FCC by learning when special DFing equipment was in the area and laying low until it left. Cooperative efforts by local Amateurs and local FCC finally produced the needed proof leading to their indictment and subsequent guilty pleas.

NEW MANAGER OF AMSAT QSL BUREAU is Ross Forbes, WB6GFJ, P.O. Box 1, Los Altos, California 94022. Former manager, WA1EHF, is stepping down after 4½ years at the helm. Ross is well qualified, having spent 1969-1972 as manager of the ARRL W6 QSL Bureau, which handles over 90,000 cards per month!

Donations From Clubs and Individuals to the solar cell and battery funds have brought in nearly $18,000, proving the effectiveness of AMSAT's recent-heavy publicity campaign.

Several Donations of $1000 Each have resulted in the names and callsigns of the donors being inscribed on a plaque to be carried into space aboard the first Phase Three satellite.

LU3AAT Heard KV4AD on 145.9 MHz November 17th when KV4AD was working OSCAR 7 Mode A — about a thousand kilometers over the present 2-meter DX record. KV4AD and KV4FZ are both working with LU3ATT and other LUs attempting to make it two way.

THE FIRST TRANSEQUATORIAL two-meter contact was logged in October when YV5ZZ exchanged signal reports with LU1DAU, who is approximately 50 km south of Buenos Aires. The distance spanned represents a 2-meter DX record of 3180 miles (4446 km). Initial contact was made at 0230Z on October 29 using CW. At 0310Z both stations switched to ssb on 145.9 MHz exchanging 55-57 reports. Signals were steady with none of fading experienced during a prior 6-meter QSO. At 0312Z YV5ZZ also worked LU7DJZ who is about 30 km north of Buenos Aires.

AMATEURS WITH AIRCRAFT or who operate Amateur gear in others' planes should review FAA Advisory Circular AC 20-98, which contains both FAA and FCC regulations on the installation and operation of "nonessential" radio equipment in an airplane.

LI2B IS OPERATING IN IRAQ with government permission as he sails his reed boat down the Euphrates River. Thor Heyerdahl has an okay to operate one hour a day, and reportedly runs 150 watts to a 20-meter dipole on the craft's mast. Unfortunately the operation won't count for DXCC credit because he's afloat.

SMØAGD Operated from Baghdad in a brief demonstration for Iraqi government officials during the Worldwide phone contest weekend. The operation from the Swedish embassy netted 18 contacts, and the Iraqi officials were reported favorably impressed.

POINT-OF-SALE CONTROL for linear amplifiers has been instituted by Canada's Department of Communications. In a Canada Gazette announcement, the DOC stated that all linear buyers must sign a special form including their names and addresses at the time of purchase. The form is then forwarded to the DOC and the buyer's name compared with lists of General Radio Service (CB) licensees to determine whether the purchaser is in violation of DOC rules barring linear possession by an operator in the General Radio Service.

If they copy the style, they can't match the quality.

If they copy the quality, they can't meet the price.

The original DenTron Super Tuner. The original Super Super Tuner. The original MT-3000A. And now DenTron brings you the original MT-2000A, an economical, full-power tuner designed to handle virtually any type of antenna.

The sleek styling and low profile of the MT-2000A is beautiful, but be assured that is only a part of the excitement you'll derive from the MT-2000A. The MT-2000A is designed and engineered using heavy-duty all-metal cabinetry, and high quality American components throughout.

When you consider the MT-2000A's unique features: 5¼"H x 14"D x 14"W, front panel coax bypass switching, front panel lightning protection antenna grounding switch, 3KW PEP, and the ability to match coax, random wire and balanced feedline, we're sure you'll decide to buy an American original and stay with DenTron.

MT-2000A $199.50 at your favorite dealer.

DenTron
Radio Co., Inc.
2100 Enterprise Parkway
Twinsburg, Ohio 44087

216 425-3173

member
arma
amateur radio manufacturer's association

. . . pacesetter in amateur radio

Kenwood's exciting 2-meter transceiver . . . still the most powerful. 800 channels, repeater offset over all 4 MHz (144-148 MHz), dual frequency readout, easy to read 6 digit display, Kenwood's unique continuous tone coded squelch system and outstanding receiver performance. All in a rugged, compact package.

The TR-7400A lets you go anyplace on the 2-meter band . . . covers the entire band without compromise. It exceeds all FCC emission requirements for amateur transceivers. Its RF output is factory spec'd at 25 watts . . . but is typically over 30! It offers a dual frequency readout with large easy to read 6 digit LED display plus a functional dial readout system, fully synthesized 800 channel operation and repeater offset over all 4 MHz (144-148 MHz). The unique Continuous Tone Coded Squelch system is a Kenwood exclusive.

Outstanding sensitivity, large-sized helical resonators with High Q to minimize undesirable out-of-band interferance, and give a 2-pole 10.7 MHz monolithic crystal filter combine to give your TR-7400A outstanding receiver performance. Intermodulation characteristics (Better than 66dB), spurious (Better than −60dB), image rejection (Better than −70dB), and a versatile squelch system make the TR-7400A tops in its class.

(Active filters and Tone Burst Modules optional)

TR-7400A

The TR-7400A is shown with its furnished hand mike and the PS-8 DC power supply (optional). Take your TR-7400A out of the car and you can use it as a powerful base station. The PS-8 is rated at 8 Amps and is among the most rugged, well-regulated supplies available for VHF transceivers requiring 12V DC.

TR-7400A Specifications

Range: 144.00 MHz to 147.995 MHz
Mode: FM
800 Channels: 5 KHz spaced
Sensitivity: Better than 0.4 uV for 20 dB quieting
Better than 1 uV for 30 dB S/N
Squelch Sensitivity: Better than 0.25 uV
Selectivity: 12 KHz at −6 dB down
40 KHz at −70 dB down
Image Rejection: Better than −70 dB
Spurious Interference: Better than −60 dB
Intermodulation: Better than 66 dB
Receive System: Double conversion
First IF: 10.7 MHz
Second IF: 455 KHz
Audio Output: More than 1.5 Watts (8 ohm load)
RF Output Power: 25 Watts (High) 5-15 Watts (Low-adjustable)
Antenna Impedance: 50 ohms
Frequency Deviation: ±5 KHz
Spurious Response: Better than −60 dB
Microphone: Dynamic, with PTT switch, 500 ohms
Current Drain: Less than 1A in receive (no input signal)
Current Drain: Less than 8A in transmit

Trio-Kenwood Communications Inc.
1111 W. Walnut, Compton, CA 90220.

broadcast quality television camera

How to combine a sync generator with three additional circuit boards to obtain a versatile, high-quality TV camera

This television camera's main features combine high quality and ruggedness with relatively low cost and easily obtainable components. Printed-circuit construction and detailed circuit descriptions were used to produce a project that will be operationally complete; it's not just another partially assembled unit, hastily placed under the workbench because of the lack of parts, technical knowledge, or article documentation. An attempt has been made to keep the special tools and materials stocked only by machinists separate from this project. And though I have found that compromises must be made to most ideal goals, every practical effort was made to keep these compromises to a minimum.

A number of interesting features were incorporated into this camera. Most of them allow flexibility, with applications extending beyond ATV use. Indeed, application flexibility weighs very heavily for any homebrew project, so study the following features and compare them to other cameras and your intended use.

1. Resolution capability. In excess of 500 lines. The video processor has a 3 dB response of approximately 6.5 MHz but actual resolution depends largely upon the quality of lens, Vidicon, and yoke in that order.

2. EIA interlaced scanning. Commercial broadcast quality sync is provided to further enhance stability, resolution capability, and weak signal lock-in when the picture is viewed through snow. Also, if a video tape recorder is used, exceptional frame lock stability is provided.

3. Crystal-controlled timebase. A 3.15 MHz crystal is used to derive horizontal and vertical scanning, eliminating a 60-Hz line requirement.

4. High acceleration voltages for the Vidicon. Resolution is basically increased as the G3-G4 grid voltage is raised but the main intent is to enhance the Vidicon's amplitude response, therefore boosting the performance of weak Vidicons.

5. High-video output. 1 volt p-p positive going video is available at the output connector. The video is ac coupled for 75-ohm line drive requirements providing sufficient video for even the most stubborn modulator.

6. Simple operating controls. The normal focus, target, and beam controls are rear panel mounted. No linearity adjustments are needed because of the current feedback, in the ramp generators, which provides a linear sweep.

7. Poor-man's special effects. Variable vertical and horizontal blanking is provided as an option for multi-camera superimposed image applications.

By Arthur Towslee, WA8RMC, 180 Fairdale Avenue, Westerville, Ohio 43081

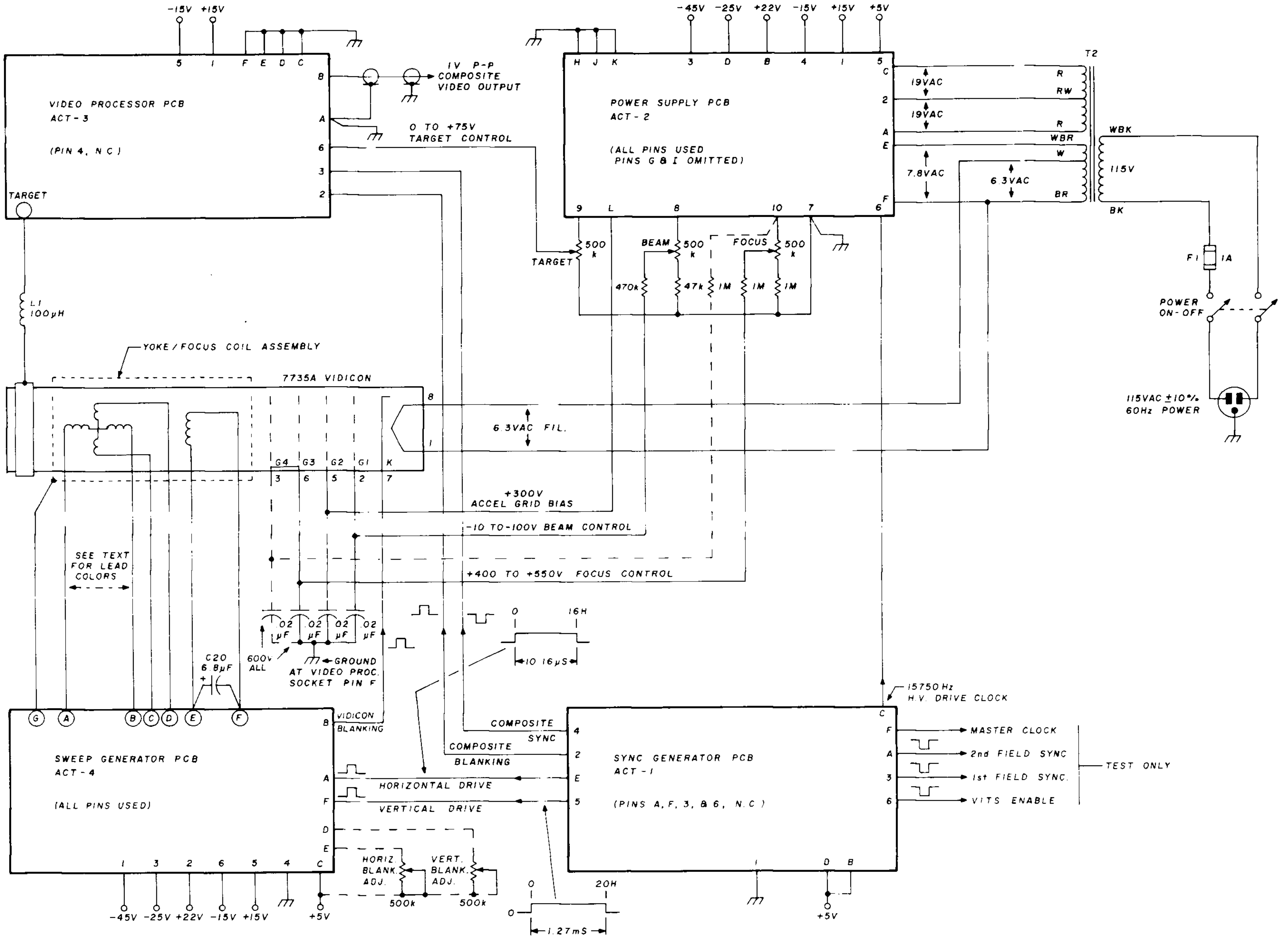


fig. 1. Wiring diagram for the frame of the camera. The connector for the power supply printed-circuit board is a Cinch 50-20A-30. The other boards use the Cinch 50-12A-30. The C-mount lens-mounting plate (3833), yoke and focus coil assembly (2045), and Vidicon socket (2100) are available from Denson Electronics, Box 85, Vernon, Connecticut 06066. A suitable power transformer (ACT-760512.0) is available from Automation Engineering for $10.00, postpaid. A set of four etched and drilled circuit boards is available for $25.00, postpaid, also from Automation Engineering.

8. Low power requirements. Only 25 watts of ac power is required; portable applications can make use of low-power inverters when 12 Vdc operation is used.

9. Printed-circuit construction. Four 3 x 6-inch (7.6x15.2cm) circuit boards are used, thereby eliminating most hand wiring.

10. Rugged and simple construction. Easy-to-obtain aluminum is used. The frame approach produces a camera that is mechanically rugged and allows easy access to all components.

11. Vidicon and yoke flexibility. The circuit design allows for many different magnetic focus/deflection Vidicons to be used. Also, a wide variety of deflection yokes can be accommodated.

12. Low cost. I estimate that the average amateur, with a well stocked junk box, can build this camera for less than 150 dollars. New parts cost (via surplus outlets) is approximately 275 dollars.

13. Optional automatic light compensation. By the addition of a 500 to 1000 megohm resistor in the video processor, reasonably good light compensation can be obtained.

14. Clamped black video level. As the average scene illumination changes, the black level position remains constant. This produces a constant reference level needed for proper setup of bias levels in video modulators and final rf amplifiers.

I've found all of these features to be important, and are lacking in many camera designs. The origin of this design grew from seeing many other camera designs; I liked some of the features of each but not all in any one camera. Thus, I undertook the task of designing a camera from scratch, the way I wanted it. Also, I was determined to finish this project before starting another, and I've got a lot of things around the house that need attention!

general description

A block wiring diagram of the camera is shown in **fig. 1**. The role of the power supply is obvious, and includes the generation of the +450 Vdc needed for Vidicon operation. All main timing and beam scan control is provided by the sync generator which was covered in detail in the September, 1977, issue of *ham radio*. This board provides the clock for the high voltage generation in the power supply, along with the horizontal and vertical pulse information to operate the sweep generator and video processor circuit boards. The sweep generator supplies the operating voltages for the yoke/focus coil and Vidicon. The video processor circuit board, as the name implies, processes the minute Vidicon target current into composite video, inserting sync and blanking on the output video. Typical horizontal and vertical output waveforms, at the video output connector, are shown in **figs. 2** and **3**.

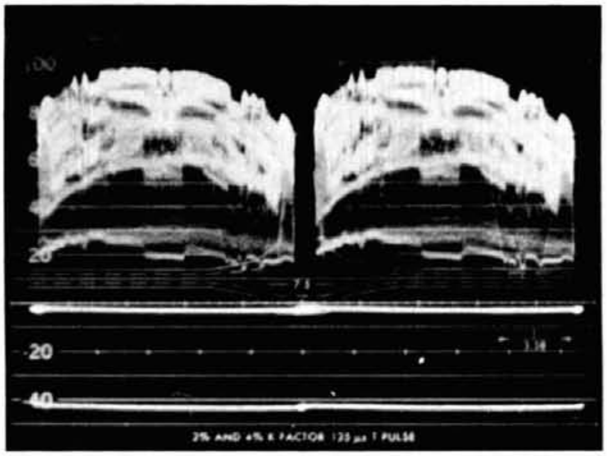


fig. 2. Photograph of the vertical video waveform. The blanking pulse can be seen as a slightly intensified portion of the base line, while the sync pulse is visible as an intensified portion on the −40 line.

Although complete circuit description and theory of operation becomes encyclopedic, and the resultant space would be prohibitively large, I hope that sufficient information is given here to enable you to properly troubleshoot and alter the circuitry as required to suit your own requirements. Most parts are non-critical and substitutions can be made if full knowledge of their function is understood. There are many areas which are considered "designer's choice," implying that there is more than one way to achieve the same result.

Sync generator. All of the outputs provided on this circuit board are not used, so I'll recap only the functions needed and generally describe what their role is in this camera.

First, the high-voltage power supply uses the 15-kHz square wave at pin C. The composite sync at pin 4 and the composite blanking at pin 2 are fed directly to the video processor for insertion into the raw video. The horizontal drive (pin E) and the vertical drive (pin 5) feed the sweep generator to trigger the respective ramp generators and also to provide Vidicon blanking during scanning beam retrace. The high-voltage disable input is not used so it must be connected to pin D (+5V) to enable the high-voltage drive.

Power supply. A great deal of effort was made to provide a complete power supply (**fig. 4**) on one circuit board that was as simple as possible, easy to troubleshoot, and used commonly available components. I almost made it, with the exception of the high-voltage transformer.

A +5 Vdc power supply circuit is used with the popular LM309K regulator IC as the series pass element. Particular attention should be given to the transformer secondary ac voltage. I point this out because I've seen many projects using a 6.3 Vac winding to obtain regulated 5 Vdc from a *bridge* rectifier. It will be found that most of these power supplies drop out of regulation at *110 Vac input*, even with very high filter capacitor values. It's possible to use a center-tapped 12 Vac transformer with a full-wave center-tap arrangement, as shown in the sync generator article, since there is only one diode voltage drop. A diode bridge has an extra voltage drop to add in, thus a higher ac voltage is required to maintain regulation.

A simple, little known formula for determining the minimum filter capacitance is presented here for those who may want to calculate the minimum value of C4.

First, the average dc voltage at the filter capacitor (C4) is roughly 1.1 times the secondary ac rms voltage. Using this information, apply the formula $CV = IT$

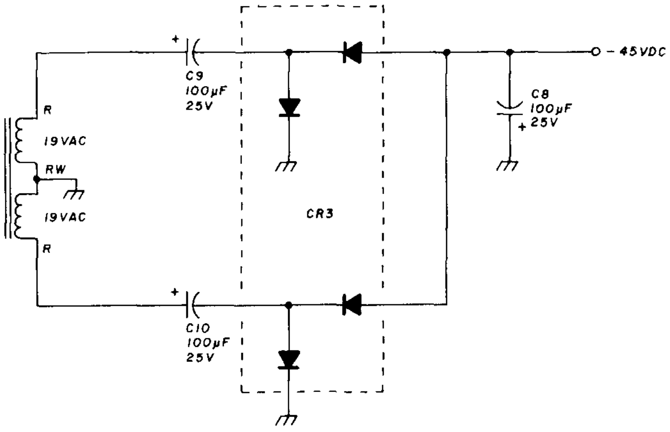
where C = Capacitor value in farads
V = Peak ripple voltage at the filter capacitor in volts
I = Load current at the output of the regulator in amperes
T = Time between charge peaks in seconds

For the LM309 to regulate, a minimum input to output differential of 1.5 volts must be maintained. Therefore, at 5 Vdc output, the input must never go below 6.5 volts. At a low line voltage of 105 Vac, the dc level will drop to 7.3 Vdc. Therefore, only 0.8 volt of ripple is allowed. These facts produce the following:

$$C = \frac{IT}{V} = \frac{0.00833 \times 0.375}{0.8} = 0.003906 \text{ farads } (3906 \mu F)$$

Therefore, at least 3900µF of capacitance is required. I might have parted a bit from the main topic here, but I feel the above information is sadly lacking from typical power-supply designs. I'm a collector of rule-of-thumb formulas and this seems to be a good place to exercise this one.

The +15 Vdc regulator circuit is similar to the +5-volt circuit except a full-wave center-tap rectifier is used. The output is taken from U1. The −15 Vdc regulator uses the other half of the CR2 bridge with the +15 Vdc output as a reference. This provides tracking between the two supplies. U3 is used as an error amplifier to compare the R1-R2 connection to ground. If +15 and −15 volts are equal and opposite, and R1 = R2, zero volt will be present between pins 2 and 3 of U3. If not, U3 will drive Q2 to change the minus voltage until the difference is zero. This arrangement works quite well despite the fact that there are dual-tracking regulators on the market doing the same job. The most cost effective approach is used here. The last of the low-voltage rectifier circuits is the −45 Vdc supply. This is a full-wave bridge doubler composed of C8, C9, C10, and CR3. This combination is used to eliminate the need for another transformer winding. The circuit, if redrawn, will reveal that it is actually two cascade voltage doublers arranged in push-pull to provide full-wave rectification with better regulation than a half-wave arrangement.



The power transformer used to supply the voltages for the previous circuits is the size of a 6.3 Vac 3-amp filament transformer. Multiple transformers to obtain the required voltages could be used here, but to fit into the available space I have designed a single unit to fulfill these specific needs. It is also possible to wind a transformer by removing the secondary of a filament transformer and winding back on the required wire (if you *really* like to wind transformers).

The high voltage needed to operate the Vidicon is obtained by the use of a dc-dc converter driven by the 15750-Hz square wave from the sync generator. T1 is a ferrite cup core around a hand-wound bobbin. In operation, when the logic level drive signal at pin 6 goes positive, Q1 turns on and saturates the core of T1. When Q1 is turned off, the collapsing field in the primary of T1 is transferred to the secondary with a magnitude determined by the turns ratio. The ac voltage induced across the secondary is then rectified and filtered in a conventional manner.

The circuit feeding the focus potentiometer is a half-wave cascade voltage doubler formed by C19, CR4, and CR5. All other voltages are obtained from simple half-wave rectification circuits. The filter on the primary of T1 is used to prevent the switching spikes and the collapsing field of T1 from being fed back into the +15 volt regulated supply. The point that Q1 switches is halfway across the horizontal active scan, so if care is not taken to suppress the spikes, they will appear as a vertical line in the center of the picture.

Various chokes were tried for L1. The best commercially available unit I could find is a Miller 100-μH hash choke. However, for those who find this item

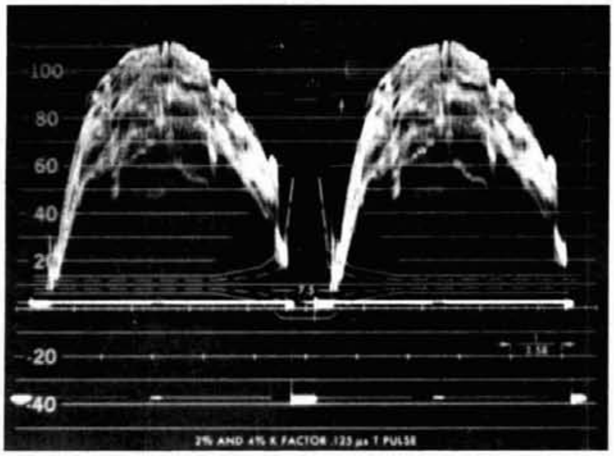


fig. 3. Horizontal video waveform as seen on an analyzer. The sync pulse is seen on the −40 line.

hard to obtain, a toroid-wound choke consisting of 24 turns of no. 22 AWG (0.6mm) enameled wire wound on an FT50-75 core is quite satisfactory.

The high-voltage transformer T1 is a homemade unit wound on a Magnetics OF42213-UG ferrite core and a PCB2213-23 bobbin. Actual winding and assembly is quite simple and total construction time should be less than 15 minutes; careful winding of the primary will save time later. See the construction section for full details.

sweep generator

The sweep generator (**fig. 5**) provides a number of functions; first and most important is the generation of linear ramp currents to sweep the electron beam across the target area of the Vidicon. In addition, logic is provided to blank the Vidicon during ramp retrace and also to blank the Vidicon in case of sweep failure. Finally, a constant-current source supplies the focus coil with the proper current to establish magnetic focus for the Vidicon.

Vertical ramp generator. Operational amplifier U1A acts as an integrater to produce a vertical ramp controlled by the vertical drive pulse. This circuit is different than most integraters because the integrating capacitor C1 is referenced to ground,[1] thereby simplifying the vertical ramp reset circuitry (Q1). This configuration also allows for any required linearity correction. The component values shown provide a linear ramp (R1 and R2 are equal) but the output is an exponential function in which the magnitude and sign of the exponent may be varied by changing the ratio of R1 and R2 while holding the total resistance constant. The sum of R1 plus R2 multiplied by C1 [$C1(R1+R2)$] determines the slope of the ramp. Values of C1 other than 1 μF may be used providing the RC constant remains unchanged and the value of R1 and R2 does not exceed approximately 250 kilohm. In **fig. 5**, C1 = 1 μF while R1 and R2 equal 100,000 ohms. Therefore, the RC constant is 200,000. If C1 was 10 μF, then R1 and R2 must each be 10,000 ohms.

The amount of positive feedback through R4 and R5 controls the exponential output. These resistors must be equal for a linear ramp but the main function is to set the gain (gain of 2). Any value of resistance for R4 and R5 between 4.7k and 100k produces no significant change in the output. Caution must be exercised when selecting values for C1. Stable, low-leakage capacitors (preferably non-electrolytic) must be used. I specify a mylar capacitor but tantalum units may be substituted if the correct polarity is observed. In operation, the positive-going vertical drive pulse resets the ramp generator by turning on Q1 and discharging C1 to ground. After the vertical pulse is completed, C1 linearly charges producing the +5 volt output at pin 12 of U1A. The next pulse resets Q1 and the cycle repeats again. The relatively large signal output (+5 volts) from U1A is intentional, to produce a large signal-to-noise ratio.

The second stage (U1B) is a voltage follower placed in the current loop to provide adjustable current gain and dc offset. The signal is reduced before pin 6 to approximately 0.6 V p-p and then compared to the 0.6 V p-p signal at pin 7. The output from pin 10 then feeds a complementary transistor pair (Q2 and Q3) which provides a current boost to drive the vertical yoke. R14 and R15 bias Q2 on slightly before Q1 turns off, eliminating crossover distortion; R16 also helps supply current at the crossover point. R17 and R18 are simply current limiters for the transistors and also provide some degree of decoupling.

Capacitor C3 shunts the small component of horizontal ramp signal around the vertical coils. R21 is used to sense the current through the vertical yoke since the voltage developed across this resistor is proportional to the current flowing through the coils. R19 and R20 form a voltage divider across R21 and

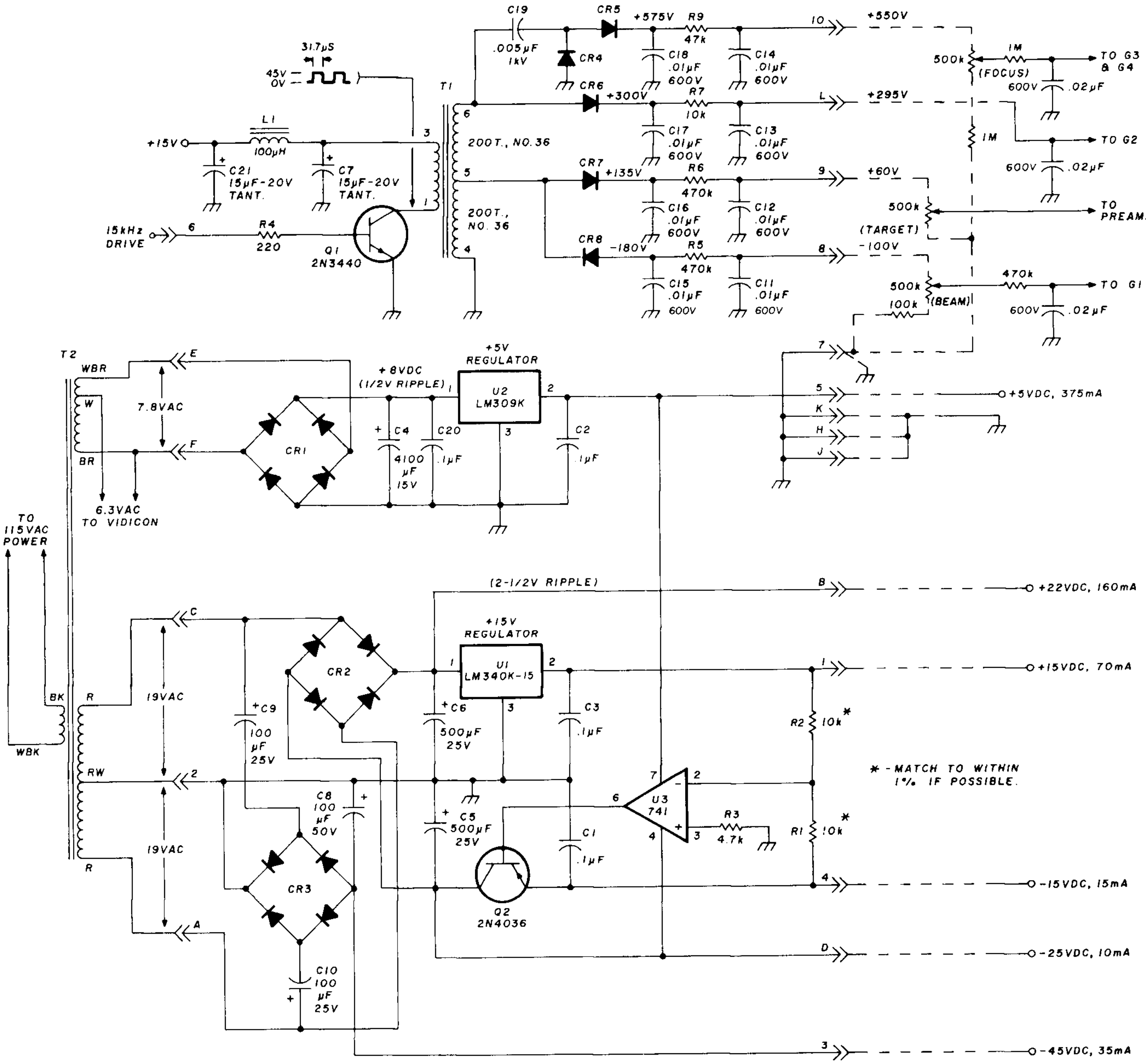


fig. 4. Schematic diagram of the power supply board. Diodes CR1, CR2, and CR3 are Varo VE18 diode bridges, or can be replaced with individual 1N4004 diodes. All other diodes are 1N4007s. R1 and R2 should be matched to within 1 per cent; all other resistors are 10 per cent tolerance. The 100 µH choke is a J. W. Miller 5250. All the capacitor values are minimum values which can be increased if the new capacitor will fit within the available space. The high-voltage transformer is mounted by an 8-32 (M3.5) screw through the circuit board. Flat washers should be used to space the transformer approximately 1/8 inch (3mm) above the board.

feed back a portion of the voltage to the inverting input of U1B. The overall gain of the loop is determined by

$$\frac{R11+R13}{R11}E_{in}=E_o$$

where E_{in} is the voltage at pin 7 and E_o is the voltage at R20's wiper.

By changing the vertical yoke current, the height is varied with minimum current equal to maximum height and vice versa. Yokes with different deflection factors can be accommodated by changing the value of R21 which changes the range of the height potentiometer R20. The value used here (100 ohms) will yield an R20 range of 12 to 80 mA. Decreasing this value to 50 ohms would produce a range of 25 to 160 mA. However, most deflection factors fall in the range of 12 to 80 mA. C2 compensates U1B and prevents ringing due to overshoot by reducing the gain of U1B at high frequencies. Centering pot R10

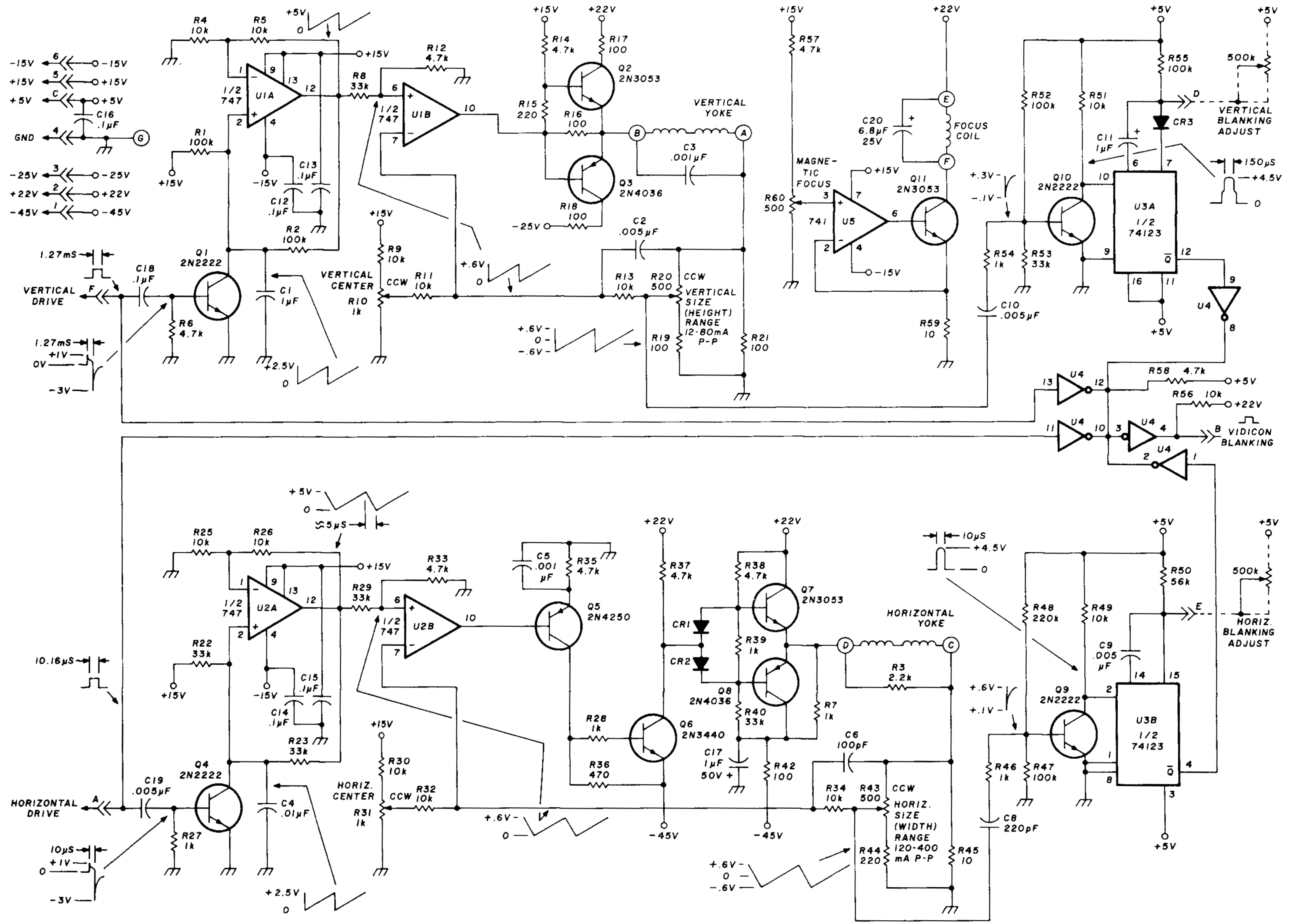
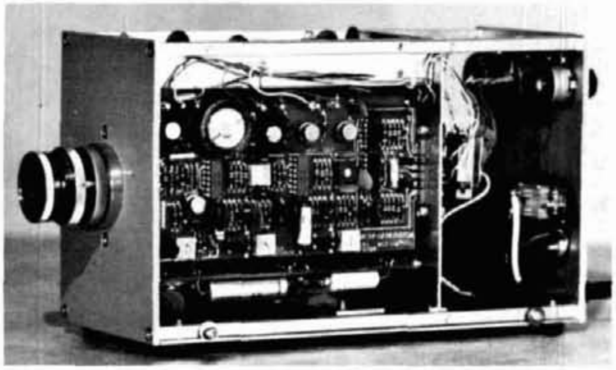


fig. 5. R7 is a ½-watt, 10 per cent, composition resistor. All other resistors, except the potentiometers, are ¼-watt, 10 per cent. The potentiometers can be either Helipot 72PM, Bourns 3386-P, or Bourns 3386-F. All diodes are 1N4151 but most other silicon diodes are acceptible. The heatsinks are Thermalloy 2212B-5 or 2227-B for Q8, and Thermalloy 2228-B for Q7 and Q11. C1 and C4 are mylar capacitors; C11 should be a tantalum capacitor.



This side view of the camera shows the sweep generator card. The additional components for the alignment coil can be seen on the socket for this circuit board.

provides a variable dc reference to center the ramp symmetrically about zero. Increasing the bias shifts the picture on the monitor from the top to bottom.

Horizontal ramp generator. This circuit is identical in concept to the vertical ramp generator discussed above. In fact, a visual inspection of the schematic will reveal only one added part, R24 in the circuit of U2A. When the horizontal pulse resets the ramp, C4 is not completely discharged due to the 10-ohm resistor, but left with a slightly positive bias which shows up at pin 6 of U2A as an offset. This small offset opposes that presented by the horizontal centering control and will provide sufficient adjustment on either side of zero.

The slew-rate upper-frequency limitation of U2A is used to an advantage here. Since slew rate is measured in volts per unit of time, the higher the ramp voltage becomes, the more time it takes to retrace. Steep slope retrace times will tend to produce ringing in the following stages; By keeping the peak ramp voltage high (+5V), the retrace takes longer due to slew-rate limiting and yoke ringing is minimized. The resistive divider (R29 and R33) then attenuates the signal to approximately 0.6 volt at pin 6 of U2A.

The output voltage and current boost circuitry, formed by transistors Q5-Q8, provide the required gain and current drive for the horizontal yoke. Q5 and Q6 provide some gain but serve primarily as dc level shifters to drive the complementary stage (Q7 and Q8). Since the use of higher voltage levels was required, I had to fall back on discrete logic. The higher peak-to-peak voltages are due to two factors. First, the horizontal deflection factor of the yoke is roughly six times higher than the vertical circuit. This is due to the smaller number of turns of wire to minimize the inductive reactance. Second, because of the increased inductive reactance, even with fewer wire turns, more voltage must be impressed across the windings to source the same current as that required by the vertical circuit.

Obviously, there are compromises and tradeoffs while trying to maximize current with a minimum of voltage. Notice that a negative supply voltage of −45 volts is used. This is because maximum current is needed during retrace where the rise time is the greatest. An oscilloscope on the collector of Q6 would reveal a sharp negative-going pulse.

Theoretically, an infinitely steep voltage pulse, discharged into a pure inductance, will produce a current ramp. This is how some commercial cameras generate a sweep. However, no circuit achieves theoretical factors so non-linearities creep in. That is why most cameras provide linearity adjustments.

Since the circuit presented here is a true closed-loop current source, the source voltage is automatically controlled to produce a linear current ramp. Thus, no linearity adjustments are needed and the only non-linearities which do exist are in the yoke itself. Because of the ramp generator design, compensation can be made to overcome this if required. For all practical purposes, however, yoke non-linearities are not detectable to the average viewer.

The zero crossover problem, discussed in the vertical circuit, is more difficult to overcome due to the higher frequency involved. Hence diode biasing is used to overlap the turn on of Q7 before Q8 turns off. R39 provides the proper degree of overlap and also balances the base drive for Q7 and Q8. Notice at this point that R7 is placed across the emitter-collector of Q8. If a yoke is used that requires more than 300 mA p-p for proper operation, base drive limiting can take place due to the low current gain of Q8. Therefore, R7 helps to source current when the ramp is maximum negative, reducing the dissipation. Even with R7 in the circuit, Q8 is driven much harder and for a longer duration of the cycle than Q7.

I would like to point out here that a large imbalance of the centering pot for a long duration will cause excessive dissipation in Q7 or Q8, depending upon which side of zero the imbalance occurs. Steps must be taken to check this when initially powering the circuit to avoid the premature replacement of the transistors.

The value of R3 depends upon the yoke inductance and is used to dampen the inductance and lower the *Q* of the circuit to prevent ringing. Use a resistor decade box and decrease the resistance to a point where any vertical bar shading irregularities at the left side of the video monitor just disappear. If an oscilloscope is handy, connect it from terminal **C** to ground and view the horizontal ramp. Adjust R3 to eliminate any ringing on the leading edge of the ramp immediately after retrace. For the yoke specified, this value is 2.2 kilohms.

The current sense element for the horizontal ramp is R45 and operates in exactly the same manner as R21 in the vertical circuit. Changing the value of this resistor will change the range of the width potentiometer R43. With an R45 value of 10 ohms, a current range of 120 to 400 mA can be accommodated. It is important to realize that when it is desired to view the ramp waveform on a scope, only the *current* waveform is meaningful, because it is the current that deflects the electron beam within the Vidicon. (Remember that we are dealing with *magnetic* deflection Vidicons.)

Don't confuse the current waveforms with voltage waveforms shown on many commercial camera schematics. In many cameras, current waveforms are difficult to make because of the lack of a grounded current reference point. However, in this case R21 (vertical) and R45 (horizontal) are in the current path. A scope from terminal **A** or **C** to ground will display current if the voltage on the CRT is divided by the R21 or R45 resistance.

The Vidicon must be blanked during both vertical and horizontal retrace even though proper blanking of the video waveform is taken care of farther downstream; this is because of the persistance and lag of the Vidicon — an actively scanned retrace will produce dark diagonal lines superimposed on the normal scan. Methods to blank the Vidicon vary from cathode blanking to G1 grid blanking or both. In this case, simple cathode blanking is used by raising the cathode approximately 22 volts positive during the retrace intervals. The vertical and horizontal drive signals are inverted, wire ORed and again inverted to drive the Vidicon cathode through U4. I have noticed that when using a type 4478 Vidicon, because of its higher cathode cutoff point, marginal cutoff of the beam can occur, especially at low-light levels, producing a very slight retrace line. Using a type 7735 Vidicon has not been any problem.

The Vidicon *must* be protected from accidental loss of either vertical or horizontal sweep, even for time durations as short as a fraction of a second. If sweep failures occur without protection, the scanning beam in the Vidicon would permanently burn the target material, causing a serious line or spot in the picture after normal sweep resumed. U3, a 74123 dual retriggerable one-shot, is the heart of a scheme devised to blank the Vidicon (turn off the scanning beam) if either horizontal or vertical sweep is interrupted. In operation, C10 and R54 integrate the vertical ramp, negative-going retrace into a short duration pulse at the base of Q10. Q10 turns on during this time to produce a positive pulse at pin 10 of U3 to reset the timer. The output (pin 12) is low at this point. After the input pulse, U3 starts a time delay

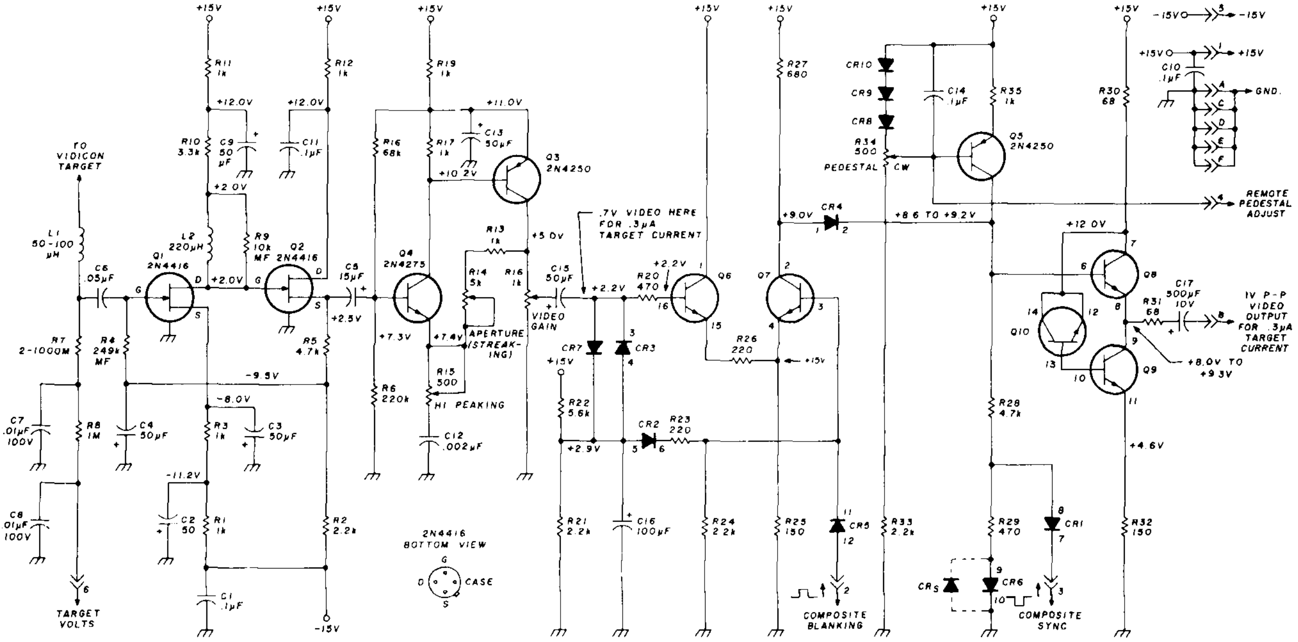
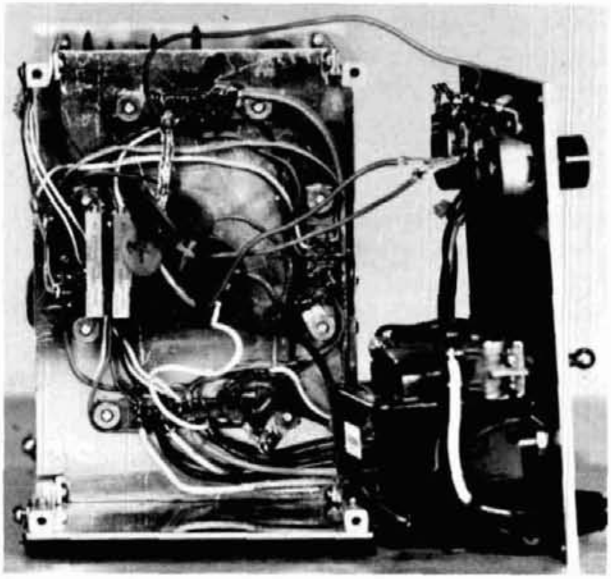


fig. 6. Schematic diagram of the video processor; all voltages are shown with no video (lens capped) and R16 turned fully counter-clockwise. R4, R7, and R9 are metal-film or deposited-carbon resistors. All other resistors are ¼-watt, 10 per cent carbon composition. Diodes CR7-CR10 are 1N4151 or equivalent silicon diodes; L1 is a Nytronics WEE-100 or J. W. Miller 70F755A1, and L2 is a Nytronics WEE-220 or J. W. Miller 70F224A1. U1 is an RCA CA3039 and U2 is a CA3083. The output voltage will vary depending upon the pedestal setting. R29's value will produce 40 IRE units of sync; to change to 20 units, R29 must be reduced to 220 ohms. All voltages were measured with a 10,000 ohms/volt meter.



Rear view of the camera with the back plate removed. The three capacitors which are connected to the Vidicon socket are grounded through a common piece of braid to the video processor socket.

which, if allowed to time out, will cause pin 12 to go high. For normal operation, before the timer times out, a new pulse arrives at pin 10 resetting the timer and repeating the cycle. If the sweep had failed to retrace, no pulse would occur at pin 10 and the timer would time out thus driving U4 pin 8 low and blanking the Vidicon.

The time delay is set by R55 and C11 and is slightly longer than a normal 16-millisecond vertical-scan cycle. The horizontal circuit operates in an identical manner. Note that I have brought the C11-R55 junction to pin D on the connector. Normally this pin is not used, but if the delay is shortened to time out before the end of the normal scan cycle the Vidicon will be blanked from that point until the start of the next cycle. By connecting a 500k potentiometer from pin D to +5 Vdc, a poor man's special effect can be made to "wipe" from bottom to top. An additional 500k potentiometer from pin E to +5 Vdc will produce a wipe from right to left. This combination will change the picture from full screen to a small square in the upper left of the screen. One caution must be observed. By blanking the Vidicon at a point normally in the active scan region for a long time on relatively bright scenes, a line will be produced on the screen when the blanking point is changed. This could produce a permanent burn in the Vidicon.

The Vidicon magnetic focus control circuit is also on this circuit board. It is a simple current sink to supply constant current to the focus coil independent of supply voltage and coil resistance variations. R60 is adjusted to set the current desired to focus the Vidicon. The voltage developed at the emitter of Q11 is compared to the voltage at the wiper of R60 by U5. U5 will then drive Q11 until these voltages are equal, producing a voltage drop across R59 which is proportional to the focus coil current. The focus coil current, $I_o = E_{R60}wiper/R59$. The op-amp's open loop gain and excellent temperature stability are combined to produce very stable regulation of the focus current.

Most focus coils typically require approximately 40 mA if the coil resistance is about 400 ohms, producing E_{R60} equal to 0.4 volts. The lower the coil resistance, the higher the required current will be. If the focus coil used approaches 100 ohms, it will be necessary to place a small resistance in series with the coil (approximately 22 ohms) to prevent excessive dissipation in Q11. The voltage across terminals **E** and **F** should be close to 15 volts. Finally, capacitor C20 must be placed across terminals **E** and **F** to suppress horizontal spikes occurring at a rate too fast to be corrected by U5 (there was not room enough to mount this capacitor on the circuit board).

video processor

The video processor, as the name implies, processes the extremely low level video signal from the Vidicon. The preamplifier portion (**fig. 6**), composed of Q1 through Q4, amplifies the signal and also provides response modification. The amplified signal (approximately 0.7 volt p-p) is then presented to the processor where blanking and sync are inserted.

The preamplifier accepts the extremely low level current, from the target of the Vidicon, which is produced by the discharge of the target by the scanning beam. This signal, in the range of 0.05 to 0.5 microamp, is ac coupled to Q1 and discharged through R4 to produce a voltage equal to:

$$I_t \left[\frac{R4 \times R7}{R4 + R7}\right]$$

at the gate of Q1. For 0.3 microamp of target current (a relatively bright scene), approximately 60 mV is developed at Q1's gate; a higher voltage level than one would suspect. Wiring must be kept to a minimum and also well shielded at this point to prevent broadcast interference pickup due to the high impedance involved.

The target bias is also applied at this point. This positive voltage will charge the capacitive surface of the Vidicon that eventually will be discharged by the scanning beam. The bias, usually about +20 volts, must be varied as the average scene level changes and ideally must be a constant-current source for automatic light compensation. By making the value of R7 very large (greater than 100 megohms) a constant-current source is approximated because the Vidicon is basically a constant-current generator. Therefore, partial ALC is achieved. My original design uses a 2.2-megohm resistor for R7 with no ALC. However, if ALC is desired, use a 500- to 1000-megohm resistor for R7 and increase the value of the target pot from 500k to 1 megohm. If this is done, the recovery from abrupt light level changes will be slow, especially as R7 approaches 1000 megohms because C6 must be charged (or discharged) to a stable level in the process.

In operation, the high impedance gate of Q1 amplifies the video signal with some series peaking in the drain circuit. This technique helps to compensate for the normal high-frequency rolloff of the Vidicon. R9 shunts L2 to shape the response of the peaking by reducing the *Q* of L2. At low frequencies R10 is primarily the load resistor, while at high frequencies, where the reactance of L2 is higher, R2 and X_L of L2 are additive to increase the gain of the

The video at Q2's source is ac coupled to Q3 and Q4; Q4 is used as a bootstrapped emitter follower with a dc gain of 1. Degenerative feedback is provided to vary the high-frequency rolloff point (aperture) and the slope of the gain curve to the rolloff point (high peaking). The aperture is normally adjusted by viewing a scene with high contrast ratios and adjusting R14 for no white *tails* following a white to black transition. The high-peaking pot, R15, is adjusted by observing the maximum picture detail without noticeable oscillation effects. The corrected video is then fed to the video gain pot R16 for presentation to the sync and blanking processing stages.

The blanking and sync insertion circuitry[2] is built around an RCA CA3039 high-speed diode array. The circuit restores the dc level to the incoming positive-going video signal, inserts blanking, sets up a pedestal level, and then adds composite sync. This type of processing precisely inserts the sync and blanking in-

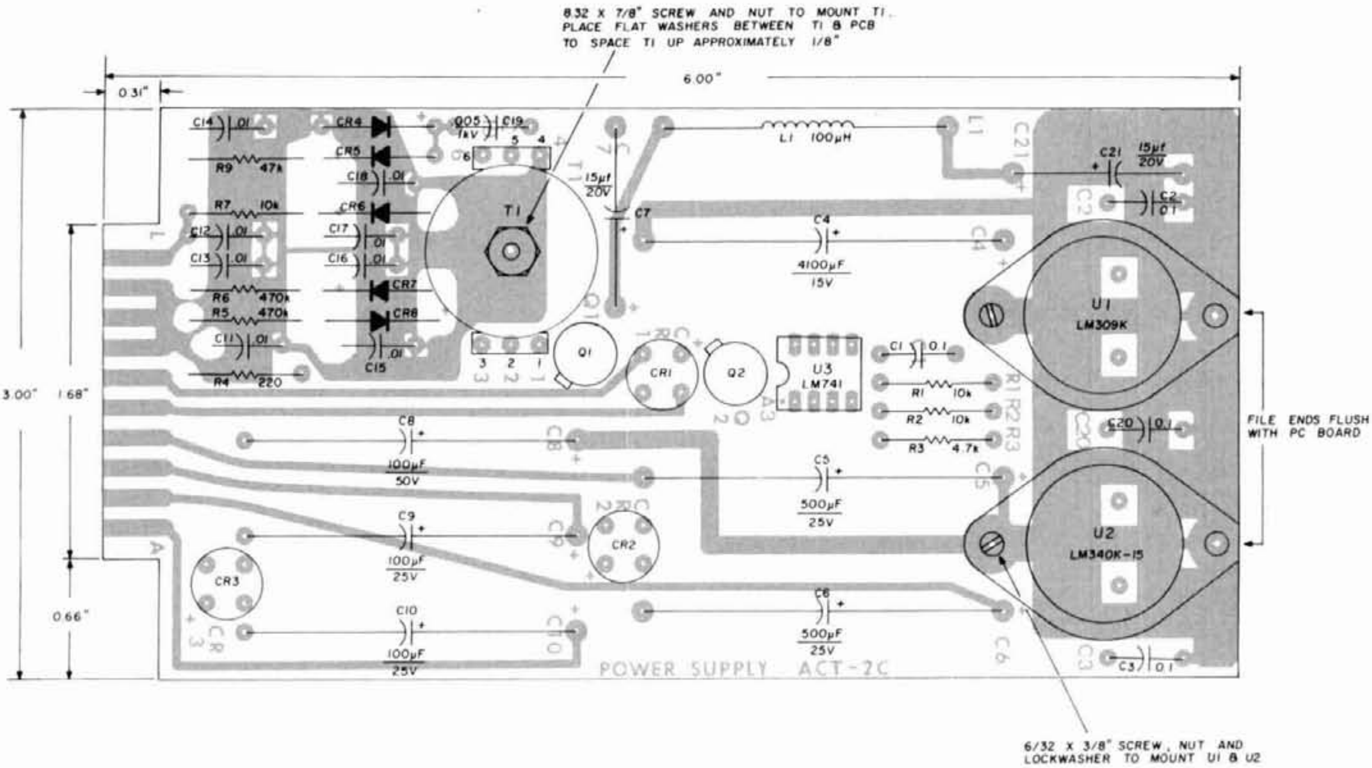
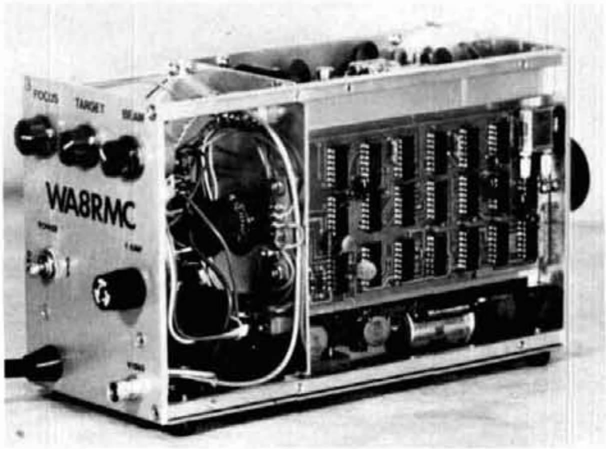


fig. 7. Component placement for the completed power supply board.

stage. Q2 is basically a source follower to isolate the signal from the previous stage and to present a lower impedance for coupling to Q4. In addition, it provides a dc stabilized feedback to Q1. Q1 and Q2 therefore operate together to provide a single inversion of the signal with a total mid-frequency gain of approximately 15.

formation, not merely adding it to the video. Linear addition is not good enough because the video information would ride on top of the sync information. Sync must only contain position information; therefore, the video is clamped to a voltage level at the positive terminal of C16 by diode CR3.

Diode CR7 protects CR3 from excessive reverse



The 0.01 μF disc capacitor mentioned in the text can be seen attached to the sync generator board. Its inclusion will eliminate a vertical line in the picture.

voltage and will clamp the absolute video excursions to approximately 0.7 volt. The resulting signal is then fed into a differential amplifier consisting of Q6 and Q7, a matched pair within the CA3086 (U2). This amplifier has a low gain (2.5) between the base of Q6 and collector of Q7 but a much higher gain (6.5) between the base of Q7 and its collector. With CR5 reverse biased during scan time, amplified video will appear at the collector of Q7. When a horizontal or vertical blanking pulse appears at pin 2, CR5 is forward biased and saturates Q7, thereby adding a very large pedestal to the video. This pedestal must then be clipped and sync added to complete the process.

Transistor Q5 and the associated circuitry is connected to function as a constant-current source which will set up a variable voltage at the cathode of CR4 depending upon the presence or absence of a sync pulse. Thus, whenever the signal at Q7's collector is more negative than this potential, CR4 will isolate the video signal from the base of Q8. However, if the level at Q7's collector is more positive, the video signal will appear at Q8. If the current from Q5 produces a level at Q8 base just beneath the video black level, the entire video will rest upon the blanking level. When CR1 conducts due to an incoming sync pulse, R29 will be short-circuited, and the voltage at the base of Q8 will drop a corresponding amount. The resultant composite video is then presented to the output transistors Q8 and Q9. Transistor Q10 is connected as a diode to provide negative feedback. Because of Q10's low reverse breakdown of 6 volts, it acts as a zener to clamp the feedback at 6 volts. R30 and R32 are purposely selected to be low values to keep impedances low and improve bandwidth.

The entire processor circuit, including the preamp, has been tested and found to have an overall 3 dB bandwidth in excess of 6.5 MHz. This value is more than adequate for all but the most expensive Vidicons.

There are a few comments about component selection which deserve mention. The preamp resistors R4, R7, and R9 should be metal film to keep noise to a minimum. C6 must be a non-polarized and low-leakage capacitor; most ceramic capacitors are fine. In the processor U1 is a diode array selected primarily for high-speed operation. Substitution of descrete slow-speed diodes could be disastrous. U2 is a high-current transistor array to handle the relatively high current in the output stage; it also runs warm in normal operation. In some applications, particularly for ATV operation, the sync amplitude may have to be altered. R29 is selected to produce approximately 40 IRE units of sync. To reduce this level to 20 IRE units, decrease this value to 220 ohms.

A number of prototypes were built before an arrangement was obtained that provided compact size, easily obtainable materials, a minimum of special tools for fabrication, and accessibility to all printed circuit boards while the camera was operational. Of course, there are always tradeoffs to any design, but the main criterion here lies in the ability for the maximum number of people to be able to reproduce this design with the minimum of effort.

A standard chassis approach was abandoned early because no standard size existed which was close to the dimensions needed to qualify the camera as a compact. Instead, I settled upon a basic frame approach. This may require more individual pieces but it keeps bending requirements to a minimum.*

Basically, the front and rear plates are made from 1/8-inch (3mm) aluminum. Thinner material could be used but mechanical rigidity will suffer. The frame studs that hold the front and rear plates are 1/4-inch (6.4mm) square aluminum bar stock. This material is not generally available in hardware stores and I had to go to an industrial aluminum supplier and buy a 12-foot (3.7m) long piece. I've got a lot left over, but the cost was less than three dollars. The back plane bracket, video PCB shield, sync generator PCB shield, and the bottom plate are all made from 1/16-inch (1.6mm) aluminum. Here, substitution of thinner material down to about 0.040-inch (1mm) thick is fully satisfactory. Thicker material, however, will be difficult to bend and should be avoided.

*A copy of the complete set of mechanical drawings is available by sending a 9½ x 11 envelope with 35 cents postage to *ham radio*, Greenville, New Hampshire 03048.

Mounted directly behind and fastened to the front plate is the front mounting block. This serves as a very convenient means of securing all four circuit boards and establishes a good low-impedance electrical ground. It also spaces the yoke/focus coil back from the Vidicon to establish proper focusing. I made this block from 1/4-inch (6.4mm) aluminum, but thicker pieces up to 3/8-inch (9.5 mm) can be used if care is taken to chamfer the edges where they contact the circuit boards so no shorts occur. Since the yoke/focus coil mounts to this block, check the mounting dimension requirements of the yoke you obtain before drilling these holes.

The outer cover that wraps around the entire camera is not detailed because of the variety of materials that could be used. Solid-sheet aluminum may be used if ventilation holes are drilled along the sides and top. Many types of decorative perforated aluminum are available at hardware stores and are desirable for ease of bending. I used 0.050-inch (1.3mm) perforated steel because of availability. Don't use this unless you have access to a bending brake and can do it right the *first* time!

Finally, the hole size in the front plate depends upon the method of mounting the lens but must be larger than 1-1/8-inch (2.9cm) in diameter in order to insert and remove the Vidicon without removing the plate. I have found that a universal lens mounting method to satisfy all situations is not obtainable. I have access to a lathe, so an adapter was machined with threads to accept a standard C-mount lens which would also screw into the front plate. Not everyone can do this so I suggest an adapter available from Denson Electronics (part 3833) to mount the lens on the front plate.

The printed-circuit board layouts may be obtained by sending a self-addressed, stamped-envelope to *ham radio*, Greenville, New Hampshire 03048 or, purchased as etched and drilled blank boards from Automation Engineering Company.* The parts placement drawings are shown in **fig. 7, 8,** and **9**. Breadboard construction is not recommended because of the somewhat critical layout of components on some boards. In general, no special assembly of components is required on any of the boards. However, I might suggest three cautions that should not be overlooked.

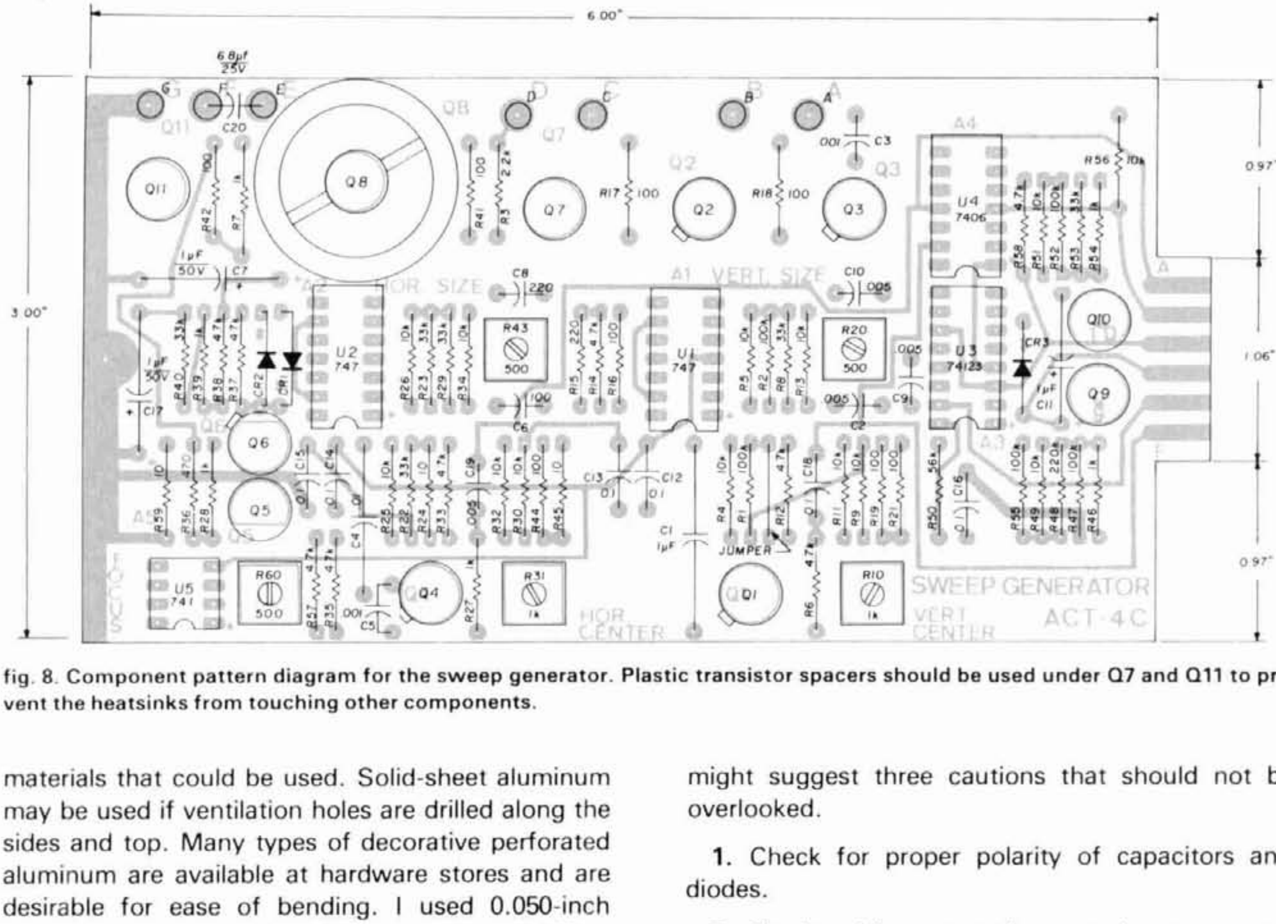


fig. 8. Component pattern diagram for the sweep generator. Plastic transistor spacers should be used under Q7 and Q11 to prevent the heatsinks from touching other components.

1. Check for proper polarity of capacitors and diodes.

2. Check solder connections on the *component* side of the board.

3. Be careful not to leave component leads too long on the solder side; they may touch the focus coil.

Most components are commonly available and

*Automation Engineering Company, 3621 Marine Drive, Toledo, Ohio 43609.

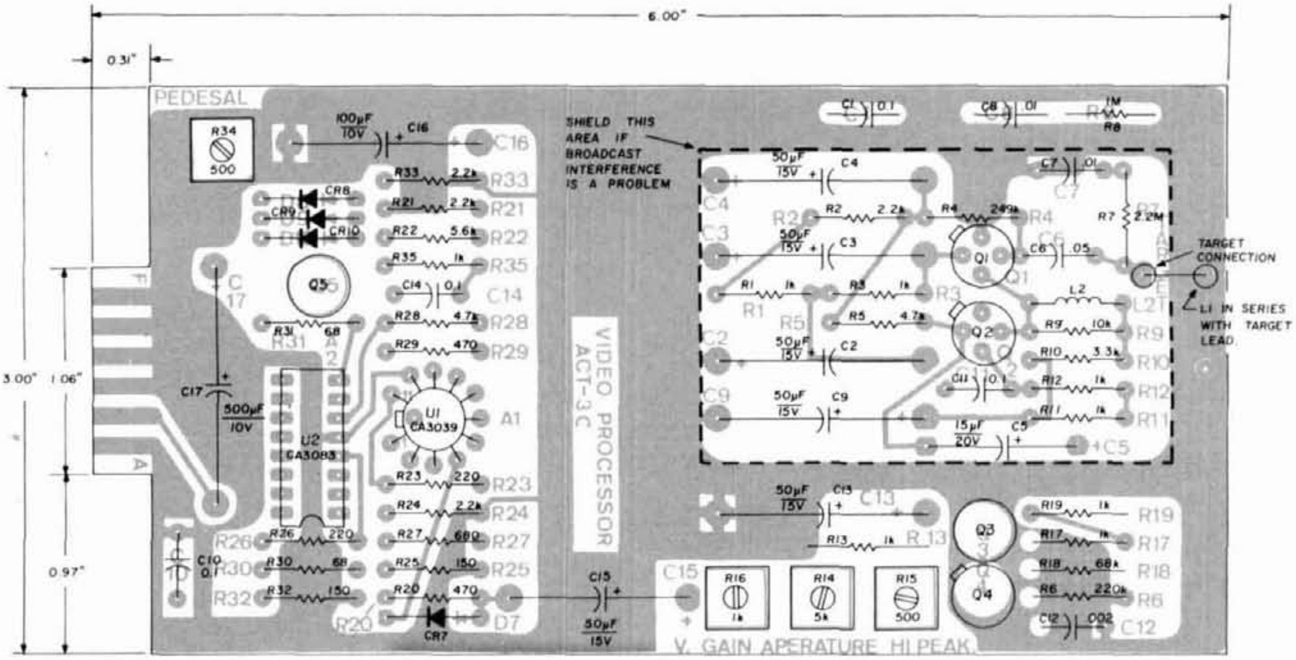


fig. 9. The area enclosed with a dotted line on the video processor board should be shielded if broadcast interference is a problem. L1 is not mounted on the board but runs directly between the board and the Vidicon. All other components are mounted as shown in this diagram.

were designed with surplus dealers in mind. Many substitutions of components are possible, but good judgement must be exercised. Hopefully, after reading the preceding technical descriptions of each board a knowledgeable substitution can be made knowing that it will work. If substitution of transistors is required for the 2N3053, 2N4036, and 2N3440, be sure to check package size, voltage rating, current gain, and power handling capacity.

The high-voltage transformer in the power supply must be wound with the Magnetics, Inc. cores detailed in **fig. 10**. The cores and bobbin are not generally available in small quantity, from Magnetics, Inc., but they can be obtained from Automation Engineering for $2.50, postpaid. Adding the required wire to these parts is quite simple. First, insert a 7/16-inch (11mm) bolt through the bobbin and secure with a nut. Now hold the bolt instead of the bobbin while winding. The primary must be wound on first, with the wire occupying the bobbin section closest to the pins. Wind with 20 turns of no. 26 AWG (0.4mm) enameled wire (approximately 3 feet or 1m) connecting the beginning of the winding to pin 1 and the finish to pin 3 (pin 2 is unused). Wind the first half of the secondary on the center section with 200 turns of no. 36 AWG wire (0.13mm). Connect the start to pin 4 and the finish to pin 5. Now, continue winding another 200 turns on the top section *in the same direction* as the first 200 turns, with the start at pin 5 and the finish at pin 6. After completion of the winding, slip spaghetti insulation over the leads and place the cores in position before soldering the leads to the pins. Careful positioning of the leads will prevent them from touching the cores. Finally, seal the wire in place on the bobbin by melting a small amount of beeswax or crayon on it.

Almost any 1-inch (2.5cm) Vidicon is usable in this camera, including the 8507 separate-mesh Vidicon. When this tube is used, however, tie G4 (pin 3) directly to power supply pin 10 through a 1-megohm resistor. G3 (pin 6) is then connected to the focus pot as shown. I recommend a yoke-focus coil assembly available from Denson Electronics (Part 2045) for this camera, but it must be altered and mounted as follows:

1. The wire on the focus coil must be unwound and rewound with 1 pound (0.45kg) of no. 28 AWG (0.3mm) or no. 29 AWG (0.27mm) wire (approximately 7000 turns).

2. A good target connection is not supplied with this assembly. However, if the front mount is removed by gently tapping it from inside and replaced with a Denson plastic front Vidicon mount and target connection (furnished with the coil as a loose item), this will make the assembly usable with a minimum of effort. The two plastic ears on the plastic front Vidicon mount, which extend behind the solid piece, must be sawed off flush so the yoke can be fully inserted.

3. A method of clamping the yoke and Vidicon to the focus coil case must be made by the builder.

4. The electrical alignment coils provided on this yoke must be powered to operate properly (many yokes have permanent magnet alignment magnets not needing electrical connections). No provision for alignment coil power is provided on the circuit boards, but the circuit shown in **fig. 11** can be used to power the coils.

Two other yokes that I've tested and found to be satisfactory are the Denson 2047 and 2013. They require approximately 300 mA p-p to operate the horizontal coils and 15 mA to operate the vertical coils. See **fig. 12**. If either yoke is used, you must furnish a satisfactory focus coil. The following tips will help if you feel confident enough to build a focus coil.

1. Wind the coil with 1 pound (0.45kg) of no. 28 (0.3mm) wire (approximately 7000 turns).

2. Use a plastic front Vidicon mount and target connection, available from Denson by description.

3. Use a permanent magnet alignment assembly, Denson 7138.

The power transformer is a special unit I wound for this application. Although standard transformers are available which could work, I found none with all of the required voltages. It is possible to hand wind a transformer using a Stancor P6466 as a core but this is somewhat laborious.

The 0.02 μF capacitors from Vidicon pins 2, 3, 5, and 6 to ground are 600 volt ceramic capacitors. They're installed on the Vidicon socket pins with as short leads as possible. The ground side of the capacitors should be connected together and then connected to the video processor socket pins C, D, E, and F at the ground lug with a short piece of shielding braid. This is for flexibility along with providing a low impedance to ground.

initial testing and setup

The testing of each circuit board should be done in a systematic manner to avoid the possibility of damaging good components on one circuit board due to a problem on another; the following steps will save a lot of time and headaches later.

First, after all frame wiring is completed (do not install the Vidicon or any circuit boards) plug the camera in and verify that, with respect to pin 2, approximately 20 Vac exists at the power supply socket pins A and C. Next, measure the voltage between pins E and F. It should be about 8 Vac. Last, check for about 7 Vac between Vidicon socket pins 1 and 8.

Now plug in the power supply circuit board and, with a clip lead, short pin 6 to ground. Turn the power on and check for ±15 Vdc, +5 Vdc, ±25 Vdc and −50 Vdc at the power supply socket and all other socket connections to which these voltages go. If an oscilloscope is available, make sure the ripple at pins 1 and 4 (±15 volts) and pin 5 (+5 volts) is below 10 millivolts.

After all the tests are complete, remove the clip lead jumper, and plug in the sync generator. Again apply power and check for proper high voltages (approximately 500-600 volts at pin 10). I assume at this point that the sync generator has been previously checked and is operational. In normal opera-

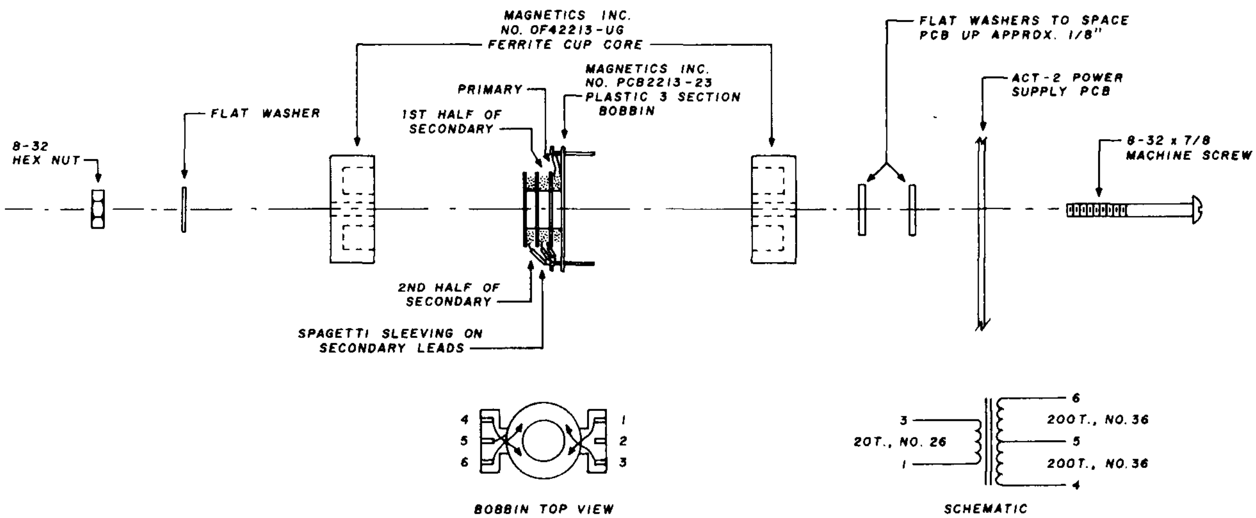


fig. 10. Construction details for the high-voltage transformer. The primary winding will require approximately 3 feet (1m) of no. 26 AWG (0.4mm) wire, while the secondary will require 50 feet (17m) of no. 36 AWG (0.13mm) wire. The core and bobbin are available from Automation Engineering for $2.50, postpaid.

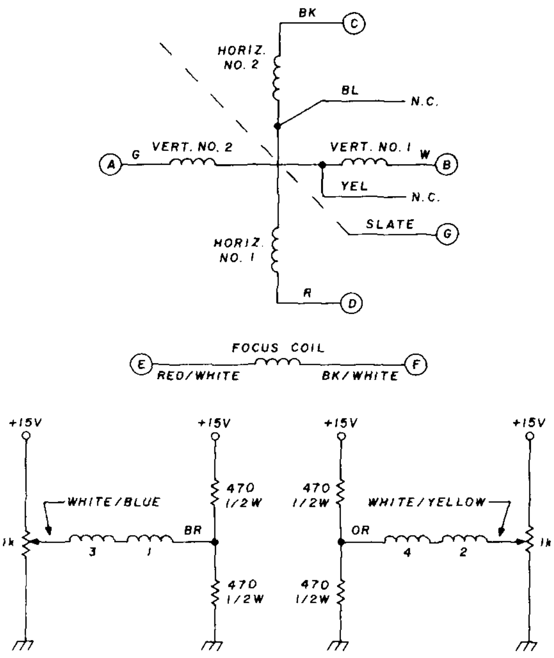


fig. 11. The upper diagrams show the lead identification colors for the Denson type 2045 yoke/focus coil assembly. After the focus coil has been rewound, the dc resistance should be approximately 250 ohms. R3, on the sweep generator board, can be reduced to about 1000 ohms when using this assembly to improve the shading. The circuits at the bottom should be used to power the electrical alignment coils. The components can be mounted on the circuit board connector socket in the frame of the camera. It is possible that in some extreme cases one of the 470-ohm resistors may have to be reduced to obtain the proper range.

tion, Q1 gets warm but never too hot to touch. If it does, either a secondary short exists or the transformer was improperly wound; too few turns on the primary will produce this problem. In a couple of cases I have found that the high voltage at pin 10 was low (about 400 volts) and Q1 ran very hot. I unwound the primary and, finding the proper number of turns, wound it back on with the same wire. When I checked, the voltage was up to 600 volts and Q1 was running cool. No explanations found — any suggestions? In any case, this could be a source of trouble. Also make sure the surfaces between the core halves are clean. My ears are sensitive to the 15 kHz whistle, so I found this early.

Next, plug in the sweep generator and connect all yoke/focus coil leads. Turn the power on and check for proper sawtooth waveforms at terminals A and C with an oscilloscope. Adjust R20 for approximately 1.4 volts p-p at terminal A (16 mA) and R43 for approximately 1.6 volts p-p at terminal C (162 mA) with the Denson 2045 assembly. Make sure the centering pots R10 and R32 are set to position the sawtooth waveform equally above and below zero. If either pot is adjusted to an extreme for an extended period of time, the output transistors will get very hot and may fail, so check this first! In normal operation Q8 will get very warm. A good check here is to place your finger directly on Q8. Count slowly to two. If you still have your finger on Q8, it is *not* too hot! This may be a crude test, but I like tests involving instruments that are handy (pun intended).

Now check the constant-current source supplying current to the focus coil. Set focus pot R60 to supply approximately 40 mA. This will produce a voltage drop of 0.4 volts across R59. Make sure that the focus coil's magnetic field polarity is correct by placing a compass at the outside of and at the image end of the focus coil. The north seeking pole must be *attracted* to the coil.

Finally, plug in the video processor and short the target lead to ground at C6 with a *very short* jumper. With a television monitor connected to the video output, vary R34. The monitor should have a blank raster that becomes lighter as the pot is rotated counter-clockwise. Remove the short at C6. By placing your hand near C6, herringbone patterns should occur, indicating that the processor is passing broadcast radio signals and is operating properly. If a vertical line is noticed near the center of the picture, it may be due either to improper grounding of the power supply or excessive pulse risetimes or the 15 kHz drive clock. If the latter is the case, a 0.01 μF capacitor *directly* across pins 7 and 8 of U19 on the sync generator will correct the problem. After all items have been checked, the camera is ready for the Vidicon and final testing.

final checks and calibration

Install the Vidicon in the camera. The short index pin should be oriented to position it at 9 o'clock when facing the camera. The Vidicon should be inserted into the yoke to a point where the tube face is approximately 1/2-inch (12.5mm) behind the lens. This dimension, however, is rough and final positioning will be necessary after the camera is operational. Apply power to the camera and perform the following steps:

1. Adjust the focus pot for +450 volts at the wiper.

2. When an image appears, adjust R60 on the sweep generator for proper magnetic focus. All electrical focusing should henceforth be done with the rear panel focus pot.

3. Rotate the yoke, if required, for proper picture orientation.

4. Adjust the centering pots. If either pot is rotated to its extreme, the round edge of the target will be seen. This can be used as a guide for proper centering along with proper positioning of the object being viewed (test pattern).

5. Adjust the horizontal and vertical size pots for correct image size. Note that *under* scanning the tube will produce a *larger* than normal picture. This is undesirable because resolution suffers, and if normal scanning is resumed a premanent burn line of the target will result.

6. With a picture in view, rotate R15 on the video processor clockwise until the picture "breaks up." Back off slightly and leave it there. In general, this pot increases the frequency response of the amplifier and a corresponding increase in resolution will occur until overcompensation is reached and oscillation takes place.

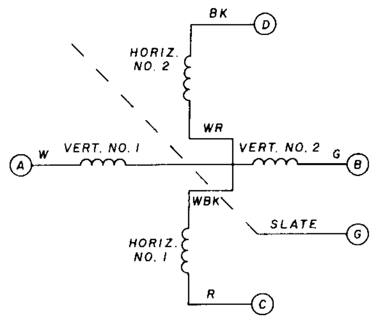
7. Next, rotate R14 (aperture) for no white tails following black-to-white transitions (pot fully counter-clockwise) or no black tails following black-to-white transitions (pot fully clockwise).

8. Finally, after all other items are satisfactory, the alignment magnets on the rear of the yoke should be adjusted to improve resolution and shading. These are *not* centering magnets and centering will possibly have to be touched up later. Rotate the focus pot on the rear panel. The image must not shift from the center position. Adjust these magnets until rotating the focus pot to each extreme produces a picture that rotates about an imaginary center axis as it goes through focus. No side-to-side or top-to-bottom shifts must take place.

conclusion

This television camera, although complex in some respects, is relatively easy to build and troubleshoot. A number of construction approaches were tried before settling on this one. Because many amateurs do not own a machine shop, as much of the design as possible takes advantage of standard workshop tools. This is not 100 per cent applicable, but I'm sure that alternate approaches, for the same result, with available tools will be devised. For this reason, I've gone into further detail than normally would be expected. The construction of this camera is not really as complex as it seems on the surface. Give it a try!

A number of extensions to this design are possible as discussed in the preceding text, and in most cases are limited only by your imagination. With a thorough understanding of this design, it is possible to produce a camera applicable to your situation. Because of the interlace quality, multi-camera control is possible (color anyone?). Portable operation, as mentioned earlier, is also possible because of the elimination of line-lock operation (how about mobile ATV?).



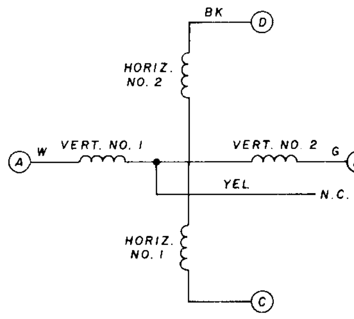


fig. 12. Connections for two additional yoke assemblies that have been tested in the camera. It is easier to mount a permanent magnet assembly on the 2047; it also has slightly better resolution capabilities than the 2013.

Before rushing to the workshop, or your local electronics store, re-read the article, understand the contents, and visualize your construction method. After all, you may already have most of the parts without realizing it. I will be happy to correspond with any individual about the existing design, construction difficulty, or improvements if a self-addressed, stamped envelope is enclosed with the correspondence. Good luck and happy construction!

references

1. William Neeland, "Function Generator has Variable Polarity Exponents," *Electronic Engineer*, January, 1971, page 44.
2. Jeremy M. C. Tucker, "A Signal Processing Circuit for a Black and White TV Camera," *Fairchild Semiconductor Application Brief 103*, Fairchild Semiconductor Corporation, Mountain view, California 94040, May, 1969.

bibliography

1. Eastman, Gerald A., *Measurement Techniques*, Tektronix, Inc., Beaverton, Oregon 97077, 1969.
2. Smith, John A., *Modern Operational Circuit Design*, John Wiley and Sons, New York, 1971.
3. *Reference Data for Radio Engineers*, 5th Edition, Howard Sams and Company, Indianapolis, 1968.
4. *Television Signal Analysis*, 2nd edition, American Telephone and Telegraph Company, April, 1963.

ham radio

The Drake MN-2000
Antenna Matching Network

A study in operator convenience

(or—how not to hang upside down behind your operating desk in order to disconnect your tuner from the line.)

FRONT PANEL SELECTION of key operating functions. No need to manually connect and disconnect the unit from the line for bypass applications.

FRONT PANEL SELECTION of up to three different antennas, or two antennas and a dummy load. The two may be selected in the matched or bypassed mode in each circuit with the flip of a switch.

FRONT PANEL SELECTION of forward or reflected rf power with a built-in precision wattmeter — not just a relative indicator.

This coax to coax 2kW tuner will tame VSWR up to 5:1 at any phase angle. If your 75 meter antenna is flat on ssb, but has high VSWR on cw, this could be just the answer.

Excellent for beams that exhibit a high VSWR on the opposite end of the band from where you set the elements.

The MN-2000 provides an additional 25 to 35 dB second harmonic attenuation which can help reduce TVI.

Covers 80-10 meter ham bands. Considering the built-in coax antenna switch, by-pass switch and rf wattmeter/VSWR bridge, the MN-2000 is a real value at $250.00.

To receive a FREE Copy of the new 1978 Drake Full Line Catalog, send name and date of this publication to:

R. L. DRAKE COMPANY DRAKE®

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

Western Service Center, 2020 Western Street, Las Vegas, Nevada 89102 · 702/382-9470

More Details? CHECK—OFF Page 142

microstrip transmission line

A discussion of
the operating parameters
of microstrip
transmission line
and how to calculate
its characteristic impedance
and propagation velocity

Printed electronic circuits were originally developed for military equipment manufactured during World War II; in the years following the war printed-circuit manufacturing techniques were developed which both improved reliability and reduced cost. While much of this development work was accomplished under the watchful eye of the military services, the television set manufacturers also played an important part — they were exploring every avenue that offered the possibility of lowering the production costs of their sets.

In 1949 Robert Barrett of the Air Force Cambridge Research Center proposed that printed-circuit techniques be adapted to uhf and microwave circuits by using flat coaxial configurations with an air or solid dielectric.[1] The only known use of this technique at that time was in an antenna power divider.

In the early 1950s several manufacturers began developing Barrett's original suggestion. Airborne Instrument Laboratories (AIL) developed a system using air dielectric which they called *stripline*;[2] ITT introduced a single ground plane, solid-dielectric strip transmission line called *microstrip*;[3] and Sanders Associates began investigating a dual ground plane, solid-dielectric arrangement that subsequently became known as *Tri-Plate* transmission line.[4] Since all three forms of strip transmission line supported the TEM mode of propagation, they had similar electrical characteristics. The major differences were in size, shielding, insertion loss, and ease of construction.

Many companies and research groups contributed to the advancement of strip transmission line techniques, and by 1955 a wide range of uhf and microwave components were in limited production. Multifunction assemblies were developed by several manufacturers which were made available commer-

By James R. Fisk, W1HR, Communications Technology, Greenville, New Hampshire 03048

cially; strip transmission line couplers were developed,[5] and multiple section lines were developed to increase the bandwidth of individual components such as directional couplers, hybrid rings, and filters.[6]

In addition to strip transmission line layout techniques, improvements were also made in dielectric materials. Early efforts produced only a few suitable dielectrics such as fiberglass, Rexolite, and Teflon. By the 1960s irradiated polyolefin, Teflon-fiberglass, beryllia, and a variety of other laminates provided a wide range of dielectric constants and operating temperatures.[7] Dielectric substrates such as quartz, alumina, sapphire, and magnesium titanate were developed later and have found wide use in microwave integrated circuits.

The Tri-Plate strip transmission line developed by Sanders Associates has been used extensively in directional couplers and other uhf and microwave circuits where shielding is required, while ITT's air-dielectric stripline has been used primarily in high-power circuits such as amateur vhf/uhf power amplifiers and vhf fm broadcast transmitters. Microstrip, on the other hand, is used widely from vhf through microwave — it has been employed in such diverse applications as frequency counters, broadband solid-state amateur vhf power amplifiers, uhf rat-race mixers, matching networks, antenna baluns, and phased antenna arrays for radar and satellite communications.

microstrip characteristics

A microstrip transmission line consists of a thin conducting strip placed on one side of a dielectric substrate which has a solid, conducting ground plane on the opposite side as shown in **fig. 1**. The substrate is usually a low-loss dielectric, but ferromagnetic and semiconductor materials have been used in some specialized applications.

The propagation characteristics of a strip transmis-

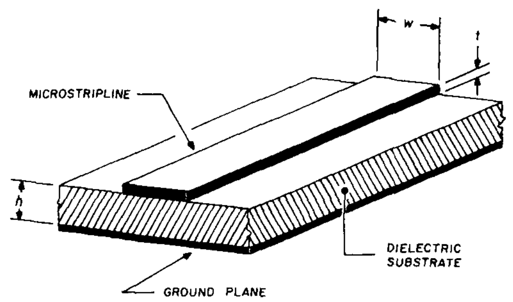


fig. 1. Microstrip transmission line consists of a thin conducting strip placed on one side of a dielectric substrate which has a ground plane on the opposite side. The characteristic impedance of microstrip is a function of the ratio of the strip width to dielectric thickness, w/h; t is the thickness of the conducting strip.

sion line are very similar to those of a coaxial transmission line, from which it evolved. The electric and magnetic field configuration of microstrip in **fig. 2** is the final stage in a progressive modification of the conventional coaxial line. The solid lines are used to indicate the electric field; the dashed lines, the magnetic field. Both are entirely in the transverse plane (at right angles to each other and at 90° to the direction of propagation), so this is called the transverse electro-magnetic or TEM mode.

In the Tri-Plate line (**fig. 2D**) the electric field is bounded entirely by the flat outer conductors and there is essentially no electric field component to the sides of the center strip. If the ratio of the outer conductor width is more than about three times the strip width, w, sidewalls are not required.

The two properties of microstrip of most importance to rf circuit designers are velocity of propagation (phase velocity) and characteristic impedance. Whereas the propagation of rf energy in coaxial lines and Tri-Plate line is purely in the TEM mode, in microstrip the field lines are not entirely contained in the substrate (**fig. 2E**). For this reason, the propagation mode in microstrip is called quasi-

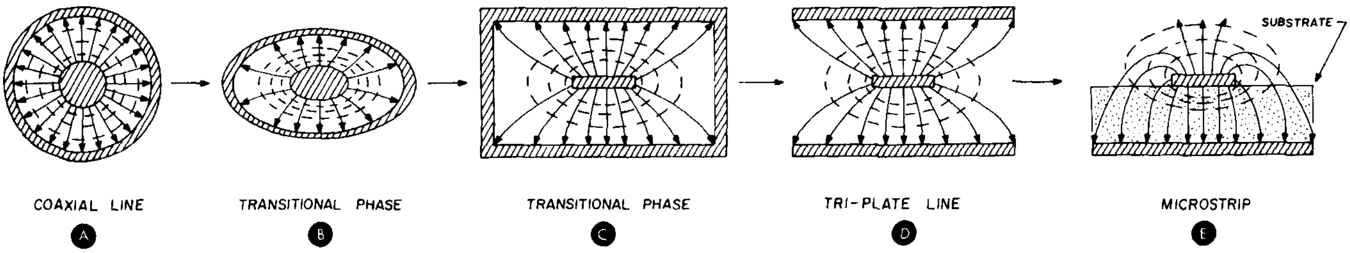


fig. 2. The propagation characteristics of microstrip (E) are very similar to coaxial line (A), from which it evolved. The solid lines indicate the electric field; dashed lines the magnetic field — both are in the transverse plane so this is the *T*ransverse *E*lectro-*M*agnetic or TEM mode. Since the microstrip field lines are not entirely within the substrate, propagation is not purely TEM but quasi-TEM (see text).

table 1. Characteristic impedance Z_o and propagation properties of microstrip etched on fiberglass-epoxy circuit board ($\epsilon_r = 4.8$) double clad with 1 ounce copper. The ratio w/h is microstrip width to dielectric height.

		microstrip width (1/32" or 0.8 mm board)		microstrip width (1/16" or 1.6 mm board)		
Z_o	w/h	mils	mm	mils	mm	v_p
10	14.93	422	10.7	887	22.5	0.481
15	9.35	264	6.7	556	14.1	0.490
20	6.59	186	4.7	392	10.0	0.498
25	4.96	139	3.5	295	7.5	0.505
30	3.89	109	2.8	230	5.8	0.510
35	3.13	87	2.2	185	4.7	0.516
40	2.56	71	1.8	152	3.9	0.520
45	2.13	59	1.5	126	3.2	0.524
50	1.79	49	1.2	105	2.7	0.528
55	1.52	41	1.04	89	2.3	0.532
60	1.30	35	0.88	75	1.9	0.535
65	1.11	30	0.76	64	1.6	0.538
70	0.955	25	0.64	54	1.4	0.541
75	0.823	21	0.53	46	1.2	0.544
80	0.711	18	0.46	40	1.02	0.546
85	0.614	15	0.38	34	0.86	0.548
90	0.532	13	0.33	29	0.74	0.550
95	0.460	11	0.28	25	0.61	0.552
100	0.399	9	0.23	21	0.54	0.553
105	0.346	7.6	0.20	18	0.46	0.555
110	0.299	6.4	0.16	15	0.39	0.556
115	0.260	5.2	0.13	13	0.33	0.557
120	0.225	4.3	0.11	11	0.28	0.559
125	0.195	3.4	0.09	9	0.23	0.560
130	0.169	2.8	0.069	7.6	0.20	0.561
135	0.147	—	—	6.5	0.17	0.562
140	0.127	—	—	5.4	0.14	0.563
145	0.111	—	—	4.5	0.11	0.564
150	0.096	—	—	3.7	0.09	0.565
155	0.0833	—	—	3.1	0.079	0.566
160	0.0723	—	—	2.5	0.064	0.567

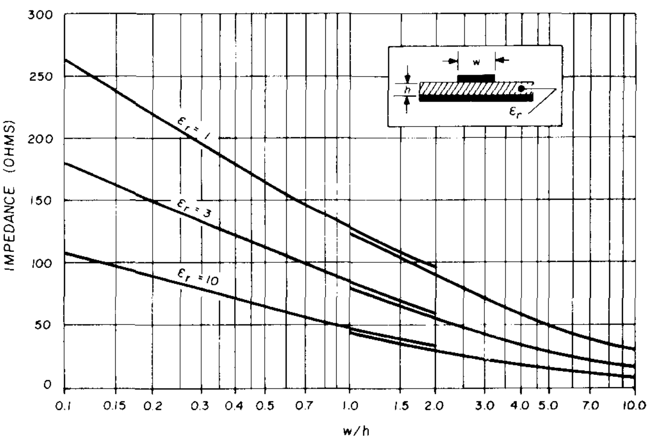


fig. 3. Characteristic impedance, Z_o, of microstrip vs the ratio w/h, as derived by Wheeler. Since the curves for wide strip don't intersect the curves for narrow strip, values which fall in the undefined region must be interpolated (w/h in the range between 1.0 and 2.0); many computer programs have been written to accomplish this task automatically, but Wheeler's microstrip equations are difficult for the amateur to use. The impedance curves plotted from the more recent microstrip design equations of Schneider, Sobol, Hammerstad, and others don't have any undefined areas.

TEM. Assuming the quasi-TEM mode, the velocity of propagation in microstrip is given by

$$v_p = \frac{c}{\sqrt{\epsilon_{eff}}} \quad (1)$$

where v_p is the velocity of propagation, c is the speed of light, and ϵ_{eff} is the effective dielectric constant of the substrate. The effective dielectric constant is always lower than the relative dielectric constant of the substrate, ϵ_r, because some of the field lines are outside the substrate.

The characteristic impedance of microstrip line, Z_o, is given by the familiar transmission line equations

$$Z_o = \frac{1}{v_p C} = v_p L \quad (2)$$

where v_p is the propagation velocity (**eq. 1**), C is the capacitance per unit length of line, and L is the inductance per unit length of line. Unfortunately, the calculation is not as simple as it may first appear because capacitance and inductance are both functions of microstrip geometry; and capacitance and

table 2. Characteristic impedance Z_o and propagation properties of microstrip etched on Teflon-fiberglass circuit board ($\epsilon_r = 2.55$) double clad with 1 ounce copper. The ratio w/h is microstrip width to dielectric height (see text).

		microstrip width (1/32″ or 0.8 mm board)		microstrip width (1/16″ or 1.6 mm board)		
Z_o	w/h	mils	mm	mils	mm	v_p
10	20.96	593	15.1	1246	31.6	0.646
15	13.27	375	9.5	789	20.0	0.654
20	9.47	267	6.8	563	14.3	0.661
25	7.21	203	5.2	429	10.9	0.667
30	5.72	161	4.1	340	8.6	0.672
35	4.66	131	3.3	277	7.0	0.676
40	3.88	109	2.8	231	5.9	0.681
45	3.28	92	2.3	195	5.0	0.685
50	2.80	78	2.0	166	4.2	0.688
55	2.42	67	1.7	143	3.6	0.691
60	2.10	58	1.5	124	3.1	0.694
65	1.84	51	1.3	107	2.7	0.697
70	1.61	44	1.1	95	2.4	0.700
75	1.42	39	1.0	83	2.1	0.702
80	1.26	34	0.86	73	1.8	0.705
85	1.12	30	0.79	64	1.6	0.707
90	0.991	26	0.66	57	1.4	0.709
95	0.882	23	0.60	51	1.3	0.711
100	0.785	20	0.51	45	1.1	0.713
105	0.700	18	0.45	39	1.00	0.714
110	0.625	16	0.40	35	0.89	0.716
115	0.558	14	0.35	31	0.78	0.717
120	0.498	12	0.31	27	0.69	0.718
125	0.445	11	0.27	24	0.61	0.720
130	0.398	9.2	0.23	21	0.54	0.721
135	0.356	8.0	0.20	19	0.48	0.722
140	0.318	7.0	0.18	17	0.42	0.723
145	0.285	6.0	0.15	15	0.37	0.724
150	0.254	5.1	0.13	13	0.32	0.725
155	0.228	4.4	0.11	11	0.28	0.726
160	0.204	3.7	0.094	10	0.25	0.727
165	0.182	3.1	0.078	8.5	0.21	0.727
170	0.163	2.6	0.066	7.3	0.19	0.728
175	0.146	–	–	6.5	0.17	0.729
180	0.131	–	–	5.6	0.14	0.730
185	0.117	–	–	4.8	0.12	0.730
190	0.105	–	–	4.2	0.11	0.731
195	0.094	–	–	3.6	0.09	0.732
200	0.937	–	–	3.1	0.08	0.732

propagation velocity are functions of the effective dielectric constant.

Early efforts to derive formulas for the characteristic impedance of microstrip were based on the quasi-TEM model, but there were serious difficulties. As pointed out in 1964 by Harold Wheeler, one of the first to derive practical microstrip design equations, "Because this was a problem in two-dimensional electric and magnetic fields, it was natural to apply the principles of . . . conformal mapping. The resulting formulas were usually so complicated that any practical utility resulted from simplified approximations for limited ranges of variables."[8] Later, Wheeler developed a set of approximate equations for microstrip and published design charts which were widely used by microwave designers.[9]

Although Wheeler published both analysis and synthesis equations,* the synthesis equations were apparently largely overlooked because most of the published articles which referred to Wheeler's work presented only the analysis equations. This meant that designers had to use lengthy, interactive trial-and-error solutions to determine the correct microstrip geometry for a required value of characteristic impedance.

One of the disadvantages of Wheeler's equations is that two different equations are required — one for

*Analysis equations give Z_o in terms of the ratio of strip width to substrate height, w/h; synthesis equations give w/h directly as a function of Z_o. Use of the analysis equation to find w/h requires ten or more iterations, a process that might require a half hour or more with a slide rule; it takes about a minute with the programmable HP-25 calculator — the synthesis equation provides an answer in less than 10 seconds.

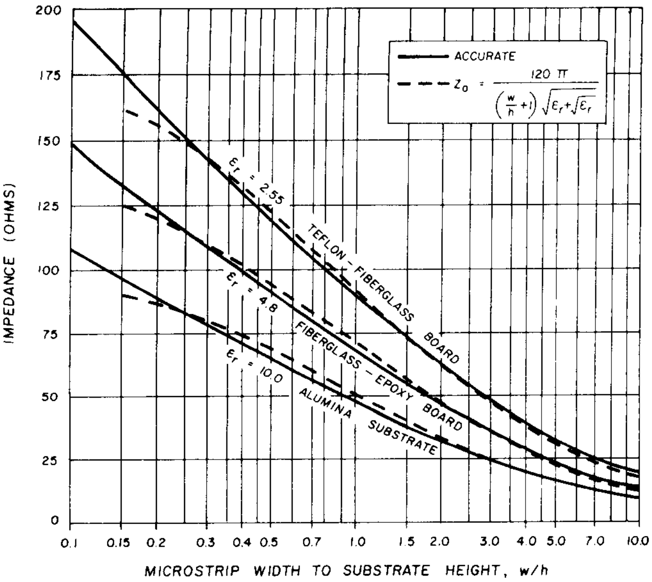


fig. 4. Plot of simplified microstrip equation derived by Fisk (eqs. 3 and 5), as compared to the more accurate expression of Hammerstad. For $w/h > 0.2$ and $\epsilon_r > 4.0$, the Fisk formula is accurate to within a few per cent.

wide strip ($w/h > 1$), and another for narrow strip ($w/h < 2$). Furthermore, the boundary between the two cases is not clearly defined, as shown in **fig. 3**, because the two curves don't intersect. Therefore, if the required w/h ratio falls in this undefined region, it's necessary to interpolate the correct value.

A few years after Wheeler's formulas were published, Schneider developed more explicit equations for the free-space characteristic impedance of microstrip and effective dielectric constant.[10] Like the Wheeler equations, two formulas are required; one for narrow microstrip and another for wide. Unlike Wheeler's work, however, curves plotted from the Schneider equations intersect, so there is no "indefinite region." Unfortunately, Schneider published only analysis equations, so synthesis of w/h for a desired Z_o required the lengthy iteration process.

In 1967 Dr. Harold Sobol fitted curves to Wheeler's analysis and published an expression for microstrip impedance which covered both narrow and wide lines.[11] This equation has been widely publicized in the literature, notably in application notes published by Motorola Semiconductor, and is the basis for many microstrip design charts. The Sobol formula is for analysis (Z_o from w/h), but many microwave designers have access to high-speed computers, and when synthesis is required, a computer can go through the necessary iterations very quickly; the single closed-form expression for both wide and narrow microstrip simplifies programming.*

Although a computer can go through the iterations quickly, programmable hand-held calculators cannot. N6TX has written an HP-25 program which provides acceptable accuracy for most amateur work, but his program begins at $w/h = 1$ and iterates out to the required value. Therefore, for high and low values of Z_o the required calculation may require a minute or more of successive iterations. To reduce the calculation time, I set about to develop a simple equation for the approximate value of w/h which could then be refined with Sobol's formula. My first try greatly reduced the calculation time for values of Z_o less than about 75 ohms ($\epsilon_r \approx 5$), but offered no improvement for higher impedance microstrip.[12] Further refinement of the approximate formula resulted in the following simple expression, which gives quite good accuracy for microstrip substrates used in most amateur work ($\epsilon_r > 3.0$)

$$w/h \approx \frac{120\pi}{Z_o\sqrt{\epsilon_r + \sqrt{\epsilon_r}}} - 1 \qquad \textbf{(3)}$$

For fiberglass-epoxy material ($\epsilon_r = 4.8$) this may be simplified to

$$w/h \approx \frac{142.6}{Z_o} - 1 \qquad \textbf{(4)}$$

As can be seen in **fig. 4**, for $w/h > 0.2$ this simplified expression for microstrip impedance is within a few per cent of the impedance calculated with more accurate equations. This covers the microstrip impedance range most commonly used in radio communications work. With fiberglass-epoxy board ($\epsilon_r = 4.8$), **eq. 3** is within about 1 ohm of the exact expression for all values of Z_o below 60 ohms. Accuracy falls off for $\epsilon_r < 3.0$, but is still acceptable for many applications.

When it's necessary to calculate Z_o from a given value of w/h, **eq. 3** can be rearranged to

$$Z_o \approx \frac{120\pi}{(w/h + 1)\sqrt{\epsilon_r + \sqrt{\epsilon_r}}} \qquad \textbf{(5)}$$

$$Z_o \approx \frac{142.6}{w/h + 1} \quad (\text{for } \epsilon_r = 4.8) \qquad \textbf{(6)}$$

The accuracy of this simplified equation is the same as that of **eq. 3** (i.e., within a few per cent for $w/h > 0.2$ and $\epsilon_r > 3.0$).

accurate impedance calculations

In 1975 E. O. Hammerstad reported to the European Microwave Conference that he had developed analysis *and synthesis* equations for microstrip which are more accurate than earlier work, and fall within 1 per cent of Wheeler's numerical results.[13] His formulas, which are based on the work of Wheeler and

*Other forms of microstrip design equations have been proposed by H. L. Clemm (*Frequenz* [Germany], July, 1968) and A. H. Kwon (*Microwave Journal*, January, 1976). Clemm's analysis equation is less accurate than Sobol's for high ϵ_r, and Kwon's equations, while purported to be *new*, are actually identical to those published by Wheeler in 1965.

Schneider, are considered to be the best available at the present time, and are shown here. First, the *analysis* equations:

For $w/h < 1$

$$Z_o = \frac{60}{\sqrt{\epsilon_{eff}}} \ln \left(8h/w + w/4h\right) \quad (7)$$

Where:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[\left(\frac{1}{\sqrt{1 + 12h/w}} \right) + 0.04\left(1 - w/h\right)^2 \right] \quad (8)$$

For $w/h > 1$

$$Z_o = \frac{120\pi / \sqrt{\epsilon_{eff}}}{w/h + 1.393 + 2/3 \ln \left(w/h + 1.444\right)} \quad (9)$$

Where:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(\frac{1}{\sqrt{1 + 12h/w}} \right) \quad (10)$$

Hammerstad's microstrip *synthesis* equations for w/h in terms of Z_o and ϵ_r are given below:

For $w/h < 2$

$$w/h = \frac{8e^A}{e^{2A} - 2} \quad (11)$$

For $w/h > 2$

$$\frac{w}{h} = \frac{2}{\pi} \left\{ B - 1 - \ln \left(2B - 1\right) + \frac{\epsilon_r - 1}{2\epsilon_r} \left[\ln \left(B - 1\right) + 0.39 - \frac{0.61}{\epsilon_r} \right] \right\} \quad (12)$$

Where:

$$A = \frac{Z_o}{60} \sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1} \left(0.23 + \frac{0.11}{\epsilon_r}\right)$$

$$B = \frac{377\pi}{2 Z_o \sqrt{\epsilon_r}}$$

Hammerstad notes that for $\epsilon_r < 16$, the maximum relative error is less than 0.5 per cent for $w/h > 0.5$; for $w/h < 20$ the stated error is less than 0.8 per cent.

Although these formulas may look formidable, they can be solved easily with a hand-held scientific calculator. These equations can also be quickly solved with programmable calculators — solutions with my HP-25 require less than 10 seconds (plus programming time, of course).* If you don't have a calculator, the graph of **fig. 5** shows how the ratio of

*Copies of the HP-25 programs will be sent to interested readers upon receipt of a self-addressed, stamped envelope. Send requests to *ham radio*, Greenville, New Hampshire 03048.

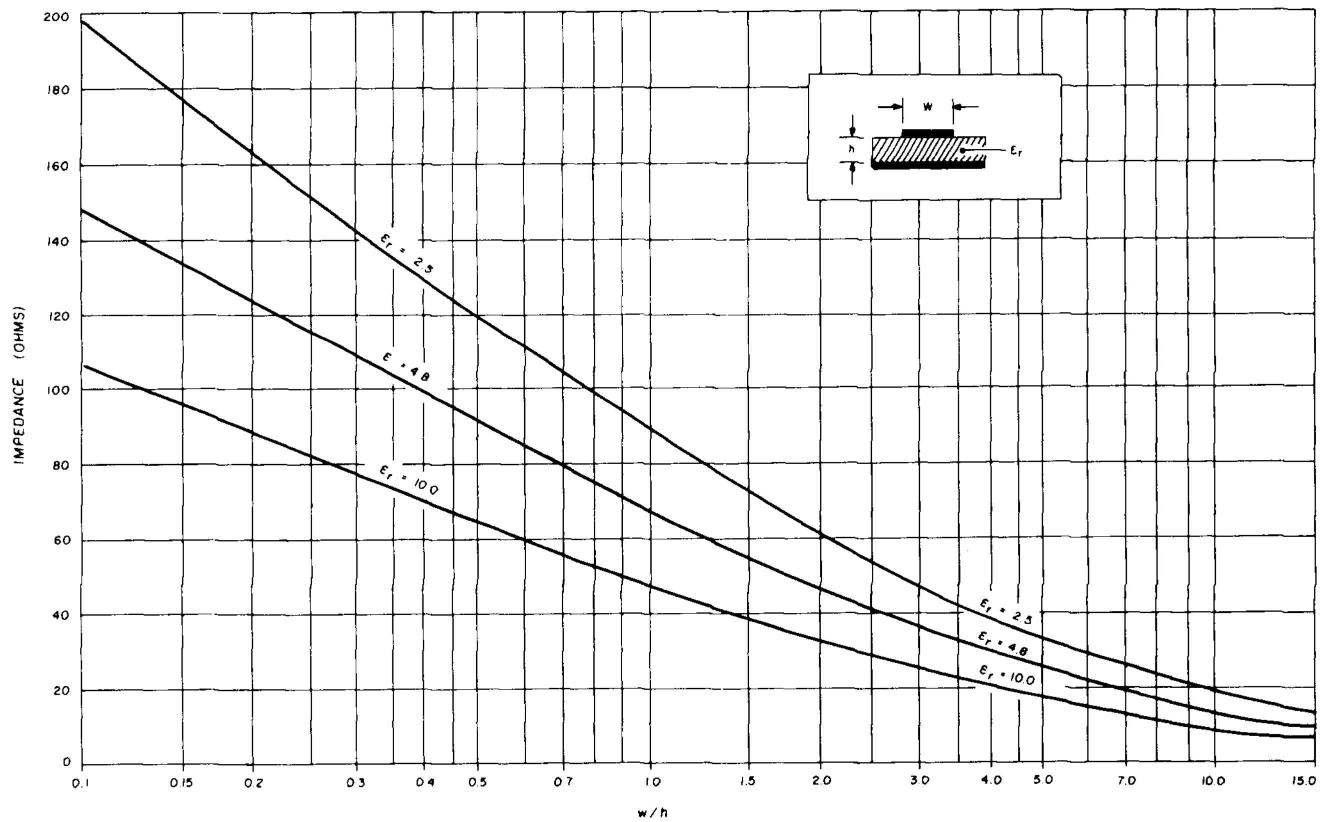


fig. 5. Characteristic impedance of microstrip as a function of w/h, plotted from the design equations derived by Hammerstad for glass-epoxy ($\epsilon_r = 4.8$), Teflon-epoxy ($\epsilon_r = 2.55$), and alumina ($\epsilon_r = 10.0$).

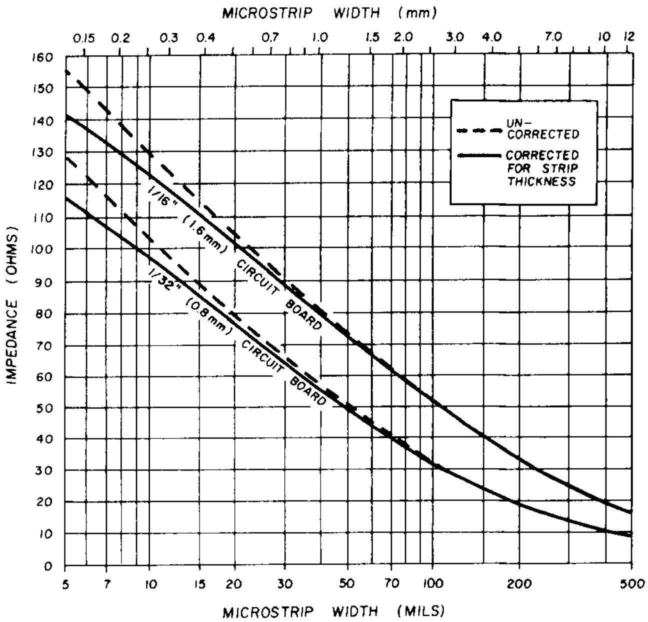


fig. 6. Effect of finite conductor thickness on microstrip impedance for 1/16" (1.6mm) and 1/32" (0.8mm) fiberglass-epoxy circuit board. In most applications the correction factor (eqs. 13 and 14) can be ignored for low impedance microstrip; at impedances above about 70 ohms the correction factor should be included in the impedance calculation.

strip width to dielectric thickness, w/h, affects the characteristic impedance of the line for fiberglass-epoxy circuit board ($\epsilon_r = 4.8$) and Teflon-fiberglass board ($\epsilon_r = 2.55$). These are the materials most often available for amateur work. For more precise results, **table 1** lists the required microstrip geometry for Z_o in 5-ohm steps.

effects of strip thickness

The microstrip impedance equations assume a two-dimensional microstrip with zero thickness. For very thin strips ($t/h < 0.005$) the experimental and theoretical results have been shown to be in excellent agreement.[14] For thicker strips, the effect of finite strip thickness can be compensated by slightly reducing the strip width as suggested by Wheeler.[9] In other words, the *effective* microstrip width, w_{eff}, is somewhat wider than the strip's physical width. The Hammerstad impedance formulas can be modified to consider the thickness of the strip by replacing strip width, w, with effective strip width calculated from the following relationships

For $\frac{w}{h} > \frac{1}{2\pi} = 0.16$

$$\frac{w_{eff}}{h} = \frac{w}{h} + \frac{t}{\pi h}\left(1 + \ln \frac{2h}{t}\right) \qquad (13)$$

For $\frac{w}{h} < \frac{1}{2\pi} = 0.16$

$$\frac{w_{eff}}{h} = \frac{w}{h} + \frac{t}{\pi h}\left(1 + \ln \frac{4\pi w}{t}\right) \qquad (14)$$

For microstrips with $w/h > 0.16$ etched on 1/16 inch (1.6mm) fiberglass-epoxy circuit board, double-clad with 1-ounce copper ($t = 35.6$ microns or 0.0014 inch), the correction factor Δw is 0.041 (i.e., $w_{eff} = w + 0.041$); for 1/32 inch (0.8mm) circuit board the correction factor Δw is 0.074. For very thin microstrip ($w/h > 0.16$), the width correction is somewhat greater; it also varies with strip width so must be calculated separately for each different width.

Except for very precise work where photo-etching techniques are used and etching is carefully controlled, the width correction factor may be ignored for low-impedance microstrip etched on common copper-clad board. For impedances above about 70 ohms, however, the effect of strip thickness should be considered (see **fig. 6**); at impedances greater than 100 ohms the 1.4 mil (35 micron) conductor thickness reduces the characteristic impedance by as much as 10 ohms. (Note that the strip widths given in **tables 1** and **2** have been compensated for strip thickness.)

microstrip materials

Of the many materials used in commercial microstrip circuits, fiberglass-epoxy (G-10) circuit board is the one available to most amateurs. Professional designers shy away from G-10 board at frequencies above 200 or 300 MHz, but amateurs have used it quite successfully in low-power circuits up to 1300 MHz. The losses of G-10 increase substantially above 1300 MHz, however, so more expensive Teflon-fiberglass board should be used for microstrip circuits designed for 2300-MHz and the higher amateur bands.

In addition to its loss, microscopic air pockets in the fiberglass-epoxy cause small changes in dielectric constant which can be troublesome in precision circuits. Some users have reported that the characteristics of G-10 tend to vary widely from one manufacturer to another, but this problem is not confined to G-10 — similar problems have been reported for Teflon-fiberglass and alumina.[15] One commercial user I have talked to buys his substrate materials from one supplier, and then purchases material only in batch lots to ensure consistency.

Fiberglass-epoxy circuit board, copper-clad on both sides with 1 or 2 ounce copper, can be obtained from many supply houses in thicknesses of 1/32 inch (0.8mm) and 1/16 inch (1.6mm). This material is also manufactured in 1/8 inch (3.2mm) and 1/64 inch

(0.4mm) thicknesses, but it's usually available only on special order. Note that the specified thickness is the overall dimension and includes the copper foil. One-ounce copper* is 1.4 mils (0.0014 inch or 36 microns) thick; therefore, the dielectric thickness of a double-clad 1/16 inch (62.5 mils or 1.6mm) board is 59.7 mils (1.5mm) $[62.5-2(1.4)]$. This is the h dimension shown in **fig. 1**. To find the required microstrip width, simply multiply w/h times the dielectric height h.

For example, assume you need a 75-ohm microstrip. From **table 1**, for 1/16 inch (1.6mm) fiberglass-epoxy board, $w/h=0.823$ for $Z_o=75$ ohms. Therefore, the required microstrip width (not including the correction factor for finite strip thickness) is

$$w = 0.823 \cdot 59.7 = 49.1 \text{ mils}$$

(about 0.049 inch or 1.3mm)

The dielectric thickness of 1/32 inch (31.25 mils or 0.8mm) board, double clad with 1 ounce copper, is 28.45 mils (0.7mm). Therefore, the microstrip width will be a little less than half that of the same impedance line on 1/16 inch (1.6mm) board — 23.4 mils or 6mm for a 75-ohm microstrip.

*Called 1-ounce copper because one square foot of foil weighs 1 ounce.

Most samples of fiberglass-epoxy circuit board which I've measured with a micrometer have been very close to the specified thickness; I've seldom found circuit-board material so far off that it would seriously affect microstrip width. If you want to make this measurement yourself, carefully strip back the copper foil from a corner of a sample and measure the thickness of the dielectric — this is the critical dimension.

You may also want to check the relative dielectric constant of the board you're going to use. This can be easily done by measuring the capacitance of a carefully cut section of circuit board. The relative dielectric constant is calculated by rewriting the well known formula for parallel plate capacitors with ϵ_r as the unknown

$$\epsilon_r = \frac{C\,h}{0.8842\ A}$$

where C is the capacitance in pF, h is the dielectric thickness in mm, and A is the area in square centimeters. For dimensions in inches the formula is

$$\epsilon_r = \frac{C\,h}{224.4\ A}$$

where C is the capacitance in pF, h is dielectric thickness in mils, and A is the area in square inches. For example, the capacitance of a 1 inch square

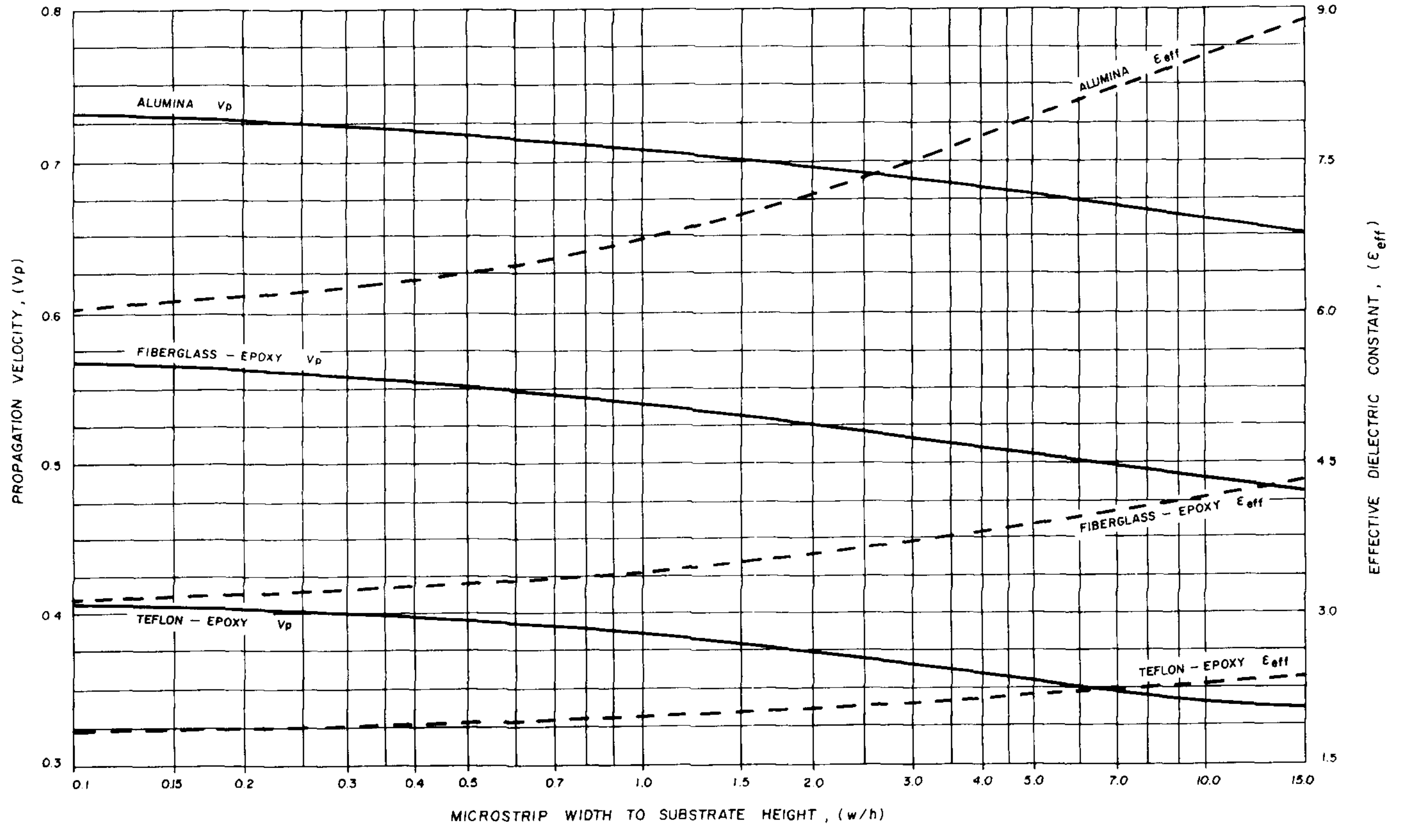


fig. 7. Propagation velocity, v_p (solid lines), and effective dielectric constant, ϵ_{eff} (dashed lines), as a function of the ratio of microstrip width to substrate thickness, w/h, for fiberglass-epoxy ($\epsilon_r=4.8$), Teflon-epoxy ($\epsilon_r=2.55$), and alumina ($\epsilon_r=10.0$).

($6.5 cm^2$) of 1/16 inch (1.6mm) board, double clad with 1 ounce copper, should be about 18 pF for $\epsilon_r = 4.8$. Note, however, that the relative dielectric constant of most materials decreases with increasing frequency. This means your low-frequency capacitance measurement may indicate a dielectric constant between 5.0 and 5.5. If the capacitance of the 1-inch square ($6.5 cm^2$) sample is between 19 and 21 pF, ϵ_r will be approximately 4.8 at the vhf and uhf frequencies.

One of the advantages of Teflon-fiberglass circuit board, other than its lower loss, is that physical microstrip width and electrical length are larger than substrates with higher dielectric constants. This is very useful at microwave frequencies where high impedance (narrow microstrip) and fractional wavelength lines are required. On the other hand, substrates with higher dielectric constants such as alumina ($\epsilon_r = 10$) are used extensively in microwave ICs where miniaturization is important.*

microstrip phase velocity

In addition to the characteristic impedance of microstrip, phase velocity is the one other property of major importance in vhf and uhf designs where precise electrical lengths are needed for impedance matching or other circuit requirements. As was shown in **eq. 1**, the phase velocity, v_p, is given by

$$v_p = \frac{c}{\sqrt{\epsilon_{eff}}}$$

where c is the speed of light and ϵ_{eff} is the effective dielectric constant. This may be rewritten to give microstrip wavelength, λ_g, as a function of free-space wavelength, λ_o

$$\lambda_g = v_p \, \lambda_o = \frac{\lambda_o}{\sqrt{\epsilon_{eff}}} \qquad \textbf{(15)}$$

where the free-space wavelength, λ_o, can be found from

$$\lambda_o = \frac{29980}{f_{MHz}} \; (cm) \qquad \textbf{(16)}$$

$$\lambda_o = \frac{11803}{f_{MHz}} \; (inches) \qquad \textbf{(17)}$$

The velocity factor, v_p, which is a function of w/h, is given in **tables 1** and **2**.

Example. Assume you need a 75-ohm quarter-wavelength matching transformer at 432.1 MHz; your circuit is to be built on fiberglass-epoxy circuit board ($\epsilon_r = 4.8$). From **table 1**, w/h for 75 ohms is 0.823; $v_p = 0.544$. A free-space quarter-wavelength at 432.1 MHz is

$$\frac{\lambda_o}{4} = \frac{29980}{4 \cdot 432.1} = 17.35 \; cm \; (6.83 \; inches)$$

Therefore $\dfrac{\lambda_g}{4} = 0.544 \cdot 17.35 = 9.44 \; cm$

If you use the Hammerstad equations to calculate the required microstrip geometry for a given value of characteristic impedance, ϵ_{eff} can be calculated accurately with either **eq. 8** (narrow microstrip) or **eq. 10** (wide microstrip). These same expressions can also be employed if you use the simplified formulas (**eqs. 3** and **5**), but there's a simpler way if you're not doing precision microstrip work.

The following formula, which was derived from the work of Wheeler and Schneider, is somewhat easier to use than the Hammerstad expressions, covers the entire range of microstrip widths, and gives good accuracy for practical work.

$$\epsilon_{eff} = 1 + (\epsilon - 1)\left[\frac{1}{2}\left(1 + \frac{1}{\sqrt{1 + \frac{10}{w/h}}}\right)\right] \qquad \textbf{(18)}$$

Consider the previous example where a 75-ohm quarter-wavelength matching transformer was required at 432.1 MHz. Using the simplified formula (**eq. 3**) to calculate w/h

$$w/h = \frac{142.6}{75} - 1 = 0.90$$

From **eq. 18**

$$\epsilon_{eff} = 1 + (3.8)\left[\frac{1}{2}\left(1 + \frac{1}{\sqrt{1 + \frac{10}{0.9}}}\right)\right] = 3.446$$

$$\sqrt{\epsilon_{eff}} = \sqrt{3.446} = 1.856$$

$$v_p = \frac{1}{1.856} = 0.54$$

$$\frac{\lambda_g}{4} = 0.54 \cdot 17.35 = 9.37 \; cm$$

The small length difference of 0.7mm (0.028 inch) will make no practical difference in circuit operation; and don't be concerned with what appears to be a large discrepancy between w/h calculated with the simple formula, and the accurate value of w/h from **table 1**. The actual difference in strip width on 1/16 inch (1.6mm) circuit board is only about 0.004 inch

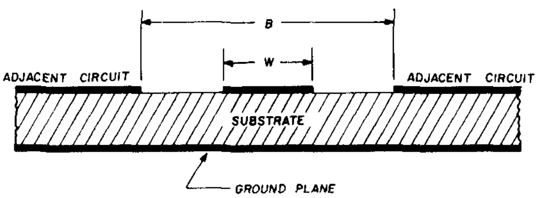
*A new microstrip substrate has been announced by the 3M Company. Called *Epsilam-10*, it's based on a ceramic-filled Teflon material and has the electrical properties of alumina, but can be cut with a razor blade or shear and may be etched like any other printed circuit.

(115 microns). Unless you are using photo-reduction techniques and carefully control both etchant temperature and etching time, you can't maintain this accuracy in your home workshop.

practical considerations

Theoretically, you can design a microstrip line for any desired characteristic impedance, but at very high values of Z_0 the conducting strip becomes so narrow that it's impossible to compensate for the effect of finite strip thickness. With a strip width of 1.4 mils (36 microns) on 1 ounce copper, for example, the microstrip is actually square; the impedance of a zero-thickness conductor of this width is about 200 ohms — the impedance of the rectangular conductor is 173 ohms or less; it can't be calculated directly (the width correction factor, **eq. 14**, is not accurate for strip widths less than 2.8 mils or 71 microns etched on 1 ounce copper).

Conversely, at very low values of Z_0 the microstrip becomes so wide the rf current isn't distributed evenly across the conductor, so it's impossible to accurately predict performance. In addition, it's difficult to prevent coupling to nearby circuitry. For microstrip impedances up to about 50 ohms, other nearby circuit traces should be spaced a minimum of one microstrip width away (i.e., in the illustration below dimension B should be a minimum of three times the strip width). *Depending on the application and the* required circuit density, this places a lower limit on Z_0 at about 10 ohms. Note that dimension B should be about 10 times the microstrip width for impedances above 50 ohms.



Also to be considered are the effects of placing the microstrip circuit in a metal enclosure. Experimental work has shown that a conducting enclosure tends to lower both the impedance and effective dielectric constant because the field lines are prematurely terminated, thereby increasing the density of the field lines in air. When the distance between the upper and lower walls is greater than five times the substrate thickness, and when side-wall spacing is five times the strip width or more, effects on microstrip characteristics are negligible.

It's not important for most amateur applications, but it should be mentioned that the formulas and tables for Z_0 and ϵ_r presented in this article are valid only to about 4000 MHz. Above 4000 MHz both Z_0 and ϵ_r begin to change with frequency due to the propagation of hybrid modes. This has been discussed in the engineering literature by a number of researchers; interested readers are referred to references 16 and 17.

conclusion

Microstrip transmission line is being used in many applications at vhf and uhf. Although microstrip is a relatively low Q transmission line and has greater losses than air-spaced coaxial or troughline structures, it provides excellent performance in many low-power circuits — indeed, there are some circuits which would be impractical to duplicate in the home workshop without the use of microstrip.

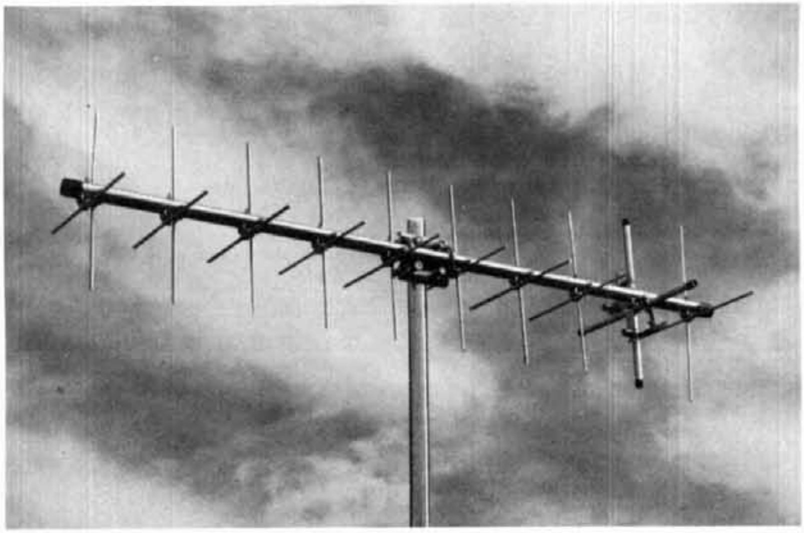
The design of microstrip circuits is the same as that for more conventional transmission-line circuits; if there is sufficient reader interest this will be the subject of a future article.

references

1. R. M. Barrett, "Microwave Printed Circuits — An Historical Survey," *IRE Transactions on Microwave Theory and Techniques*, MTT-3, March, 1955, page 1.
2. H. S. Keen, "Scientific Report on the Study of Strip Transmission Line," AIL Report 2830-2, December, 1955.
3. D. D. Grieg and H. F. Engelmann, "Microstrip — A New Transmission Technique for the Kilomegacycle Range," *Proceedings of the IRE*, December, 1952, page 1644.
4. N. R. Wild et al, *Handbook of Tri-Plate Microwave Components*, Sanders Associates, Inc., Nashua, New Hampshire, 1956, ASTIA no. AD110157.
5. S. B. Cohn, "Shielded Coupled-Strip Transmission Line," *IRE Transactions on Microwave Theory and Techniques*, MTT-3, October, 1955, page 29.
6. G. Matthaei et al, *Microwave Filters, Impedance-Matching Networks, and Filters*, McGraw-Hill, New York, 1964.
7. D. R. Ayer and C. A. Wheeler, "The Evolution of Strip Transmission Line," *The Microwave Journal*, May, 1969, page 31.
8. H. A. Wheeler, "Transmission-Line Properties of Parallel-Wide Strips by a Conformal-Mapping Approximation," *IEEE Transactions on Microwave Theory and Techniques*, May, 1964, page 280.
9. H. A. Wheeler, "Transmission-Line Properties of Parallel Strips Separated by a Dielectric Sheet," *IEEE Transactions on Microwave Theory and Techniques*, March, 1965, page 172.
10. M. V. Schneider, "Microstrip Lines for Microwave Integrated Circuits," *Bell System Technical Journal*, May-June, 1969, page 1421.
11. H. Sobol, "Extending IC Technology to Microwave Equipment," *Electronics*, March 20, 1967, page 112.
12. J. R. Fisk, W1HR, "Simple Formula for Microstrip Impedance," *ham radio*, December, 1977, page 72.
13. E. O. Hammerstad, "Equations for Microstrip Circuit Design," *Proceedings of the European Microwave Conference*, Hamburg (Germany), September, 1975, page 268.
14. M. A. R. Gunston and J. R. Weale, "Variation of Microstrip Impedance with Strip Thickness," *Electronic Letters*, December 27, 1969, page 697.
15. S. Hagelin and L. Wernlund, "Properties of Microstrip Transmission Lines," Swedish Research Institute of National Defense Report C3769-E2, June, 1974, page 60.
16. W. J. Getsinger, "Microstrip Dispersion Model," *IEEE Transactions on Microwave Theory and Techniques*, January, 1973, page 34.
17. R. P. Owens, "Predicted Frequency Dependence of Microstrip Characteristic Impedance Using the Planar-Waveguide Model," *Electronic Letters*, May 27, 1976, page 269.

ham radio

2 METERS...

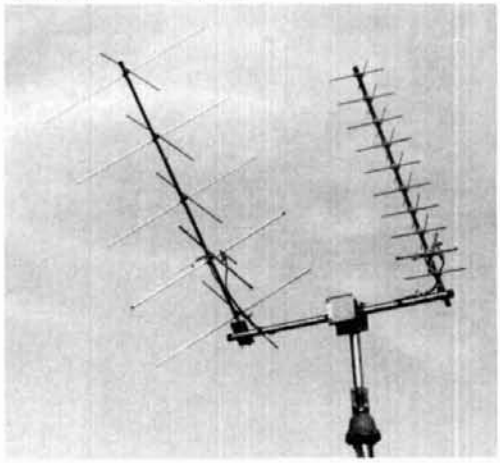


. . . *Alive* with activity at *both* ends of the band! Be a part of the total 2 Meter picture with the Cush Craft Twist Antenna. Actually two, easily assembled, 10 element yagis in one — the vertical elements are cut for the high end, the horizontal elements for the low end, and separate feed lines are used. The A147-20T is tailored to meet the demands of the operator who enjoys the best of both worlds — FM and SSB/CW.

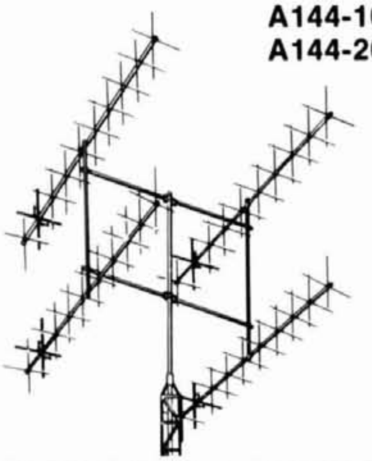
A147-20T $54.95

CQ OSCAR .... ..

. . . *Extend your horizon* — Explore the exciting new world of amateur satellite communications using low power with our multi-polarized Twist Antennas. All models include phasing harness for selectable linear or right/left circular polarization. Two of these Twists may be mounted on the A14T-MB mounting boom which is complete with a pre-drilled plate for a readily available mast-through rotator. *Face this challenging frontier — Become a Specialist!*



A144-10T $34.95
A144-20T $54.95
A432-20T $49.95
A14T-MB $15.95



PERFORMANCE ARRAYS . . .

Enjoy fade-free contacts on VHF/UHF with Twist Antennas and Arrays. Excellent for scatter and other long-haul techniques. Double your effective radiated power by stacking two Twists, or quadruple ERP by stacking four Twists. Arrays are easily assembled for your special communications requirement. Write for stacking and phasing harness details concerning amateur and commercial frequencies.

Dependable communications — *Now Yours!*

SPECIFICATIONS

Model	A147-20T	A144-10T	A144-20T	A432-20T
Center Freq. (MHz)	144.5/146.5	145.9	145.9	432
No. Elements	10/10	10	20	20
Weight (lbs.)	6	3.5	6	3.5
Wind Surf. Area (ft.²)	1.42	.74	1.42	.37
Mounting	Center	Rear	Center	Rear
Dimensions (Inches)	40x40x140	40x40x70	40x40x140	14x14x57

IN STOCK WITH DISTRIBUTORS WORLDWIDE

cushcraft

THE ANTENNA COMPANY

P.O. BOX 4680, MANCHESTER, N.H. 03108

More Details? CHECK — OFF Page 142

microwave path evaluation

How to plot line-of-sight microwave paths under varying propagation conditions to determine if the path is clear

Interest in amateur microwave radio seems to be at an all time high. Amateurs in the United Kingdom recently set a new 10-GHz DX record of 324 miles (521km) and with the recent introduction of inexpensive Gunn diode transceivers, equipment availability has never been better.[1]

The communications capabilities of microwave equipment now within easy reach of the average amateur are initially rather astounding to the commercial microwave user. The difference is, of course, the luxury of working with 0 dB fade margins (on DX paths) and substantially narrower bandwidths. Those two factors allow far greater working range with a given power output.

One area of concern to both amateur and professional is proper path clearance. Since obstacles along the path introduce loss, a signal should clear path obstacles, either optically or effectively through beam bending.

This article reviews the essential information an amateur will need to evaluate a potential microwave path before trying it. The information will be useful to both microwave DX enthusiasts and to those who wish to install permanent microwave links for repeater control or other purposes.

distance and azimuth

For the short distances involved in nearly all microwave paths, great-circle formulas are normally not used to calculate distance and azimuth. This is because these formulas assume a perfect spherical model of the earth when, in fact, the earth's surface is oblate. In addition, it is difficult on very short paths with small differences in latitude and longitude to achieve the necessary degree of trigonometric function accuracy. The usual method used for short microwave paths up to about 300 miles (482km) is to first determine the number of miles per degree of latitude and longitude in the vicinity of the path, and then use a plane right triangle to determine the distance and azimuth.

By incorporating a table of these distances into linear regression formulas, it is possible to devise equations which allow you to dispense with the tables, within certain limits. The regression-derived

By Dennis L. Haarsager, N7DH, 483 South Walnut, Boise, Idaho 83706

formula for the length of the horizontal portion of the triangle is*

$$H = (0.004009m + 69.108348)(\cos m)(h) \qquad (1)$$

and for the vertical part of the triangle

$$V = (0.011993m + 68.513612)(v) \qquad (2)$$

The distance along the path is given by

$$D = \sqrt{H^2 + V^2} \qquad (3)$$

where m = the arithmetic average of the two latitudes
v = the difference between the two latitudes
h = the difference between the two longitudes

It is easiest to perform the arithmetic if minutes and seconds are converted to decimal degrees before performing the mathematical operations. These regression equations are normalized for latitudes between 25°N and 60°N.

To find the azimuth, use **equation 4**

$$A = \arctan V/H \qquad (4)$$

Note that A will be positive in the second and fourth quadrants, and negative in the first and third quadrants. Add this angle algebraically to 90° if the destination is east of the starting point, and 270° if the destination is west of the starting point. The result will be the azimuth of the destination in degrees east of north from the starting point. A bit of ingenuity on your part will enable you to incorporate angle A (not the azimuth) into a procedure for finding intersecting points on map edges where you need to use two or more maps to draft your path profile.

map usage

An essential step in path evaluation is drafting a vertical profile of the path. Use standard graph paper that has at least 10 squares to the inch or, better yet, millimeter divisions. Choose vertical and horizontal scales which will enable you to conveniently plot the range of your path elevations and distance. The smaller the scale you choose, the better the resolution will be.

For rough initial path evaluation, especially in hilly or mountainous areas, the 1:250,000 scale topographic maps published by the United States Geological Survey (USGS) are adequate. Final evaluation of potential obstruction points requires use of the USGS's 7.5- or 15-minute series quadrangle maps. The latter are available for most areas in the United States. Maps and map indexes are available at nominal prices from private map dealers, from USGS sales counters in major cities, or by mail order from certain USGS offices.*

Another source of topographical maps, although they are less useful for plotting microwave paths, is your local airport's private aviation flight shop; they sell Sectional and World Aeronautical Charts (1:500,000 and 1:1,000,000 scales, respectively) published by the National Oceanic and Atmospheric Administration. The scale of these maps is too large for accurate microwave path profiles, but significant changes in elevation are shaded on these maps, making them useful for identification of possible DX paths.

In making a path profile, assume the earth is flat and choose some arbitrary elevation — normally the lowest one along your path — as the base elevation for your profile. Enter it on the bottom of your graph paper and add elevation indicators from there according to your vertical scale as illustrated in **fig. 1**.

The next step is to draw a line between the two points which define your path on the map or maps you are using. In most cases you will need to use

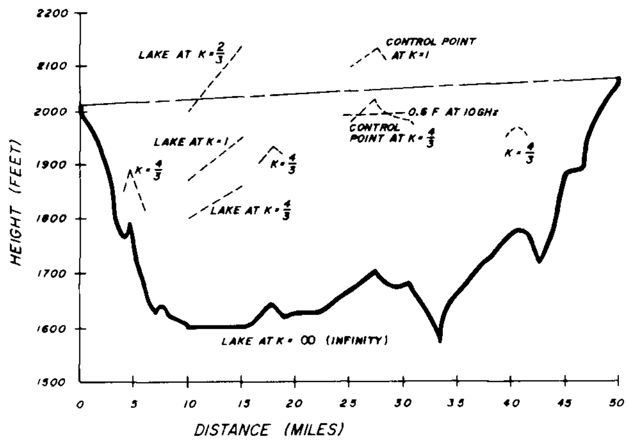


fig. 1. Simple microwave path evaluation between two sites 50 miles (80km) apart. The dashed lines show the effects of different values of K, a factor which indicates the earth's effective radius and results from varying degrees of refraction (see text).

more than one map to cover your path. You may either tape adjoining map sections together or determine where your line intersects map edges by application of the angle A and **eqs. 1** through **4**. It will be very important to the mathematical procedure to determine the latitude and longitude of the two end points as close as you can. Use the smallest scale maps available for this determination. Carefully

*To convert the results of **eqs. 1**, **2**, and **3** to kilometers, multiply by 1.609344.

*For maps of areas east of the Mississippi write to the USGS at 1200 South Eads Street, Arlington, Virginia 22202; for areas west of the Mississippi, including all of Louisiana and Minnesota, write to USGS c/o Federal Center, Denver, Colorado 80225.

transfer elevations shown on the maps to the appropriate distances on your profile.

Once the path profile is constructed, it will be necessary to add a correction factor on top of the plotted terrain to allow for the curvature of the earth. This is a bit more complicated than it sounds because the *effective* curvature of the earth changes with varying atmospheric conditions.

Most amateurs are familiar with something called the "4/3 radio horizon," but it is less well known that this horizon is different in different geographical areas, at different times of the day and year, and at different elevations.

The amount and direction of bending or refraction of a radio beam is dependent upon several atmospheric variables. A factor called K is used to indicate the effective earth's radius which results from these varying degrees of refraction. On a *grazing* path, that is, on a path where the microwave beam just barely clears an obstruction, small changes in K can make or break the path for communications by "moving" that obstruction in and out of the beam path.

The K factor is determined by how much another variable, the radio refractivity index, changes over a given change in altitude. The radio refractivity index is normally designated as N and is calculated from pressure, temperature, and water vapor data. When N decreases by 40 units with a one kilometer increase in altitude (the so-called *standard atmosphere*) K equals 4/3. When N decreases by more than 40 units per kilometer, the earth effectively flattens. At -157 N units/km, K equals infinity and the earth is effectively flat. When N decreases by more than -157 N units/km, K adopts a negative value and the earth becomes effectively concave. Such extreme conditions are called *superrefractive*.

Under certain atmospheric conditions the index decreases by less than 40 N units/km or even increases with increasing altitude. Under these conditions the earth's effective radius decreases (as measured by K) and path obstructions are effectively higher. When the atmosphere is homogenous, N remains constant over the 1-km range and K equals unity. In this case, there is no refraction and the effective earth's radius is the same as the true earth's radius. During a humidity inversion, N can increase by over 200 N units/km and K is reduced to less than 1/2. Such extreme conditions are called *subrefractive*.[2]

table 1. Average K values for different localities and atmospheric conditions (adapted from reference 3).

K	description
1.17	Normal K for light refraction; radio refraction in dry, mountainous areas above 7500 feet (2290 meters) elevation
1.20	Dry mountainous areas between 5000 and 7500 feet (1525 to 2290 meters)
1.25	Dry mountainous areas up to 5000 feet (1525 meters)
1.30	Inland plains during winter
1.34	Standard atmosphere K
1.50	Inland plains and northern coastal areas during summer; southern coastal areas during winter
1.60	Southern coastal areas during summer
1.75	Extreme southern coastal areas during summer

The amateur microwave DX enthusiast will be most interested in typical values of K for the path in use. The values for K given in **table 1** will suffice for this purpose.[3] These values of K should be used in **eq. 5** to determine the earth's effective bulge.*

$$B = d_1 d_2 / 1.5K \qquad \textbf{(5)}$$

where: B = earth's effective bulge in feet
d_1 = distance from starting point to test point in miles
d_2 = distance from test point to destination in miles

This earth bulge should be added on top of the point you are testing for an obstruction as shown in **fig. 1**. Amateurs interested in establishing permanent microwave links should add an amount for earth bulge at $K = 1$ to allow for adverse propagation conditions at certain times.[4]

other clearance requirements

In evaluating the path profile, an allowance should be made for any trees or buildings known to be at the *control point*. That's the point along the path which gives the least vertical clearance for the microwave beam. Consideration should also be given to these non-terrain obstructions for points close in elevation to the control point.

Finally, an allowance should be made for the space taken up by the microwave beam itself. Without going too deeply into wave theory, every radio beam is composed of concentric Fresnel (pronounced *fray-NEL*) zones. The first Fresnel zone is defined by a grouping of points representing *all* possible paths which are one-half wavelength longer than a straight line between transmitter and receiver.[5] If it were possible to view these points from the side of the path they would represent a cigar-shaped ellipse. The width of a Fresnel zone is therefore greater in the middle of a path than at the ends. To avoid obstruction loss, it is necessary to have a beam clearance equal to at least 0.6 first Fresnel zone radius over the

*In metric form, **eq. 5** is

$$B = d_1 d_2 / 12.75\,K$$

where B is in meters, and d_1 and d_2 are in kilometers.

potential control point (terrain + earth's bulge + trees or buildings). The formula for this Fresnel zone clearance is given as*

$$0.6F_1 = 43.25\sqrt{d_1 d_2/Df} \qquad \textbf{(6)}$$

where $0.6F_1$ = 0.6 first Fresnel zone radius in feet
D = path length in miles
f = frequency in GHz
d_1, d_2 are defined in **eq. 1**

To plot this additional clearance draw a straight line from the antenna elevations at both the starting (transmitting) and destination (receiving) points. The Fresnel zone clearance is then added below this line as shown in **fig. 1**. If there is 0.6 first Fresnel zone radius clearance over your obstruction at the normal K for your area, you will have near free space conditions over the path most of the time. If there is 0.6 first Fresnel zone radius over $K = 1$ (true earth curvature), near free space conditions will exist over the path for all but the most extreme atmospheric conditions.

reflection analysis

Microwave signals may be reflected off certain surfaces such as open water or dew-laden fields of grain — surfaces that appear smooth relative to the wavelength of the microwave beam. If this reflected energy arrives at the receiving antenna at or near 180° out of phase with the direct beam (when clearance over the point is an even-numbered Fresnel zone radius), severe fading can take place. Because of this, it is recommended that amateurs interested in installing permanent, reliable microwave links also evaluate their potential paths for such reflection points.

Since the position of a reflection point varies with any change in the earth's effective radius (K), reflection analysis begins with sketching in the potentially reflective surface and other terrain features at differing values of K. This procedure makes use of **eq. 5** and is illustrated in **fig. 1**. If the reflective surface is not clearly blocked by intervening terrain at the same K factor, it is advisable to make some computations to determine if a reflected wave will reach your desired receiving antenna.

The following formula may be used for such computations.†

$$h_2 = d_2\left[\frac{h_1}{d_1} + \frac{(d_2 - d_1)}{1.5k}\right]$$

where h_1, h_2 = higher antenna and reflection heights, respectively, in feet, above the reflective surface plotted at $K = \infty$.
d_1, d_2 = distance from each antenna to the potential reflection point, in miles

In **fig. 1**, the potential reflecting surface is the lake which runs from mile 10 to mile 15 along the path. Assume that the obstructing point for $K = 4/3$ at about 27.5 miles is not there. To calculate where the reflection crosses mile 50, use **eq. 7**. Substituting, $h_1 = 410$ *feet*, $d_1 = 10$ *miles*, $d_2 = 40$ *miles*, and $K = 4/3$. This makes $h_2 = 2240$ *feet*. Adding this to the height of the reflecting surface at $K = \infty$ (1600 feet) gives 3840 feet above sea level. Since this is well above the planned receiving antenna height, no reflection problems will be experienced because of this reflection point. Similar calculations should be made for other unobstructed potential reflection points and at other projected values of K.

summary

In **fig. 1**, the example given assumes an operating frequency of 10 GHz, and a *normal* K of 4/3. The path profiled is 50 miles (80km) long.

At this K value, the user will have little more than grazing clearance over the control point, which is located 27.3 miles (44km) from the transmitting antenna. There is not 0.6 first Fresnel zone clearance over the control point, however, indicating that a small amount of obstruction loss will be experienced. For casual use, this loss will pose no major problem, but for permanent installations the small clearance will give fading problems whenever K goes below 4/3. Note that the receiving point is *shadowed* when K decreases to about 1.22 or less.

The techniques outlined here will give the amateur microwave user the basic information needed to evaluate any potential path for normal communications possibilities. It does not preclude use in path analysis for tropospheric scatter or refractive duct communications, but such techniques require additional analysis beyond the scope of this article.

*In metric form, **eq. 6** is

$$0.6F_1 = 10.39\sqrt{d_1 d_2/Df}$$

where d_1, d_2, and D are in kilometers.

†Adapted from reference 4, page 17.

references

1. J. Fisk, W1HR, "Solid-State Microwave RF Generators," *ham radio*, April, 1977, page 10.
2. "Anomalous Propagation — Part I," *GTE-Lenkurt Demodulator*, July/August, 1975, page 280.
3. B. R. Bean, J. D. Horn, and A. M. Ozanich, Jr., *Climatic Charts and Data of the Radio Refractive Index for the United States and the World*, National Bureau of Standards Monograph 22, 1960, page 80.
4. R. F. White, *Engineering Considerations for Microwave Communications*, GTE Lenkurt, San Carlos, California, 1970, page 51.
5. I. T. Corbell, "Microwave Engineering for the Broadcaster," *NAB Engineering Handbook*, 6th edition, page 615.

ham radio

More Details? CHECK—OFF Page 142

There's more for the Amateur at Heath!

Heathkit accessories to make your shack a showplace!

1

2

3

4

5

6

7

8

1 Fully assembled desk mike
Hi-Z dynamic, grip-to-talk, VOX and PTT with cables. **HDP-121A** **39.95**

2 VHF wattmeter
1-25 and 10-250 W ranges. Built-in SWR bridge.
Kit HM-2102 ....**37.95**

3 HF wattmeter/SWR bridge
1.8-30 MHz range, handles up to 2000 watts.
Kit HM-102 ....**37.95**

4 Hybrid phone patch
Has VU meter, 30 dB isolation, matches 3-16Ω speakers & hi-Z or 600 ohm inputs.
Kit HD-15 ....**37.95**

5 Multiple antenna coax switch
SWR 1.1:1 max, 2 kW PEP rating.
Kit HD-1234 ....**10.95**

6 Hi-Z ceramic mobile mike
PTT or PTT and VOX operation. Fully assembled. **GH-12A** **12.95**

7 "Cantenna" dummy load
1 kW max. input; 1.5-300 MHz range with SWR 1.5:1 or less. Oil not included.
Kit HN-31 ....**14.95**

8 Solid-state dip meter
Covers 1.6 through 250 MHz. Battery powered. Bat. not included.
Kit HD-1250 ....**59.95**

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

Get a Catalog from your local Heathkit Electronic Center Too!

You can get a FREE retail catalog by redeeming this coupon in person at any of the 50 Heathkit Electronic Centers (Units of Schlumberger Products Corporation) in major markets coast-to-coast, where Heathkit products are displayed, sold and serviced. (Retail prices on some products may be slightly higher.)

See list at right

AVAILABLE LOCALLY
Visit the Heathkit Electronic Center nearest you (Units of Schlumberger Products Corporation) and see our Complete Product Line.
Parts and service available. Retail prices on some products may be slightly higher.

ARIZONA — Phoenix, 85017
2727 W. Indian School Rd. 602-279-6247
CALIFORNIA
Anaheim, 92805
330 E. Ball Rd. 714-776-9420
El Cerrito, 94530
6000 Potrero Ave. 415-236-8870
Los Angeles, 90007
2309 S. Flower St. 213-749-0261
Pomona, 91767
1555 Orange Grove Ave. N. 714-623-3543
Redwood City, 94063
2001 Middlefield Rd. 415-365-8155
Sacramento, 95825
1860 Fulton Ave. 916-486-1575
San Diego (La Mesa, 92041)
8363 Center Dr. 714-461-0110
San Jose (Campbell, 95008)
2350 S. Bascom Ave. 408-377-8920
Woodland Hills, 91364
22504 Ventura Blvd. 213-883-0531
COLORADO — Denver, 80212
5940 W. 38th Ave. 303-422-3408
CONNECTICUT — Hartford (Avon, 06001)
395 W. Main St. (Rte. 44) 203-678-0323
FLORIDA
Miami (Hialeah, 33012)
4705 W. 16th Ave. 305-823-2280
Tampa, 33614
4019 West Hillsborough Ave. 813-886-2541
GEORGIA — Atlanta, 30342
5285 Roswell Rd. 404-252-4341
ILLINOIS
Chicago, 60645
3462-66 W. Devon Ave. 312-583-3920
Chicago (Downers Grove, 60515)
224 Ogden Ave. 312-852-1304
INDIANA — Indianapolis, 46220
2112 E. 62nd St. 317-257-4321
KANSAS — Kansas City (Mission, 66202)
5960 Lamar Ave. 913-362-4486
KENTUCKY — Louisville, 40243
12401 Shelbyville Rd. 502-245-7811
LOUISIANA — New Orleans (Kenner, 70062)
1900 Veterans Memorial Hwy. 504-722-6321
MARYLAND
Baltimore, 21234
1713 E. Joppa Rd. 301-661-4446
Rockville, 20852
5542 Nicholson Lane 301-881-5420
MASSACHUSETTS
Boston (Peabody, 01960)
242 Andover St. 617-531-9330
Boston (Wellesley, 02181)
165 Worcester Ave.
(Rt. 9 just west of Rt. 128) 617-237-1510
MICHIGAN
Detroit, 48219
18645 W. Eight Mile Rd. 313-535-6480
E. Detroit, 48021
18149 E. Eight Mile Rd. 313-772-0416
MINNESOTA — Minneapolis (Hopkins, 55343)
101 Shady Oak Rd. 612-938-6371
MISSOURI — St. Louis (Bridgeton) 63044
3794 McKelvey Rd. 314-291-1850
NEBRASKA — Omaha, 68134
9207 Maple St. 402-391-2071
NEW JERSEY
Fair Lawn, 07410
35-07 Broadway (Rte. 4) 201-791-6935
Ocean, 07712
1013 State Hwy. 35. 201-775-1231
NEW YORK
Buffalo (Amherst, 14226)
3476 Sheridan Dr. 716-835-3090
Jericho, Long Island, 11753
15 Jericho Turnpike 516-334-8181
Rochester, 14623
937 Jefferson Rd. 716-244-5470
White Plains
(North White Plains, 10603)
7 Reservoir Rd. 914-761-7690
OHIO
Cincinnati (Woodlawn, 45215)
10133 Springfield Pike 513-771-8850
Cleveland, 44129
5444 Pearl Rd. 216-886-2590
Columbus, 43229
2500 Morse Rd. 614-475-7200
Toledo, 43615
48 S. Byrne Rd. 419-537-1887
PENNSYLVANIA
Philadelphia, 19149
6318 Roosevelt Blvd. 215-288-0180
Frazer (Chester Co.) 19355
630 Lancaster Pike (Rt. 30) 215-647-5555
Pittsburgh, 15235
3482 Wm. Penn Hwy. 412-824-3564
RHODE ISLAND
Providence (Warwick, 02886)
558 Greenwich Ave. 401-738-5150
TEXAS
Dallas, 75201
2715 Ross Ave. 214-826-4053
Houston, 77027
3705 Westheimer 713-623-2090
VIRGINIA
Alexandria, 22303
6201 Richmond Hwy. 703-765-5515
Norfolk (Virginia Beach, 23455)
1055 Independence Blvd. 804-460-0997
WASHINGTON — Seattle, 98121
2221 Third Ave. 206-682-2172
WISCONSIN — Milwaukee, 53216
5215 W. Fond du Lac 414-873-8250

More Details? CHECK—OFF Page 142

solution to the low-band antenna problem

The Marconi antenna works great on the lower amateur frequencies — here's how to make it play using simple methods and inexpensive parts

Since many transceivers include 160 meters, many amateurs need a low-band antenna. However, this can raise a number of questions or comments, such as:

1. Most trap or shortened antennas are very narrow band. Is there something simple that will cover the entire low bands?

2. The cost of an antenna and transmatch may be wasted if I find I don't like 160 meters.

3. My lot is too small for even a quarter wavelength on 160, so how can I put up something effective?

4. I tried to load a "compromise" antenna but burned up my final amplifier before I got it to load. I don't intend to buy an antenna lab just to check out an antenna!

background

Radio Handbook has, for years, included one antenna — a 180-foot (55m) Marconi. This length works as a 3/4-wavelength antenna on 80 meters and as a 1/4-wavelength on 160 meters by shortening its electrical length with a variable capacitor. This antenna works nicely, but may still be too long. The Handbook suggests a 90-foot (27.4m) length for 80 and 40, and may make you think about loading it for 160.

The latest edition of *Radio Handbook* suggests the antenna be pruned to favor desired band segments. This seemed to fit the needs of a friend who needed a modest 160-meter antenna, so I agreed to "wring it out." The antenna started as a 94-foot-long (28.7m) antenna and was a real bear on 80, since the 1/2-wavelength point was at 4 MHz. Since it was end-to-end with my Bobtail Curtain, I assumed it was coupling to that antenna, so I re-erected it in the opposite direction completely clear of all antennas and utility lines. This was no improvement, so the antenna was progressively shortened until it behaved.

taming the antenna

Table 1 shows the results. The column labeled **compensation** indicates the component in series with the antenna to make it purely resistive at that frequency. At that point the R value was determined. Notice that the 82-foot (25m) version will provide operation on the high end of 160, all of 40, and all of 15 with low swr, and no matching is needed other than the simple compensating element. You might feel that the 94 footer (28.7m) should behave exactly as the 180 footer (55m) does, with respect to impedances. It won't for this reason: 160 and 80 are very nearly harmonically related (1.8 to 3.6 MHz and 2 to 4 MHz). 80 and 40 are not: (3.5 to 7 MHz and 4 to 8 MHz). If you set up the 94 footer (28.7m) for resonance at 8 MHz, it will perform nicely at 80 meters. The 82 foot (25m) version in **table 1** is resonant at 7450 kHz.

It might be a temptation to let the antenna behave as a 1/2 wavelength at 75 meters. It could be loaded with a parallel-resonant tank circuit link coupled to the rig. If your version had a flat top at a height of 1/8 wavelength or less, if it was built of no. 12 (2.1mm) or smaller, and if it were located over soil having excellent conductivity (or a radial ground system), its

By Bill Wildenhein, W8YFB, 41230 Butternut Ridge, Elyria, Ohio 44035

table 1. Values of compensating components for use with the low-band Marconi antenna (160 through 10 meters).

frequency kHz	R (ohms)	94 ft (28.7m) to north compensation	R (ohms)	94 ft (28.7m) to south compensation	R (ohms)	82 ft (25m) to north compensation	R (ohms)	82 ft (25m) to south compensation
1803	22	15.5µH	25	19.5µH	25	22.0µH	20	20.5µH
1890	30	11.5µH	30	18.0µH	30	16.0µH	40	17.5µH
3557	300	100pF	250	100pF	160	120pF	145	120pF
3646	500	100pF	350	80pF	200	90pF	160	100pF
3780	900	80pF	500	70pF	250	75pF	240	80pF
3980	5k	30pF	1.5k	36pF	1k	35pF	500	50pF
7005	100	240pF	48	3.35µH	75	1.2µH	58	2.3µH
7150			50	2.7µH			60	1.8µH
7200	115	150pF			63	RESONANT		
7292	125	125pF	55	1.9µH	65	520pF	63	1.2µH
14,010			750	RESONANT	750	SEE TEXT	350	75pF
14,240			900	0.54µH	800	SEE TEXT	1000	RESONANT
14,300			900	1.2µH	600	SEE TEXT	800	0.26µH
21,015	90		100	1.2µH	65	0.7µH	75	0.85µH
21,360	125		95	1.0µH	58	0.25µH	60	0.72µH
21,450	130		90	0.85µH	60	0.25µH	58	0.68µH
28,020	250	1.4µH	90	325pF	175	0.25µH	110	190pF
28,600	130	1.0µH	120	170pF	250	0.4µH	80	100pF
29,560	100	0.54µH	150	RESONANT	100	0.55µH	110	75pF

end impedance will be well over 10,000 ohms. That means very high rf voltage in the station, BCI and TVI become more severe, lead-in losses rise, capacitor spacing would have to be much greater (and cost much more). There would be a possibility of very serious rf burns if a child happened to touch the lead-in. It would be beyond the capabilities of commercial transmatches.

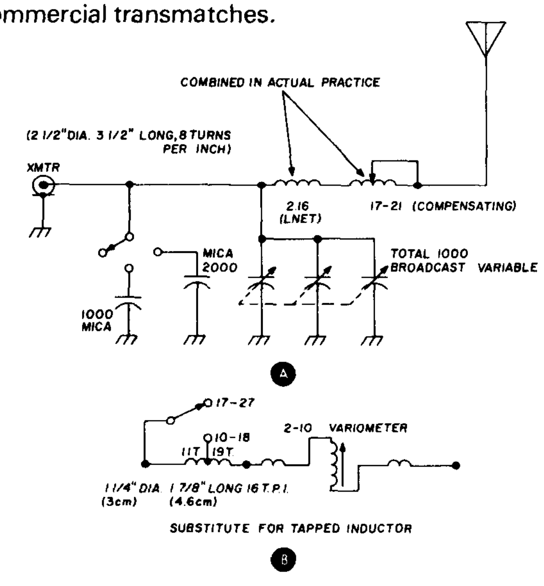


fig. 1. Loading circuit for the low-band Marconi. The L network and compensating coil are one unit in the practical circuit. Voltage is low in this system, so an ordinary capacitor from a broadcast receiver can be used for tuning. Sketch B shows an alternative method for a tapped inductance.

Instead, deliberately detune it by pruning it well above 40 meters. The 82-foot (25m) version is resonant at 7450 kHz in my backyard. Notice that the 80-meter numbers become quite reasonable. Also notice that the 40- and 15-meter numbers do not change appreciably with changes in length. You might be concerned that the antenna will lose efficiency if not cut to exact resonance. By adding the small compensating coil, you are resonating the entire system.

the ground system

A good ground is essential for a Marconi antenna. I use three radials for each band, 1/4-wavelength long, and fanned out under the antenna. These radials are tied to a ground stake just outside the basement window. The lead-in is a scrap of no. 4 AWG (5mm) wire but could just as well be a scrap of RG-8/U coax cable with shield and center conductor tied together. A second ground stake about 8 feet (2.4m) away is tied to the first with another scrap of no. 4 AWG (5mm) wire. Inside the window, my copper plumbing is also tied in with a piece of no. 4 AWG (5mm) wire. If you have hot water heating, the plumbing in the basement may be copper pipe buried in the concrete. This results in a large area of copper capacitively coupled to ground. The ground wire may be fastened to the copper plumbing with hose clamps. A ground system such as this is very effective and results in an efficient antenna.

An easy way to enter a basement window is to replace a pane with plexiglass. This material may be drilled (cautiously) for 1/4-20 (M7) brass bolts for antenna and ground lead. Keep the antenna lead well separated from the sash and ground lead. The most desirable location for the tuner is on a shelf at the basement window, with coax running to the rig. A long ground lead is undesirable. In short, when using a Marconi, don't cheat on the ground! I have used Marconis with only one radial cut for the lowest band; another had no radials and only a water-pipe ground. With the latter antenna I worked over 20 states on 160 with 12 watts on a-m. The present antenna has convinced me of the value of a good ground. I get good, solid contacts over at least a 500-mile (800km) radius running 35 watts PEP on ssb. This, again, on 160 meters.

leading circuit

Now let's see how cheaply we can load this thing. If you want the entire 160-meter band with unity swr, the arithmetic goes like this:

$$X_L = \sqrt{R\,R_{IN} - R^2} = \sqrt{20 \times 50 - 20^2}$$

$$= \sqrt{1000 - 400} = 24.5 \text{ ohms}$$

$$X_C = \frac{R\,R_{IN}}{X_L} = \frac{20 \times 50}{24.5} = 40.8 \text{ ohms}$$

$$L_{\mu H} = \frac{0.159160\, X_L}{f_{MHz}} = \frac{0.159160 \times 24.5}{1.8} = 2.17 \mu H$$

$$C_{pF} = \frac{159160}{f_{MHz} X_C} = \frac{159160}{1.8 \times 40.8} = 2167\, pF$$

This is for the case where the antenna presents 10 ohms. **Fig. 1** shows the circuit. The voltage across the capacitor is low so an ordinary 3-gang broadcast capacitor will do nicely. The inductance above can be added to the compensating inductance in the form of one single coil.

Next, there are two ways to match the antenna for 80 meters. If you have an Amidon balun core it can be rewound with the same number of turns, trifilar, and connected as an autotransformer. Connect the *finish* end of one winding to the *start* of the next. **Fig. 2** shows the hookup. If you jockey the impedance values to duplicate mine (by varying antenna length), this system will result in a maximum swr of 1.5 at any point in the 80-meter band.

The total expense of matching components for 160 and 80 is low enough that you can have separate, pretuned networks for each band. On 40 meters the antenna is so close to the proper impedance that you need only a 2.5 μH coil in series with the antenna lead, and with tap set for minimum swr. This will allow you to assess the capabilities of the setup. If you like it, you can buy a *Transmatch* later. You may have to add series inductance to get a commercial *Transmatch* to tune 160.

Another solution for 80-meter matching is shown in **fig. 3**. This is the reverse of the network shown in **fig. 1**, since we want to step up the impedance. This network will allow unity swr at any point in the 80-meter band. Component values allow reasonable cost if you are operating a transceiver barefoot. Values are computed in this manner:

$$X_C = R\sqrt{\frac{R_{IN}}{R - R_{IN}}} = 500\sqrt{\frac{50}{500 - 50}}$$

$$= 500\sqrt{0.1111} = 166 \text{ ohms}$$

$$X_L = \frac{R\,R_{IN}}{X_C} = \frac{500 \times 50}{166} = 150 \text{ ohms}$$

$$C_{pF} = \frac{159160}{f_{MHz} X_C} = \frac{159160}{4 \times 166} = 240\, pF$$

$$L_{\mu H} = \frac{0.159160\, X_L}{f_{MHz}} = \frac{0.159160 \times 150}{4} = 6 \mu H$$

This gives us the values for the 500-ohm point. In the same way you can calculate the values for the 3.5-MHz point.

Before you run away from the simple math shown here, let me say that the amateur who usually uses guesswork would look at that choice of coil and say, "You're nuts! That coil might work on 20 but will never tune on 80!" Substituting a coil that "looked" like an 80-meter coil, he'd hunt at length for a tap position that would result in a match. Finding it with the coil nearly shorted out, he'd say, "Anyone can see this isn't right! It must be loading on a harmonic or something! Better junk that antenna before you get in trouble with the FCC!"

Component values for an L network are, to a large extent, controlled by the ratio of impedances to be matched. Another reason for calculating the values is that it often enables you to see trouble ahead. If you didn't take the time to calculate the values, you might say, "Most commercial transmatches seem to use big capacitors. I have a pair of 450 pF variables here. With these I should be able to match *ANYTHING*." A good example of this is the "Moose" shown in the photo. Since I do a lot of antenna experimenting I built this thing to give me a wide range of capabilities as a pi network, or either version of an L network. I calculated the values needed for my antenna on 20 meters. The minimum capacitance required made me suspicious. I wasn't disappointed! The network in the photo has a minimum capacitance too high to permit using it on

20! The minimum plus distributed capacitance of the 450-pF capacitors would certainly also be too high.

While this antenna is primarily intended for 160-80-40-meter operation, it will work the higher-frequency bands. On the higher bands it begins to take on the characteristics of a long-wire antenna. For example, as can be seen from **table 1**, variations in impedance between voltage-feed and current-feed points become progressively less as frequency increases. The antenna will begin to exhibit directional tendencies and can supply occasional surprises when you hit the correct conditions. You'll probably want to use a more effective antenna on the higher bands, but this one is quite useful as a standby antenna. By the same token, it will, obviously, do a good job of radiating harmonics.

If TVI is a problem, a lowpass filter in the lead from the transmitter to the matching network should do the job. In my case, the TV set is located directly above the rig. Total separation is less than 10 feet (3m). The rig can be operated with shield covers removed, but no TVI occurs on 160 through 40. Of course, I use low power — 35 watts PEP, while the big amplifier is down for modification. If you do experience trouble, the lowpass filter should be the

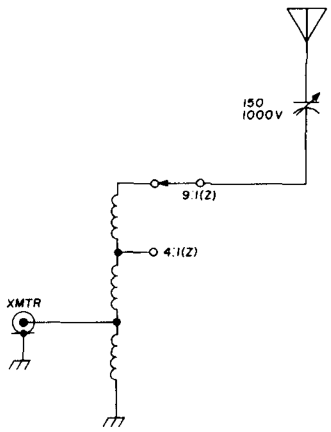


fig. 2. Schematic showing a method for matching the Marconi to your rig for 80-meter operation. By varying impedance values, this circuit will provide an swr of 1.5 across the entire band.

answer unless you have excessive ground-lead length. This will tend to couple the rf to the ac line. In that case a lowpass filter may still help but may not be quite as effective.

While on the subject of lowpass filters, it might be a temptation to build one of the simple lowpass filters described in the ARRL *Handbook* (late editions) for use in cleaning up vfo outputs. This little filter is very useful for its intended purpose but will behave as a halfwave filter when used in the output of a transmitter. For example, if the cutoff frequency were set a little beyond 20 meters (for instance, if you used a combination of 620 and 820 pF capacitors to yield a 14.5 MHz cutoff), it will work beautifully on 20 meters. If you check it with the signal going into a good 50-ohm load you'll find that each lower band will show greater reflected power, making it useless as a wide-range unit. The halfwave filter is a very effective single-band device. If you have TVI problems on a single band, the filter can be an inexpensive and effective cure. Just don't be misled into thinking it will perform well on all bands below the cutoff frequency!

instrumentation and design aids

If you aren't the experimenter type, you're probably worrying about all the L and C calculations. Be smart! Send $2.00 to the ARRL for their *Type A Calculator*. With this thing you can solve your L, C, and F calculations in seconds. I've worn out three of them over the years, and keep one at work and one at home. Once you get used to the thing, you're hooked. Instructions are printed right on the calculator, so it's impossible to mislay or forget this information.

A good practical example of the savings in time and money is this: You might not have a grid dipper but may want a cheap and dirty model just for this antenna work. Perhaps you have a little two-gang broadcast capacitor but don't know its capacitance range. Be assured it will work very well in a conventional Colpitts oscillator. Perhaps you leave it on the original chassis, use an existing socket, and haywire the circuit. You may have some defunct octal tubes. The bases can be the plugin coil forms. Take a guess that in the Colpitts circuit the little capacitor will hit 100 pF somewhere in the vicinity of a capacitor setting that puts it two-thirds meshed.

The ARRL calculator gives you the correct number of turns on the tube base to hit some desired frequency. Once you have the instrument running, you can determine the total range of frequencies the coil will cover.

Now you know the coil inductance and the end frequencies. With the calculator you can determine accurately the exact number of turns for any range. The calculator will also tell you the true maximum and minimum capacitance you have, which will include stray capacitance. You can use the calculator to juggle turns to give a desired amount of overlap in coil ranges. In other words, it takes out the guesswork, and the time-consuming work of removing turns or rewinding coils repeatedly to achieve a specific range.

The calculator also gives positive verification of a hoped-for cost saving. For instance, in making the dipper, you might look at the tube base and say, "I'll never get a 160-meter coil on that form!" But the calculator says you certainly will. For example, very often an article might specify a certain length of husky coil stock. Your calculator tells you what inductance this represents. It enables you to say confidently, "That coil from a surplus tuning unit will be correct, too." Think about it. You saved the price of the calculator with that one decision!

measuring antenna impedance

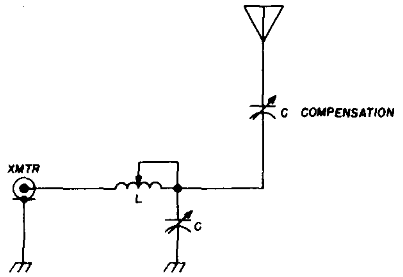
Possibly in your location the antenna impedances will be somewhat different from mine. Or you might have heard that two or three spaced wires, instead of a single wire, will decrease the impedance at the halfwave points. How much lower? You need to measure the impedance but have no tools? The *Radio Handbook* has carried a description of a simple little bridge for a number of years. It is the *Antennascope*. The latest edition has a version that only goes to 100 ohms. Earlier editions had a model that went to 1000 ohms. For hf antenna work, that model is entirely adequate. It is an inexpensive, two-evening project and can be made from standard parts.

The meter need not be an expensive one since we're concerned only with a null. You can substitute one of the $1.50 surplus tuning meters used in stereo amplifiers. It should have a 100 or 200 microampere movement. Calibration requires nothing more than a handful of resistors between 10-1000 ohms.

If you really want to go all out on antenna measurements, Hank Keen described a bridge that independently measures the R and X components.[1] I described a similar one in reference 2. While only a little more costly and complex, both instruments will do an excellent job. However, if properly used, the little *Antennascope* is entirely adequate.

In addition to the *Antennascope*, you'll need a source of low-power rf. This source can be a vacuum-tube-type grid dipper (the solid-state models don't have the power output necessary to serve as bridge drivers). You could also use a simple crystal oscillator. This oscillator should be a vacuum-tube type with a tuned-plate circuit link coupled to the *Antennascope*. No tuning meter is required since the *Antennascope* meter can be used to indicate maximum output from the oscillator. Again, this could be built out of a scrap ac-dc set. The tuning capacitor in the ac-dc set will be adequate. Plug-in coils wound on tube bases will be satisfactory.

With the original tuning capacitor you can hit two adjacent bands with a single coil. For instance, one coil will hit both 160 and 80 meters. A second coil will hit 40 and 20 meters. If you don't have an rf choke handy, use one pie from an old 455-kHz i-f transformer.



band	L	C	C compensation
80	3-6μH 12 turns 2" dia. (51mm) 1-1/2" (38mm) long	240-440pF, 1kV	50-120pF, 1kV
20	1.4-2.5μH 12 turns 2" dia. (52mm) 1-1/2" (38mm) long	40-80pF, 1kV	shorted out
10	0.25-0.35μH 12 turns 2" dia. (51mm) 1-1/2" (38mm) long	50-60pF, 500V	75-200pF, 500V

fig. 3. Alternative matching circuit for 80 meters.

Another solution is possible if you have a service-type signal generator. Many of these units have an open circuit output of about 0.3 volts. Make a "mini linear" using a hot pentode such as a 6AG7, 6CL6, or 6GK6. Don't tune the input — just use a 10k resistor to ground. Tune the output and link couple it to the *Antennascope*. Set it up according to the tube manual values for class A operation. If output is marginal, tune the link. If you're using this technique or a grid dipper, don't rely on dial calibration; verify the frequency with your communications receiver.

measurement technique

The proper technique to ensure accurate measurements is this: In each case, the antenna must first be made resonant. **Table 1** will give you a rough idea of the compensating element needed to ensure exact resonance. Example:

1. On 160 meters, connect about 30 μH of inductance between antenna and ground.

2. Couple a dipper to the coil and carefully short turns until a dip occurs at the desired frequency.

3. Disconnect the grounded end of the coil from ground and insert the *Antennascope* between ground and the end of the coil.

4. Feed power to the *Antennascope* at the same frequency.

5. Adjust the *Antennascope* for a null on its meter and read the resistance indicated. Also note the inductance needed to obtain resonance.

On 40, if your antenna is similar to mine, you could use the same technique but with a smaller coil. On 80 you'd use a section or two of a broadcast capacitor in series with the antenna. The free end of the capacitor goes to a 2-turn link coil to ground. The dipper is coupled to the link, and the series capacitor is adjusted for a dip. Then the *Antennascope* is connected in place of the link. At halfwave resonance, the impedance is very high. If you connect a link to ground, you may not be able to find a dip — or the dip may be very shallow. Thus, on 80 meters, it would be best to start at 3.5 MHz. The antenna will be far enough from the half-wavelength resonant point to enable you to get a dip. The dip may still be shallow, but it can be found. A similar situation exists on 20 meters.

Another technique is to judge resonance by deepness of dip on the *Antennascope*. For instance, the *Antennascope* could be connected directly from antenna to ground on 80 meters. You may find that its null is shallow. This will make it difficult to determine the exact R value. You can connect the series capacitor between the *Antennascope* and antenna. Adjust the capacitor carefully to find the point where the null on the *Antennascope* is deepest. If this is at the point of minimum capacitance on the series capacitor, you may want to use a smaller capacitor. Finally, find a point with the series capacitor where the null is deep and sharp. This makes it easy to obtain the exact R value.

On 20 meters you may have to use either a small inductance or fairly large capacitance to find resonance (depending upon the frequency in the 20-meter band). At some point the antenna may be resonant and will require no compensation. (This is the advantage of using the more complex bridge mentioned earlier.) Incidentally, in a situation such as the 82-foot (25m) antenna at 20 meters, the reactive component is small enough so that no compensating element must be used with an L network. A standard L network will accommodate this reactive component, which simplifies matching.

This antenna does a good job on the low-frequency bands. I hope this description makes it easy for you to obtain top performance. With the simple equipment and techniques described, you can be assured of an exact match without even turning on your rig. One last warning: The antenna length is measured from the far end to the point where it connects to the tuner. Have fun!

references

1. Henry S. Keen, W2CTK, "A Simple Bridge for Antenna Measurements," *ham radio*, September, 1970, pages 34-38.
2. Bill Wildenheim, W8YFB, "Low Cost RX Impedance Bridge," *ham radio*, May, 1973, pages 6-15.

ham radio

a review of
ssb phasing techniques

Phasing methods for ssb signal generation have provoked much controversy — here's an article that provides some interesting information to the contrary

A revival of interest in ssb phasing systems seems to have occurred in recent years, a trend I wholeheartedly endorse. Thus it's time to discuss the various phasing techniques used and to introduce some new or little-known techniques, which in my opinion, may revolutionize traditional approaches for obtaining ssb signals by this method.

Using the rf-phasing methods discussed near the end of the article, it is my opinion that direct-conversion ssb generators and receivers can be made that cover an octave or more in bandwidth. This is the so-called "third-method" of ssb-signal generation in which the desired output signals can be obtained without using cumbersome heterodyne methods with filters and their problems of frequency drift, which require periodic realignment.

economic considerations

A block diagram of the classic phasing method of ssb generation is shown in **fig. 1(A)**. More usually for practical reasons it's implemented as shown in **fig. 1(B)**. The key to the whole technique is the phasing networks — this may be stating the obvious, but their design, construction, and adjustment, and the difficulties encountered therein account for much constructor resistance to phasing ssb. Phasing ssb is mostly looked on as not a "proper" method of generating ssb, an opinion I entirely reject. I've always thought that the filter method is really a brute-force technique.

It's possible to obtain opposite-sideband suppression of more than 50 dB with narrow bandwidths, but the subsequent amplifier stages degrade this

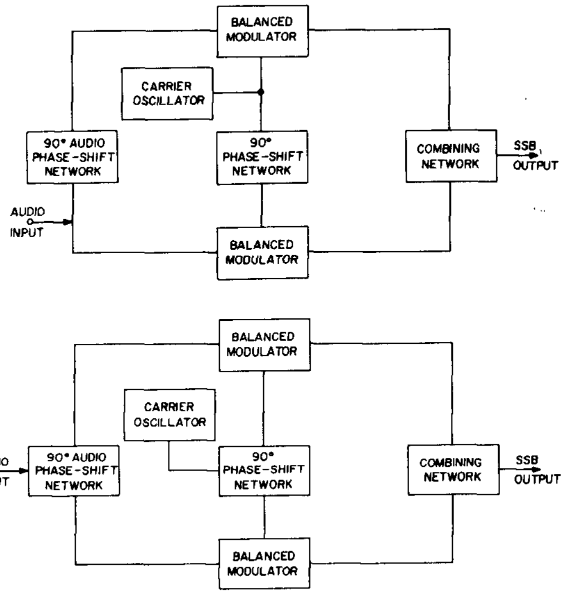


fig. 1. Classic phasing method for generating ssb signals (upper). For practical reasons, the method is implemented as shown in the lower drawing.

suppression and, as they generate intermodulation products at high levels, some of the advantage is lost.

As the state of the art existed some 20 years ago, when most ssb equipment was homebrewed, the

By Roger Harrison, VK2ZTB, 14 Rosebery Street, Balmain 2041, Australia

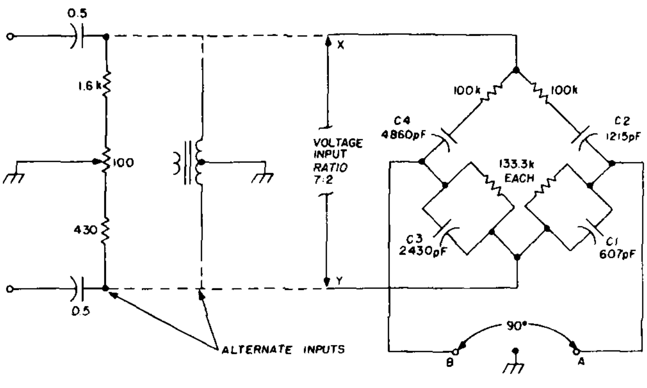
filter method was somewhat easier to implement. However, cost is almost always a consideration in homebrew projects, and the phasing method has a great advantage here. Furthermore, using some circuit techniques described later, my opinion is that the phasing method is easier to implement than the filter method. Although you must spend $30 - $50 on a filter and matched upper and lower sideband crystals and a further $5 - $10 on components, a phasing generator can be built for around $10 or less.

Even if you buy a batch of surplus crystals and make your own filter the cost will be considerable. Furthermore, the filter will require a great deal of time and effort to align — without guaranteed results. In my opinion, simplification of both circuit and alignment, as in the phasing system, is a step forward in which you can do the job required and still achieve adequate specifications.

ssb requirements

Let's look at what specifications are considered "adequate" for ssb. Opposite sideband suppression is important; after all, you have to live with your neighbors. Opposite sideband suppression of −40 dB is quoted in many texts as reasonable. However, with moderate output power −35 dB can be tolerated. Such suppression can be obtained with phasing techniques, but with some circuits it's difficult to maintain this number; in other circuits it can be exceeded.

Carrier suppression with phasing ssb depends on balanced-modulator performance, as with filter systems. Suppression of −50 dB may be obtained with filter systems, depending on the type of mixer. The bandwidth of filter-type ssb systems is mostly determined by the filter. These bandwidths range between 2.1 and 3.2 kHz for most commercially available equipment, which usually has a 6-60 dB shape factor of more than 2.



C1	607 pF (560 pF and 47 pF, 5% capacitors in parallel)
C2	1215 pF (390 pF and 820 pF, 5% capacitors in parallel)
C3	2430 pF (2200 pF and 220 pF, 5% capacitors in parallel)
C4	4860 pF (4700 pF and 150 pF, 5% capacitors in parallel)
R1,R2	133.3k (E96 series) or 100k and 33k, 1% resistors in series, or 1.2 meg, 5%, and 150k, 1% resistors in parallel

fig. 2. An audio phase-shift network (psn) for homebrew ssb projects popular from the early 1950s to the present. It was marketed by the Millen Company and by Central Electronics. Preferred capacitors are 1% or 2% silver mica, NPO ceramic, or polystyrene.

With phasing systems bandwidth depends on audiostage bandwidth and the audio phase-shift network. Unless elaborate sharp cutoff audio filters are used, the shape factor is not as good as in the filter system. However, this isn't a major problem, and many operators find phasing-type ssb easier to tune (on receive) and often describe it as having a more natural quality. It's easy to weight the audio response of a phasing generator to provide improved intelligibility.

Maintaining the specifications, particularly opposite sideband suppression, has always been a problem with phasing-type ssb systems, requiring periodic realignment of the phase-shift circuits. Opposite-sideband suppression was largely a function of component stability (that is, frequency drift).

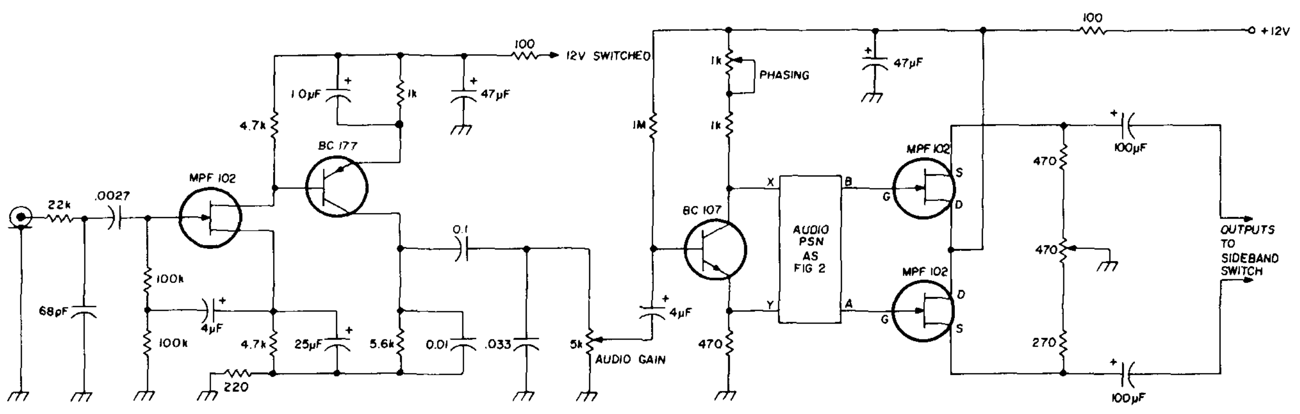
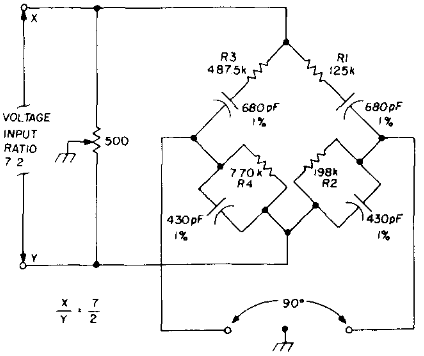


fig. 3. Audio stages of the "Tucker Tin Mark II" (reference 1), a phasing ssb transmitter using the phase-shift network shown in fig. 2.



C1	24.2 nF or 24200 pF (22 nF polycarbonate or polystyrene and a 470 pF silver mica, NPO ceramic, or polystyrene, connected in parallel)
C2	8.06 nF or 8060 pF (4.7 nF and 3.3 nF in parallel, or 6.9 nF and 1.2 nF in parallel, or 8.2 nF and 0.47 μF in series, polycarbonate or polystyrene capacitors)
C3	5.35 nF or 5350 pF (5.6 nF and 0.12 μF in series, or 4.7 nF and 680 pF in parallel, polycarbonate or polystyrene capacitors)
C4	4.03 nF or 4030 pF (3.9 nF and 120 pF in parallel, polycarbonate or polystyrene capacitors)
C5	1.78 nF or 1780 pF (1.8 nF and 0.18 μF in series, or 1.5 nF and 270 pF in parallel)
C6	892 pF (560 pF and 330 pF in parallel; use silver mica, NPO ceramic, or polystyrene capacitors)
R1	20k E96 series or two 10k, 1% resistors in series
R2,R3	60.4k E96 series, or 27k, and 33k, 1% in series, or two 120k in parallel

fig. 4. Phase-shift network first popularized by W2KUJ (reference 1).

With modern components and circuit techniques, these problems can be overcome, as we shall see.

audio phase-shift networks

Two types of phase-shift networks are used — active and passive. The latter are most widely used, but we'll examine both.

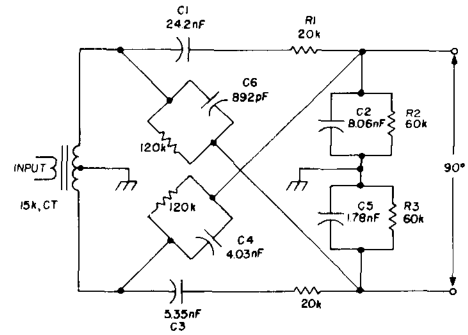
In the heyday of homebrew ssb, several commercially made audio phase-shift networks were available; the Millen and B&W 2Q4 being perhaps most widely used. The Millen network is shown in **fig. 2.** Its popularity over the past 20 years is probably due to its relative simplicity. When properly adjusted the differential phase shift between outputs can be maintained within ± 1.3° of 90° over the audio range from 225 to 2750 Hz. This results in an average opposite-sideband suppression of 45 dB. Using off-the-shelf 1% or 5% resistors and 2% or 5% capacitors, an opposite-sideband suppression of 40 dB can be achieved. The circuit has two other distinct advantages: it requires a minimum of 12-14 components, and the overall loss is about 10 dB, which is the lowest of all the RC networks to be described.

The Millen circuit requires unequal drive voltages at inputs X and Y (**fig. 2**) in the ratio of 7:2. The source impedance is about 2k. The circuit may be driven by a specially wound transformer (well-nigh impossible to obtain today), which would have to be built. Another alternative is to drive the circuit from a phase splitter (that is, 180° out of phase) through the RC network shown. The 100-ohm trimpot is then adjusted so that the audio voltage on input Y is only 28.5% of that on X. Alternatively, the pot may be adjusted to provide equal-amplitude signals at the outputs, A and B.

The audio bandwidth must be restricted as the differential phase shift between A and B departs further from the required 90° outside the bandwidth mentioned, thus markedly degrading the opposite sideband suppression. A rolloff of at least 12 dB per octave above about 2.5-3.0 kHz is recommended — preferably 16 dB per octave. The low frequency should be rolled off at about 10-12 dB per octave below 300 Hz.

The outputs must drive a very high impedance, preferably an fet source follower. The "Tucker Tin Mark II" ssb transmitter[1] used this phase-shift network, which was driven by a phase splitter. The outputs drove two fet source followers as shown in **fig. 3**. The audio amplifier, which has a high-impedance input, is arranged to provide the appropriate frequency response and gain, making it suitable for use with either crystal, ceramic, or dynamic microphones.

The phasing and audio-frequency balance pots are adjusted to provide minimum opposite-sideband suppression during alignment and rarely need readjustment. The phase-pot is used to adjust the input drive voltages to the phase-shift network in the correct ratio. The Tucker Tin was a highly successful kit. It was made available by the Upper Hutt branch of the NZART. Phase-shift network components were standard off-the-shelf 1% resistors and 5% capacitors.



R1	125k (124k or E12 series, 120k and 4.7k, 1% resistors in series)
R2	198k (196k E96 or E12 series, 180k and 18k, 1% resistors in series)
R3	487.5k (487k E96 or E12 series, 470k and 18k, 1% resistors in series, or 3.9 meg, 5%, and 560k, 1% resistors in parallel)
R4	770k (768k E96 or E12 series, 12 meg, 5%, and 820k, 1% resistors in parallel, or 680k and 82k, 1% resistors in series)

fig. 5. Network designed by Dome (reference 4). Circuit must be driven by equal-amplitude, opposite-phase signals as shown or from a phase splitter. Output must be a very high impedance.

C1	10.5 nF or 10500 pF (10 nF and 470 nF in parallel)
C2	32.3 nF or 32300 pF (27 nF and 560 pF in parallel)
C3	7.14 nF or 7140 pF (6.8 nF and 330 pF in parallel)
C4	5.38 nF or 5380 pF (4.7 nF and 680 pF in parallel)
C5	2.38 nF or 2380 pF (2.2 nF and 180 pF in parallel)
C6	1.2 nF or 1200 pF (1 nF and 200 pF in parallel)
R1,R2	90k (22k and 68k, 1% in series)

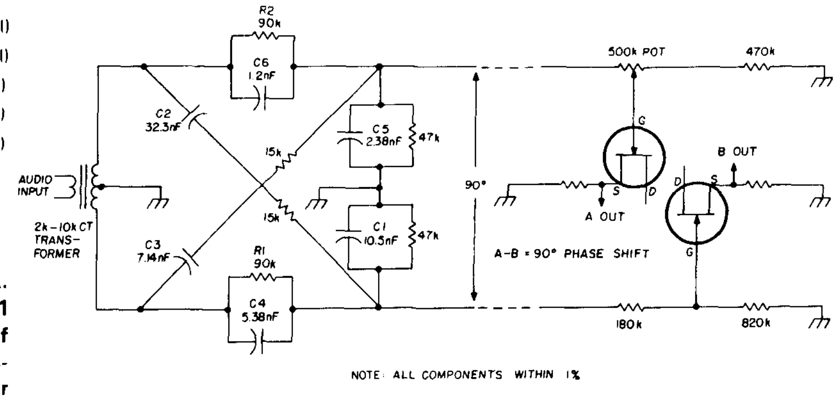


fig. 6. Modified Dome phase-shift network. Outputs may drive an impedance as low as 1 meg, which swamps the input impedance of the following stages (usually a source follower or similar circuit). Polycarbonate or polystyrene capacitors should be used for values above 1 nF (1000 pF); polystyrene, silver mica, or NPO ceramics below 1000 pF.

A similar circuit (**fig. 4**), having different values to accommodate a lower input impedance, was first popularized in the "SSB Jr.," a phasing-type ssb transmitter designed and described by Don Norgaard, W2KUJ.[2] Bandwidth and differential phase shift characteristics are much the same as in the circuit of **fig. 2**, which has the distinct advantage of a minimum component count of 14. Standard E24-series 1% or 5%, silver mica, or NPO ceramic capacitors are preferred and are readily available.

The resistors may be 1% or 5% with values from the E96 series as indicated. Alternatively, they may be derived from 1% or 2% tolerance types from the E12 series. If E96-series resistors are used, the component count is 9, whereas if E12 series are used with values in series or parallel combination, the component count is 13 (including the 100-ohm pot). The pot can be a carbon or wirewound type. A carbon type with a Cermet element is preferred.

As for the circuit in **fig. 2**, the phase-shift network requires the X and Y input voltages to be in the ratio of 7:2. The pot is used to set this ratio. The circuit can be driven from a simple fet phase splitter with equal-amplitude outputs or by a transformer. A very high impedance must be presented to the outputs, and fet source followers are again recommended.

For maximum results the two networks just described (**figs. 3** and **4**) can be aligned by making a portion of each capacitance a trimmer, then the entire phase-shift network can be adjusted for minimum phase deviation (from 90°) over the frequency range. An audio oscillator and scope are necesssary. The procedure is described in reference 3. Details for aligning the Tucker Tin circuit are given in reference 1.

A detailed and very useful discussion on the design, construction, and alignment of audio phase-shift networks is given in reference 3. An alternative procedure is to measure a group of components on a precision bridge, selecting those within 1% of the values given in the circuit. The only adjustment then is to get the input-voltage ratios correct.

The Dome network[4] shown in **fig. 5** has the advantage that it can be driven directly from a balanced input such as a center-tapped transformer or phase splitter. However, as with the two previous circuits, the outputs must be presented to a very high impedance. If components are close to the values specified, deviation from 90° phase shift will be about ±1.5° between about 270 Hz and 2.9 kHz. Restricted audio bandwidth must be used, as discussed previously.

Another disadvantage of the circuit in **fig. 5** is its high loss, which is about 15 dB compared with 10 dB

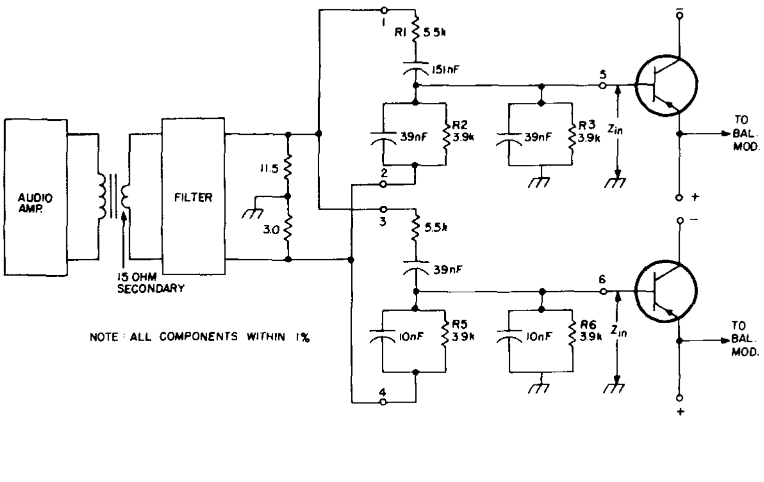


fig. 7. Network designed by Van Heddgem (reference 5) for solid-state applications. Values of R3 and R6 include Z_{in}. All values shown in the schematic should be within 1% or better. The ratio of R7/R8 = 3.83 (within 1% or better).

for the previous two circuits. However, it's usually not too difficult to provide sufficient gain margin in the audio stages to compensate.

One of the disadvantages with all the circuits described thus far is the necessity for the outputs to be presented with a very high impedance. The phase shift is affected by load-impedance variations, with a consequent degradation in opposite-sideband suppression. If the output impedance can be defined, could be built for solid-state applications. See **fig. 7**.The input impedance of the following emitter-follower stages is taken into account when calculating R3 and R6. Note that input and output impedances are quite low compared with those in the previous circuits. Many standard component values may be used.

In contrast with the original Dome network, the circuit of **fig. 7** requires that the input drive voltage

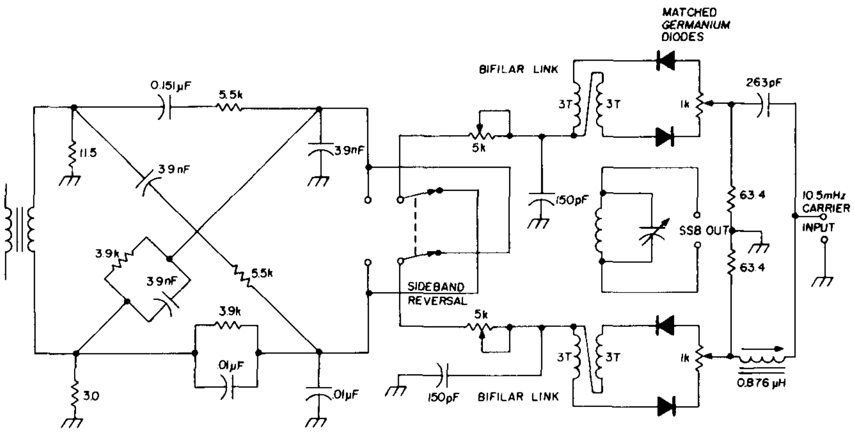


fig. 8. Passive phasing generator by W. Doyle, W7CMJ (reference 6).

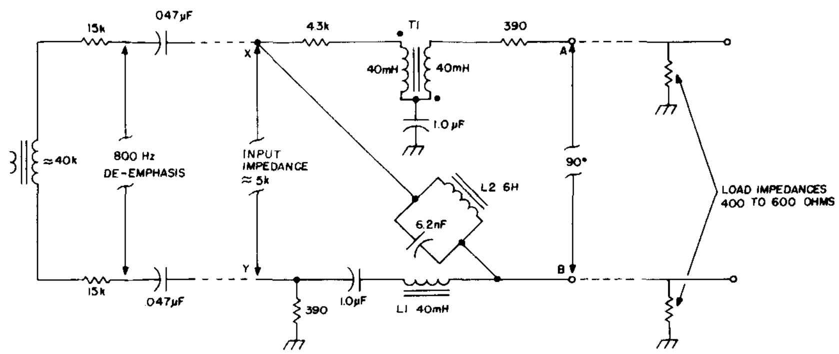
and a practical value lower than the input impedance of the following stage selected, then the effect of any variations in load impedance can be swamped.

Southwell[3] discusses a variation of the Dome network[4] in which the network outputs drive 1-megohm loads placed across the inputs of the following stages. The circuit is shown in **fig. 6**. Amplitude balance at the outputs may be obtained by a fixed voltage divider and by a pot in the other load resistance. The original circuit was designed to drive a cathode follower, whereas I've shown a source-follower stage.

Van Heddegem[5] discussed modifications to the basic Dome network in which a suitable network be in the ratio of 3.83:1. The circuit was later used by Doyle[6] in his passive ssb generator. The ratio of the two input resistors, which determine the input-voltage ratios, must be accurate to within ±1% or better.

Input impedance is noncritical but should be low. Doyle[6] uses two 5k pots to adjust output levels and impedance for best opposite-sideband suppression. His circuit is shown in **fig. 8**. According to Van Heddegem[5] the network should work well between 280 Hz and 2.8 kHz. Audio must be restricted in bandwidth to maintain opposite sideband suppression. No numbers are given as to how close the phase shift remains at 90°. Component count is

fig. 9. Phase-shift network using RLC components developed by Westinghouse in 1944 and described by Cheek (reference 7). Circuit has a minimum of 9 components. The 40-mH inductors may be made from 88-mH toroids. The 6-henry inductor may be an ordinary iron-core choke. Alternatively, all inductors may be wound on pot cores or low-frequency toroid cores.



L1	176 turns no. 26 (0.3mm) enameled wire on a single bobbin in a Vinkor LA2330 pot core
L2	2090 turns no. 42 (0.06mm) on a single bobbin in a Vinkor LA2330 pot core
T1	2 windings, 176 turns each, no. 34 (0.16mm) enameled wire, in each half of a double bobbin in a Vinkor LA2330 pot core

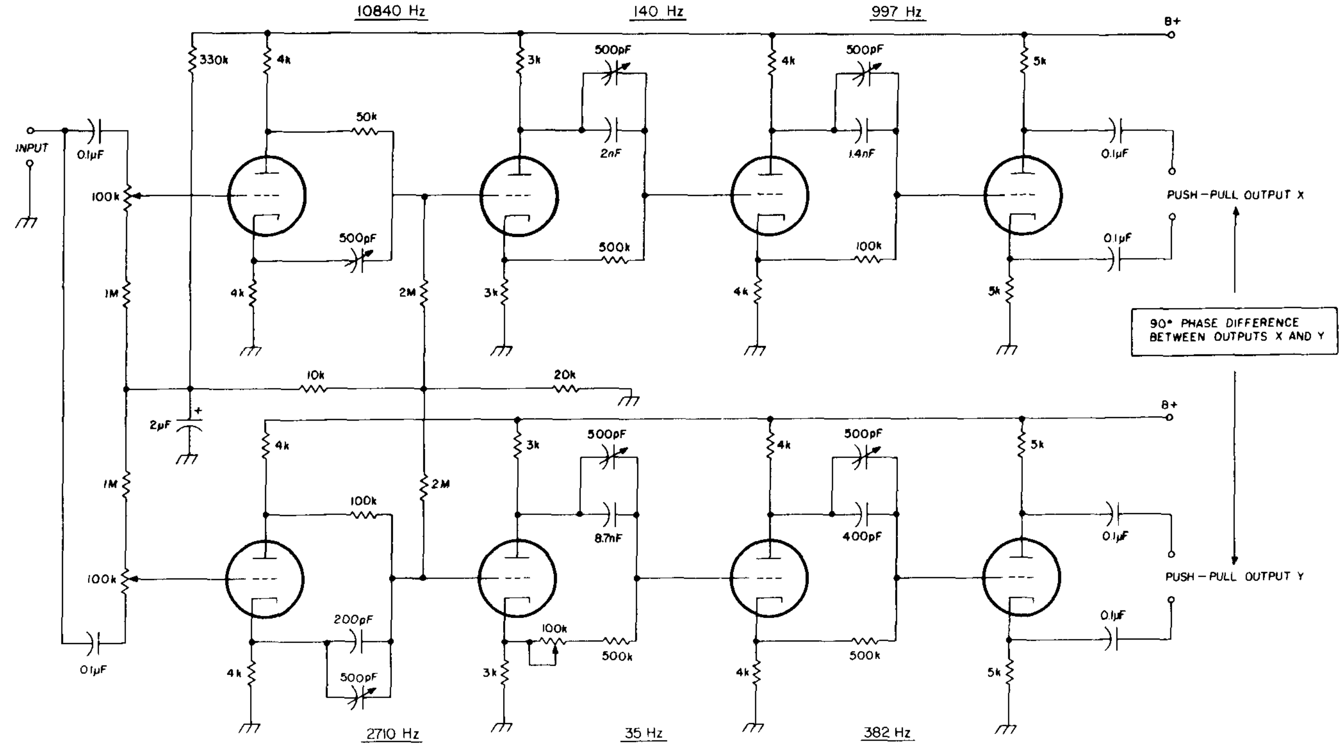


fig. 10. Wideband active audio phase-shift network described by Norgaard (reference 2) and Southwell (reference 3). Each RC network is adjusted for 45° phase shift, grid-to-grid, at the frequencies indicated. Circuit loss is about 8-10 dB.

only 12 if E96-series or selected E12-series components are used.

If you wish to build this ssb generator, I recommend that you read reference 3 for adjustment and alignment. (The rf phase-shift circuit is discussed later.) No numbers are given for opposite-sideband suppression, but it appears that at least 30 dB is obtainable.

So far all phase-shift networks considered have been made of RC combinations. Networks using R, L, and C combinations are quite rare in the literature, probably because the inductances in a phase-shift network of this type are not off-the-shelf items. Nevertheless, such a circuit has certain merits; one in particular is shown in **fig. 9**. This circuit was developed by Westinghouse in 1944 and subsequent-

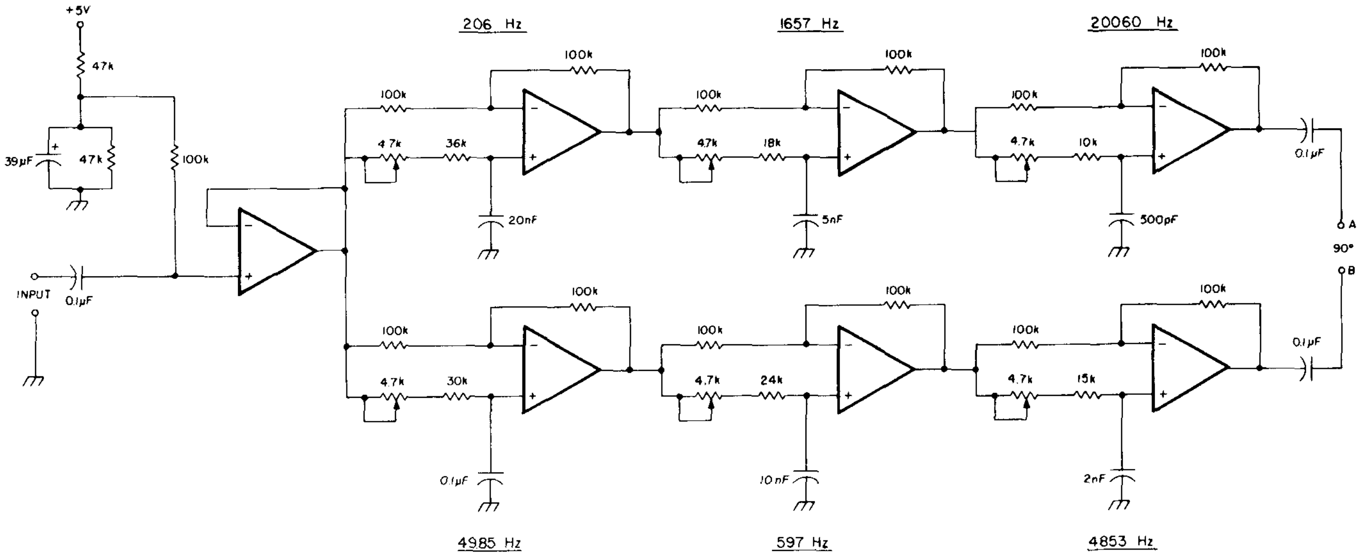


fig. 11. Modern wideband active phase-shift network described by Dickey (reference 8) uses two LM324 quad op amps. Input circuit provides operation from a single 5-volt supply. Each stage is adjusted for 90° phase shift, input-to-output, at the frequencies indicated. Circuit has unity gain (no loss).

ly described by Cheek.[7] Components are noncritical. Resistors and capacitors can be standard 5% or 10% components. Composition resistors and paper capacitors were used in the original circuit. The main requirement is that each 40-mH inductor resonate with the 1-μF capacitor at 800 Hz. Exact values aren't critical as long as components of the specified nominal values are used.

The 6-henry inductor and the 6200-pF capacitor must resonate at 800 Hz. The 40-mH inductors may be made from 88-mH toroids, which are readily available in the surplus outlets. These inductors consist of two 44-mH coils wound on a toroid core and connected in series.

Using a scope or vtvm and an audio oscillator, it's easy to resonate a 44-mH inductor and a 1-μF capacitor to 800 Hz. Just remove turns from the 44-mH winding until resonance is obtained. The exact frequency has no magic about it; 800 Hz is the geometric mean of 160 and 4000 Hz, which adequately covers the speech band. Ensure that each LC circuit resonates to the same frequency. This frequency could just as easily be 750 Hz (geometric

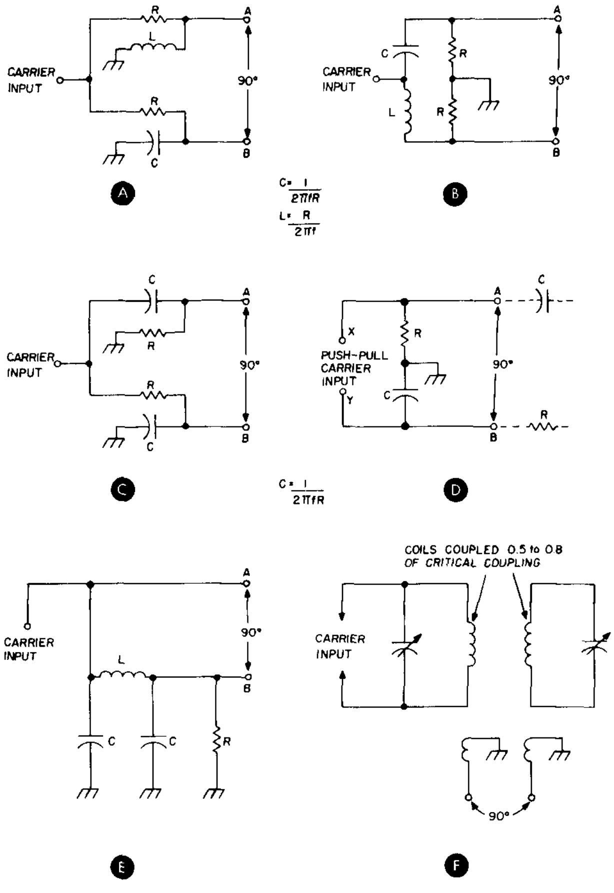


fig. 12. Passive rf phase-shift networks commonly used in phasing ssb designs over the past 30 years, which are discussed in the text. All are suitable only for single-frequency use or for a very small frequency range.

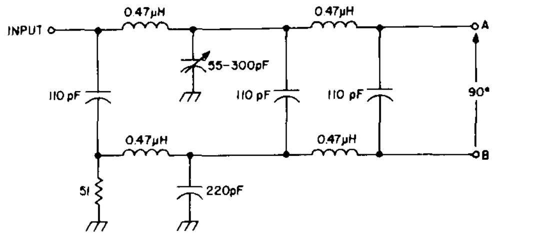


fig. 13. Coaxial-cable quadrature phase-shift network.

mean of 200 and 2800 Hz) or 900 Hz (geometric mean of 270 and 3000 Hz).

Transformer T1 consists of two windings having equal numbers of turns wound on the same core resonated at 800 Hz with the 1-μF capacitor. The two windings are connected in series: dots in the circuit in **fig. 9** for T1 indicate the start (or finish) of each winding. As an alternative, each inductor could be wound on a standard pot-core assembly or a low-frequency toroid.

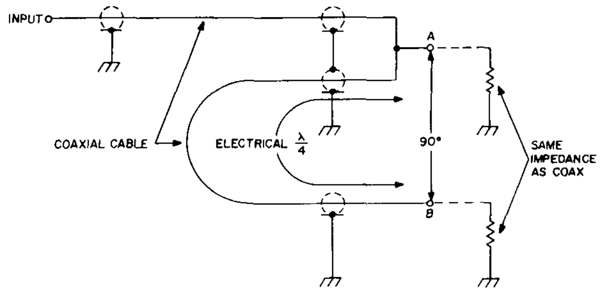
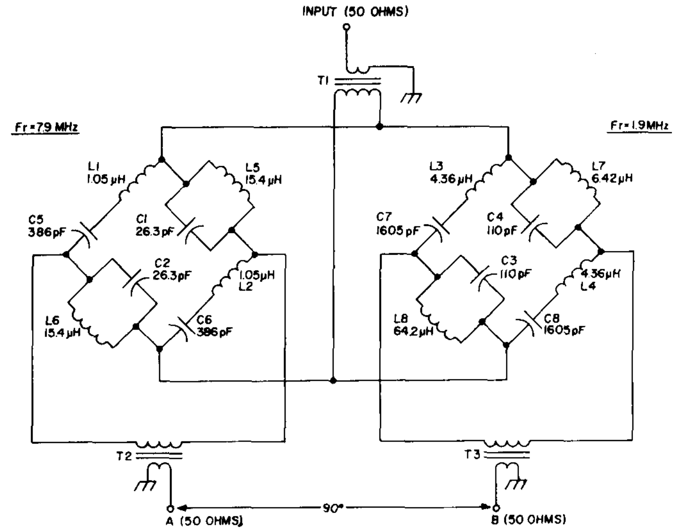


fig. 14. Quadrature phase-shift network after Taylor (reference 13) centered on 14.25 MHz. Output amplitudes are within 0.8 dB between 13.8-14.6 MHz.

The two quadrature outputs, A and B, can drive low-impedance loads. The characteristics of the phase-shift network are unaffected by the load impedance, which may be between 400 and 600 ohms. Input impedance is about 5k and should be floating with respect to ground. The input should be driven by a transformer or a differential amplifier.

The speech amplifier preceding the phase-shift network should include deemphasis for frequencies below 800 Hz. If the network is transformer driven, a deemphasis network consisting of two 15k resistors and two 47 nF (= .047 μF) capacitors, connected in series with each input terminal, serves this purpose. The input impedance then will increase to about 40k and the input transformer should be selected to drive such an impedance. This is suggested by Cheek.[7]

The network will maintain the phase shift within 1° or better between 300 Hz and 3.5 kHz. The amplitude balance between the quadrature outputs is within 2% or better between 200 Hz and 4 kHz. Thus, it's easy to achieve an opposite-sideband suppression of about 40 dB, which is certainly one of the advantages of this particular circuit. That and the quite low



C1,C2	26.3 pF (27 pF, 5% NPO ceramic or silver mica)
C3,C4	110 pF, 5% NPO ceramic or silver mica
C5,C6	390 pF, 5% NPO ceramic or silver mica
C7,C8	1605 pF (2700 pF and 3900 pF, 5% polyfilm capacitors in series)
L1,L2	1.05 µH. 5 turns no. 26 (0.4mm) enameled, closewound on Philips 020-91010 toroid core
L3,L4	4.36 µH. 12 turns no. 26 (0.4mm) enameled wound on Philips 020-91010 toroid core, turns spread evenly around circumference of core
L5,L6	15.4 µH. 24 turns no. 26 (0.4mm) enameled, wound on Philips 020-91010 toroid core
L7,L8	64.2 µH. 48 turns no. 30 (0.25mm) enameled, wound on Philips 020-91010 toroid core
T1,T2 T3	See text

fig. 15. Wideband 90° phase-shift network using two 45° bridge circuits (courtesy of Jim Koehler, VE5FP/VK2BOV).

input and output impedances together with the relatively noncritical nature of the components, gives this circuit quite an edge on the RC circuits discussed.

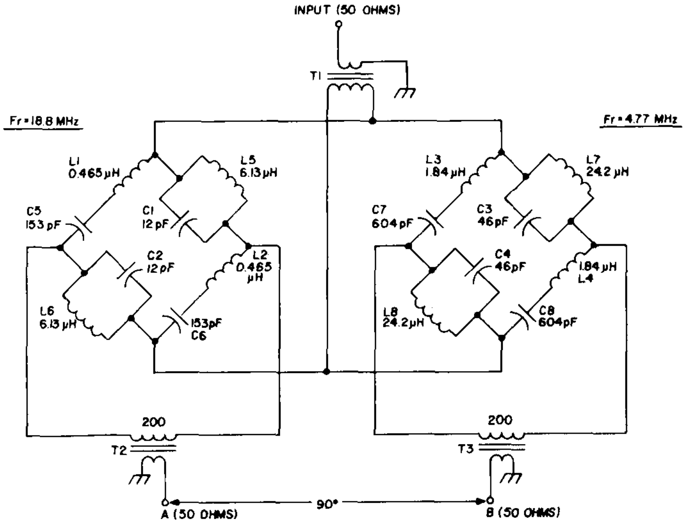
The overall loss is 12-14 dB (excluding the deemphasis circuit), which is comparable to the RC circuits. The audio stages preceding the network must have a sharp cutoff above 3 kHz, a common feature of all networks discussed. The minimum component count of 9 is also an attractive feature and is competitive with the circuit in **fig. 4**.

A point worth noting is that the low output impedance of the network in **fig. 9** makes it suitable for driving low-impedance diode bridge balanced modulators.

Active audio phase-shift networks were used in many early designs for ssb exciters. These circuits generally consisted of a cascaded series of triode phase splitters with RC networks coupling each stage as shown in **fig. 10**. This circuit is discussed by both Sothwell[3] and Norgaard,[2] amongst others. Each stage produces a 45°phase shift at a particular frequency. The frequency of each RC network is chosen so that the entire network produces a differential phase shift within ±1° between 70 Hz and 5.5 kHz.

This type of network needs alignment, but the procedure is more complicated to explain than to accomplish and is not outside the expertise of most amateurs. All you require is a passing acquaintance with a scope and an audio oscillator. Once adjusted, the network will maintain its alignment for considerable periods. The wide bandwidth allows good opposite-sideband suppression over the speech bandwidth of 300 Hz to 3 kHz. The circuit has excellent phase and amplitude stability. Overall loss is about 8-10 dB. The circuit can obviously be adapted to use modern fets.

A more recent circuit, using two quad op-amps, was described by Dickey.[8] He claims this circuit will provide two equal-amplitude outputs that differ in phase by 90° within ±2° over the frequency range



C1,C2	12 pF, 5% NPO ceramic or silver mica
C3,C4	46 pF (47 pF, 5% NPO ceramic or silver mica)
C5,C6	153 pF (150 pF, 5% NPO ceramic or silver mica)
C7,C8	604 pF (680 pF, 5% NPO ceramic or silver mica in series with 5600 pF, 5% polyfilm capacitor)
L1,L2	0.465 µH. 5 to 6 turns no. 22 (0.6mm) enameled on 579x250x312/900 Neosid toroid, turns spread evenly around circumference
L3,L4	1.84 µH. 6 turns no. 30 (0.25mm) enameled wire, closewound on Philips 020-91010 toroid core
L5,L6	6.13 µH. 12 turns no. 26 (0.4mm) enameled, wound on Philips 020-91010 toroid core, turns spread around 2/3 the circumference
L7,L8	24.2 µH. 27 turns no. 30 (0.25mm) enameled, wound on Philips 020-91010 toroid core
T1,T2, T3	Wound on Neosid 1050-1-F14 of Indiana General F684-1 balun core. Twist together three 7" (180mm) lengths of no. 26 (0.4mm) enameled wire and wind 3 turns through 2 holes; connect two wires in series for the 200-ohm winding

fig. 16. 3-30 MHz quadrature phase-shift network. Maximum phase error is about 1°. Overall loss of this network and that of fig. 15 is about 6 dB.

100 Hz to 10 kHz. High-fidelity ssb! The circuit is shown in **fig. 11**. Two LM324 quad op-amps are used. Each stage is adjusted, using the 47k trimpot, to produce a 90° phase shift at the frequencies shown. The design values were calculated from data published by S. D. Bedrosion,[9] if you're interested in getting into heavy phase-shift network design. The circuit in **fig. 11** has the advantage of having minimal loss.

Alignment techniques for both circuits in **figs. 10** and **11** involve the use of an audio oscillator and a scope, as mentioned above, a phase meter, or a network analyzer. A technique using the oscillator and scope is discussed in detail in the references.

For further reading the article by Wade[10] is recommended. An excellent description of simple methods for aligning phasing-type ssb exciters is given by Fred Johnson.[1]

rf phase-shift networks

Again, both active and passive phase-shift network designs are available. The networks commonly used in phasing ssb designs over the past 30 years are illustrated in **fig. 12**. Popularity seems evenly divided among the various circuits with the exception of E, the pi network. The RLG circuit in B is simply a variation of that in A. Input or output impedances are a consideration in all cases; the component values are dimensioned to accommodate external circuit conditions.

The networks in **figs. 12 A**, **B**, **C** and **D** are quite simple to set up. Usually, one of the components is made variable to provide phase adjustment for final circuit trimming. Extra components may be added to account for circuit strays as necessary.

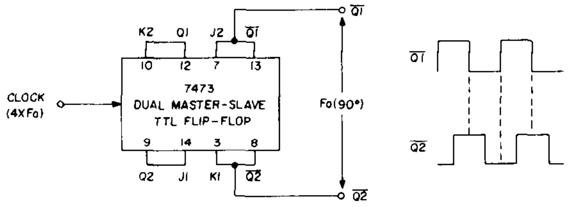


fig. 17. The 7473 IC connected to produce quadrature square waves.

The first two circuits exhibit an output phase characteristic that does not vary with frequency, but the relative amplitudes vary markedly either side of the design frequency. The circuits in C and D also exhibit the same characteristics, but the impedance varies also. The network in C exhibits least variation in this respect. Alternatively, another capacitor and resistor may be inserted in series with output terminals A and B respectively in the circuit of **fig. 12D** to reduce output impedance variation.

The technique of using two under-coupled tuned circuits, as in **fig. 12F**, was first popularized in reference 11 in 1950 and has been used in several phasing ssb transmitter designs since then. In practice, the two tuned circuits are coupled by 50% and 80% of critical coupling, and the links are adjusted to achieve equal-amplitude output. Secondary tuning is adjusted to provide the correct phase shift between the outputs. A very complete discussion on theory and practical considerations of this technique is given by R. W. Martin, VK2AHI.[12]

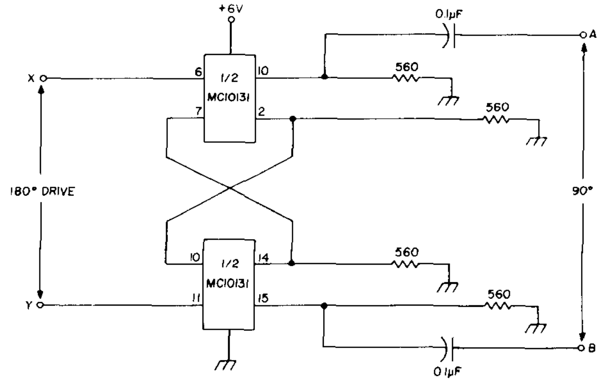


fig. 18. Digital quadrature-phase rf circuit given by Shubert, WAØJYK (reference 15).

All circuits shown in **fig. 12** suffer from three disadvantages:

A. They work only over a narrow range of frequencies and are thus limited to fixed-frequency applications or operation over bandwidths of 100 to 200 kHz at best.

B. All need periodic realignment as they are subject to drift due to environment (temperature, etc.) and component aging.

C. The practical upper-frequency limit is about 15 MHz at best, depending mostly on strays, external-circuit conditions, and component performance. In any case, using these circuits above 10 MHz is not recommended.

A technique that has occasional mention in the literature, but which I've not yet seen applied, is the use of coax cable as a phase-shift element in an ssb exciter. An electrical quarter wavelength of coax exhibits a phase shift of 90° at the design frequency and will remain within ±1° of this amount over a small bandwidth. Coax cables are relatively unaffected by temperature changes that would cause marked changes in the circuits discussed so far. The low impedance is an advantage in some instances (e.g., where diode-ring balanced modulators are used). Amplitude differences between the two outputs are not a consideration. This technique is extensively used in antenna phasing applications.

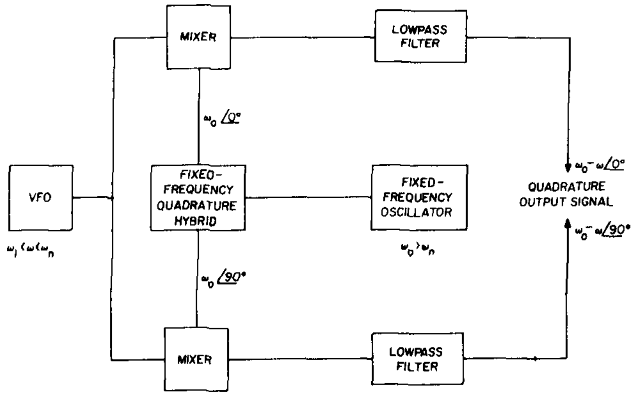


fig. 19. Quadrature signals can be generated over a wide band by adapting the third method of ssb-signal generation.

A coax-cable quadrature phase shifter is shown in **fig. 13**. No real theoretical upper frequency limit exists for this method, but practical limitations put it at about 150 MHz. A coaxial line-stretcher would be useful here. A coax-cable quadrature phase-shift network has the same disadvantages as those of the circuits in **fig. 12**, only slightly less so. An electrical quarter wavelength of coax on 10 MHz is nearly 16.5 feet (5m) long. This technique is probably best for fixed-frequency or narrowband use above about 15 MHz. Small-diameter cables, such as Microdot, of a suitable impedance are best as they are less bulky than standard cables such as RG-58/U.

Passive wideband rf phase-shift networks for application in phasing ssb exciters are rare in the literature. Richard Taylor, W1DAX, described a circuit in the Septmember, 1969, issue of *QST*[13] used in a direct-conversion ssb receiver for 14 MHz. The article was reprinted in the ARRL's *Single Sideband for the Radio Amateur*, fifth edition, 1970.

This circuit, **fig. 14**, will maintain 90° phase-shift and output amplitudes within 0.8 dB between 13.8 and 14.6 MHz. A bandwidth of 800 KHz isn't exactly wideband, but is certainly much better than the 100-200 kHz bandwidth of the circuits in **fig. 12**. The trimmer provides phase adjustment. As mentioned, Taylor[13] used this circuit in a direct conversion receiver, but it could be used in a transmitter as well. You could generate ssb signals directly on the desired output frequency rather than on a fixed frequency, which requires heterodyning to the desired output frequency, as in common practice.

Real advantages exist when generating ssb signals on the desired output frequency. The only spurs to contend with are those associated with opposite-sideband suppression and with intermodulation distortion, both of which must be considered in any heterodyning system.

Then there's the simplicity of the circuitry. A major push behind the development of modern IC circuits is the simplicity of the following circuitry; therefore, circuit simplicity is certainly an advantage. Circuit complexity isn't necessarily synonymous with sophistication or "the state of the art."

Quadrature rf phase-shift networks that operate over an octave or more in frequency were described many years ago. However, you must search the literature on antennas and circuit theory to find them.

The network in **fig. 15** is through the courtesy of Jim Koehlor, VE5FP/VK2BOX, who designed it for a circularly polarized antenna system. Two bridge networks each provide 45° phase-shift between 1 and 15 MHz, resulting in a differential phase shift of 90° over that range. Phase error is less than 1°, and the amplitude differences between outputs is less than 0.5 dB over the range. This rf phase-shift network

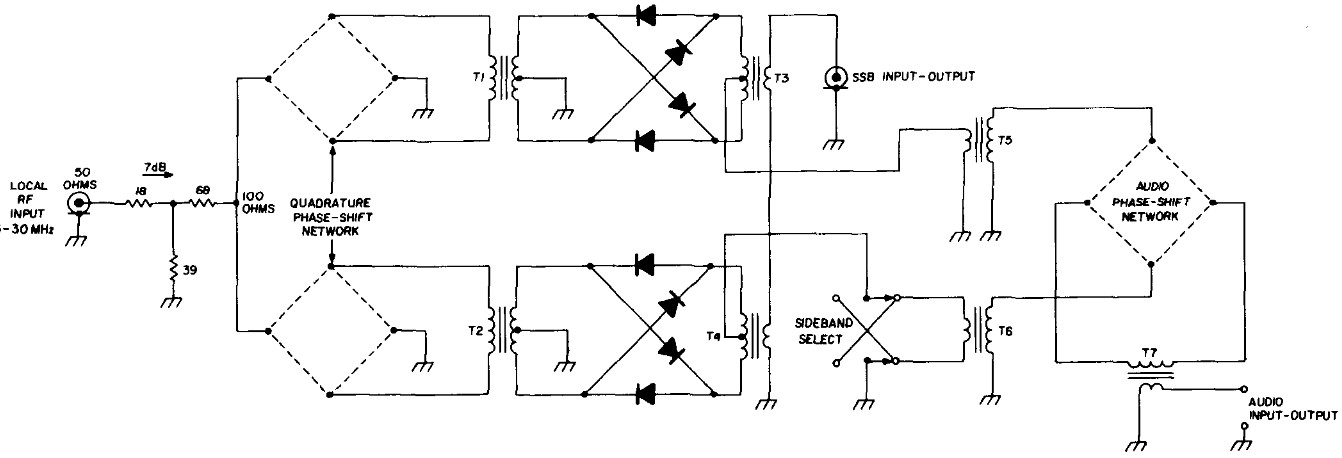


fig. 20. Suggested bilaterial direct-conversion phasing ssb generator-detector. T1-T4 are wideband rf transformers. T5-T7 are audio transformers to suit the audio phase-shift network used. A wideband rf transformer may be used instead of the 7-dB pad.

makes direct-conversion phasing ssb generation possible and has application in direct-conversion receivers. Third-method ssb generation, with output directly on any desired frequency between 1 and 15 MHz, is also a possiblity.

A network designed to cover 3 to 30 MHz is shown in **fig. 16**. It has characteristics similar to those of **fig. 15**. Input and output impedances of each bridge in both networks is 200 ohms. Transformers T2 and T3 transform the impedance to 50 ohms, which is convenient.

Although the inputs of each bridge are in parallel, making the input impedance 100 ohms, T1 may be the same as T2 and T3, as the mismatch has no serious effect on network performance. The three transformers are constructed as wideband baluns having a turns ratio of 2:1. Small toroids or dual-hole balun cores, such as the Neosid 1050/1/F14 or Indiana General F684-1, are suitable. The input and output windings must be isolated. To use dual-hole balun core, twist together three 7-inch (180mm) lengths of 26 or 30 B&S or AWG (0.3 or 0.25mm) enameled copper wire at about two twists per 3/8 inch (10m). Wind three turns through the two holes and connect two of the wires in series to make the 200-ohm winding. If desired, the secondaries of T2 and T3 may be arranged to drive diode-ring balanced modulators directly.

It's important that coupling between the tuned circuits in each arm of the bridge, and between each bridge, be kept to a minimum. Also, the *Q* of each coil must be at least above 50 or 60. Consequently, toroids have been suggested, although standard coil-former and screened-can assemblies (with ferrite cup cores) have been used successfully. Each arm is constructed individually and the inductor adjusted to resonate with the capacitor at the frequency indicated. Each series arm is temporarily connected as a parallel-tuned circuit to enable adjustment. This is very simply done with grid-dipper and a monitoring receiver. Sufficient accuracy is easily obtained. Of course, if you have a network analyzer or phase meter, the job is a little simpler.

Wideband active rf phase-shift networks involve digital techniques. This technique involves cross-coupled JK flip-flops and was described by A. J. Turner.[14] The circuit is shown in **fig. 17**. The upper frequency of such circuits is limited by the phase jitter between the two outputs and is somewhat below the upper clock speed limit of the device used. The clock frequency of the circuit shown in **fig. 17** must be four times the desired output frequency.

A circuit that requires a clock frequency only twice the desired output frequency is presented in **fig. 18**. This circuit is by G. K. Shubert.[15]

The disadvantage of the digital technique is the nonsinusoidal output waveform and the attendant harmonics that must be removed. Although these may be reduced with simple low-pass filters, extra spurs are undesirable. The digital technique has the big advantage of requiring no adjustment.

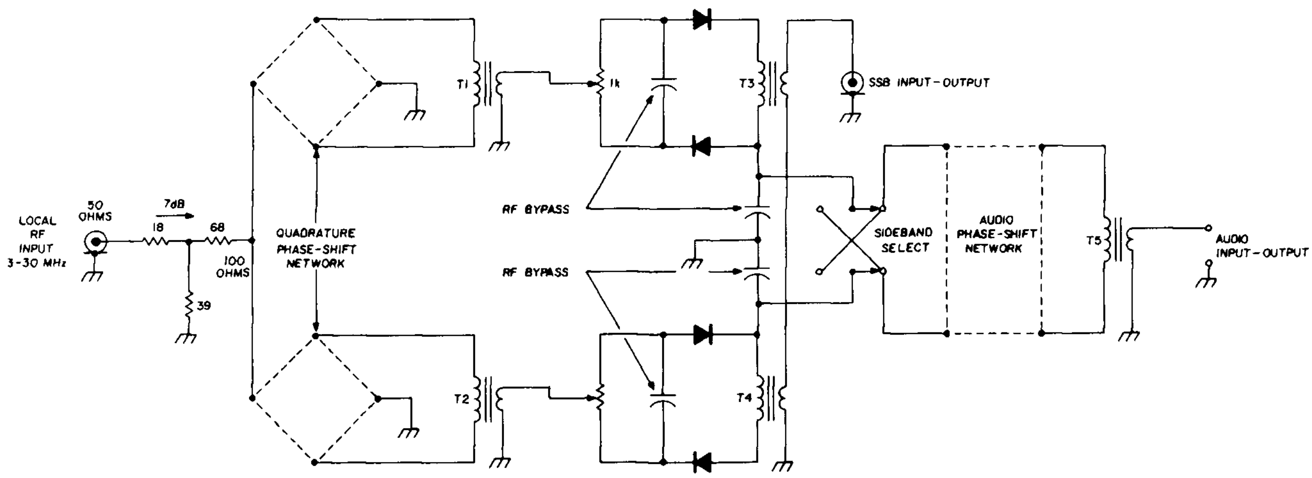


fig. 21. Another suggested bilateral direct-conversion phasing ssb generator. T1-T4 are wideband rf transformers. T5 is an audio transformer chosen for the phase-shift network used. As in the circuit of fig. 20, the 7-dB pad may be replaced by a wideband rf transformer.

Another technique for producing broadband quadrature rf signals, adapted from third-method ssb generation, is suggested by Taylor.[13] A block diagram, **fig. 19**, illustrates this. However, its relative complexity puts this technique at a disadvantage.

The networks in **figs. 15** and **16** and the circuits in **figs. 17** and **18** may be used for direct-conversion generation or reception of ssb signals using either the phasing method or the third-method as already mentioned. Indeed, it should be possible to build a passive phasing exciter using a combination of the techniques discussed. The third method produces superior performance with regard to opposite sideband and carrier suppression than either the phasing or filter techniques.

Fig. 20 shows a suggested bilateral direct-conversion phasing-type ssb generator/detector. It may be possible to use all-passive techniques. The audio phase-shift network may exhibit too much loss for successful operation and the bilateral feature of the circuit may be impossible to realize. T1, T2, T3, and T4 are wideband rf transformers as suggested previously. T5, T6, and T7 are audio transformers to suit the audio phase-shift network. A 7-dB resistive pad may be used to isolate the local rf input. Alternatively, a wideband transformer may be substituted.

Fig. 21 is a somewhat simpler circuit using series-bridge-diode balanced modulators instead of the ring-diode balanced modulators. Comments similar to those for **fig. 20** apply. Performance may not be quite as good as the previous circuit, but the simplicity may be an advantage. The phasing of the secondaries of T3 and T4 in both circuits is important.

references

1. Fred Johnson, ZL2AMJ, "The Tucker Tin Mark II, An SSB Transmitter of Simple Design," *Break-in* (New Zealand Association of Radio Transmitters Journal), August, 1971, pages 251-272.
2. Don Norgaard, W2KUJ, "Versatile Single Sideband Exciter," *CQ*, March, 1949, page 34.
3. N. Southwell, VK2ZF, "Wideband Audio Phase-Shift Networks," *Amateur Radio* (Wireless Institute of Australia Journal), June, 1955, pages 2-5 and July, 1955, pages 2, 3, and 12.
4. R. B. Dome, W2WAM, "Wideband Phase-Shift Networks," *Electronics*, December, 1946, page 112.
5. W. van Heddgem, "Audio Phase-Shift Network for Transistorized SSB Transmitters and Receivers," *QST*, December, 1964, page 27.
6. W. Doyle, W7CMJ, "Phasing-Type SSB Generator," *ham radio*, April, 1973, pages 22-25.
7. Robert C. Cheek, W3LOE, "Single Sideband for Everyone," *CQ*, November, 1948, page 17.
8. Richard K. Dickey, "Outputs of Op-Amp Networks Have Fixed Phase Difference," *Electronics*, August 21, 1975.
9. S. D. Bedrosion, "Normalized Design of 90° Phase Difference Networks," *IRE Transactions (Circuit Theory)*, June, 1960, pages 128-136.
10. A.I.H. Wade, G3RNW, "Design Criteria for SSB Phase-Shift Networks," *ham radio*, June, 1970, page 34.
11. "SSB Junior," *GE Ham News*, November - December, 1950.
12. R. W. Martin, VK2AHI, "The Coupled Tuned Circuit RF Phase-Shift Network," *Amateur Radio* (Wireless Institute of Australia Journal), September, 1967, pages 7-10.
13. Richard S. Taylor, "A Direct-Conversion SSB Receiver," *QST*, September, 1969. Reprinted in *Single Sideband for the Radio Amateur*, ARRL, fifth edition, 1970.
14. A. J. Turner, G3UFP, "Single-Sideband Suppressed Carrier Generation," *Wireless World* (England), September, 1973, pages 453-455.
15. G. K. Shubert, WA0JYK, "Phasing-Type Single Sideband Transmitter," *ham radio*, June, 1975, pages 8-22.

ham radio

RTTY test generator

Construction details for the *Digiratt* R/Y generator that can be used with the *Digiratt* afsk generator or as a stand-alone accessory

The Digiratt R/Y test generator is a companion unit to the original Digiratt precision AFSK generator and phase-locked-loop terminal unit featured in an earlier issue of *ham radio* magazine (September, 1977); it can be used with that unit or as a stand-alone accessory for RTTY enthusiasts.

While it would be simpler, from a design standpoint, to use a PROM (Programmable Read Only Memory) as the heart of the unit, I decided not to go this route for two reasons. First, few hams possess the required equipment necessary to program the PROM. Second, few people have the patience to do the programming. I also thought that more people would be interested in building a unit which used readily obtainable ICs. Those who do build the complete unit will have a non-mechanical device which generates 64 RYs, a carriage return, and a line feed.

The Digiratt R/Y generator is an eleven IC, TTL-based device for generating the 5-level Baudot code. It has on-board encoding for automatic sequential generating of the Baudot code necessary to print the letters R and Y. Additionally, encoding is provided for carriage return and line feed code generation. Logic is provided which keeps track of the number of characters printed and steers the output port to select either the RY message, carriage return (CR) or line feed (LF) code.

The unit was designed in such a way that by constructing only that portion of the schematic (**fig. 1**) enclosed by the dashed line, an RY generator only, can be built which deletes the CR and LF provisions. If this is done, the unit will print RYs continuously without regard to line length. Additionally, provision is made for "normal" and "inverted" output data to key transmitters with either mark high or space high signals. Finally, the unit is designed to operate at slightly less than the full 60 wpm. Older *Teletype* machines and those slightly out of adjustment should be able to copy the test message with little difficulty.

shift registers

Before examining the details of the schematic diagram (**fig. 1**), the basic operation of a shift register should be understood. The SN74165 registers used in this design are capable of changing an 8-bit parallel data bus into a serial stream of pulses. The parallel information is first loaded into the registers by the application of the load data pulse. Next, for each clock pulse that is received the bit pattern is serially shifted one register to the right. In this way, at the end of eight clock pulses the entire 8-bit data pattern is now in a serial form. By hardwiring the parallel input ports to a known pattern, a specific character, in this case CR and LF, can be generated. The hardwired pins, from right to left, or the first to last bit out are, 6, 5, 4, 3, 14, 13, 12, and 11.

The Baudot code used for *Teletype* is composed of 5 either mark or space conditions. Different combinations of the marks and spaces represent the actual letters, symbols, and functions. In addition to the first 5 bits, a start mark precedes the actual information. Finally, a stop pulse is used to indicate the end of the character. For the RY test generator I've combined the last two bits from the shift register into a

By John Loughmiller, WB9ATW, Route 1, Box 480C, Borden, Indiana 47106

slightly longer than normal stop pulse, 44 *vs* 31 ms. While this will slightly reduce the speed of the machine, it insures that older machines will print correctly.

circuit description

U1 is the clock pulse generator and, as such, is the heart of the system. The output from pin 3 provides a pulse train with a 45.45 hertz rate which is applied to the clock inputs of shift registers U4, U9, and U10. These pulses are also applied to pin 4 of U2 which divides the rate by a factor of eight (5.68). The divided signal then becomes the load data pulse for the shift registers.

To generate the required pulse configuration for the CR and LF functions, the eight parallel inputs of the shift register are hardwired to either 1 or 0. Initially, the load data pulse loads this hardwired information into the shift register. Each clock pulse then shifts the information one position. On the eighth pulse, new information is again entered into the shift register. Every eight pulses you will have a complete bit pattern available for use.

In addition to functioning as the load data pulse, the 5.68 hertz pulse rate is inverted and then used to clock U5, U6, and U7. U5 is a J-K flip-flop that will alternately change the hardwired pattern of the RY shift register. In this way, the shift register will produce an R and then a Y as the IC toggles. U6 and U7 are wired to divide by the fixed rate of 66. And, with the addition of U8, are the basis for producing the 32 RYs and the CR, LF on each line.

With the count initially at 66, a CR is generated, count 65 produces a LF with RYs being produced on the rest of the counts. At the end of the count cycle, the counters are preset to 66 and then start decrementing again. The actual selection of the RY, CR and LF bit pattern is done by a 4:1 multiplexer, U11. The signals from U8 determine which pattern is selected as the ultimate output.

Switch S1 is used as a manual reset to ensure that each line starts with an R. Normally, the reset is performed after the counter decrements down from 66. Holding the switch closed will result in continuous CRs being sent. This technique is not recommended if 74LS series ICs are used.

construction

The construction of the RY test generator is noncritical. The only special precaution that should be

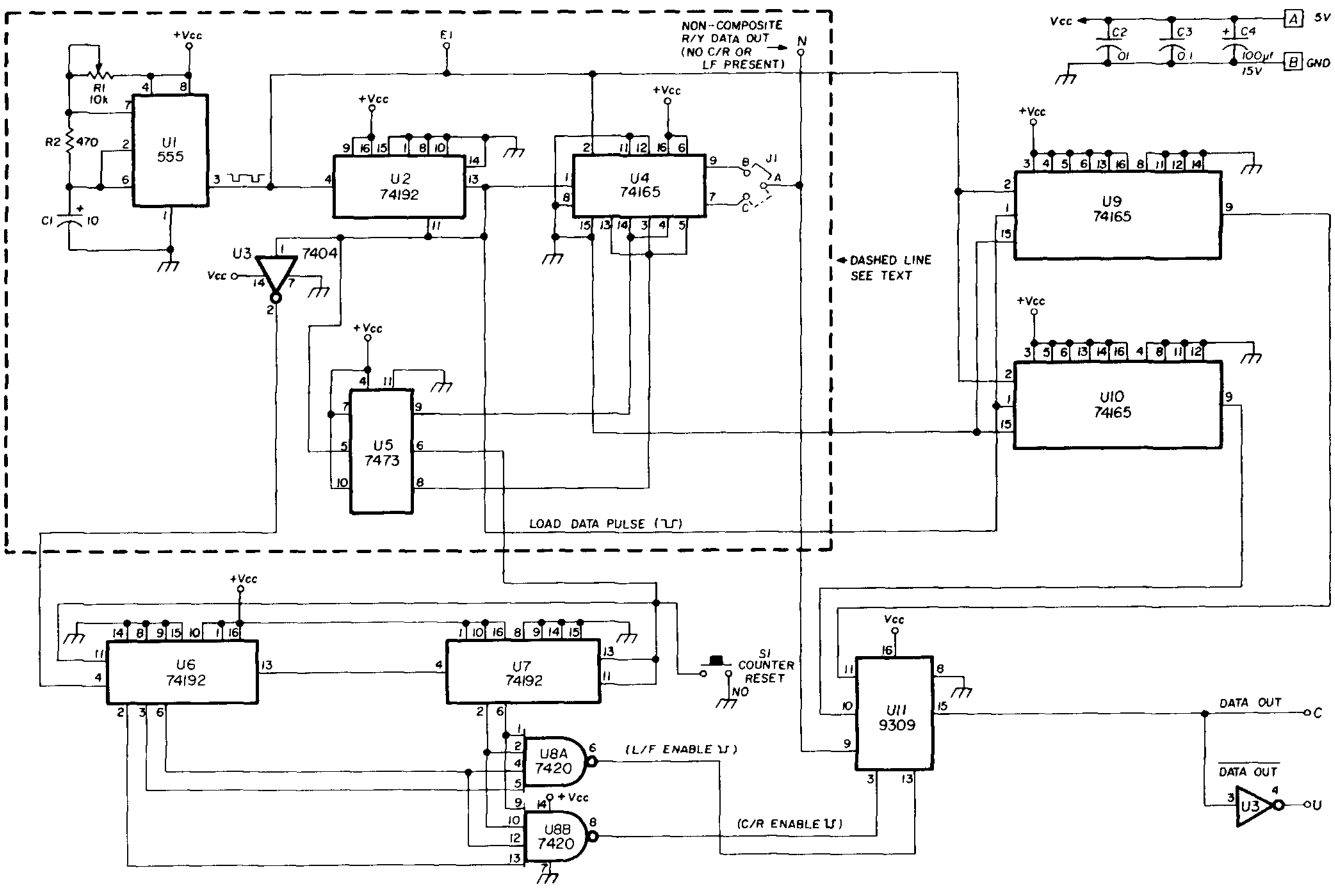


fig. 1. Schematic diagram of the RY test generator. The position of the jumper will permit you to select either inverted or normal RY information. A suitable loop keyer is shown in fig. 1, ham radio, September, 1977, page 27.

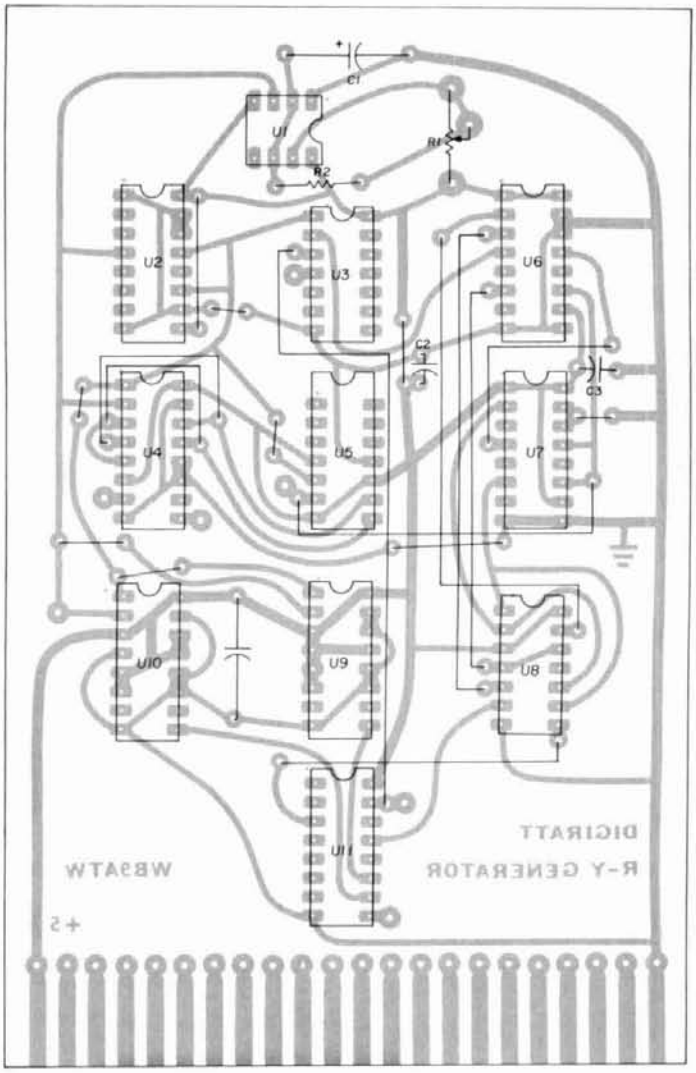


fig. 2. Component placement diagram for the board supplied by Circuit Specialists.

observed is to install the V_{cc} bypass capacitors on the board with the ICs (**fig. 2**). In extreme cases of rf interference, you may have to install additional bypass capacitors on the ICs. The power supply can be based on the popular LM309 with adequate heat sinking.

The first portion that should be assembled is indicated by the dotted line in **fig. 1**.* This portion will send a continuous stream of RYs. R1 should be adjusted to have the oscillator running at 45.45 Hz. If a counter is not available, R1 can be adjusted until the machine starts to print correctly.

*A drilled and plated circuit board is available from Circuit Board Specialists, Box 969, Pueblo, Colorado 81002 for $6.50. A complete kit of parts is also available from Circuit Specialists for $22.00.

ham radio

Two kinds of experts appreciate Rockwell-Collins equipment: People who buy it, and people who sell it.

Every Rockwell-Collins Distributor is a real pro at answering questions and solving problems.

He'll show you how to operate specific equipment, discuss peripheral gear, check everything out when you get it, even help with installation. And he'll be there to support your needs for years to come.

Get in touch with the distributor in your area. (And ask for a copy of the Rockwell-Collins Amateur Equipment Catalog.) Or contact Collins Telecommunications Products Division, Rockwell International, Cedar Rapids, Iowa 52406. Telephone 319/395-4493.

ALABAMA
Birmingham — Ack Radio Supply Company

ARKANSAS
De Witt — Moory Electronics Company

CALIFORNIA
Anaheim — Henry Radio Co., Inc.
Burlingame — *Ham Radio Outlet
Los Angeles — *Henry Radio Co., Inc.
San Diego — *Gary Radio Inc.
San Jose — Quement Electronics

COLORADO
Denver — *C. W. Electronic Sales Company

FLORIDA
Miami — Amateur Radio Center, Inc.
Miami Springs — *Argon Electronics Company
Orlando — Amateur Electronics Supply
Pensacola — *Grice Electronics, Inc.

GEORGIA
Atlanta — *Ack Radio Supply

HAWAII
Honolulu — *Honolulu Electronics

ILLINOIS
Peoria — Klaus Radio Inc.

INDIANA
Terre Haute — *Hoosier Electronics, Inc.

KANSAS
Overland Park — *Associated Radio Communications, Inc.

LOUISIANA
Metairie — *Thomas J. Morgavi Electronics

MARYLAND
Wheaton — *Electronics International Service Corp.

MICHIGAN
Muskegon — Electronics Distributors, Inc.

MINNESOTA
Minneapolis — *Electronic Center, Inc.

MISSISSIPPI
Jackson — **Coker Electronic Service

MISSOURI
Butler — Henry Radio Company
St. Louis — *Ham Radio Center
St. Louis — *MidCom Electronics, Inc.

NEBRASKA
Potter — **Western Nebraska Electronics

NEW HAMPSHIRE
Concord — Evans Radio, Inc.

NEW JERSEY
Maple Shade — **Communications Service Company

NEW YORK
Amsterdam — Adirondack Radio Supply, Inc.
Farmingdale, L.I. — *Harrison Radio Corporation
New York — *Barry Electronics Corporation
New York — Harvey Radio Company
Valley Stream — Harrison Radio Company

NORTH CAROLINA
Asheville — Freck Radio & Supply Company
Otto — Slep Electronics Company

OHIO
Cleveland — Amateur Electronic Supply
Columbus — **Central Communications

OKLAHOMA
Ponca City — **Starks Avionics & Communications Service

OREGON
Portland — *Portland Radio Supply Company

PENNSYLVANIA
Drexel Hill — Kass Electronic Distributors
Trevose — *Hamtronics

TEXAS
Abilene — *Howard Radio
Dallas — *Electronic Center, Inc.
Garland — *Teco, Inc.
Houston — *Madison Electronics Supply

WASHINGTON
Seattle — *ABC Communications
Spokane — *HCJ Electronics
Tacoma — C & G Electronic Company

WISCONSIN
Milwaukee — *Amateur Electronic Supply

*DISTRIBUTORS/SERVICE AGENCIES
**SERVICE AGENCIES ONLY

Rockwell International

...where science gets down to business

microwave bibliography

If you're interested in trying microwaves, but don't know where to start, this bibliography of amateur microwave articles will get you off on the right foot

Many amateurs have expressed an interest in microwave communications, but the techniques at microwave frequencies are considerably different than those used at vhf and uhf, so many amateurs don't know where to start. The following bibliography was prepared with this in mind. Far more good microwave information is documented in the amateur radio publications than is generally realized. Also included is a number of excellent books on the subject, as well as a short list of articles in other publications which are especially useful to the amateur microwave enthusiast; these publications can often be found in a local library.

If you're looking for the maximum amount of microwave information in the least amount of space obtain a copy of the 3rd edition of the RSGB's *VHF/UHF Manual* and read Chapter 3 — it contains more amateur microwave data per page than any other single publication.

In the field of microwave textbooks, there are a great many which are of limited use to amateurs; those books are not listed in the following bibliography. Microwave books which are listed in the bibliography were chosen because they had something to offer to the amateur microwave enthusiast. Lance's *Microwave Measurements*, for example, is an excellent introduction to microwave techniques for those readers who are looking for the non-mathematical approach. *Microwave Transmission Design Data* is a paperbound reference which covers many microwave subjects but is especially valuable for its explanation of circular waveguides. *Very High Frequency Techniques* is a compilation of a number of experiments from which the amateur can obtain cavity design information and practical transmission line information for new designs. The book, *Principles and Applications of Waveguide Transmissions*, provides excellent coverage of transmission lines and conical antenna design.

Microwaves are really simple, when you get to know them, and microwaves are far superior to the lower frequencies for line-of-sight point-to-point communications. Microwaves are also an experimenter's paradise, and far less expensive than 432 MHz was fifteen years ago — and much more satisfying. Microwave is one area where amateurs can still contribute to the art of radio communications — the following bibliography will head you in the right direction.

By Cliff Buttschardt, W6HDO, 1488 Warner Street, Chico, California 95926

ham radio magazine

Adams, F. E., W6BPK, "Pogo Stick for Reflex Klystrons," *ham radio*, July, 1973, page 71.

Fisk, J. R., W1DTY, "Simple Untuned Crystal Mount," *ham radio*, June, 1968, page 68.

Fisk, J. R., W1HR, "Solid-State Microwave RF Power Generators," *ham radio*, April, 1977, page 10.

Foot, N. J., WA9HUV, "Narrow-band Solid-State 2304-MHz Preamplifiers," *ham radio*, July, 1974, page 6.

Foot, N. J., WA9HUV, "2304-MHz Power Amplifier," *ham radio*, February, 1975, page 8.

Franke, J. M., WA4WDL, "Marker Generator for 3cm Amateur Band," *ham radio*, June 1969, page 69.

Franke, J. M., WA4WDL, "Finding the Focal Length of Surplus Microwave Dish Antennas," *ham radio*, March, 1974, page 57.

Franke, J. M., WA4WDL, "Waveguide Klystron Cooler," *ham radio*, October, 1974, page 64.

Franke, J. M., WA4WDL, "Dielectric Antenna for 10 GHz," *ham radio*, May, 1975, page 79.

Franke, J. M., WA4WDL, "Microwave Frequency Doubler," *ham radio*, March, 1976, page 69.

Franke, J. M., WA4WDL, and Cohen, N. V., WB4LJM, "Simple 10-GHz Antenna," *ham radio*, May, 1977, page 40.

Jackson, H., K7PMY, "New DX Record for 40,000 MHz," *ham radio*, December, 1968, page 70.

Kolbly, R. B., K6HIJ, "Standards for Amateur Microwave Communication," *ham radio*, January, 1969, page 54.

Kolbly, R. B., K6HIJ, "Low-Cost Microwave Antenna," *ham radio*, November, 1969, page 52.

Kowhler, J. A., VE5FP, "Proportional Temperature Control for Crystal Ovens," *ham radio*, March, 1972, page 16.

Laakman, P., WB6IOM, "A Large Homebrew Parabolic Reflector," *ham radio*, August, 1969, page 8.

Roubal, W. T., "Getting Started in Microwaves," *ham radio*, June, 1972, page 53.

Stanton, W., K2JNG, and Moser, D., WA2LTM, "Solid-State 2304-MHz Converter," *ham radio*, March, 1972, page 16.

Tillitson, G., K6MBL, "Microwave Polaplexer Design," *ham radio*, March, 1977, page 40.

Vilardi, D., WA2VTR, "Solid-State 2304-MHz Preamplifier," *ham radio*, August, 1972, page 20.

Wade, P. C., WA2ZZF, "High Performance Balanced Mixer for 2304 MHz," *ham radio*, October, 1975, page 58.

QST

Badger, G., W6RXW, "An Introduction to the Klystron," *QST*, August, 1961, page 11.

Baird, W. H., W6VIX, "A Radio Club for Microwave Enthusiasts," *QST*, December, 1957, page 45.

Biancomano, V., WB2EZG, "A Prototype Pulse-Code Modulation System," *QST*, January, 1977, page 24.

Bray, D. W., K2LMG, and Kirchuwer, P. H., W2YBP, "Antenna Patterns from the Sun," *QST*, July, 1960, page 11.

Bredon, A. D., W6BGK, "Let's go Microwave," *QST*, June, 1958, page 11.

Fisher, R. E., W2CQH, "Interdigital Converters for 1296 and 2304 MHz," *QST*, January, 1974, page 11.

Goodman, B., W1DX, "A 2400-Mc Oscillator Cavity," *QST*, October, 1947, page 65.

Guba, R. F., W1QMN, "Pulse: A Practical Technique for Amateur Microwave Work, Part 1," *QST*, February, 1963, page 11.

Guba, R. F., W1QMN, "Pulse: A Practical Technique for Amateur Microwave Work, Part 2," *QST*, March, 1963, page 26.

Guba, R. F., W1QMN, "Pulse: A Practical Technique for Amateur Microwave Work, Part 3," *QST*, April, 1963, page 31.

Guba, R. F., W1QMN, "Pulse: A Practical Technique for Amateur Microwave Work, Part 4," *QST*, May, 1963, page 58.

Hatherell, G. A., K6LK, "Putting the G-Line to Work," *QST*, June, 1974, page 11.

Jensby, W., WA6BQO, "Stable Microwave Oscillators," *QST*, July, 1966, page 33.

Knadle, R. T. Jr., K2RIW, "A Twelve-Foot Stressed Parabolic Dish," *QST*, August, 1972, page 16.

Kolby, D., K6HIT and Munn, E., W6OYJ, "Microwave DX — California Style," *QST*, September, 1970, page 88.

May, L., W5AJG/W5HN and Lowe, B., K4VOW/WA5UVM, "A Simple and Efficient Mixer for 2304 MHz," *QST*, April, 1974, page 15.

McGregor, J. A., W2RIM, "Dishing out the Milliwatts on 10 KMc," *QST*, February, 1947, page 19.

Merchant, R., W2LFG, and Harrison, A. E., W6BMS, "Duplex phone on 5300 Megacycles," *QST*, January, 1946, page 19.

Peterson, K. E., K3KRU, "Practical Gear for Amateur Microwave Communication," *QST*, June, 1963, page 17.

Petit, R. C., W7GHM, "Coherent CW — Amateur Radio's New State of Art," *QST*, September, 1975, page 26.

Prechtel, C. J., W8DRR, "Experimental Transceivers for 5600 Mc," *QST*, August, 1960, page 11.

Sharbaugh, A. H., W1NUL/2 and Watters, R. L., W9SAD/2, "Our Best DX — 800 Feet," *QST*, August, 1946, page 19.

Sharbaugh, A. H., W1NUL/2 and Watters, R. L., W9SAD/2, "The World above 20,000 Megacycles," *QST*, May, 1959, page 11.

Smith, B., W5TUB, "Simple Approach to 2300-MHz Space Reception," (The World Above 50 Mc), *QST*, March, 1974, page 88.

Sumner, D., K1ZND, "How to Promote Microwaves, British Style," *QST*, November, 1976, page 71.

Tilton, E. P., W1HDQ, "To the Moon and Back on 2300 MHz," *QST*, July, 1969, page 54.

Vilardi, D., WA2VTR, "Simple and Efficient Feed for Parabolic Antennas," *QST*, March, 1973, page 42.

Wilson, P. M., W4HHK and Knadle, R. T. Jr., K2RIW, "Houston, This is Appollo," *QST*, April, 1971, page 34.

Zimmer, J., W2BVU, "225 Miles on 2300 MHz," *QST*, February, 1969, page 53.

"Preview — DX Contest high 'Phone Scores," *QST*, June, 1954, page 54.

CQ Magazine

Harris, F. S., W1FZJ, "A 3800 Mc Crystal Oscillator," (VHF Column), *CQ*, September, 1958, page 102.

Harris, F. S., W1FZJ, "The Parametric Amplifier," *CQ*, November, 1958, page 74.

Katz, A., K2UYH, "Simple Parabolic Antenna Design," *CQ*, August, 1966, page 10.

Kretzman, B. H., W2JTP, "Microwave and the Amateur," *CQ*, August, 1967, page 53.

Massey, W., W4EXL, "A Coax Wavemeter for 300-2000 Mc," *CQ*, February, 1960, page 40.

Schauers, C. J., W4VZO, "Klystron Discussion," (Ham Clinic), *CQ*, September, 1963, page 66.

73 Magazine

Hoisington, B., K1CLL, "The World of X-Band," *73 Magazine*, March, 1973, page 33.

Olbert, S. M., W1SNN, "Mobile Smokey Detector," *73 Magazine*, Holiday issue, 1976, page 32.

"The Reach for Higher Frequencies," (*Lenkurt Demodulator*, October, 1969), Reprinted in April, 1971 issue, *73 Magazine*, page 34.

Radio Communications

Burt, G., GM3OXX, "The GM3OXX portable 3cm Transceiver," *Radio Communications*, June, 1975, page 450.

Evans, D. S., G3RPE, "Gunn diodes at 10,000 MHz," (Microwaves column), *Radio Communications*, April, 1971, page 271.

Evans, D. S., G3RPE, "A Gunn-diode power supply unit and modulator," *Radio Communications*, March, 1972, page 158.

Evans, D. S., G3RPE, "A Wideband 30 MHz i-f amplifier stroke detector," *Radio Communications*, July, 1972, page 430.

Evans, D. S., G3RPE, "A Self-calibrating wavemeter for 3cm," (Microwaves column), *Radio Communications*, February, 1973, page 106.

Evans, D. S., G3RPE, "Operating in the new 24 GHz (12mm) band," (Microwaves column), *Radio Communications*, March, 1973, page 192.

Evans, D. S., G3RPE, "Putting together waveguide equipment," (Microwaves column), *Radio Communications*, October, 1973, page 692.

Evans, D. S., G3RPE, "Practical 10-GHz Gunn Oscillators," *Radio Communications*, May, 1974, page 288.

Evans, D. S., G3RPE, "The 1-3 GHz Band," (Microwaves column), *Radio Communications*, November, 1975, page 852.

Evans, D. S., G3RPE, "Gunn diode Power Supply Units," (Microwaves column), *Radio Communications*, December, 1976, page 919.

Wakeman, A., G3EEZ, "A Simple 3cm Polaplexer," *Radio Communications*, November, 1970, page 752.

other publications

Myers, F. A., "Gunn Effect Technology — Diodes," *Microwave Systems News*, April/May, 1975, page 67.

Myers, F. A., and Foster, W., "Gunn Effect Technology — Oscillators," *Microwave Systems News*, August/September, 1975, page 83.

Myers, F. A., and Foster, W., "Gunn Effect Technology — Tuning and Temperature Effects," *Microwave Systems News*, October/November, 1975, page 57.

"The Reach for Higher Frequencies," *Lenkurt Demodulator*, October, 1969.

"Anomalous Propagation," *Lenkurt Demodulator*, July/August, 1975.

recommended microwave books

Evans, D. S., G3RPE, and Jessop, G. R., G6JP *VHF-UHF Manual*, 3rd edition, Radio Society of Great Britain, London, 1976.

Ginzton, E. L., *Microwave Measurements*, McGraw-Hill, New York, 1957.

Lance, A. L., *Introduction to Microwave Theory and Measurements*, McGraw-Hill, New York, 1964.

Mattaei, G., Young, L., Jones, E., *Microwave Filters, Impedance-Matching Networks and Coupling Structures*, McGraw-Hill, New York, 1964.

Montgomery, C. G., *Techniques of Microwave Measurements*, (MIT Radiation Lab Series), McGraw-Hill, New York, 1947.

Montgomery, C. G., Dicke, R. H., and Purcell, E. M., *Principles of Microwave Circuits*, (MIT Radiation Lab Series), McGraw-Hill, New York, 1947.

Moreno, T., *Microwave Transmission Design Data*, Dover Publications, New York, 1958, especially pages 120-122 and 126-129.

Reich, H. J., *Very High-Frequency Techniques*, Harvard Radio Research Laboratory, Boston Technical Publishers, Cambridge, Massachusetts, 1965.

Shrader, R. L., *Electronic Communications*, 3rd edition, McGraw-Hill, New York, 1975, Chapter 26, "Microwaves."

Southworth, G. C., *Principles and Applications of Waveguide Transmission*, Bell Laboratories, New Jersey, 1966, especially pages 415-419.

Thomas, H. E., and Clark, C. A., *Handbook of Electronic Instruments and Measurement Techniques*, Prentice-Hall, Englewood, New Jersey, 1967.

Wheeler, G. J., *Introduction to Microwaves*, Prentice-Hall, Englewood, New Jersey, 1963.

Reference Data for Radio Engineers, 5th edition, International Telephone and Telegraph, Howard A. Sams, Indianapolis, 1969.

ham radio

KENWOOD'S TS-520S AND DG-5 DIGITAL FREQUENCY DISPLAY

A NEW STANDARD IN ECONOMY TRANSCEIVERS

The NEW TS-520S combines all of the fine, field-proven characteristics of the original TS-520 together with many of the ideas, comments, and suggestions for improvement from amateurs worldwide. Kenwood's ultimate objectives . . . to make quality equipment available at reasonable prices.

FULL COVERAGE TRANSCEIVER

The new TS-520S provides full coverage on all amateur bands from 1.8 to 29.7 MHz. Kenwood gives you 160 meter capability, WWV on 15.000 MHz., and an auxiliary band position for maximum flexibility. And with the addition of the TV-502 and TV-506 transverters, your TS-520S can cover 160 meters to 2 meters on SSB and CW.

DIGITAL DISPLAY DG-5 (option)

The new Kenwood DG-5 provides easy, accurate readout of your operating frequency while transmitting *and* receiving.

OUTSTANDING RECEIVER SENSITIVITY AND MINIMUM CROSS MODULATION

The new TS-520S incorporates a 3SK-35 dual gate MOSFET for outstanding cross modulation and spurious response characteristics. The 3SK35 has a low noise figure (3.5 dB typ.) and high gain (18 dB typ.) for excellent sensitivity.

NEW IMPROVED SPEECH PROCESSOR

A new audio compression amplifier gives you extra punch in the pile ups and when the going gets rough.

VERNIER TUNING FOR FINAL PLATE CONTROL

A new vernier tuning mechanism allows easy and accurate adjustment of the plate control during tune-up.

FINAL AMPLIFIER

The new TS-520S is completely solid state except for the driver (12BY7A) and the final tubes. Rather than substitute TV sweep tubes as final amplifier tubes in a state of the art amateur transceiver, Kenwood has employed two husky S-2001A (equivalent to 6146B) tubes. These rugged, time-proven tubes are known for their long life and superb linearity.

HIGHLY EFFECTIVE NOISE BLANKER

An effective noise blanking circuit developed by Kenwood that virtually eliminates ignition noise is built-in to the TS-520S.

RF ATTENUATOR

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

VFO-520S — NEW REMOTE VFO

The VFO-520S remote VFO has been designed to match the styling of the TS-520S and provide maximum operating flexibility on the band selected on your TS-520S.

AC POWER SUPPLY

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

EASY CONNECTION PHONE PATCH

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

CW-520 — CW FILTER (OPTION)

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

AMPLIFIED TYPE AGC CIRCUIT

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

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

Specifications

Amateur Bands: 160-10 meters plus WWV (receive only)
Modes: USB, LSB, CW
Antenna Impedance: 50-75 Ohms
Frequency Stability: Within ±1 kHz during one hour after one minute of warm-up, and within 100 Hz during any 30 minute period thereafter
Tubes & Semiconductors:
- Tubes .... 3 (S2001A x 2, 12BY7A)
- Transistors 52
- FETs 19
- Diodes 101

Power Requirements: 120/220 V AC, 50/60 Hz, 13.8 V DC (with optional DS-1A)
Power Consumption: Transmit: 280 Watts Receive: 26 Watts (with heater off)
Dimension: 333(13⅛) W x 153 (6-0) H x 335(13-(13-3/16) D mm(inch)
Weight: 16.0 kg(35.2 lbs)

TRANSMITTER
RF Input Power: SSB: 200 Watts PEP CW: 160 Watts DC
Carrier Suppression: Better than -40 dB
Sideband Suppression: Better than -50 dB
Spurious Radiation: Better than -40 dB
Microphone Impedance: 50k Ohms
AF Response: 400 to 2,600 Hz

RECEIVER
Sensitivity: 0.25 uV for 10 dB (S+N)/N
Selectivity: SSB:2.4 kHz/-6 dB, 4.4 kHz/-60 dB
Selectivity: CW: 0.5 kHz/-6 dB, 1.5 kHz/-60 dB (with optional CW-520 filter)
Image Ratio: Better than 50 dB
IF Rejection: Better than 50 dB
AF Output Power: 1.0 Watt (8 Ohm load, with less than 10% distortion)
AF Output Impedance: 4 to 16 Ohms

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

VFO-520S

Here's the perfect companion for your TS-520S ... the new solid state remote VFO designed for the TS-520S. This handsome accessory features its own RIT circuit and control switch and, of course, adds greatly to the versatility and pleasure of your own station. (Also compatible with the TS-520.)

AT-200

A versatile addition to any station. Serves as an antenna tuner, an antenna switch, an SWR bridge and an in-line wattmeter. May be used on all HF amateur bands from 160 to 10 meters. Perfectly matched to the TS-520S and TS-820S, but can be used with any HF transceiver or transmitter with less than 200 watts output.

TRIO-KENWOOD COMMUNICATIONS INC. 1111 WEST WALNUT / COMPTON, CA 90220

KENWOOD
... pacesetter in amateur radio

introduction to GaAs field-effect transistors

What's a GaAs fet? Certainly not a gaseous field-effect transistor, as a misguided soul recently asked. *GaAs fet* is short for Gallium-Arsenide field-effect transistor; it is the hottest new uhf and microwave component, and is being widely used in industrial and military applications.

Gallium Arsenide is one of the newer semiconductor compounds, which until recently was used primarily for LEDs and microwave diodes. If you remember the *Periodic Chart of the Elements* from basic chemistry, you'll find the common semiconductors, silicon (Si) and germanium (Ge) in column IV of the chart, indicating they have four free electrons. It has also been found that semiconductors can be made by combining an element from column III, such as gallium (Ga) or indium (In), with an element from column V, such as phosphorous (P) or arsenic (As). The combined compound apparently has an average of four free electrons and acts as a semiconductor. The more successful combinations are gallium arsenide (GaAs), indium phosphide (InP), and gallium phosphide (GaP).

What is the advantage of using these exotic semiconductors? It arises from the higher carrier mobility of these materials — the electrons move faster than they do in silicon or germanium. This is the key to high-frequency performance; the maximum operating frequency of any amplifying device is limited by the time it takes a signal to pass through it (transmit time in a vacuum tube for example).

GaAs fet construction

Gallium arsenide is the most commonly used of these III-V semiconductors; with appropriate doping, it is used for field-effect transistors, infrared LEDs, and many types of microwave diodes including Gunn oscillators. The fets are fabricated on an epitaxial layer of the proper doping, with the channel defined between the high-conductivity source and drain areas (**fig. 1**). To take full advantage of the high carrier mobility for high-frequency performance, very short channels or gate lengths, are used. Typical gate length is one micron (10^{-6} meter) for a microwave GaAs fet; some devices are available with a half-micron gate length. The fundamental limitation is the wavelength of the ultraviolet light used to expose the photoresist, which is approximately 1/3 micron.

A one-micron gate seems very small, and it is, even though it is much wider than it is long — typically 100 to 150 microns wide. The current path is therefore relatively short and wide, a good high-frequency configuration. To increase power capability, several gates are paralleled for higher current. **Fig. 2** shows a typical GaAs fet structure with four gates in parallel (hidden by metallization). The gate itself is a Schottky junction, as opposed to the common P-N junction found in low-frequency fets.

How high in frequency do GaAs fets work? In the laboratory they have been operated to 22 GHz and higher. Commercially available devices work well up to about 12 GHz as low-noise amplifiers and power

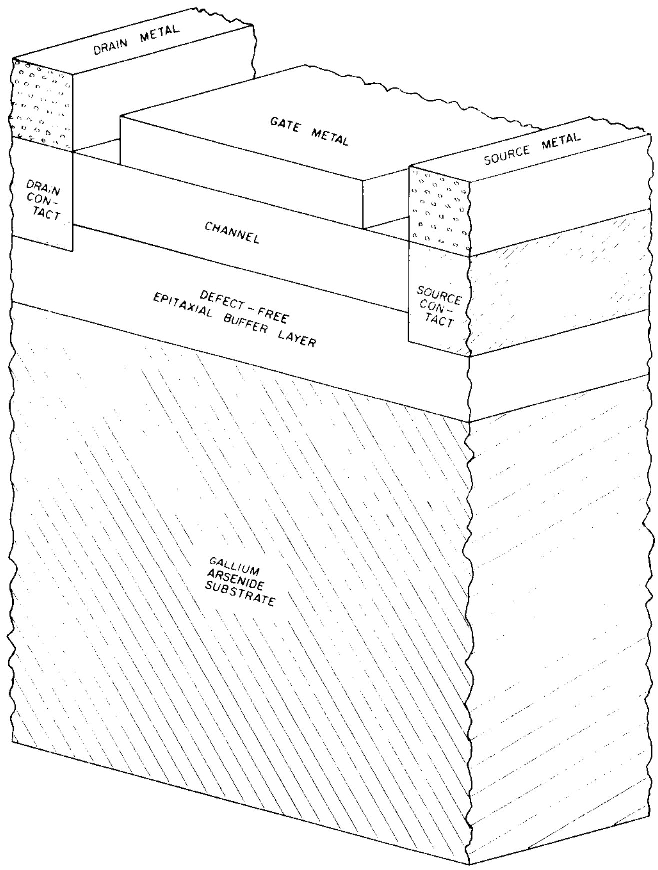


fig. 1. Construction of the GaAs fet, showing the channel between the high-conductivity drain and source areas.

By Paul C. Wade, WA2ZZF, GaAs FET Applications Leader, Microwave Semiconductor Corporation, 100 School House Road, Somerset, New Jersey 08873

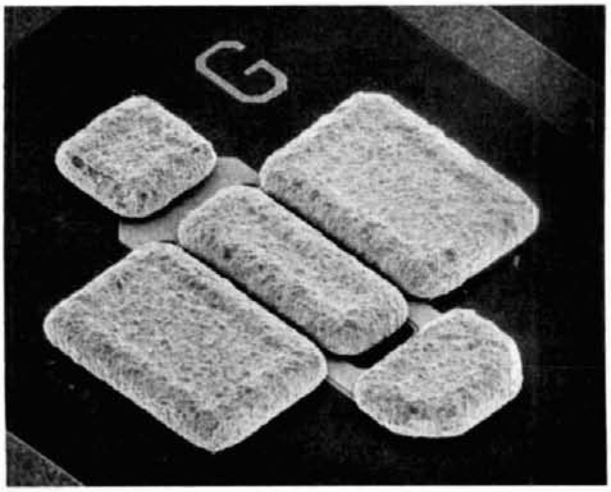


fig. 2. GaAs fet chip structure as seen by a scanning electron microscope.

amplifiers, and at even higher frequencies as oscillators. And this performance is obtained at low supply voltages, 3 to 12 volts.

At present, it is as low-noise amplifiers that GaAs fets really shine. Available noise figures were previously only obtainable with the best parametric amplifiers and MASERs. For instance, some GaAs fets offer noise figures under 2 dB at 4 GHz, and under 4 dB at 12 GHz. A few of these devices are finding their way into amateur hands; at the recent Eastern VHF/UHF Conference, K2UYH's 432-MHz preamp, using a NEC V244 GaAs fet, had a measured 0.8 dB noise figure! However, the prices for these devices, while dropping, are still rather steep.

Power GaAs fets are newer, but are also showing respectable performance. Devices are commercially available with 1 watt output up to 8 GHz, and more than 6 dB power gain. Since these are linear devices, unlike bipolar microwave transistors, the power and gain are specified at the standard 1 dB compression point.

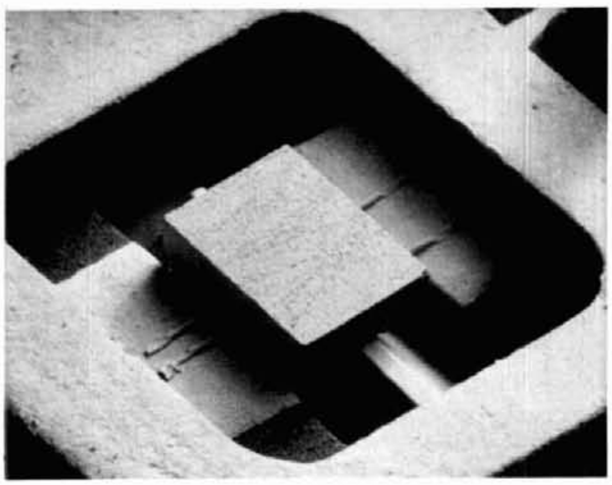


fig. 3. GaAs fet chip flip-chip mounted in package.

One problem with power GaAs fets is adequate heat sinking, since gallium arsenide has a thermal conductivity much lower than silicon. Normally, planar transistors are fabricated with the active area up and the heat is conducted through the bulk semiconductor material underneath. With power GaAs fets, however, some manufacturers are using an inverted mounting technique, with the source metallization attached directly to ground, as shown in **fig. 3**. This technique not only halves the thermal resistance, but also reduces the source inductance, which improves stability.

Investigation of GaAs fets as oscillators has only begun recently. To date, we have obtained as much as 0.6 watt output at 9 GHz from an oscillator. The highest frequency oscillator we have made so far was at 17.1 GHz, where we obtained 100 milliwatts from the waveguide oscillator shown in **fig. 4**.

precautions

GaAs fets also have a reputation for being fragile, but all new semiconductor devices pass through this stage; they inevitably become more rugged as better manufacturing techniques are developed. The latest

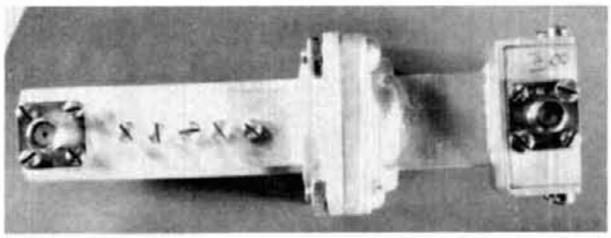


fig. 4. A GaAs fet 17-GHz waveguide oscillator.

GaAs fets are damaged only by excess voltage or extremely high temperature (>300°C). An excessive voltage applied between the source and drain causes a bulk breakdown, which unlike avalanche breakdown in a transistor, is irreversible. With the addition of protective zener diodes, however, GaAs fets are as rugged as most microwave semiconductor devices.

It may seem that GaAs fets are too rare, exotic, and expensive for amateur use, but many new devices started out this way. Then, radio amateurs like K2UYH, who needs the improved low-noise performance for his moonbounce work, began using them. Finally, after a few years, price and availability become more reasonable and formerly exotic devices come into general usage. This may or may not happen with GaAs fets, but amateurs should keep an eye on new technologies for the future.

*All photographs courtesy Microwave Semiconductor Corporation.

ham radio

new op amp challenges the 741

The new CA3140 IC op amp from RCA features a high-impedance mosfet input stage, improved slew rate, and wider frequency response at comparable cost to the popular 741

For several years the 741 op amp IC has been the popular workhorse for both industrial and hobbyist circuit designers. Why? Because it's inexpensive and simple to use. Of course, its slew rate isn't too great, and its input bias current isn't anything to write home about, but what do you expect for twenty-five cents?

Now there's another op amp IC on the market which I think deserves as much attention as the 741; it's the new RCA CA3140. Like the 741, it requires no external frequency compensation components, and its output is short-circuit proof. Its pin configuration is the same as the 741, and RCA claims the CA3140 is a direct plug-in replacement for the 741 in most applications.

So, what's so special about the CA3140? For openers, it has mosfet input transistors (diode protected) which means you can use much higher value resistors in the input circuit without worrying about their effect on output offset voltage. Another big advantage is that the slew rate of the CA3140 is an order of magnitude faster than that of the 741. Supply voltage range for both op amps is the same; ±2 to ±18 volts.

Now for the price. At this writing, it's available in an 8-pin TO-5 can for 80 cents in small quantities. It is reported that it will soon be available in the popular 8-pin minidip plastic package for 72 cents. The slight difference in cost as compared to the 741 seems very reasonable for the higher performance of the CA3140.

Table 1 lists some important parameters for both the 741 and the CA3140, so you can quickly see what you're getting for your money. Specs given are for the commercial versions.

The big differences between the two op amps are clearly input resistance and bias current, and slew rate. Typical curves for the devices show that maximum output voltage swing for the 741 is flat out to 10 kHz before it starts falling off at higher frequencies, while the CA3140 is flat out to 100 kHz. **Fig. 1** shows a block diagram of the CA3140, and **fig. 2** shows the schematic diagram.

a disadvantage

There is one point on which the 741 is superior to the CA3140: the 741 will drive a lower resistance load than the CA3140 will. My experience shows that severe clipping of the output occurs on negative peaks when the load resistance on the CA3140 is 1200 ohms. If the load resistance is increased to 2000 ohms, this problem disappears. The 741 output circuit is a complimentary npn-pnp emitter follower, while the CA3140 has an npn emitter follower with a current source in the emitter circuit.

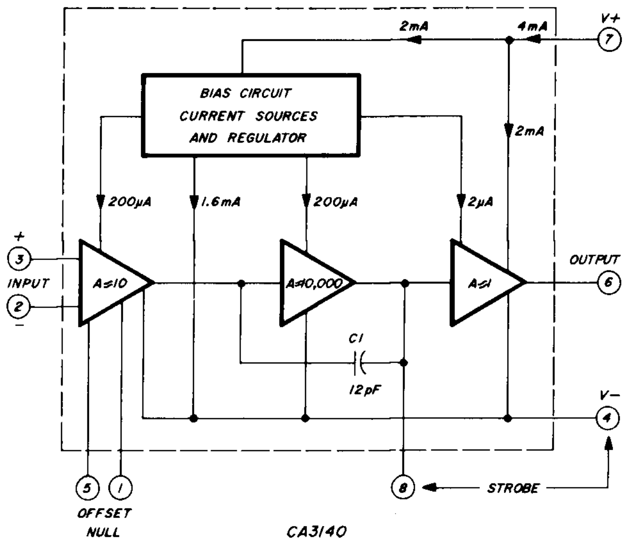


fig. 1. Block diagram of the new RCA CA3140 op amp IC which is a direct plug-in replacement for the popular 741 in most applications, but features a mosfet input stage for high input impedance.

application

Since the input current to the CA3140 is so low, many megohms of unbalanced resistance may be

By Courtney Hall, WA5SNZ, 7716 La Verdura Drive, Dallas, Texas 75248

table 1. **Specifications of the 741 and RCA CA3140 op amp ICs, compared at +25°C.**

parameter	741	CA3140	units
Input resistance (typical)	2.0	1.5×10^6	megohms
Input bias current (max)	500,000	50	picoamps
Input offset voltage (max)	6	15	millivolts
Slew rate (typical)	0.5	9	volts/μs
Large signal voltage gain (min)	20,000	20,000	volts/volt
Output resistance (typical)	75	60	ohms
Power supply rejection (max)	150	150	μ volt/volt
Common mode rejection ratio (min)	70	70	dB

used in the input circuit with no appreciable dc output offset due to bias current. Consider the circuit of **fig. 3**. The inverting input terminal sees a parallel equivalent resistance of 10 megohms. Since the maximum input bias current is 50 pico-amperes (0.00005 microamp), the offset voltage due to bias current will be no more than 0.5 millivolt. Therefore, for most applications, you can use just about any resistor network you choose on the input and forget about its effect on the offset voltage.

I took advantage of this feature of the CA3140, plus its high slew rate, to build the simple Wien bridge sine wave generator shown in **fig. 4**. Both ICs are CA3140s. U1 is the oscillator, and U2 provides a constant 600-ohm output impedance, regardless of the amplitude setting.

The resistor network at the output lets U2 see a load resistance of 2000 ohms when the output terminals are connected to a 600-ohm load; it also causes the output terminals to look like a 600-ohm source. Maximum output amplitude into a 600-ohm load is about one volt rms.

Frequency range of the Wien bridge oscillator is 30

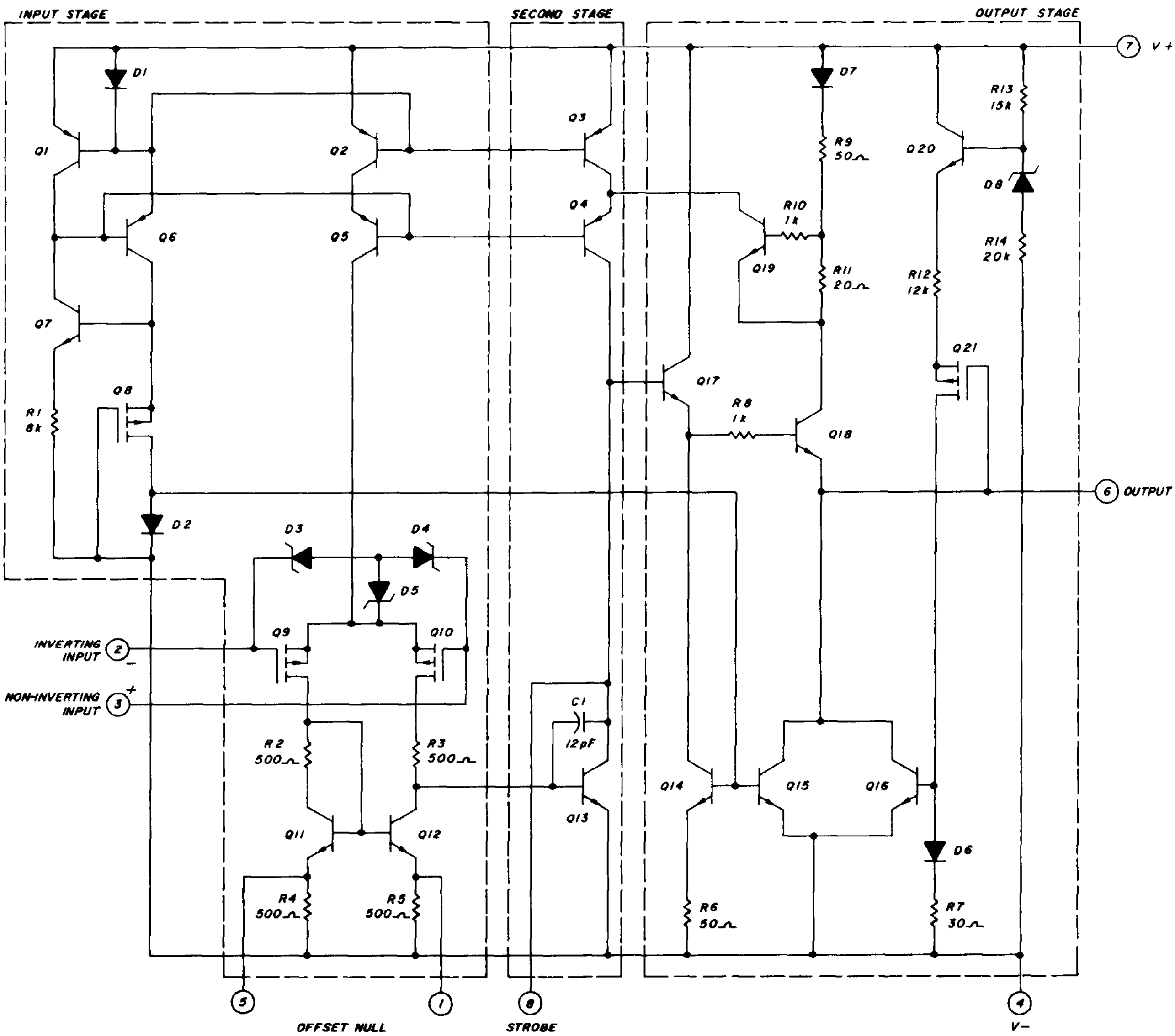


fig. 2. Schematic of the RCA CA3140 op amp IC with diode-protected mosfet input stage. As compared to the 741 op amp, the CA3140 offers higher input impedance and improved slew rate. Typical specifications for the two devices at room temperature are listed in *table 1*.

Hz to 100 kHz and is flat within 0.5 dB, due to the excellent gain control characteristic of the thermistor in the feedback circuit of U1. The 10k pot is adjusted for best waveform. Total harmonic distortion is less than 0.5 per cent at all frequencies. C1 and C2 is a two-gang 450-pF air variable. Its frame must be insulated from ground; I mounted it on a piece of plexiglass and used an insulated shaft coupling to connect it to the dial. A trimmer capacitor is needed to balance out stray capacitance from the capacitor frame to ground.

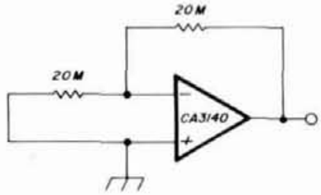


fig. 3. Maximum dc offset of this circuit due to bias current is 0.5 millivolt.

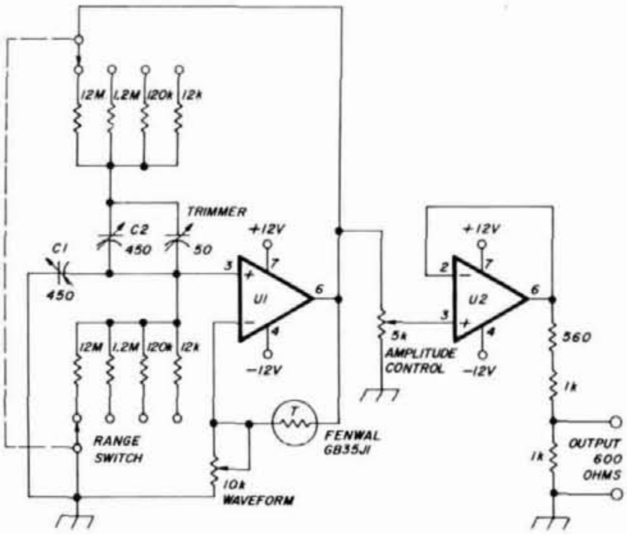


fig. 4. Wien bridge sine-wave oscillator using two RCA CA3140 op amps covers 30 Hz to 100 kHz with less than 0.5 per cent total harmonic distortion. The 10k pot is adjusted for best waveform. Capacitor C1 and C2 is a two-gang 450-pF variable with its frame isolated from ground. Maximum output into a 600-ohm load is about 1 volt rms.

a word of caution

The input bias currents given above are for +25°C ambient temperature (room temperature). As temperature increases, the input bias current of the CA3140 will approximately double for each 10°C rise. At +125°C, its value will be roughly 1000 times greater than at room temperature. Input bias current for the 741, however, actually decreases as temperature rises.

ham radio

the answer is MAXI

The only No-Compromise Antenna Tuner on the market

Where else can you find all these features?

- Presents 50-75 ohm resistive load to your transmitter using virtually any antenna system
- Improved ultimate transmatch circuit
- Continuous coverage 1.7-30 MHz, including MARS plus much more
- Rotary inductor (28 UH)
- Dual 500 pF capacitors, 6000 volts peak to peak
- Handles 3 kw PEP
- Heavy duty custom balun transformer
- Matches unbalanced coax lines, balanced open-wire or twin-lead lines, and random length end-fed wires
- Cast aluminum counter dial on rotary inductor, 0-99.9 turns
- 6 to 1 ratio vernier drives on both capacitors for velvet-smooth tuning
- 0-100 logging scale on verniers for accurate resetability
- Monimatch SWR metering
- Available in kit form or assembled
- One year warranty!
- 14½ inches wide, 6½ inches high, 13½ inches deep, 15 pounds
- Custom vacuum variable designs and individual components available

MAXI TUNER without SWR (Assembled) $259.00
MAXI TUNER with SWR (Assembled) $289.00
MAXI TUNER without SWR (Kit Form) $229.00
MAXI TUNER with SWR (Kit Form) $259.00

Export inquiries invited — Ideal for Military, Industrial, Scientific and Coastal off-shore users —

Communications Technology Group

Post Office Box 103, Rockville Centre, N.Y. 11570 — Phone (516) 536-5724

See Our Booth at all the popular Hamfests

INFO-TECH M-93 TERMINAL UNIT

Check these advanced features:

- State of the art **three shift** active filter demodulator
- **Three shift** AFSK using function generator chip
- **Regeneration** on both receive and transmit using UART
- C.W.I.D. (prom programmed)
- 60 ma constant current loop supply
- Autostart
- L.E.D. tuning indicators for easy tuning

PRICED AT ONLY $239.50

Write for information or see them at

Cohoon Amateur Supply
Highway 475
Trenton, Ky. 42286

Germantown Amateur Supply
3202 Summer Ave.
Memphis, Tenn. 38112

Ham Radio Center
8342 Olive Blvd.
St. Louis, Mo. 63132

G. Hutter-Kunststofftechnik
Postfach 2129
D-8990 Lindau (B)
West Germany
(Dealer for Germany, Austria, Switzerland)

International Commercial Sales
14 Pleasant View Drive
Annawan, Ill. 61234

Mid Com Electronics, Inc.
2506 South Brentwood Blvd.
St. Louis, Mo. 63144

N & G Distributors
4545 N.W. 7th St.
Miami, Florida 33126

INFO-TECH INCORPORATED *Specializing in Digital Electronic Systems*

2349 Weldon Pkwy. St. Louis, Missouri 63141 Phone (314)576-5489

More Details? CHECK—OFF Page 142

MICROPROCESSORS

microprocessors: a microprocessor controlled CW keyboard

Now that the microprocessor has made the homebrew computer possible, its popularity should tend toward dedicated applications in amateur radio. In this article, a preprogrammed microcomputer is designed to function as a Morse Code keyboard with extra features providing the utmost in flexibility. This project is an attractive alternative to its discrete equivalent with numerous gates, flip-flops, binary counters, and diode matrices.

The code computer was designed around the MCS-6504 microprocessor by MOS Technology. The other devices connected to the processor chip comprise a software simulation of a discrete logic system. The software for this project was developed and debugged with the aid of a KIM-1 microcomputer. After the program was working to my satisfaction, the source listing for the software package was transferred to the 1702A EPROMs for permanent storage. Thus, the system is running upon application of power.

However, this system does more than synthesize Morse code from an ASCII keyboard. It also provides control functions, for operator convenience, which are unheard of in similar units of discrete design. The features of this system are:

1. Variable code speed, 5 to 99 wpm range. Code speed is entered digitally from the numeric keys on the keyboard.

2. 256-character first-in-first-out (FIFO) buffer memory. This allows the operator to type faster than the machine is sending. At 10 wpm, it's possible to get five minutes ahead of the machine.

3. Automatic character spacing. Word spacing is provided by the operator's depressing the SPACE bar on the keyboard.

4. 64-character auxiliary buffer for storing repeated messages like CQ or call-up sequences. Data can be entered into the auxiliary buffer without causing interference to the FIFO.

5. BACKSPACE command. A backspace routine is included in the software for FIFO error correction, and operates like the BACKSPACE key on a typewriter. For ASCII keyboards without a BACKSPACE key, CONTROL H can be used.

6. Automatic default. Illegitimate control characters are ignored by the program to prevent a software lock-up condition. Control characters are used for code speed entry, auxiliary buffer data entry, auxiliary buffer data transfer to FIFO, and backspacing.

7. TRANSMIT/RECEIVE output. This reed output automatically switches your transceiver from receive to transmit when you begin typing. The rig will stay on the air until the FIFO is empty.

8. Warning lights. Two indicator lamps are provided to prevent the operator from filling the FIFO to the OVERFLOW point. Lamp 1 lights when there are less than 64 character spaces left in the FIFO. Lamp 2 (condition red) turns on when the operator is within 16 characters of OVERFLOW.

9. FIFO full output. This signal from U13 goes to a logic 1 when the condition red lamp goes on. It stays high until the condition yellow lamp turns off. This output can be used to control a paper-tape reader.

By James W. Pollock, WB2DFA, 6 Terrace Avenue, New Egypt, New Jersey 08533

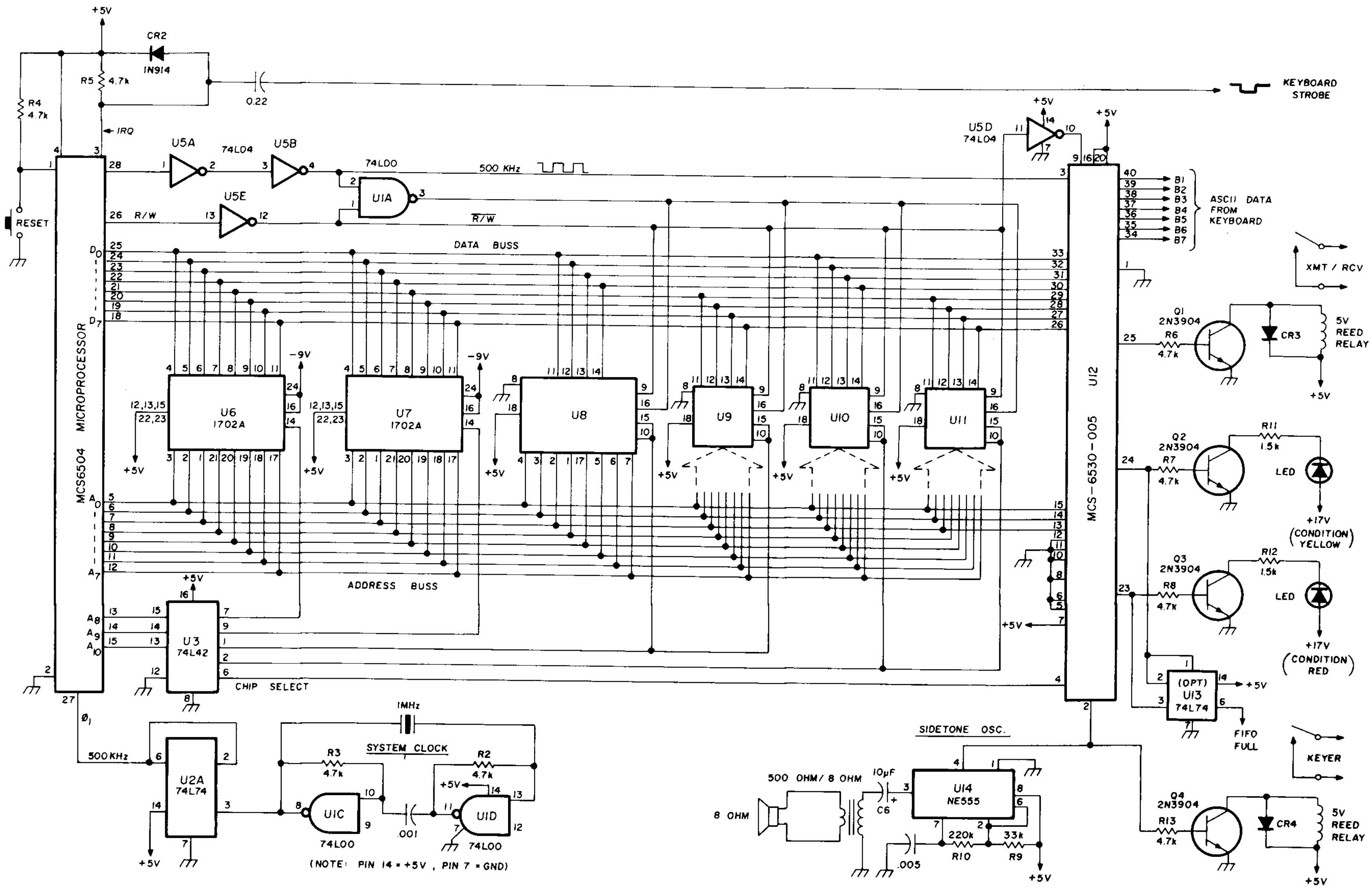


fig. 1. Schematic diagram of the microprocessor controlled keyboard. The MCS-6504 and MCS-6539-005 are available from Falk-Baker Associates, 382 Franklin Avenue, Nutley, New Jersey 07110, for $20 and $14, respectively. The 2111 RAMs can also be obtained from the same source.

10. By adding a serial-to-parallel converter, like a UART, the system can be used with an ASR-33 or similar Teletype, CRT serial data terminal, etc.

Although construction is not especially critical, this project is not recommended for the beginner; an experienced hardware hacker should encounter no difficulty. The cost of this project including power supply, ASCII keyboard, enclosure, and all parts is less than $200. About half of that figure will be invested in the ICs alone. Knowledge of basic microprocessor operation and programming is recommended, but is not a requirement to build the system since the EPROMs store the system's operation program.

It's important that the builder be very meticulous while assembling the system. Since computers do only what they are told to do, a miswired address or data line will wreak havoc. Interchanging EPROMs U6 and U7 will have the same effect. The instructions for the program have been listed in a specific order to define the behavior of the Morse keyboard. Interchanging the EPROMs, in effect, scrambles the order in which the instructions are to be executed.

system operation

The heart of this code computer is a 6504 microprocessor which is a software compatible cousin to the 6502. The 6504 was chosen for its lower cost and compact 28-pin package design.

The crystal oscillator (U1C and U1D) functions as the system clock (see **fig. 1**). U2A divides the 1-MHz clock down to 500 kHz to compensate for the slow speed of the 1702A EPROMs. Since the access time for the 1702A is usually specified at 1 μsec, the operation of surplus units may be marginal at the full 1-MHz clock rate. Thus, a system clock of 500 kHz was chosen to prevent EPROM access timing problems without resorting to buying factory prime units.

Pin 28 (ϕ2 out) on the 6504 is used to coordinate the read/write timing of the RAMs (U8-U11) and the peripheral interface adapter (PIA), U12. U5A, U5B, and U5C buffer the read/write and ϕ2 signals to prevent loading effects on the microprocessor.

The PIA (U12) is used to interface the data bus of the microprocessor to the ASCII keyboard, keying relay, xmt/rcv relay, side tone oscillator, and the FIFO warning lamps. Thus, the PIA chip is used as an I/O port for the system. Port A is used to read the seven-bit input from the ASCII keyboard. Pin 2 of the PIA is bit 0 of Port A and is used as the serial output for the Morse code information that switches the side tone oscillator (U13) and the keying relay driver transistor (Q4). Port B is used as an output latch for the FIFO status flags.

1. Pin 25 — TRANSMIT/RECEIVE output
2. Pin 24 — Condition yellow output
3. Pin 23 — Condition red output

In addition to two I/O ports, the PIA is equipped with a read/write interval timer that is used extensively for the timing of dots, dashes, and spaces. The timer is programmable in discrete steps of two milliseconds with a 500-kHz time base.

The PIA also has a 64 by 8 bit RAM that can be used for scratch pad, or temporary program storage. The RAM, however, was not used on this system.

The RAMs (random access memories) chosen for this project are 2111's (U8, 9, 10, 11). These chips are organized as 256 by 4 bit devices, and are used in pairs to accommodate the 8-bit data bus of the microprocessor. Thus each pair (U8, U9, and U10, U11) makes up a 256 by 8 bit memory page for a total RAM storage of 512 bytes. As seen in **fig. 1**, the RAMs are used as temporary storage for the system scratch pad and messages entered via the keyboard.

These particular RAMs, like the microprocessor, have a bi-directional data bus that permits OR tying to the CPU for ease of construction. The $\overline{R/W}$ signal from U5E, when a logic 0, allows the RAMs to send data to the CPU; when a logic 1, they will accept data.

The bi-directional data bus of the CPU, pins 18-25, is OR tied with the data bus pins of the EPROMs, RAMs, and the PIA. Since these lines are tri-state, ORing them in this fashion greatly simplifies construction. These I/O pins are in a high impedance state when the chip select ($\overline{CS}$) pin of the IC is a logic 1. Since the address bus is a "one-way street," these lines are also tied together.

Selection of the support devices is accomplished by U3. The high order address lines of the CPU, are decoded by U3 which in turn presents a logic 0 at the $\overline{CS}$ pin of the appropriate device. Address lines A8-A10 select the support device (RAM, EPROM, PIA) while the low order address lines A_0-A_7 select a memory cell within that device. **Table 1** shows the selection scheme with regard to the address lines.

table 1. Device selection by the microprocessor.

device selected	A10	A9	A8
U8 and U9	0	0	0
U10 and U11	0	0	1
U12	1	0	1
U6	1	1	0
U7	1	1	1

*A PROM programming service is available from Keith Petersen, 1418 Genesee Street, Royal Oak, Michigan 48073. For this project only, the cost is $6 for programming plus $1 for shipping and handling, per pair. Send the PROMs in a conductive carrier to prevent static discharge damage.

In order to have data from the keyboard processed by the CPU, the strobe output from the keyboard drives the Interrupt Request pin (IRQ) with a negative-going pulse. The negative-going pulse at the IRQ input is about 10 μsec long. Using the IRQ input in this manner alerts the CPU to the fact that keyboard data has been entered for processing. A

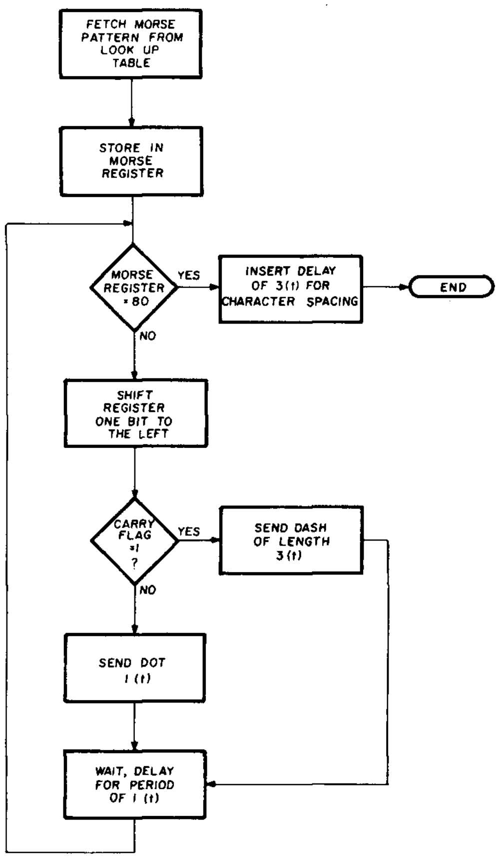


fig. 2. This flow chart shows the ASCII to Morse conversion used in the keyboard.

subroutine then fetches the keyboard data from the PIA and stores it in memory each time a key is pressed.

Any ASCII encoded keyboard with TTL compatible output levels will easily interface with the computer. Pins 34-40 are the ASCII inputs to the PIA, with pin 40 being the least significant bit, B1. The KBD-5 ASCII keyboard kit by South West Technical Products is a good choice. Regardless of the keyboard you select, bear in mind that the keyboard must be programmed for upper case characters; lower case characters will not work in this system.

On the KBD-5, the BACKSPACE key is uncommitted and must be connected to the on-board encoder. In my case, I connected the leads for the BACKSPACE key to pins 26 and 36 of the AY-5-2376 encoder. The ASCII output will then be 0001000 when the key is pressed. One additional point should be remembered: the ASCII outputs are not latched, and will only be present when the key is pressed.

ASCII to Morse conversion

The generation of the Morse character for its ASCII equivalent begins by using **table 2** for U6. As an example, the ASCII code for the letter F is 1000110 or 46_{hex}. The CPU looks at the 46th position in **table 2.** At position 46_{hex} the number is 00101000 or 28_{hex}. The CPU stores this value in a memory location for shift operations during the code synthesis process and for future reference.

table 2. Look-up table listing for U6

	ASCII	hex	Morse code group	hex equivalent	
A	1000001	41	01100000	60	
B	1000010	42	10001000	88	
C	1000011	43	10101000	A8	
D	1000100	44	10010000	90	
E	1000101	45	01000000	40	
F	1000110	46	00101000	28	
G	1000111	47	11010000	D0	
H	1001000	48	00001000	08	
I	1001001	49	00100000	20	
J	1001010	4A	01111000	78	
K	1001011	4B	10110000	B0	
L	1001100	4C	01001000	48	
M	1001101	4D	11100000	E0	
N	1001110	4E	10100000	A0	
O	1001111	4F	11110000	F0	
P	1010000	50	01101000	68	
Q	1010001	51	11011000	D8	
R	1010010	52	01010000	50	
S	1010011	53	00010000	10	
T	1010100	54	11000000	C0	
U	1010101	55	00110000	30	
V	1010110	56	00011000	18	
W	1010111	57	01110000	70	
X	1011000	58	10011000	98	
Y	1011001	59	10111000	B8	
Z	1011010	5A	11001000	C8	
Ø	0110000	30	11111100	FC	
1	0110001	31	01111100	7C	
2	0110010	32	00111100	3C	
3	0110011	33	00011100	1C	
4	0110100	34	00001100	0C	
5	0110101	35	00000100	04	
6	0110110	36	10000100	84	
7	0110111	37	11000100	C4	
8	0111000	38	11100100	E4	
9	0111001	39	11110100	F4	
(,)	0101100	2C	11001110	CE	
(=)	0101101	2D	00010110	16	$\overline{SK}$
(.)	0101110	2E	01010110	56	
(?)	0101111	2F	00110010	32	
([ )	1011011	5B	01010100	54	$\overline{AR}$
( ])	1011101	5D	10010100	94	$\overline{DN}$
(↑)	1011110	5E	10001100	8C	$\overline{BT}$
(:)	0111010	3A	11100010	E2	
(;)	0111011	3B	10101010	AA	

The Morse buffer register will contain the information from **table 2** as:

C	B7	B6	B5	B4	B3	B2	B1	B0	
X	0	0	1	0	1	0	0	0	$= 28_{hex}$

The 0s represent dots and the 1s represent dashes. The actual code pattern is determined by inspecting the bits, from most to least significant. The remaining bits are used to denote completion of the character by putting a 1 after the character and 0s after the one. The software will then check for 10000000 (80_{hex}).

The *arithmetic shift left* (ASL) instruction is used to shift the code group into the CARRY flag one bit at a time.

	C	B7	B6	B5	B4	B3	B2	B1	B0
START	X	0	0	1	0	1	0	0	0
1st ASL	0	0	1	0	1	0	0	0	0
2nd ASL	0	1	0	1	0	0	0	0	0
3rd ASL	1	0	1	0	0	0	0	0	0
4th ASL	0	1	1	0	0	0	0	0	0

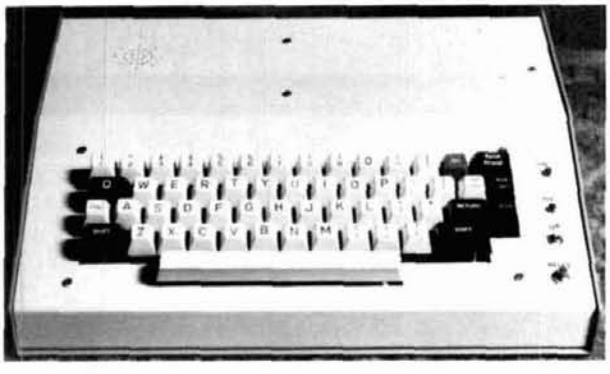
Upon execution of ASL, B7 is shifted into the CARRY flag and the other bits in the Morse register are subsequently shifted to the left. The shifts are performed until the content of the register is 1000 0000 (80_{hex}). In the case of the letter F, four shifts are used.

Morse characters are synthesized in dot-space and dash-space pairs. The state of the CARRY flag determines whether a dot-space or dash-space pair will be sent by the timing loop software to the keying relay. When the final shift occurs, the program inserts a time delay equivalent to three dots to provide proper spacing before the next character.

The flow chart illustrating the entire ASCII to Morse conversion technique is shown in **fig. 2**.

control characters

Control characters lend a greater flexibility to the system by allowing the operator to change the course of program execution, and perform software generated control sequences solely from the keyboard. The control character is implemented by pressing the CONTROL key first and while keeping it depressed, the desired alpha-numeric key. The following control characters are programmed for use with this system:



The CW keyboard is housed in a 14 x 11 x 3 inch (36x28x8 cm) cabinet available from Nu Data Electronics, 104 North Emerson Street, Mount Prospect, Illinois 60056.

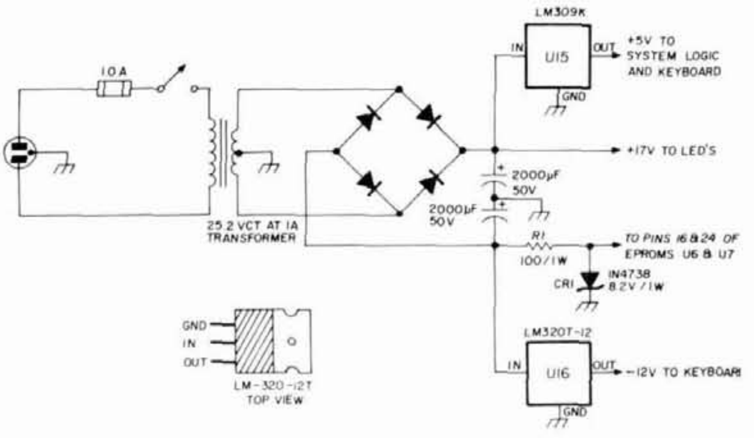


fig. 3. Schematic diagram of the power supply. The LM309K should be mounted on a heatsink. Note that the case of the LM320-12T must *not* be grounded. The bridge rectifier's rating is 100 PIV, 1 ampere; the transformer is 25.2 Vac, 1 ampere.

		+5 volts	ground	−8 to −9 volts
U1	SN74L00	14	7	
U2	SN74L74	14	7	
U3	SN74L42	16	8, 12	
U4	MCS-6504	4	2	
U5	SN74L04	14	7	
U6, 7	1702-A	12, 13, 15, 22, 23		16, 24
U8-11	2111	18	8	
U12	MCS-6530-005	7, 16, 20	1, 5, 6, 8, 10, 11, 12	
U13	SN74L74	14	7	
U14	NE555V	8	1	

1. BACKSPACE (CONTROL H)
2. CONTROL X
3. CONTROL S
4. CONTROL L
5. CONTROL T
6. RETURN (Carriage return)

BACKSPACE is used only for FIFO error correction. This key backs up the FIFO pointer to the last character entered; the keystroke that follows will replace that character. This feature literally makes it possible to send perfect code. Since the BACKSPACE key can be used to correct mistakes as they are made, a special key for the standard error signal (8 dits) was not included in the software.

CONTROL X is used for entering the code speed entry routine. For example, the code speed can be changed to 25 words per minute by the following sequence:

1. CONTROL X
2. 25
3. CONTROL S

CONTROL X allows the operator to enter the two-digit code speed into a buffer. CONTROL S then initiates a subroutine that programs the interval timer by calculating the equivalent time element for that code speed. The calculation was based on the ARRL rule that 12 wpm is analogous to 5 dits per second, or 10 Hz. Thus, from wpm, the time interval can be calculated. Since the interval timer is binary and not decimal, the timing interval must be converted to hexidecimal.

After all the conversion constants are computed, the final equation is

$$t_{16} = \frac{550}{wpm} \quad milliseconds \qquad (1)$$

The division is performed in the microprocessor by using a repeated subtraction technique that performs the subtraction in decimal, and counts the number of subtractions in hex (base 16).

CONTROL L is used to store call-up or CQ sequences in the 64-character auxiliary buffer. When CONTROL L is activated, the contents of this buffer are, in effect, erased. The auxiliary buffer can be loaded as follows:

1. CONTROL L
2. CQ CQ CQ CQ CQ CQ DE WB2DFA WB2DFA WB2DFA K
3. RETURN

The RETURN key jumps the program back into its normal flow, and the auxiliary buffer can be recalled by depressing CONTROL T. If it is desired to save the auxiliary buffer for later recall, the RETURN key is used so that the operator can go on with typing data into the FIFO.

There are many situations in which this buffer can be used to make the operator more efficient. For example, while your QSO partner is answering, you can load a signing sequence as follows:

1. CONTROL L
2. K2SMN K2SMN DE WB2DFA
3. RETURN

When he is finished, you go on the air instantly by hitting CONTROL T and start typing your QSO. After the auxiliary buffer is empty, the FIFO memory is read out, in the order in which characters were entered.

To finish your transmission, you can recall the auxiliary buffer data by using CONTROL T again.

1. CONTROL T
2. AR AR K

After the content of the transmission has been sent, the FIFO will send K2SMN K2SMN DE WB2DFA AR AR K.

If a mistake is made while entering data into the auxiliary buffer, you must start all over again by depressing CONTROL L. BACKSPACE will not correct auxiliary buffer errors. When using a data terminal or a TV type terminal to enter data, the capacity of the auxiliary buffer will be one line of text.

construction

Since construction of this project involves the handling of MOS devices, their handling precautions should be observed. It is best to leave the EPROMs,

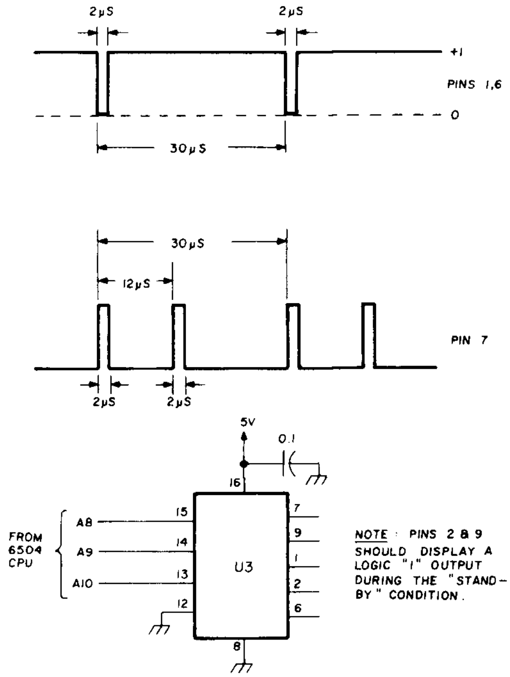


fig. 4. System timing pulses that are on U3, the chip select IC, during the halt loop.

CPU, PIA, and RAM chips in their protective carriers, installing them last. The use of sockets is highly recommended; a one-dollar socket is good insurance for the prevention of irreparable damage to a 20 dollar CPU or 18 dollar PIA.

The best place to start building is the power supply (**fig. 3**), measuring the output voltage from regulators U15 and U16, +5 and −12 volts respectively. The potential at the cathode side of CR2 should be −8 to −9 volts. After the voltage checks have been made, all capacitors, resistors, diodes, and transistors should be installed. Do not install any of the ICs before checking the pin voltages shown in **fig. 3**. When the voltage and continuity checks agree, it's safe to proceed installing the U1, U2, and U14 circuitry.

After you've re-applied power, check pin 8 of U1C for a 1-MHz signal, then pin 6 of U2 for a 500-kHz square wave. The tone oscillator, U14, should put out an 800-hertz square wave when pin 4 is tied to +5 volts by a clip lead. The tone should stop when pin 4 of the 555 oscillator is grounded.

The next step is the installation of the CPU, EPROMs, and RAM chips, along with their support devices, U3, U5, and U12. When power is re-applied, the tone oscillator should be running. Momentarily grounding pin 1 of U4 will stop the tone. This means that the microprocessor has stepped through the configuration software, and is executing the STAND-BY routine in U6. Verification of this condition can be made by comparing the waveforms from U3's outputs, with those depicted in **fig. 4**. Also, the output pins of U12, pins 2, 23, 24, and 25 should be at logic 0.

The address and data lines of the CPU can only drive one standard TTL load. Therefore, it is necessary to use low-power TTL (SN74L00 series) devices so the microprocessor can reliably drive the address, R/W, and clock pins of the EPROMs, RAMs, and the PIA. SN74LS00 devices could also be substituted. Note that the 1-MHz oscillator uses an SN74L00 in a self-biasing scheme provided by the 4.7k resistors. A standard SN7400 will not work with the values shown in the schematic.

The system, as is, represents a minimal configuration. The CPU itself is capable of addressing a total of 8192 bytes of memory; of this amount, only 1024 bytes are used for RAM and PROM. Address locations 0200 to 04FF are not used.* Thus, the system can be expanded by adding RAMs or more I/O with software to supervise the expansion in the PROMs for locations above address 0800. However, expansion of the basic system means buffering the address and data bus by means of TTL inverter pairs on the address lines, and a transceiving buffer on the data bus.

*A copy of the memory map and programming information for the EPROMs is available by sending a self-addressed, stamped envelope to *ham radio*, Greenville, New Hampshire 03048.

references

1. Brice, Ward, *Microprocessor/Microprogramming Handbook*, Tab Books, Blue Ridge Summit, Pennsylvania, 1975.

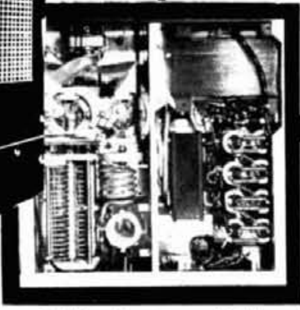
2. L. Krakauer, "Efficient Storage of Morse Character Codes," *BYTE*, October, 1976.

3. W. Sewell, WB5NYC, "If Sam Morse could see us now," *BYTE*, October, 1976.

4. J. Pollock, WB2DFA, "1000 WPM Morse Code Type," *73*, January, 1977.

ham radio

The New Sigma XR3000D Linear Amplifier Compare!



HOLIDAY SALE

$699

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

Features:

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

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

HOLIDAY INTRODUCTORY SPECIAL!

New! Sigma Model AF250L Deviation/Modulation Meter

Fully Certifiable for Commercial Use

HOLIDAY SALE

$169

Features:

Extremely stable local oscillator for easy measurement of HF, VHF, and UHF bands employing negative feedback to insure extremely high stability ● Easy to read, accurate linear scale ● **Direct off the air signal measurement capability.**

Specifications:

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

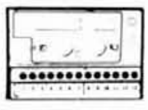
SIGMA RF-2000 SWR & POWER METER

$29
Introductory Price

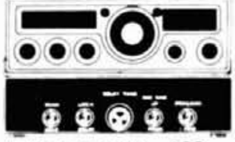
Cal PWR Scales 200W-2000W Freq Range 3.5-150 MHz. Please do not confuse the RF2000 with similar appearing lower priced units. RF2000 is an individually calibrated professional quality instrument. Unequaled at many times the price. Size 7" (w) x 2 1/3" (d).

SPECIAL SCANNER SALE

FOR KENWOOD TR-7400A



14 Channel Programmable
reg $109 — **$65**



FMSC-1 reg $169 — **$99**
7400 Scanner II Reg $189-$119

FMSC-1 Scanner for KDK FM 144 and 7400 Scanner II for Trio-Kenwood TR-7400A. ● Full scan 146 and 147 MHz consecutively or 1 MHz, or any MHz range ● Scan rate: 1 MHz/2 seconds (adjustable) ● Controls: Scan/Hold, Latch/Delay, 600 KHz offset (off, up, down), program 1 MHz ● Simple installation.

KDK SPECIAL SALE FM 144 Accessories

FMTP-1	Touch Tone Pad	$59
FMTP-2	Touch Tone Pad with 10 Number Programmable Memory	$99
FMTD-1	Private Call Decoder for use with and Programmed by Any Touch Tone Pad	$75
SC-12A	Audible Tone Encoder Decoder	$65
FMSC-1	Scanner-Random Any Range	$99
MARS-CAP	Option Kit - Any Frequency, Any Split	$12
FMOF-1	Offset Option Kit - 2 Extra Positions, Crystals Required	$10
FMOF-2	+1 MHz Offset Option Kit (No Crystals to Buy)	$10
FMTE-1	Sub Audible Tone (100 Hz-Adjustable 67-203 Hz)	$15
	Owners Manual (Extra)	$5

FM 2015R Accessories:

FMPS-4R	Regulated AC PS	$49
FMMC-1	Microphone with Built-in Touch Tone Pad	$49
MARS-CAP*	Option Kit - Any Frequency, Any Split	$6
FMAT-1	½ Wave Portable Antenna for Hotel, Motel or Apartment	$7.95
	Extra DC Cord & Plug	$3.50
	Service Manual	$4.00
	Mounting Bracket (Extra)	$6.00

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

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

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

Our Price **$289**

NEW! 6 METER FM50-10SXRII

51.00-53.995 MHz. 600 channels
Holiday Sale—Price $339

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

AMATEUR-WHOLESALE ELECTRONICS

8817 S.W. 129th Terrace, Miami, Florida 33176
COURTEOUS PERSONAL SERVICE—SAME DAY SHIPMENT • Prices subject to change without notice.
Telephone: (305) 233-3631 • Telex 51-5628 • Store Hours: 10-5 Mon.-Fri.

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

More Details? CHECK—OFF Page 142

NEW!
THE FUTURE NOW!
FM2015R

KDK

Does Your Unit Cover The New Sub-band 144.5 - 145.5 MHz? The FM2015R Does, PLUS MARS-CAP!*

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

● 5 MHz Band Coverage - 1000 Channels (instead of the usual 2MHz to 4MHz-400 to 800 Channels) ● 4 CHANNEL RAM IC MEMORY WITH SCANNING ● MULTIPLE FREQUENCY OFFSETS ● ELECTRONIC AUTO TUNING - TRANSMIT AND RECEIVE ● INTERNAL MULTIPURPOSE TONE OSCILLATOR ● RIT ● DISCRIMINATOR METER - 15 Watts Output - Unequaled Receiver Sensitivity and Selectivity - 15 POLE FILTER, MONOLITHIC CRYSTAL FILTER AND AUTOMATIC TUNED RECEIVER FRONT END, COMPARE! ● Superb Engineering and Superior Commercial Avionics Grade Quality and Construction Second to None at ANY PRICE.

INTRODUCTORY PRICE

$399.00

Regulated AC/PS Model FMPS-4R . . . $49.00

FMMC-1 Microphone with Built-in Touch Tone Pad.

- New! Auto Key-up
- LED indicator
- Adj. level and tone balance
- only 3-3/4" x 2"

$49.00

- **FREQUENCY RANGE**: Receive and Transmit: 144.00 to 148.995 MHz, 5Khz steps (1000 channels) INCLUDING NEW BAND 144.5-145.5MHz + MARS-CAP.*
- **LED DIGITAL READOUT.**
- **4 CHANNEL RAM SCANNER WITH IC MEMORY**: Program any 4 frequencies and reprogram at any time using the front panel controls-scan all or part of the memory-search for occupied (closed) channel or vacant (open) channels. Internal Ni-Cad included to retain memory (no diode matrix to wire or change).
- **MULTIPLE FREQUENCY OFFSETS**: Three positions A,B,C, provided for installation of optional crystals: EXAMPLE - 1 MHz offset. Duplex Frequency Offset Built in - 600 Khz PLUS or MINUS 5 KHz steps, plus simplex, any frequency.
- **INTERNAL MULTIPURPOSE TONE OSCILLATOR BUILT IN**: 1750Hz tone burst for "whistle on operation" and sub-audible tone operation possible by simply adding a capacitor across the terminals provided. Internal 2 position switch for automatic and manual operation, tone burst or sub audible tone PL - adjustable 60-203Hz (100 Hz provided).
- **AIRCRAFT TYPE FREQUENCY SELECTOR**: Large and small coaxially mounted knobs select 100KHz and 10KHz steps respectively. Switches click-stopped with a home position facilitate frequency changing without need to view LED's while driving and provides the sightless amateur with full Braille dial as standard equipment.
- **FULL AUTOMATIC TUNING OF RECEIVER FRONT END AND TRANSMITTER CIRCUITS**: DC output of PLL fed to varactor diodes in all front end RF tuned circuits provides full sensitivity and optimum intermodulation rejection over the entire band. APC (AUTO POWER CONTROL) - Keeps RF output constant from band edge to band edge. NO OTHER AMATEUR UNIT AT ANY PRICE has these features which are found in only the most sophisticated and expensive aircraft and commercial transceivers.
- **TRUE FM**: Not phase modulation - for superb emphasized hi-fi audio quality second to none.
- **RIT CONTROL**: Used to improve clarity when contacting stations with off frequency carrier.
- **MONITOR LAMPS**: 2 LED's on front panel indicate (1) incoming signal-channel busy, and (2) Transmit.
- **FULLY REGULATED INTEGRAL POWER SUPPLY**: Operating voltage for all 9v circuits independently regulated. Massive Commercial Hash Filter.
- **MODULAR COMMERCIAL GRADE CONSTRUCTION**: 6 Unitized modules eliminate stray coupling and facilitate ease of maintenance.
- **ACCESSORY SOCKET**: Fully wired for touch tone, phone patch, and other accessories. Internal switch connects receiver output to internal speaker when connector is not in use.
- **MULTI-PURPOSE METER**: Triple Function Meter Provides Discriminator Meter, "S" Reading on receive and Power Out on Transmit.
- **RECEIVE**: Better than .25uv sensitivity, 15 POLE FILTER as well as monolithic crystal filter and AUTOMATIC TUNED LC circuits provide superior skirt selectivity - COMPARE!
- **HIGH/LOW POWER OUTPUT**: 15 watts and 1 watt, switch selected. Low power may be adjusted anywhere between 1 and 15 watts. Fully protected-short or open SWR.
- **OTHER FEATURES**: Dynamic Microphone built in speaker, mobile mount, external 5 pin accessory jack, speaker jack, and much, much more. Size 2½ x 7 x 7½. All cords, plugs, fuses, microphone hanger, etc. included. Weight 5 lbs.

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

AMATEUR-WHOLESALE ELECTRONICS

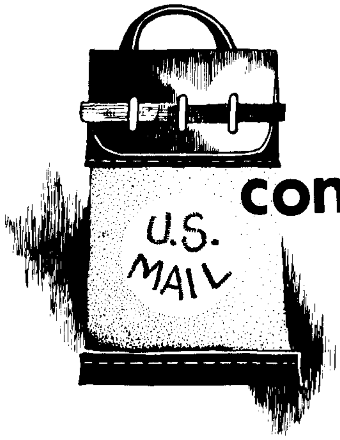
8817 S.W. 129th Terrace, Miami, Florida 33176
Telephone (305) 233-3631 ● Telex: 51-5628
U.S. DISTRIBUTOR

DEALER INQUIRIES INVITED.

PLEASE ORDER FROM YOUR LOCAL DEALER OR DIRECT IF UNAVAILABLE.

Regional Sales & Service Centers:
Northeast: Buzzards Bay Electronics
Buzzards Bay, Mass.
(617) 759-3376
East: Sanford Communications, Inc.
Colonia, N.J.
(201) 574-3003
Midwest: Universal Service
Columbus, Ohio
(614) 221-2336

More Details? CHECK—OFF Page 142



comments

mobile color code

Dear HR:

I would like to propose a standard color-coding system for mobile antennas so that one mobiler could quickly tell visually what band another mobiler was operating on at that time. Using the standard resistor color code, the following colors would be used for each of the high-frequency amateur bands:

80 meters	gray-black
40 meters	yellow-black
20 meters	red-black
15 meters	brown-green
10 meters	red-gray

The red-gray code is chosen for 28 MHz because of its higher visibility over brown-black for *10* meters.

The two colors for each of the bands could be applied with colored tape (or paint) to the antenna loading coil, displayed on a pennant flying from the tip of the antenna, or shown with two colored tape strips on the rear bumper.

Ray Day, WB6JFD
Palos Verdes, California

fm repeater channel spacing

Dear HR:

I wish to thank Jerry Pulice, WB2CPA, for his fine article on direct synthesizers (August, 1977). The technical portions appear to be most needed in the fm community, especially for repeater usage (it's amazing what spurs on a mountain can do).

This letter is to comment on a statement made by Jerry in discussing the local-oscillator noise performance of his synthesizer. His statement, "In normal operation, crystal-controlled equipment would be able to maintain DX communications within 10 kHz of a repeater channel," is misleading and requires clarification.

As is well known, fm spectrum width is wider than the actual deviation. In fact, the bandwidth actually occupied by a narrowband fm signal is very close to twice the sum of the deviation and maximum modulation frequency. For voice operating a 5 kHz peak deviation (typical repeater operation), the bandwidth of the transmitted signal is 13 kHz or 6.5 kHz from the carrier or no-modulation frequency. A receiver with 15 kHz bandwidth would have interference when tuned within 7.5 +6.5 = 14 kHz of the transmitter. In actual practice a physical spacing of 40-50 miles (64-80km) is required for operation of 15-kHz channels, and 10-kHz spacing is totally impractical.

This condition is becoming a serious problem in the high density areas (like Southern California), not because of Jerry's statement, but primarily because of the transceiver manufacturers' insistence that their radios offer "400 channels" simply because they can be tuned to 400 discrete 5-kHz frequencies. In reality, there are only a theoretical maximum of some 100 channels from 146-148 MHz, but due to the repeater bandplans based on 15-kHz (or 30-kHz) spacing, only a theoretical maximum of some 80 channels are available. This is with *ideal* equipment. With real receivers and transmitters available today, this number is closer to 60 discrete simultaneous channels available from one location.

Robert O. Thornburg, WB6JPI
Studio City, California

300-Hz crystal filter for Collins receivers

Dear HR:

Referring to the article by W1DTY in September 1975 *ham radio*, I have found that the transistor impedance matching circuit, which has an input impedance of less than 15 thousand ohms, caused a 10 dB insertion loss when used with my 75S3C. To present a high impedance input, I modified the circuit as shown in **fig. 1**. This method gives the same output as the other filters in the receiver and properly matches the crystal filter.

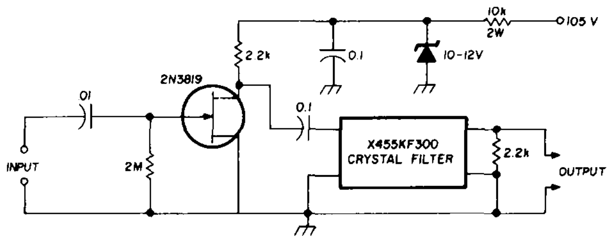


fig. 1. High-impedance matching circuit for the 75S3C.

The circuit is mounted on a small Veroboard held in place with nuts on the filter mounting screws. The whole unit fits nicely under the screening can without defacing the receiver in any way. I am very pleased with the performance of the filter. The attenuation is approximately 80 dB when 600 Hz from the center frequency.

C. H. Foulkes, G3UFZ
Herts, England

IC-crystal oscillator

Dear HR:

VK2ZTB is to be congratulated for his excellent article in March 1976 *ham radio*. However, it did have one omission in the section on IC oscillators. The Motorola MC12060 and MC12061 are specifically designed as series-mode crystal oscillators. The MC12060 covers 100 kHz to 2 MHz and the MC12061 2 MHz to 20 MHz. Both ICs produce sinusoidal, ECL and TTL outputs. The MC12061 has also been operated as an overtone oscillator by connecting the components as shown in **fig. 1**. Also, not mentioned in the data sheet* is the ability to get twice the oscillator frequency by tying the sinewave outputs (pins 2 and 3) together. This connection performs a full-wave rectification of the sinewaves to achieve the doubling. These two features allow VHF oscillator signals to be easily developed in one IC package with only one tank circuit.

*Motorola MTTL Phase-Locked Loop Components, MC12060 Data Sheet.

Ron Treadway, W7EKC
Scottsdale, Arizona

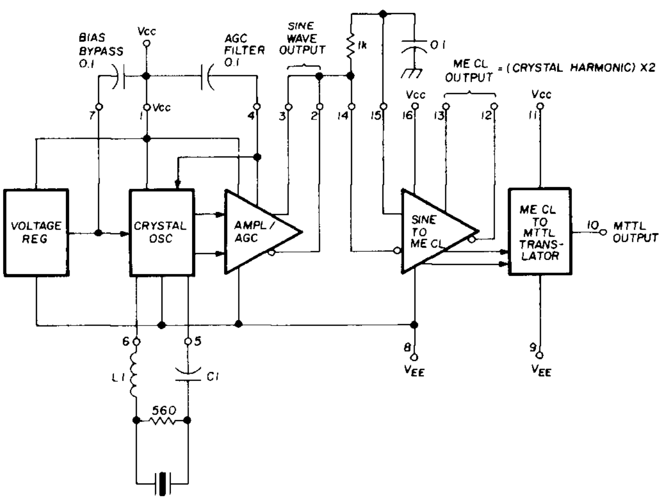


fig. 2. Pin connections for using the MC12061 as an overtone oscillator.

low-resistance measurements

Dear HR:

In the September, 1977, issue of *ham radio*, the accuracy of a low-resistance measurement method is indicated as being in the range of 1 or 2%.

This is not always the case, however, since an error of plus 100% will occur when the resistance being measured, R_x, is equal to the resistance of the millivoltmeter, R_m. In fact, only when the resistance of the millivoltmeter is infinite is the method strictly accurate.

Since the millivoltmeter shunts the unknown resistor and the total line current is 100 mA

$$(V_m/R_m) + (V_m/R_x) = 0.1 \text{ ampere}$$

Hence $10\ V_m = R_m \times R_x/(R_m + R_x)$

where V_m is the voltage across the millivoltmeter. In other words, the method gives the resistance *not* of the unknown resistor, R_x, but of the combined resistance of R_x and R_m in parallel.

When selecting the millivoltmeter, one should be sure that its resistance is at least 50 times (and preferably 100 times) the highest resistance to be measured to maintain the stated accuracy of this useful method. The percentage accuracy of the method, insofar as the resistance of the millivoltmeter is concerned, is limited to $100\ (R_x/R_m)$.

Ed Sampson, W1PT
Brockton, Massachusetts

magnetron development

Dear HR:

I have read with considerable interest W1HR's article on "Solid-State Microwave RF Generators" in the April, 1977, issue of *ham radio*.

In the opening paragraphs where W1HR briefly reviewed the history of devices used to generate microwave power leading up to the modern solid state devices, I felt that some reference should have been made to the considerable work done by Dr. Eric Megaw, G6MU, on the split and multi-segment anode magnetrons principally done for the Marconi Company. Eric Megaw worked at the General Electric Co. Ltd., Research Labs at Wembley. Also the development of the first high power cavity magnetron developed at Birmingham University in February, 1940, which gave 400 watts CW at 9.8cm, and later pulse types for our radar, might have been mentioned.

You are no doubt well aware that microwave activity in the UK is growing significantly, largely under the direction of Dain Evans, G3RPE, and his associates. We how have three 10-GHz beacons operating at the Isle of Wight, Alderney (Channel Islands), and Romford in Essex. Microwave Associates at the Luton factory are considering another beacon in this band, and one in Aberdeen is projected.

G.R. Jessop, G6JP
General Manager, RSGB
London, England

More Details? CHECK—OFF Page 142

CMOS programmable divide-by-N counter

Most divide-by-N counters require either a complicated system of gates or pin strapping; changing the divisor is difficult for either method. If the speed of the circuit is such that a CMOS IC can be used, a single connection change will permit division by any integer between 2 and 10. This can be done with a simple, single-pole switch.

This divide-by-N counter uses an RCA CD4017A Johnson decade counter. In normal operation, the counter provides decimal outputs that are low and go high only at their respective time slots. For divide-by-N operation, the reset line of the counter is connected to one of these outputs, depending on the desired divisor. As the count progresses, each decimal output goes high and then low until the count reaches the one connected to the reset line. The counter is then reset, and the output of the divider appears on the 0 line.

Fig. 1 shows the circuit connected to divide by 7.

It should be noted that to divide by 10, no feedback is used and the internal gating of the counter is permitted to function in the normal manner. Division by 0 and 1 are not permitted. For division greater than 10, this circuit can be cascaded with other divider schemes.

Ken Stone, W7BZ

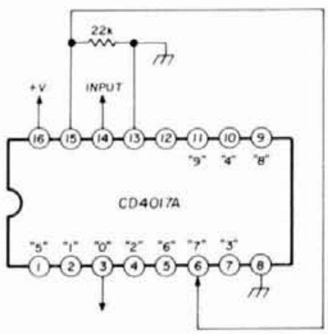
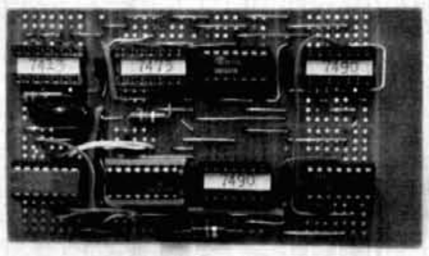


fig. 1. The CD4017A connected as a divide by 7 counter. The resistor is used to hold the reset line low. When the appropriate number is reached, that output and the reset line are driven high, resetting the counter. To divide by other integers, pin 15 should be connected to the desired output. For example, pin 1 for a divide by 5, or pin 7 for a divide by 3.

socket label for integrated circuits

How many times have you borrowed integrated circuits from other boards and then when you went to return them, forgot which chip went in which socket? Well, it happened once too often for us. We decided that anything would be better than retracing circuits to determine which integrated circuit goes where.

Various labeling methods were tried. Decals were too hard to apply in cramped spaces; painting was out due to a total lack of manual dexterity. Finally, strip labeling worked and has been adopted for labeling old and new boards. This is done by typing,



or printing , the IC type on strips of gummed paper which are then trimmed to fit the goove between the rows of pins. The result is neat, accurate, and inexpensive. In addition, the labels are visible only when the integrated circuit is removed from its socket.

John M . Franke, WA4WDL
Norman J. Cohen, WB4LJM

using the National NCL-2000 with the Drake T-4XC

After finally moving to a QTH

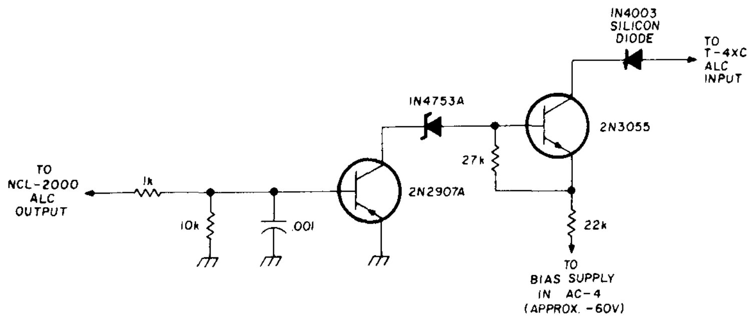


fig. 2. Schematic diagram of the amplifier for use between the NCL-2000 amplifier and a T-4XC. The zener diode has a 36-volt rating. A 1N4003 or equivalent diode is used in the collector of the 2N3055.

where I could use my NCL-2000, I found that the alc output level was insufficient to drive the T-4XC. To overcome this difficulty, I designed a simple amplifier to make the equipment compatible. No adjustments are necessary, and the circuitry can be conveniently built into the Drake AC-4 power supply.

Parts selection is not critical. If a higher voltage transistor is used in place of the 2N2907A, the zener diode can be eliminated. However, a very low-leakage transistor will be necessary to keep from turning the 2N3055 on. The 2N3055 was probably overkill for this application, but it was the only high-voltage transistor in the author's junkbox.

Without the modification, the NCL-2000 would severely flat top unless careful attention was paid to the GAIN control on the transmitter. After modification, no flat topping is evident on the monitor scope even if the GAIN control is operated wide open. Of course, the severe compression renders speech unintelligible.

Edwin R. Ranson, K5ER

a simple adjustable IC power supply

Last year, National Semiconductor introduced the first 3-terminal adjustable positive voltage regulator. When used with a few external components, the LM117 is capable of delivering voltages from 1.25 to 37 volts at 1.5 amps. Mounted in a TO-3 case, this device is also protected

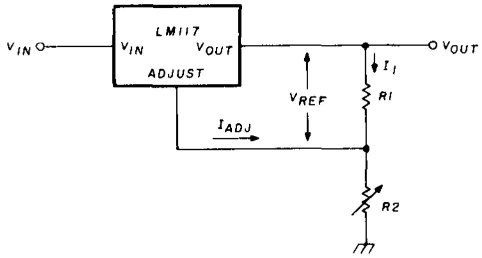


fig. 3. Basic configuration for the LM117 adjustable IC voltage regulator.

against current and thermal overloads.

In normal operation,[1] the LM117 regulator develops a 1.25 V reference (V_{REF}) between its output and adjustment terminals, as shown in **fig. 3.** Since this reference voltage is constant across R1, a constant current flows through the output set resistor R2, so that the output voltage can be calculated from

$$V_{OUT} = V_{REF}(1 + \frac{R2}{R1}) + I_{ADJ}R2$$

Typically, $V_{REF} = 1.25V$, and $I_{ADJ} = 50\ \mu A$, so that

$$V_{OUT} = 1.25\,(1 + \frac{R2}{R1}) + (50\ \mu A)(R2)\ volts$$

As shown in **fig. 4**, the input voltage is provided by a simple bridge rectifier and capacitor input filter arrangement delivering approximately 37 Vdc. The 0.1 μF disc bypass capacitor C2 is strongly recommended if the regulator is physically located some distance from C1. C3 (10-μF tantalum) is added to improve the ripple rejection.

Although the LM117 is capable of good load regulation, typically 0.3 per cent at constant junction temperature, the 240-ohm current-set resistor R1 should be connected directly to the regulator's output terminal, rather than near the load. When external capacitors are used with any IC regulator, it is wise to add protective diodes to prevent the capacitors from discharging through low current points in the regulator. Therefore, CR1 protects against C4, and CR2 protects against C3.

reference

1. Linear Data Book, National Semiconductor Corporation, Santa Clara, California 95051, June, 1976.

Howard Berlin, W3HB

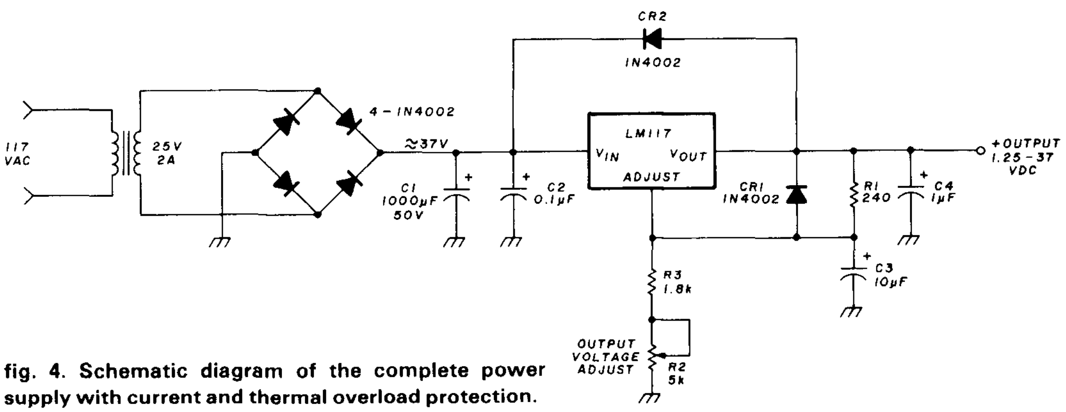


fig. 4. Schematic diagram of the complete power supply with current and thermal overload protection.

On most 4, 5 and 6-element antennas, only 3 elements at any one time on any one band are working. The rest are goofing off.

So counting elements is no way to judge an antenna.

This 3-bander uses every one of its 4 elements all the time for maximum forward gain and maximum front-to-back ratio.

And that adds up to an antenna that works harder. With no idle elements to increase windage and bulk.

A good reason why the TB-4HA is known both for performance *and* toughness.

In fact, all of Swan's beam antennas share a reputation for working harder for every dollar you invest in them.

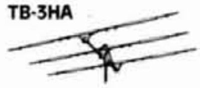
Swan beams are precision engineered for a full 2000-watt PEP rating and a VSWR of 1.5:1 or better at resonance. And besides optimum gain and front-to-back ratio, they're easy to install and tune.

Order a Swan beam today. Use your Swan credit card. Applications at your dealer or write to us. Who needs antennas that goof off?

TB-4HA

Heavy-duty, four-working-element antenna for 10, 15 and 20 meters. **$259.95**

TB-3HA

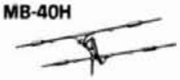


Heavy-duty, three-working-element antenna for 10, 15 and 20 meters. **$199.95**

TB-2A

Light-weight, two-working-element antenna for 10, 15 and 20 meters. **$129.95**

MB-40H



Heavy-duty, two-working-element antenna for 40 meters. **$199.95**

SWAN BEAM ANTENNA SPECIFICATIONS. For 52-ohm coaxial feedlines.

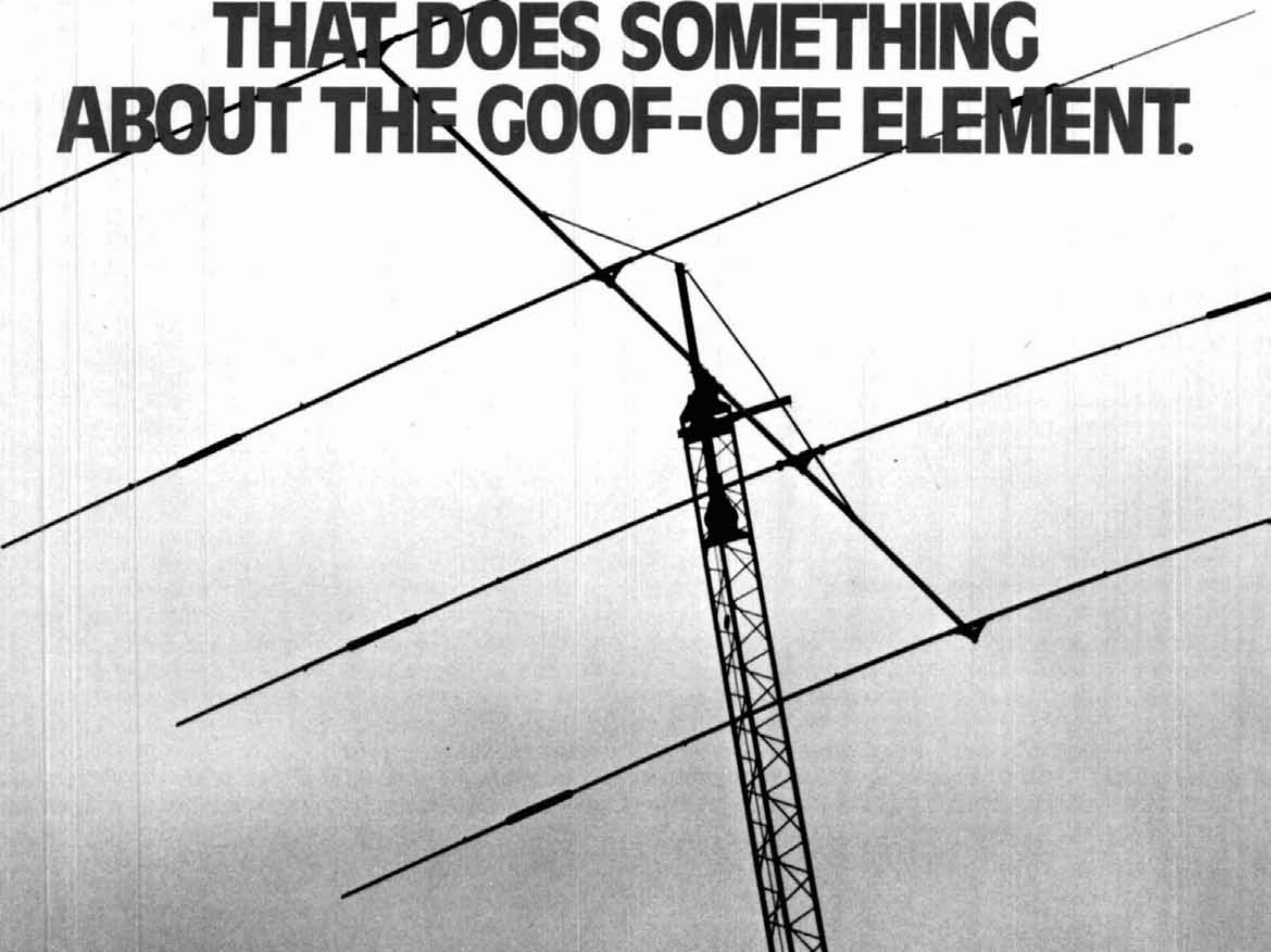
Antenna Model Number	Boom Length & Diameter	Longest Element	Turning Radius	Maximum Wind Survival	Wind Load @ 80 MPH	Wind Surface Area	Net Weight
TB-4HA	24' x 1.5"	28'-10"	18'-6"	100 mph	148 lbs.	6 sq.ft.	54 lbs.
TB-3HA	16' x 1.5"	28'-2"	16'	100 mph	110 lbs.	4 sq.ft.	44 lbs.
TB-2A	6.5' x 1.5"	27'-8"	14'-3"	80 mph	60 lbs.	1.8 sq.ft.	18 lbs.
MB-40H	15.75'x1.5"	30'-4"	17'-6"	100 mph	80 lbs.	2.5 sq.ft.	40 lbs.

(Prices FOB Oceanside, CA)

Dealers throughout the world or order direct from

SWAN® ELECTRONICS
A subsidiary of Cubic Corporation
305 Airport Road, Oceanside, CA 92054
(714) 757-7525

SWAN TB-4HA. FINALLY, A BEAM ANTENNA THAT DOES SOMETHING ABOUT THE GOOF-OFF ELEMENT.



Our new 4010V expandable 4-band antenna is designed for the operator who wants to straddle continents at a down-to-earth price.

One reason the 4010V saves you money is because it's simpler. For example, it doesn't need a counterpoise. And it's easy to install.

The new 2000-watt PEP trap vertical comes in short lengths complete with mounting plate. So with easy set-up and no ground radials to contend with, you can't beat it for getting on the air fast when you're in the great outdoors.

And it's also ideal for mobile homes and apartments.

Then when you feel like exploring 75 meters, expand your 4010V to five bands with the Swan 75 AK kit and you're into a whole new world.

75 AK 75-meter kit

1040V Vertical Antenna.
But if you're interested in a more permanent installation with one of the most effective verticals made, check out our 1040V.

The rugged 4-band 1040V trap vertical for 40 through 10 meters is well-known for completeness.

When you open your 1040V box what you see is what you need.

Like copper wire to make two counterpoise radial wires for each band, egg insulators and a base mounting plate.

And when you're ready for 75 meters you can expand to five bands with the Swan 75 MK kit. Which is noted for the same attention to completeness as the 1040V.

Buy a Swan 4010V or 1040V expand-a-band-later vertical today.

75 MK 75-meter kit

Use your Swan credit card and pay later, too. Applications at your dealer or write to us.

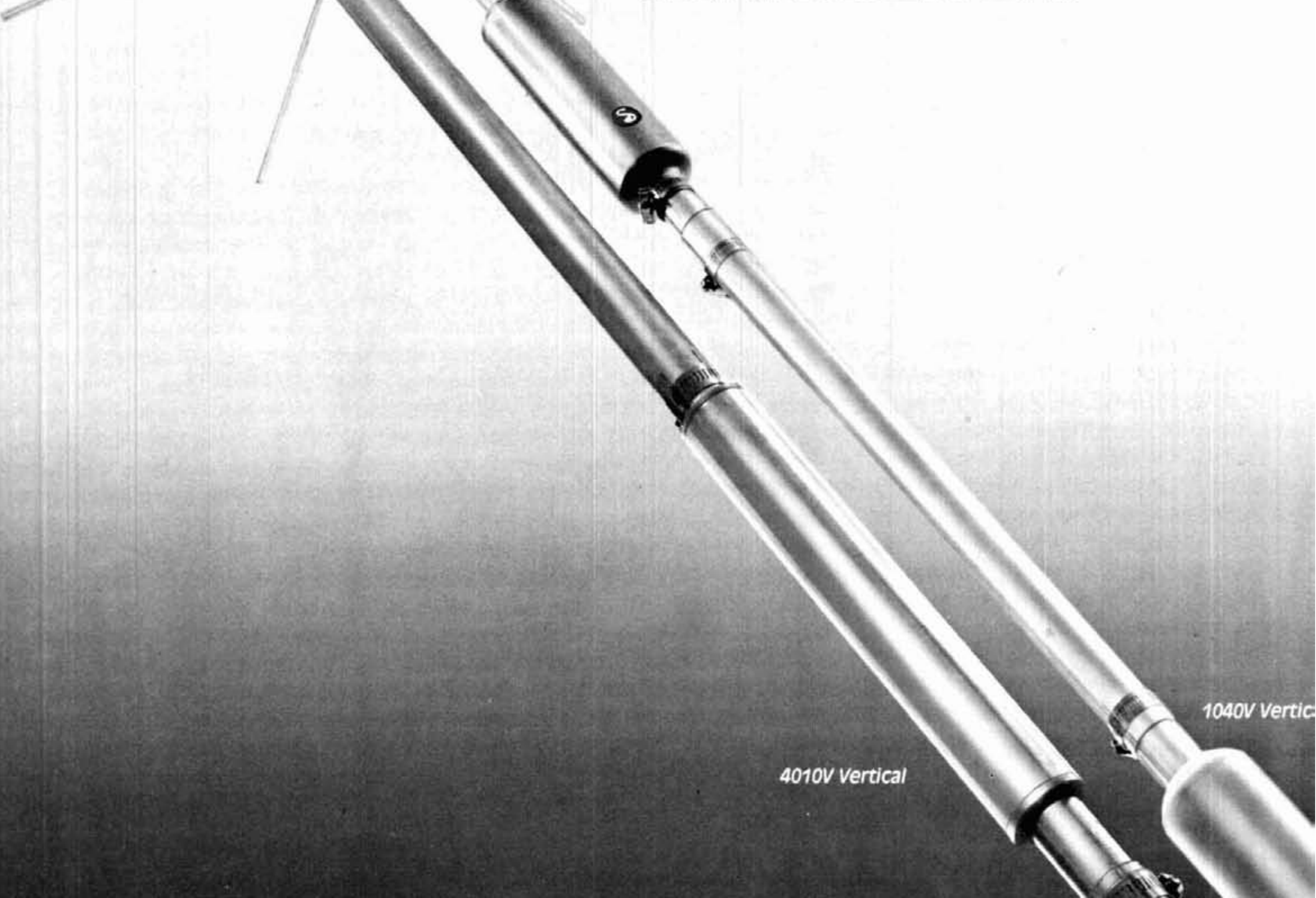
4010V 4-band trap vertical antenna.	$ 74.95
75 AK 75-meter kit.	$ 39.95
1040V 4-band trap vertical antenna.	$122.95
75 MK 75-meter kit.	$ 39.95

(Prices FOB Oceanside, CA)
Dealers throughout the world
or order direct from

SWAN® ELECTRONICS
A subsidiary of Cubic Corporation
305 Airport Road, Oceanside, CA 92054
(714) 757-7525

NEW 4010V VERTICAL ANTENNA.

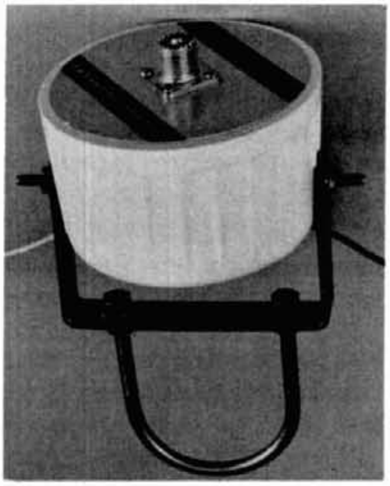
IT LOOKS AS GOOD TO YOUR POCKETBOOK AS IT DOES TO YOUR TRANSCEIVER.



NEW products

For literature on any of the new products, use our *Check-Off* service on page 142.

5-kW beam balun



Palomar Engineers introduces a new balun for beam antennas. With a ratio of 1:1, the balun couples coaxial cable to balanced 50- or 75-ohm antennas. An adjustable U-bolt provides convenient mounting to a 2-in. (51 mm) mast or boom.

The balun is rated at 5 kW PEP (2 kW CW Continuous Commercial Service) between 1.7 and 30 MHz. It features all stainless-steel hardware. The wire leads from the transformer are brought out for direct connection to the beam driven element — no solder lug connections to deteriorate in the weather. All input and output terminals are directly connected at dc to provide lightening protection.

The beam balun is wound with teflon-insulated wire on an rf ferrite toroid core, has uhf (SO-239) connectors, and is epoxy encapsulated in a white PVC case so it can be used in any climate. Loss through the balun is less than 1.0 dB. Size is 4¼ in. (114mm) diameter with case height of 2½ in. (64 mm). Weight of balun and hardware is 2½ pounds (1.2kg).

Price is \$37.50 postpaid in U.S. and Canada. For more information, write to Palomar Engineers, P.O. Box 455, Escondido, California 92025.

full-feature frequency counter

Here's a high accuracy frequency counter for those working within the Citizen Band and Amateur disciplines. The counter has recently been made available from Communications Power, Inc. Designated model CPI FC-70, the frequency counter features a bright seven-digit LED readout with anti-glare louvers — great when you're working in a dimly lit environment.

Resolution is within 10 hertz; accuracy is rated at 0.0003 per cent, which is considerably higher than the FCC's 0.005 per cent requirement. The FC-70 accepts 400 watts of throughput power. It has a high-impedance input, which means it's easily used with rf oscillators and grid dippers. It's also useful for testing i-fs, filter characteristics, and crystal response.

The FC-70 operates from either 12 Vdc or 115 Vac. Quick disconnect cables are supplied for both voltages. The FC-70 has a guaranteed upper frequency limit of 40 MHz; 55 MHz is typical. Looks like a nice piece of test equipment for the serious technician working with high-frequency communications equipment.

For more information on the CPI FC-70 counter, as well as information on CPI's complete product line, write Mr. Robert Artigo, Communications Power, Inc., 2407 Charleston Road, Mountain View, California 94043.

prototype high-frequency receiver

Ulrich Rohde, DJ2LR, has contributed many excellent articles on the subject of high-frequency receiver design, and a number of readers have asked if these design ideas have ever been incorporated into a receiver. The answer is yes — in a prototype built by DJ2LR's firm, Rohde & Schwarz. Although the receiver is a prototype and has never been placed in production (so is not available on the market), a list of its

More Details? CHECK — OFF Page 142

performance characteristics should spark the imagination of those amateurs who are still interested in building their own receivers.

The Rohde & Schwarz prototype is a frequency-synthesized, double-conversion communications receiver covering the range from 10 kHz to 32 MHz in steps of 100 Hz, selectable by thumbwheel switches. In addition, the receiver is fine-tuneable ±500 Hz from any preselected frequency set by the thumbwheel switches!

In operation, a signal is received by an *internal active antenna* or from either of the two external antenna input terminals and applied through switchable filters to a high-power, double-balanced mixer where it is converted to the first i-f at 41 MHz.

The first i-f signal is amplified by a push-pull, low-noise fet amplifier, passed through a ±3.5 kHz bandwidth crystal filter, and delivered to another high-power, double-balanced mixer where it is converted to the second i-f at 455 kHz.

The output signal from the second i-f is fed into a low-noise, power fet and a diode circuit, and then through selectable mechanical filters. The signal is then demodulated by either the ssb/CW product detector or the a-m detector, depending upon the receive mode desired. Two independent agc circuits provide fast-attack slow-decay characteristics (hang agc) for ssb/CW or medium response for a-m reception.

The audio amplifier has a built-in limiter and an active CW filter for improved reception. Audio output is through a built-in speaker, or may be taken from a rear panel connector. A rechargeable, built-in Ni-Cad battery power supply provides for five hours of continuous operation. An external power supply may be plugged in, if desired; requirements are 13.5 volts minimum, 24 volts maximum; nominal current drain is only 250 milliamperes.

Frequency stability is ±1 ppm, internal, or an external frequency

More Details? CHECK—OFF Page 142

standard may be plugged in to provide laboratory-grade stability. Image i-f rejection is greater than 70 dB, independent of frequency setting, and adjacent-channel selectivity is high because of the mechanical filters in the second i-f, and the active audio filter (CW).

Reception modes are LSB, USB, CW, RTTY, and a-m. The noise figure is 10 dB; sensitiivity is 0.3 μvolt for a 10 dB S/N ratio (ssb), and 1 μvolt (a-m).

This little receiver, barely a double handful, features an active antenna horizontally or vertically polarizable, meaning that no external antenna is required for most applications! It is designed for long-range monitoring, broadcast reception, public activities, press, military, coastal services, ships, time signals, and many other radio services.

Ten-Tec Triton IV *Digital* Transceiver

All of the good features of the Triton IV appear in the Triton IV *digital*, with the added benefits of a built-in digital frequency display, *plus* a new zero-beat switch.

The Model 544, as the Triton IV digital transceiver is known, incorporates a six-digit display with 0.43-inch (11mm) high numerals in red, except for the least significant digit (hundreds of hertz) which is in green.

The frequency-counter circuit was the latest large-scale integrated circuit available for this function, and CMOS medium-scale ICs for the remaining requirements.

All crystal-tolerance deviations in the vfo mixer oscillators are accounted for in the final reading since the counter is fed from the vfo output. The remaining error from the carrier oscillator is adjusted out by setting the time-base gating oscillator while receiving WWV, assuring band-to-band accuracy.

When used with Ten-Tec's Model 242 remote vfo, the display indicates the vfo inuse at the time, whether it be the internal or the remote vfo.

The Model 544 has incorporated a zero-beat switch on the rf control. By pulling the knob out, engaging the switch, it is possible to zero beat an incoming CW signal, putting the transmitter on exactly the same frequency. This eliminates the need to tune to a 750-kHz beat note, as in the case with the Triton IV.

Specifications for the digital Model 544 are identical with those for the Model 540 Triton IV, with these exceptions and additions:

Frequency accuracy:	+/−200 Hz.
Receiver power required:	12-14 volts dc, @ 1 ampere.
Semiconductors:	1 LSI; 19 ICs; 63 Transistors; 33 diodes.

Zero-beat switch on rf control.
No crystal calibrator included (or necessary).

The suggested Amateur Net Price is $869. For additional information, write Ten-Tec, Inc., Servierville, Tennessee 37862.

new rf and microwave semiconductor catalog from Hewlett-Packard

A new 128-page diode and transistor designer's catalog from Hewlett-Packard contains complete product specifications and design data for H-P's line of rf and microwave semiconductors. This 7-page catalog includes Schottky diodes, signal-control diodes, microwave-source diodes, devices for hybrid integrated circuits, military-approved devices, microwave transistors, and integrated-circuit products such as double balanced mixers and comb generators.

A numerical index lists each component by part number. A selection quide for each product group helps the designer easily choose a specific device. Appropriate application notes and bulletins are listed at the end of the catalog. The Hewlett-Packard

More Details? CHECK—OFF Page 142

1977 diode and transistor designer's catalog is available free of charge. For a copy, mail your request to Inquiries Manager, Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, California 94304. Ask for publication 5952-9825.

six-digit frequency counter

A full feature, low-cost 30-MHz portable frequency counter has just been announced by B&K-Precision, Dynascan Corporation. Designated Model 1827, the frequency counter's low cost, versatility and ease of operation make the concept of a consumer's frequency counter a reality. Not much larger than a pocket calculator, the model 1827 offers a full six-digit LED display and guaranteed operation to 30-Mhz, with 1-Hz resolution.

Broad range of optional accessories gives the model 1827 versatility. An optional signal tap allows the 1827 to monitor continually the output frequency of a 23- or 40-channel CB transceiver without affecting normal set operation. The signal tap is rated at 100 watts, so it can also be used with amateur radio transmitters. Other optional accessories include rechargeable batteries and an ac adapter-charger, an under-dash or under-shelf mounting bracket, accessory pickup antenna (for use near portable transceivers), general purpose input clip-lead, and vinyl carrying case.

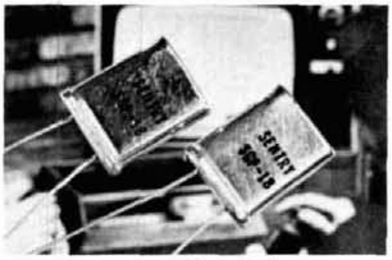
The B&K-Precision Model 1827

provides full autoranging operation or it can be switched to a 1-second position for 1-Hz resolution — even while measuring CB radio frequencies. Decimal-point position is automatic as is a MHz/kHz indication. An exclusive battery saver feature shuts off power to the LED display after 15 seconds of operation. A touch of the DISPLAY button restores the display for another 15 seconds. When operated by an external power source, dc or ac, the display remains on continuously.

The model 1827 can be powered for more than 8 hours of normal use by ordinary AA batteries or by rechargeable nickel-cadmium batteries. With appropriate accessories, the 1827 will also operate from either external 6.7-9.7 Vdc (for mobile operation) or 110 Vac. Batteries are not required when external power is used.

The 1827 uses a custom LSI integrated circuit that was designed by B&K-Precision in cooperation with a major semiconductor manufacturer. The model 1827 will be available at local distributors shortly.

For additional information, contact B&K-Precision, Dynascan Corporation, 6460 West Cortland Avenue, Chicago, Illinois 60635.



improved television game crystal

The smallest 3.579545 MHz quartz crystal for television games, the new Sentry Model SGP-18, has been developed and introduced by Sentry Manufacturing Company, Chickasha, Oklahoma, a precision frequency-control industry leader in quality

More Details? CHECK—OFF Page 142

communications and quartz time-base crystals.

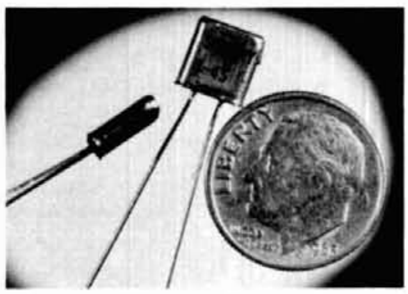
Other specific applications of the new Sentry crystal include amateur radio equipment, pocket-pagers and other telecommunications equipment.

The new Sentry Model SGP-18 offers significant improvements over conventional plastic-packaged, color-burst crystals. Key advantages include improved circuit density and gold plating for greater long-term stability.

The new crystal exceeds MIL-C-3098 specifications for quartz-crystal units and complies with military type designation CR-64/U. The crystal measures 0.147 in. (3.73mm) deep, 0.399 in. (10.13mm) wide, and 0.510 in. (12.95mm) long. Total volume is only 0.0364 $in.^3$ ($5.9710mm^3$).

Additional technical information and samples of the new Sentry SGP-18 miniature quartz crystal are available from the Sales Department, Sentry Manufacturing Company, Crystal Park, Chickasha, Oklahoma 73018.

smallest quartz crystal



The world's smallest commercial quartz crystal, the new Sentry Model S-45, has been developed and introduced by Sentry Manufacturing Company, Chickasha, Oklahoma, a precision frequency-control industry leader in quality communications and quartz time-base crystals.

Available in 6-25 MHz fundamental frequencies and 18-125 MHz overtone frequencies, the new Sentry S-45 was specifically designed for hand-held pagers, miniature CB transceivers, and other size-critical

More Details? CHECK – OFF Page 142

applications requiring precision frequency control.

Dimensions of the new Sentry Model S-45 crystal include a depth of only 0.078 in. (1.98 mm), a width of 0.275 in. (6.98mm), a length of 0.285 in. (7.24mm), and total volume of just 0.0077 in.^{3} (0.1263cm^3). Gold-plated and mounted in a hermetically sealed metal holder, the new crystal meets or exceeds MIL-C-3098 specifications for quartz-crystal units.

Additional technical information and samples of the Sentry S-45 subminiature quartz crystal are available from the Sales Department, Sentry Manufacturing Company, Crystal Park, Chickasha, Oklahoma 73018.

transistor and fet analyzer

Sencore announces the new TF-46 portable Cricket tester, especially designed for transistor and FET testing in the field or at the bench. The battery-operated portable tester automatically turns off after 20 minutes of operation to extend battery life. At the bench, the TF46 plugs into a $9.95 power adapter (PA202) that automatically bypasses the power-off feature, so you don't have

More Details? CHECK—OFF Page 142

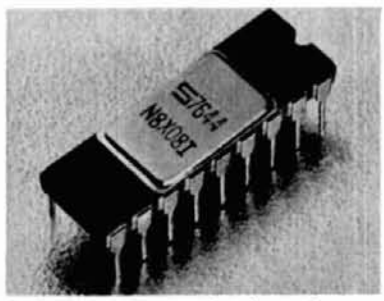
to turn the tester back on after every 20 minutes of use.

The TF46 is the first and only completely automatic transistor analyzer that Sencore has designed, with each function designed to test exactly what is labeled on the control knob and pushbuttons. The TF46 automatically determines transistor and FET lead connections, transistor type, transistor polarity, whether the transistor is good or bad, plus all parameter tests such as actual gain and leakages.

The TF46 was especially made to be portable to expand complete transistor testing at hard-to-get-to places, such as aircraft, boats, communications equipment in automobiles and trucks, computers, switchboards, and the thousand-and-one other places that have permanent installations but where complete solid-state testing is essential. The TF46 sells for $195, $45.00 less than the earlier model TF30 Super Cricket, which didn't have the portable features.

For more information on the new TF-46, write Sencore, 3200 Sencore Drive, Sioux Falls, South Dakota 57107.

hf and vhf signal generator IC



A frequency synthesizer that uses digital phase-locked-loop techniques to generate radio frequency signals in the hf and vhf range is now available as a large-scale integrated circuit (LSI) from Signetics.

With low-power Schottky and emitter-coupled logic (ECL) technolo-

More Details? CHECK—OFF Page 142

gies integrated into a single substrate, the new Signetics circuit, designated 8X08, operates at 80 MHz input with a typical power of 1.6 mW per gate.

The 8X08 incorporates an onboard reference crystal oscillator and an ECL prescaler. The new frequency synthesizer should have major applications in the design of aircraft and marine radio equipment, in instrumentation circuits such as signal generation in test equipment, and in synthesized a-m/fm radios.

The 8X08 provides the major functional elements of a phase-locked-loop frequency synthesizer within a single LSI device. A VCO and loop filter are all that are required to complete the synthesizer circuit. The 8X08 contains all other major functional blocks, including a fixed-frequency reference oscillator and divider chain, a phase comparator, and a programmable counter chain for channel selection.

The fixed prescaler for the fm input is a key to the design, since the prescaler is required in phase-locked loops where very high frequencies are to be generated in order to divide the local oscillator frequency to a frequency compatible with the programmable counter.

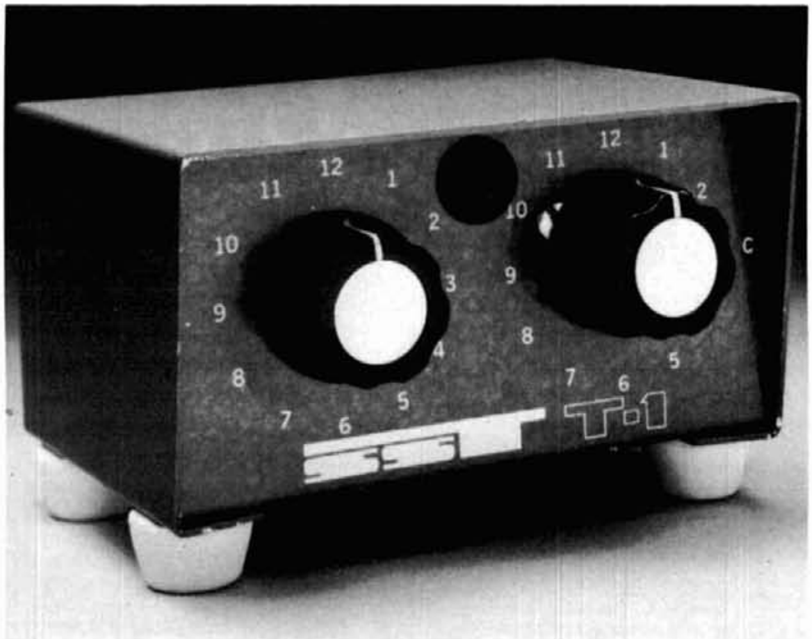
In the 8X08, the ECL prescaler makes programmable channel spacing possible to 100 kHz for fm receiver local-oscillator signal generation when using a 3.6-MHz reference oscillator crystal and an external divide-by-two circuit. Two-thousand channels are possible when using the fm input. Operating features include maximum power dissipation of 680 mW with a single 5-volt power supply.

The 8X08 a-m/fm-frequency synthesizer is available in an 18-pin package from Signetics and its authorized distributors. Price is $13.65 each in quantities of one hundred.

For further information, contact Signetics, 811 East Arques Avenue, Sunnyvale, California 94086.

More Details? CHECK—OFF Page 142

SST T-1 RANDOM WIRE ANTENNA TUNER



All band operation (160-10 meters) with any random length of wire. 200 watt **output** power capability—will work with virtually any transceiver. Ideal for portable or home operation. Great for apartments and hotel rooms—simply run a wire inside, out a window, or anyplace available. Toroid inductor for small size: 4-1/4" X 2-3/8" X 3." Built-in neon tune-up indicator. SO-239 connector. Attractive bronze finished enclosure.

only $29.95

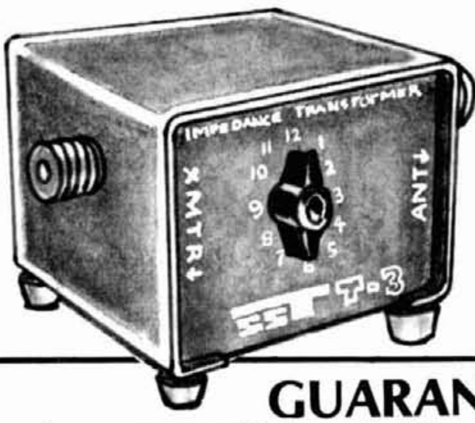
sst t-2 ULTRA TUNER

Tunes out SWR on any coax fed antenna as well as random wires. Works great on all bands (160-10 meters) with any transceiver running up to 200 watts power output.

Increases usable bandwidth of any antenna. Tunes out SWR on mobile whips from inside your car.

Uses toroid inductor and specially made capacitors for small size: 5¼" x 2¼" x 2½." Rugged, yet compact. Attractive bronze finished enclosure. SO-239 coax connectors are used for transmitter input and coax fed antennas. Convenient binding posts are provided for random wire and ground connections.

only $49.95



sst t-3 IMPEDANCE TRANSFORMER

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

only $19.95

GUARANTEE

All SST products are guaranteed for 1 year. In addition, they may be returned within 10 days for a full refund (less shipping) if you are not satisfied for any reason. Please add $2 for shipping and handling. Calif. residents, please add sales tax. COD orders OK by phone.

SST ELECTRONICS
P.O.BOX 1 LAWNDALE, CALIF.
90260 · (213) 376-5887 S10

More Details? CHECK—OFF Page 142

Compare the Atlas 350-XL with other transceivers . . .

TYPE	ALL SOLID STATE			HYBRID (VACUUM TUBE P.A.)			
MODEL	ATLAS 350-XL	TEN TEC	YAESU FT-301	DRAKE TR4-CW	HY-GAIN 3750	KENWOOD TS-820	TEMPO 2020
INPUT POWER	350 WATTS	200	200	300	200	200	180
BANDS	10-160M	10-80M 160M OPT	10-160M	10-80M	10-160M	10-160M	10-80M

. . . and see why it's your best buy!

Above is a chart comparing leading HF Transceivers that fall in approximately the same price range as *the Atlas 350-XL. The Drake TR4-CW is least ex-*pensive, while the HY-Gain 3750 is the highest. Rated power input (SSB) and bands covered are listed in the chart, but below is a discussion on a number of other interesting comparisons which will help you choose the right transceiver for your station.

1. STATE-OF-THE-ART, ALL SOLID STATE

The first 3 transceivers listed above are all solid state. The real designs of the future! Having manufactured and sold over 12,000 of our little 210x/215x's, *we can attest to the high performance and* reliability of all solid state design. Tubes for the driver and P.A., with their tuning circuits and high voltage power supplies are rapidly becoming obsolete. As a result their resale value will be declining.

2.POWER RATING.

The higher power rating on the 350-XL provides you with a comfortable edge over the others. Running barefoot you can easily ride over the competition. If you're driving a linear you don't have to strain for every bit of drive from the transceiver. It can loaf along with ease. The 350 watt input rating *is really very conservative. Typical input power runs* upwards of 400 to 450 watts without flat-topping. Considerably more than the others.

3. BAND COVERAGE

Not only does the 350-XL cover the 10 through 160 meter bands (including all of 10 meters in four 500 kHz segments), but one of its exclusive features is that you can install up to 10 auxiliary 500 kHz ranges anywhere from 2 to 5 MHz, and from 6 to 23 MHz. This gives you great flexibility for MARS operation and possible future amateur bands. Crystals for Auxiliary Ranges are installed internally. In *addition, the 350-XL provides reception of WWV at* 5, 10, and 15 MHz, without having to add any auxiliary range crystals.

4. DIGITAL FREQUENCY READOUT

On the 350-XL, the optional Digital Dial can be in*stalled, and you still retain the conventional analog* dial, with the option of switching the digital dial off if you wish. With the Ten-Tec or Yaesu 301, you lose the analog dial if you purchase the digital dial model, making you totally dependent on the digital dial.

5. FULL BREAK-IN CW

Only two rigs offer this feature; the Atlas 350-XL and the Ten-Tec ! The others are all "semi-break-in". And the Atlas includes CW sidetone with pitch and volume adjustments.

6. NARROW BAND CW FILTER

This is another standard feature in the Atlas, optional on the Ten-Tec , Yaesu, and Kenwood. Ours is an I.F. filter with 500 Hz bandwidth, and shape factor of better than 3 to 1.

7. A.F. NOTCH FILTER

This 350-XL standard feature permits nulling out heterodynes and other interference. The Yaesu, Hy-Gain and Kenwood include a similar feature.

8.SPEECH COMPRESSION

The standard Atlas ALC system provides up to 20 dB of R.F. compression which increases your talk *power and at the same time reduces "flat-topping"* and splatter. An optional speech processor to provide up to 20 dB additional A.F. compression will be available soon for installation in the AC supply. The Hy-Gain, Kenwood, and Yaesu also provide some *form of speech processing.*

9. AUXILIARY VFO

All of the rigs listed offer an optional second VFO for split frequency operation. But Atlas is the only one with an Auxiliary VFO that is not an add-on box. The Atlas Auxiliary VFO plugs right into a space provided in the upper right hand corner of the front panel. Although miniature in size it tunes the same 500 kHz as the primary VFO, and does it smoothly with coarse and fine controls that have 10:1 planetary drives. Green, yellow, and red LED's let you know which VFO you have set up for *receiving and transmitting.* Very neat, and all self-contained.

An option to the Model 305 Auxiliary VFO is the Model 311 crystal oscillator that provides up to 12 crystal controlled channels. It also plugs into the front panel just like the 305. Vernier controls provide fine tuning of the crystal frequency.

10. MOBILE/PORTABLE OPERATION

The Atlas, Ten-Tec , and Yaesu, being solid state, are unique in that they will operate mobile or portable directly from a 12-14 volt DC battery. Also, the solid state rigs are considerably smaller and lighter weight than the hybrid rigs. The Atlas is unique in having a very handy plug-in mobile bracket for the 350-XL that makes it a simple matter to plug-in and go mobile.

11. OTHER 350-XL STANDARD

FEATURES include R.I.T., VOX, Crystal Calibra*tion, ANL, and* Noise Blanker.

Compare the Atlas 350-XL SSB-CW Transceiver with the others, and we think you'll agrea the Atlas has everything you'll ever need in a transceiver. And it's made in America.

And let us not forget to mention Our Customer Service which is second to none. Just ask the ham who owns one.

Model 350-XL (less options) . . . $995.
Model DD6-XL Digital Dial . . . . $229.
Model 305 Auxiliary VFO . . . . . $155.

★ MADE IN AMERICA ★

We're very proud that every Atlas transceiver is made right here in America, (as are the Ten-*Tec and Drake*). We think the American worker, and our employees in particular, are the most talented, industrious people in the world. The quality and versatility of our transceivers are proof of this.

And by using this American quality workmanship, advanced value engineering in design and manufacture, and rigid quality control, the Atlas transceiver is not only competitively priced with the imports, but is actually a better value!

Merry Christmas and Holiday Greetings from all the gang at Atlas!

ATLAS RADIO INC.
417 Via Del Monte, Oceanside, CA 92054
Phone (714) 433-1983
Special Customer Service Direct Line
(714) 433-9591

More Details? CHECK—OFF Page 142

We Don't Claim That Your **ALPHA** Linear Will Run A Kilowatt Key-Down FOREVER . . .

. . . But We Don't Put A Time Limit On It, Either.

YOU'LL PROBABLY NEVER SET A BRICK ON YOUR KEY FOR 26,000 MINUTES, BUT WE DID IT TO ILLUSTRATE WHAT ETO'S NO TIME LIMIT [NTL] CONTINUOUS DUTY RATINGS REALLY MEAN TO EVERY **ALPHA** AMPLIFIER OWNER.

April 7th: A standard **ALPHA 76** was taken from production, loaded up to a full 1000 watts key-down dc input, and left operating with a brick on the key.

April 25th: The '76 was still operating completely normally, delivering about 675 watts of continuous rf carrier output into a very hot dummy load — after 18 days — 435 hours — some 26,000 consecutive minutes key-down at a full kilowatt. You may have seen the same unit running key-down all day long the following week-end at the Dayton Hamvention. It's still as good as new — a fact which will surprise no one who knows how all **ALPHA's** are built. You'd expect no less.

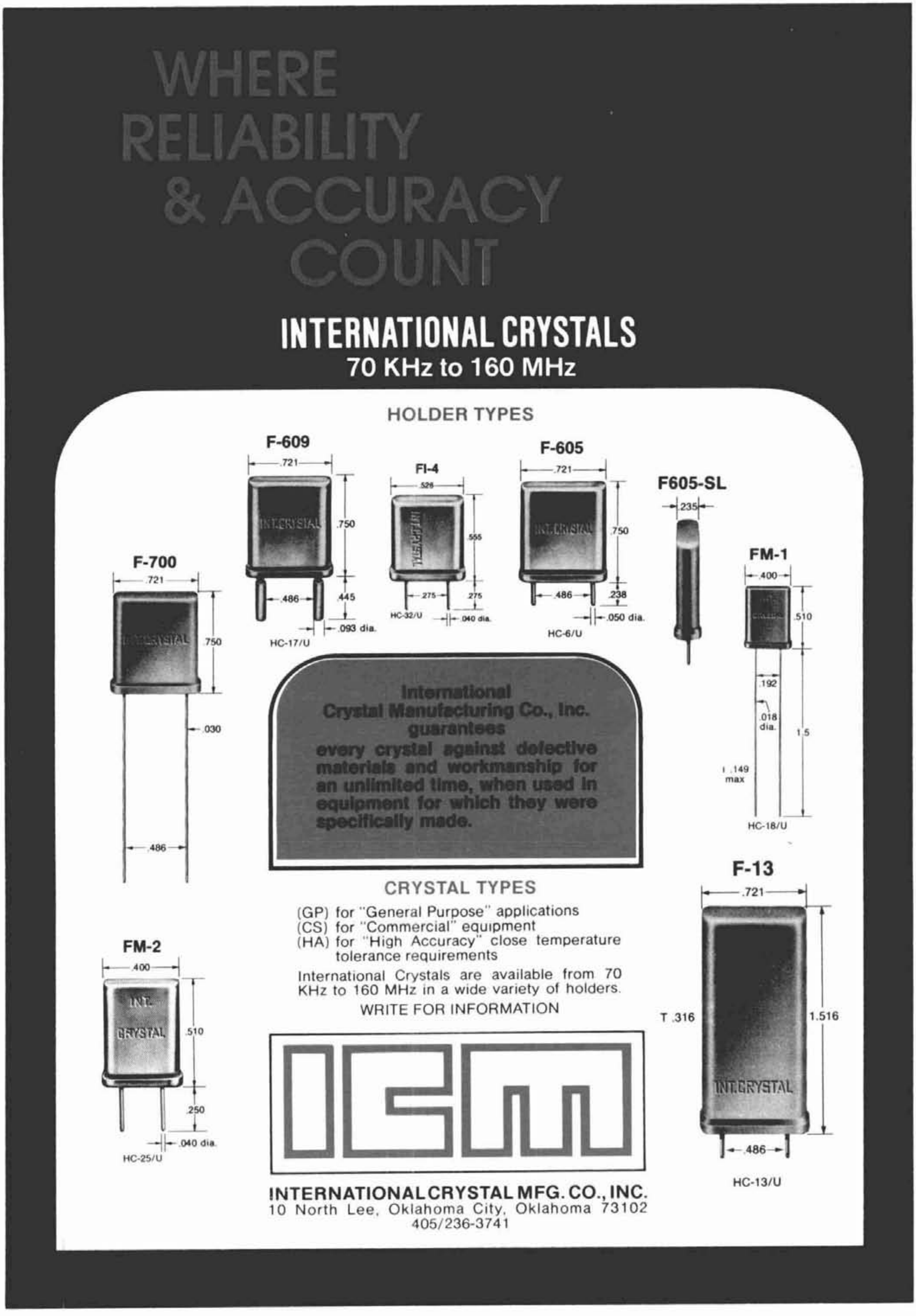
The point is, every **ALPHA** linear amplifier — including the power- and value-packed **ALPHA 76** and the exclusive NO-TUNE-UP **ALPHA 374** — is meticulously engineered and built to handle continuous operation IN ANY MODE AT MAXIMUM LEGAL POWER [NTL] . . . No Time Limit. And ETO's warranty on every **ALPHA** amplifier protects you FOR EIGHTEEN MONTHS — FIVE TIMES LONGER than most amateur equipment warranties!

ALPHA: SURE YOU CAN BUY A CHEAPER LINEAR . . . BUT IS THAT *REALLY* WHAT YOU WANT?

A LINEAR AMPLIFIER IS A BIG INVESTMENT . . . MAKE IT WISELY. For an enlightening glimpse at what goes into the design of every **ALPHA** *by ETO's power professionals, or to aid you in comparing one linear with another, call or write for our brief guide entitled, "EVERYTHING YOU ALWAYS WANTED TO KNOW ABOUT (COMPARING) LINEARS . . . BUT DIDN'T KNOW WHOM TO ASK." We'll also send you fully detailed and illustrated literature describing the entire ETO line of superb* **ALPHA** *power amplifiers and ALPHA/VOMAX — the new split-band speech processor that's your key to rf clipper type "talk power" combined with easy mike-line installation and low-distortion, practically foolproof operation.*

ETO

EHRHORN TECHNOLOGICAL OPERATIONS, INC.
P.O. BOX 708 — INDUSTRIAL PARK
CANON CITY, CO. 81212 PHONE (303) 275-1613


WHERE RELIABILITY & ACCURACY COUNT
INTERNATIONAL CRYSTALS
70 KHz to 160 MHz
HOLDER TYPES
F-609
.721
.750
.486
.445
.093 dia.
HC-17/U
FI-4
.526
.555
.275
.275
HC-32/U
.040 dia.
F-605
.721
.750
.486
.238
.050 dia.
HC-6/U
F605-SL
.235
FM-1
.400
.510
.192
.018 dia.
1.5
.149 max
HC-18/U
F-700
.721
.750
.030
.486
International Crystal Manufacturing Co., Inc. guarantees every crystal against defective materials and workmanship for an unlimited time, when used in equipment for which they were specifically made.
CRYSTAL TYPES
(GP) for "General Purpose" applications
(CS) for "Commercial" equipment
(HA) for "High Accuracy" close temperature tolerance requirements
International Crystals are available from 70 KHz to 160 MHz in a wide variety of holders.
WRITE FOR INFORMATION
FM-2
.400
.510
.250
.040 dia.
HC-25/U
F-13
.721
T .316
1.516
.486
HC-13/U
INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee, Oklahoma City, Oklahoma 73102
405/236-3741

More Details? CHECK—OFF Page 142

Sooner or later . . .

every Ham will probably own at least one

Wilson

Hand-Held

NEW!

Small size . . . giant performance

TWO MODELS AVAILABLE:
2.5 Watt MARK II and
4 Watt MARK IV

SPECIFICATIONS:

- Range: 144-148 MHz
- 6 Channel Operation
- Individual Trimmers on all TX and RX Xtals.
- Current Drain: RX 15 mA, TX - Mark II, 500 mA. Mark IV 900 mA
- 12 KHz Ceramic Filter
- 10.7 MHz and 455 kHz IF
- Spurious and Harmonics: 50 dB *below carrier*
- BNC (Twist type) Antenna Connector
- .3 Microvolt Sensitivity for 20 dB Quieting
- Uses special rechargeable Ni-Cad Battery Pack
- New improved Rubber Duck included
- One pair Xtals 52/52 included
- Weight: 16 oz. (.45 Kg) inc. batteries
- Size: 6" x 1.770" x 2.440"

ACCESSORIES AVAILABLE

Include LC-4 Leather Case, WC12 AC Wall Battery Charger, BC4 Desk Type Battery Charger, SM4 Speaker Mic, Touch Tone Pad, Tone Options.

The new arrivals to the Wilson family of quality high performing hand-held radios are the small American-made small sized MARK II and MARK IV. The ultimate hand-held for the amateur who demands quality, performance and value.

FEATURES:

— Lightweight and compact size — fits comfortably in the palm of your hand.
— Rugged Lexan® case.
— Same dependable performance as all Wilson Hand-Helds.
— *Microswitch Speaker-Mic* built in.

— Priced at

$199.95 MARK II (2.5 watt)
$239.95 MARK IV (4 watt)

Not available for sale until January 1978

FOR SIZE COMPARISON, THE NEW MARK IV IS ILLUSTRATED NEXT TO WILSON'S 1405SM SWITCHABLE 1 & 5 WATT RADIO.

Other Wilson units available are the VHF Models 1402SM, 2.5 watt, Model 1405SM Switchable 1 and 5 watt and 4502SM, 450 MHz, 2202SM, 220 MHz UHF units and Wilson's WE800 synthesized 2 meter portable rig.

DON'T MISS OUT ON THE EXPLODING HAM MARKET!

FCC certification pending.

ATTENTION AMATEUR DEALERS:
Wilson is accepting new dealers in many areas . . . contact us if you are interested.

For an illustrated Amateur Products Buyers Guide, write:

Wilson Electronics Corp.

P.O. Box 19000 • Las Vegas, Nevada 89119 • (702) 739-1931 • TELEX 684-522

More Details? CHECK — OFF Page 142

BREAD BOARD JUMPER WIRE KIT

Each kit contains 350 wires cut to 14 different lengths from 0.1" to 5.0". Each wire is stripped and the leads are bent 90° for easy insertion. Wire length is classified by color coding. All wire is solid tinned 22 gauge with PVC insulation. The wires come packed in a convenient plastic box.

JK1 .... $10.00 / kit

SOCKET JUMPERS

Mates with two rows of .025" sq. or dia. posts on patterns of .100" centers and shielded receptacles. Probe access holes in back. Choice of 6" or 18" length.

Part No.	No. of Contacts	Length	Price
924003-18R	26	18"	$ 5.38 ea.
924003-06R	26	6"	4.78 ea.
924005-18R	40	18"	8.27 ea.
924005-06R	40	6"	7.33 ea.
924006-18R	50	18"	10.31 ea.
924006-06R	50	6"	9.15 ea.

JUMPER HEADERS

Solder to PC boards for instant plug-in access via socket-connector jumpers. .025" sq. posts. Choice of straight or right angle.

Part No.	No. of Posts	Angle	Price
923863-R	26	straight	$1.28 ea.
923873-R	26	right angle	1.52 ea.
923865-R	40	straight	1.94 ea.
923875-R	40	right angle	2.30 ea.
923866-R	50	straight	2.36 ea.
923876-R	50	right angle	2.82 ea.

INTRA-CONNECTOR

Provides both straight and right angle functions. Mates with standard .10" x .10" dual row connectors (i.e. 3m, Ainsley, etc.) Permits quick testing of inaccessible lines.

Part No.: 922576-26 No. of contacts: 26 Price $6.90 ea.

INTRA-SWITCH

Permits instant line-by-line switching for diagnostic or QA testing. Switches actuated with pencil or probe tip. Mates with standard .10" x .10" dual-row connectors. Low profile design. Switch buttons recessed to eliminate accidental switching.

Part No.: IS-26 No. of contacts: 26 Price $13.80 ea.

CRYSTALS

THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY2.01	2.010 MHz	HC33/U	$1.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100	PINS (Wire Wrap)	$6.95
50/100A (.100 Spacing)	PINS (Wire Wrap)	$6.95

25 PIN-D SUBMINIATURE (RS232)

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

HEAT SINKS

205-CB 680-.75A

205-CB	Beryllium Copper w-black finish for T0-5	$ .25
291-.36H	Aluminum for T0-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum for T0-3	$1.60
Dude 4	Black Anodized Aluminum — predrilled mounting holes for T0-3 — 4¾ x 1¼ x 2"	$1.75

Etching Kits (cannot be shipped via air)

32 X A-1	P.C. Etch Materials Kit enough for 5 circuit boards	$29.95 ea.
27 X A-1	Etched Circuit Kit Complete kit — only add water	$ 9.95 ea.

Plugboards

3662	6.5 X 4.5 X 1/16 Epoxy glass P Pattern-44 P.C. Tabs-spaced .156	$ 6.95 ea.
22/44	Mating connector for plugboard — 22 pin double readout	$ 2.95 ea.
8800V	Universal Microcomputer/Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5.313 X 10 X 1/16 copper clad	$19.95 ea.

Vector

1/16 VECTOR BOARD

	0.1" Hole Spacing Part No.	P Pattern L	W	Price 1-9	10 up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062WE	4.50	6.50	2.07	1.86
	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

63 KEY KEYBOARD $29.95

This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13 x 4 base suits most applications.

HD0165	Encoder Chip (encodes 16 Keys)	$7.95 ea.
AY-5-2376	Encoder Chip (encodes 88 Keys)	$14.95 ea.

MICROPROCESSOR COMPONENTS

8080A	CPU	$16.00	CDP1802	CPU	$19.95
8212	8 Bit Input/Output	4.95	MC6800	8 Bit MPU	24.95
8214	Priority Interrupt Control	15.95	MC6820	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	9.95	MC6830L8	1024 x 8 Bit ROM	15.00
8228	System Controller Bus Driver	10.95	Z80	CPU	29.95

CPU'S

80804	Super 8008	16.00
2650	8 BIT MPU	26.50
P8085	CPU	29.95

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2522	Dual 132 Bit SSR	2.95
2524	512 Dynamic	1.95
2525	1024 Dynamic	3.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	[illegible]

UART'S

AY-5-1013	30K Baud	$3.95

ROM'S

2513(2140)	Char. Gen. upper case	$ 9.95
2513(3021)	Char. Gen. lower case	9.95
2516	Char. Gen.	10.95
MM5230	2048 BIT (512 x 4 or 256 x 8)	1.95

RAM'S

1101	256 x 1	Static	$ 1.49
2101	256 x 4	Static	3.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
21L02/91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00
UPD414(2104)	4K	Dynamic 16 Pin	5.95

PROMS

1702A	2048	Famos	$ 9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	19.95
2716	16K	Eprom	34.95
6301-1	1024	Tri State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95

SPECIAL REQUESTED ITEMS

FCM3817	$5.00	11C90	19.95	7205	19.95	9368	3.95
AY-3-8500-1	8.95	4N33	3.95	ICM7045	24.95	LD110/111	25.00/set
AY-5-9100	17.50	8T20	7.50	ICM7207	7.50	95H90	11.95
AY-5-9200	14.95	8T97	2.00	ICM7208	22.00	MC3061P	3.50
AY-5-9500	4.95	HD0165	7.95	ICM7209	7.50	MC4016 (74416)	7.50
AY-5-2376	14.95	MCM6571	13.50	MK50240	17.50	MC1408L7	8.95
9374	1.95	MCM6574	13.50	DS0026CH	3.75	MC1408L8	9.95
82S115	25.00	MCM6575	13.50	TIL308	10.50		

CLOCK CHIPS

MM5309	$9.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5841	9.95
CT7001	5.95

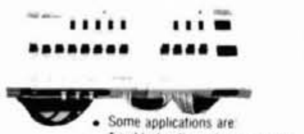
PARATRONICS

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit Model 100A

$229.00/kit

Model 100A assembled $295.00



- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.

(Model 100A Manual - $4.95)

- Some applications are:
  - — Troubleshooting microprocessor address, instruction, and data flow
  - — Examine contents of ROMS
  - — Tracing operation of control logic
  - — Checking counter and shift register operation
  - — Monitoring I/O sequences
  - — Verifying proper system operations during testing

PARATRONICS TRIGGER EXPANDER - Model 10

Adds 16 additional bits. Provides digital delay and qualification of input clock and 24-bit trigger word. — Connects direct to Model 100A for integrated unit.

Model 10 Kit — $229.00
Model 10 Assembled — $295.00
Baseplate — $9.95
Model 10 Manual — $4.95

B&K PRECISION 3½-Digit Portable DMM

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

Ranges: DC Voltage ±0-1000V/ AC Voltage 0-1000V
Freq. Response: 50-400 HZ
DC/AC Current: 0-100mA
Resistance: 0-10 meg ohm
Size: 6.4" x 4.4" x 2"

Model 2800 $99.95

Comes with test leads, operating manual and spare fuse

Accessories:

AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power sources, i.e. batteries, 110 or 220V with charger, 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator *use power from car battery* — Model 100 — CLA $3.95

Charger/Eliminator use 110 V AC — Model 100 — CAI $9.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95 (6" long X 4" wide)

Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	129.95

LOGIC MONITOR

for DTL, HTL, TTL or CMOS Devices **$84.95**

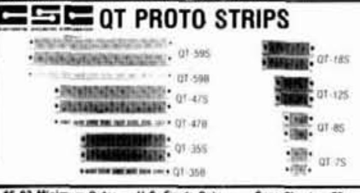
PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

DESIGN MATES

DM1 - Circuit Designer $69.95
DM2 - Function Generator $74.95
DM3 - RC Bridge $74.95

CSC QT PROTO STRIPS



QT type	# holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$ 9.95
Experimentor 600	$10.95

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

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

NOW OPEN SATURDAYS

James ELECTRONICS

1978 CATALOG NOW AVAILABLE

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097

All Advertised Prices Good Thru January

The Incredible "Pennywhistle 103"

$129.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications for the deaf. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable)
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space; 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) – 1070 space, 1270 mark; High – 025 space, 2225 mark
Receive Sensitivity	-46 dbm acoustically coupled
Transmit Level	-15 dbm nominal. Adjustable from -6 dbm to -20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 9" printed circuit board. All components included

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align.

ERC AM/FM 8-Track Stereo Receiver With BSR Changer

- PLL System
- BSR Record Changer
- Slide Controls
- Automatic AFC Control
- 4 Speaker Output
- Walnut finish vinyl covered wood veneer with smoke dust cover

Size: 20"W x 9⅜"H x 15¼"D

Model 8365 $149.95

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One: Times Single Event — Split & Taylor
- Size 4.5 x 2.15 x .90 (4½ ounces)
- Uses 3 Penlite Cells

Kit —	$39.95
Assembled —	$49.95
Heavy Duty Carry Case	$5.95

Stop Watch Chip Only (7205) $19.95

IMC 3½ DIGIT DPM KIT

- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	$49.00
Model 311D-5C-5V Power Kit	$17.50

JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2¾" x 1". It utilizes a MAN72 high brightness readout and the MM5314 clock chip.

12 or 24 Hour

115 VAC KIT ONLY **$16.95**

HEXADECIMAL ENCODER 19-KEY PAD

- 1 - 0
- ABCDEF
- Shift Key
- 2 Optional Keys

$10.95 each

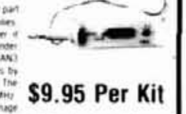
INSTRUMENT/CLOCK CASE

Injection molded unit. Complete with red bezel. 4½" x 4" x 1-9/16".

$3.95 ea.

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (H) 1 (LOW) - 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.



$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only

$9.95 Per Kit

More Details? CHECK—OFF Page 142

RATES Non-commercial ads 10¢ per word; commercial ads 60¢ per word both payable in advance. No cash discounts or agency commissions allowed.

HAMFESTS Sponsored by non-profit organizations receive one free Flea Market ad (subject to our editing). Repeat insertions of hamfest ads pay the non-commercial rate.

COPY No special layout or arrangements available. Material should be typewritten or clearly printed (not all capitals) and must include full name and address. We reserve the right to reject unsuitable copy. **Ham Radio** cannot check each advertiser and thus cannot be held responsible for claims made. Liability for correctness of material limited to corrected ad in next available issue

DEADLINE 15th of second preceding month.

SEND MATERIAL TO: Flea Market, Ham Radio, Greenville, N.H. 03048.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 93862.

YAESU EQUIPMENT OWNERS — Present or Prospective — Join the seven-year-old, 2500 member, 42-country, International Fox-Tango Club. Members receive valuable monthly Newsletter, money-saving purchasing service, technical committee consultation, free ads, FT net, more. Back issues of Newsletter available from 1972. To join, send $5 for calendar year (includes all 1978 issues of Newsletter) or $1 creditable towards dues, for complete information and sample Newsletter. Milton Lowens, WA2AOQ/N4ML, 248A Lake Dora Drive, W. Palm Beach, Fl. 33411.

FREE Catalog. Solar Cells, Nicads, Kits, Calculators, Digital Watch Modules, Ultrasonics, Strobes, LEDS, Transistors, IC's, Unique Components. Chaney's, Box 27038, Denver, Colo. 80227.

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

Foreign Subscription Agents for Ham Radio Magazine

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

Ham Radio Belgium
Stereohouse
Brusselsesteenweg 416
B-9218 Gent
Belgium

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

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

Ham Radio France
Christiane Michel
F-89117 Parly
France

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

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

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

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

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

Holland Radio
143 Greenway
Greenside, Johannesburg
Republic of South Africa

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

HW-12 $90, DX-60 $75, BC-348 $50. John Townsend, 1522 Branch St., Wilson, N.C. 27893.

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

COLLINS CW Filter, 300Hz bandwidth X455KF300. For use in 75S3, 75S3B and 75A4 receivers. See Sept. 1975 H.R. for article. $60.00 postpaid. W1EBC, Gary Firtick, 40 Pilgrim Trail, Woodbury, CT. 06798.

FOR SALE: FAIRCHILD/DUMONT OSCILLOSCOPES 765MH/76-08/7413A, 50 MHz, 5 MV, dual trace, delayed sweep, silicon solid state $550. Microdot 412A FM signal generators 400-550 MHz, 6 digit readout, 0.0003% accuracy, calibrated attenuator, solid state, unique self-calibrating FM deviation system, cost govt. $11,000+, $575. HP/Boonton 250A RX meter $525. EST 291B, impedance bridge assembly $PUR, military TS-413B/U, $85. Write for detailed specifications. All calibrated and guaranteed. Becken Co., White Oaks Route, Carrizozo, N.M. 88301.

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

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

TELETYPEWRITER PARTS, gears, manuals, supplies, tools, toroids. SASE list. Typetronics, Box 8873, Ft. Lauderdale, FL. 33310. N4TT Buy parts, late machines.

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

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

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

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

PARTS and SERVICE SUPPLIES — Free catalog. National distributors for Oneida Electronics and Crystek Crystals — Write Tommy, WD4EKJ, Comm-Tech, Inc., 104 North Third Street, Richmond, Ky.

FOR SALE — DRAKE 2B with 2AQ $175, Regency HR 2A $150. Both units good, manuals, pictures and information available. Will Ship. Want Kenwood R 599 A receiver. A.H. Davis, 212 Santa Fe, Halstead, Ks. 67056.

COLOR VIDEO RECORDER — $249. Zoom lens TV camera — $179, good for Betamax, Quasar, other VTR and SSTV, ATV. Will trade — need Atlas 180/210/215X, IC-22A or better 2M transceiver, SSB CB transceiver. W6DOM, 6017 Majorca Ct., San Jose, California 95120. (408) 997-0132.

HAM RADIO HORIZONS, a super new magazine for the Beginner, the Novice and anyone interested in Amateur Radio . . . What it's all about, How to get started, The fun of ham radio. It's all here and just $12.00 per year. HURRY! HURRY! Ham Radio HORIZONS, Greenville, NH 03048.

OLD QSTs wanted for collection. Al Blank, W1BL 727 Pine St., Bristol, Ct. 06010.

TELETYPE FOR SALE: Model 28ASR's, KSR's, typing reperfs, and TD's. New and used parts available including cabinets, tables, mod kits, gears and gearshifts. Paper, ribbons, and supplies. Some 8-level Model 33 and 35 equipment available. Send SASE for complete list and prices. K9WJB, Lawrence R. Pfleger, 2141 N. 52nd St., Milwaukee, WI 53208.

BUY-SELL-TRADE. Write for free mailer. Give name, address and call letters. Complete stock of major brands new and reconditioned equipment. Call for best deals. We buy Collins, Drake, Swan etc. SSB & FM. Associated Radio, 8012 Conser Overland Park, Kansas 66204 (913) 381-5901.

RTTY — NS-1A PLL demodulator. Board $3.50; Parts $15.00; W/T $24.95, all postpaid. SASE for info. Nat Stinnette Electronics, Tavares, Fl. 32778.

FOR SALE: DRAKE TR22 and AA10PA, $140. CV57/URR $50. Hallicrafter receiver S9, with original speaker, make offer. W2GRN, Tom Myers, 540 Maple Dr. W., New Hyde Pk., N.Y. 11040. (516) 354-5550.

More Details? CHECK—OFF Page 142

flea market

SELL: Heath Hamscan, Model 620. WØPHY.

450 REPEATER — Motorola, 74BBB-3000, 100W, PL, Outdoor cabinet, manual. Good condition. $350 or swap SB11DA or Swan 250C. WA1RHT, (203) 589-7086.

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

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

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

QSL CARDS 500/$10. 400 illustrations, sample. Bowman Printing, Dept. HR, 743 Harvard, St. Louis, Mo. 63130.

MAGAZINES wanted by collector. 1945 CQ, pre-1930 QST, RADEX, RADIO, and others. Swap my duplicate Ham Radio issues and others. Donald Erickson, 6059-P Essex, Riverside, California 92504. (714) 687-5910.

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

TEST EQUIPMENT: Knight 5 MHz scope $40; Signal Generator $15; Heath tube tester $40; EMC ss vtvm $25, all with manuals, very good condition. W9HDA, 2349 Wiggins, Springfield, Illinois 62704.

HELP! Need to contact anyone that was part of the group that set up a ham station on the Isla del Coco, off the coast of Costa Rica. Need maps and photos of the island, info on communication problems and sea transport to the island. J.F. Welch, TUSLOG Det-8, Box G, A.P.O. New York 09294.

HIGHEST QUALITY AMPEREX, GENALEX, TELEFUNKEN & SIEMENS transmitting and receiving tubes available at very competitive prices from the S.J. Wallace Co., 201 McMasters Dr., Monroeville, Pa. 15146 (412) 373-2602.

CQ AND QST 1950-1975 issues for sale. Send SASE if ordering Ham Radio, 73, or other CQ and QST issues. One dollar minimum order and all issues cost 25¢ each, including USA shipping. Send chronological list and full payment to W6LS, 2814 Empire, Burbank, California 91504.

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

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

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

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

VERY in-ter-est-ing! Next 4 issues $1. "The Ham Trader", 2435 Fruitville, Sarasota, FL 33577.

D & V RADIO PARTS — Large selection of variable capacitors. Stamp for up to date flyer listing many new items. In stock for immediate shipment. 12805 Sarle, R #2 Freeland, Michigan 48623.

HOMEBREWERS: Stamp brings component list. CPO Surplus, Box 189, Braintree, Mass. 02184.

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

CHANNEL ELEMENTS NEEDED KXN1024A, Motorola for Micor Radio. Need several. WA6COA, 4 Ajax, Berkeley, CA 94708. (415) 843-5253.

PHOTOGRAPHERS: I am a retired broadcast engineer who would like to meet active hams, on the air, who are interested in the historical processes of photography such as Carbro, Oil, Bromoil, etc. for the purpose of exchanging data on the air with the hope of working together to preserve the knowledge of these beautiful processes for future generations of ham-photographers. I work all bands, 2 through 160 meters, AM or SSB. For sked info please contact Tracy Diers, W2OQK, 58-14-84th Street, Elmhurst, N.Y. 11373.

QSL FORWARDING SERVICE — 30 cards per dollar. Write: QSL Express, 30 Lockwood Lane, West Chester, PA. 19380.

More Details? CHECK—OFF Page 142

More Details? CHECK — OFF Page 142

TOROID CORES

√ All the popular sizes and mixes.
√ Fast Service. Same day shipment via first class mail or air.
√ No minimum order.

IRON POWDER TOROIDS:

CORE SIZE	MIX 2 5-30 MHz u = 10	MIX 6 10-90 MHz u=8.5	MIX 12 60-200 MHz u = 4	SIZE OD (in.)	PRICE USA $
T-200	120			2.00	3.25
T-106	135			1.06	1.50
T-80	55	45		.80	.80
T-68	57	47	21	.68	.65
T-50	51	40	18	.50	.55
T-25	34	27	12	.25	.40

RF FERRITE TOROIDS:

CORE SIZE	MIX Q 1 u=125 .1-70 MHz	MIX Q2 u = 40 10-150 MHz	SIZE OD (in.)	PRICE USA $
F-240	1300	400	2.40	6.00
F-125	900	300	1.25	3.00
F-87	600	190	.87	2.05
F-50	500	190	.50	1.25
F-37	400	140	.37	1.25
F-23	190	60	.23	1.10

Chart shows uH per 100 turns.

FERRITE BEADS:

$2.00 DOZEN

WIDE BAND CHOKES

95¢ EACH

TO ORDER: Specify both core size and mix for toroids. Packing and shipping 50 cents per order USA and Canada. Californians add 6% sales tax.

Fast service. Free brochure and winding chart on request.

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

flea market

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

EZ does it best. Deals, that is, on Yaesu, ICOM, Drake, Swan, Cushcraft, Larsen, KLM, Dentron, VHF Engineering and Wilson. For new or used gear call, see or write WØEZ, Bob Smith Electronics, 12 So. 21st St., Fort Dodge, Iowa 50501. (515) 576-3886.

BARLOW-WADLEY XCR-30 Mark II Crystal controlled communications receiver. Continuous tuning 0.5 to 31 MHz and 87.5 to 108 MHz FM. Excellent condition, in original box, $225 or offer. Harris, 171, Kresge College, Santa Cruz, CA. 95064.

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

TECH MANUALS for Govt. surplus gear — $6.50 each: SP-600JX, URM-25D, OS-8A/U, TS-173/UR. Thousands more available. Send 50¢ (coin) for 22-page list. W3IHD, 7218 Roanne Drive, Washington, DC 20021.

WHY WAIT UNTIL THE NEXT HAMFEST? Your call sign and handle custom printed on a quality T-shirt. Colors available: white, black, tan, gold, red, yellow, or blue. Sizes: Small-Medium-Large-Extra Large. Clubs quantity discounted. $6.00 — TEE-SHIRTERY, K9PM, P.O. Box 101-B, Medinah, Illinois 60157.

Coming Events

SOUTH BEND, INDIANA Hamfest Swap & Shop January 8, 1978, first Sunday after New Years Day at NEW CENTURY CENTER downtown by river on U.S. 31 ONEWAY North across from St. Joseph Bank Building. Half acre in one large room at same ground level as entrances and loading dock. Tables $2 each. Food catering service, automobile museum and Art Center in the same building. Four lane highways to door from all directions. Talk-in freq: 146.52-52, 04-64 East, 13-73, 25-85 SE, 34-94; 147.99-39, 93-33, 84-24, 69-09. Wayne Werts K9IXU, 1889 Riverside Drive 46616.

THE ANNUAL FORT WAYNE WINTER HAMFEST is at Shiloh Hall, North of Fort Wayne, on January 22 from 8 AM until 4 PM local time. Early parking is available and 28/88 and 52/52 will be monitored. This yearly event is sponsored by the Allen County Amateur Radio Technical Society (AC/ARTS). Admission is $2.00 at the door. Table space is available at $1.50 per half table (about 4 feet). For information or table reservations (held until 9:30 AM) write: Hamfest Chairman; AC/ARTS, P.O. Box 342, Fort Wayne, IN. 46801.

RICHMOND, VIRGINIA WINTERFEST — 78 January 15, 1978, Bon Air Community Center, sponsored by The Richmond Amateur Telecommunications Society. Talk-in 28-88 and 52 simplex. ARRL coordinated. Technical symposium, drawing, home brewers contest — 2 divisions, over 18 and under — with framed certificate to winners with Most Original Idea, Best Mechanical and Best Electrical Construction. FCC exams will be administered, starting at 10:00 a.m., to take exam, mail Form 610 at least five days prior to Fest to address below. Send self-addressed, stamped envelope if you need Form 610. Commercial Exhibits, Indoor Flea Market, $2.00 (table included), Outdoor Frost Bite Tail Gate Flea Market, $1.00. Admission $2.00, children under 12 free. R.A.T.S. members excluded from contest and drawing. Bring the family and spend the weekend in beautiful, historic Richmond. Richmond Amateur Telecommunications Society, Post Office Box 1070, Richmond, Virginia 23208.

17th ANNUAL MICHIGAN CROSSROADS HAMFEST Saturday 3/4/78 8:00 opening Marshall High School, Exit 110 from I-94 near I-69. Over $300 in door prizes. Check in 146.07/67 146.52 for lucky QSL card. Donation $1.50 advance, $2.00 at door. Table donation 50¢ each foot. Contact K8UCQ, Goodrich 110 Perrett, Marshall, MI 49068. (616) 781-3554.

NEW FROM GLB

A complete line of *QUALITY* 50 thru 450 MHz TRANSMITTER AND RECEIVER KITS. Only two boards for a complete receiver. 4 pole crystal filter is standard. Use with our *CHANNELIZER* or your crystals. Priced from $69.95. Matching transmitter strips. Easy construction, clean spectrum, *TWO WATTS* output, unsurpassed audio quality and built in *TONE PAD INTERFACE*. Priced from $29.95.

SYNTHESIZER KITS from 50 to 450 MHz. Prices start at $119.95.

Now available in KIT FORM — GLB Model 200 MINI-SIZER.

Fits any HT. Only 3.5 mA current drain. Kit price $159.95 Wired and tested. $239.95
Send for FREE 16 page catalog.
We welcome Mastercharge or VISA

GLB ELECTRONICS
1952 Clinton St., Buffalo, N. Y. 14206

TEST EQUIPMENT

All equipment listed is operational and unconditionally guaranteed. Money back if not satisfied — equipment being returned must be shipped prepaid. Include check or money order with order. Prices listed are FOB Monroe.

BOONTON 190A Q-mtr 30-200mHz $425
FLUKE 803B Diff ac-dc vtvm 295
GR916A RF Imp bridge 420kHz 60MHz . 325
GR1001A LF sig gen 5kHz-50mHz 385
HP120B 450kHz gen pur scope 215
HP160B(USM105) 15mHz scope with reg horiz, dual trace vert plugs 375
HP166B(Mil) Delay sweep for above ... 130
HP170A(USM140) 30mHz scope with reg horiz, dual trace vert plugs 475
HP175A 50mHz scope with reg horiz, dual trace vert plugs 565
HP185A Sampling scope to 1 gHz 186B xstr rise time plug 585
HP202B LF Osc .5Hz-50kHz 10v out....... 75
HP205AG Lab audio gen .02-20kHz 195
HP212A Pulse gen .06-5kHzPRR 65
HP524D Freq counter basic range 10Hz-10mHz extends w-plug-ins....... 195
HP540B Trans osc to 12.4gHz for use w-HP524-type counters 145
HP616 Sig gen 1.8-4gHz FM-CW 365
HP686 Sweep gen 8.2-12.4gHz sweep range 4.4mHz-4.4gHz.................. 495
HP803A VHF Ant bridge 50-500mHz 135
HP2801A Prec dig thermometer -80 to 250 deg Cels with 1 osc, less sensors 1295
Tek181 Time-mark scope calib.......... 55
Tek190 Sig gen(const ampl) 50mHz 125
Tek 545(mil vers by HickokLavoie) 33MHz gen pur scope less plugin 495
Tek565 Dual beam 10mHz scope less plug-ins (3 series)................ 625
Tek585 80MHz gen pur scope less plugin 645

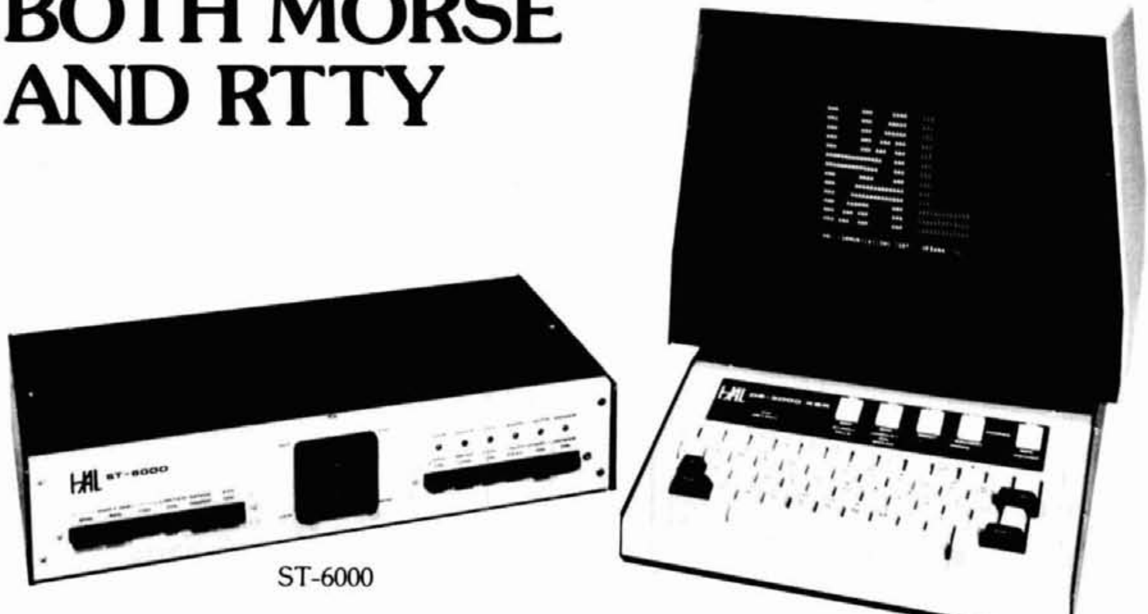
For complete list of all test equipment send stamped, self addressed envelope

GRAY Electronics
P.O. Box 941, Monroe, Mich. 48161
Specializing in used test equipment.

More Details? CHECK—OFF Page 142

YOU ASKED FOR IT-

BOTH MORSE AND RTTY



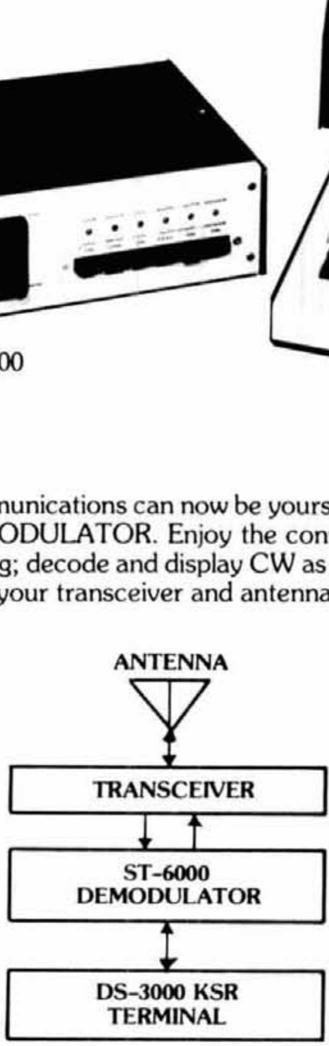
ST-6000

DS-3000 KSR

The ULTIMATE in coded communications can now be yours with the new DS-3000 KSR TERMINAL (Version 3) and ST-6000 DEMODULATOR. Enjoy the convenience of composing and editing your messages BEFORE transmitting; decode and display CW as well as RTTY signals. Connect the HAL ST-6000 and DS-3000 KSR to your transceiver and antenna and work the world on RTTY and CW.

ST-6000

- 170-425-850 Hz Shift
- Low or High tones
- Crystal tone keyer
- Active band-pass filters
- Autostart and antispace
- ATC and DTH
- KOS for keyboard break-in
- Scope or meter tuning indicator
- AM or FM limiter modes
- Table or rack mounting
- I/0 interface to current loop, RS-232, MIL-188, and CMOS



DS-3000 KSR

- MORSE, BAUDOT, and ASCII codes
- Full 72 character lines
- 16 lines of display
- Word wrap-around
- Edit with WORD, LINE, & PAGE modes
- Keyboard programmable HERE IS message
- Up to 175 WPM CW, 5 speeds BAUDOT & ASCII
- 8080A microprocessor controlled
- MORSE also output as ASCII or BAUDOT
- I/0 interface to current loop or RS-232
- New streamlined 12 inch display
- On-screen indicators of WORD & PAGE modes

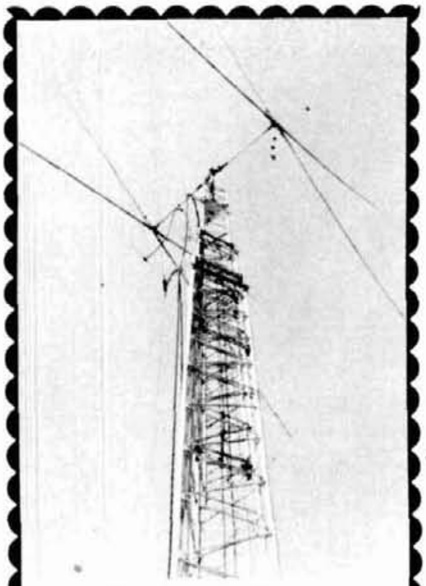
ST-6000M (Meter) **$495.00**
ST-6000S (Scope)........ **$595.00**

DS-3000 KSR V3 .... **$1575.00**
DS-3000 KSR V2 (NO MORSE) . **$1195.00**

Write or call us for our new amateur catalog.

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

For our European customers see HAL equipment at:
Richter & Co.; Hannover
I.E.C. Interelco; Bissone
Primetek Systems; Handen, Sweden
Radio Shack of London



The popular CUA 64-12 by Heights

Light, permanently beautiful **ALUMINUM** towers

THE MOST IMPORTANT FEATURE OF YOUR ANTENNA IS PUTTING IT UP WHERE IT CAN DO WHAT YOU EXPECT. RELIABLE DX — SIGNALS EARLIEST IN AND LAST OUT.

ALUMINUM

Complete Telescoping and Fold-Over Series available

Self-Supporting

Easy to Assemble and Erect

All towers mounted on hinged bases

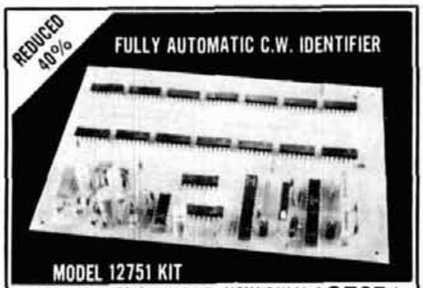
And now, with motorized options, you can crank it up or down, or fold it over, from the operating position in the house.

Write for 12 page brochure giving dozens of combinations of height, weight and wind load.

ALSO TOWERS FOR WINDMILLS

HEIGHTS MANUFACTURING CO.

In Almont Heights Industrial Park
Almont, Michigan 48003



REGULAR $59.95 VALUE, NOW ONLY **$35.97***

● CONNECTS IN LINE BETWEEN MIC. AND MIC. JACK, REQUIRING NO MODIFICATION TO TRANSCEIVER ● SOLID STATE RELIABILITY ● AUTOMATIC TIMER CAN BE SET FROM 1 MIN. TO 10 MIN. ● ADJUSTABLE CODE SPEED FROM 5 TO 40 WPM ● ADJUSTABLE CODE TONE AND AUDIO LEVEL ● EASILY PROGRAMMED ● SPECIALLY DESIGNED CIRCUITRY GENERATES SQUELCH TAIL & ASSURES CORRECT & FULL I.D. EVERY TIME ● OPERATES IN AUTOMATIC OR MANUAL MODES ● IDEAL FOR BASE, MOBILE, OR REPEATER OPERATION.
QUALITY 5 x 7 PCB, 20 pg. instruction & assembly manual.

NEW "CIR-KITS" AVAILABLE

MODEL 11765 — miniature 1½" x 2" CW Beacon IDer (great for 1750M band) ● Code speed programmable. ONLY $19.95/KIT*

MODEL 11764 — semi-automatic modulated CW IDer. 1.7" x 3" PCB ● adjustable code audio level ● programmable code speed, tone & repeat interval. ONLY $29.95/KIT*

*Memory elements factory programmed to your specifications (254 bits maximum).

MODEL 1776 universal auto/home alarm control module.

MODEL 1777 alarm timer module for 1776.

*Calif. res. add 6% tax. Incl. $2 shpg./hdlg. $4 for.

Write for additional information.
AVAILABLE NOW!
Send check or MO to:
Phone (408) 294-8383

SECURITRON
P. O. Box 24899
San Jose, Ca 95154

Save time and energy

the easy way — just call TOLL FREE 800-258-5353

to order books from Ham Radio's Communications Bookstore and subscriptions to Amateur Radio's best publications, Ham Radio HORIZONS, HAM RADIO Magazine and HR Report.

SAVE MONEY TOO!

5% discount plus Free Shipping on orders of $35 or more.

Please use this number to PLACE ORDERS ONLY. To inquire about book orders and subscriptions please write, or call (603) 878-1441.

ham Radio's Communications Bookstore

GREENVILLE
NH 03048

We're Amateur Radio's Book People!

SAVE

Money - Time

QUALITY HAM EQUIPMENT AT LOWEST PRICES

Save on Name Brands like:

SWAN	TEMPO	DRAKE
YAESU	HY-GAIN	TEN-TEC
ICOM	KENWOOD	MIDLAND
CDE	STONER	DENTRON

CALL TOLL FREE
1-800-228-4097
or (402) 466-8402
in Nebraska

Communications Center

443 N. 48th
Lincoln, Nebraska 68504

master charge THE INTERBANK CARD
BANKAMERICARD

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

DIPOLE ANTENNA CONNECTOR

HYE-QUE (HQ-1) dipole connector has coax SO-239 socket molded into glass filled plastic body to accept coax PL-259 plug on feedline. Drip-cap keeps coax fittings dry. Instructions included. Guaranteed. At your dealers or **$4.95 postpaid.** Companion insulators **2/$.99.**

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

CURTIS KEYER CHIP $24.95

8043; IC only, 50-up group rate	$ 7.95
8043-1; IC, PCB, Manual	$ 24.95
8043-2; Semi-kit	$ 49.95
Add for air postage and handling	$ 1.50

(See Feb 75 CQ, Apr 75 HR, Feb 76 QST, Radio Handbook 75)

KB4200 Keyboard Keyer (Oct 74 QST)	$549.95
EK420/KM420 Keyer/Memory (Oct 73 QST)	$439.90
EK430 CMOS Keyer (Feb 76 QST)	$124.95
IK440 Instructokeyer (Mar 76 QST)	$224.95

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

master charge
Your BANKAMERICARD welcome here

More Details? CHECK—OFF Page 142

ME-3 microminiature tone encoder

Compatible with all sub-audible tone systems such as: Private Line, Channel Guard, Quiet Channel, etc.

- **Powered by 6-16vdc, unregulated**
- **Microminiature in size to fit inside all mobile units and most portable units**
- **Field replaceable, plug-in, frequency determining elements**
- **Excellent frequency accuracy and temperature stability**
- **Output level adjustment potentiometer**
- **Low distortion sinewave output**
- **Available in all EIA tone frequencies, 67.0 Hz-203.5 Hz**
- **Complete immunity to RF**
- **Reverse polarity protection built-in**

$29.95 each

Wired and tested, complete with K-1 element

communications specialists

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

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

$3.00 each

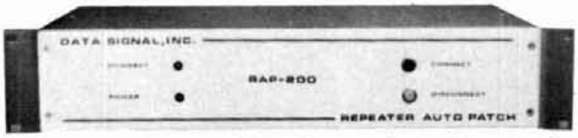
More Details? CHECK—OFF Page 142

More Details? CHECK—OFF Page 142

Tone Encoding – Decoding at its BEST

EXCITING NEW PRODUCTS

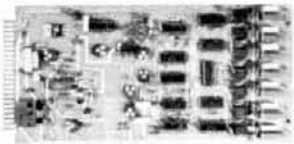
RAP-200



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 TONE TO DIAL PULSE CONVERTER



The Data Tone to Dial Pulse converter Model DPC-221 provides full compatibility between Touch-Tone* encoders and rotary dial-pulse telephone exchanges. Two separate outputs for the * and # digits provide remote control operation, and a **cancel** function permits the caller to automatically stop and reset the converter's dialing circuits.

DPC-221 P. C. Board	**$219.00**
DPC-221R Rack Mount	**$299.00**

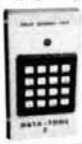
MIGHTY MOS

Complete C-MOS keyer, versatile controls allow wide character-weight variations, speeds from 5- to 50-wpm plus volume and tone control. Solid state output switching transistors are compatible with both grid-block and solid-state transmitters. Unit also available in kit and wired p. c. board only versions.

MIGHTY MOS	**$39.50**
P. C. Card - Wired	**$24.95**
P. C. Card - Kit	**$19.95**

TTP-1

TTP-2



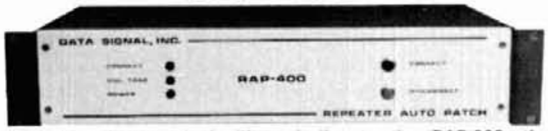
UNIVERSAL TOUCH-TONE ENCODERS

The Data Signal TTP Series of keyboard encoders is used to generate the standard 12 or 16 DTMF digits. The encoders provide fully automatic transmitter keying and feature a delayed **Transmit Ready** light, an interdigit timer, and a built-in audio monitor. Features also include all solid-state, crystal-controlled, digitally-synthesized tones and an optional internal 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.

RAP-400



A complete Autopatch facility, similar to the RAP-200, that additionally provides for half- or full-duplex operation and features built-in compression amplifiers plus a long-distance inhibit function on digits 1 and 0.

RAP-400	**$749.00**

SME

SUB-MINIATURE TOUCH TONE ENCODERS

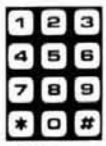
MODEL SME — Smallest available Touch Tone Encoder. Thin, only .05" thick, keyboard mounts directly to front of hand-held portable, while sub-miniature tone module fits inside. This keyboard allows use of battery chargers. Price $34.50, with your choice of keyboards.

DTM

MODEL DTM — Completely self-contained miniature encoder for hand-held portables. Only 5/16" thick. Three wire connection. Automatic PTT keying optional. With your choice of keyboards. **Price: DTM - $49.50, DTM-PTT - $59.50.**

DATA SIGNAL AND DIGITRAN KEYBOARDS

Style A

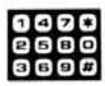


2¼" x 3"

Style B

1⅝" x 2⅛"

Style C

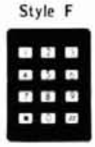


2⅛" x 1⅝"

Style D

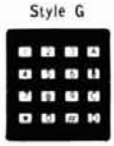
2⅛" x 2⅛"

Style F



2" x 2 11/16"

Style G



2½" x 2 11/16"

Ask About Our Deluxe Receiver Preamplifier For HF & VHF

and

Send For Free New Catalog

dsi

DATA SIGNAL, INC.

2403 COMMERCE LANE
ALBANY, GA. 31707, 912-883-4703

BANKAMERICARD

master charge

VANGUARD LABS CATALOG VANGUARD LABS

SAME DAY SHIPMENT ON MOST ITEMS

PREAMPS

HIGH GAIN • LOW NOISE
30 dB power gain, 2.5-3.0 dB N.F. at 150 MHz, 2 stage, R.F. protected, dual-gate MOSFETS. Manual gain control and provision for AGC. 4-3/8" x 1-7/8" x 1-3/8" aluminum case with power switch and your choice of BNC or RCA receptacles. Available factory tuned to the frequency of your choice from 5 MHz to 350MHz with approximately 3% bandwidth. Up to 10% B.W. available on special order. Requires 12 VDC @10mA.

Model 201 price (5 200 MHz) $29.95
201-350 MHz $34.95

EXTRA LOW NOISE
Excellent for weather satellite reception and recommended by Dr. Ralph E. Taggart in his Weather Satellite Handbook. Less than 2 dB noise figure and approximately 17 dB gain. Uses a low noise J-FET in a common source neutralized circuit. Available factory tuned to your choice of frequency from 135 MHz to 250 MHz. Bandwidth approximately 4 MHz. Supplied in a 2-1/4" x 1-1/8" x 1-3/8" die cast aluminum weather-proof case with a filter for powering it through the antenna. Requires 12 VDC @ 5 mA. Choice of VHF, type "N", or BNC receptacles.

Model 102 PRICE $36.95

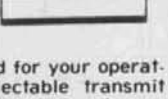
UHF
3 TO 5 dB MAX. N.F.
20 dB MIN. POWER GAIN
Uses 2 of TI's low noise J-FETS in our special circuit board design which gives a minimum of 20 dB power gain at 450 MHz. Stability is such that you can have mismatched loads without it oscillating and you can retune (using the capped openings in the case) over a 15-20 MHz range simply by peaking the maximum signal. Available tuned to the frequency of your choice between 300-550 MHz. 4-3/8" x 1-7/8" x 1-3/8" aluminum case with power switch and your choice of BNC or RCA receptacles. Requires 12 VDC @ 10mA.

Model 202 price $34.95

CONVERTERS

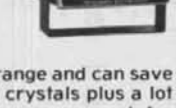
2 METERS
This converter has a minimum of 20 dB gain and a noise figure of 2.5-3.0 dB which assures you of a sensitivity of .1 microvolt or better. The circuit uses a dual-gate MOSFET R.F. stage and a dual-gate MOSFET mixer (thereby giving you a minimum of cross-modulation products), 6 tuned circuits, a bipolar oscillator and .005% crystal. Covers 144-146 MHz at 28-30 MHz output with one crystal included and 146-148 MHz at 28-30 MHz with an extra crystal (available for $6.00 more). The glass epoxy circuit board is enclosed in a 16 gauge aluminum case measuring 3-1/2" x 2-1/4" x 1-1/4" with your choice of either BNC or RCA receptacles. Also included is a power and antenna switch. Requires 12 VDC @ 15 mA. The converter is also available at other input and output frequencies. Call us for prices. PRICE: Model C-144-A available from stock at $39.95 with one crystal. Additional crystal $6.00 extra.

HF & VHF
40 dB GAIN 2.5-3.0
N.F. 150MHz
2 RF stages with transient protected dual-gate MOSFETS give this converter the high gain and low noise you need for receiving very weak signals. The mixer stage is also a dual-gate MOSFET as it greatly reduces spurious mixing products — some by as much as 100 dB over that obtained with bipolar mixers. A bipolar oscillator using 3rd or 5th overtone plug-in crystals is followed by a harmonic bandpass filter, and where necessary an additional amplifier is used to assure the correct amount of drive to the mixer. Available in your choice of input frequencies from 5-350 MHz and with any output you choose within this range. The usable bandwidth is approximately 3% of the input frequency with a maximum of 4 MHz. Wider bandwidths are available on special order. Although any frequency combination is possible (including converting up) best results are obtained if you choose an output frequency not more than 1/3 nor less than 1/20 of the input frequency. Enclosed in a 4-3/8" x 3" x 1-1/4" aluminum case with power and antenna transfer switch and your choice of BNC or RCA receptacles. Requires 12 VDC @ 25 mA.



Model 407A price:
5-200 MHz $54.95
201-350 MHz $59.95
Prices include .005% crystal. Additional crystals $8.95 ea.

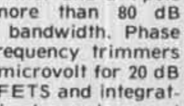
UHF
20 dB MIN. GAIN
3 TO 5dB MAX. N.F.
This model is similar in appearance to our Model 407A but uses 2 low noise J-FETS in our specially designed RF stage which is tuned with high-Q miniature trimmers. The mixer is a special dual-gate MOSFET made by RCA to meet our requirements. The oscillator uses 5th overtone crystals to reduce spurious responses and make possible fewer multipliers in the oscillator chain which uses 1200 MHz bipolars for maximum efficiency. Available with your choice of input frequencies from 300-550 MHz and output frequencies from 14-220 MHz. Usable bandwidth is about 1% of the input frequency but can be easily returned to cover more. Requires 12 VDC @ 30 mA.



Model 408 price $59.95
.005% crystal included.

VHF RECEIVER

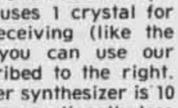
11 crystal controlled channels. Available in your choice of frequencies from 135-250 MHz in any one segment from 1-4 MHz wide. I.F. bandwidth (channel selectivity(available in your choice of $\pm$7.5 kHz or $\pm$ 15 kHz. 8-pole quartz filter and a 4-pole ceramic filter gives more than 80 dB rejection at 2X channel bandwidth. Phase locked loop detector. Frequency trimmers for each crystal. .2 to .3 microvolt for 20 dB quieting. Dual-gate MOSFETS and integrated circuits. Self contained speaker and external speaker jack. Mobile mount and tilt stand.



Aluminum case, 6" x 7" x 1-3/8"
Model FMR 260-PL price:
135-180 MHz $149.95
181-250 MHz $159.95
Price includes one .001% crystal. Additional crystals $8.95 ea. This receiver is recommended in Dr. Taggart's Weather Satellite Handbook.

SYNTHESIZERS

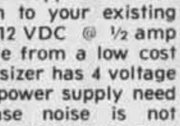
FOR ALL TRANSCEIVERS
The STR series synthesizers are available for any transceiver operating from 20 MHz to 475 MHz that uses crystals in the 5 to 85 MHz range. It has a thumbwheel dial calibrated for your operating frequency plus a selectable transmit offset of plus or minus 600 kHz, plus or minus 1 MHz, and 2 spare offsets that you can add later. Frequency accuracy is .0005% and spurious outputs are 60 to 70 dB down. To process your order we must have the crystal formula of your transmit and receive crystals. If your transceiver uses 1 crystal for both transmitting and receiving (like the Motorola Metrum 11), you can use our receive synthesizer described to the right. Maximum tuning range per synthesizer is 10 MHz above 100 MHz and proportionally less at lower frequencies. Dial increments are in 1 kHz steps from 5 to 30 MHz and 5 kHz steps above.



Model STR synthesizer price:
5-150 MHz $259.95
151-475 MHz $279.95

Vanguard Labs
196-23 Jamaica Ave.
Hollis NY 11423
(212) 468-2720

FOR VHF RECEIVERS
This synthesizer has 8000 channels and can tune a continuous 40 MHz segment of your choice from 110-180 MHz in 5 kHz steps. This will satisfy most of your requirements in the VHF range and can save you hundreds of dollars in crystals plus a lot of time. Stock units are programmed for receivers with the crystal formula Fc = Fs -10.7 divided by 3 but we can program it to almost any other IF at no additional cost at the time of your order. It is supplied with an interface for plugging in to your existing crystal socket. Requires 12 VDC @ ½ amp which is easily obtainable from a low cost power supply. The synthesizer has 4 voltage regulators therefore the power supply need not be regulated. Phase noise is not detectable as the VCO is coarse tuned by a DAC thereby easing the requirements of the phase locked loop. Not affected by vibrations encountered in mobile use. Enclosed in an 8" x 3-7/8" x 1-1/2" aluminum case and supplied with a combination tilt stand/mobile mounting bracket.



Price: Model SR 140D-05 .... $179.95

NOTE: We can make any synthesizer from audio to 475 MHz. Call us for prices.

HOW TO ORDER: All items on this page are available only from Vanguard Labs. For receivers and converters state model, input and output frequencies, and bandwidth where applicable. For the fastest service call (212) 468-2720 between 9 AM and 4 PM Monday through Friday, except holidays. Your order can be shipped COD by Air Parcel Post.

BY MAIL: Send your order to Vanguard Labs, 196-23 Jamaica Avenue, Hollis, NY 11423 and include remittance by postal money order, cashiers check or certified check. Personal checks are also accepted, but banks now require 3 weeks for checks to clear, therefore this will delay your order. Include sales tax if you reside in New York State.

PURCHASE ORDERS: We accept purchase orders from US and Canadian government agencies, universities, and AAA rated corporations. Our terms are Net 30 days.

FOREIGN ORDERS: Must remit payment in full in US funds plus postage and insurance fees. If complicated customs forms are required, please forward your order to an import-export agent.

SHIPPING: We ship all our merchandise by insured parcel post or air mail. Special delivery is also available. Prices include shipping by regular parcel post if you remit with your order. For air mail shipping add $1.00. Postage will be added on all CODs, purchase orders, and foreign orders.

SAME DAY SHIPMENT ON MOST ITEMS

SPECSCAN-S Programmable Scanner

.. . The ONLY Digital Scanner made for the IC-22S. It adds a whole new dimension to 2M FM. If any other accessory can make your IC-22S as versatile as the SPECSCAN-S does, Buy It!

- Scans the entire 146-147 MHz Band in 15 kHz steps, automatically, or manually
- Automatically reads out your other 21 channels when they are used.
- Can be used as a remote programming unit with the radio hidden under the seat, etc.
- Exclusive VARI-SCAN™ control allows full control of scan rate *in either direction*!
- Full compatibility with the duplex mode.
- Uses state of the art CMOS logic.
- Low current drain. Less than 500 mA.
- RF immune. Unaffected by nearby equipment and in high RF areas.
- Large LED display lets you see every channel at a glance.
- Manual mode features lets you scan past any portion of the band and manually select a desired channel.
- Easy installation. Uses only one matrix position leaving the other 21 useable for manual programming.
- Plugs into 9 pin accessory socket.
- Adjustable scan delay feature.
- 90 day limited warranty.

ONLY 149⁹⁵ Amateur Net

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

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

arma
amateur radio manufacturer's association

MOTOROLA GOODIES

TU540S . . . narrowband filter for "G"-series receivers **$7.00 each**

Mobile rapid-charger for HT-220 Omni. **$50.00**

U43HHT . . . Hi Band Mobile with most accessories **$150.00**

Channel Elements for MICOR model K1007/K1005 **$10.00 each**

Channel Elements for Model TLN 1081 & 1083 . . . . . . **$6.00 each**

UHF "B"-Series receivers . . . dual squelch, two-frequency, narrowband . . . . . . **$10.00 each**

U51LLT 50-watt MOTRAN . . . 40-50 MHz, all solid state, with most accessories (have one only). **$329.00**

CDE ROTORS . . . JANUARY *SPECIAL*

Model CD 44, ideal for your VHF antenna array. List $129.00 **Our price $99.95**

Ham III, in-tower mounting, rated 12.5 square feet **Our price $129.00**

RADIO AMATEUR CALLBOOK, INC.

CALLBOOKS

SPECIAL OFFER!

$14.95 plus shipping

Order both U.S. and Foreign Callbook and receive FREE Deluxe Reference Map Library! A $3.75 value.

$13.95 plus shipping

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 over 250,000 calls, names and addresses of radio amateurs outside the USA plus many valuable additional features of interest to the DXer.

Model 43

$120 + shipping

BIRD

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

WE WANT TO MEET YOU!

We will be exhibiting at the following hamfests:

January 21st: Waukesha, Wisconsin

February 5th: Wheaton, Illinois

Come by and say hello.

SPECTRONICS, INC.

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

HOURS

STORE HOURS:

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

master charge BANKAMERICARD

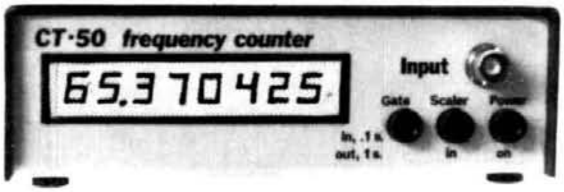
More Details? CHECK—OFF Page 142

More Details? CHECK — OFF Page 142

NEW

Frequency Counter

$79.95 kit



UTILIZES NEW MOS-LSI CIRCUITRY

You've requested it, and now it's here! The CT-50 frequency counter kit has more features than counters selling for twice the price. Measuring frequency is now as easy as pushing a button, the CT-50 will automatically place the decimal point in all modes, giving you quick, reliable readings. Want to use the CT-50 mobile? No problem, it runs equally as well on 12 V dc as it does on 110 V ac. Want super accuracy? The CT-50 uses the popular TV color burst freq. of 3.579545 MHz for time base. Tap off a color TV with our adapter and get ultra accuracy — .001 ppm! The CT-50 offers professional quality at the unheard of price of $79.95. Order yours today!

CT-50, 60 MHz counter kit $79.95
CT-50 WT, 60 MHz counter, wired and tested 159.95
CT-600, 600 MHz prescaler option for CT-50, add 29.95

SPECIFICATIONS

Sensitivity: less than 25 mv.
Frequency range: 5 Hz to 60 MHz, typically 65 MHz
Gatetime: 1 second, 1/10 second, with automatic decimal point positioning on both direct and prescale
Display: 8 digit red LED .4" height
Accuracy: 10 ppm, .001 ppm with TV time base!
Input: BNC, 1 megohm direct, 50 Ohm with prescale option
Power: 110 V ac 5 Watts or 12 V dc @ 1 Amp
Size: Approx. 6" x 4" x 2", high quality aluminum case
Color burst adapter for .001 ppm accuracy available in 6 weeks.
CB-1, kit $14.95

CLOCK KIT
6 digit 12/24 hour

Want a clock that looks good enough for your living room? Forget the competitor's kludges and try one of ours! Features: jumbo .4" digits, Polaroid lens filter, extruded aluminum case available in 5 colors, quality PC boards and super instructions. All parts are included, no extras to buy. Fully guaranteed. One to two hour assembly time. Colors: silver, gold, black, bronze, blue (specify).

Clock kit, DC-5 . . . . $22.95
Alarm clock, DC-8, 12 hr only 24.95
Mobile clock, DC-7 . . . . 25.95
Clock kit with 10 min ID timer, DC-10 . . . 25.95
Assembled and tested clocks available, add $10.00

CHEAP CLOCK KIT $8.95

DC-4 Features:
- 6 digit .4" LED
- 12 or 24 format

Does not include board or transformer

PC Board $2.95
Transformer $1.49

VIDEO TERMINAL KIT $149.95

A compact 5 x 10 inch PC card that requires only an ASCII keyboard and a TV set to become a complete interactive terminal for connection to your microprocessor asynchronous interface. Its many features are single 5 volt supply, crystal controlled sync and baud rates (up to 9600 baud), 2 pages of 32 characters by 16 lines, read to and from memory, computer and keyboard operated cursor and page control, parity error display and control, power on initialization, full 64 character ASCII display, block type see thru cursor. Keyboard/computer control backspaces, forward spaces, line feeds, rev. line feeds, home, returns cursor. Also clears page, clears to end of line, selects page 1 or 2, reads from or to memory. The card requires 5 volts at approx. 900 ma and outputs standard 75 ohm composite video.

TH3216 Kit . . . $149.95
TH3216, Assembled and Tested . . . 239.95
VD-1, Video to RF Modulator Kit . . . 6.95

CAR CLOCK KIT $27.95

12/24 Hour 12 Volt AC or DC
- High Accuracy (1 minute/month)
- 6 jumbo .4" LED readouts
- Easy, no polarity hookup
- Display blanks with ignition
- Case, mounting bracket included
- Super instructions

Complete Kit, DC-11 $27.95

AUTO-DIMMER $2.50

Automatically adjusts display brightness according to ambient light level. For DC-11 Car Clock.

MINI-KITS

TONE DECODER KIT

A complete tone decoder on a single PC Board. Features: 400-5000 Hz adjustable frequency range, voltage regulation, 567 IC. Useful for touch-tone decoding, tone burst detection, FSK demod, signaling, and many other uses. Use 7 for 12 button touchtone decoding. Runs on 5 to 12 volts.
Complete Kit, TD-1 . . . . $4.95

SUPER-SNOOP AMPLIFIER

A super-sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as a general purpose test amplifier. Full 2 watts of output, runs on 6 to 12 volts, uses any type of mike. Requires 8-45 ohm speaker.
Complete Kit, BN-9 . . . . $4.95

FM WIRELESS MIKE KIT

Transmit up to 300' to any FM broadcast radio, uses any type of mike. Runs on 3 to 9 V. Type FM-2 has added super sensitive mike preamp.
FM-1 . . . . . $2.95 FM-2 . . . . . $4.95

COLOR ORGAN/MUSIC LIGHTS

See music come alive! 3 different lights flicker with music or voice. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300 watts. Great for parties, band music, nite clubs and more.
Complete Kit, ML-1 . . . . $7.95

LED BLINKY KIT

A great attention getter which alternately flashes 2 Jumbo LEDs. Use for name badges, buttons, or warning type panel lights. Runs on 3 to 9 volts.
Complete Kit $2.95

POWER SUPPLY KIT

Complete triple regulated power supply provides variable ±15 volts at 200 mA and +5 volts at 1 Amp. 50 mV load regulation good filtering and small size. Kit less transformers. Requires 6-8 V at 1 Amp and 18 to 30 VCT.
Complete Kit, PS-3LT $6.95

SIREN KIT

Produces upward and downward wail characteristic of police siren. 5 watts audio output, runs on 3-9 volts, uses 8-45 ohm speaker.
Complete Kit, SM-3 . . . . $2.95

DECADE COUNTER PARTS

Includes: 7490A, 7475, 7447, LED readout, current limit resistors, and instructions on an easy to build low cost frequency counter.
Kit of parts, DCU-1 . . . . $3.50

600 MHz PRESCALER

Extend the range of your counter to 600 MHz. Works with all counters. Less than 150 mv sensitivity. Specify ÷10 or ÷100
Wired, tested, PS-1B $59.95
Kit, PS-1B $44.95

30 watt 2 meter Power Amp

The famous RE class C power amp now available mail order! Four Watts in for 30 Watts out, 2 in for 15 out, 1 in for 8 out, incredible value, complete with all parts, instructions and details on T-R relay. Case not included.
Complete Kit, PA-1 . . . . $22.95

CALENDAR ALARM CLOCK

Has every feature one could ever ask for. Kit includes everything except case, build it into wall, station or even car!

FEATURES:
- 6 Digits, .5" High LED
- 12/24 Hour Format
- Calendar shows mo./day
- Snooze button
- True 24 Hour Alarm
- 7001 chip does all!!
- Battery back up with built in on chip time base

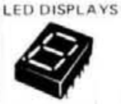
Complete Kit, less case, DC-9 . . . . $34.95

LINEAR				REGULATOR		TRANSISTORS	
5314 Clock	$2.95	555	$ .50	78MG	$1.49	MRF-238 30W VHF	$11.95
74S00	.35	556	.75	309k	.89	NPN 2N3904 type	10/$1.00
74S112	.75	566	1.49	309H	.99	PNP 2N3906 type	10/$1.00
7447	.79	567	1.49	340K-12	.99	NPN Power Tab 40W	3/$1.00
7473	.35	1458	.50	7805	.89	PNP Power Tab 40W	3/$1.00
7475	.50	LED DRIVER		7812	.89	FET MPF-102 type	3/$2.00
7490A	.55	75491	.50	7815	.89	UJT 2N2646 type	3/$2.00
74143	3.50	75492	.50	7818	.89	2N3055 NPN Power	.75

SPECIAL

DIODES: 1KV,2.5A . . . . 5/$1.00 100V,1A . . . . 10/$1.00 1N914A type . . . . 50/$2.00

LED DISPLAYS



FND 359 75
FND 510 . . . . . 1.25
DL 707 . . . . . 1.25
HP 7730 . . . . . 1.25
Red Polaroid Filter . . . 4.25" X 1.125" 59

741 OP-AMP SPECIAL
Factory prime mini dip with both Xerox and 741 part numbers
10 for $2.00

SOCKETS
14 PIN 5/$1.00
16 PIN 5/$1.00
24 PIN 2/$1.00
40 PIN 3/$2.00

FERRITE BEADS
with info and specs
15/$1.00
6 hole Balun Beads
5/$1.00

ramsey electronics

P.O. Box 4072 Rochester NY 14610

(716) 271-6487

TELEPHONE ORDERS WELCOME

master charge BANKAMERICARD

Minimum Order $6.00

Satisfaction guaranteed or money refunded. COD, add $1.00. Orders under $10.00 add $.75. NY residents add 7% tax.

Vhf engineering

PRICES EFFECTIVE JAN. 15, 1977

THE WORLD'S MOST COMPLETE LINE OF VHF-FM KITS AND EQUIPMENT

RECEIVERS

RX28C	28-35 MHz FM receiver with 2 pole 10.7 MHz crystal filter . . .	$ 64.95
RX28C W/T . .	same as above—wired & tested. .	117.95
RX50C Kit . .	30-60 MHz rcvr w/2 pole 10.7 MHz crystal filter	64.95
RX50C W/T . .	same as above—wired & tested .	117.95
RX144C Kit . .	140-170 MHz rcvr w/2 pole 10.7 MHz crystal filter	74.95
RX114C W/T .	same as above—wired & tested .	119.95
RX220C Kit . .	210-240 MHz rcvr w/2 pole 10.7 MHz crystal filter	74.95
RX220C W/T .	same as above—wired & tested .	117.95
RX432C Kit . .	432 MHz rcvr w/2 pole 10.7 MHz crystal filter	84.95
RX432C W/T .	same as above—wired & tested .	129.95
RXCF	accessory filter for above receiver kits gives 70 dB adjacent channel rejection	8.95
RF28 Kit . . .	10 mtr RF front end 10.7 MHz out	13.50
RF50 Kit . . .	6 mtr RF front end 10.7 MHz out	13.50
RF144D Kit . .	2 mtr RF front end 10.7 MHz out	18.50
RF220D Kit . .	220 MHz RF front end 10.7 MHz out	18.50
RF432 Kit . . .	432 MHz RF front end 10.7 MHz out	29.50
IF 10.7F Kit . .	10.7 MHz IF module includes 2 pole crystal filter	29.50
FM455 Kit. . .	455 KHz IF stage plus FM detector	18.50
AS2 Kit	audio and squelch board	16.00

TRANSMITTERS

TX50	transmitter exciter, 1 watt, 6 mtr .	44.95
TX50 W/T . . .	same as above—wired & tested . .	64.95
TX144B Kit . .	transmitter exciter—1 watt—2 mtrs	34.95
TX144B W/T .	same as above—wired & tested. . .	59.95
TX220B Kit . .	transmitter exciter—1watt—220 MHz	34.95
TX220B W/T .	same as above—wired & tested . .	59.95
TX432B Kit . .	transmitter exciter 432 MHz . . .	49.95
TX432B W/T .	same as above—wired & tested . .	79.95
TX150 Kit. . .	300 milliwatt, 2 mtr transmitter .	24.95
TX150 W/T . .	same as above—wired & tested . .	39.95

POWER AMPLIFIERS

PA2501H Kit .	2 mtr power amp—kit 1w in—25w out with solid state switching, case, connectors	64.95
PA4010H Kit .	2 mtr power amp—10w in—40w out—relay switching	64.95
PA50/25 Kit. .	6 mtr power amp, 1w in, 25w out, less case, connectors & switching	54.95
PA144/15 Kit .	2 mtr power amp—1w in—15w out—less case, connectors and switching	44.95
PA144/25 Kit .	same as PA144/15 kit but 25w . .	54.95
PA220/15 Kit .	similar to PA144/15 for 220 MHz	44.95
PA432/10 Kit .	power amp—similar to PA144/15 except 10w and 432 MHz	54.95
PA140/10 W/T	10w in—140w out—2 mtr amp .	219.95
PA140/30 W/T	30w in—140w out—2 mtr amp .	189.95

Blue Line . . . RF power amp, wired & tested, emission—CW-FM-SSB/AM

Model	BAND	Power Input	Power Output	
BLC 10/70	144 MHz	10W	70W	149.95
BLC 2/70	144 MHz	2W	70W	169.95
BLC 10/150	144 MHz	10W	150W	259.95
BLC 30/150	144 MHz	30W	150W	239.95
BLD 2/60	220 MHz	2W	60W	164.95
BLD 10/60	220 MHz	10W	60W	159.95
BLD 10/120	220 MHz	10W	120W	259.95
BLE 10/40	420 MHz	10W	40W	179.95
BLE 2/40	420 MHz	2W	40W	179.95
BLE 30/80	420 MHz	30W	80W	259.95
BLE 10/80	420 MHz	10W	80W	289.95

POWER SUPPLIES

PS15C Kit . . .	15 amp—12 volt regulated power supply w/case, w/fold-back current limiting and overvoltage protection . . .	94.95
PS15C W/T. . .	same as above—wired & tested. . .	124.95
PS25M Kit. . .	25 amp—12 volt regulated power supply w/case, w/fold-back current limiting and ovp, with meter	154.95
PS 25M W/T. .	same as above—wired & tested. . .	179.95
O.V.P.	adds over voltage protection to your power supplies, 15 VDC max. . .	12.95
PS3A Kit . . .	12 volt—power supply regulator card with fold-back current limiting . .	10.95
PS3012 W/T .	new commercial duty 30 amp 12 VDC regulated power supply w/case, w/fold-back current limiting and overvoltage protection	249.95

REPEATERS

RPT50 Kit. . .	repeater—6 meter.	499.95
RPT50	repeater—6 meter, wired & tested	799.95
RPT144 Kit . .	repeater—2 mtr—15w—complete (less crystals)	499.95
RPT220 Kit . .	repeater—220 MHz—15w—complete (less crystals)	499.95
RPT432 Kit . .	repeater—10 watt—432 MHz (less crystals)	579.95
RPT144 W/T .	repeater—15 watt 2 mtr.	799.95
RPT220 W/T .	repeater—15 watt—220 MHz. . . .	799.95
RPT432 W/T .	repeater—10 watt—432 MHz. . . .	849.95
DPLA50. . . .	6 mtr close spaced duplexer	575.95
DPLA144 . . .	2 mtr, 600 KHz spaced duplexer, wired and tuned to frequency	379.95
DPLA220 . . .	220 MHz duplexer, wired and tuned to frequency	379.95
DPLA432 . . .	rack mount duplexer	319.95
DSC-U	double shielded duplexer cables with PL259 connectors (pr.) . . .	25.00
DSC-N	same as above with type N connectors (pr.)	25.00

TRANSCEIVERS

TRX50 Kit . .	Complete 6 mtr FM transceiver kit, 20w out, 10 channel scan with case (less mike and crystals).	244.95
TRX144 Kit .	same as above, but 2 mtr & 15w out	234.95
TRX220 Kit .	same as above except for 220 MHz	234.95
TRX432 Kit .	same as above except 10 watt and 432MHz	254.95
TRC-1	transceiver case only	29.95
TRC-2	transceiver case and accessories . .	49.95

SYNTHESIZERS

SYN II Kit. . .	2 mtr synthesizer, transmit offsets programmable from 100 KHz 10MHz, (Mars offsets with optional adapters)	169.95
SYN II W/T . .	same as above—wired & tested. . .	239.95
SYN 220 Kit .	same as SYN II Kit except 220-225 MHz	169.95
SYN 220 W/T .	same as above—wired & tested . .	239.95

OTHER PRODUCTS BY VHF ENGINEERING

CD1 Kit	10 channel receive xtal deck w/diode switching.	$ 7.95
CD2 Kit	10 channel xmit deck w/switch and trimmers	15.50
CD3 Kit	UHF version of CD1 deck, needed for 432 multi-channel operation	13.50
COR2 Kit . . .	carrier operated relay.	22.75
SC3 Kit	10 channel auto-scan adapter for RX with priority	19.95
Crystals	we stock most repeater and simplex pairs from 146.0-147.0 (each). .	5.00
CWID Kit . . .	159 bit, field programmable, code identifier with built-in squelch tail and ID timers	39.95
CWID	wired and tested, not programmed	54.95
CWID	wired and tested, programmed .	59.95
MIC 1	2,000 ohm dynamic mike with P.T.T. and coil cord	12.95
TS1 W/T. . . .	tone squelch decoder.	59.95
TS1 W/T. . . .	installed in repeater, including interface accessories	89.95
TD3 Kit	2 tone decoder	35.95
TD3 W/T . . .	same as above—wired & tested .	59.95
HL144 W/T . .	4 pole helical resonator, wired & tested, swept tuned to 144 MHz ban . .	29.95
HL220 W/T . .	same as above tuned to 220 MHz ban	29.95
HL432 W/T . .	same as above tuned to 432 MHz ban	29.95

arma

Vhf engineering

DIVISION OF BROWNIAN ELECTRONICS CORP.

BOX H / 320 WATER ST. / BINGHAMTON, N.Y. 13901 / Phone 607-723-9574

master charge BANKAMERICARD

Prices and specifications subject to change without notice. Export prices slightly higher. 502 3100-1 78

HAM MART

Ham Radio's guide to help you find your local

Alabama

LONG'S ELECTRONICS
2808 7TH AVENUE SOUTH
BIRMINGHAM, AL 35202
800-633-3410
Call us Toll Free to place your order

Arizona

HAM SHACK
4506 A NORTH 16TH STREET
PHOENIX, AZ 85016
602-279-HAMS
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.

MASTERS COMMUNICATIONS
7025 N. 57th DRIVE
GLENDALE, AZ 85301
602-939-8356
Rohn tower distributor, Atlas, Icom, Tempo, HyGain & service.

POWER COMMUNICATIONS
6012 NORTH 27th AVE.
PHOENIX, AZ 85017
602-242-8990
Arizona's #1 Ham Store.

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 5232
CARSON, CA 90745
213-834-5868
Not the Biggest, but the Best — since 1962.

CARSON ELECTRONICS
12010 EAST CARSON ST.
HAWAIIAN GARDENS, CA 90716
213-421-3786
Dealing exclusively in ICOM communications equipment.

COMMUNICATIONS CENTER
705 AMADOR STREET
VALLEJO, CA 94590
707-642-7223
Who else has a Spectrum Analyzer?

HAM RADIO OUTLET
999 HOWARD AVENUE
BURLINGAME, CA 94010
415-342-5757
Visit our stores in Van Nuys and Anaheim.

QUEMENT ELECTRONICS
1000 SO. BASCOM AVENUE
SAN JOSE, CA 95128
408-998-5900
Serving the world's Radio Amateurs since 1933.

TOWER ELECTRONICS CORP.
24001 ALICIA PARKWAY
MISSION VIEJO, CA 92675
714-768-8900
Authorized Yaesu Sales & Service. Mail orders welcome.

Colorado

C W ELECTRONIC SALES CO.
1401 BLAKE ST.
DENVER, CO 80202
303-573-1386
Rocky Mountain area's complete ham radio distributor.

MILE-HI COMMUNICATIONS, INC.
1970 SOUTH NAVAJO
DENVER, CO 80223
303-936-7108
Rocky Mountain's newest ham store. Lee Tingle KØLT.

Connecticut

ARCOMM ELECTRONICS
2865 MAIN STREET
BRIDGEPORT, CT 06606
Come on in, Tues. thru Sat. 10:00 - 6:00

AUDIOTRONICS 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 33515
813-461-HAMS
West Coast's only full service Amateur Radio Store.

CENTRAL EQUIPMENT CO.
18451 W. DIXIE HIGHWAY
NORTH MIAMI BEACH, FL. 33160
305-932-1818
Specializing in Amateur, CB & Marine Equipment.

RAY'S AMATEUR RADIO
1590 US HIGHWAY 19 SO.
CLEARWATER, FL 33516
813-535-1416
West coast's only dealer: Drake, Icom, Cushcraft, Hustler.

Illinois

KLAUS RADIO, INC.
8400 NORTH PIONEER PARKWAY
PEORIA, IL 61614
309-691-4840
Let us quote your Amateur needs.

SPECTRONICS, INC.
1009 GARFIELD STREET
OAK PARK, IL 60304
312-848-6777
Chicagoland's Amateur Radio leader.

Indiana

HOOSIER ELECTRONICS, INC.
P. O. BOX 2001
TERRE HAUTE, IN 47802
812-238-1456
Ham Headquarters of the Midwest. Store in Meadows Shopping Center.

KRYDER ELECTRONICS
GEORGETOWN NORTH SHOPPING CENTER
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
12 SOUTH 21ST STREET
FT. DODGE, IA 50501
515-576-3886
For an EZ deal.

Kentucky

COHOON AMATEUR SUPPLY
HIGHWAY 475
TRENTON, KY 42286
502-886-4535
Yaesu, Ten-Tec, Tempo, Dentron. Our service is the BEST.

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

Amateur Radio Dealer

Maryland

COMM CENTER, INC.
9624 FT. MEADE ROAD
LAUREL PLAZA RT. 198
LAUREL, MD 20810
301-792-0600
New & Used Amateur Equipment.
Wilson, Ten-Tec, R. L. Drake, Tempo

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

Massachusetts

TUFTS RADIO ELECTRONICS
209 MYSTIC AVENUE
MEDFORD, MA 02155
617-395-8280
New England's friendliest ham store.

Michigan

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

Minnesota

DACOM
3926 BEAU D'RUE DRIVE
EAGAN, MN 55122
612-454-7420
Full Sales & Service
HF thru UHF

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

PAL ELECTRONICS INC.
3452 FREMONT AVE. NORTH
MINNEAPOLIS, MN 55412
612-521-4662
The Midwest's Fastest Growing Ham Dealer.

Missouri

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

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

Nebraska

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

New Hampshire

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

New Jersey

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

New Mexico

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

New York

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

CFP COMMUNICATIONS
211 NORTH MAIN STREET
HORSEHEADS, NY 14845
607-739-0187
Jim Beckett, WA2KTJ, Manager
Bryant Hozempa, WB2LVW, Sales

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

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

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

Ohio

UNIVERSAL AMATEUR RADIO, INC.
1280 AIDA DRIVE
REYNOLDSBURG, (COLUMBUS) OH 43068
614-866-HAMS
Drake, Yaesu, Ten-Tec, KDK, Wilson, Dentron, Tempo, Sigma.

Oklahoma

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

Oregon

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

Pennsylvania

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

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

HAM MART

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

Tennessee

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

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

Texas

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

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

Wisconsin

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

Washington

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

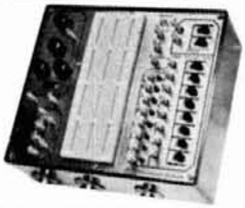
Wyoming

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

YOUR BEST BUY IN KITS FREQUENCY COUNTERS

6 GOOD REASONS FOR BUYING A HAL-TRONIX FREQUENCY COUNTER

(1) 100% COMPLETE KIT, (2) EASY ASSEMBLY, (3) COMPLETELY ENCLOSED IN METAL CABINET, (4) IC SOCKETS USED THROUGHOUT FOR EASY TTL REPLACEMENT (5) EASY ON YOUR POCKET BOOK, AND (6) NO EXPENSIVE CHIPS TO REPLACE (EXAMPLE — IF YOU LOSE A DECODER, LATCH OR DRIVER IN A HAL-TRONIX COUNTER, THE AVERAGE COST OF REPLACEMENT OF THE LOW-COST TTLS IS LESS THAN $1.00 EXCLUDING THE PRE-SCALE CHIP. IN SOME OF THE NEWER COUNTERS NOW BEING MARKETED BY MY COMPETITION, THEY ARE USING THE EXOTIC SINGLE CHIP AND WOULD COST YOU CLOSE TO $30.00 TO REPLACE). THIS IS SOMETHING YOU SHOULD CONSIDER.



ANALOG-DIGILAB KIT $139.50

DESIGNED BY HAL-TRONIX AND MIKE GOLDEN OF R.E.T.S. ELECTRONICS SCHOOL OF DETROIT. FOR RUGGED CLASSROOM USE.

FOR THE RADIO AMATEUR, STUDENT, EXPERIMENTER OR DESIGNER

SPECIFICATIONS: OUTPUT VOLTAGES: +5V, +12V, −12V; USABLE CURRENT: 750mA; % Regulation at 500mA: 0.2%; Short-circuit limited at 1.0 amp; Thermal overload protected. Power requirements: 117VAC, 60HZ, 40 Watts. Function Generator: Frequency range: 1HZ to 100 HZ in 5 bands. Amplitude adjustable from 0 to 10 VPP. DC offset adjustable from 0 to ± 10V. Waveforms: Sine, square, triangular and TTL Clock. TTL Clock 0 to +5V level, 200 ns rise and fall time. Frequency determined by Function Generator. Output impedance 1.2K ohm.

Most of all, it's easy to construct and service. PC boards are predrilled, plated thru and solder flowed. Over 1000 units sold to schools.

NEW FROM HAL-TRONIX FIRST TIME OFFER

SIX-DIGIT ALARM CLOCK KIT for home, camper, RV, or field-day use. Operates on 12-volt AC or DC, and has its own 60-Hz time base on the board. Complete with all electronic components and two-piece, pre-drilled PC boards. Board size 4″ x 3″. Complete with speaker and switches. If operated on DC, there is nothing more to buy.°

PRICED AT **$16.95**

Twelve-volt AC line cord for those who wish to operate the clock from 110-volt AC. $2.50

°Fits clock case advertised below.

6-DIGIT CLOCK

12/24 HOUR

COMPLETE KIT CONSISTING OF 2 PC G10 PRE-DRILLED PC BOARDS, 1 CLOCK CHIP, 6 FND 359 READOUTS, 13 TRANSISTORS, 3 CAPS, 9 RESISTORS, 5 DIODES, 3 PUSH-BUTTON SWITCHES, MOLDED POWER TRANSFORMER CORD AND INSTRUCTIONS.

DON'T BE FOOLED BY PARTIAL KITS WHERE YOU HAVE TO BUY EVERYTHING EXTRA.

PRICED AT **$12.95**

4-DIGIT ALARM CLOCK

12 HOUR ONLY

COMPLETE KIT CONSISTING OF 2 PC G10 PRE-DRILLED PC BOARDS, 1 CLOCK CHIP, 4 FND 503 READOUTS, ALL NECESSARY TRANSISTORS, CAPS AND RESISTORS INCLUDING 5 PUSH-BUTTON SWITCHES, MOLDED POWER TRANSFORMER CORD PLUS SPEAKER; COMES COMPLETE WITH INSTRUCTIONS.

PRICED AT **$16.95**

CLOCK CASE

Available and will fit any one of the above clocks

Regular Price . . . $6.50 **But Only $4.50 when bought with clock**

60-HZ TIME BASE

CRYSTAL TIME BASE KIT. WILL ENABLE MOST ALL DIGITAL CLOCKS TO OPERATE FROM 12 VDC. LOW PROFILE UNIT, EASY 3-WIRE HOOKUP. ACC 2PPM, ADJUSTABLE.

COST ONLY $5.95 EACH OR 2 FOR $10.00 — OR ONLY $4.50 WITH CLOCK PURCHASE.

10-MHz CRYSTALS

HI-QUALITY CRYSTALS, DESIGNED FOR FREQUENCY CONTROL AND ELECTRONIC TIME PIECES; AGING FACTOR 5PPM. MEETS OR EXCEEDS MIL-C-3098 SPECS. MADE ESPECIALLY FOR HAL-TRONIX BY SENTRY.

PRICE $5.95 OR 2 FOR $10.00

NEW FROM HAL-TRONIX FIRST TIME OFFER

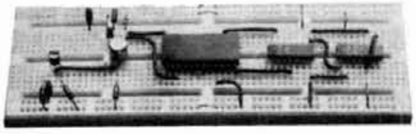
DELUXE 12-BUTTON TOUCH-TONE ENCODER KIT utilizing the new ICM 7206 chip. Provides both VISUAL AND AUDIO indications! Comes with its own two-tone anodized aluminum cabinet. Measures only 2¾ x 3¾″. Complete with Touch-Tone pad, board, crystal, chip and all necessary components to finish the kit.

PRICED AT **$29.95**

For those who wish to mount the encoder in a hand-held unit, the PC board measures only 9/16″ x 1¾″. This partial kit with PC board, crystal, chip and components.

PRICED AT **$14.95**

DISTRIBUTOR FOR **A P PRODUCTS, INCORPORATED**



SUPER STRIP
SS-2 #923252
PRICE $17.00

COMPLETE KITS: CONSISTING OF EVERY ESSENTIAL PART NEEDED TO MAKE YOUR COUNTER COMPLETE.

HAL-600A 7-DIGIT COUNTER WITH FREQUENCY RANGE OF ZERO TO 600 MHz. FEATURES TWO INPUTS: ONE FOR LOW FREQUENCY AND ONE FOR HIGH FREQUENCY; AUTOMATIC ZERO SUPPRESSION. TIME BASE IS 1.0 SEC OR .1 SEC GATE WITH OPTIONAL 10 SEC GATE AVAILABLE. ACCURACY ± .001%. UTILIZES 10-MHz CRYSTAL 5 PPM.

COMPLETE KIT **$149.00**

HAL-300A 7-DIGIT COUNTER WITH FREQUENCY RANGE OF ZERO TO 300 MHz. FEATURES TWO INPUTS: ONE FOR LOW FREQUENCY AND ONE FOR HIGH FREQUENCY; AUTOMATIC ZERO SUPPRESSION. TIME BASE IS 1.0 SEC OR .1 SEC GATE WITH OPTIONAL 10 SEC GATE AVAILABLE. ACCURACY ± .001%. UTILIZES 10-MHz CRYSTAL 5 PPM.

COMPLETE KIT **$124.00**

HAL-50A 8-DIGIT COUNTER WITH FREQUENCY RANGE OF ZERO TO 50 MHz OR BETTER. AUTOMATIC DECIMAL POINT, ZERO SUPPRESSION UPON DEMAND. FEATURES TWO INPUTS: ONE FOR LOW FREQUENCY INPUT, AND ONE ON PANEL FOR USE WITH ANY INTERNALLY MOUNTED HAL-TRONIX PRE-SCALER FOR WHICH PROVISIONS HAVE ALREADY BEEN MADE. 1.0 SEC AND .1 SEC TIME GATES. ACCURACY ± .001%. UTILIZES 10-MHz CRYSTAL 5 PPM.

COMPLETE KIT **$124.00**

HAL-TRONIX BASIC COUNTER KITS STILL AVAILABLE

THE FOLLOWING MATERIAL DOES **NOT** COME WITH THE BASIC KIT: THE CABINET, TRANSFORMER, SWITCHES, COAX FITTINGS, FILTER LENS, FUSE HOLDER, T-03 SOCKET, POWER CORD AND MOUNTING HARDWARE.

HAL-600X (Same Specifications as HAL-600A) **$124.00**
HAL-300X (Same Specifications as HAL-300A) **$99.00**
HAL-50X (Same Specifications as HAL-50A) **$99.00**

PRE-SCALER KITS

HAL-0-300PRE (Pre-drilled G10 board and all components) **$19.95**

HAL-0-300P/A (Same as above but with preamp) **$29.95**

HAL-0-600PRE (Pre-drilled G10 board and all components) **$39.95**

HAL-1GHZ (New Item - Available in December) **$124.95**

PRE-BUILT COUNTERS AVAILABLE

(HAL-600A — $229.00) (HAL-300A — $199.00) HAL-50A — $199.00). ALLOW 4- TO 6-WEEK DELIVERY ON PRE-BUILT UNITS.

"HAL" HAROLD C. NOWLAND
W8ZXH

HAL-TRONIX
P. O. BOX 1101
SOUTHGATE, MICH. 48195
PHONE (313) 285-1782

SHIPPING INFORMATION: ORDERS OVER $15.00 WILL BE SHIPPED POSTPAID EXCEPT ON ITEMS WHERE ADDITIONAL CHARGES ARE REQUESTED. ON ORDERS LESS THAN $15.00 PLEASE INCLUDE ADDITIONAL $1.00 FOR HANDLING AND MAILING CHARGES.

SEND **SASE** FOR FREE FLYER

More Details? CHECK—OFF Page 142

More Details? CHECK—OFF Page 142

2 METER FM

and HF too . . .

SATELLITE HEADQUARTERS

See Erickson for all your Amateur Radio needs!

WN9ANF, WB9JKT, WB9VIK serving you with . . .

- Ameco • ASP • Atlas
- Belden • Bird • CDE
- CES • Collins • Cushcraft
- Dentron • Drake • HAL
- Hy-Gain • Icom • KLM
- Kenwood • Larsen • MFJ
- Midland • Mosley • NPC
- Newtronics • Nye
- Regency • Shure • Swan
- Standard • TPL • Tempo
- Ten-Tec • Wilson • Yaesu

Hours: 9:30-9 Mon. & Thurs, 9:30-5:30 Tues, Wed. & Fri. 9-3 Sat.

ERICKSON COMMUNICATIONS
5935 N. Milwaukee Ave.
Chicago, IL 60646
(312) 631-5181

There's nothing like it !

RADIO AMATEUR **callbook**

Respected worldwide as the only complete authority for radio amateur QSL and QTH information.

The **U. S. Callbook** has 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.

RADIO AMATEUR **callbook** INC.
Dept. E 925 Sherwood Drive
Lake Bluff, Ill. 60044

ALL BAND TRAP ANTENNA !

5 BAND OPERATION - ONLY ONE NEAT SMALL ANTENNA. FOR CONGESTED HOUSING AND APARTMENT DWELLERS!

FOR ALL AMATEUR HF TRANSMITTERS GUARANTEED FOR 1,000 WATTS POWER. LIGHT, NEAT WEATHERPROOF.

Complete as shown total length 102 ft. with 90 ft. of 52 ohm RG58U coax and PL259 connector. Hi-impact molded resonant traps. (wt. 3 oz. 1"x 5" long) You just tune to desired band for excellent reports! Excellent for ALL world - wide receivers and amateur transmitters. For NOVICE AND ALL CLASS AMATEURS! NO EXTRA TUNERS OR GADGETS NEEDED! Eliminates 5 separate antennas with excellent performance guaranteed. Can be used as inverted V. NO HAYWIRE HOUSE APPEARANCE! EASY INSTALLATION!

80-40-20-15-10 meter bands. Complete $39.95
40-20-15-10 meter bands. 54-ft. ant. $38.95
20-15-10 meter bands. 24-ft. ant. $37.95

SEND ONLY $5.00 (cash, ck., mo.) and pay postman balance COD plus postage on arrival or send full price for pp. del. BankAmericard - - - Master Charge - - - Ph 308-236-5333 Free info. available only from. WESTERN ELECTRONICS Dept. A7-1 Kearney, Nebraska, 68847

12 Button Touch Tone Encoder, 90 day guarantee **$14.00**
Plastic Mounting Box for ITT, S/C, WECO, or A.E. pads, Black, Gray, or Beige **$4.75**
Complete System with cable (battery not included) **$24.95**
Complete System as above but with speaker, amplifier, and battery **$39.95**
Transmitter keying circuit (100 ma max) with delay drop out feature installed in each system $7.50

Florida Residents add 4% Sales Tax. Orders under $20, add $1.00 for shipping and handling.

TELEPHONE EQUIPMENT COMPANY
Post Office Box 596, Leesburg, Florida 32748
(904) 728-2730

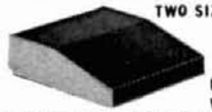
SEE HAM MART THIS ISSUE FOR YOUR LOCAL DEALER!

NEW ELECTRONIC PARTS

IC'S - TRANSISTORS - PROTOBOARDS - RESISTORS CAPACITORS - DIODES - SWITCHES - CONNECTORS VOLTAGE REGULATORS - CABINETS - HEAT SINKS FUSES & MUCH MORE - - STAMP BRINGS CATALOG

SPECIALS

KEYBOARD ENCLOSURES



TWO SIZES W	D	H	PRICE
14	8.3	3	$13.50*
14	11.3	3	$14.50*

BLUE BASE SPECIFY WHITE OR BLACK TOP

BREADBOARD KIT $10.75*
2" X 6"

BankAmericard

***SHIPPING INCLUDED**

NuData Electronics
104 N EMERSON ST. MOUNT PROSPECT, ILLINOIS 60056

More Details? CHECK — OFF Page 142

BULLET ELECTRONICS

P. O. BOX 19442 DALLAS, TEXAS 75219

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

PHONE ORDERS (214/823-3240) ON MASTERCHARGE & VISA

Did Somebody Mention Parts? Well, Here Are Just A Few Of The Items We Have. All Parts Are Prime & Guaranteed!

160W NPN Darlingtons

HOUSE NO. 2N6283 TO–3 Power Transistors with Hfe of over 5,000! 80V Vceo. Outperforms MJ3001.

Limited Qty.! - $1.00

PICK A PAIR!

8A Complimentary Darlington Power Transistors. MJ900 PNP, MJ1000 NPN. 90 Watts. Build high power audio amps.

Buy a Pair for $3.00!

ZENER Special!

ALL UNITS PRIME!
Overstocked on these units:
1N3030 1W 27 volt
House no. ½W 5.4V
House no. .4W 12.6V

9 for $1.00 (Same type)

MC1351P FM IF, Limiter, Discriminator & AF Pre-Amp

14 PIN IC. COMPLETE FM SOUND SUB SYSTEM USES MINIMUM EXTERNAL COMPONENTS. COMPLETE SPECS AND APPLICATIONS INFORMATION.

House # - 5/$1.00

General Purpose NPN

2N3569 Fairchild Vceo = 60V Hfe to 300. 800MW power, epoxy TO–5. Limited Qty!

6 for $1.00

Wideband AMP IC, High Gain

100Khz to over 20Mhz. Good for IF's and low frequency Complete Specs!

CA3011 50¢ each

MULTICOLORED 26 CONDUCTOR

Ribbon Cable No. 28 wire with a woven binder for easy seperation. Super flexiblility! Compare our price!
10' Roll $2.95
50' Roll $9.95

MC1469R
VOLTAGE REGULATOR IC

Versatile 500Ma regulator is adjustable with a single external resistor from 3 to 30 volts. Provisions for current limit and remote shutdown. Complete specs and application notes are included. $1.25 each or 10/$10. External series pass will provide currents to 20 amps.

Heatshrink Tubing

SPECIAL A very good assortment of 3/32", 1/8", 3/16", 1/4" and 7/16" heatshrink tubing 12 6" lengths for .75 Assorted colors

Quad Matched Diodes

Four closely matched 1N914 type diodes for balanced bridge or modulator circuits. One set – $1.00

2N5590
RF POWER TRANSISTOR

Just what you've been looking for: 10 Watts with 13.5VDC supply. Frequencies to 300 MHZ. Limited Quantity!

$3.95

PMOS Counter Chips

Single digit pre-settable up or down BCD counter with 7 segment decoded output/driver has internal latch. Requires +12, & +24VDC. Build counters, timers, etc. Complete specs. 24 Pin IC 4/$5.00

#30 Silver Plated

Wirewrap wire with Kynar® jacket. 4 colors available, 100 ft. of each color.

$4.95 (400')

BULLET LUCKY NUMBER 158071
The holder of the ticket which matches the above number must return the original ticket stub to us no later than 1/20/78 to claim the cash prize of $100.00. A NEW winning number will appear in next month's issue, so save those ticket stubs and watch for your Lucky Number!

WE ALSO SELL A GROWING LINE OF QUALITY KITS. WE HAVE SHIPPED 1000's!

MINI GRANDFATHER CLOCK KIT

Just in case you have spent the last six months in Siberia, we will tell you one more time that **BULLET** has the **ONLY** Completely **Electronic Grandfather Clock Kit** in the world that has all the below listed features. The biggest problem we have is to try and describe how unique and fascinating this clock really is! The **Swinging LED Pendulum and Matching Tick-tock sound** are available only on our clock. In addition the electronic chime notes each hour (ie: 3 times for 3 o'clock). Housed in the optional **SOLID HARDWOOD CASE**, the unit makes a beautiful addition to any room as well as a great gift.

* ½" 4 digit LED readout
* Adjustable Tone & Duration on Chime
* AM/PM indicator
* Simulated swinging pendulum uses LEDS
* All CMOS construction
* All electronics, switches and transformer inc.
* Quality plated PC boards (2) 6.5" x 4.5"

MG-01 $39.95

BEAUTIFUL SOLID HARDWOOD CASE FOR MG–01: Case is cut, grooved and finished for clock. Includes Ruby front filter. Quick easy assembly requires only 4 screws (included) $19.95
CHRISTMAS/HOLIDAY SPECIAL: Buy an MG–01 at regular price and get the case for a low $12.95. Your total cost **$52.90. Good till 1/31/78.**

New! PS-14 HIGH CURRENT REGULATED POWER SUPPLY KIT

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

12V @ 15A CONTINUOUS Less Case meters & jacks

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

$39.95
UPS SHIPPING PAID!

POWER SUPPLY ACCESSORIES

Quality 3½" Meters for PS-14 (0-25A; 0-15 VDC) Individually Packaged. Not Surplus $12.50/set

OVERVOLTAGE PROTECTION KIT

Provides cheap insurance for your expensive equipment. Trip voltage is adjustable from 3 to 30 volts. Overvoltage instantly fires a 25A SCR and shorts the output to protect equipment. Should be used on units that are fused. Directly compatible with the PS 12 and PS 14. All electronics supplied. Drilled and plated PC board. (Order OVP-1)

$6.95

MK-05 MINI MOBILE CLOCK

$12.95

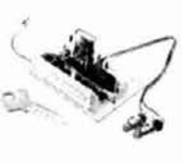
With punched front aluminum case – $15.95

The smallest and best priced mobile clock kit on the market. Designed to be a mobile clock from the ground up. There has been no compromise on quality.

FEATURES

* Quartz crystal timebase
* Toroid & zener noise & overvoltage protection
* Magnified .15", 6 digit LED readout
* Complete with presettable 24 hr. alarm
* 9–14 VDC @ 40 to 50 ma
* Readouts can be suppressed
* EASY, QUICK ASSEMBLY
* All components required included (you supply the speaker)
* Top quality drilled and plated PC boards.
  Clock board: 2.6" x 2"
  Readout board: 2 3/8" x .75"

Small enough to mount in the instrument panel!



MK–06 CLOCK/CALENDAR AUTO/HOME CLOCK KIT

Nothing else to buy!
Can be panel mounted.
Great for Vans & RV's!

We designed this to be a SUPER CLOCK with ALL the features you want. Quality double sided PC boards make assembly easy. Mobile (12VDC) or home (12VAC)

* Large ½" LED Readout
* AM/PM Indication
* 28/30/31 day calendar displays automatically or manually
* Display can be dimmed or blanked
* Flashing Colon counts the seconds
* Intergal Timebase is adjustable
* Presettable Alarm with Snooze Feature
* Noise and voltage protection circuits
* Single front mounted rotary switch selects all functions

Additional Options
24 hour format; Add $2.
12VAC XFMR for 110 operation add $1.75

$21.50 LESS CASE

ORLANDO HAMCATION 78 ORLANDO HAMCATION 78 ORLANDO HAMCATION 78 ORLANDO HAMCATION 78

OH!

.....Have you been thinking about a wonderful Florida vacation, to places such as Disney World, Cypress Gardens, Sea World, the famous East and West coast beaches, and many of our other near by attractions???......
.....NOW, think about combining that vacation with one of the South's greatest Hamfest.........

ORLANDO'S HAMCATION '78'

and the

FLORIDA STATE ARRL CONVENTION

AT THE SHERATON'S TWIN TOWERS HOTEL & CONVENTION CENTER, ON S–435 NEAR THE CROSSROADS OF THE FLORIDA TURNPIKE AND I-4 INTERCHANGE.

FEBRUARY 17*-18-19, 1978

DOORS OPEN.......*6PM FRI. the 17th (Swapfest area only),
7AM SAT.the 18th, 8AM SUN. the 19th.

● ARRL FORUMS

● TECHNICAL FORUMS

ADMISSION, $3 Advance, $4 At the door.
Ladies FREE, Children 14 and under FREE!!!

THOSE ADMITTED FREE MUST BE IN THE COMPANY OF A REGISTERED TICKET HOLDER AT THE DOOR.

● MANY DOOR AWARDS ●

GIGANTIC SWAPFEST AREA

25,000 SQ.FT. OF AIR CONDITIONED INDOOR COMFORT.

SWAPFEST TABLES $5 PER TABLE PER DAY

● LARGE COMMERCIAL EXHIBIT AREA

● LADIES' ACTIVITIES

SATURDAY NIGHT BANQUET

$8 per person —Great speaker lineup.

RESERVE BANQUET TICKETS IN ADVANCE, LIMITED QUANITY AVAILABLE.

FOR ADVANCE REGISTRATION, SWAPFEST AND BANQUET TICKETS

SEND CHECK PAYABLE TO : THE ORLANDO AMATEUR RADIO CLUB,INC.
HAMCATION CHAIRMAN, WB4HAK
6 CAMELLIA DRIVE
De BARY, FLORIDA 32713

All advance ticket sales will be confirmed by return mail. Last postmark for advance sales will be Feb. 12th 1978.

FOR SHERATON TWIN TOWERS HOTEL RESERVATIONS, WRITE DIRECTLY TO:
The Sheraton Towers, 5780 Major Blvd. Orlando, Fla. 32805. Sing. $28, Doub. $36 per day.
Call toll free 1-800-327-2110 (except Fla. residents), Mention Hamfest Convention for special rates.

Sorry!!! City ordnance prohibits overnight camping (Rec. vehicles,etc.) on parking lots.

More Details? CHECK—OFF Page 142

Advertisers check-off

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

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

INDEX

- ABC ___ 571
- AGL ___ 558
- Aldelco ___ 347
- Am. Wholesale Elect ___ 003
- Amcomm ___ 500
- Amidon ___ 005
- Atlantic Surplus ___ 644
- Atlas ___ 198
- Atronics ___ 382
- B & K Prec ___ 516
- Bencher ___ 629
- Budwig ___ 233
- Bullet ___ 328
- CFP ___ 022
- CIR ___ 548
- Cal-Com ___ 282
- Cleng ___ 465
- Comm. Center ___ 534
- Comm. Power ___ 360
- Comm. Spec. ___ 330
- Comm. Tech. Group ___ 645
- Crystal Banking ___ 573
- Curtis ___ 034
- Cushcraft ___ 035
- Dames Comm. ___ 551
- Dames ___ 324
- Data Signal ___ 270
- Davis Elect. ___ 332
- DenTron ___ 259
- Direct Conv. Tech. *
- Disc Cap ___ 449
- Drake ___ 039
- E. T. O. *
- Elect. Distr. ___ 044
- Epsilon ___ 046
- Erickson ___ 047
- Excel ___ 535
- Fair Radio ___ 048
- FT Accessories ___ 646
- GLB ___ 552
- Gilfer ___ 207
- Godbout ___ 647
- Gray ___ 055
- Gregory *
- Gull Elect. ___ 635
- Hal ___ 057
- Hal-Tronix ___ 254
- Ham Center ___ 491
- H R C B ___ 150
- Hamtronics ___ 246
- Heath ___ 060
- Heights ___ 061
- Henry ___ 062
- Hewlett Packard ___ 281
- Icom ___ 065
- Info Tech ___ 351
- Integ. Circuits ___ 518
- Int. Crystal ___ 066
- James ___ 333
- Jan ___ 067
- Jensen ___ 293
- Jones ___ 626
- K-Enterprises ___ 071
- Kenwood *
- Kester Solder *
- Lafayette ___ 598
- Long's ___ 468
- Lunar ___ 577
- Lyle ___ 373
- MFJ ___ 082
- Madison *
- Masters ___ 555
- NuData ___ 455
- Oak Hill Am. Radio Sess. ___ 213
- Optoelectronics ___ 352
- Orlando Hamcation *
- Palomar ___ 093
- Partridge ___ 439
- Pipo ___ 481
- Printed Circuits ___ 648
- RF Power Labs ___ 602
- Callbook ___ 100
- Radio World *
- Ramsey ___ 442
- Regency ___ 102
- Rockwell Collins ___ 258
- Rohde Schwartz ___ 306
- Ross Dist. ___ 581
- SST ___ 375
- Savoy ___ 105
- Securitron ___ 461
- Sencore ___ 650
- Sentry ___ 600
- Signetics ___ 174
- Solid State Time ___ 636
- Space ___ 107
- Spectronics ___ 191
- Spectrum Comm. ___ 336
- Spectrum Int. ___ 108
- Swan ___ 111
- TPL ___ 240
- Tele. Equip. ___ 496
- Telrex ___ 377
- Ten-Tec ___ 114
- Tri-Ex ___ 116
- Tufts ___ 321
- VHF Eng. ___ 121
- Valley Instru. ___ 583
- Vanguard *
- Varian ___ 043
- Webster Comm. ___ 423
- Weinschenker ___ 122
- Westcom ___ 649
- Western Elect. *
- Whitehouse ___ 378
- Wilson Elect. ___ 123
- Yaesu ___ 127

*Please contact this advertiser directly.

Limit 15 inquiries per request.

January 1978

Please use before February 28, 1978

Tear off and mail to

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

NAME ....

CALL ....

STREET ....

CITY ....

STATE .... ZIP ....

Advertisers iNdex

ABC Communications	114
AGL Electronics	142
Aldelco	118
Amateur Wholesale Electronics	88, 89
Amcomm	78
Amidon Associates	136
Atlantic Surplus Sales	128
Atlas Radio	109
Atronics	112
Bencher, Inc.	112
Budwig Mfg. Co.	122
Bullet	139
CFP Communications	136
CIR Industries	92, 93
Cal-Com Systems, Inc.	128
Cleng Electronics	130
Communications Center	122
Communications Specialists	112, 123
Communications Technology Group	79
Crystal Banking Service	106
Curtis Electro Devices	122
Cushcraft	38, 39
Dames Communications Systems	136
Dames, Ted	130
Data Signal, Inc.	125
Davis Electronics	100, 106
DenTron Radio Company	7
Direct Conversion Technique	136
Disc-Cap	66
Drake Co., R. L.	27
Ehrhorn Technological Operations	111
Electronic Distributors	106
Epsilon Records	130
Erickson Communications	138
Excel Circuits	112
Fair Radio Sales	118
FT Accessories	104
GLB	120
Gilfer Associates	128
Godbout Electronics	93
Gray Electronics	120
Gregory Electronics	87
Gull Electronics	117
Hal Communications Corp.	121
Hal-Tronix	135
Ham Radio Center	71
Ham Radio's Communications Bookstore	87, 110, 122, 124, 138
Hamtronics, Inc.	143
Heath Company	44, 45
Heights Mfg. Co.	122
Henry Radio Stores	Cover II
Icom	5
Info-Tech	80
Integrated Circuits Unlimited	137
International Crystal	113
James Electronics	116
Jan Crystals	124
Jensen Tools & Alloys	104
Jones, Marlin P. & Assoc.	130
K-Enterprises	104
Trio-Kenwood Communications, Inc.	8, 9, 72, 73
Kester Solder	93
Klaus Radio, Inc.	88
Lafayette Radio Electronics	102
Long's Electronics	144
Lunar Electronics	100
Lyle Products	128
MFJ Enterprises	2, 102
Madison Electronic Supply	118
Masters Communications	124
NuData Electronics	138
Oak Hill Academy Amateur Radio Session	128
Optoelectronics	119
Orlando Hamcation	140
Palomar Engineers	103, 120
Partridge (HR) Electronics	134
Pipo Communications	134
Printed Circuits Products	136
RF Power Labs	104
Radio Amateur Callbook	114, 138
Radio World	134
Ramsey Electronics	129
Regency Electronics	105
Rockwell International, Collins Groups	67
Ross Distributing Company	136
SST Electronics	108
Savoy Electronics	63
Securitron	122
Solid State Time	124
Space Electronics	122
Spectronics	127
Spectrum Communications	101
Spectrum International	110
Swan Electronics	96, 97
TPL Communications	51
Telephone Equipment Co.	138
Telrex Labs	128
Ten-Tec	1
Tri-Ex Tower Corp.	99
Tufts Radio Electronics	141
VHF Engineering, Div. of Brownian	131
Valley Instrument Products	114
Vanguard Labs	126
Varian, Eimac Division	Cover IV
Webster Communications	128
Weinschenker	134
Westcom	107
Western Electronics	138
G.R. Whitehouse & Co.	134
Wilson Electronics	115
Yaesu Electronics Corp.	Cover III

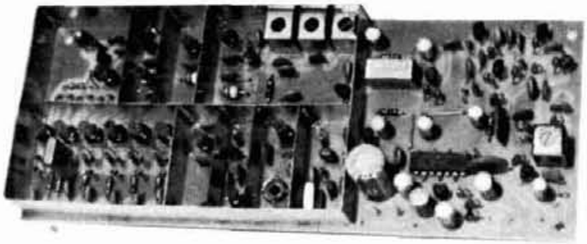
More Details? CHECK — OFF Page 142

ANNOUNCING--A New Generation of VHF/UHF FM RECEIVER KITS

More Sensitive, More Selective, Easier to Build, Smaller Than Ever Before!

CHECK THESE FEATURES-

- Lower system cost than ever before
- Better selectivity, 70-80 dB adjacent channel, over 100 dB with crystal filter option
- Six channels at no extra cost
- 60 dB image rejection
- *Latest design — new easy-to-wind high Q coils, compartmentized shielding*
- Easy to build, test circuits on board allow tune up with only sig gen & vtvm



VHF MODEL R70 $69.95

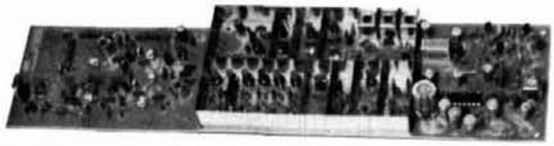
- Available for 2M, 6M, 10M, 220 MHz, or com'l bands
- Sensitivity 0.4uV for 20 dB

Optional Crystal Filter Kit $10
Channel Crystals $5.95 ea

UHF MODEL R90 $89.95

- For any 2 MHz segment of the 380-520 MHz range
- Sensitivity 0.8uV

Optional crystal filter kit $10
Channel crystals $5.95 ea



These low noise PREAMPS let you hear the weak ones!

Great for OSCAR, SSB, FM, ATV. Over 8000 in use throughout the world.

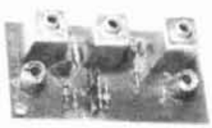
P8 KIT $10.95
P16 Wired $21.95
Miniature model for tight spaces - only 1/2 x 2-3/8 inches

- 20dB gain
- Covers any 4 MHz band in range

MODEL	RANGE
P8-LO	20-83 MHz
P8-HI	83-190 MHz
P8-220	220-230 MHz
P16 Wired	Give exact band

P9 KIT $12.95
P14 Wired $24.95

Deluxe model for applications where space permits.



- 1-1/2 x 3 inches
- Covers any 4 MHz band in range
- Ideal for OSCAR
- Diode protection
- Connectors
- 20 dB gain

MODEL	RANGE
P9-LO	26-88 MHz
P9-HI	88-172 MHz
P9-220	172-230 MHz
P14 Wired	Give specific band

P15 KIT $18.95
P35 Wired $34.95

- Covers any 6 MHz band in band in range of 380-520 MHz
- 20 dB gain

These new CONVERTER KITS

let you receive OSCAR signals and other exciting VHF & UHF activity on your present HF receiver.

either one
ONLY $34.95
including crystal

MODEL	RF RANGE (MHZ)	IF RANGE
C50	50-52	28-30
C144	144-146	28-30
C145	145-147	28-30
C146	146-148	28-30
C220	p/o 220-230	28-30
Special	Other rf & i-f ranges are available on special request	

MODEL	RF RANGE (MHZ)	IF RANGE
C432-2	432-434	28-30
C432-5	435-437	28-30
C432-9	439.25 (ATV)	61.25
Special	Other rf & i-f ranges are available on special request	

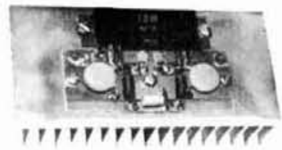
An extruded aluminum case is available for vhf and uhf converters at $12.95, including connectors and hardware.

FM/CW TRANSMITTER KITS

200 MW EXCITER MODULE KITS

T40 Eleven Channel Exciter Kit for 2M or 6M band.......................... ...... $39.95

T20 Tripler/Driver Module Kit, 150 mW 2M input, 200 mW 450 MHz output $19.95



RF POWER AMPLIFIER MODULES

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

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

TEST PROBE KITS

only $9.95 ea

Contain scope type probe, ground clip, cable, & all components except plug for test equipment.

TE-3	RF Detector Probe for vtvm; good from 100 kHz to over 500 MHz
TE-4	Direct Probe for ac/ohms, etc.
TE-5	DC Probe w/res for 11 meg input vtvm
TE-6	Blocking Capacitor Probe for counter, signal generator, etc.
TE-7	Wideband Detector Probe for scopes
TE-8	High Z/Low Capacitance scope probe

*FREE 1978 CATALOG

is yours for the asking. NEW 40 page catalog gives details on these and other kits, including scanner adapters, receiver multicouplers, NPC power supplies, M-tech PA's, CES tone pads & mics, Hy-Gain *HT's & hf rigs, & antennas. GET YOURS TODAY!*

FREE SHIPPING ON LARGE STOCK OF ANTENNAS!!! We now offer free delivery of Cushcraft, Larsen, & Hy-Gain antennas in the 48 states. Popular models such as Ringo Rangers, VHF & triband beams, magnet mount whips, hf verticals, rubber duckies, lightning arrestors, Reyco traps, W2AU & Hy-Gain baluns. *Call* or write NOW! We'll be glad to send free catalogs.

IN CANADA:
Send order to COMTEC; 5605 Westluke Ave.; Montreal, Que H4W 2N3 or call 514-482-2640. Add 28% to prices shown above to cover customs duty, exchange rate, and federal tax.

It's Easy To Order!

- CALL OR WRITE NOW FOR FREE CATALOG OR TO PLACE ORDER!
- PHONE 716-663-9254. (Answering service for evenings and weekends for your convenience. Personal service 9-5 eastern.)
- Use credit card, COD, check, m.o.
- Add $2.00 shipping & handling.

hamtronics, inc.

182-A Belmont Rd; Rochester, NY 14612
Dealer Inquiries Invited