HOW NEW FTC HI-FI RULES AFFECT YOU

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE NOVEMBER 1974/60¢

What's New in 1975 Color TV Receivers

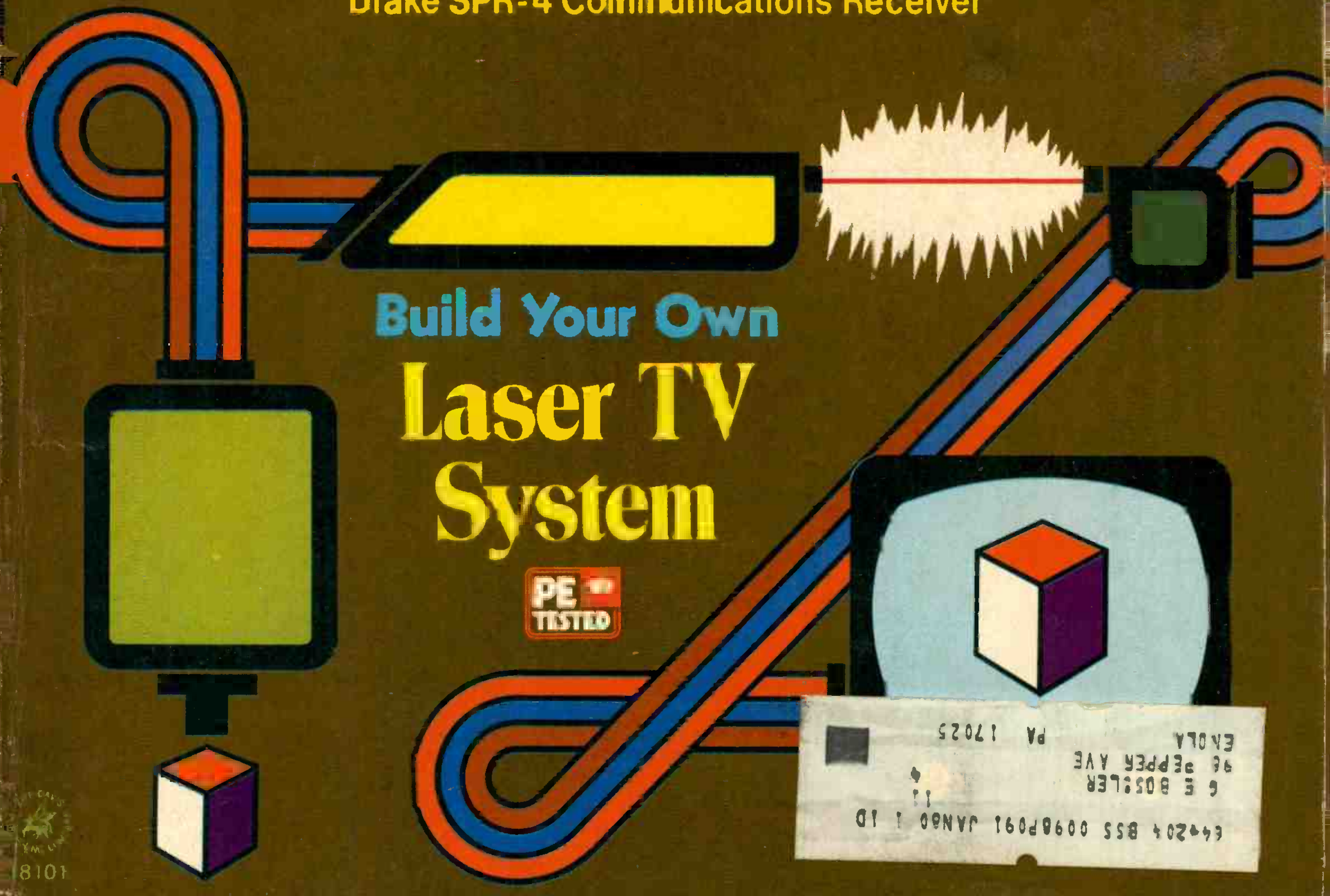
Build a Multimeter Range Extender

Career Opportunities for Tech Reps

A Direct-Conversion AM/SSB Project

Test Reports

Pioneer SX-636 Stereo Receiver
Pickering OA-3 Stereo Headphones
American Circuits & Systems MK1 Function Generator
Royce 1-600 CB Mobile Transceiver
Drake SPR-4 Communications Receiver



speed while a record is playing. Both of these sophisticated units are even equipped with a strobe light directed at the strobe marks for easy viewing. Pioneer's engineers really think of everything.

Electronic speed adjustment for each speed

Automatic features without automatic drawbacks

If you prefer to let your tonearm and turntable do all the work, consider Pioneer's all new PL-A45D. With it you can play your records without ever touching the tonearm. Unlike other single play automatics which depend upon complicated mechanical linkages to provide the necessary tonearm cycling motion, the PL-A45D uses a separate precision gear motor just to move the tonearm in accordance with your instructions. Its other 4-pole synchronous motor is free to drive only the 12-inch aluminum alloy die-cast platter without interruption or change of torque and speed.

Automatic operation—manual precision

Superb S-Shaped tonearms for better tracking

The tonearm of every Pioneer turntable system is the "S-shaped" design, for optimum groove tracking. All are statically balanced and all use adjustable counterweights with direct readout of tracking force. All have adjustable anti-skate control and oil-damped cueing for the gentlest application of stylus tip to record groove. Lightweight plug-in cartridge shells insure positive electrical contact and optimum stylus position and angle for lower distortion and reduced record wear.

S-shaped tonearm for ideal tracking

The tradition of unexcelled performance

Still, all of these features and refinements alone do not guarantee the performance specifications of Pioneer's new turntables. Each tonearm and turntable platter combination is shock mounted in its specially designed natural grain cabinet (with hinged dust cover). Precision machining of all rotational parts of each unit, plus a program of continuous quality control insure that each Pioneer turntable will meet or exceed its published specifications — a time honored tradition with all Pioneer components.

Manual turntables— choice of the professionals

Engineers, experts and enthusiasts agree: to get the best performance, you need a manual turntable. And to get the best manual turntable, you need a Pioneer. Every Pioneer manual turntable offers a level of precision and performance unparalleled in its price range. And every one is a total system — complete with dust cover and base — and designed for years of professional trouble-free sound reproduction.

ble that's right for you.

PL-A45D	PL-51A	PL-71
Belt	Direct	Direct
4-pole synch.	DC Servo	DC Servo
—	±2%	±2%
ore than 47dB	More than 55dB	More than 60dB
.1% (WRMS)	0.06% (WRMS)	0.05% (WRMS)
tatic Bal. "S"	Static Bal. "S"	Static Bal. "S"
8¹¹⁄₁₆"	8¹¹⁄₁₆"	8¾"
12"	12¼"	12¼"
2 lbs. 3 oz.	3 lbs. 1 oz.	3 lbs. 8 oz.
$169.95	$249.95	$299.95

For the best manual turntable get a Pioneer.

The manual turntable is rapidly becoming the first choice of hi-fi enthusiasts everywhere. The reason why is quite simple. Today's enthusiasts are more knowledgeable, more sophisticated and more involved with their music. And only the manual turntable can provide the involvement and performance they demand

At Pioneer, this trend comes as no surprise. We have long recognized the superiority of the manual turntable. And long recognized a simple fact: a record changer in no way improves performance. It can detract from it.

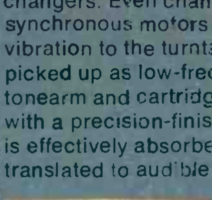
As a result, we now offer the finest and most complete line of manual turntables available. Manual turntables that are designed with the needs of today's hi-fi enthusiast in mind. Turntables that are engineered for precision response.

When you get right down to it, good record playing equipment really has only two requirements: uniform rotation of a turntable, and accurate tracing of a record groove by a tonearm and its cartridge.

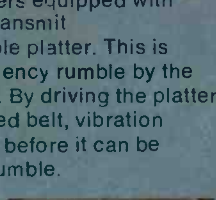
Pioneer's engineers have long recognized that these requirements are best met by single-play turntables and precision engineered tonearms. Our five new belt-drive and direct-drive turntable systems mean you needn't settle for the higher wow and flutter and the poorer signal-to-noise ratios (rumble) of record changers. Whether you've budgeted $100 or $300 for this vital element of your high fidelity system, there's a Pioneer turntable that outperforms any record changer in its price class.

Consider the performance advantages

Belt-drive, featured in Pioneer's PL-10, PL-12D and PL-A45D, means smoother, more uniform platter rotation than can be achieved with typical idler-wheel/pulley arrangements normally found in record changers. Even changers equipped with synchronous motors transmit vibration to the turntable platter. This is picked up as low-frequency rumble by the tonearm and cartridge. By driving the platter with a precision-finished belt, vibration is effectively absorbed before it can be translated to audible rumble.



Belt-drive for rumble-free rotation



Direct-drive motor reduces friction

Pioneer's direct-drive models, PL-51A and PL-71 go even a step further in achieving noise-free, precision platter rotation. The DC electronically controlled servomotors used in these models rotate at exactly the required 33⅓ or 45 rpm platter speed. Their shafts are directly connected to the center of the turntable, with no intermediate pulleys or other speed reduction devices. This means no extra friction-producing bearing surfaces.

Because of the unique technology embodied in these new, direct-drive motors, it's possible to control their speed electronically. This is more precise than any mechanical drive system. Both our PL-51A and PL-71 offer individual pitch control for both 33⅓ and 45 rpm speeds. Their turntable platters are edge-fitted with stroboscopic marks, so you can adjust precise

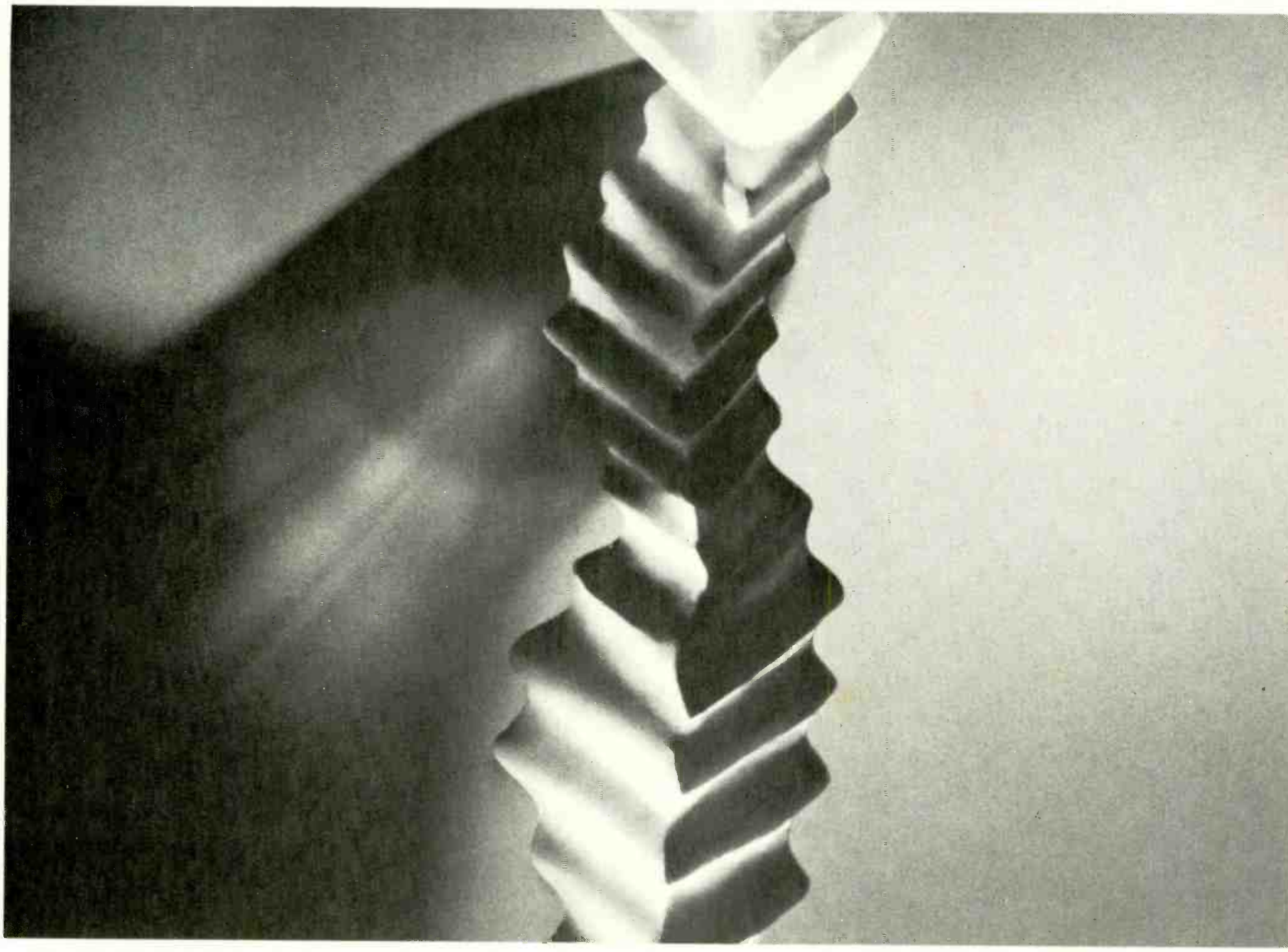
Choose the Pioneer turnta

Model	PL-10	PL-12D
Drive system	Belt	Belt
Drive motor	4-pole synch.	4-pole synch.
Speed control	—	—
S/N (Rumble)	More than 47dB	More than 47dB
Wow & Flutter	0.1% (WRMS)	0.1% (WRMS)
Tonearm Type	Static Bal. "S"	Static Bal. "S"
Tonearm Length	8$\frac{11}{16}$"	8$\frac{11}{16}$"
Turntable Diameter	12"	12"
Turntable Weight	2 lbs. 3 oz.	2 lbs. 3 oz.
Price:	$99.95	$119.95

For the best performance, get a manual turntable.


PIONEER

*traceAbility™



(A)

Pickering cartridges feature low frequency tracking and high frequency tracing ability*

Pickering offers you "The Best of Both Worlds" in discrete 4-channel and in stereo cartridges. These cartridges have been specifically designed and engineered to peak specification and performance characteristics. They possess traceAbility, vital for both stereo and discrete playback.

For example, take the case of discrete playback. You are looking at a model of a discrete groove, magnified 3,000 times (figure A). You can see it is made up of complex groove undulations. This makes the demands on the cartridge and its stylus much greater than ever before. The left side of the groove possesses all of the information recorded on the left side of the room, and the right side likewise. The stereo signals for the front speakers are represented by the broad sweeps (figure B), and the special discrete high frequency tone carrier is represented by the wiggles on the same groove walls (figure C). This high frequency carrier centered at 30,000 Hz, demands a superior stylus assembly (and shape of the tip) which we call our Quadrahedral™ another Pickering exclusive which makes it possible for the stylus to trace both the stereo and discrete signals in the groove.

(B)

(C)

So, the Quadrahedral™ stylus picks up all 4 signals, which the computerized demodulator sorts for the amplifier, which in turn transmits the sound to the proper speaker.

So, whether you look forward to the fabulous reality of discrete 4-channel sound in your home, or the finest stereo to satisfy your listening taste — depend on the traceAbility of Pickering cartridges to make possible "The Best of Both Worlds". . . . the world of stereo and matrix, and the world of discrete 4-channel.

For further information write to Pickering & Co., Inc., Dept. PE Sunnyside Blvd., Plainview, New York 11803

PICKERING

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TM-PICKERING TRADEMARK

CIRCLE NO. 30 ON READERS SERVICE CARD

NOVEMBER 1974 VOLUME 6, NUMBER 5

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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CONSTRUCTION STORIES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

POPULAR ELECTRONICS, November 1974, Volume 6, Number 5 Published monthly at One Park Avenue, New York, NY 10016. One year subscription rate for U.S., Possessions and Canada, $6.98; all other countries, $8.98. Second class Postage paid at New York, NY and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. Subscription service and Forms 3579; P.O. Box 2774, Boulder, CO 80302.
POPULAR ELECTRONICS Including ELECTRONICS WORLD, Trade Mark Registered. Indexed in the Reader's Guide to Periodical Literature.

Ziff-Davis also publishes Boating, Car and Driver, Cycle, Flying, Modern Bride, Popular Photography, Skiing and Stereo Review.
Forms 3579 and all subscription correspondence should be addressed to POPULAR ELECTRONICS, Circulation Dept., P. O. Box 2774, Boulder, CO 80302. Please allow at least eight weeks for change of address. Include your old address, as well as new—enclosing, if possible, an address label from a recent issue.
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Editorial

RUN IT UP THE FLAGPOLE

As some readers know, a Notice of Proposed Rule Making by the FCC is simply the Commission's public pronouncement that it is *considering* a change in Rules and Regulations. Of course, some proposals never come to fruition, while others are severely modified before adoption, depending on comments received by interested persons and groups.

For example, the FCC created a furor almost two years ago when it invited comments on its proposal to transfer the 220-MHz amateur radio band to CB to relieve congestion. We haven't heard a word since, and suspect that hamdom's vociferous outcry against it has shelved it for a while. Now there are some startling, new proposals concerning CB, plus some action. To keep you abreast of what's going on, here are some current developments.

In the action area, CB'ers can now use omnidirectional antennas and support structures that are 60 feet above ground! (Present 20-foot restrictions on *directional* antennas remain.)

On the proposal side, the FCC proposes to allocate the 27.230-MHz to 27.540-MHz band to the Class D Citizens Radio Service as a means of relieving congestion. This would add 47 channels to the existing 23 channels if eventually adopted. Further, the Commission is toying with the idea of allowing hobby-type activities to be communicated via CB so long as it doesn't relate to use of the radiotelephone equipment . . . considering deletion or modification of rules on relaying messages by licensees . . . reducing the age requirement from 18 years to 16 years . . . using Channel 11 (27.085 MHz) as a calling channel to establish contact for communicating on another channel . . . reducing the communications silent period from five minutes to one minute (that's five on and one off) . . . and modifying the requirement of a transmitting station to use both its call sign and that of the station being contacted to the sender's call sign only, among other proposals issued.

In another recent proposal, the FCC admits its failure to eliminate extensive use of r-f power amplifiers (those illegal "linears") by Class D stations. As a consequence, the Commission wishes to prohibit sale or lease of linears in the 20- to 40-MHz band, excepting multiband equipment for use in the Amateur Radio Service and single-band amplifiers made on a single-unit basis. Until further clarification, I presume that the latter allows one to build his own linear. Under any circumstance, of course, linears cannot be used legally for Class D communications.

It's clear from the proposed major rule amendments that the Commission intends to enhance two-way short-range radio communications for individual citizens. Offhand, we like some of the proposals and have reservations on others. Nonetheless, we're pleased to learn of some positive FCC action concerning CB. Ignored, however, was a way to compel CB'ers to obtain a license and to use call signs.

Running such proposals up the flagpole provides the FCC with input from a variety of public sources. Therefore, proposals generally take considerable time to finalize, if acted upon at all. And should additional channels actually be added at some future time, you can be sure that manufacturers will be delighted to sell you an add-on adapter to expand your radio service. So go ahead and buy that CB rig, if that's what you're planning to do. It's the same suggestion offered here when Class E, now apparently dormant, was proposed. And it proved to be a sound one.

Art Salsberg

Letters

IT TAKES TECHNICAL KNOW-HOW

The implication in "How to Set Up a Home TV Service Shop" (August 1974) that anyone with a small amount of electronics knowledge and an investment in the neighborhood of $50 can start his own business in color TV servicing is ridiculous. Although I am not aware of author Margolis' competence or history in color TV servicing, I challenge his statement that only a small percentage of TV troubles require great skill and expensive test equipment. On the contrary, it has been my experience and the experience of my associates with whom I have discussed this article that a correct statement of fact would be that only a small percentage of TV troubles are simple and easy to repair.

EWELL A. FERGUSON, JR., CET, Executive Director
North Carolina Electronic Technicians Assoc. Inc.

The article did not focus on color TV servicing only – nor even solid-state receivers only. We know service technicians who have started with as little as $50, though they continually added to their parts inventory and test equipment. The article was directed to readers who have a good technical knowledge of TV receiver circuits, are presently employed in another area of electronics, and who yearn for their own business. (We apologize if our reader target was not clear.) For these skilled people, most TV troubles are easy to isolate and correct. For untrained persons, this is, of course, untrue.

LEGALITY OF CB "PHONE PATCHES"

The Commission's (FCC) Rules contain no prohibition against the manual interconnection of a Citizens Class D radio station to commercial telephone facilities under conditions whereby a properly authorized operator is available to monitor and control the operation of the Citizens Radio station. Particular attention should be given to the provisions of Paragraph (d) of Section 95.119 which prohibits remote control of a Class D station and Section 95.87 (a) which requires a licensee to maintain control at all times over the transmitters operated under his license. "Phone patch" devices which permit telephone calls to automatically actuate a Class D station are in violation of both stated sections. Messages from a commercial telephone can be fed directly into a Citizens Class D transmitter through a phone patch only if an authorized operator had direct manual control of the transmitter.

Attention should also be given to Section 95.83(a)(14) of the FCC Rules which states in essence that a Citizens radio station shall not be used for relaying messages or transmitting communications for a person other than the licensee or members of his immediate family.

The connection of a phone patch to the telephone lines for interstate and intrastate communication is governed by tariff regulations filed by the telephone companies with the FCC and the state regulatory agencies. Generally, these regulations permit the connection of customer-provided communications systems. Connection by acoustic/inductive means is subject to the condition that certain "minimum protection criteria" regarding signal input power are met. Local telephone companies will explain these criteria to interested licensees and operators. On the other hand, direct electrical connection can be made only through a connecting arrangement provided by the telephone company.

CHARLES A. HIGGINBOTHAM
Chief, Safety & Special Radio Services Bureau,
Federal Communications Commission, Washington, D.C.

FEEDBACK ON DOUBLE-SIDED PC BOARDS

The process detailed in "How To Make Double-Sided PC Boards" (June 1974) can be simplified in the following manner:

First, photo-reverse the exposure masks. Use IC-pad holes as references to align the reversed films, and tape the edges together along three sides. Punch holes through both films in unused areas (preferably in each corner) of the layout.

In a safe-lighted area, slide the pc blank between the films and apply small squares of transparent tape over the punched holes to secure the film to both sides of the blank. Expose the board, one side at a time, using a photographic contact printer with foam backing. Finally, remove the tape and develop and etch the blank.

GERALD G. CRAMM
Quantico, Va.

I feel I must criticize Mr. Burawa's statement that "If you can trace a circuit, you can design any type of pc board." I am afraid that many readers are going to get themselves into difficulties if they follow this advice. Pc boards are not a toy for the unskilled. Having been in the pc-board design field since its inception, I can attest that it takes many hours of training to acquire the design knowledge required for making pc boards.

Also lacking in the article was any mention of the fact that pads or land areas are chosen in relation to the hole size for the component lead or that there are strict rules on clearances between components and the foil conductors. The greater the packaging density, the more problems will be encountered and the more you must rely upon the rules that govern pc designs. Hence, without a formal education in design, expensive trial and error are going to cause short tempers.

RICHARD MAYER
Crown Point, N.Y.

"I do not deny that formal training would better prepare the experimenter for tackling pc board design and fabrication. But I also feel that it is not absolutely necessary in the great majority of cases. I contend that if you can trace a circuit, you can design just about any type of pc board. I would only add that good layout procedures be practiced in high-gain, r-f, and other critical designs to avoid crosstalk, feedback, etc. —*Author*

LINEARS ON CB ARE A NO-NO

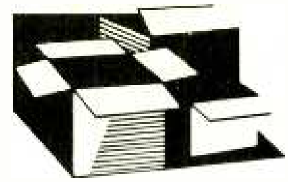
I would very much appreciate any information you can pass on with regard to using a linear amplifier with my CB transceiver.

Name Withheld

The best information we can pass on is don't. *The use of a linear power amplifier with a CB transceiver is forbidden by the FCC rules.*

Where do the pros get their training?

Almost half of the successful TV servicemen have home study training and among them, it's NRI 2 to 1. It's a fact! Among men actually making their living repairing TV and audio equipment, more have taken training from NRI than any other home study school. More than twice as many!

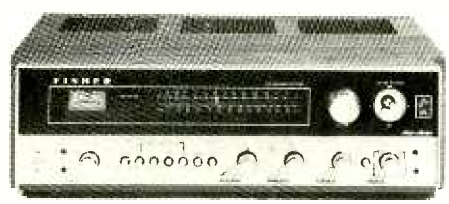


New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

FISHER 4-CHANNEL RECEIVER

The Fisher Studio Standard Model 334 4-channel receiver boasts 40 watts rms/channel with all channels driven into 8-ohm loads and an IHF power bandwidth of 30 to 22,000 Hz at 1 percent IM and 0.8 percent THD. It features built-in SQ and

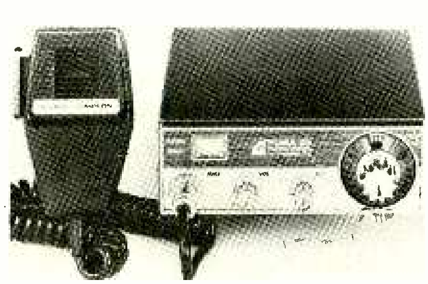


CD-4 decoding circuitry. Besides husky power rating, the receiver also has a "joystick" channel-balance control, loudness contour that is automatically disengaged when the output level is raised, and a sensitive (2-μV) tuner. If stereo operation is desired, the amplifiers can be "strapped" to double the power per channel. Other features include Baxandall-type tone controls, FM muting, tape monitoring circuitry, output jacks for 4-channel recorders, tuning meter with Fisher's "Stereo Beacon," and an AM tuner.

CIRCLE NO. 70 ON READER SERVICE CARD

PEARCE-SIMPSON CB TRANSCEIVER

The Puma 23B is a 23-channel AM mobile CB rig (crystals supplied) from Pearce-Simpson. Its S/r-f meter glows amber on receive, red on transmit, and flashes bright red when fully modulated. A switch permits selection of r-f or PA output. The transmitter operates at the legal power limit. A dual-conversion receiver with 0.5-μV sensitivity, with a crystal filter for selectivity and an automatic noise limiter, simplify the task of receiving signals on the crowded



channels. A noise-cancelling microphone, mobile mounting bracket, and external power cord are supplied with the transceiver.

CIRCLE NO. 71 ON READER SERVICE CARD

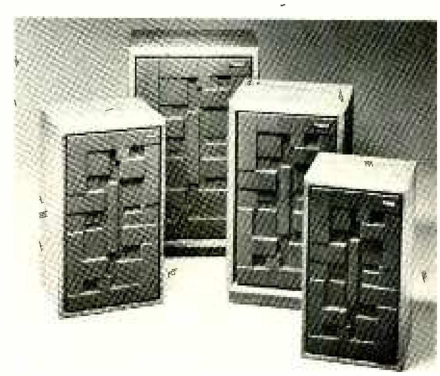
JBL DECADE SERIES SPEAKER SYSTEM

The Model L36 is a moderately-priced three-way speaker system that incorporates some of the hardware that comprises the JBL Century L100 and professional Model 4311 Studio Monitor systems. The L36 contains a 10-in. (25.4-cm) woofer with a 2.5-lb (about 1-kg) magnet, 5-in. (12.7-cm) midrange driver, and a 1.4-in. (3.56-cm) tweeter. Crossover frequencies are at 1500 and 6000 Hz. Nominal impedance of the system is 8 ohms. Power capacity is rated at 50 watts rms of continuous program material, requiring 10 watts rms minimum drive power. The enclosure uses a ducted-port design and comes finished in natural oak with fabric color options. The system measures 24 in. by 13⅝ in. by 13½ in. (61 × 34.6 × 34.3 cm) and weighs 45 lbs (20.5 kg). Retail price is $198.

CIRCLE NO. 72 ON READER SERVICE CARD

TECHNICS SPEAKER SYSTEM

Technics by Panasonic has introduced a new series of speaker systems that includes bookshelf and floor-standing models. The top-of-the-line Model T-500 is a



four-way, seven-driver system that features a frequency response of 35 to 20,000 Hz ±3 dB and handles between 10 watts minimum and 100 watts maximum program power. Frequencies up to 2000 Hz are covered by two 10-in. (25.4-cm) woofers, a 5-in. (12.7-cm) driver handles the midrange, and a pair of wide-dispersion tweeters take care of the highs. Frequencies above 8000 Hz are reproduced by an angled super tweeter assembly composed of two 2-in. (5.1-cm) transducers with a 180° dispersion angle. Two-position level controls are provided for the midrange and tweeter.

CIRCLE NO. 73 ON READER SERVICE CARD

CONWAY MASTERANGER

The Model 639 Masteranger from Conway is an unusually versatile multimeter that covers 93 ranges and 11 parameters. It features a FET front end for dc volts, 100-

C-MOS

4000AE	$ .55
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4037AE	4.00
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4042AE	2.95
4043AE	2.95
4044AE	2.95
4048AE	1.50
4049AE	1.35
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Waveform Generator Kit

XR205K Only $28.00

Here's a highly versatile lab instrument at a fraction of the cost of conventional unit. Kit includes two XR205 IC's, data & applications, PC board (etched & drilled, ready for assembly) and detailed instructions.

Audio Amps

LM352: 6-15V, 1.15W, 8Ω	1.60
LM354A: 6-27V, 2.80W, 8Ω	2.50
TAA611B12: 6-15V, 1.15W, 8Ω	1.60
TAA621A12: 6-27V, 1.40W, 8Ω	2.00
TBA641B11: 6-18V, 2.20W, 4Ω	3.00
TBA800: 5-30V, 4.70W, 8Ω	2.20
TBA810AS: 4-20V, 2.50W, 4Ω	3.00
TBA820: 3-16V, 0.75W, 4Ω	1.70
TCA830: 5-20V, 2.00W, 4Ω	2.20
TCA940: 6-24V, 6.50W, 8Ω	4.40

DUAL LOW NOISE OP AMP

LM331N:
V_{io} = 6mV
I_{ie} = 1000nA
I_b = 2000nA
Noise = 1.5dB
$2.20

FM Stereo Demodulator

XR1310 $3.90

HYBRID POWER AMPLIFIERS

Power	RMS	IHF	Price
SI-1010Y	10W	25W	$ 6.40
SI-1025E	25W	65W	18.00
SI-1050E	50W	120W	25.40

Voltage Regulators

LM100H	$ 5.50
LM104H	6.50
LM105H	5.10
LM105F	8.50
LM109H	9.50
LM109K	6.30
LM200H	3.80
LM204H	4.70
LM205H	3.00
LM209H	3.50
LM209K	3.70
LM300H	.90
LM300N	1.40
LM304H	1.40
LM305H	1.10
LM305AH	1.40
LM305N	1.20
LM309H	1.75
LM309K	1.95
LM335	2.30
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megohms input impedance, and an exceptionally large mirrored meter movement scale. Although the instrument is designed to be battery operated, an accessory power supply permits line operation. With optional probes, ranges are further extended, and they permit r-f voltage and temperature to be measured. A zero scale permits null detection and galvanometer operation. The tester can also be used for in-circuit resistance checks on semiconductors without damaging them. Accuracy is claimed to range from ±1.5 percent for ac and dc voltages up to 1500 volts to ±5 percent for r-f. R-f, HV, and peak-to-peak probes, external high-current shunt, ac power supply, capacitive HF voltage divider, and temperature probe are available as optional accessories.

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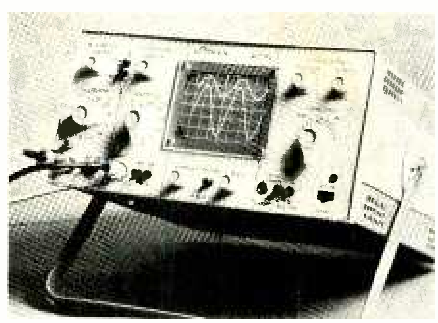
The dual-trace Scopex Model 4D-10 oscilloscope from Jermyn features 10 mV/cm sensitivity and a dc to 10-MHz bandwidth. The all-solid-state circuitry includes MOS devices. Direct calibration is in V/cm and



s/cm. A horizontal control incorporates a ×5 expansion function that holds the trace under observation in the display when activated. Triggering is regulated by a single control that governs both level and polarity. In the absence of a trigger signal, the trace operates in the free-running mode. All other controls are pushbutton and chop modes, external trigger, and ac and dc coupling. Price of the scope is $450.

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The Heathkit Model GD-1024 telephone amplifier kit makes it possible to carry on a conversation without being tied to the phone or to conduct "conference" calls with many individuals participating in one location. The amplifier operates with virtually any type of telephone instrument. To use it, the handset of the telephone instrument is placed on the amplifier's cradle. The incoming signal is then acoustically coupled to the amplifier where it undergoes amplification and is reproduced by the amplifier's speaker. Volume can be adjusted to suit the listening area. Other features include all solid-state circuitry for low no-signal load, 8-ft (2.44-m) speaker cord to reduce feedback, and low-cost battery operation. Mail-order price is $14.95.

CIRCLE NO. 5 ON READER SERVICE CARD

LAFAYETTE DOLBY CASSETTE DECK

Lafayette Radio Electronics' new No. 99-16156W stereo cassette deck features built-in Dolby noise reduction circuitry. A

three-position bias switch is provided for adjusting equalization for standard and high-output ferric-oxide and chromium-dioxide tape formulations. Other features include dual VU meters, slide controls for microphone and line inputs and line outputs, three-digit tape counter with reset button, memory rewind, and total automatic mechanism shutoff. The deck is capable of performing sound-with-sound mixing. Frequency response is 30-12,000 Hz ±3 dB at 20 dB below 0 VU. S/N is rated at 49 dB (59 dB with Dolby circuit switched in). Wow and flutter is 0.12 percent. Retail price is $239.95.

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LECTROTECH COLOR SIGNAL GENERATOR

The compact Model BG-10 color signal generator from Lectrotech, Inc., is small enough to fit into a shirt pocket. Yet, it is a full-function instrument that provides crosshatch, dots, single horizontal/vertical lines, center-screen dot, and three- and 10-bar color test patterns. The 10-oz (283.5-g) instrument employs CMOS LSI chips for all counting functions for minimal drain from inexpensive 9-volt transistor batteries. The generator's r-f output is on TV Channel 4 or 5. Overall size is 5½ in. by 3 in. by 1⅛ in. (14 × 7.6 × 2.9 cm). List price is $89.50.

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CIRCLE NO. 78 ON READER SERVICE CARD

New Literature

ALTEC ENCLOSURE DESIGN MANUAL

"Loudspeaker Enclosures—Their Design and Use" is a well-illustrated 32-page publication for the do-it-yourself audio enthusiast. It is a rich source of information to aid in the design and construction of systems of predictable and satisfactory performance. Topics include the function of the enclosure, loudspeaker design theory, and types of enclosures—from infinite baffles to base reflex enclosures to tuning the bass reflex port. Details on selection of materials are abundant—types of board, acoustic damping material, stiffeners, and grille material. Other useful information includes a chart of common sound pressure levels, frequency ranges of musical instruments, and a glossary of audio terms. Available for $2 from Altec Corp, 1515 S. Manchester, Anaheim, CA 92803.

ELPA TAPE RECORDER TESTING BOOKLET

"Tape Recorder Clinic Procedures" offered by Elpa Marketing is a 21-page booklet that describes the step-by-step methods for conducting a tape -recorder test clinic using the Ferrograph Ferrotester. The booklet lists sources from which test tapes are available and includes a sample Tape Recorder Clinic Test Report sheet. Address: Elpa Marketing Industries, Inc., Thorens & Atlantic Aves., New Hyde Park, NY 11040.

VACTEC PHOTOTRANSISTOR BULLETIN

A bulletin featuring the company's complete line of phototransistors and photo-Darlingtons is available from Vactec. The 8-page No. VTTA-1 bulletin describes the two basic chip sizes and various packaging configurations. In addition to mechanical data, it also covers electro-optical parameters and provides 24 graphs of characteristics and environmental information. Address: Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Hts., MO 63043.

STANCOR TRANSFORMER CATALOG

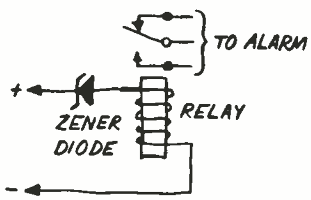
The new Stancor Transformer Catalog (No. 407) available from Essex Controls, lists 1600 standard transformers and gives full technical data, mounting dimensions, and other specifications on the company's complete line of audio and power transformers and chokes and inductors. Address: Essex Int'l., Inc., Controls Div., Stancor Prods., 3501 W. Addison St., Chicago, IL 60618.

Hobby Scene

Voltage Warning Device

Q. ***I would like some type of warning device that will alert me in the event the dc voltage from my bench power supply exceeds some predetermined level. I am looking for something simple that can be put together quickly.***

A. The circuit shown here is a zener-controlled relay. Select the zener

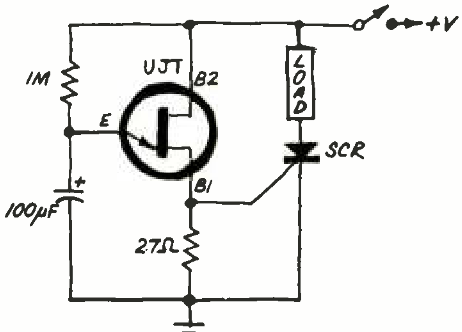


diode for the maximum voltage you want from your power supply. Then use a relay whose coil current is similar to the zener current of the diode. When the voltage is below the zener point, nothing happens. But when the voltage exceeds the zener diode's breakdown voltage, the relay will energize and trigger on the external alarm connected across the relay's contacts. The relay will remain on for all voltages above the zener point, and will immediately drop out at voltages below the zener point.

Alarm Delay Circuit

Q. ***I need a time-delay circuit for my car that will arm an intruder alarm a minute or so after I leave the vehicle. It must work on dc and use a minimum of parts.***

A. The simple timer circuit shown here should suit your needs. When the

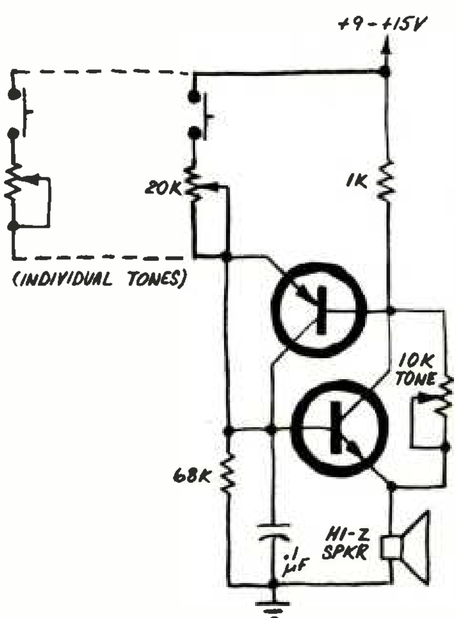


switch is closed and power is applied to the system, the capacitor starts to charge through the 1-megohm resistor. When the voltage at the emitter of the UJT reaches the firing potential of the UJT used, a positive spike will appear at the gate of the SCR, at which point the SCR fires. Because the circuit employs only dc voltages, the SCR will remain conducting until the power switch is opened.

Electronic Door Bell

Q. ***I have repaired my front doorbell so many times that I'm getting fed up with it. Isn't there some simple electronic substitute for the mechanical buzzer?***

A. There are many oscillator circuits that will deliver a pleasant sounding



tone when a switch is closed. The one shown here uses a pair of transistors and as many switches as you wish. Each switch is associated with its own tone-control potentiometer so you can adjust each one differently. If you don't have a high-impedance speaker, try an ordinary transistor output transformer and speaker. Any general-purpose transistors can be used.

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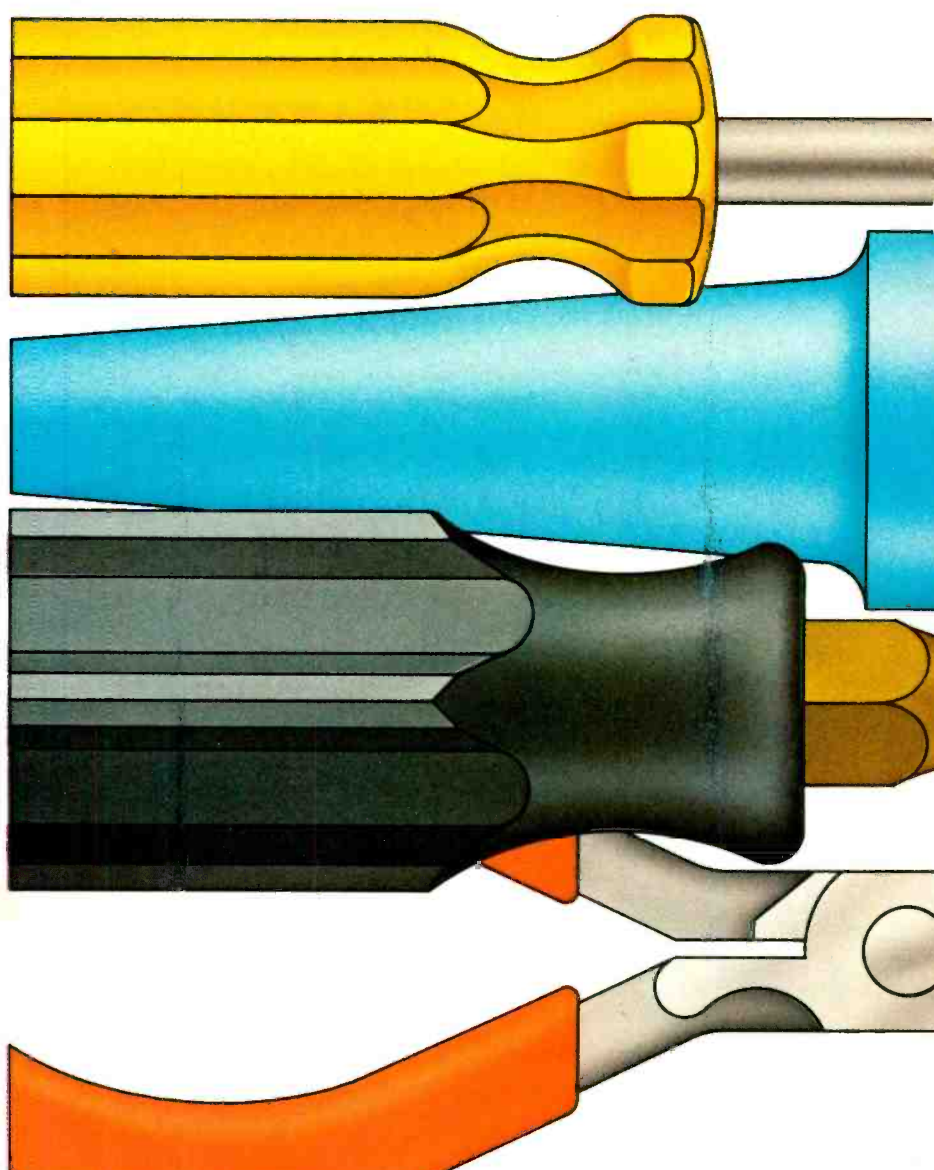

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Most of us at one time or another have put a screwdriver, a pair of pliers or some other basic tool to work. Fixing a bicycle wheel, tightening a window latch, putting up a bookshelf, or what have you.

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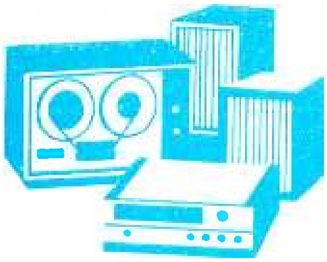

Stereo Scene

By Ralph Hodges

BLAZING SPEAKERS

HAVE you blown out any good loudspeakers lately? The question is not frivolous, because the factory return rates for many high-quality speaker systems, certified safe for *loud* home listening, are apparently on the rise. Manufacturers have even begun encouraging the press to print more stories about loudspeaker failure, presumably in the hope of educating the consumer and forestalling disaster. The trouble is, such stories have a way of growing into "pageants," to use the word of one company spokesman. Although most speaker blow-outs result from a simple causation—an attempt on the speaker's part to absorb more electrical energy than is good for it—it is next to impossible to be both exhaustive and concise about all the ways in which this can happen. There are more, it seems, than meet the eye (figuratively) or the ear (literally).

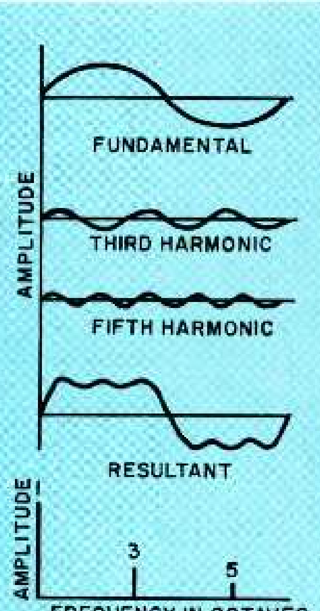

Fig. 1. Sine-wave fundamental with two harmonics results in a waveform approaching a square wave, which ideally would have an infinite series of odd-order harmonids.

Big Amps and Small. One cause of speaker failure is obvious, you'd think: the proliferation of super-power amplifiers. And yes, I'm sure there are and will continue to be those who overpower their systems into occasional attacks of silence, although the likelihood is that this comes about most often through accidental signals—a loose ground connection, a severe switching transient, a dropped tone arm, or even (as used to plague rock groups when setting up) a sudden outbreak of acoustic feedback to the microphones when no one can get to the controls in time to save the situation. Now and again someone does destroy a speaker by playing loud music through it. But since the speaker almost certainly exhibited audible signs of distress before succumbing, he usually can't say that he wasn't warned.

Excessive amplifier power isn't always to blame, however. From the latest reports, one of the serious and growing problems is the blowing out of speakers by *under*-powered amplifiers. This was first brought to my attention in an article by Peter Mitchell, who among other distinctions is the president of the Boston Audio Society. His written explanation was so plausible in a theoretical sense that I was first tempted to think the whole business was just that: a theoretical possibility that doesn't occur much in real life. A few phone calls to manufacturers set me straight. It's not a rarity. Naturally, the resulting customer unhappiness is worse, as a rule, than when one of the super-power aficionados does *his* direful deed. The under-powered customer, you see, thought he was taking pains to stay within the power limitations specified by the speaker manufacturer, and yet he still got into trouble.

This is what evidently takes place. An amplifier called upon to operate at its limits much of the time will clip frequently, squaring off the tops and bottoms of any waveforms it can't pass. According to waveform analysis, these flat tops and bottoms represent odd-order harmonics of a sine-wave fundamental: i.e., spurious high frequencies of significant amplitude (see Figs. 1 and 2). These harmonics—and some of them can be very high in frequency—get routed to the tweeter, which has to cope with them in some way. If clipping is frequent, the tweeter has an almost continuous input of distortion products to handle. In time its relatively fragile voice coil, given no chance to cool off, shorts, or opens up, and that's it.

The putative problem here is that there's more (and more frequent) high-frequency energy in the clipping distortion than in most music, and therefore more energy than the tweeter's designer anticipated its having to take. Of course, you wouldn't expect the distortion to sound too good. But perhaps, if it were high enough in frequency, and if the recording had a typically hard, wiry top end and a continuous background of high-hat cymbal, it wouldn't be especially annoying. In any case, it evidently happens, as the man says, and audiophiles are advised to give a close listen to the high frequencies whenever they run their systems up near maximum levels to make sure things don't sound worse than they should. This is a particularly good idea with pop music having heavily compressed dynamics, since a constant level means constant clipping when the amplifier is operating at its design limits.

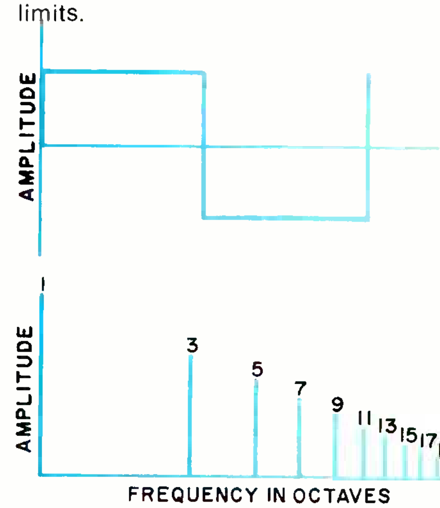

Fig. 2. Part of the spectrum for a perfect square wave.

Bandwidth. If excessive amplifier power is sometimes a problem, excessive amplifier frequency response (bandwidth) can be worse. Now and again a speaker manufacturer will refer nostalgically to the carefree days when amplifiers had output transformers, those wonderful low-pass filters that blocked dc and never let anything much higher in frequency than the ear could hear (and sometimes not even that much) get through to the speakers.

Today it almost seems as if many transistorized amplifiers have power responses from dc to practically infinity. Occasionally a defective unit is found with so much ultrasonic oscillation running around inside that it almost violates the FCC's regulations on illegal r-f radiation. Ultrasonic stuff, particularly when it's a constant, steady-state signal, is extremely hard on tweeters. At some high frequency the mass of any tweeter will prevent it—or at least parts of it—from moving in response to the signal. This means that the entire input is converted into heat; being unable to move, the voice coil doesn't even have the benefit of the circulating currents of cooling air that are set up to some extent during normal operation. Recently, I heard of a case in which an amplifier so afflicted, when hooked up to speakers of extremely high power-handling capability, wiped out all the tweeters before the music even had a chance to start. The preventive measure you should take here—and I've been observing it ever since the big, wide-bandwidth amplifiers started to arrive—is to connect up the oscilloscope before you connect up the speakers. This will enable one to check for ultrasonic output, and also to inspect any low-frequency turn-on pulses. It's best to have the rest of the system hooked up too, since certain *combinations* of components seem occasionally able to set up oscillations that other combinations avoid.

Most woofers today are quite sturdy, physically and electronically. You've got to be in a position to deliver really brutal amounts of power to them before they'll sustain much damage. Still, this is a possibility that must be considered. I have not heard lately of any woofers being hurt by record warps and such perturbations, although the amount of subsonic energy they can generate is sometimes startling. But amplifier misbehavior is another subject.

Any decent amplifier should be stable within the limits of its power-output capabilities, and even beyond them. And yet stories persist about certain designs that are believed to produce horrendous, speaker-destroying pulses of subsonic energy when overdriven, presented with an unfortunate type of speaker load, or otherwise mistreated. True enough, some early amplifiers were subsonically unstable, and probably the remembrance of them feeds the fires of suspicion about modern units. Furthermore, there are undoubtedly numerous cases of amplifier *defects* that have caused strange, unpredictable signals to appear at the outputs. But from what I've been able to learn, no such misbehavior can clearly be attributed to any of the modern, popular models. Speakers are returned to their manufacturers daily with the woofer voice coils torn out by the roots, among other sorts of mayhem. But it's rarely possible to tell whether the blame lies with the amplifier or the user.

Needless to say, an amplifier would have to be a big one to destroy a woofer in such dramatic fashion. Cautionary notes are always in order with high-power amplifiers. Whether he suspects trouble or not, it's probably a good idea for any owner of one to spend an evening listening with the speaker grilles off, just to familiarize himself with the degrees of excursion the woofer cones routinely go through.

Another point worth discussing is the matter of dc voltages (or dc "offsets") that may appear at the output capacitors. In a paper presented several years ago, Kerry Gaulder, who has served in design and engineering capacities with several major companies, treated this subject at length. An amplifier with dc offset will, of course, produce a constant current through the woofer voice coil. But this source of voice-coil heating is rarely of sufficient magnitude to concern anyone. What is problematic, according to Gaulder, is the possibility of serious woofer-cone offset. In other words, the dc current displaces the voice coil in the magnetic gap (either forward or back, depending on polarity), so that it is approaching the limits of its excursion in one direction, even when it's not reproducing any sound and is presumably at rest.

If this theoretical possibility is true, acoustic-suspension woofers might be more susceptible to this effect than others. Whereas other woofers have relatively springy mechanical suspensions that resist offset, acoustic-suspension designs depend largely on the air cushion within their sealed enclosures to restore the voice coil to its proper "rest" position. Slow leaks in the enclosure could cause air pressures within and without the enclosures to be equalized, after a time, for any position the woofer cone cares to assume, and that becomes the new "rest" position. But theory aside, I have no in-practice facts to support such a supposition.

A voice coil offset significantly in the rearward direction is in danger of striking the bottom of the magnetic gap with even moderate low-frequency signals. Aside from the distortion and noise generated, this may do no immediate harm. But in time the edge of the voice-coil former (usually cardboard) may become flattened or turned over so that it can no longer clear the magnetic gap freely. An offset in the forward direction may launch the voice coil out of the gap entirely when a strong signal comes along, and a safe return cannot be guaranteed. Both these mishaps may also occur when a woofer is overdriven by a powerful amplifier, but voice-coil offset greatly increases the probability.

Intrigued by Gaulder's paper, I managed to dig up a direct-coupled amplifier with a relatively high dc offset on one channel. (Gaulder suggests 25 millivolts as the maximum permissible value.) After letting it work over an acoustic-suspension speaker with some pipe-organ music for about an hour, I measured the offset as 0.16 volt across 4 ohms (the dc resistance of the speaker system). Despite this unacceptable voltage I was unable to detect any displacement of the woofer cone after the ordeal, which may prove something or nothing. My inclination is to defer to Gaulder's greater experience in this area, and so I suggest you pay some attention to dc voltages when present. Many amplifier manufacturers now routinely specify permissible offset values, and others would probably give you the figures they allow if requested.

TIM. Some investigations are currently being made into a new type of amplifier distortion—"new" in the sense that it hasn't been seriously studied or quantified up to now. It goes by the name of transient intermodulation distortion or TIM. Its cause appears to be lateness of the negative feedback signal in getting back to its assigned earlier stage of amplification and engaging properly the signal being processed. The effect is too brief to be detected by conventional distortion measuring techniques with steady-state test signals, it is said. But, in effect, what happens is that the initial onset of an abrupt new signal within the amplifier (a transient, in other words) gets through without being correctly processed by negative feedback. This results not only in the feedback's failing to do its distortion-compensating job, but also in possible overload of subsequent amplifier stages.

I don't understand all the aspects of TIM, or even whether it is the problem it's been trumped up to be. But if it is, indications point to the generation of large amounts of high-frequency energy and the existence of frequent overload conditions within the amplifier. (Perhaps I should point out here that some amplifiers are considered to be more subject to TIM than others.) There's really no reason to suspect that it's directly responsible for any kind of speaker failure, since its duration is so brief. However, all the results are not in as yet. Readers interested in pursuing the subject further should consult the papers by Dr. Matti Otala in past issues of the *Journal of the Audio Engineering Society.*

The Stitch in Time. The readiest protection you can give a speaker from excesses of the amplifier is a fuse—preferably a fast-blow instrument fuse of the correct value inserted in series with the speaker. But what is the correct value? The individual drivers in a multi-way speaker system are not likely to have the same power-handling capacity. Nor should they. A few speaker manufacturers are now fusing some of the drivers in their systems individually, which is a great help. But in all frankness I should mention that I hear frequent complaints about blown fuses from people who religiously follow manufacturer's fusing recommendations. Probably the manufacturers, with worst-case situations uppermost in their minds, have tended to be a little conservative. Still, their advice is the best you can get for your particular speakers.

For over a year I have used 1½-amp fuses in my speaker lines and have never (fortunately) lost a speaker. I do lose fuses however—sometimes as many as three sets a month, although I have never blown a fuse on music signals except on one occasion when I was asking for it. This is not, I emphasize, a recommendation, and if you blow out a speaker following my practice you can't sue. But if you have no idea on how to go about fusing your speaker, this may be a good way to start. Pay no attention to the nominal impedance of your speaker system, because it is in most cases "nominal," having little or nothing to do with the impedance over most of its frequency range.

There are on the market a few electronic speaker-protection devices that work very well, if you can accept the way in which they work. Usually they're connected in parallel with the power amplifier, so that they can sense the amplifier output and limit the amplifier input when a certain level is exceeded. Their thresholds are adjustable, with very approximate calibrations provided. But what they do, in fact, is convert your 100-watt amplifier into a 50-watt amplifier, or a 10- or 1-watt amplifier. This is because they act so fast—faster than a fuse, which will usually pass high-level signals of a brief, transient nature. (The comparative slowness of fuses is a controversial issue when speaker safety is considered, but it definitely makes more sense musically.)

More sophisticated devices are also available. Several years ago SAE began equipping some *speakers* with active, transistorized "black boxes" that electronically disconnected the amplifier when hostile signals appeared. (This made sense because the tweeters in these systems were electrostatics and had to be plugged into a wall socket anyway.)

An elaborate protective mechanism operating at the amplifier is the "Dynaguard" circuit built into the Dynaco Stereo 400 power amp. It is adjustable to limit the steady-state output of the amplifier from anything from 20 to 200 watts per channel in five steps. But its attack time is slow enough to permit short, "safe" signal peaks to get through. Perhaps more important, its action, which affects only the signal peaks, does not lop off the tops and bottoms of waveforms but merely rounds them, curtailing the generation of high-frequency distortion products (see Fig. 3). The circuit, by the way, is rarely obvious to the ear in operation.

Finally, relays that disconnect the speakers in the presence of dc or strong subsonic signals are being incorporated in some amplifiers now. Basically they function to prevent "thumps" and other noises from the speakers when the equipment is turned on, but they will also serve in a protective capacity, blocking other hazardous signals that might be generated any time during operation.

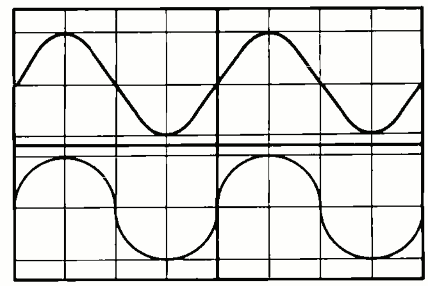

Fig. 3. Lower waveform shows effect of Dynaguard action on sine wave and lack of high-order harmonics.

Small Comforts. Articles on speaker failure always risk stirring up a lot of anxiety that is frequently unjustified. Speaker systems are rugged devices, and have to be. It is understood that they'll be used hard by anyone enthusiastic about music listening, and thus they're generally designed to hold together under any drive conditions capable of producing an undistorted, listenable output. If in spite of this they begin failing chronically, then manufacturers have to begin considering every possibility, since consumers are frequently not competent to diagnose what went wrong, and sometimes their complaint reports are not honest for fear of falling outside warranty terms. This is why the list of *potential* hazards has grown so long.

This discussion concentrates on the relatively obscure hazards—the ones that can't readily be heard or otherwise detected, and which therefore can't be prevented with a little bit of common sense. It's possible, even likely, that not one in a thousand of you will ever encounter a single one of them. But if someone, somewhere is helped by the above to discover a problem in time, or tipped off as to the cause of a mishap that has already occurred, then perhaps the telling of this grisly tale is worthwhile. ◈

news HIGHLIGHTS

Computer Pen

A new type of data input device that utilizes a special ballpoint pen and recognition circuitry that immediately translates hand-printed data into computer language has been announced by the Stanford Research Institute. The Alphabec-70 system, developed at SRI, is being introduced by Xebec Systems, a California company in computer peripheral equipment. Using the Alphabec-70, it will be possible to instantaneously enter hand-printed data into a processing system. In remote locations, the data can be recorded for later transmission to the data processing center. . . . The first Alphabec-70 system will have a 16-character capability (10 digits and six control characters). A company spokesman estimates that the system will replace many of the 700,000 or so keyboard entry devices now in use. The pen system eliminates keyboard-based procedures in data entry—and with them, document re-transcription, a source of human error, delay, and expense. It is expected to expedite field data collection in such applications as utility meter reading and sales order entry by routemen. The system is also applicable to banking, telephone-call logging, inventory control, and industrial data collection.

Purchase Only 53% of TV Receiver Cost

According to a study released by MIT, the purchase price of a color TV receiver accounts for only 53 percent of the total amount spent on the receiver during its useful life. Servicing accounts for 35 percent, and electrical power required for the receiver's operation claims 12 percent over the estimated 10-year lifetime of the receiver. "This means that the owner of a $400 color TV [receiver] can expect to spend another $400 during its usable life," according to the study. These figures do not take into consideration future inflation; so, the total cost of ownership could go progressively higher. . . .The purpose of the study was to "examine alternatives for increasing appliance service productivity in the context of what the consumer pays for a product during its usable life." The study notes a substantial increase in product reliability as evidenced by a 50-percent decline in the need for color receiver servicing during the last eight years. However, service costs have increased so greatly as to offset what would have been a sharply reduced life-cycle cost.

UA Releases 10-in. 78-rpm Disc

In keeping with the present popularity of "nostalgia," United Artists has released a 78-rpm disc containing two selections from its *Golden Age of the Hollywood Musical* album. "We're in the Money" and "Lullaby of Broadway" (both from Busby Berkeley film musicals of the 1930's) were pressed on a 10-in. mold and fitted with record labels that mirror the typographic and design style of the period. This necessitated the retooling of UA's pressing plant since 10-in., 78-rpm discs had not been pressed there in more than a decade and there was only one 10-in. die to be found in all of Los Angeles. . . .The reported vinyl shortage did not hamper progress on the project because 78-rpm discs are composed mainly of shellac and filler materials. ◈

Why a Sylvania home training program may be

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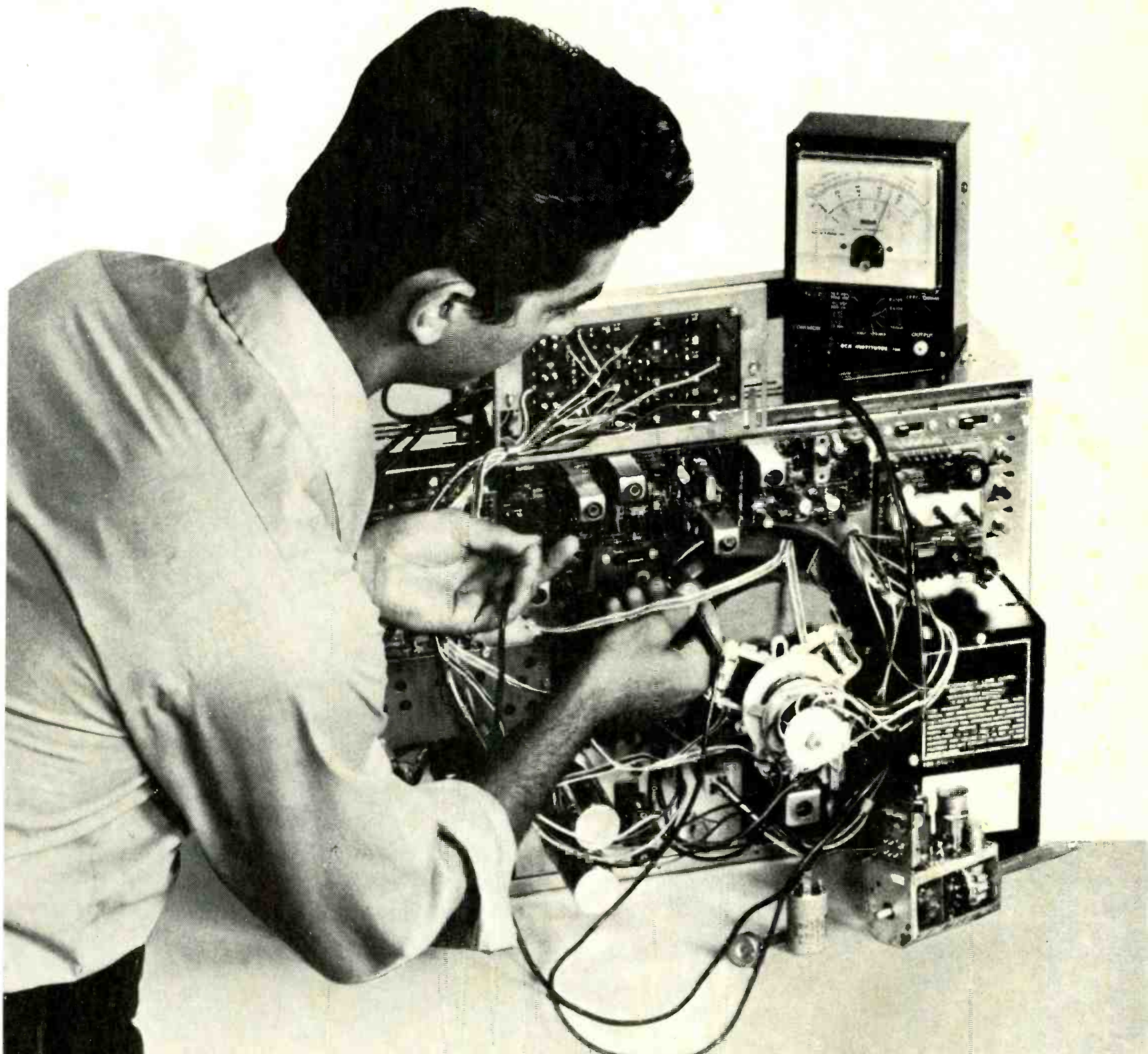

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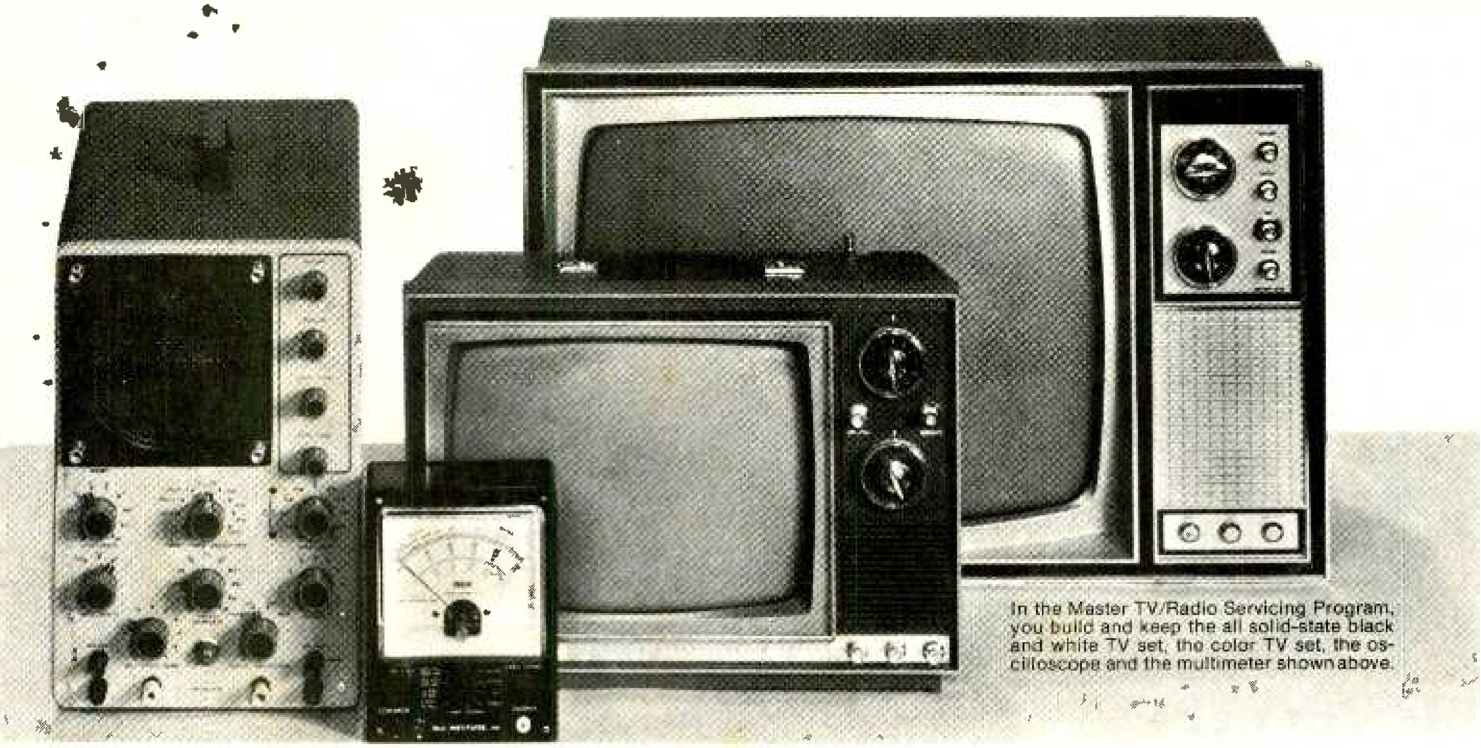
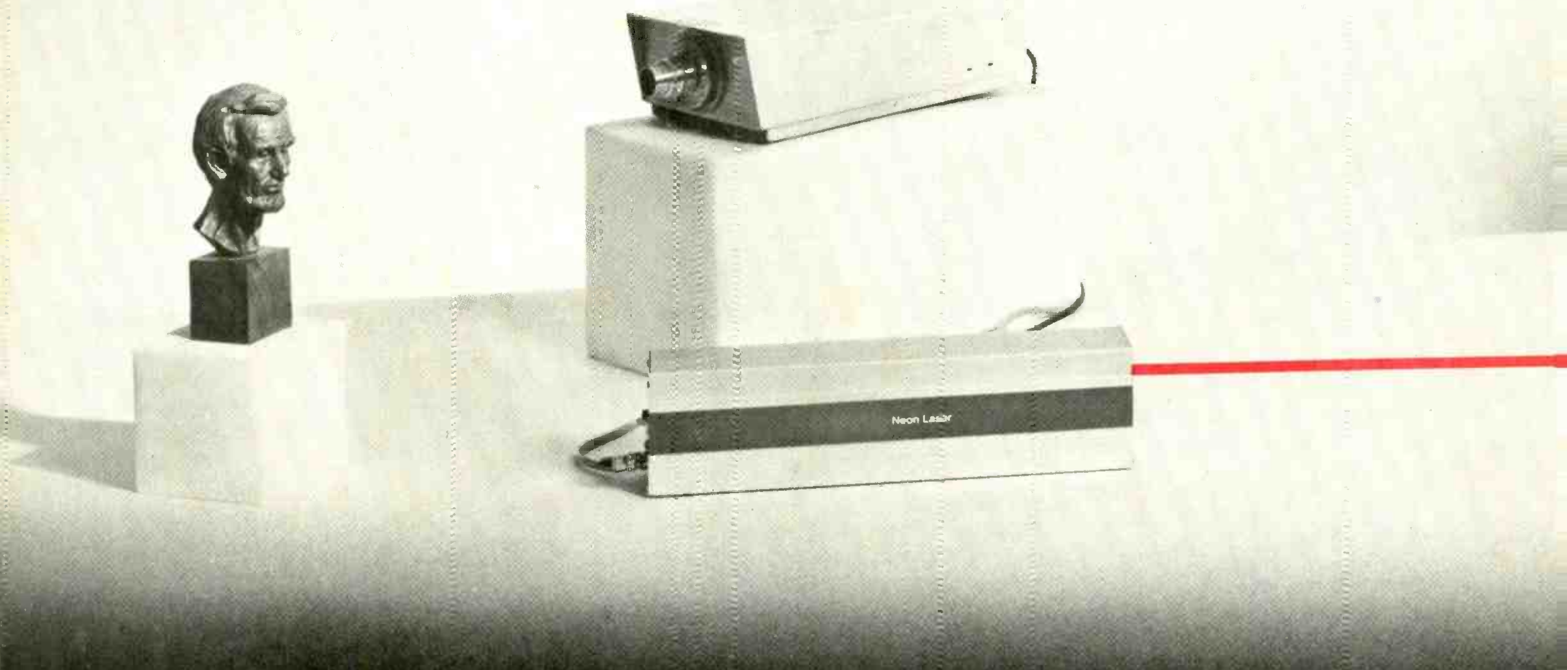


In the Master TV/Radio Servicing Program, you build and keep the all solid-state black and white TV set, the color TV set, the oscilloscope and the multimeter shown above.

Popular Electronics

NOVEMBER 1974



EVER since we published construction plans for the world's first hobbyist experimenter's laser in December of 1969, POPULAR ELECTRONICS has kept readers abreast of laser developments. For example, in January 1970, we gave details on how to use the laser for making three-dimensional holograms. Then, in May 1970, we published plans for assembling a laser voice communicator (which, incidentally, was featured for several weeks in the Smithsonian Institution).

Now, we have another breakthrough—plans for building the world's first experimenter's laser video (TV) system for a moderate $150. (The TV camera and receiver are extra items.)

THE POPULAR ELECTRONICS laser TV system gives you an advance look at a communication system of the future. There are two key devices in the system. One is the composite laser tube/video modulator "transmitter" that works in conjunction with a low-cost TV camera. The other is the detector/r-f modulator "receiver" that feeds an ordinary TV receiver. (See box on Class-1 requirements.)

The helium-neon laser tube used in the system employs the latest aluminum cathode design. The tube is used in conjunction with solid-state modulation and detection circuits.

With the laser TV system, you can expect a range up to 50 ft without special optics. For extended range, you can use a telescope and/or a converging lens. More about range later in the article.

Overall System. The block diagram of the overall laser TV system is shown in Fig. 1. The video (or audio, not both simultaneously) output signal from the TV camera is typically on the order of 1 volt peak-to-peak. This signal is fed to the laser modulator, which is designed to provide a gain of 2 mA/volt. Hence, the 1-volt p-p video output signal from the camera, after passing through the modulator, is converted to a 2-mA p-p signal that current-drives the laser tube.

The gain of the laser tube is about 0.1 mW/mA, while the laser detector has a gain of 1.25 mA/mW. The r-f oscillator in the detector is tunable over a 60- to 72-MHz range to permit the system to operate on TV channel 3 or channel 4, whichever is not in use in your area.

The output of the r-f modulator is an amplitude-modulated (AM) signal that is adjustable from 0 to 5 mV rms. This signal can be fed into an ordinary TV receiver through its vhf antenna terminals by means of 300-ohm twin-lead cable.

Laser/Modulator Circuit. In the laser/modulator power supply, shown schematically in Fig. 2, *T1*, *C5-C8*, and *D9-D14* are arranged in a voltage doubler configuration that serves as the main high-voltage supply. This supply delivers about 1700 volts to the laser tube. Diodes *D1-D8* and capacitors *C1-C4* form two more voltage doublers that are "stacked" on top of the main high-voltage supply for ionizing the gas in the laser tube. As soon as ionization is complete, current starts to flow through the laser tube. However, the values of *C1-C4* are too low to support the 5-mA tube current. So, the starting voltage collapses and only the main sustaining voltage remains.

Transformer *T2* and its associated rectifiers (*D15-D18*) and filter capacitors (*C9-C14*) make up

ANOTHER

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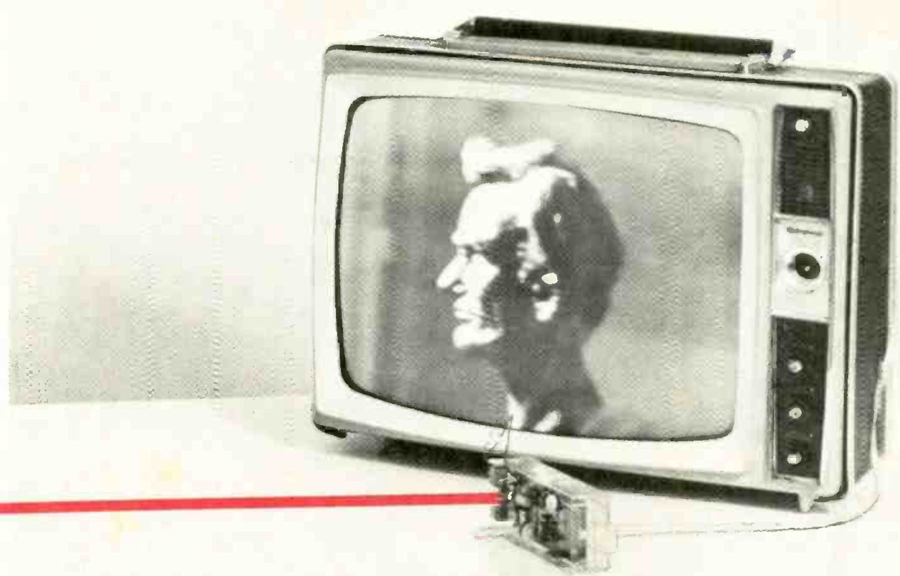


BUILD A

Laser TV System

BY GIANCARLO PUNIS
AND JOSEPH O'DONNELL

Now you can transmit and receive black and white TV pictures over a substantial distance with a license-free laser beam video link

the low-voltage supply that delivers the +20- and −20-volt lines for the low-voltage portions of the modulator.

High-impedance amplifier *Q1* preamplifies low-level microphone signals of about 0.1 volt p-p to the 1-volt p-p level required to drive *Q2* to obtain the full 15-percent modulation. (See Fig. 3 for the modulator schematic diagram.) The high-level 1-volt p-p video input at *J2* and the collector of *Q1* are both ac-coupled to the base of *Q2* and, therefore, to each other. Hence, when using either of the *J1* (audio) or *J2* (video) inputs, it will be necessary to disconnect the unused input. This is important to prevent interference between the two signals as well as to prevent loading *Q1*'s collector.

Transistors *Q2-Q4* each provide some gain at the lower frequencies and one stage each of high-frequency boost, starting at about 250 kHz and ending at about 1 MHz. The boost characteristics are achieved by the RC networks used as emitter loads for the transistors. In addition, there are two broadly tuned traps consisting of *C24/L1/R16* and *C25/L2/R22* centered at 160 kHz and 330 kHz.

The frequency response of the laser tube only is shown in Fig. 4A. The strong peak at 170 kHz would cause severe overshoots and ringing on the fast edges of TV sync pulses or any sharp white-to-black transitions. In addition, the −3-dB bandwidth is only 250 kHz wide, with correspondingly poor picture resolution. So, to smooth out the frequency response and to extend it beyond 500 kHz, the modulator combines boost circuitry and traps to yield the compensating response shown in Fig. 4B. Combining the A and B response curves, the overall laser tube/modulator system has the frequency response characteristic shown in Fig. 4C, which is adequate for most applications.

The frequency-compensated signal is coupled to *Q5*, which acts as a current source for both the dc bias (trimmed to 5 mA by *R33*) and the ac signal currents for the laser tube. Except for a small amount of current through *R27* and *R28*, the current sourced by *Q5* also flows through *Q6* and *Q7*, ballast resistor *R26*, and the laser tube. Each rated at 300 volts, *Q6* and *Q7* are cascaded to act as one transistor with a 600-volt break-down rating.

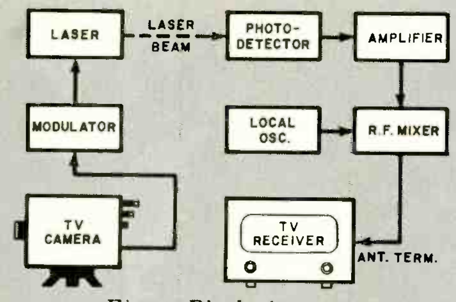


Fig. 1. Block shows the basic arrangement of the laser video link.

Detector Circuit. Phototransistor *Q1* in Fig. 5 is connected as a photodiode, providing a 40-µA p-p signal, depending on the intensity of the laser beam. This results in a 200-mV video signal at the base of *Q2*.

Transistor *Q3* is a Hartley oscillator stage, whose operating frequency is determined by *L1* (printed on the circuit board as part of the conductor pattern), *C7*, and *C8*. Capacitor *C7* is adjustable to permit the circuit to operate on either the TV channel 3 or channel 4 frequency.

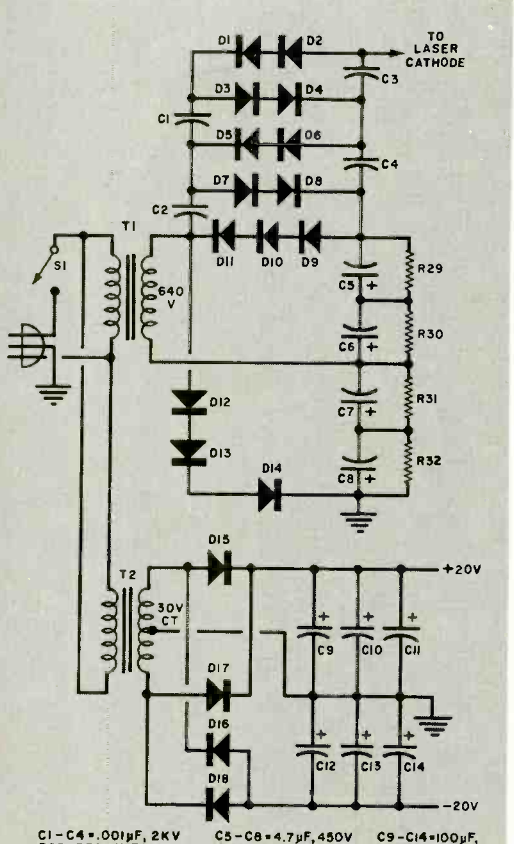


Fig. 2. Half of high-voltage supply "drops out" when laser starts. Low-voltage supply is more conventional.

The vhf carrier is ac-coupled to mixer diode *D1* through *C6*, resulting in a video-modulated vhf signal of about 5 mV rms with r-f level control set for maximum output. The r-f signal goes directly to the vhf antenna input terminals through 300-ohm twin-lead antenna cable. Note, however, that when the output of the detector circuit is connected to the TV receiver's antenna terminals, the regular TV antenna cable must be removed.

Zener diode *D2* provides a 3.6-volt dc bias supply for *Q2* and serves as the dc supply regulator for the *Q3* oscillator circuit.

Assembling the System. Except for the laser tube, jacks *J1* and *J2*, transformer *T1*, and power switch *S1*, all components shown in Figs. 2 and 3 mount on a single printed circuit board. The actual-size etching and drilling guide and components placement diagram for the laser/modulator system are shown in Fig. 6. To permit the etching and drilling guide to be reproduced without reduction, it is shown in two parts. The left edge of the lower portion butts against the right edge of the upper portion, with the ground bus (heavy black areas) aligned.

When wiring the circuit board according to the diagram in Fig. 6, take care to properly orient the components. Pay particular attention to electrolytic capacitor polarities, transistor basing, and *T2*'s lead routing. Bear in mind that *T2* and the laser tube mount on the *foil* side of the board. Also, all resistors (except *R26* and *R29-R32*) and *L1* and *L2* mount on-end. The rest of the components mount on the board in the conventional manner. Note that only *C5-C8* are axial-lead capacitors, designed to mount flat on the board, while all other electrolytic capacitors are upright types.

Potentially lethal voltages are developed in the laser circuit. Consequently, it is imperative that the entire assembly be mounted inside a rugged — preferably metal — enclosure. Use only nylon screws when mounting anything inside the enclosure to prevent access to any high-voltage points in the circuit once the system is assembled. Select an enclosure that is large enough to accommodate the laser tube, pc board assembly, and transformer *T1*. Mount closed-circuit miniature phone jack *J1*, BNC jack *J2*, and power switch *S1* on the rear wall of the enclosure. In another hole on this wall should be the three-conductor power cord, held in place with a plastic strain relief. (Or line the hole with a rubber grommet, pass the line cord through, and tie a knot in the cord.)

The exit hole for the laser beam must be drilled through the enclosure's front wall, directly in line with the beam's travel. Use a ¼-in. (6.35-mm) diameter drill bit. If possible, mount a tubular flange with a ferrous outer ring as a bezel over the hole. The ferrous ring is a convenience feature that supports the various lenses that come mounted in circular magnets in the event you decide to perform other experiments using the laser.

Solder push-on connectors to one end of a red and a black 3-in. (7.72-cm) or less pieces of 5-kV test-lead cable. Shrink tubing over the connections. Then solder the free end of the red cable to point A and the black cable to point C on the foil side of the pc board.

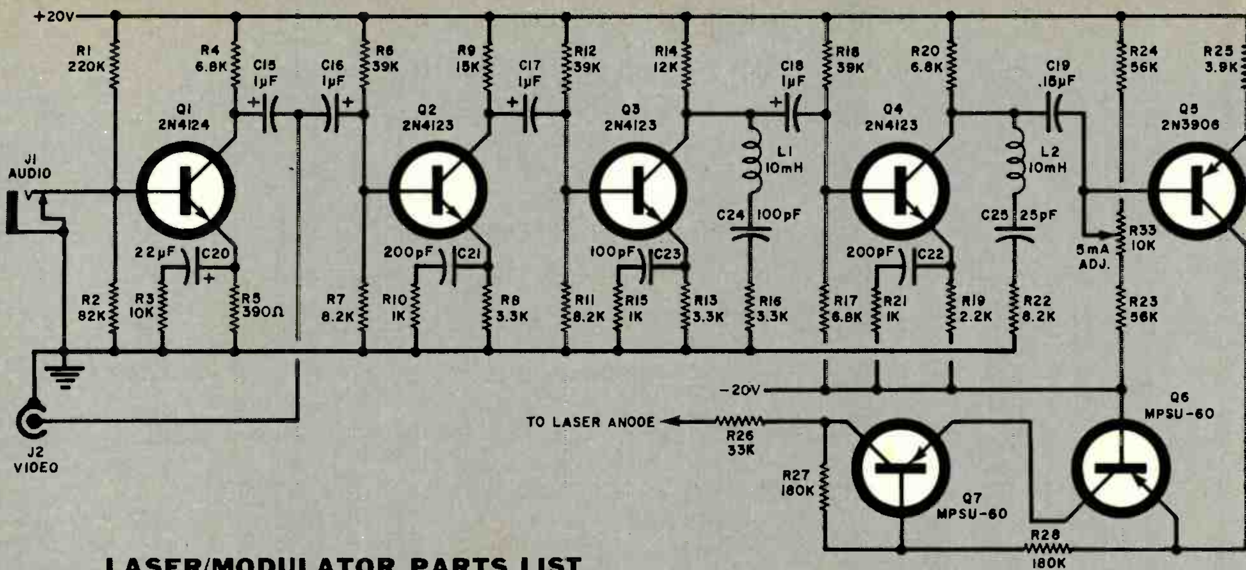
Drill ⅛-in. (3.27-mm) holes through the donuts marked X on the pc board. Mount a tube mounting clamp at each hole location. Orient the laser tube so that its pin-connector end is toward *T2* and the anode pin on the narrow neck points toward the red cable. Set the tube down in the clamps and anchor it in place with rubber hold downs. Caution: Do not mount or handle the laser tube by its narrow necks.

Slip the red cable connector onto the anode pin of the laser tube. Then locate the cathode pin on the opposite side of the tube from the anode pin, and slip the black cable's connector onto it.

Solder 10-in. (25.4-cm) long pieces of hookup wire, preferably color coded for easy identification, to the remaining holes in the pc board. Slip 1-in. (2.54-cm) long pieces of heat-shrinkable tubing over the wires connected to the *T1* secondary points. Then mount the board in the enclosure with nylon screws and insulated spacers.

Mount *T1* on the floor of the enclosure. Then locate the leads with the shrinkable tubing on them. Route these leads along the component side of the board, and connect and solder them to *T1*'s secondary winding, trimming as necessary. Shrink the tubing tightly over the connections. Complete the wiring, referring to Figs. 2, 3, and 6.

Assembling the detector is a very simple, straightforward process. Except for phototransistor *Q1* (Fig. 5), output connector, and power switch,



LASER/MODULATOR PARTS LIST

C1-C4—0.001-μF, 2-kV ceramic disc capacitor
C5-C8—4.7-μF, 450-volt axial-lead electrolytic capacitor
C9-C14—100-μF, 25-volt upright electrolytic capacitor
C15-C18—1-μF, 50-volt upright electrolytic capacitor
C19—0.15-μF disc capacitor
C20—22-μF, 10-volt upright electrolytic capacitor
C21, C22—200-pF, 100-volt disc capacitor
C23, C24—100-pF, 100-volt disc capacitor
C25—25-pF, 100-volt disc capacitor
D1-D18—1000-PIV, 1-A rectifier (1N4007 or similar)
J1—Miniature shorting-type phone jack
J2—BNC jack
L1, L2—10-mH choke
Q1—2N4124 transistor
Q2-Q4—2N4123 transistor
Q5—2N3906 transistor
Q6, Q7—MPSU-60 transistor (Motorola)
R1—220,000-ohm
R2—82,000-ohm
R3—10,000-ohm
R4, R17, R20—6800-ohm
R5—390-ohm
R6, R12, R18—39,000-ohm
R7, R11, R22—8200-ohm
R8, R13, R16—3300-ohm
R9—15,000-ohm
R10, R15, R21—1000-ohm
R14—12,000-ohm
R19—2200-ohm
R23, R24—56,000-ohm
R25—3900-ohm
R27, R28—180,000-ohm
R29-R32—1-megohm

All resistors ½-watt, 10%

R26—33,000-ohm, 2-watt resistor
R33—10,000-ohm upright pc trimmer potentiometer
S1—Spst switch
T1—640-volt, 25-mA power transformer
T2—Dual 15-volt, 25-mA power transformer
Misc.—Metal enclosure; printed circuit board; laser tube No. PE719; mounting clamps for laser tube mounting; 5-kV test-lead cable; three-conductor line cord; pin connectors (2) for anode and cathode cables; heat-shrinkable tubing; rubber grommet or plastic cable clamp/strain relief; nylon mounting hardware and insulated spacers; 1000—ohm, ½-watt resistor (for transmitter checkout); hookup wire; solder; etc.
Note: The following items are available from Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, NJ 08030: No. PE719 laser tube ($96); No. PE640 640-volt power transformer ($7); No. PE101 etched and drilled transmitter pc board ($6); No. PE201 etched and drilled detector/ modulator pc board ($3); No. PE669 complete kit of transmitter parts, including laser tube, pc board, transformers, metal housing, etc. ($124.50); No. PE301 complete kit of detector/ modulator parts, including housing ($25); No. PE500 complete kits of transmitter and detector/modulator parts (not including TV camera) ($148). All prices postpaid. Canadian readers can order from Merlan Scienfific, Ltd., 825 Lake Shore Rd., Port Credit, Ontario, Canada.

Fig. 3. Frequency response of video amplifier is "tailored" to improve laser tube's response. Resulting video modulates laser beam.

CAUTION
Never look into the laser beam proper or directly into its reflection.

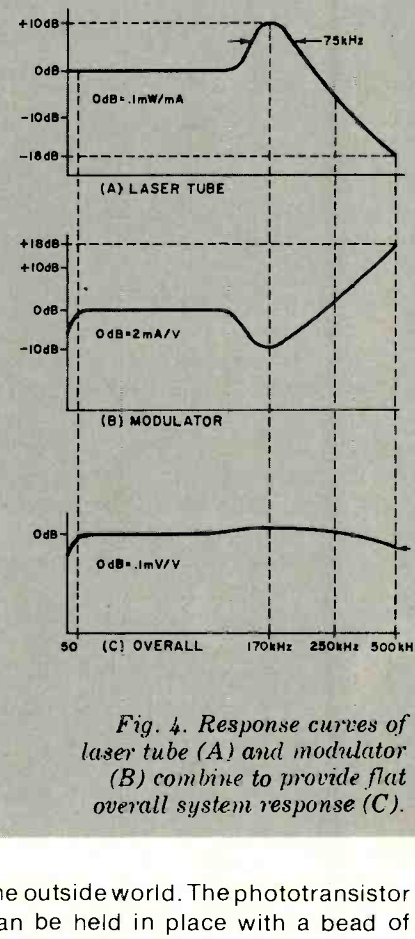
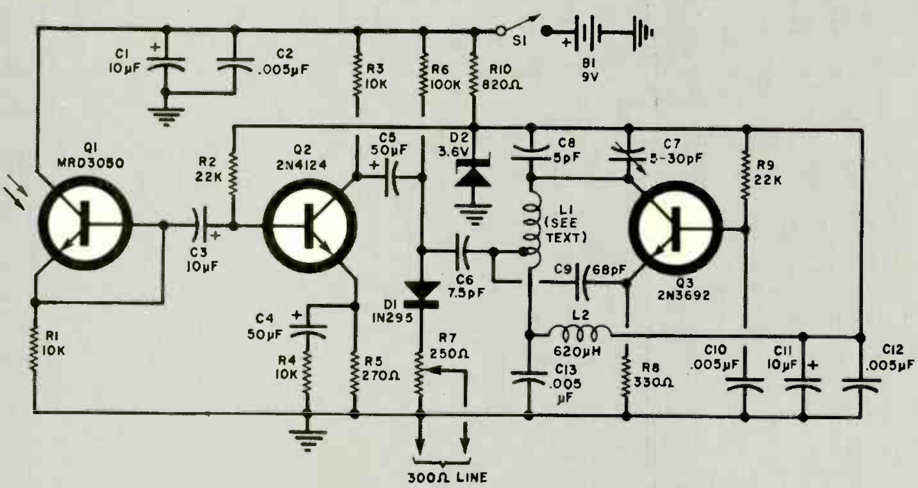


Fig. 4. Response curves of laser tube (A) and modulator (B) combine to provide flat overall system response (C).

everything mounts on a small pc board. The actual-size etching and drilling guide and components placement diagram for the detector are shown in Fig. 7. Note that coil *L1* is part of the printed wiring.

The on-board components mount in the conventional manner. Just be sure to properly polarize the electrolytic capacitors and transistors. Transistor *Q1* mounts in a hole on one wall of the metal enclosure, its lens "looking" to the outside world. The phototransistor can be held in place with a bead of clear epoxy or plastic glue.

Install the battery on the floor of the enclosure, under the pc board assembly, in a battery clip. And power switch



DETECTOR/R-F MODULATOR PARTS LIST

B1—9-volt battery
C1, C3, C11—10-µF, 10-volt electrolytic capacitor
C2, C10, C12, C13—0.005-µF disc capacitor
C4, C5—50-µF, 10-volt electrolytic capacitor
C6—7.5-pF silver-mica capacitor
C7—5-30-pF miniature ceramic trimmer capacitor
C8—5-pF silver-mica capacitor
C9—68-pF silver-mica capacitor
D1—1N295 diode
D2—3.6-volt zener diode (1N747 or similar)
L1—R-f coil (etched on pc board)
L2—620-µH choke
Q1—MRD-3050 phototransistor (Motorola)
Q2—2N4124 transistor
Q3—2N3692 transistor
R1, R3, R4—10,000-ohm
R2, R9—22,000-ohm
R5—270-ohm
R6—100,000-ohm
R8—330-ohm
R10—820-ohm
(All resistors ½-watt, 10%)
R7—250-ohm vertical pc-type trimmer potentiometer
S1—Spst switch (optional)
Misc.—Chassis box; printed-circuit board; battery clip; output cable connector (optional); 300-ohm twin-lead cable; hookup wire; spacers (2); hardware; etc.
(Note: For kit information, see Laser/Modulator Parts List.)

Fig. 5. Photodetector modulates oscillator on channel 3 or 4 to generate signal that goes via 300-ohm line to television receiver's antenna terminals.

S1 and the output cable connector mount on the rear wall of the enclosure.

System Checkout. Before applying any power to the laser/modulator, double check all components for proper installation. Check particularly for cold solder joints and solder bridges. If everything checks out okay, disconnect the primary of *T1*, *Q6*, and the laser tube from the circuit.

Temporarily connect a 1000-ohm, ½-watt resistor between *Q5*'s collector and the −20-volt bus. Turn on the power. Now, using a high-impedance multimeter (a 20,000-ohms/volt VOM will do), check to verify that +20 and −20 volts dc is available from the power supply. Because of the temporary collector load, *Q5*'s collector will be at about −15 volts. Adjust *R33* for a reading of exactly 5 volts across the temporarily installed 1000-ohm resistor. Alternatively, insert a milliammeter in series with the resistor and adjust *R33* for a reading of exactly 5 mA. Turn off the power and disconnect the line cord from the ac receptacle.

Wire *T1* into the circuit. Before applying power, remember that potentially lethal voltages are present at the negative end of *C5* and the cathode (black) lead. Keep the latter well away from ground and the low-voltage circuits. The starting voltage at the top of *C3* can be checked, but the meter has a loading effect on the circuit. So, do not expect to read more than about 3.5 kV when making measurements on the 5-kV range with a 20,000-ohms/volt meter. Turn off the power, and remove the plug from the ac receptacle. After power is removed, *do not touch any part of the circuit for about five minutes* until the high-voltage charges on the capacitors dissipate.

When the circuit is safe to handle again, remove the temporary resistor from *Q5*'s collector circuit and reconnect *Q6*. Connect the anode lead to the tube and a 0-10-mA meter in series with the tube's cathode pin and the cathode (black) lead. Make certain that the milliammeter and its leads are well separated from ground and the low-voltage circuits.

Plug in the line cord and turn on the power. After a short lag, the gas in the laser tube should ionize and glow

CLASS-1 TV DEVICES

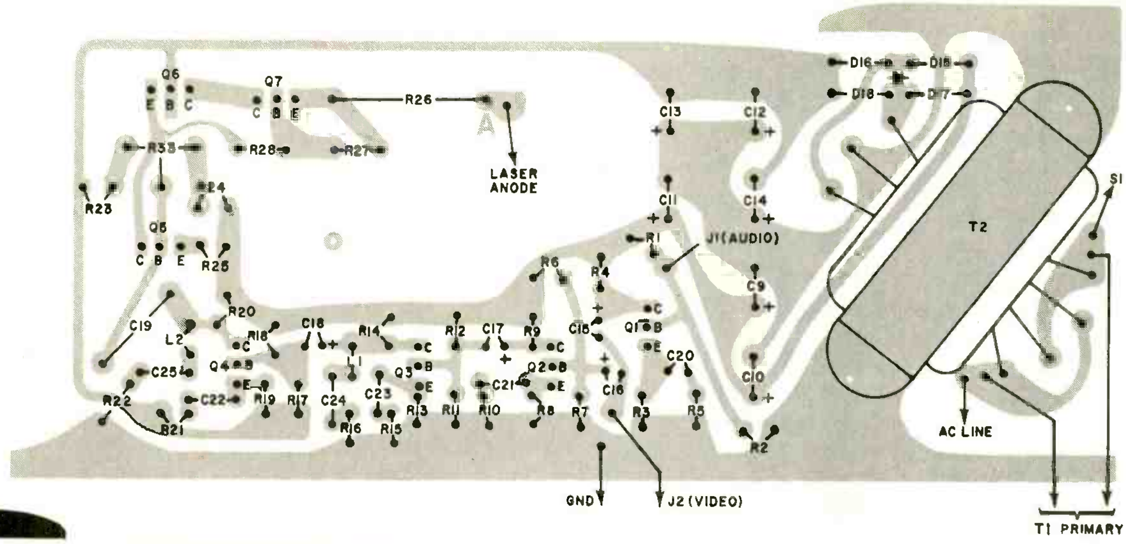
There has recently been a proliferation of electronic games designed to be used with a conventional TV receiver. These so-called "Class-1" devices apply a modulated low-level r-f carrier signal directly to the receiver's antenna terminals. Because they might produce interference, the FCC has placed restrictions on the manufacture, sale, and use of Class-1 devices, of which the laser detector/r-f modulator in this article is one.

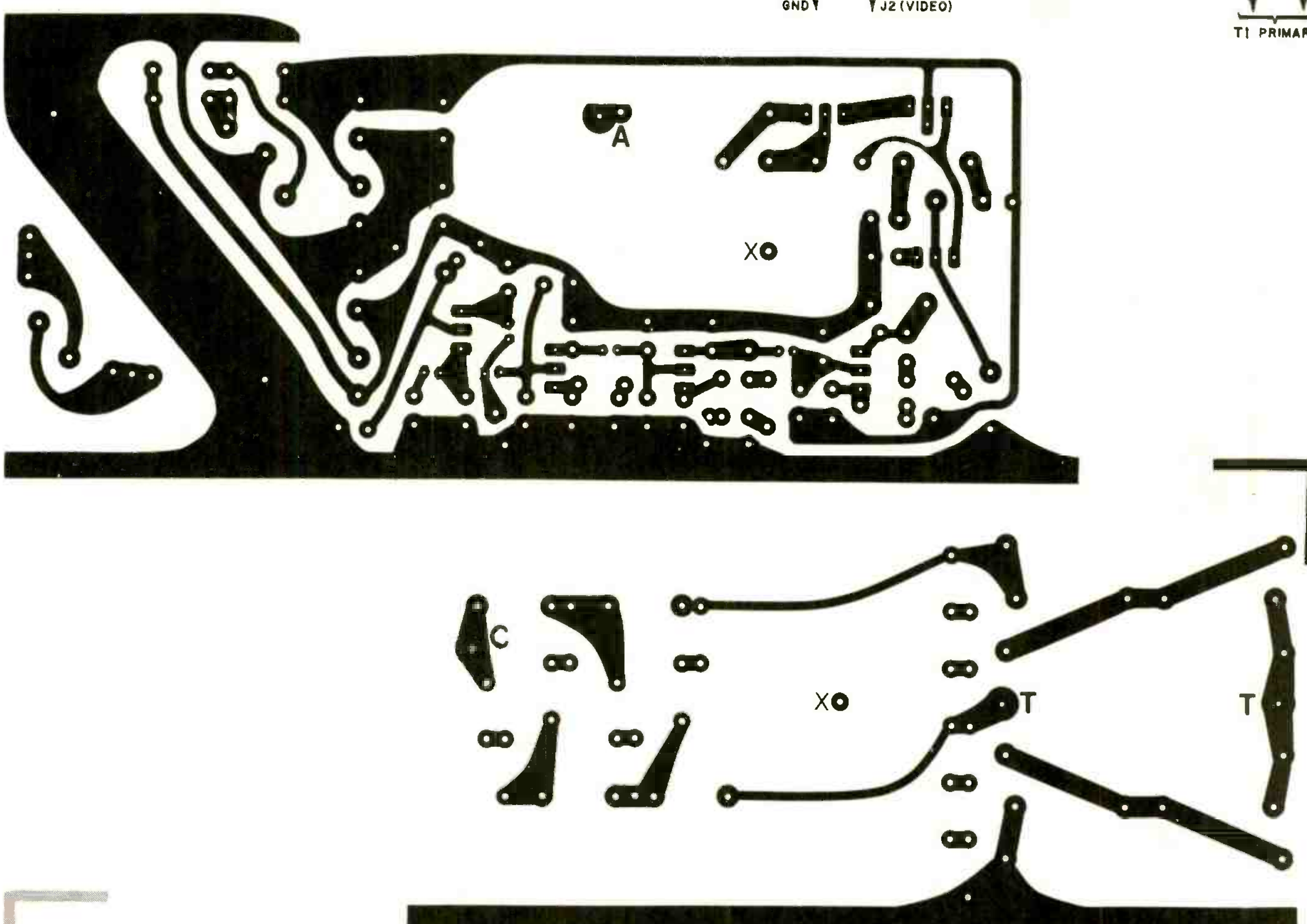
Class-1 TV device requirements are:

1. They must operate on a channel allocated for vhf or uhf broadcast TV.
2. They must transmit the r-f signal to the TV receiver by wire or cable.
3. The r-f output level must be less than 6 mV rms into a 300-ohm output.
4. A transfer switch with 60 dB of isolation must be used for switching the antenna terminals between the TV antenna and the Class-1 device.
5. The peak envelope power of any spurious emission at frequencies 3 MHz or more from either edge of the standard TV channel being used must be 30 dB or more below the peak envelope power of the in-band signal.
6. Radiated EMI from the device must be less than 15 µV/meter at 2.6 ft. (0.79 m) from the detector modulator.
7. The device must be formally type approved by the FCC. In the case of a kit-form Class-1 device, only the manufacturer of the kit is required to obtain type approval.

The above list of regulations applies only to the detector/r-f modulator portion of the laser TV system. No specific restrictions are placed on the laser transmitter. With regard to the isolating switch, the laser TV system has none, but removing the TV receiver's antenna will satisfy the requirement. (Bear in mind that it is illegal to have the detector's output cable and the TV antenna hooked up to the TV receiver at the same time.)

The detector/r-f modulator has been type approved by the FCC. However, it is strongly urged that if you build your own instead of buying the kit from Metrologic, you faithfully follow the pc layout and assembly instructions presented in this article.





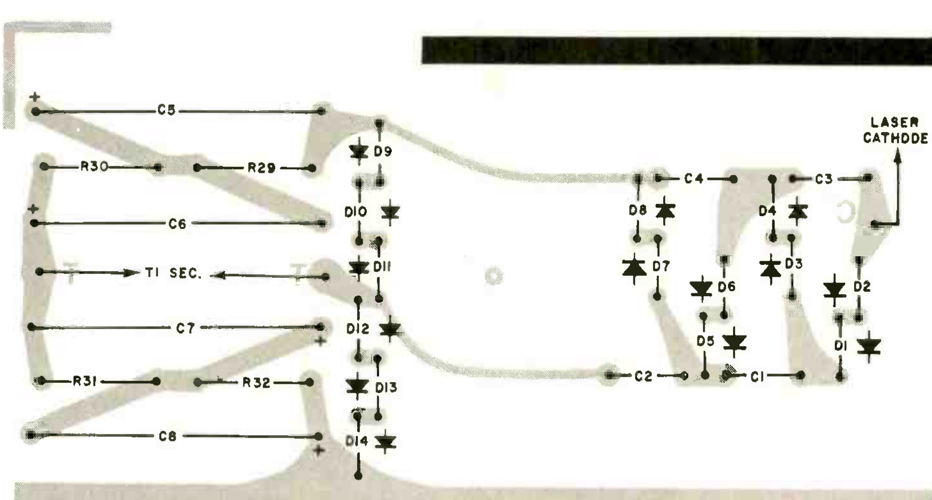


Fig. 6. Actual-size etching and drilling guide for power supply and modulator is shown in two parts (center). The component-placement guides are shown above (top) and below (left) their respective etching guides.

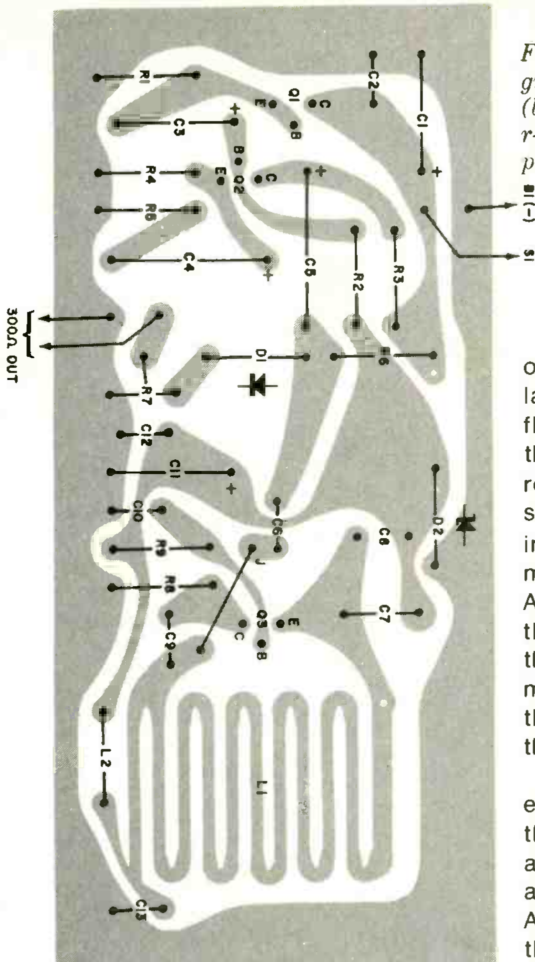


Fig. 7. Actual-size etching guide for detector/modulator (bottom) features printed r-f oscillator coil. Component-placement guide is at left.

orange. (Caution: Never look into the laser beam or directly into the reflected beam.) The milliammeter at this time should indicate a 5-mA current flow. If necessary, touch up the setting of *R33* to obtain a 5-mA reading. Then turn off the power and remove the line cord from the ac line. Again, do not touch the assembly until the high-voltage charges have bled off the electrolytic capacitors. Then remove the milliammeter and reconnect the black cable to the cathode pin on the laser tube.

Reapply power to the system. Now, exercising extreme caution, measure the collector-emitter voltages on *Q6* and *Q7*. Both transistors should have approximately the same voltage drop. An unequal drop indicates that something is wrong, meaning that you will have to troubleshoot the circuit.

Since the detector employs only a low-voltage battery supply, it is safer to work on than the laser/modulator. The emitter of *Q1* should be at 0 volt with no light entering the phototransistor through its lens. With the laser beam impinging on the sensitive surface of *Q1*, the emitter will be at about 2 volts. (Note: A 20,000-ohms/volt meter will load this down to about 1.6 volts.)

Connect the r-f output line to the antenna terminals of a conventional TV receiver, after first removing the TV antenna cable. Adjust *C7* for operation on either channel 3 or channel 4, whichever is not in use in your area. Now, modulating the laser with a TV camera, an oscilloscope should reveal the composite video signal at the emitter of *Q1* at a level of about 220 mV p-p. (Almost any type of oscilloscope can be used here.) The waveform at the cathode of *D1* will be the video-modulated r-f signal operating at about a 5-mV p-p level. It may be necessary to adjust *R6* to obtain the correct signal level.

If you do not have access to a scope, set potentiometer *R7* to the middle of its range. Set the TV receiver to the unused channel 3 or 4. Very slowly adjust *C7* for the clearest, sharpest picture on the screen of the TV receiver, while video-modulating the laser. Then adjust pot *R7*, and the TV receiver's brightness and contrast controls for the best picture quality. Also, if the TV camera does not have a wide agc light range, its lens should be adjusted as well for best picture.

Setup and Use. In setting up the laser TV system, bear in mind that adequate light must be on the subject to be televised. Avoid subjects (pictures) that have very bright and very dark contrasts close to each other. Focus the camera carefully, and select the best lens opening for the subject to be televised.

When mounting the laser/modulator and receiver, use solid supports to obviate vibrations and shifts that might cause the laser beam to miss the phototransistor in the detector and result in transmission drop-outs.

The uncollimated beam from the laser has a 1-milliradian divergence characteristic that causes the spot to spread to about 1 meter in diameter at 1000 meters. So, if you plan on long-distance transmission of the laser beam, you must use collimation to keep the beam as narrow as possible. The collimator is simply a telescope used backwards, with the laser beam fed into the eye-piece and exiting through the large end of the telescope. You can use either a reflecting or a refracting telescope.

The greater the power of the telescope used, the greater the range you can expect and the tighter the laser beam. However, with increasing range, optical alignment becomes a critical factor. So use a solid mount for the telescope.

Range can also be increased with a light-gathering lens at the detector end. This is comparable to using a high-gain antenna for radio waves. You can buy lightweight plastic Fresnel lenses measuring up to 11 in. (27.94 cm) square at very reasonable prices. Such lenses make excellent light gatherers. They must be focused on the sensitive surface of the phototransistor in the detector.

Long-distance alignment can be simplified in several ways. Use a rigid mounting system and some form of vernier positioner (for fine adjustment) for aiming the laser. Perform the alighment at night when the bright red laser beam is easier to see. For night setups, a bicycle safety reflector will prove useful in following the beam to the detector target. ◈

HOW THE NEW FTC HI-FI RULES AFFECT YOU!

BY LEONARD FELDMAN

EFFECTIVE November 4, 1974, new rules governing the disclosure of the output power of audio amplifiers and receivers go into effect. The new rules were promulgated by the Federal Trade Commission after several years of study. They follow a long period of advertising abuse by some segments of the electronic home-entertainment industry.

Well-known "low-fi" products claiming output power capabilities of as much as 100 watts "instantaneous peak power (IPP)" have been measured by reputable laboratories and have consistently produced no more than a few watts of output power per channel at best. Meaningless terms such as IPP, peak power, peak music power, and dynamic music power—if they are to be used in the future at all—will have to be given less typographical prominence in all advertising media.

Fig. 1. When all three amplifiers are measured the same way, "lower spec" amplifier A turns out to be the highest powered unit among the three.

Still Room for Ambiguities. Will the FTC rule end the confusion about power ratings in the minds of all consumers? Unfortunately, the answer is a resounding "No!" While the rule goes a long way towards enforcing honesty in audio equipment advertising, adherence to its requirements will not, in and of itself, make everyone's power specifications read like everyone else's. The consumer can still be thoroughly confused when reading specification sheets describing competitive amplifiers and receivers. Here is why confusion can arise:

Henceforth, manufacturers will be required to state continuous output power delivered by their products into a specified impedance, at a specified harmonic distortion, and over a specified power bandwidth. The power specified in this manner must be delivered by the amplifier or receiver when all its channels are driven simultaneously. For a stereo receiver or amplifier, this means that both channels must be going at the same time, while in a 4-channel setup, all four amplifier channels must deliver the rated power to all four loads at the same time.

Let us consider the following sets of competitive specifications, all of which would comply with the "letter of the law":

AMPLIFIER A: 50 W/channel output power into 8 ohms at 0.3 percent harmonic distortion from 20 Hz to 20,000 Hz.

AMPLIFIER B: 60 W/channel into 4 ohms at 0.5 percent harmonic distortion from 60 Hz to 400 Hz.

AMPLIFIER C: 65 W/channel into 4 ohms at 1.0 percent harmonic distortion from 60 Hz to 4000 Hz.

Reading these three descriptions, the uninitiated consumer might conclude that Amplifier C has the greatest output power capability. He would be wrong. Nearly all solid-state amplifiers produce their greatest output power levels when connected to 4-ohm speaker loads. Connected to more popular 8-ohm speaker system, Amplifier C might well produce less than 50 watts.

Notice, too, that the rated distortion of Amplifier C is 1.0 percent. How much less power would it be able to deliver—even into its 4-ohm specified loads—if distortion were limited to 0.5 or 0.3 percent, as in the cases of Amplifiers B and A? For that matter, we have no way of knowing from the figures given whether or not the distortion level will ever go down to the 0.3-percent level. Perhaps 1.0 percent is the best Amplifier C can do even at low output power levels.

The new FTC rule merely requires that the amplifier be able to deliver its specified power at a harmonic distortion that does not exceed the published figure. Doing some hypothetical calculation based on typical measurements observed with "real" amplifiers, Fig. 1 plots power versus distortion curves for our three fictitious amplifiers. The parameters were changed so that each amplifier was operated into 8-ohm loads, and all three were permitted to reach a distortion level of 1.0 percent, so that the comparison would be fair.

As you can see, the results are just the reverse of what is implied by an uninformed reading of the specification listings given earlier. Amplifier A produced 68 watts under these conditions, Amplifier B produced 50 watts, while the amplifier with the highest "published" power rating—Amplifier C—produced only 48 watts.

In the example, we were dealing with only a single middle-of-the-band audio frequency. However, the FTC rule requires that the power bandwidth over which the rated power can be developed at rated (or less) distortion must be specified as well. Referring again to the "published" specifications given above, each manufacturer has complied with this requirement. The maker of Amplifier C has honestly stated that his amplifier will deliver 65 watts at any frequency between 400 and 3000 Hz. But most of us know that the real test of a good amplifier is its ability to deliver maximum power at the frequency extremes. This is particularly important at low bass frequencies where musical energy demands are usually greatest. The thundering beat of a bass drum calls for more power than is required when reproducing the sounds of instruments and voices in the midrange register.

Reading the specifications of Amplifier C, we have no way of knowing how much power the product can deliver (if any) at 40 Hz and lower frequencies, or at what level of distortion. The curves in Fig. 2 show what the distortion of each of our fictitious amplifiers might look like even if we were to use 50 watts/channel as a reference power level. Again, contrary to first impressions, Amplifier A comes up the winner as far as distortion is concerned.

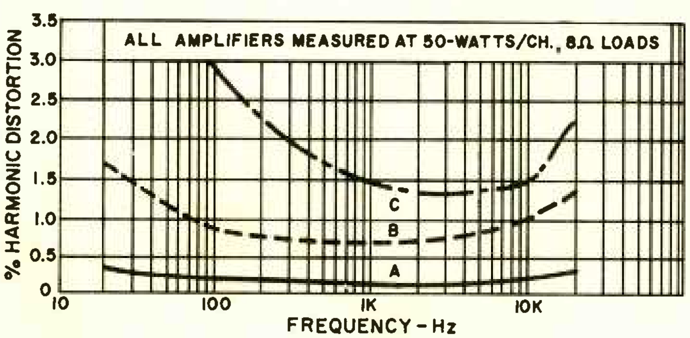


Fig. 2. Again, amplifier A proves to be much lower in distortion than amplifiers B and C, in spite of its more conservative published spec.

Buyer Beware—Still. So, while the new FTC rule may alleviate some of the worst abuses of the industry, it does not entirely correct them. In fact, many consumers may falsely conclude that, with the FTC in the act, all product specification sheets are going to read the same—that they will be comparing apples to apples.

You can be sure that manufacturers who have reason to "gimmick" their specifications will still find enough ways to obscure the facts. The component manufacturers who have always sought to tell the true performance story of their products did not have to wait for federal legislation to adhere to truth-in-advertising doctrines. They have been specifying continuous power over the entire audio range, from 20 Hz to 20,000 Hz, at low distortion levels and with all impedances defined since long before the FTC ever heard about watts, decibels, and THD.

The Institute of High Fidelity (IHF) hopes, before long, to publish more complete measurement standards for amplifiers. If adhered to, the new standards would help to eliminate the many ambiguities that still remain prevalent, even in the face of the new FTC requirements. ◈

What's New in Color TV Receivers for 1975

BY ART MARGOLIS

MANUFACTURERS of TV receivers unveiled many innovations in their 1975 models. For example, major moves have been made toward providing brighter, sharper color pictures; tuning is getting closer to the one-button concept; power-supply designs indicate a trend toward compensation for anticipated voltage fluctuations caused by power shortages; and serviceability has been improved with modular designs and other niceties. Here are details on what each major color TV manufacturer is offering in their 1975 all-solid-state chassis lines.

Admiral. The latest in Admiral's line of color TV receivers is the Touch Tuning M25 chassis. Its main feature is a tuning system programmed with toothed cards. Six printed-circuit cards are used to program uhf channel number readouts. A seventh is for programming the remote control channel selector to go to the next higher active channel, bypassing all inactive channels. The cards are prepared for individual viewing situations with the aid of longnose pliers.

Once the cards are prepared, they are inserted into connectors in the tuner. This permits the viewer to select a channel from the keyboard or the remote control transmitter. The channel appears on the screen, and a separate readout indicator displays the channel number.

In the companion M30 chassis, a special transformer provides voltage regulation. The transformer is wound in such a way that its secondary produces fixed-amplitude square waves, with the transformer operated at saturation. The transformer is tuned to resonate at the line frequency with the aid of a capacitor.

When the input voltage is nominally 117 volts ac, the clipped output voltage is a fixed-amplitude square wave. Should the line voltage vary (within ±10 percent of nominal), any change produces an inverse change in the clipping action. The peak-to-peak square wave applied to the rectifiers then remains at about the same amplitude.

While the Admiral chassis does not tilt (it is horizontal), it does slide out for easy servicing.

General Electric. MB, MC, QB, and YA are the designations given by General Electric to its 1975 chassis. The stress is on reliability, quality, and performance. For 1975, GE is introducing the third generation of its Quadline color picture tube. In-line gun arrangements are featured in the Porta-Color 13- and 15-in. picture tubes. The tubes have short necks and 90° deflection angles. The necks are up to 2 in. shorter than comparable tubes with triangular gun arrangements, which eliminates the bump on the rear of the cabinet. Also, the in-line arrangement reduces from 12 to 8 the number of convergence adjustments that must be made.

In addition to manual and preset color, tint, and brightness controls, there is a Custom Picture Control. Coupled to the contrast, color, and brightness circuits, it adjusts all three parameters simultaneously to maintain a balanced ratio.

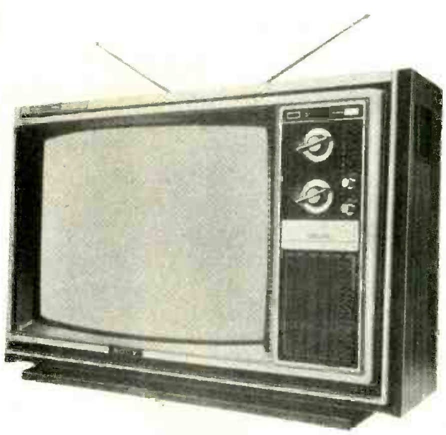
A One-Touch Color system incorporates tint lock, avc, and the preset color tint and brightness. The tint lock widens the demodulation angle by cross-coupling B−Y and G−Y at the output of the chroma demodulator IC.

The seven models in the YA series have chassis that accommodate about 90 percent of all the electrical components. Off-the-module components are overrated to increase reliability. More than 95 percent of component failures are claimed to be repairable by module replacement, and all IC's plug in for easier servicing. To further endear itself to the serviceman, GE has a lot of the service information pasted on the inside of the cabinet and printed on the circuit boards. This includes layouts, catalog part numbers, detailed adjustment instructions, and even the schematic.

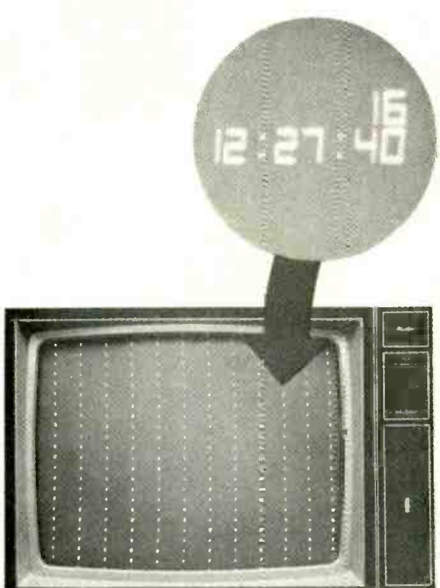
In the larger chassis (like the MC series), a high-voltage quadrupler that develops 30 kV is used instead of the usual tripler. Regulation of the 30 kV is achieved with a three-winding saturable reactor circuit.

Heath Company. The latest kit marvel from Heath is its Model GR-2000 digital color TV receiver. The tuner uses a varactor diode that eliminates

Philco Model C1922FRW



Sony Model KV-1920



Heath Model GR-2000 with on-screen channel and optional time

moving parts. An up/down counter digital programming board has provisions for presetting up to 16 channels in the vhf and/or uhf bands in any sequence, even repeating channels if desired. The tuning, activated by a front-panel control or a button on the optional remote control transmitter, sweeps up or down through the 16 preset channels.

The number of the channel selected can be placed anywhere on the screen for a preset time of up to 90 seconds, or it can be set permanently on. The brightness of the display is adjustable. And the numerals can be instantly recalled at any time by tapping the volume-down button on either the receiver or the remote control transmitter. The numeral readout is digitally generated by a special character generator IC on one of the receiver's modular boards.

As icing on the readout cake, Heath offers an optional 12/24-hour digital clock accessory that fits into the receiver. It generates the time in an hours/minutes/seconds format. The time is displayed on the screen, simultaneously with the channel number.

The receiver's plug-in IC amplifier/fixed-tuned LC filter i-f strip eliminates the need for periodic sweep alignment. Serviceability is aided by such niceties as modular circuit boards, built-in dot generator, slide-out service drawer, and an illustrated troubleshooting guide in one of the manuals. A test meter also comes as a basic part of the receiver kit.

Magnavox. The latest color TV receiving system from Magnavox is called the STAR (for Silent Tuning At Random), which refers to its varactor-diode tuner. The viewer can call up any vhf or uhf channel by punching buttons on a compact remote control transmitter. The receiver instantly and silently tunes to the selected channel. The tuning system is not sequential; it goes directly to the selected channel without having to clunk through all the in-between channels. A special circuit in the receiver displays the channel's number in bright numerals on the upper left of the screen for about 3 seconds.

Depressing the M (for mute) button on the remote control transmitter turns off the sound for 1 minute without disturbing the picture.

The latest in negative guard band color picture tubes is used in the 13- through 19-in. STAR chassis. These tubes have a black matrix surrounding color *stripes* (not dots). The electron guns are arranged in-line (rather than in the usual triad configuration), reducing the number of convergence adjustments that must be made. Finally, the picture tubes' necks are shorter than usual. (The 25-in negative guard band picture tube requires a wide deflection angle that precludes an in-line gun arrangement.)

The power supply employs a new voltage-regulating transformer in a special circuit whose output maintains relatively constant voltage during minor changes (a few percent) in

THE NEW 1975 ALL-SOLID-STATE TV RECEIVER CHASSIS

Company	Chassis	Tuner	I-F Strip	Channel Indicator	Muting
Admiral	M25	Varactor	Transistor	Selector dial	Yes
General Electric	MC	Varactor	IC	Digital (on control panel)	No
Heath	GR-2000	Varactor	IC/Fixed-tuned LC	On screen (Time optional)	Yes
Magnavox	Star	Varactor	MOSFET	On screen	Yes
Panasonic	Quatrecolor	Detent	IC	Selector dial	No
Philco	Boss	Varactor	—	Selector dial	No
Quasar	QS-3000	Detent vhf Varactor uhf	IC	Selector dial	Yes
RCA	XL-100	Detent	—	Digital (on control panel)	No
Sony	KV series	Detent	—	Selector dial	—
Sylvania	GT-matic II	Varactor	Transistor	Digital	Yes
Zenith	Chroma-color II	Varactor	Transistor	Selector dial	Yes

Note: All chassis are solid-state and modular and have negative guard band picture tubes, aft, audio output jacks, automatic degaussing, and 300/75-ohm antenna inputs. All have electronic remote control except Zenith (see text).

NEGATIVE vs POSITIVE GUARD BAND COLOR PICTURE TUBES

In a standard color picture tube, 85 percent of the screen is covered with phosphor dots, with nothing between them but an aluminized coating that covers the entire face of the tube. The dots are 17 mils across, while the electron beams are 13 mils in diameter. This means that the beams cannot completely excite the dots. In fact, only about half the area of each dot ever becomes excited. The part not excited is required as a "guard band" to prevent degradation of color purity resulting from the beams overlapping onto adjacent dots.

Ambient light is reflected from the aluminized coating and tends to wash out the picture. So, a tinted face glass must be used to reduce glare. Tinting works, but it also kills about half of the light from the dots. This system is referred to as "positive guard band" because the unexcited portions of the dots protect purity.

In the "negative guard band" system, as employed in many of the latest color picture tubes, the dots are surrounded by an opaque black material. The electron beams are allowed to become thicker than the diameter of the dots by increasing the sizes of the holes in the shadow mask. The entire dot can now be excited, while the black material serves as the guard band. Tinting is not required because ambient light is not reflected by the black surround. Hence, a full 85 percent of the light produced by the excited dots comes through the picture tube's face plate.

the line voltage. The high-impedance MOSFET i-f module gives the i-f strip improved sensitivity and reduces any tendency to overload.

The STAR's modular design caters to serviceability. And the vertical chassis has 20° and 45° tilt positions.

Panasonic. Quatrecolor is the name of Panasonic's line. The new Quintrix color picture tube employs a negative guard band black matrix with an additional pre-focus lens to make the picture sharper and brighter by bunching the electrons into a narrower beam. The featured Q-lock one-button color system is like the preset control systems, except that the color and tint are adjusted on a continuous basis, while brightness and contrast adjustments are made via preset potentiometers with a fixed control.

The electronic remote control system permits up/down channel selection. A "vacation" switch on most models defeats the Speed-O-Vision instant-on feature. The vhf dipole antenna is detachable to permit it to be moved around the room to where it exhibits the best signal-gathering performance. This is a convenience if the TV receiver is set into a permanent location.

Philco. The solid-state modular color TV receiver chassis from Philco is called BOSS (for Best Of the Solid States). It features a 37- to 47-percent power saving over last year's hybrid receiver models, tilt-out front controls, and a built in Invis-A-Tenna with its own reception selector.

Voltage regulation and suppression are accomplished by Picture Guard and Surge Guard in the Philco receivers. In the event of a sudden voltage spike, due to lightning or voltage transients on the power line, a filter capacitor absorbs the temporary overload.

Hands-off tuning is accomplished by a network of automatic circuits. The viewer engages the Philco Master Control button and selects a channel. When the Philcomatic COLOR Control light comes on, he pulls his hand away and the receiver automatically tunes itself.

Quick On replaces Instant Play to eliminate power wastage by not having the picture tube's filaments continuously powered. The audio still comes on immediately, while the picture follows a few seconds later.

Quasar. The "works in a drawer" people are featuring more serviceability, line-voltage regulation, a picture system responsive to ambient lighting, and more simplified and reliable modules. A special twist-lock connector is used to simplify removal of the power supply by the serviceman. This connector eliminates multiple wire leads that could have been potential trouble spots.

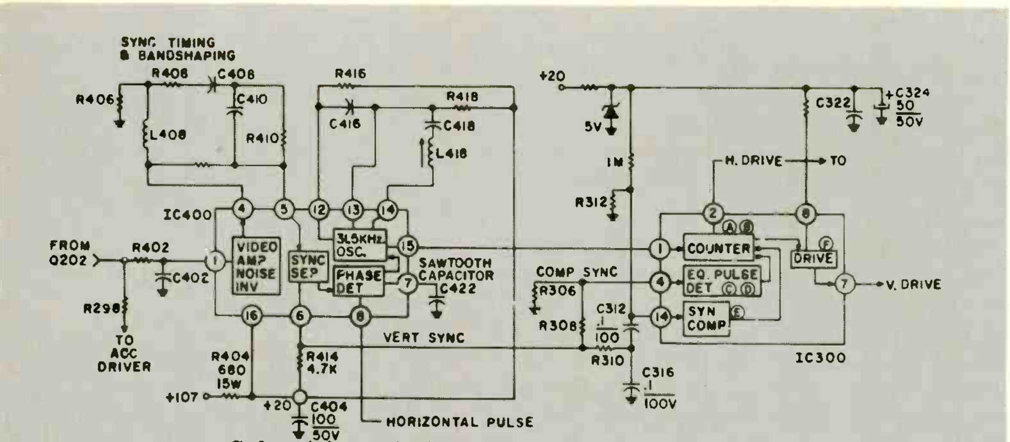
Quasar's Insta-Matic system employs a patented demodulator IC that works in conjunction with a light-dependent resistor. The LDR is mounted behind a honeycomb lens located on the front panel of the receiver where it measures the ambient light and allows more or less current to flow into the video-chroma circuit. This automatically raises or lowers the brightness, contrast, and color to suit the light level in the viewing location.

On the remote control panel is a

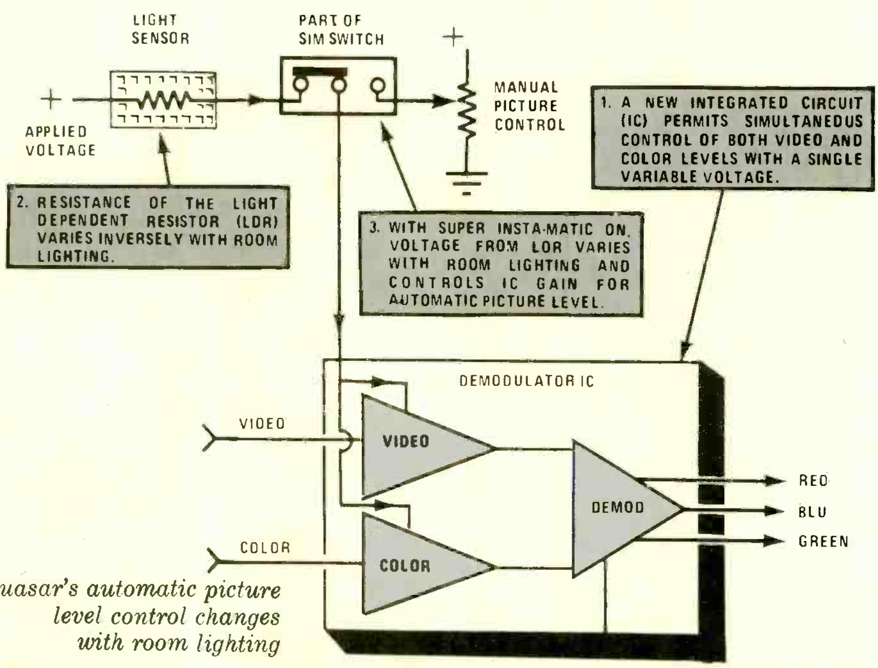
Choosing channels on Zenith's color TV receiver line is accomplished with non-detented slide control

RCA XL-100 Model GT-795

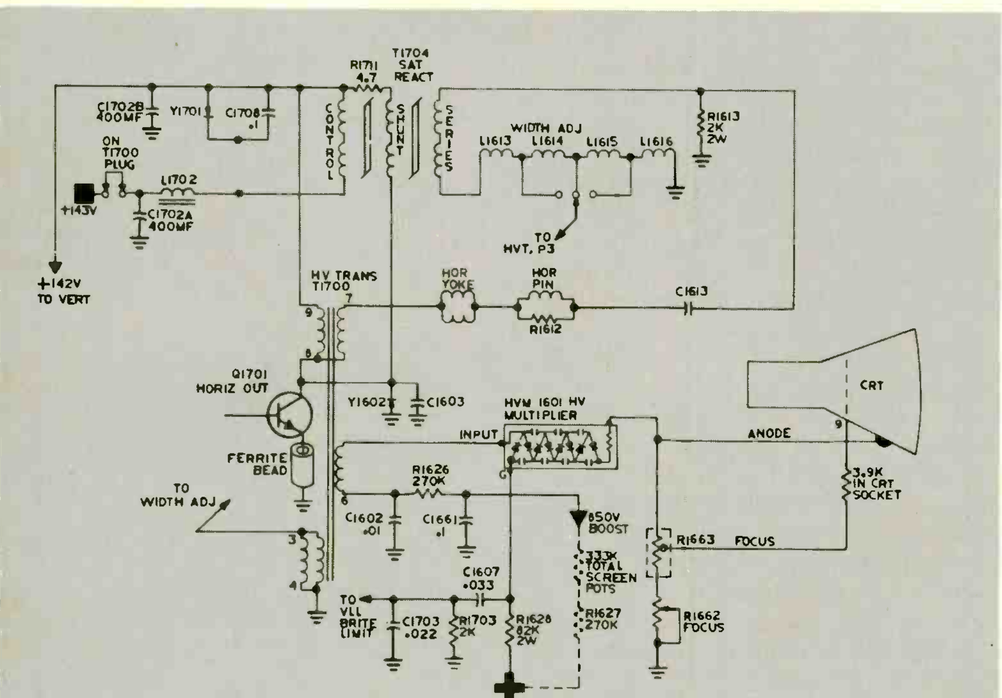
Panasonic Model CT-934



Sylvania's vertical ramp and drive waveform generator



Quasar's automatic picture level control changes with room lighting



GE's MB chassis uses saturable reactor (T1704) for high-voltage regulation.

volume-step IC/LED system. Volume is muted or varied by the differences in brightness produced by the LED's glow. In the receiver is a Slumber Sentry circuit. It samples the vertical and composite sync pulses. If the receiver is left on after the station signs off, the Slumber Sentry detects the loss of sync pulses. Then it automatically shuts off the receiver following a short delay. [*Panasonic recently purchased Quasar from Motorola—Ed*]

RCA. Continuing its XL-100 color TV receiver system, RCA has shaped up the 1975 line by installing an electronic digital display for the vhf and uhf channel numbers. The display is on the control panel, rather than on-screen.

There are no more tubes (except for the latest negative guard band color picture tube) in the RCA lineup. The instant-on feature common in earlier XL-100 models has been eliminated in a move toward energy conservation. Going all solid state and eliminating instant-on, RCA claims an energy savings of 27.5 percent over its tube-type receivers.

The concentration in the XL-100 line is on the Acculine portable color TV receivers. The deflection yoke is permanently bonded to the Acculine picture tube (which, incidentally, has an inline electron gun arrangement) to prevent it from shifting position. Hence, the yoke is an integral part of the picture tube.

Between the Acculine tube and the bonded yoke, there are only four dynamic convergence adjustments instead of the usual 12 that must be made for setting up the receiver. There is also only one purity adjustment—the purity magnet—instead of the usual two. The second purity adjustment—the yoke—is already fixed in the correct position.

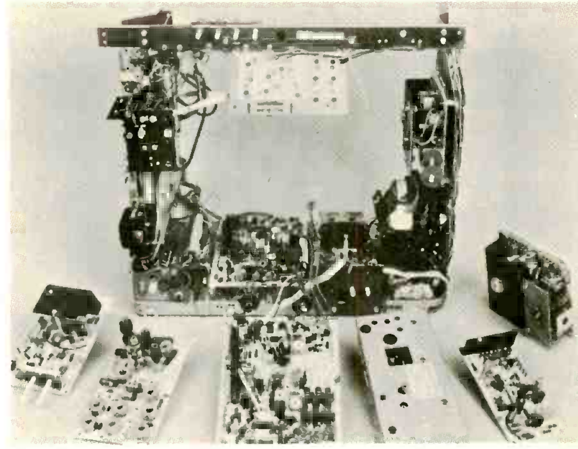
Sony. Sony this year offers the KV color series, featuring its Trinitron system, which uses color stripes in a negative guard band matrix, and an in-line gun arrangement, and the TV transportable lifestyles line. Sony incorporates 114° wide-angle deflection picture tubes and Econoquick instant-on features for greater viewer pleasure and convenience. One of the major benefits of the Trinitron system is the elimination of costly, time-consuming set-up adjustments that conventional three-gun color systems require.

The KV series features one button control for Automatic Fine Tuning, Color and Hue for accurate and simple color reception adjustment. Optional accessories for the Sony line include rechargeable battery packs, car battery cords, sun glare filters and auto and home antennas.

Sylvania. The new Sylvania chassis, called GT-matic II, is said to add another dimension to no-button tuning. Parroting preset adjustments, the viewer simply turns on the power and selects the channel. Then, the receiver automatically sets the proper volume, brightness, contrast, color, tint, and other major tuning requirements. Automatic vertical and horizontal holds and Perma Tint supplement the preset controls. A pushbutton varactor tuner, muting, instant-on, remote control, and 100-percent solid-state chassis round out the GT-matic II's features.

The automatic vertical and horizontal holds are controlled by a six-section IC that produces a synchronized horizontal and vertical scan system. Other automatic circuits work on reducing airplane flutter, maintaining a constant voltage, etc.

The Perma Tint circuit acts as a monitor to maintain color at preset levels. It attempts to reduce flesh-tone changes. Once the hidden controls are adjusted as desired, the Perma Tint control can be activated, increasing the demodulation angle between R−Y and B−Y to provide a wider range of phase angles for determining the actual color of the flesh tone.



Quasar's 100-percent solid-state chassis' modular design system

The red demodulator IC gates the Perma Tint on only when there is a positive component of R−Y present. This limits the effect of the increased angle to only those colors in the flesh-tone range without affecting the yellow-green, green, cyan, and blue colors.

Serviceability in the GT-matic II chassis is supported by plug-in devices and modular arrangement of the pc boards.

Zenith. For 1975, Zenith is introducing its Chromacolor II receiver line. It features an all-solid-state vertical chassis, voltage regulation, and one-button preset controls.

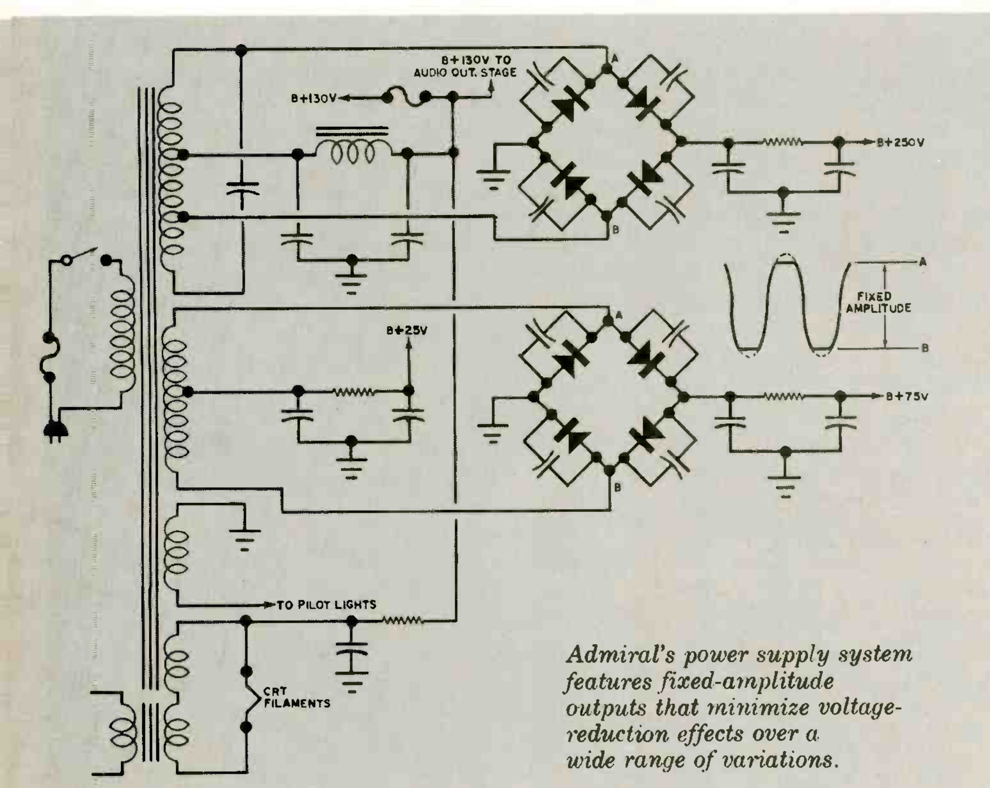
The Space Command remote control transmitter still uses a mechanical, rather than an electronic, scheme. A tiny hammer in the transmitter strikes a rod that then vibrates at a specific frequency. The sound thus produced (it's beyond human hearing) activates the specific control channel in the remote control receiver.

Magnavox's remote-control system features on-screen channel number in seven-segment format.

Zenith calls its modular construction "plug-in/pull-out" Dura-Modules. Eight modules accommodate 75 percent of the circuitry in the receiver.

Tuning in the Zenith receivers is accomplished with 14 preset channels and a slide-switch arrangement. The presetting need not be sequential.

In Conclusion. So it is obvious that the consumer has many new features to look for when buying a 1975 TV receiver. Of course, he will have to expect to pay a little more for these innovations. But, in the long run, the initial investment may be returned to him in the form of fewer service charges and an increase in the life of the set. ◈



Admiral's power supply system features fixed-amplitude outputs that minimize voltage-reduction effects over a wide range of variations.

NEW DOLBY-ENCODED FM BROADCASTS

THE FCC now allows FM stations to use a combination of Dolby B-Type noise reduction and reduced pre-emphasis in their signal processing. Here's why the new proposal was accepted and how it affects the performance of your FM tuner.

For years, many responsible people in the broadcasting field have privately or publicly suggested a reduction in pre-emphasis. This process was introduced in the early days of FM. It boosts the level of high-frequency content by passing the baseband signal through an RC high-pass filter with a 75-µs time constant, a break frequency of 2.123 kHz, and a 6-dB/octave slope. In this way, the S/N (signal-to-noise) ratio of the FM channel is increased. At the receiver, de-emphasis must be introduced to balance the spectral content of the received signal as in the original information. The de-emphasis network is a simple low-pass RC filter, with a −6-dB/octave slope, a 75-µs time constant and 2.123-kHz break frequency. The time constant was chosen at a time when there was marginal high-frequency content, by today's standards, in recorded sound. A low break frequency was required to radically boost the highs to prevent them from being lost in the high-frequency noise that is characteristic of FM.

Today, we have reached a point where the recording media can give much flatter frequency response. Anyone who has compared an old and a recent recording of a certain piece will note a dramatic increase in high-frequency content, or a more "brilliant" sound. This presents problems to FM broadcasters, though. They are constrained to a frequency deviation of 75 kHz, and with increased high-frequency content, they must either lower the modulation index, or use high-frequency limiting. Stations with integrity will not color the sound of the modulating signal, and thus lose some of their potential audience to less scrupulous, but louder competitors who shape the spectral content of the baseband signal to achieve higher levels of modulation while staying within the law.

The proposal by Dr. Dolby will redress the inequities of the situation. If the level of pre-emphasis were reduced, using a 25-µs time constant and 6.36-kHz break frequency, stations could modulate their carriers more fully, and their signal strengths would increase an average of 4 dB. However, the sound from the millions of FM tuners already in use, with their 75-µs de-emphasis networks, would be exceedingly dull. Obviously, the FCC could not allow such incompatibility to be introduced. If FM stations simultaneously change the time constant of their pre-emphasis networks to 25 µs *and* incorporate Dolby B-Type noise reduction, an interesting situation arises.

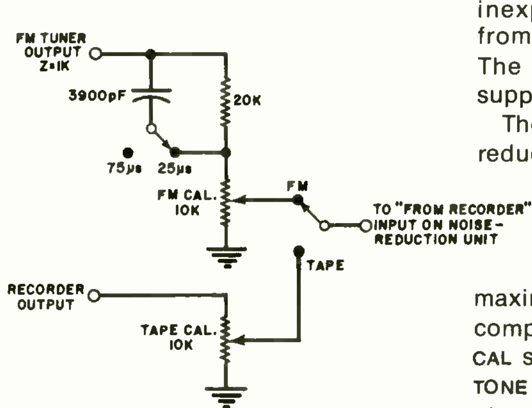
The reduction of high-frequency brilliance caused by pre-emphasis reduction is almost completely counterbalanced by the effects of B-type compression. In low-to-medium-quality equipment, there is no noticeable difference, and the increase in the highs noticed from medium-to-high-quality equipment can be compensated for by a slight reduction of high response of the amplifier using the treble control(s).

Brilliance is a subjectively measured quantity, and to ascertain the effects of B-type encoding, several stations switched unannounced to the new system. Many listeners wrote letters praising the increased quality of the sound. Not one complaint was received.

For those with conventional receivers and no noise reduction, there will be a reduction of high-frequency distortion, and an increase in brilliance and program level. Listeners equipped with 25-µs de-emphasis and Dolby B-Type noise reduction, as produced now by Dolby licensees as per Dolby's advice, will receive four benefits: improved signal to noise ratio; full program dynamic range, even at high frequencies; better reception in weak-signal areas; and reduced likelihood of SCA interference.

Some tuners and receivers are already equipped to receive the 25-µs Dolby encoded FM broadcasts. If a 75/25 switch is on the back of the unit it should be set at 25 during reception of all subsequent Dolby FM broadcasts. Otherwise, ordinary B-Type noise reduction units can be easily adapted to take advantage of the new broadcast technique by installing the FM Compensator shown in the diagram. Only one channel is illustrated; two will be required for stereo reception. Anyone may build a compensator for personal use or manufacture it for resale without a license. The parts are inexpensive and may be obtained from any electronics supply house. The unit does not require a power supply.

The PLAY CAL controls on the noise reduction unit should be turned to maximum, and TAPE CAL control on the compensator used in their place. FM CAL should be set so that the DOLBY TONE broadcast by the desired station gives a DOLBY LEVEL reading on the meters of the noise reduction unit. ◈



FM compensator provides choice of 75- or 25-µs time constant.

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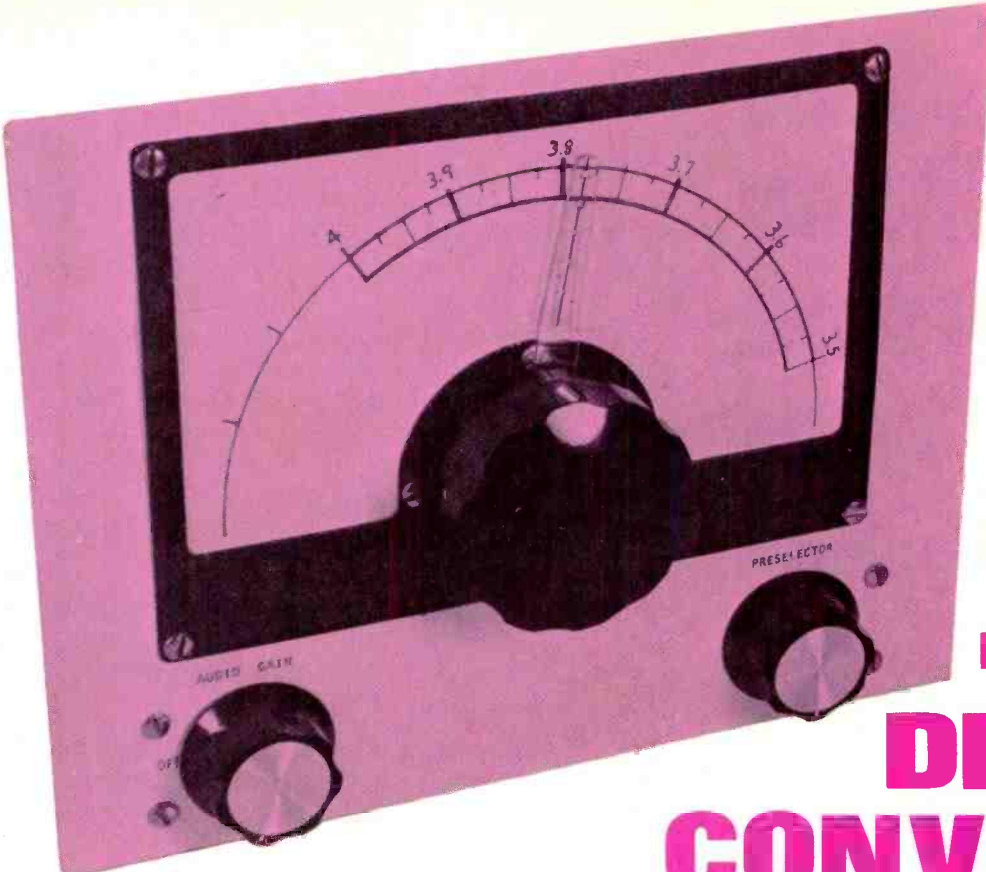


Good AM-SSB-CW performance at a fraction of a superhet's cost

BUILD A DIRECT-CONVERSION COMMUNICATION RECEIVER

BY JIM WHITE, W5LET

AN essential ingredient for the neophyte in amateur radio is a good receiver—one that is sensitive enough to pick up signals that are down near the noise level and selective enough to separate adjacent signals and provide clear copy. Without such a receiver, one can only look forward to "unanswered" CQ's and lots of frustration. However, a good communications receiver can cost anywhere from $250 to $500, and most beginners don't have that kind of money. Even a good used receiver can cost $150. As an alternative, a direct-conversion receiver should be tried. It performs well over a range of 3.5 to 4.3 MHz on AM, SSB, and CW and is easily constructed at a cost near $30.

Direct conversion is a much-neglected type of design that can best be described by comparing it to the more common system, superheterodyning. In the superhet system (Fig. 1), the first stage is an r-f amplifier. This is followed by a mixer where the signal is combined with the output of a local oscillator. The frequency of the latter is a certain amount above or below that of the r-f and the difference is called the intermediate frequency. The output of the mixer contains a high-frequency component and a low-frequency component.

These two signals are produced by superheterodyning; that is, combining two signals to produce one at a frequency equal to the sum of the frequencies of the original signals, and one at a frequency equal to their difference. At this point we filter out the high-frequency component and amplify the lower in a stage that has high gain and a narrow passband, which affords selectivity. The output of the i-f amplifier is sent to a detector, which may be of two types: for AM reception, it is an envelope detector (a diode followed by a low-pass filter); for SSB and CW, a product detector, which is really a second mixer, fed by a beat frequency oscillator (BFO), is used. The difference component of this heterodyning process is an audio signal, which is then amplified through one or more stages and passed on to phones or a speaker.

As you can see, there are usually four or more stages that must be properly tuned in conjunction with each other for proper signal recovery in a superhet receiver. Most quality communications receivers have two or three i-f stages, with separate mixers, local oscillators, and tuned amplifiers for each stage. These complications drive the cost of receivers out of the reach of a large portion of newcomers to the hobby.

The direct-conversion technique is a much simpler process. The block diagram of this system is shown in Fig. 1. The r-f amp supplies the mixer with an amplified version of the signal received from the antenna. The mixer is also fed an r-f signal of the same frequency as the incoming carrier from a local oscillator whose frequency is adjusted by the main tuning dial. The output of the mixer contains one audio frequency signal and one r-f signal at twice the frequency of the original. The r-f signal is then filtered out by a low-pass filter and we are left with an audio signal. This is then amplified by one or more stages of high gain and the output is connected to a speaker or a pair of phones. That's all there is to it. We have none of the complexities of dual- or triple-conversion superhet receivers; but do have good sensitivity, and if we use a high-quality, narrow audio filter, we have selectivity that will rival that of a superhet unit costing ten to twenty times more. The simplicity of operation is reflected in the ease of construction.

Circuit Operation. A comparison of the block diagram (Fig. 1) and the schematic diagram (Fig. 2) will point out a few differences. For economy's sake, an r-f amplifier has been omitted from this receiver. However, the receiver is still sensitive enough to pick up many signals that would be missed with a cheap "communications-type" superhet model. Signals from the antenna are coupled to the MOSFET mixer, *Q1*, over the tuned LC circuit composed of *L1*, *C1*, and *C2*. Transistor *Q4* is the local oscillator and its output is coupled through a small silver mica capacitor, *C28*, to the second gate of *Q1*. The antenna coil, *L1*, and the oscillator coil, *L2*, are wound on small toroidal cores, which is an effective way of attaining high Q circuits, which are the basis of the selectivity of the receiver's front end.

The other contributor of selectivity in a direct conversion receiver is the audio filter. This filter performs two functions. It rejects the high-frequency component of the mixer output, passing the audio signal, and it provides a large part of the receiver's selectivity by virtue of its audio band-pass characteristics. In this circuit, *L3*, *C5*, *C7*, and *C8* comprise the low pass filter. Coil *L3* is a variable TV width coil, and the capacitors are of the Mylar type.

Transistors *Q2* and *Q3* are conventional audio amplifiers, and almost any npn silicon transistor will work well in this circuit. Variable resistor *R10* serves as a volume control in the standard voltage divider mode and *IC1* serves as a high-gain audio output amplifier. Any one of the common audio modules furnishing 0.5 to 1 watt output can be utilized for this purpose. If desired, a headphone jack can be installed as in Fig. 2.

A power supply was not incorporated into the receiver. A suitable source supplying 500 mA at 9 volts should be used. If you intend to use the receiver for portable operation, or don't wish to construct a supply, six D cells in series will work perfectly. An inexpensive plastic holder can be obtained for handling them. It is important to take care in observing polarities while connecting the supply. To protect the sensitive semiconductors, diode *D2* has been incorporated. If the wrong polarity is applied to the receiver, *D2* is reverse biased and will not conduct. If this diode was not installed, the transistors and the IC would be destroyed in the event of accidental reversal of power supply polarity. However, when incorrect polarity is applied, the receiver simply will not work, thanks to the protective action of *D2*.

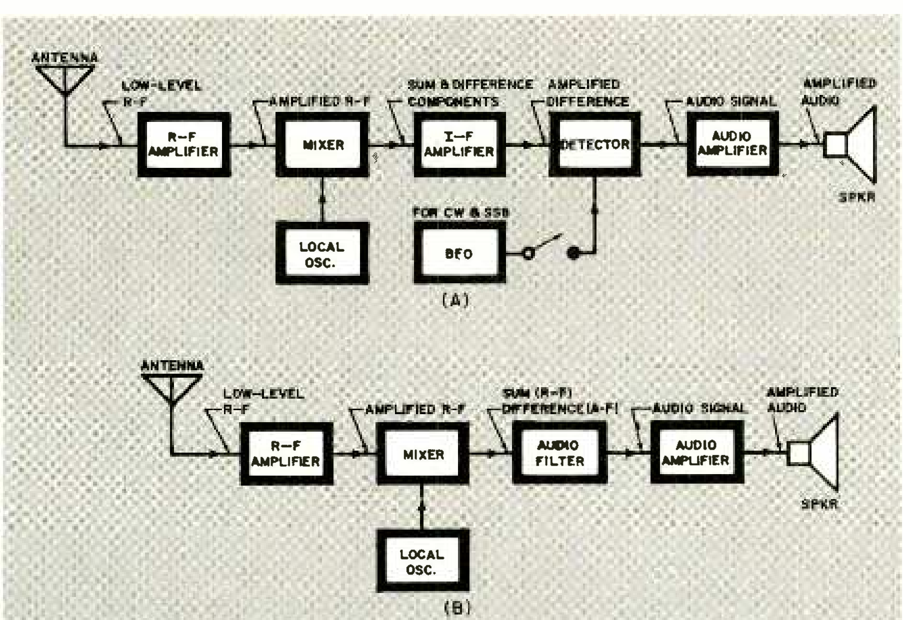
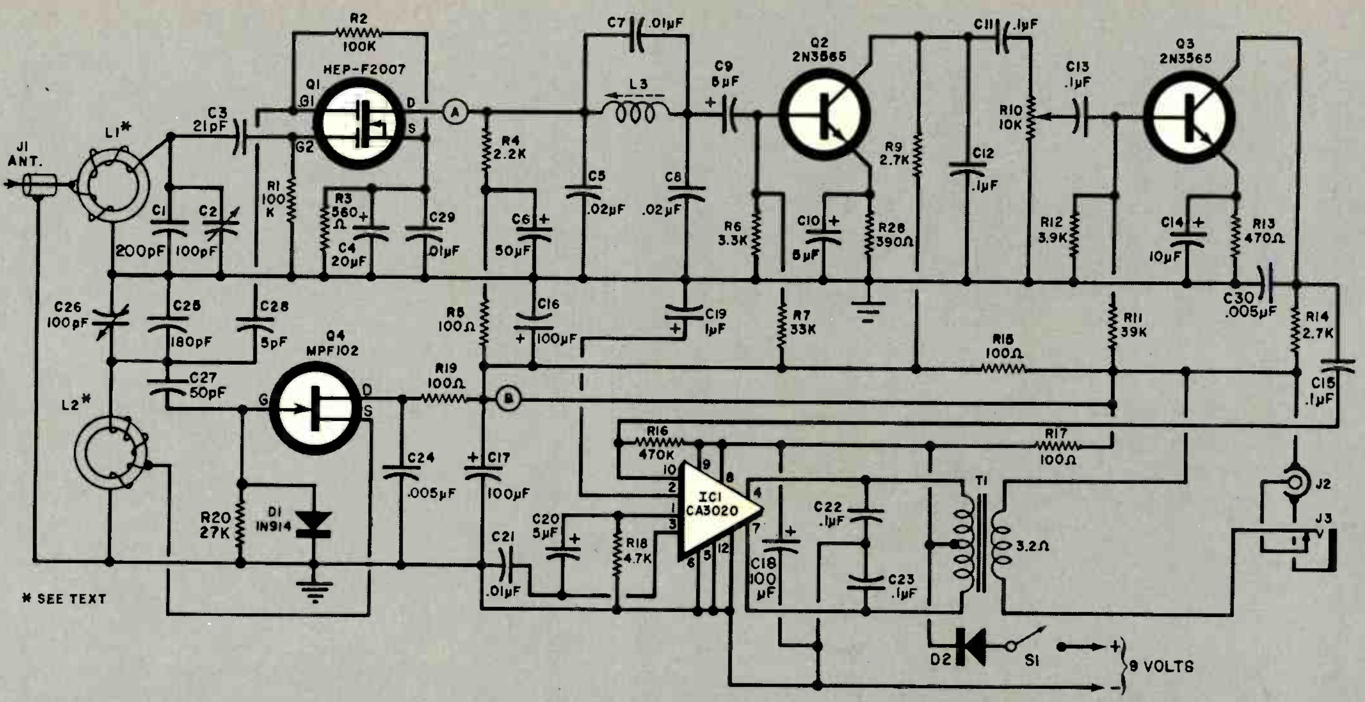


Fig. 1. Several stages are tuned simultaneously in superhet (A). Direct-conversion receiver (B) is much simpler to operate.

Construction Details. The receiver was assembled on a 7" x 9" x 2" aluminum chassis. Two separate circuit boards were used, and laid out on the chassis as seen in Fig. 3. The two cutouts for the boards should be made following this scheme, but layout is not critical. The use of individual boards for the r-f and audio stages eases troubleshooting as well as construction.

Mount the components on the audio board first. When you have done this, position the board in its cutout and secure it to the chassis. Connect the positive lead of the power supply to the center-tap of the transformer and the negative lead to the chassis ground. Then connect a speaker to the secondary of transformer *T1*. If you have correctly assembled this board, you will hear a hum or buzz from the speaker when you touch the base lead connection of *Q3*. The remaining board can then be assembled and mounted on the chassis. Try to keep all leads as short as possible.

After the boards are in place, spray a 7" x 10" piece of ¼" masonite with aluminum paint. When it has dried, mount the tuning dial on the panel, and secure the panel to the chassis. Mount the oscillator tuning capacitor, *C26*, on a small bracket, and insert the shaft of *C26* into the dial drive mechanism. After you have made sure that the shaft is correctly lined up, fasten the bracket to the chassis. Using a pair of pliers, turn the tuning capacitor's shaft until the plates are fully meshed. Then turn the dial to the 9 o'clock position and tighten the setscrew on the shaft receptacle. You can then log frequencies on the dial using a crystal calibrator or an accurate VFO. The audio gain control, *R10*, and the preselector capacitor, *C2*, are mounted in ⅜" holes in the front of the chassis. Drill the holes all the way through the front panel. Three holes must be drilled through the back of the chassis, for the antenna and speaker jacks, and the power supply leads. If you choose to include a headphone jack, it can be mounted either on the front or the rear of the chassis.



PARTS LIST

C1—200-pF, 500-V silver mica capacitor
C2,C26—Variable 100-pF capacitor
C3—21-pF, 50-V disc ceramic capacitor
C4—20-μF, 15-V electrolytic capacitor
C5,C8—0.02-μF, 100-V Mylar capacitor
C6—50-μF, 15-V electrolytic capacitor
C7—0.01-μF, 100-V electrolytic capacitor
C9, C10,C20—5-μF, 15-V electrolytic capacitor
C11,C12,C13,C15,C22,C23—0.1-μF, 50-V disc ceramic capacitor
C14—10-μF, 15-V electrolytic capacitor
C16,C17,C18—100-μF, 15-V electrolytic capacitor
C19—1-μF, 15V electrolytic capacitor
C21,C29—0.01-μF disc capacitor
C24,C30—0.005-μF disc capacitor
C25—180-pF, 500-V silver mica capacitor
C27—50-pF, 500-V silver mica capacitor
C28—5-pF, 500-V silver mica capacitor
D1—1N914 diode
D2—Silicon power diode (100 PIV, 750 mA)
IC1—Integrated circuit (RCA CA3020)
J1—Chassis-mounting coax connector
J2—Phono jack
J3—Two-circuit phone jack (optional)
L1—34 turns No. 22 wire tapped 11 turns from ground end
L2—34 turns No. 22 wire tapped 5 turns from ground end
L3—TV width coil, 10-50 mH (Miller 6319 or equivalent)
Q1—Dual-gate MOSFET (Motorola HEPF2007)
Q2,Q3—2N3565 transistor
Q4—JFET (Motorola MPF102)
R1—100,000-ohm
R3—560-ohm
R4—2200-ohm
R5,R15,R17,R19—100-ohm
R6—3300-ohm
R7—33,000-ohm
R8—390-ohm
R9,R14—2700-ohm
R11—39,000-ohm
R12—3900-ohm
R13—470-ohm
R16—470,000-ohm
R18—4700-ohm
R20—27,000-ohm
(All resistors ½-W, 10%)
R10—10,000-ohm potentiometer
S1—Spst switch (part or R10)
T1—Transformer: 200-ohm CT primary; 3.2-ohm secondary (Calectro D1-729)
Note—Q1 ($1.65) and T50-2 toroids (3 for $1) are available from Circuit Specialists, Box 3047, Scottsdale, AZ 85257.

Fig. 2. Receiver employs toroid-wound coils for L1 and L2. Q1 is a dual-gate MOSFET.

Other Frequencies. The receiver can also be used on other frequency bands. Only the LC combination at the input of the mixer and the tuned circuit of the local oscillator need modification.

For forty-meter operation, remove *C1*. Remove *L2* and replace it with 15 turns of No. 22 enamelled wire, wound uniformly spaced on a T50-2 toroid, and tapped 7 turns from the ground end. Also, connect a 225-pF silver mica, 500-V capacitor in parallel with *C25*.

For twenty meters, remove *C1*, and wind a new oscillator coil, *L2*, on a T50-2 toroid core. It should be 7½ turns of No. 22 enamelled wire, evenly spaced, and tapped 2½ turns from the ground end. Remove the 225-pF capacitor across *C25*, if it was installed for 40-meter operation.

For ten and fifteen meters, *L1*, the antenna coil, must be replaced with 8 turns of No. 22 enamelled wire, wound on a T50-2 toroid core. Then *L2* must be replaced with 5 turns of No. 22 enamelled wire, tapped 2 turns from the ground end. In winding both coils, spread the turns to space them evenly around the forms.

Alignment. Making sure that you observe correct polarities, connect a 9-volt power supply to the receiver. Connect a speaker and antenna to their respective jacks. Turn the audio gain control until you feel it click, and then advance it further until you hear the "rushing" sound of atmospheric noise. Rotate the preselector capacitor, *C2*, slowly. At one point there will be a noticeable increase in sound from the speaker. Carefully adjust *C2* for this peak. There is only one adjustment for receiver alignment, setting the value of inductance of *L3*. This prevents any r-f components from local oscillator feedthrough or the heterodyne process from entering the audio stages of the receiver. The procedure is very simple. Adjust *L3* until the tuning slug is positioned about half-way into the coil. This completes receiver alignment.

Operating the Receiver. As you tune across a band, keep the front end of the receiver resonant by adjusting the preselector capacitor. You will notice one basic difference in receiver operation between the direct conversion receiver and a superhet. On the conventional receiver, there is a mode switch which must be adjusted for the type of signal you want to receive.

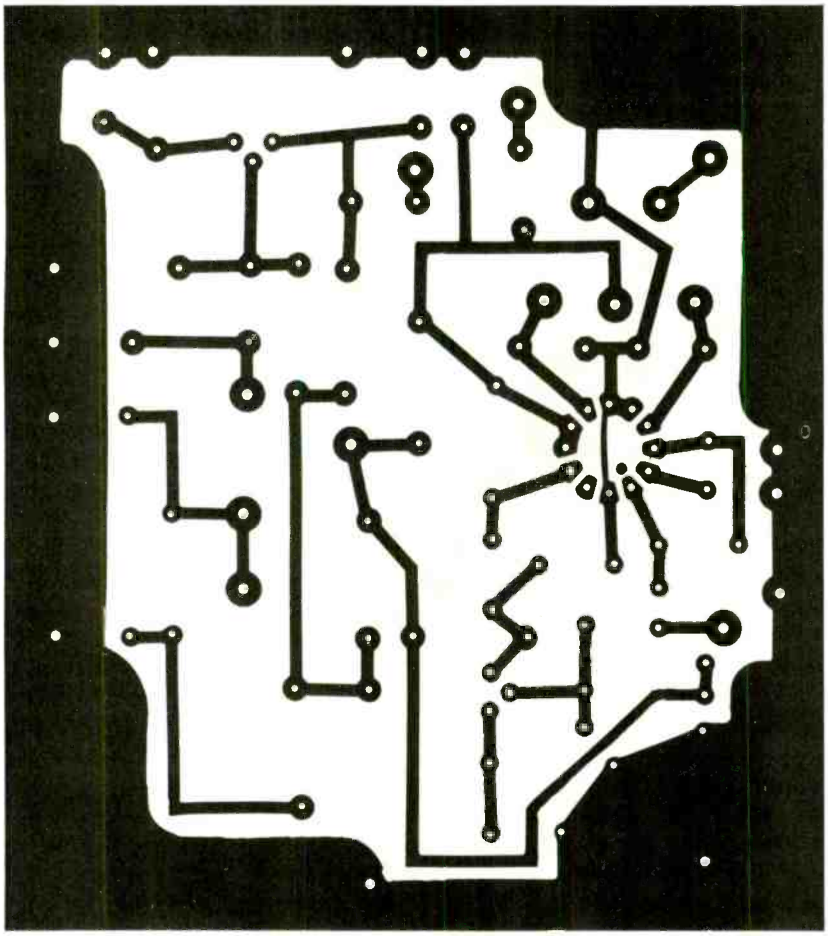
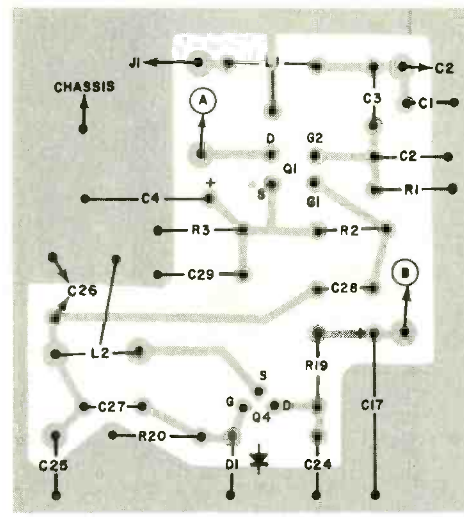
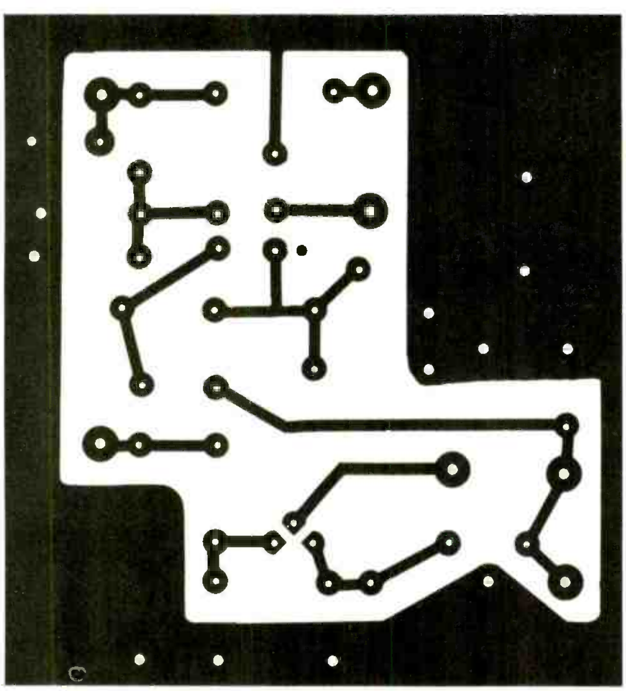
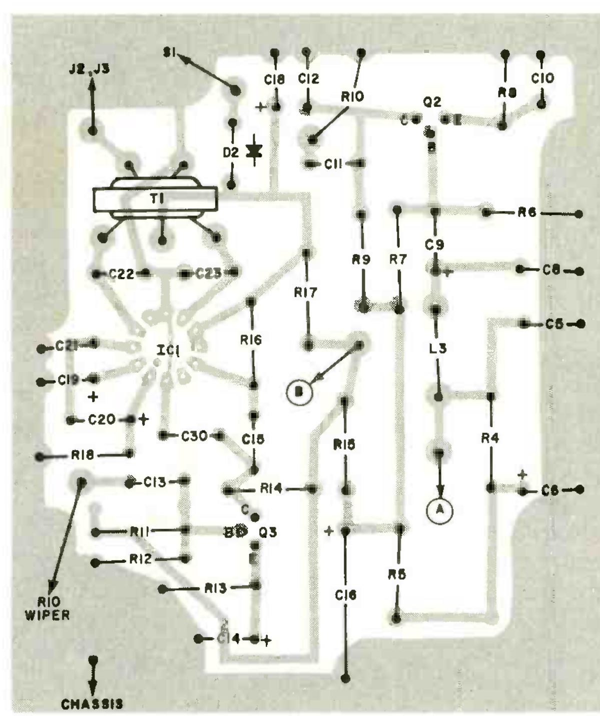


Fig. 3. Etching and drilling guides for audio and r-f pc boards are at left and bottom left. Component layout guides for r-f and audio boards are shown immediately below and at bottom.



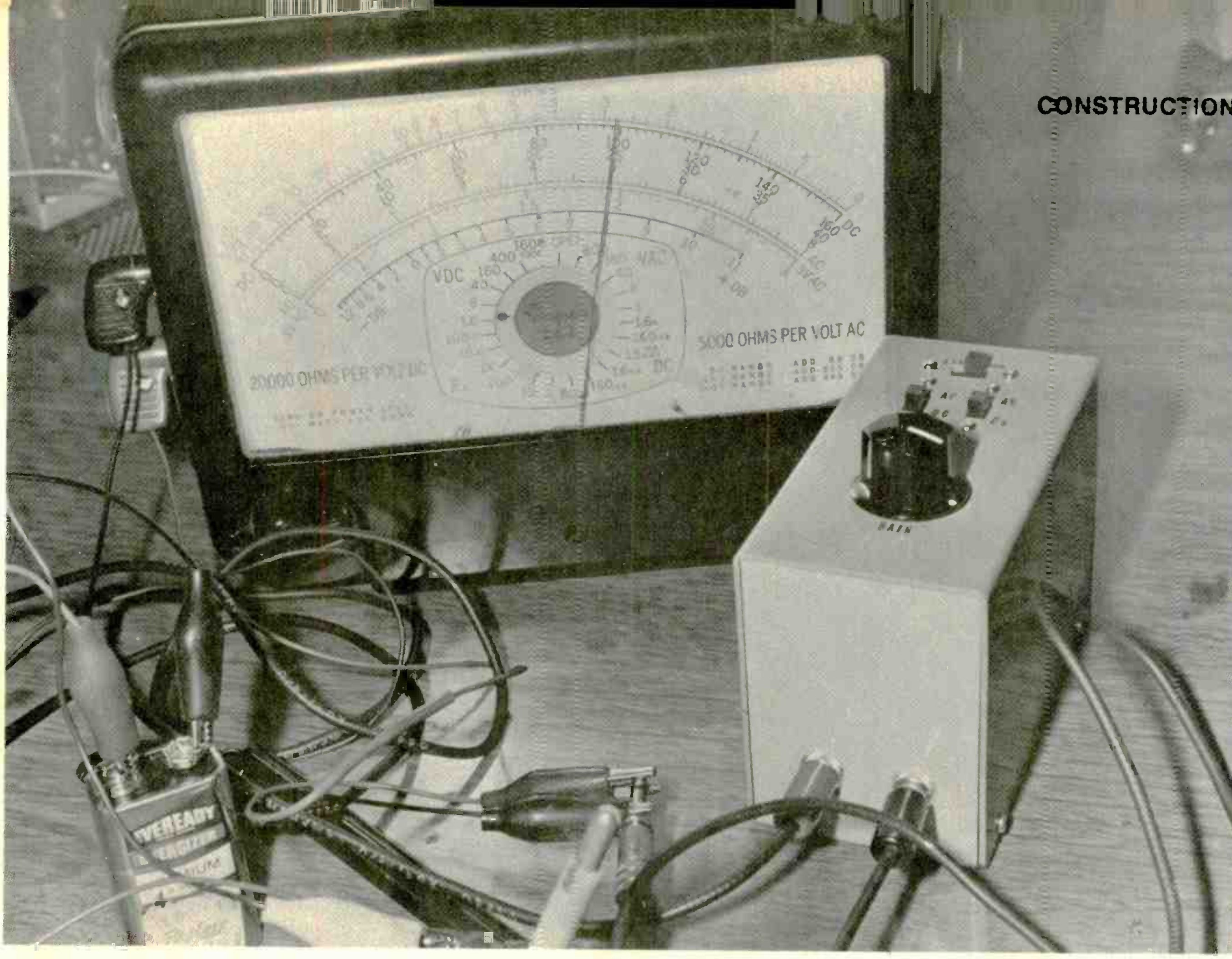




NOTE: C7 MOUNTS ON LUGS OF L3

When this switch is in the SSB/CW position, it activates the BFO and product detector. It is not possible to properly demodulate such signals when the switch is in the AM position, which directs the signal to a simple envelope detector. With the direct conversion receiver, no such switching is necessary and any signal (CW, AM, SSB, or FM) is properly detected just by adjusting the frequency of the local oscillator, which is accomplished by turning the main tuning dial.

Thus, the direct-conversion receiver provides many advantages over the superheterodyne model. It is less expensive, easier to build, and simpler to operate. Why not try something different—you'll be pleasantly surprised. ◈



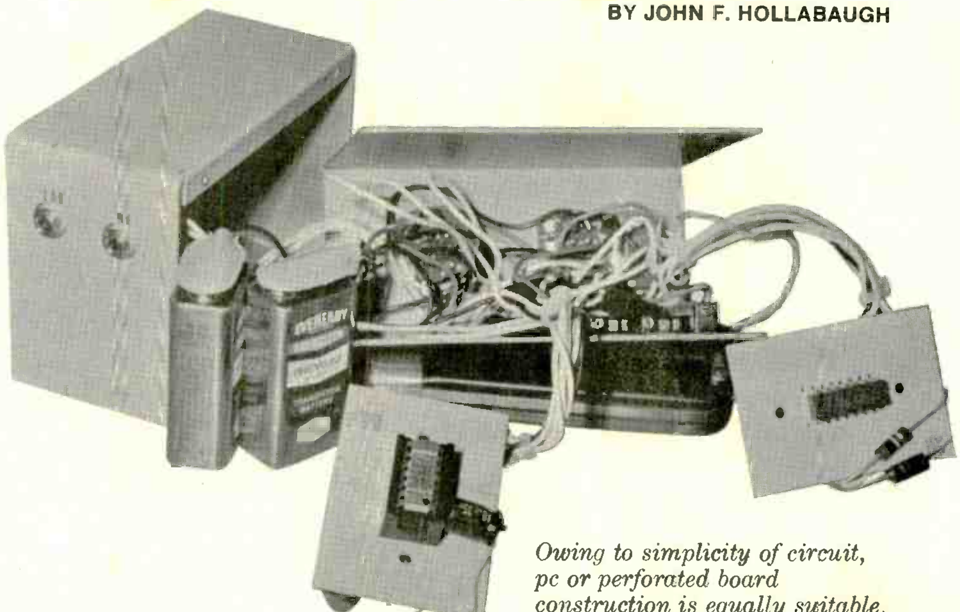
Measure Low Millivolts with a Multimeter

Range expander increases sensitivity by X10 or X100

BY JOHN F. HOLLABAUGH

HAVE you ever needed a simple device that would let you expand the ranges of your multimeter so that you could measure low-millivolt ac and dc voltages? Perhaps you need a small amplifier for checking out the high-level inputs of an audio amplifier. Well, the decade meter range expander described here will do both and more.

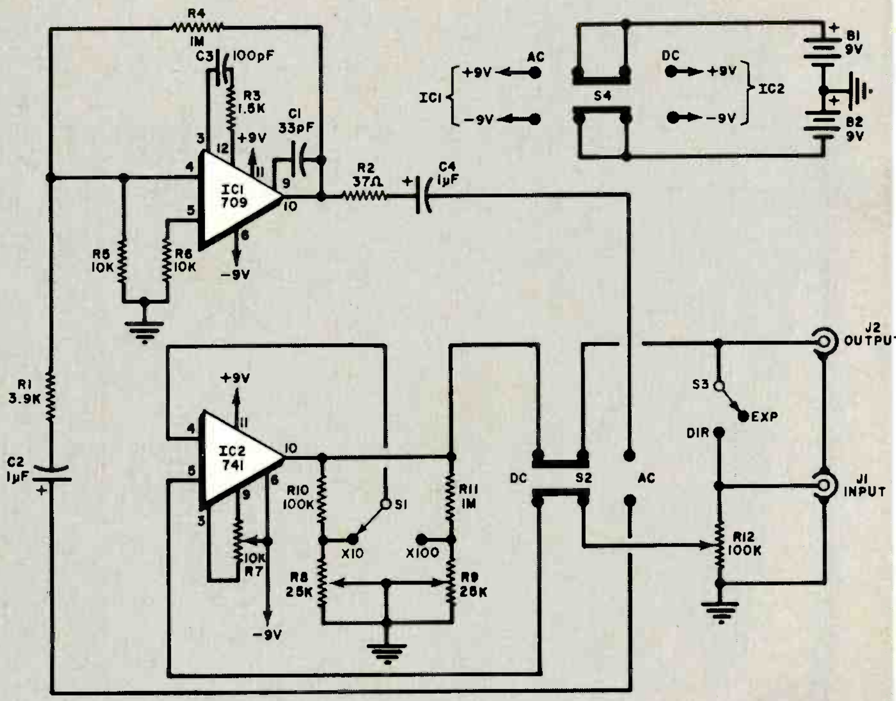
The decade range expander can be used to increase the usefulness of a multimeter by adding ranges divided by 10 and 100. It can also be used on decibel scales, subtracting 20 or 40 dB from the existing ranges in your VOM. Use the expander as a sensitive signal tracer to obtain quantitative measurements of the signal level at points of interest, or to read voltage amplifier stage gain directly in decibels on your



Owing to simplicity of circuit, pc or perforated board construction is equally suitable.

PARTS LIST

B1, B2—9-volt battery
C1—3-pF capacitor
C2, C4—1-μF, 15-volt electrolytic capacitor
C3—100-pF capacitor
IC1—709 operational amplifier
IC2—741 operational amplifier
J1, J2—Phono jack
R1—3900-ohm, ¼-watt resistor
R2—37-ohm, ½-watt resistor
R3—1500-ohm, ¼-watt resistor
R4, R11—1-megohm, ¼-watt resistor
R5, R6—10,000-ohm, ¼-watt resistor
R7—10,000-ohm trimmer potentiometer
R8, R9—25,000-ohm trimmer potentiometer
R10—100,000-ohm potentiometer
R12—100,000-ohm linear potentiometer
S1—Spdt toggle or slide switch
S2—Dpdt slide or toggle switch
S3—Spst toggle or slide switch
S4—4-position, double-throw slide switch
Misc.—Chassis box, 9-volt transistor battery clips, shielded cable and audio phono plugs (for test cables), IC sockets or Molex Soldercons®, pc board or perforated phenolic board and solder clips, hookup wire, solder, hardware, control knob, etc.



Two operational amplifiers (IC1 and IC2) form heart of expander.

meter. You can even use the range expander to measure the output voltage of a phono cartridge. Try that with an ordinary multimeter.

About the Circuit. The range expander makes use of two operational amplifier IC's (*IC1* and *IC2* in the schematic), exploiting the particular advantages of the types 709 and 741 op amps. A monolithic amplifier using bipolar transistors appears to the signal being processed as a series of resistances and shunting capacitances. An RC system like this forms a phase-shift network that at some frequency will cause the amplifier to oscillate.

Compensation is required to insure low gain at the frequency at which oscillation occurs. The 741 op amp is unconditionally compensated. (Gain is reduced to unity at the point where oscillation is possible.) The 709 op amp is not internally compensated, requiring external components to obtain the necessary compensation. However, it can be compensated for frequencies up to 1 MHz, while the 741 is restricted to a top-end frequency of about 1 kHz by its internal compensation.

The 741 op amp has provisions for input offset nulling, which makes it operate well as a dc amplifier. In the range expander, the 741 (*IC2*) is used as a dc amplifier with output nulling and a feedback network that minimizes drift. The 741 has input overvoltage protection and output short-circuit protection, while the 709 has neither. To provide input overvoltage and output short-circuit protection for the 709, *R1* and *R2* are used.

The 709 (*IC1*) in the range expander is compensated for a 40-dB gain up to about 200 kHz by *C1*, *C3*, and *R3*. It has a feedback network consisting of *R4* and *R5*. Both ac and dc amplifiers (*IC1* and *IC2*) have a common vernier control (*R12*) that can be used where exact values of gain are not required.

The incoming signal (or voltage) is applied via *J1*, while the mode of operation (ac or dc) is selected with *S2*. Switch *S1* permits selection of X10 or X100 in the dc mode, while switch *S3* applies power to either the *IC1* or the *IC2* circuit. The final switch, *S3*, permits the range expander to be bypassed when in the DIR position. In this position, it routes the incoming signal at *J1* directly to output jack *J2*. (Note: When *S3* is in the DIR position, *S4* can be switched to off to conserve battery life.)

Construction. Assembling the range expander is relatively easy, owing to the simplicity of the circuit. The entire circuit can be easily accommodated inside a 4 in. by 2¾ in. by 2 in. metal utility box, with the four switches and vernier control *R12* mounted on the top of the box for convenience.

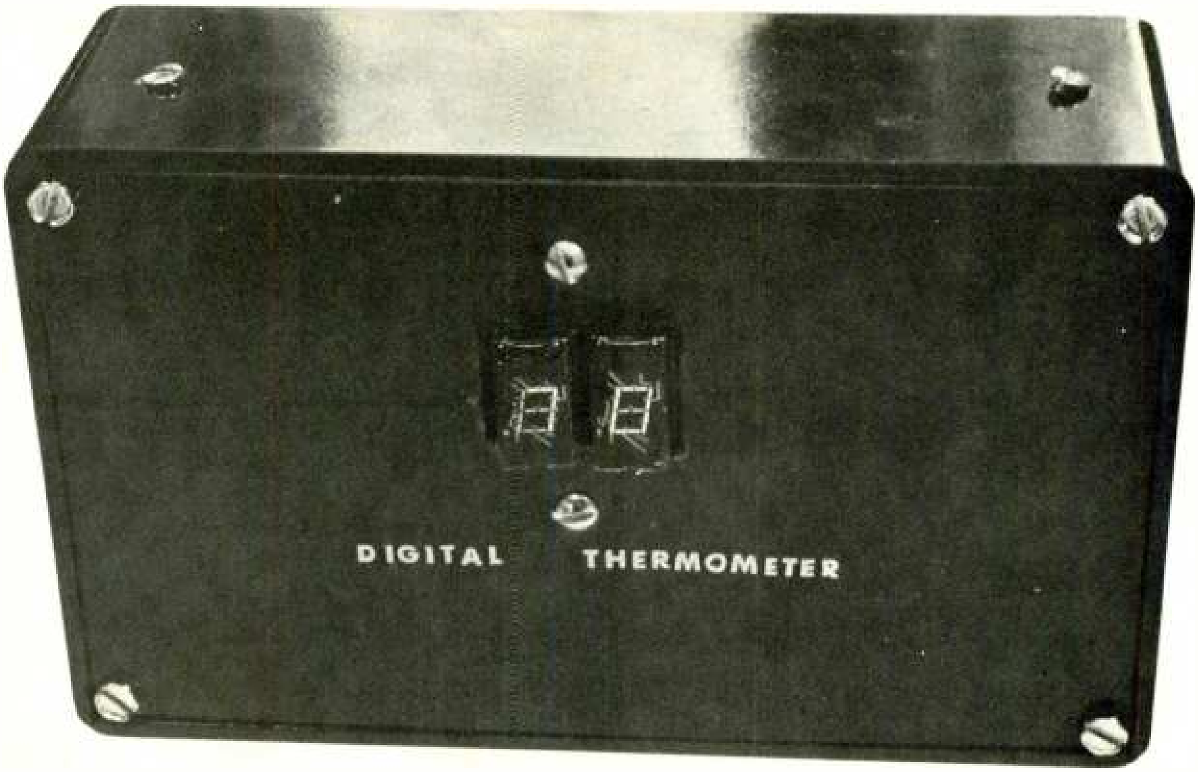
You can use a printed circuit board of your own design or perforated phenolic board and solder clips for mounting the *IC1* and *IC2* amplifier circuits inside the box. Jacks *J1* and *J2* can be mounted at one end of the box.

When the circuit has been fully assembled and all parts are mounted in place, use dry-transfer letters to label the control, switches, and jacks.

Calibration. With the range expander switched to DC (both *S2* and *S4* must be set to this position) and *R12* set for maximum sensitivity, connect a multimeter set to a low-voltage range across *J2*. Adjust *R7* for a zero indication on the multimeter's scale.

Connect a variable-output power supply or a potentiometer in parallel with a 1.5-volt battery to *J1* and adjust the supply or pot for a 0.1- to 0.5-volt indication on the multimeter's scale. Adjust *R8* for an indication of 10 times the reading of the input voltage level. (Use the multimeter to monitor both the input and output voltage levels.)

Now, decrease the output voltage of the power supply (or battery/pot setup) again for a meter reading of 0.1 to 0.5 volt and switch *S1* to the X100 position. Adjust *R9* for a reading of 10 times the previous meter reading. With the input disconnected, recheck the null produced by adjustment of *R7*. If necessary, readjust the null. ◈



Build a VERSATILE DIGITAL LED THERMOMETER

Low-cost, accurate device can be used as
- *indoor/outdoor thermometer*
- *heater/cooler thermostat*
- *temperature alarm*
- *fishing thermometer*

BY THOMAS R. FOX

THE digital thermometer described here was designed for low cost and simplicity, as well as accuracy. If you check the semiconductor sales ads in this magazine and use a conventional thermistor, you can build the thermometer for about $15. If you decide to use a precision thermistor, the cost will be about $20. Since the thermometer operates from a +5-volt line, it can be used in a car, boat, or camper. With a line-powered 5-volt supply, it can be used in the home.

It is possible to use two switchable thermistors to check temperature differentials—such as between the outside and inside, or between two rooms. If a long lead is used between the thermistor and the electronic circuit, the project can be used as a fishing thermometer.

How It Works. The frequency of the CMOS multivibrator (Fig. 1) depends on the resistance of thermistor *TDR1*, which is determined by the ambient temperature. Thus, if the temperature goes up, the frequency of the multivibrator goes up, and vice versa. Trimmer potentiometer *R23* is used to adjust the linearity.

The two-transistor multivibrator (*Q1* and *Q2*) automatically resets the two

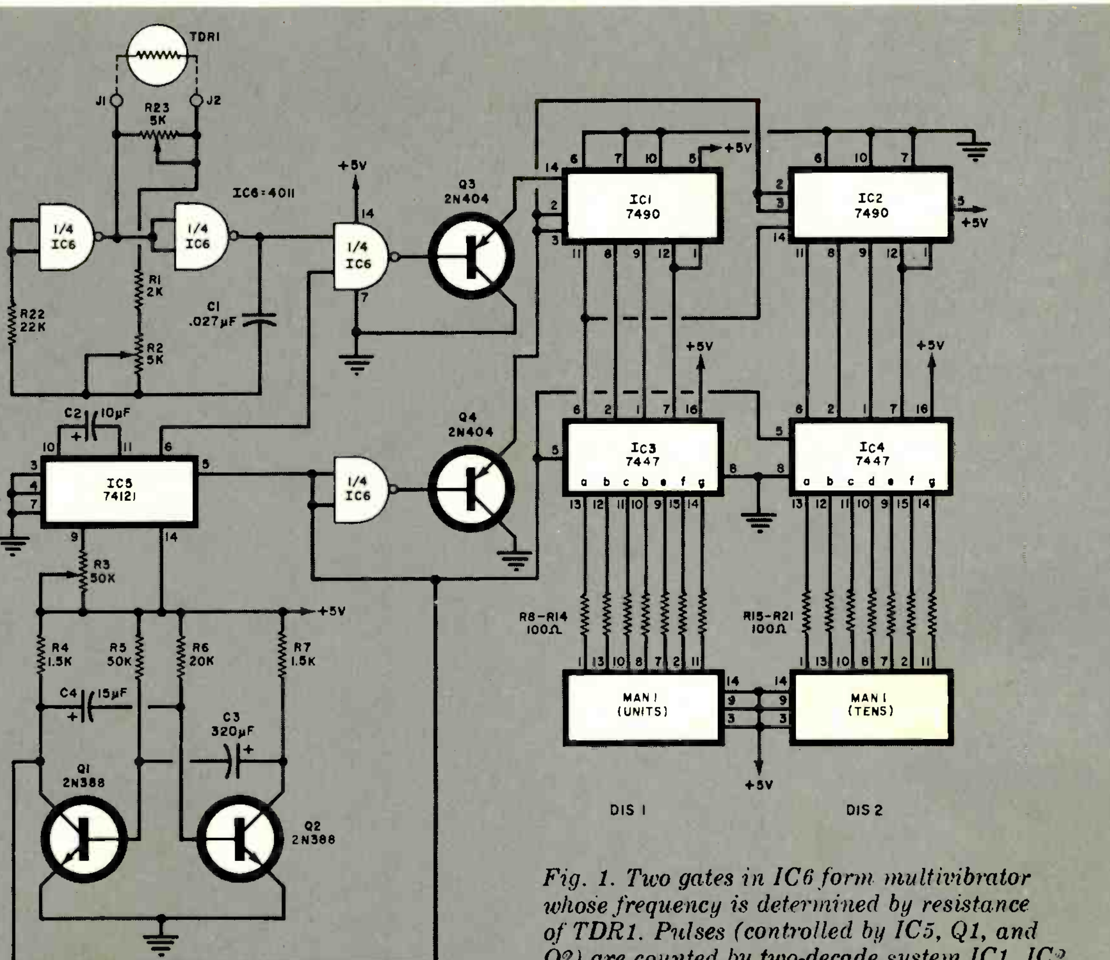


Fig. 1. Two gates in IC6 form multivibrator whose frequency is determined by resistance of TDR1. Pulses (controlled by IC5, Q1, and Q2) are counted by two-decade system IC1, IC2.

PARTS LIST

C1—0.027-µF silver mica capacitor
C2—10-µF, 10-V tantalum capacitor
C3—320-µF, 10-V electrolytic capacitor
C4—15-µF, 10-V electrolytic capacitor
DIS1, DIS2—LED display (Monsanto MAN-1 or similar)
IC1, IC2—7490 TTL decade counter
IC3, IC4—7447 TTL decoder/7-segment driver
IC5—74121 TTL monostable multivibrator
IC6—Quad NAND gate (RCA CD4011 or similar).
J1, J2—Banana jacks
Q1, Q2—2N388, HEP641 or similar
Q3, Q4—2N404, HEP739 or similar
R1—2000-ohm, 5%, ¼-watt resistor
R2, R23—5000-ohm miniature trimmer potentiometer
R3—50,000-ohm miniature trimmer potentiomer
R4, R7—1500-ohm, ¼-watt resistor
R5—50,000-ohm, ¼-watt resistor
R6—20,000-ohm, ¼-watt resistor
R8-R21—100-ohm, ¼-watt resistor
R22—22,000-ohm, 5% ¼-watt resistor
TDR1—1000-ohm, negative coefficient thermistor (USI 44004, available from Yellow Springs Instruments, Box 279, Yellow Springs, OH 43587)
Misc. —Suitable enclosure, flexible wire for thermistor leads, rubber glue, optional 9-oz plastic jar and cover, optional switch for two thermistors, mounting hardware and sockets.

decade counters (*IC1* and *IC2*) and *IC5*, which triggers the monostable multivibrator. When *IC5* operates, it closes the CMOS AND gate and allows the output of the temperature-dependent multivibrator to pass to the counters. The length of time that *IC5* is on is determined by the value of *C2* and the setting of *R3*.

Construction. The circuit can be assembled on perforated board, using sockets for the IC's and transistors. Everything is on one board except the power supply and thermistor.

Choose an enclosure that will accommodate the board, the power supply, and the two readouts. Be sure you have access to the three trimmer potentiometers (*R2*, *R3*, and *R23*) through suitable holes. If you use the thermistor called for in the Parts List, you can use an 1800-ohm fixed resistor for *R23*. Other 1000-ohm thermistors will require some adjustment of *R23*. For stability, *C1* should be silver mica and *C2* should be tantalum.

The on and off times of the display are determined by the values of *R5/C3* and *R6/C4*, respectively. These can be varied to suit individual choice of times.

If the temperature of more than one area is to be measured, a simple switching scheme can be arranged between *J1* and *J2*.

Carefully solder the flexible two-wire cable to the thermistor and insulate the joints. If the thermistor is to be used only indoors, coat it with some rubber glue. If it is to be used outside, it must be protected from the direct rays of the sun and other weather conditions. In this case, mount the thermistor in a plastic jar (about 9-oz capacity), being sure to drill many ventilation holes. The thermistor (mounted through the cover) should not come in contact with the jar. The jar must be positioned so that it does not get the direct rays of the sun.

Power Supplies. Three possible power supplies are shown in Fig. 2. Select the one that suits your needs. Any 5-volt supply that can deliver at least 300 mA can be used. If the digital thermometer is for fishing, use the ac-powered circuit. In this case, omit the transformer and diodes and use a battery holder to mount four 1.35-volt mercury cells, with an spst switch to control power.

Calibration. Connect the thermistor to *J1* and *J2* and apply power to the circuit. Allow it to warm up for at least 30 minutes. You will see a numerical display that will "blink" as the multivibrator operates every few seconds.

Fill a glass with ice cubes and top it off with cold water. Fill another glass with water that is as close to 90 degrees as possible. (Use an accurate mercury thermometer.) Set *R23* to its midpoint; and place the thermistor in the ice water *adjacent* to an ice cube. Without disturbing the glass or thermistor, adjust *R3* until the display indicates 33. Place the thermistor in the 90° water. If the display shows greater than 90, increase the value of *R2* until a reading of 90 is obtained. If the display indicates below 90, decrease the value of *R2*.

Insert the thermistor back in the ice water and touch up *R3* if the reading is less than 33. These adjustments will have to be repeated several times to get the readings as accurate as possible. If you encounter difficulty in attaining a linear display, adjust *R23*. In general, a decrease of resistance in *R23* results in an increase in sensitivity near the high end and a decrease in sensitivity at the low end.

Once calibration is complete, the digital thermometer should be within 1 degree between 0° and 90° F and usable between −50° and 130° F. Although this project was designed for the 0-90 range, it could be used to take readings of temperatures below zero and above 100° F. A reading of 90 on a bitter-cold winter day would mean that the true temperature is −(100-90) or −10°F. A display of 5 on a hot summer day means the temperature is 100 + 5 or 105° F.

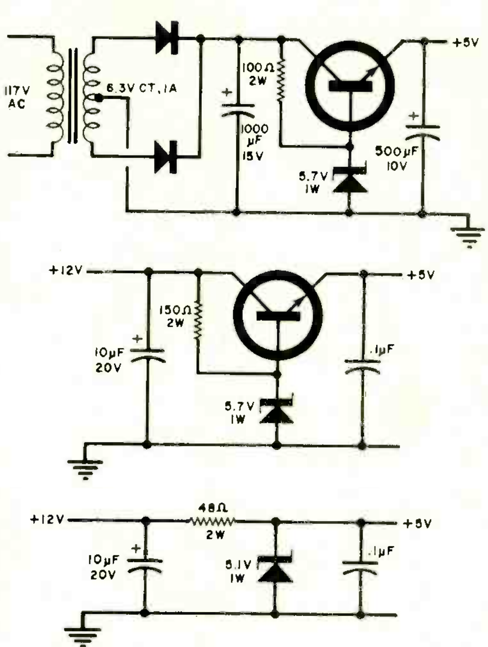


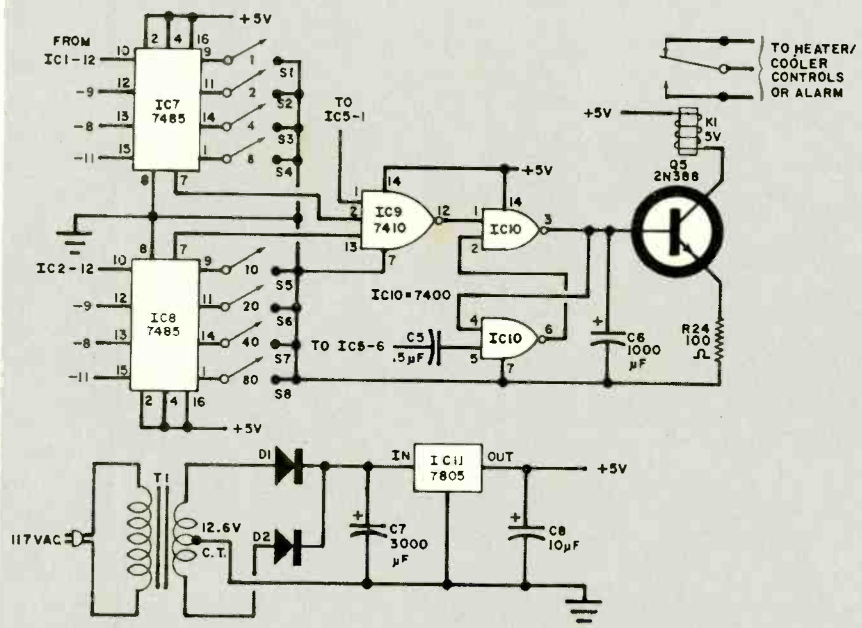
Fig. 2. Three typical power sources for thermometer. Top is for line power, other two are for mobile operation.

THERMOSTAT CONTROL MODIFICATION

You can convert the digital thermometer described in this article into a multipurpose heating/cooling thermostatic control with a 0° to 99° F temperature range by adding to it the circuit shown below. Relay *K1* and any alarm or circuit connected to it can be made to trip at any temperature selected by switches *S1* through *S8*.

The reference temperature selected by the switches is the sum of the closed-switch designations. For example, to set the system up for 34° F, you would close *S3, S5,* and *S6* (4° + 10° + 20° = 34°). If the sensed temperature falls below 34°, *K1* will sound an alarm or turn on the heat. Conversely, if the reference temperature is 99° and the sensed temperature rises to 101°, *K1* can sound a different type of alarm or turn on the cooling system.

The use of a 5-volt relay for *K1* and suitable connections for its contacts to the heating/cooling controls produces a state-of-the-art environmental control system that eliminates troublesome mechanical thermostats. For the most reliable thermostatic operation, increase the value of *C3* to at least 2000-μF and change the value of *R5* to 100,000 ohms. Also surround thermistor *TDR1* with ¼-in. (6.35 mm) of insulating material and protect it from drafts.



ADD-ON PARTS LIST

C5—0.5-μF disc capacitor
C6—1000-μF, 10-volt electrolytic capacitor
C7—3000-μF, 20-volt electrolytic capacitor
C8—10-μF, 15-volt electrolytic capacitor
D1,D2—1-ampere silicon diode (1N4001 or similar)
IC7,IC8—7485 magnitude comparator integrated circuit
IC9—7410 triple 3-input NAND integrated circuit
IC10—7400 quad 2-input NAND integrated circuit
IC11—7805 5-volt regulator integrated circuit
K1—5-volt relay with spdt contacts
Q5—2N388 (or similar) transistor
R24—100-ohm, ½-watt resistor
S1-S8—Spst switch
T1—12.6-volt, 1-ampere filament transformer

BY FORREST M. MIMS
AND H. EDWARD ROBERTS

BASIC DIGITAL LOGIC COURSE

PART 2: CONCEPTS AND CIRCUITS

IN PART 1 of our short course in digital logic, we discussed the binary number system, binary arithmetic, and the octal number system. In Part 2, we are concerned with logic concepts and circuits.

Boolean Logic. In 1847, George Boole, a British mathematician, published his *Mathematical Analysis of Logic*. This booklet did not equate mathematics with logic, but it did demonstrate how any logic statement can be analyzed with basic mathematical relationships. Boole published a much longer and refined version of his theory of logic in 1854. To this day, all practical digital computers and countless other electronic digital circuits are based on the concepts pioneered by Boole.

Boolean logic (or algebra) makes the important assumption that a logic statement is either true or false. Since electronic circuits can easily be made to operate in either of two states, on or off, it is convenient to equate "true" with "on" and "false" with "off." Similarly, we can equate the binary 1 with on and the binary 0 with off. With the foregoing in mind, let us review Boole's basic logic concepts.

The mathematical explanation of logic put forth by Boole can be simplified into three basic logic functions: AND, OR, and NOT. The AND function requires that one logic state or condition *and* at least one other be true before the entire statement is true. The OR function requires that one logic state *or* at least one other be true before the

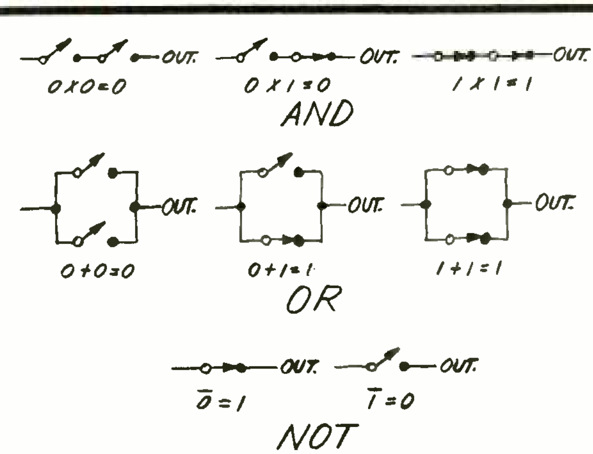
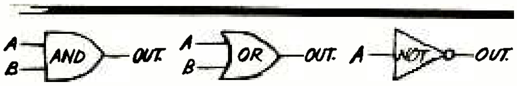


Fig. 1. Switches are arranged to illustrate three basic digital electronic functions.

entire statement is true. The NOT function simply reverses a stazement from true to false, or vice versa. Electronic NOT circuits are commonly referred to as "inverters" because their function is to invert the polarity of the signal.

The above definitions can be tabulated into a table such as shown in Fig. 1. Such a table is useful in showing the relationships among Boole's three logic functions and their electronic and arithmetic counterparts. This type of table is sometimes called a "truth table" since it sets forth the various logic conditions for which each statement is true. Generally, truth tables are arranged in a more compact form similar to those shown for the three basic logic functions in Fig. 2.

Truth tables can be created for *any* logic function. Specification sheets for digital logic circuits almost always include a truth table.



A	B	OUT.
0	0	0
0	1	0
1	0	0
1	1	1

A	B	OUT.
0	0	0
0	1	1
1	0	1
1	1	1

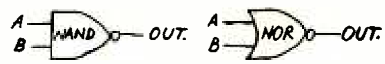
A	OUT.
0	1
1	0

Fig. 2. AND, OR, and NOT symbols are shown with truth tables.

Logic Symbols. Boolean logic statements can be implemented by simply writing them on paper, using alphabetic symbols to correspond to "true" and "false" conditions. Electronic logic diagrams, however, are much easier to design and interpret if a sort of block diagram of the circuit is presented. For this reason, standardized logic-block symbols have been devised for the three basic logic functions. They are shown in Fig. 2.

Compound Logic Circuits. Two circuit combinations (the NOT-AND and the NOT-OR) are used so frequently that they are treated as basic logic elements and given their own logic symbols and truth tables.

When the AND function is followed by a NOT statement, the meaning of the AND function is reversed to NOT-AND, commonly called a NAND function. Similarly, when the OR function is followed by a NOT statement, the meaning of the OR statement is reversed to NOT-OR, commonly referred to as a NOR function. The logic symbols and truth tables for the NAND and NOR functions are shown in Fig. 3.



A	B	OUT.
0	0	1
0	1	1
1	0	1
1	1	0

A	B	OUT.
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 3. NAND and NOR symbols with associated truth tables.

DeMorgan's Theorem. About the same time Boole developed his logic theories, Augustus DeMorgan was also developing some fundamental theories of logic. His most important contribution, known as DeMorgan's Theorem, relates the AND, OR, and NOT functions as follows:

$$\overline{A + B} = \overline{A} \times \overline{B}.$$
$$\overline{A \times B} = \overline{A} + \overline{B}.$$

The arithmetic symbols + and × mean OR and AND, respectively. The bar, or vinculum, over a letter indicates the NOT function. Thus $\overline{A}$ means NOT A.

The importance of DeMorgan's Theorem is that an AND circuit containing a NOT at each input corresponds to an OR circuit followed by a NOT. Similarly, an OR circuit with a NOT at each input corresponds to an AND circuit followed by a NOT. This does not equate the NAND and NOR functions, but it does mean that NAND circuits can be used to implement NOR functions, and vice versa.

Complex Logic Systems. Logic systems that contain three or more basic logic elements are termed "complex." One of the simplest of the complex logic systems is the EXCLUSIVE OR (sometimes written XOR) function shown diagramatically in Fig. 4. From the truth table, note that this function is identical to the OR function with one important exception: A true condition exists only when one *or* the other condition, but not both, is true.

The EXCLUSIVE OR function completes the connection between Boolean logic, the binary number system, and electronic switching circuits, for it can be used to add two binary bits. To see how this is accomplished, assume a logic 1 at input A and a logic 0 at input B in the EXCLUSIVE OR circuit shown in Fig. 4. Since only one input is enabled (input A), AND circuit 1 does not turn on. Hence, a 0 is present at the CARRY output. OR circuit 1 does turn on, since only one input need be present. Since the NOT circuit inverts the 0 from AND circuit 1 into a logic 1, AND circuit 1 has two input signals and is therefore turned on. The result is a logic 1 at the SUM output. (The circuit has added 0 + 1 to obtain 1.)

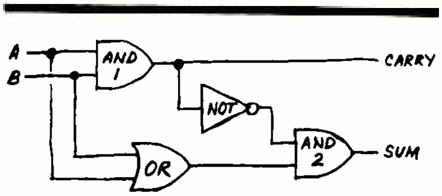


Fig. 4. Logic array for XOR circuit.

The EXCLUSIVE OR circuit is often called a "half-adder." Try verifying its operation yourself by adding 1 + 1 in binary.

Practical Logic Circuits. Figure 1 demonstrated how simple switching circuits can be used to implement each basic logic function. However, it is usually not practical to employ switches in real systems. Instead, transistors, SCR's, tunnel diodes, or other solid-state switches are employed.

The most commonly used switch in digital electronics is the transistor. Relatively simple circuits that combine diodes, resistors, and transistors can be used to implement the AND, OR, and NOT functions. Thanks to integrated circuit (IC) technology, several or even dozens of individual logic circuits can be placed on a single compact silicon chip. Resistor-transistor logic (RTL) was once the most popular type of digital IC, but it has been largely replaced by the more noise-immune transistor-transistor logic (TTL) type.

In recent years, field-effect transistor (FET) technology has been adapted to integrated logic circuits of amazing complexity. By insulating the gate of a FET with a layer of silicon dioxide, extremely high impedances are made possible. The result is a logic circuit that requires microamperes or nanoamperes of operating current at relatively low voltages.

Insulated-gate fabrication techniques are collectively known as MOS (for metal oxide semiconductor) technology. Since MOS transistors are unipolar (p- or n-type) and do not require separate p and n sections like conventional bipolar pnp and npn transistors, MOS IC's can have a much higher component density than most conventional IC's. The result is large-scale integration (LSI). So, the next time you read or hear the phrase "MOS LSI," you will know that it refers to a large-scale integrated circuit employing metal oxide semiconductors. ◈

Product Test Reports

PIONEER MODEL SX-636 AM/STEREO FM RECEIVER

(A Hirsch-Houck Labs Report)

25-watts/channel receiver with superlative stereo FM tuner section

ROUGHLY in the middle of the current line of stereo receivers from Pioneer, the Model SX-636 features a tuner section that makes the most effective use of integrated circuit technology that we have yet seen in a hi-fi component. The result is a level of performance, in a moderate-priced receiver, that in some respects surpasses that of most separate components—to say nothing of far more expensive receivers.

The receiver's audio amplifiers are rated at 25 watts/channel over the entire audio range, with less than 0.5 percent THD. They are operated from balanced positive and negative power supplies and are direct-coupled to the speakers. The preamplifier section features tone controls with 11 lightly detented click-stop settings, and a balance control with a detented center setting. The phono preamplifier, whose gain allows the rated output to be developed with only a 2.5-mV input, can handle signals greater than 100 mV in amplitude without distortion.

The FM tuner section employs a fairly conventional front end containing a FET r-f amplifier followed by a dual ceramic i-f filter featuring linear phase characteristics. All other FM functions are performed by a single large-scale integrated (LSI) circuit—a proprietary development of Pioneer, containing circuitry that provides i-f amplification, five stages of limiting, and FM (apparently quadrature) detection. The detected signal then goes to a phase-locked loop IC for multiplex demodulation. The entire AM tuner consists of only one IC, plus a handful of external components. Consequently, Pioneer has made an AM/FM tuner with only three IC's and a relatively small number of discrete components, the performance of which proved quite exceptional in our laboratory tests.

The receiver has two pushbutton switches labelled TAPE MONITOR that allow two tape decks to be used simultaneously, with off-the-tape monitoring from either deck and the ability to copy tapes from one deck to the other. The FUNCTION switch has a PHONO/MIC position, in addition to the usual AM, FM, and AUX positions. Plugging a microphone into its jack automatically disconnects the phono pickup and applies a monophonic microphone signal to the preamplifiers of both channels. Another pushbutton switch is for the high-cut filter. And for maximum convenience, there are two ac outlets on the rear apron, one of which is switched.

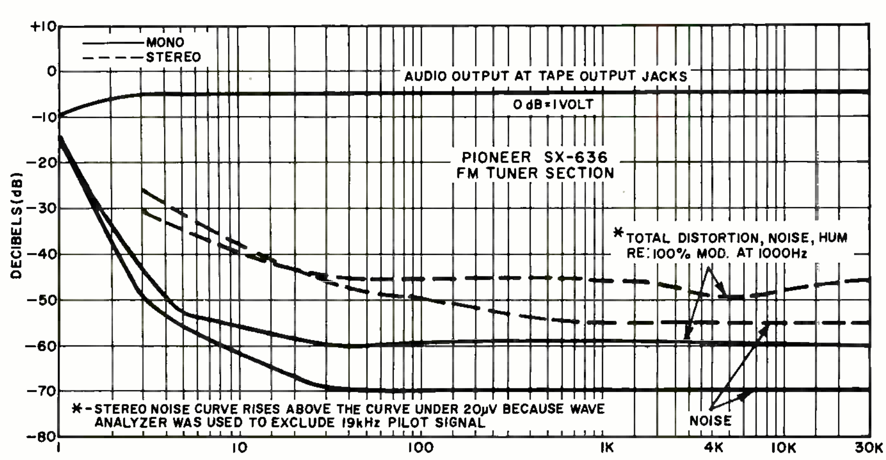
The Pioneer Model SX-636 AM/stereo FM receiver comes complete with a walnut-finished cabinet for a fair-trade retail price of $349.95.

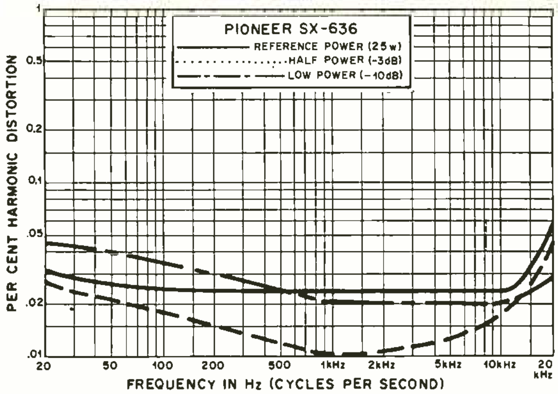
Laboratory Measurements. The audio amplifiers of the Model SX-636 receiver clipped at 29.7 watts/channel with both channels driven simultaneously at 1000 Hz into 8-ohm loads. Into 4 ohms, the power was 36.7 watts, while into 16 ohms, it was 20.5 watts/channel. The 1000-Hz THD was less than 0.1 percent from 0.1 to 30 watts, typically measuring less than 0.03 percent. The IM distortion was also less than 0.1 percent from 25 watts all the way down to less than 5 mW output.

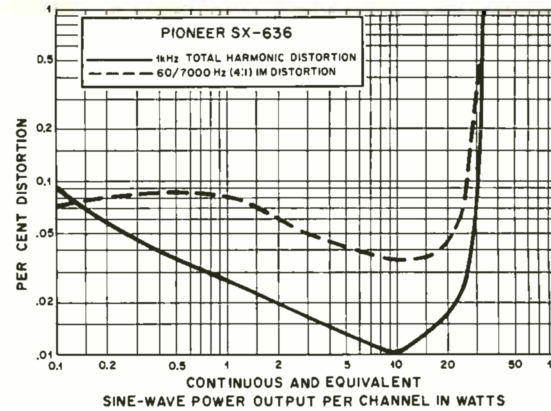
At the rated 25-watt output level, and at one-half and one-tenth of rated power, the distortion was typically 0.025 percent or less over most of the audio-frequency range. It never exceeded 0.055 percent, this at full power and 20,000 Hz. At normal listening levels, the THD was about 0.01 percent. Our figures were a great deal better than Pioneer's *very* conservative 0.5-percent published figure.

A 10-watt reference output level was obtained with an input of 75 mV (AUX), 1.25 mV (PHONO), and 3.6 mV (MIC). The respective hum and noise levels were −81 dB, −75 dB, and −61 dB. The PHONO inputs overloaded with a 100-mV input, and the MIC input overloaded with a 275-mV input.

The bass tone controls had a sliding



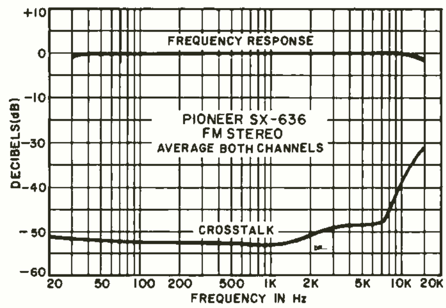




turnover frequency that allowed appreciable correction at the lower frequencies with no effect on the midrange. The treble tone control's characteristic was hinged at about 2000 to 3000 Hz. Loudness compensation boosted both the low and the high frequencies. The high-cut filter had a 6-dB/octave slope, with the −3-dB point at 4700 Hz, while the RIAA equalization was virtually perfect over most of its range (less than ±0.25 dB variation between 50 and 20,000 Hz).

There was a very slight bass roll-off caused by the loading of the 10,000-ohm input impedance of our graphic level recorder on the tape recording outputs where we made the RIAA measurement. The cartridge inductance had only a moderate effect on the equalization, about as much as we have found on most other good amplifiers. The microphone response was essentially flat, within ±0.5 dB from 25 to 6000 Hz, falling off to −1.5 dB at 10,000 Hz.

The FM tuner had an IHF usable sensitivity of 1.8 µV in mono and 10 µV in stereo. The 50-dB quieting sensitivity was 3µV in mono and 100 µV in stereo. Ultimate queting was 70 dB in mono and 55 dB in stereo, while ultimate distortion was about 0.11 percent in mono (very low) and about 0.5 percent in stereo.



The capture ratio was an impressive 0.7 dB, about the best we have ever measured in a tuner. AM rejection was 51 dB. Image rejection was 75.5 dB, alternate-channel selectivity was 63 dB, and muting threshold was 2.2 µV—the last low enough to exclude noise but not any receivable signals. Automatic mono/stereo switching occurred at 2.5 µV. The 19-kHz pilot carrier leakage into the audio outputs was 41 dB below full modulation.

The stereo FM frequency response was within ±0.25 dB from 30 to 13,500 Hz. It was down only 1.5 dB at 15,000 Hz. The channel separation was extraordinary, measuring between 50 and 53 dB over a frequency range of 30 to 2500 Hz. It reduced to 40 dB at 10,000 Hz and was still an extraordinary 31.5 dB at 15,000 Hz. Clearly, this must be credited to the linear-phase i-f filters and the phase-locked loop demodulator, which operate with remarkable effectiveness. The AM tuner's frequency response was down 6 dB at 100 Hz and 5300 Hz.

User Comment. As the above test data shows, the Pioneer Model SX-636 receiver merits the use of superlatives in describing some of its characteristics. In particular, the stereo FM separation taxed the abilities of our signal generator. In this one respect, the system's tuner performed in a manner that has been matched only by a component tuner that sells for $2500!

Impressive as our measurements may appear to be, they cannot adequately describe the performance of this receiver. It is not enough to state that the receiver surpassed *every* one of its published specifications during our tests, even though this in itself is a rather unusual event in our experience. The real proof is in the using. The operation of the receiver is totally smooth, with noise-free muting, very accurate dial calibration, and not a trace of switching transients or other undesirable side effects. One can easily be lulled into taking these things for granted, but it is surprising how many audio components—in all price ranges—are deficient in some of these important respects.

CIRCLE NO. 65 ON READER SERVICE CARD

ROYCE MODEL 1-600 MOBILE CB TRANSCEIVER

Moderately priced unit features crisp speech quality

THE moderately price Model 1-600 solid-state mobile CB transceiver from Royce Electronics features crystal-synthesized operation at full legal power on all 23 AM channels. It has a meter that indicates relative signal strength on receive and relative output power on transmit. Additionally, the transceiver incorporates only the main essentials: adjustable squelch, a-f volume control, automatic noise limiting (anl), and external-speaker jacks for receiver or PA operation. Supplied with the transceiver are a detachable dynamic microphone and mobile mounting hardware. The rig is designed to be operated from 12- to 13.8-volt dc, negative- or positive-ground, electrical systems. Retail price is $124.95.

The Receiver. The receiver section

of the transceiver employs double conversion. The first i-f is nominally at 10.6 MHz, while the second i-f is at 455 kHz. The r-f stage ensures good sensitivity, which measured out at 0.3 µV for 10 dB (S + N)/N. This is enhanced by low-noise first and second mixers.

Six synthesizer crystals cut for frequencies between 37.600 MHz and 37.850 MHz provide heterodyning signals for the first-conversion i-f, which occurs over a 40-kHz-wide spread from 10.595 MHz to 10.635 MHz according to the heterodyning crystal frequency used in relation to the CB channel frequencies. Four synthesizer crystals between 10.140 MHz and 10.180 MHz provide the heterodyning signals for the second conversion to the 455-kHz i-f.

Selectivity is obtained at the second i-f amplifier with a ceramic band-pass filter which, together with the receiver's a-f response, provided a total response of 300 to 4200 Hz at the 6-dB points.

Adjacent-channel rejection was found to be at least 45 dB. Two 455-kHz i-f stages are used in an unusual setup that has two direct-coupled transistors in lieu of the usual transformer coupling. This permits high gain to be obtained with good stability.

The diode detector furnishes an agc voltage that maintained an a-f output within 12 dB with a 20-dB r-f input change (1-10 µV) and 7 dB with a 60-dB input change (10-10,000 µV). A second diode provides a dc voltage in accordance with the signal strength and actuates the S meter, which registered S9 with a 100-µV input signal.

The squelch, driven from the emitter of the second mixer, was exceptionally smooth in operation. It eases nicely in and out of operation without "plopping." The squelch threshold range was less than 0.5 µV to 1000 µV.

The a-f section consists of two cascaded stages, followed by a class-B push-pull output stage that developed a bit more than 4 watts with 11 percent distortion at the start of limiting when driven by a 1000-Hz signal into an 8-ohm load in both the receive and the PA modes. When the a-f system is used for PA work or for modulating the transmitter, an extra speech amplifier is switched into the system.

The Transmitter. On transmit, one of the four crystal signals, spotted between 10.595 MHz and 10.635 MHz, is mixed with one of the six nominal 32.7-MHz signals from the synthesizer to generate the on-channel carrier. A three-section bandpass filter at the mixer's output minimizes spurious responses.

The rest of the transmitter consists of an r-f amplifier, a driver, and the power amplifier, with the two last stages collector-modulated as usual. A three-section antenna-matching network, plus a TVI trap, are incorporated into the power amplifier's output. Antenna switching is accomplished electronically. And no relay is used for send/receive transfer.

The output power of the carrier into a 50-ohm dummy load measured 3.5 watts when the transceiver was operated from a 13.8 volt source. Complete modulation of the carrier was obtained with 9.5 percent distortion at 1000 Hz. However, the positive peaks did not reach the point where peak power would normally be four times the carrier power. On the other hand, further raising the speech level extended the positive peaks to nearer the full amount, with clipping occurring on both positive and negative peaks to just 100 percent without crossing over or overmodulation. Under these conditions with the EIA standard test tone of 2500 Hz, the adjacent-channel splatter was 35 dB down. With normal voice operation, it was at least 55 dB down.

The normal overall a-f response was 300 to 4200 Hz at the 6-dB points. The frequency tolerance was 450 Hz or better on any channel.

Comment. The Model 1-600 Royce CB transceiver is attractively styled, with a wood-grain-finished control panel and a chrome-finished bezel. The edgewise-mounted S/power meter is somewhat easier to read than usual. It is illuminated in white on receive and switches to red on transmit where it varies in brilliance in step with the percentage of modulation.

The receiver is a relatively quiet one which, with an effective anl and crisp speech quality on both transmit and receive, make this transceiver well suited for Citizens Band communication.

CIRCLE NO. 66 ON READER SERVICE CARD

PICKERING MODEL OA-3 STEREO HEADPHONES
(A Hirsch-Houck Labs Report)

Comfortable open-air phones provide "airy" sound quality

THE Pickering Model OA-3 "open-air" stereo headphones provide little or no isolation from room sounds. Unlike conventional isolating-type phones that have air-tight seals betweeen the ear-cups and the listener's head, the Model OA-3 phones are fitted with vinyl-covered foam rings that rest lightly over the ears. The lack of sound isolation works in both directions. The program being played through the phones can be audible to others in the immediate vicinity, as well as letting outside sounds in.

Open-air phones have a distinctly different sound quality than coventional phones. The quality might be described as "airy" or "light," perhaps because the normal room ambience is not excluded from the listener's ears (although it does not directly interact with the musical program as it does when listening through loudspeakers). This type of headphone is also exceptionally comfortable to wear, owing to its very light weight of only 8.5 ounces (about 0.86 kg) and the slight pressure it exerts on the ears and head of the person listening with them.

It is generally recognized that good low-bass response through headphones requires a tight phone-to-ear seal. While this statement appears to contradict accepted acoustical theory in the open-air design, it is not really so. The bass response of an open-air phone may extend down to 60 Hz or so, but subjectively appear to go to a much lower frequency. Since there is little music content in the lowest octave of hearing, one is not aware of any lack of deep bass sound when listening with good open-air headphones.

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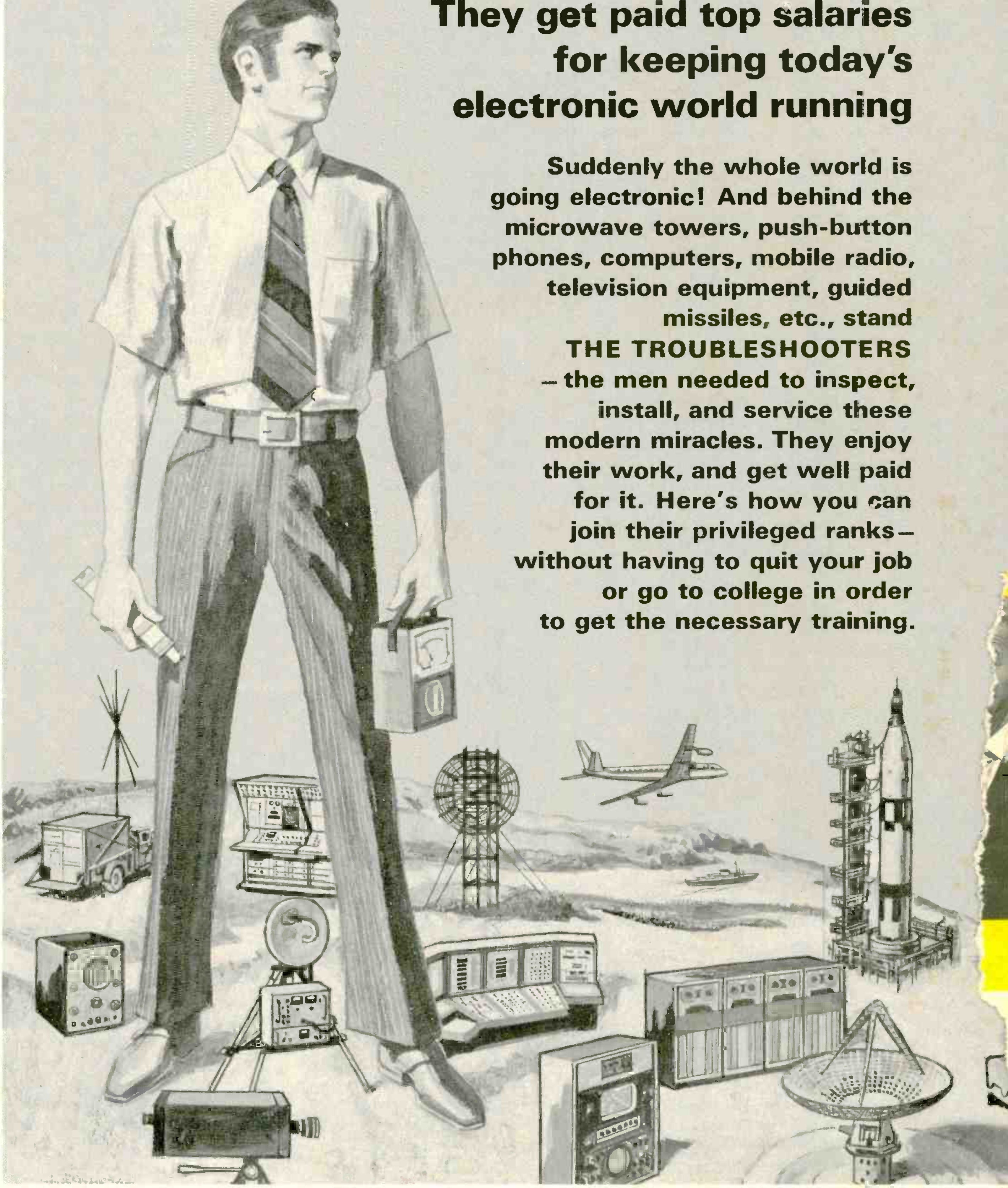

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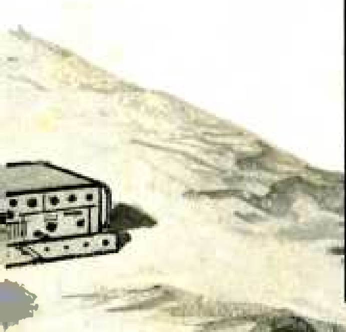

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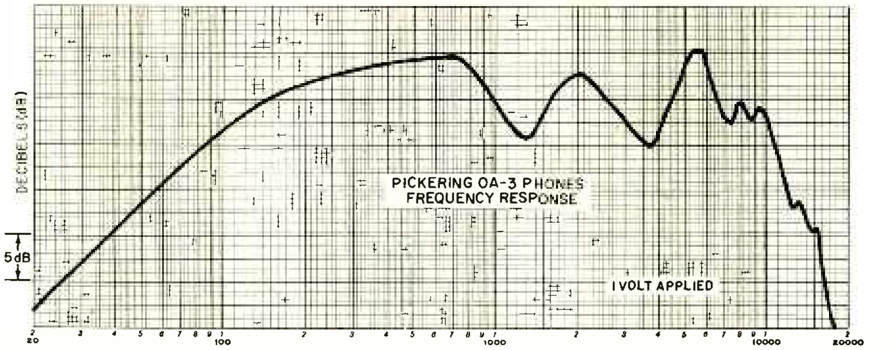


The published specifications of the Model OA-3 phones indicate that they are quite efficient, requiring only 0.1 volt across their nominal 15-ohm impedance to produce a 100-dB sound pressure level (SPL) at 1000 Hz. The maximum rated input power is 0.2 watt/channel, but the series resistors built into all amplifier headphone output circuits will provide adequate protection even with a high-powered amplifier. The distortion is specified at 0.5 percent for a 110-dB SPL output.

The Pickering Model OA-3 headphones are supplied with an adapter plug to permit them to be used with small transistor radios and cassette decks. Retail price of the phones is $39.95.

Laboratory Measurements. We tested the frequency response of the phones on a Koss-designed coupler, which is a slightly modified version of an accepted standard earphone coupler. The measured frequency response of any headphone is closely connected with the dimensions of the coupler (or artificial ear) on which it is mounted so that it is virtually impossible to compare data on different coupler designs, especially at the higher frequencies. However, one can obtain a reasonably valid picture of the headphone's overall response even though the specific peaks and dips on the response curve may be as much a property of the coupler as of the phone (and would certainly be still different through the ears of any individual wearing the phones).

The measured frequency response was relatively uniform from 100 Hz to 11,000 Hz, with a total variation of only ±5 dB over that range. The output fell rather quickly at frequencies beyond 11,000 Hz and at a smooth 6 dB/octave at low frequencies. The response was measured with 1 volt applied to the phones, producing an average 120-dB SPL over the measurement range, which happens to agree exactly with the published specifications.

Normally, one would expect distortion to be a function of frequency, but the published specifications do not specify the test frequency. We measured the distortion at several frequencies between 200 Hz and 1000 Hz, where the output was both strong and smooth, at a 110-dB SPL. The distortion was typically between 1.2 and 1.6 percent and was principally second harmonic. In view of the high SPL used, this amount of distortion cannot be considered serious, even if it does slightly exceed the published rating.

The electrical impedance of the phones was an almost constant 20 ohms across the audio range. It gently rose to 25 ohms at 150 Hz and underwent a slight drop to a 16-ohm minimum at 20 Hz.

Comment. Since our first experience with open-air phones several years ago, we have enjoyed their special qualities—which eliminate many of the objections voiced about headphone listening (heavy weight and pressure exerted, inability to hear desired outside sounds, such as the ring of a telephone, etc.). The Model OA-3 phones embody all the virtues of a good open-air headphone and have a smooth response and the ability to handle high volume levels without objectionable distortion.

The vinyl-coated ear cushions make the Pickering phones a little less "open" to outside noises than are some other types that feature simple foam pads. In fact, in a quiet room, one might almost believe that the phones are the isolating type.

The low impedance and high efficiency of the phones makes them exceptionally well suited for use with small radio receivers and tape recorders.

CIRCLE NO. 67 ON READER SERVICE CARD

DRAKE MODEL SPR-4 COMMUNICATIONS RECEIVER
(A Hirsch-Houck Labs Report)

Versatile solid-state receiver for shortwave, amateur radio, CB

THE Drake Model SPR-4 solid-state communications receiver covers any 23 bands (each 100-kHz wide) between 150 kHz and 30 MHz. Thus, it offers the user reception of international SW, amateur radio, and CB radio transmissions, among others.

The receiver measures 12¼ in. deep by 10¾ in. wide by 5½ in. high (31.1 × 27.3×14 cm) and weighs 18 lb (8.2 kg). Its built-in 5-in. by 3-in (12.7 × 7.6-cm) speaker is mounted on the left side of the metal receiver cabinet. The price of the Model SPR-4 receiver is $579. Various crystal kits are available for the amateur radio, marine, aeronautical, MARS, Citizens Radio, and other special-interest bands. The external optional speaker, 100-kHz calibrator, and noise blanker are priced at, respectively, $22, $20, and $65.

Technical Details. The receiver employs a double-conversion superheterodyne design. Its first i-f of 5645 kHz is obtained by the mixed product of a crystal oscillator selected by the band switch, while a stable permeability-tuned oscillator (PTO) takes care of the 4955-kHz to 5466-kHz range. The PTO alone is used for the lowest-frequency band.

Following the first mixer, selectivity is provided by a crystal filter, and the signal goes without further amplification to the second mixer. Here, it is converted by a crystal oscillator (with switched crystals for USB and LSB reception) to 50 kHz. Then a four-pole LC filter and a tunable-notch filter provide additional selectivity. After two stages of i-f amplification, the signal goes to a product detector for

SSB and CW or a separate diode detector for AM. The audio amplifier is rated at 3 watts output into a 4-ohm speaker load.

The PTO's dial is calibrated at 1-kHz intervals from 0 to 500, with about 50 kHz of "overrun" at each end. The dial's reference mark can be shifted to calibrate the receiver precisely to any known frequency. At the upper center of the receiver's front panel is a small opening for the frequency range dial, which is marked to indicate each of the 10 basic bands, together with the appropriate settings of the RANGE switch and the PRESELECTOR control knob. Decals are supplied for the 13 blank spaces on the dial, to be added when other crystals are installed.

The front-panel controls include concentric a-f and r-f gain controls, mode switch (with positions for AM CW, LSB, and USB), and an accessory switch. The last activates an optional 100-kHz crystal calibrator and i-f noise blanker when they are installed. Concentric with the accessory switch is a knob that is used to tune the rejection notch filter through the i-f passband to reduce interference from heterodynes.

On the rear apron of the receiver are phono jacks for the antenna and muting connections and an audio in/out jack that can be used either to supply a signal to a tape recorder, ahead of the volume control, or to amplify an external signal through the SPR-4's amplifier. There is also a 120/240-volt line selector and a switch that disables the dial lights for low battery drain (only 2.5 watts at 12 volts).

Laboratory Measurements. The Model SPR-4 receiver has sensitivity ratings for a 10-dB (S + N)/N ratio of 0.25 µV on CW and SSB and 0.5 µV for AM at 30 percent modulation. We measured the sensitivity at the center of each band (except the two lowest where the input impedance is too high to match our signal generator). It proved to be substantially better than claimed and varied little from band to band.

The CW sensitivity measured better than 0.15 µV throughout and about 0.1 µV on most bands. The SSB sensitivity was typically about 0.18 µV and reached 0.22 µV on the highest and lowest frequency bands tested. The AM sensitivity was better than 0.35 µV and was typically a little better than 0.30 µV.

The agc is stated to hold the audio level within 6 dB for an input signal variation of 100 dB. We were able to check it over only an 86-dB signal range, where it varied by only 3.2 dB. The i-f bandwidths at the −6-dB points were essentially as rated: 4.8 kHz on AM, 2.4 kHz on SSB, and 0.4 kHz on CW.

The dial calibration was within 1 kHz on all bands, even without "zeroing" the dial on each range as recommended. When we set the zero at either end of the tuning range, the dial was about as accurate as it could be read—certainly within 200 Hz at all points. And there was no discernible drift over extended periods; the rating, incidentally, is less than ±100 Hz.

The S meter is, of course, a relative signal strength indicator. On the 7-MHz band, an input of 1.8 µV gave an S2 indication, while S9 was attained with only 17µV of input signal strength. This is by any standards a most "generous" meter. Furthermore, a reading of S9 + 20 dB required 38 µV, which is only about 6 dB greater than the S9 input. To reach S9 + 40 dB, we had to supply a 5500 μV input, which is actually 50 dB over the S9 input and 43 dB over the S9 + 20 input.

Comment. The Drake Model SPR-4 receiver, in spite of its deceptively simple appearance, is a highly sophisticated unit. It is not to be confused with the many low-priced "communication receivers" directed toward the young SWL and novice ham. It may be simple enough to be operated by beginners, but it is obviously meant for the advanced SWL, while also offering excellent flexibility for the intermediate and advanced operator.

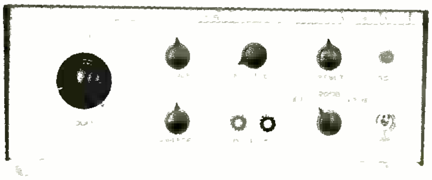
The SWL in search of an elusive DX station can set the dial to the station's frequency with complete assurance that he is tuned to what the dial says. In addition, if his antenna and propagation conditions are right, he will surely hear the station he is after—assuming, of course, it is on the air.

If you plan to buy the Model SPR-4 receiver, we feel you should seriously consider including the optional crystal calibrator in your order. Without it, the receiver will probably be tuned to within a kilohertz of the indicated frequency, but why settle for that when it can be "on the nose?"

CIRCLE NO. 68 ON READER SERVICE CARD

AMERICAN CIRCUITS & SYSTEMS MODEL MK1 FUNCTION GENERATOR

Sine, square, or triangle waveforms from 6 Hz to beyond 1.25 MHz



THANKS to low-cost integrated circuits and new approaches in design, a very important change is taking place in audio (and digital) signal generators. Until fairly recently, audio signal generators simply provided sine and square waves that were variable in level and covered a frequency range of about 20 Hz to 100,000 Hz. The new "function" generators that have begun to make their appearance, by contrast, provide sine, square, and triangle (or ramp) waves over a range of about 10 Hz to 1 MHz and beyond.

One good example of a low-cost function generator is the Model MK1 made by American Circuits & Systems, Inc. The MK1 sells for $135 in kit form. It is also available factory-wired, tested, and adjusted for $195.

The Model MK1 function generator features sine-, square-, and triangle-wave outputs that are selectable by a WAVEFORM switch. The waveforms, available at a pair of color-coded binding posts on the front panel, are continuously variable from 0 to 20 volts peak-to-peak via an AMPLITUDE control. Another control, labelled ATTENUATE, can be used to provide 0, 20, or 40 dB or attenuation.

Built into the instrument is a dc OFFSET control that permits the ac signal to be dc biased anywhere from +10 to −10 volt into an open circuit (±5 volts into 600 ohms).

Selecting a frequency is a two-step process: First, the RANGE switch must be set to the desired position (X10, X100, X1K, X10K, X100K). Then, the FREQUENCY control, calibrated in equally spaced increments from 0.9 to 11, is set for the desired frequency. Hence, if you wanted a 5000-Hz output frequency, you would set the RANGE switch to X1K and the FREQUENCY control to 5. (The actual range of the MK1 is from less than 10 Hz to beyond 1.1 MHz.)

On the rear panel of the instrument is a TTL output jack that provides a TTL-compatible signal of the same frequency as that at the OUTPUT binding posts on the front panel. The logic-0 and logic-1 levels of this signal are 0 and +5 volts, respectively. (CMOS logic can be driven directly from the OUTPUT binding posts.)

Also on the rear panel is a VCO input jack that virtually doubles the versatility of the function generator. With the appropriate inputs applied to this jack, the output can be swept through a range of frequencies, be frequency modulated with tone or voice, or be frequency shift keyed.

Within the instrument itself are six IC's, two of which are precision voltage regulators, with the remainder being linear devices. The power supply employs circuit-protecting fusing and operator-protected three-conductor line cord.

Kit Details. We selected the Model MK1 function generator kit for our test report. Upon opening the carton in which it arrived, we were gratified to note that all components were of premium quality. Most of the resistors, even some in noncritical parts of the circuit, were of 5-percent tolerance, while the trimmer potentiometers that serve as hidden set-up controls were of OEM quality. The large printed circuit board on which the majority of the components are mounted is made from G-10 epoxy fiberglass.

Assembly is simple and straightforward, guided by clear step-by-step instructions and detailed drawings.

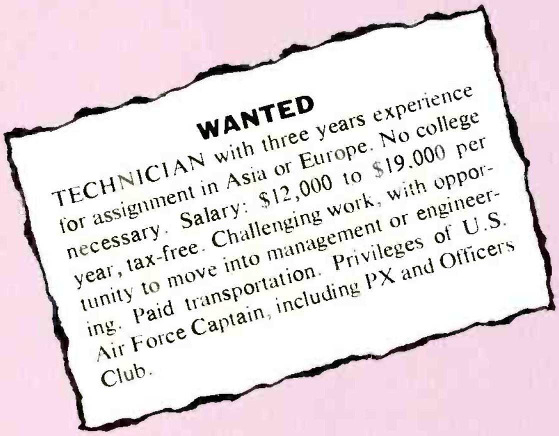
The only test instruments needed to put the function generator into service order are a multimeter (for the voltage checks) and an oscilloscope (for distortion adjustments). A frequency counter comes in handy, but is not necessary, for calibration. (Three methods of calibration are detailed in the instructions.) Using the scope, the sine-wave distortion can be set within a few percent of optimum, while it can be fully optimized with the aid of a distortion meter.

After Assembly. Once the function generator was ready to be put into service, we subjected it to a few tests. Using a precision frequency counter, we determined that its frequency range was from 6 Hz to 1.254 MHz in five overlapping bands. The FREQUENCY control's dial calibration was well within the specified ±5-percent figure over almost the entire range.

The amplitude of the output signals could be adjusted from 0 to slightly more than 20 volts peak-to-peak, while the dc offset was adjustable to its specified ±10-volt limits into an open circuit. Triangle waveform linearity was better than 1 percent between 10 Hz and 100 kHz and about 2.8 percent maximum from 100 kHz to 1 MHz. Without using a distortion meter, the distortion in the sine-wave function averaged an excellent 6 percent. When a distortion meter was used, the figure could be optimized at 2.4 percent. All other specifications were met or exceeded.

Comment. The American Circuit & Systems Model MK1 function generator is an excellent buy, particularly in kit form. It offers a quality and versatility that should appeal to the audio or digital experimenter and service technician.

CIRCLE NO. 69 ON READER SERVICE CARD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TECHNICIAN with three years experience for assignment in Asia or Europe. No college necessary. Salary: $12,000 to $19,000 per year, tax-free. Challenging work, with opportunity to move into management or engineering. Paid transportation. Privileges of U.S. Air Force Captain, including PX and Officers Club.

CAREER OPPORTUNITIES FOR THE TECH REP

BY ALLAN C. STOVER

If you read an ad like the above in the classified section of your newspaper, you might think it was too good to be true. However, it accurately describes many technical representative and field engineering opportunities available in the electronics field. On the whole, a tech rep job pays well, offers excellent opportunities for travel, and encompasses a number of duties.

A tech rep is hired by an electronics company which, in turn, sells his services where needed. The U.S. Government, private industry, and local and foreign governments sometimes need electronics technicians for special projects. So, they often sign a contract for enough tech reps to get the job done. The contract might call for the tech reps to do anything from teaching a Job Corps class in New Jersey to manning a lonely tropospheric scatter site in Thailand.

On the job, a tech rep's work varies from assignment to assignment. On one assignment, he might be an advisor, telling a crew of workers what to do. On his next assignment, his job might be to teach a group of students or working technicians the theory and operation of new avionics equipment. Then again, he might operate and maintain a communications system. Most tech reps are called upon to do a bit of everything. In a typical month, he might spend a few days each at teaching a class in electronics theory and practices, helping out on installing or renovating electronics gear, and repairing a radio or radar system.

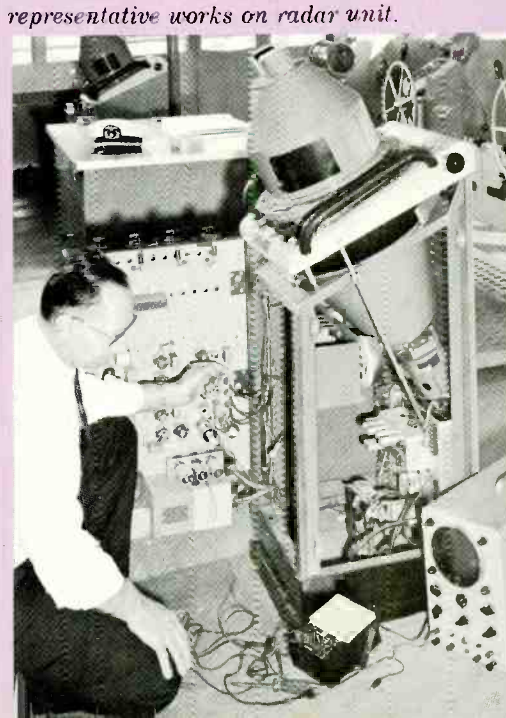
Tech reps have been known to operate, maintain, and repair computers, avionics equipment, radar gear, communications systems, test equipment, navigational aids, and just about everything else that uses electronic circuitry. One tech rep might specialize, his duties confined to repairing a single complex transceiver model, while another might be called upon to repair a dozen or so different models and types of equipment. Some tech reps specialize in teaching.

An assignment might put a tech rep in the heart of downtown Manila, right in the midst of civilization. On the other hand, assignment locations can be lonely and far from the amenities of civilization, such as in the heart of a jungle or atop a mountain. Assignments can be almost permanent or highly mobile, depending on the contract. Some tech reps stay in the same location for years, while others must pack up and move to a new location every few months.

Most tech reps enjoy their assignments, but few find "paradise." The Manager of International Recruiting for Page Communications Engineers says, "One word of caution to those who are tempted to cast all aside and dash off to unknown places: To the neophyte who expects to find all the creature comforts he is accustomed to, my advice is to look before he leaps. Instead of some pleasurable off-duty relaxation in exotic Bankok, he might find himself repairing a radio (transmitter) on an isolated mountaintop in Iran."

Electronics companies employ thousands of tech reps, stationing them in every corner of the world. You can find tech reps in almost every state of the Union, Germany, on the island of Crete, in Taiwan, Ethiopia, and Iran, Vietnam and Korea, Spain, Turkey, the Philippines, New Guinea, Jamaica, the Arctic, and on some Pacific islands, and aboard ships and submarines.

RCA Service Co. Technical Services representative works on radar unit.



What and Where. ITT's Federal Electric Corporation ships their tech reps all over the world. Sometimes they include tech rep services as part of a contract for new equipment. In December 1973, Federal Electric signed $56-million worth of new contracts and renewals, which gives an idea of the size of the corporation's operations. Here are a few of the hundreds of jobs the Federal Electric tech reps have handled:

They have installed a microwave communications system in South Vietnam. (The South Vietnam government issued a stamp in their honor.) In Italy, Germany, France, Belgium, England, and the Netherlands, they installed a tropospheric scatter system. For years, they have operated and maintained DEWLine (Distant Early Warning Line) sites ranging from Iceland and Greenland to northern Alaska in some of the bleakest and frostiest locations inhabited by man. The Federal Electric Corporation has held this contract since 1956—almost two decades.

Federal Electric tech reps performed operational and maintenance services as the prime contractor on the Air Force's Western Test Range, where they manned range tracking ships and stations, among other things. They installed a computerized reservations system in the British Overseas Airways Corporation's offices in New York.

Tech reps from RCA Service Company have tackled hundreds of different jobs in as many different places all over the world.

A satellite ground station was installed in the People's Republic of China. They operated and maintained a tracking site in the Arctic, and they operated and maintained missile tracking stations on islands in the Atlantic Ocean for the Air Force's Eastern Test Range.

The RCA teach reps gave technical assistance and training to the Philippine, South Korean, Ethiopian, and Spanish air forces.

Salaries and Extras. Most companies pay their tech reps well. Base pay usually is on an average with a good technician, but "extras" can push the total-package up to more than what the average electronics engineer earns, from $10,500 to $19,000 per year. Overtime can run these figures even higher. The extras depend on the company the tech rep works for and the assignment on which he is sent. Examples of extras include:

Per Diem: A daily allowance that is designed to repay the tech rep for most of his extra expenses. It covers hotels, meals, cleaning bills, tips, and other expenses. Per diem is usually a flat rate; so, if a tech rep cuts corners, he can pocket the money he saves. The per diem rate runs from a few dollars up to and beyond $25 per day. Some companies pay per diem for as long as the tech rep remains on the assignment, while others pay it for three to six months only. Still other companies pay per diem only when the tech rep travels on business away from his regular assignment. A few companies pay the tech rep's actual expenses instead of per diem.

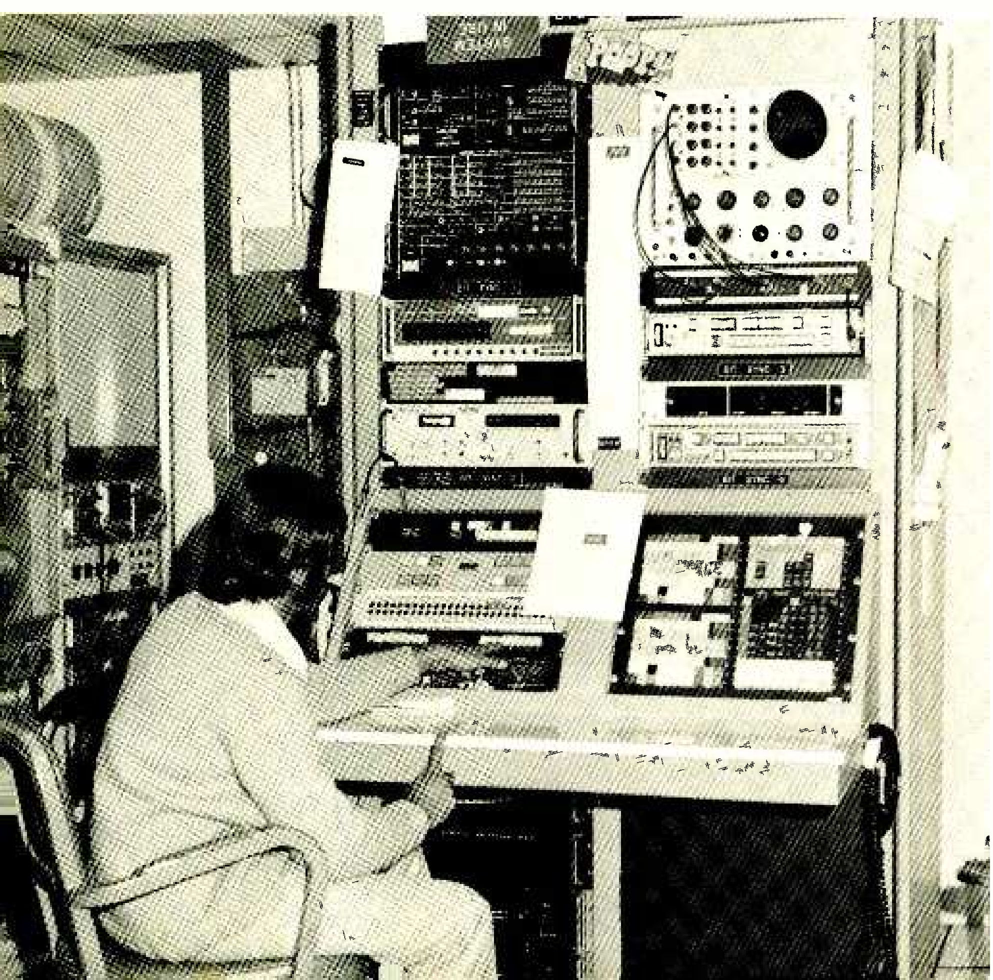
Cost-of-Living Allowance (COLA): A few companies pay COLA to cover the difference in living costs between a U.S. city and an overseas location. The COLA in Tokyo, the world's most expensive city in which to live, can run hundreds of dollars a month. One company gives a flat 30 percent of base pay no matter where they assign a tech rep. Some U.S. Air Force contracts direct the local military disbursement officer to pay a COLA to each rep. COLA can start at $7 per day on some contracts.

Bonuses: Some companies pay a flat bonus for overseas service. It can be 10 percent of base pay or $125 per month, depending on the company for which the tech rep works. Some companies pay a bonus that depends on the location of the assignment; a tech rep who lives in a soggy tent in South Vietnam gets a bigger bonus than one who works in downtown Brussels.

This patchwork of pay and allowances makes it difficult to predict a tech rep's pay package. But the average paycheck for tech reps, all extras considered, runs from $12,000 to $16,000 per year, with some reps receiving salaries above and other below these figures.

The tech rep who works overseas has an opportunity to take advantage of one of the juiciest Internal Revenue tax laws ever written. If he spends 510 days (about 17 months) out of 18 months outside the U.S., up to $20,000

RCA Service Co. Government Services Technician works on Meteorological Data Handling System Center's computer control console at the Goddard Space Flight Center.



of his yearly income during that period is tax-free! If his company withholds any taxes, the tech rep claims a refund.

Other privileges sweeten the picture even more. Most military contracts with overseas assignments grant the tech rep most of the privileges of a captain. This means that he can live in the Bachelor Officers Quarters, eat and drink in the Officers Club, and shop in the PX and commissary.

The company handles the tech rep's transportation to his assignments. In return for paying per diem while the man is en route to his assignments, the company requires him to spend at least a year on assignment. Should the tech rep decide to terminate his employment before the year is up, he must pay back all the company spent on getting him to his assignment.

Becoming a Tech Rep. The qualifications for becoming a tech rep are surprisingly light. Only a handful of positions call for an engineering degree. Most require only technician-level electronics training and three to five years of specialized practical experience. If you worked on a new system in the armed forces, no matter what your rank, you stand an excellent chance of landing a tech rep job. Many companies train some tech reps, but most prefer to hire the man who already has the knowledge and practical experience to go right to work.

If you live near an electronics company that hires men for tech rep positions, apply in person. Alternatively, you can type up a resume and mail it to the companies that hire tech reps and field engineers. (Consult the want ads in your newspaper for addresses.) If your background fits in with a company's needs, you will receive a job application form in the mail or be hired on the spot. (When making up your resume, keep it down to two pages. Just give the facts about education and experience and some personal data.)

The personal data in your resume should include full name, age and date of birth, marital status, state of health, and dates of military service, if any. Under education, list all schools you attended in which you received training for the type of work you are applying for. Include resident, home-study, and military courses taken, detailing the titles of the courses and types of equipment you studied.

When giving details of your work experience, start with your present position and work back in time. List job titles, the dates you held the positions, and short descriptions of your work duties. List the names and model numbers of all the equipment with which you are familiar. Also, mention any achievements and awards you have received or earned.

Who Needs Tech Reps? Scores of large and small companies need qualified men to serve as tech reps. As a rule of thumb, try the large companies first. If you think you can qualify for the work, you might try the following three companies first:

Federal Electric Corp., 621 Industrial Ave., Paramus, NJ 07652. (Address correspondence to the attention of Mr. Ridings, Director, Field Services.)

Page Communications Engineers, Inc., Vienna, VA 22180. (Attn.: Manager, International Recuiting)

RCA Service Co., Camden, NJ 08101.

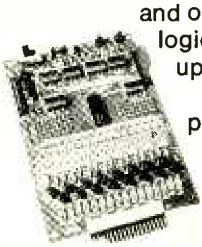
If these companies do not need your talents, try Bendix, Philco-Ford, and Kentron. ◈

There's a new Heathkit everyone on

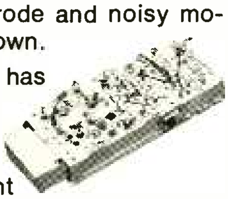
The Heathkit Digital Color TV is for two kinds of people

... those who understand electronics, and those who don't

People who understand electronics will appreciate the GR-2000's advanced digital design, incorporating on-screen channel readout and optional clock. Digital logic circuitry programs up to 16 stations in any sequence. Then just press a button—you'll never have to switch through a "dead" channel again. And our exclusive VHF/UHF varactor tuner eliminates clunking contacts that corrode and noisy motors that break down.



The GR-2000 also has the industry's first fixed-filter IF amplifier. There's no need for instrument IF alignment ever, so the picture stays bright and clear year after year. And even in urban areas where stations are packed closely together, there's virtually no adjacent channel interference.



The 100% solid-state chassis uses 19 integrated circuits—more than any other TV around. You'll get superior performance and reliability no conventional set can match.

A built-in dot generator and test meter make it easy to keep the GR-2000 in peak condition without expensive service calls. The slide-out service drawer and hinged, swing-out chassis put everything in easy reach. If anything ever goes wrong, an extensive trouble-shooting guide will help you fix it.

And people who don't understand electronics will enjoy the best looking picture around. *Popular Electronics* said the picture on the 25″ (diagonal) screen "can only be described as superb. The Black (Negative) Matrix CRT, the tuner and IF strip, and the video amplifier provide a picture equal to that of many studio monitors..."

Everyone likes the on-screen readout that puts the channel number into the picture whenever you want it. When you change channels or touch the recall button, the big, bright digits reappear. Add the optional clock module and you'll see the time as well as the channel.

The optional wireless remote control makes the GR-2000 even more enjoyable. Change channels, adjust the volume, set tint and color intensity and turn the set on or off from across the room. And, a touch of the Volume bar automatically returns the digital readout to the screen momentarily. It's an amazing handful of convenience.

Even if you don't have a lot of kit-building experience, you'll enjoy the GR-2000. Illustrated step-by-step instructions, prefabricated wiring harnesses, transistor and IC sockets and modular circuit boards greatly simplify assembly.

See the TV the experts are talking about. *Popular Electronics* summed it all up: "In our view, the color TV of the future is here—and Heath's GR-2000 is it!"

GR-2000—the TV everyone can appreciate.

Mail order price for chassis and tube, $669.95. Remote control, $89.95, mail order.

Cabinets start at $154.95, mail order. (Retail prices slightly higher.)

Christmas gift for your list

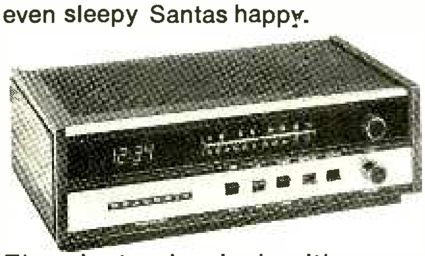
Our new Heathkit Desktop Electronic Sliderule Solves Your Gift-Giving Problems

Give your scientist, engineer or student a gift he'll use all year long. Finger-sized keys and 8 bright ½" digits make it easier to use than pocket calculators. Cumulative memory and register exchanges virtually eliminate scratchpad work. Performs arithmetic plus trig and arc trig in degrees or radians, common and natural logs,

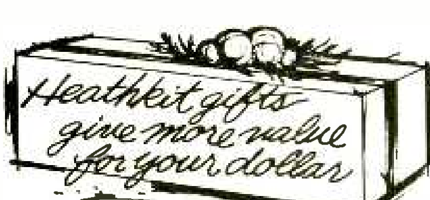
powers of e, square roots, inverses, pi and exponential functions. **Kit IC-2100,** 4 lbs., mailable . . **119.95***

Unique New Heathkit AM/FM Digital Clock Radio

Our outstanding clock radio makes even sleepy Santas happy.



The electronic clock with snooze alarm features a gentle "beep" with adjustable volume. Or wake to the component-quality AM/FM radio. Standby batteries (not included) keep the clock on time during power interruptions. **Kit GR-1075,** 10 lbs., mailable **129.95***

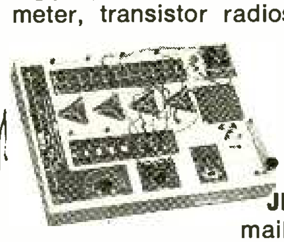


New Heathkit Aircraft Strobe

A bright idea for the pilot on your list—or for anyone who needs an emergency marine or marker light. It meets FAR 23.1401 and assembles easily in just one evening. For 12 VDC neg. ground. With clear lens, optional red and red/clear lenses available. **Kit OL-1155,** 3 lbs., mailable **54.95***

Learning's Fun With Our New Heathkit "Electronics Workshop"

The JK-18A teaches kids electronics the easy learn-by-doing way. 35 exciting projects include light meter, sound meter, transistor radios. For safety, it's battery powered and requires no soldering. (Batteries not included) **Kit JK-18A,** 10 lbs., mailable . . **34.95***



New Heathkit Electronic Clock/Timer for Car, Boat or Plane

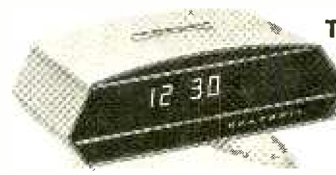
A timely gift—an electronic clock and a 20-hour rally timer, both with quartz crystal accuracy. Bright ½"-tall digits dim automatically at night. 12 VDC, mounts on or under dash. **Kit GC-1093,** 2 lbs., mailable **62.95***

Two Heathkit Electronic Clocks with Standby Power

Two beautiful gifts—the GC-1092A is a clock with a snooze alarm; the GC-1092D reads the time in 6 digits, the month and date in 4 digits. Both have standby power to keep the clock on time without the display even during temporary power interruptions. (Batteries not included.) **Kit GC-1092A or D,** 5 lbs., mailable . . . . . .**each 82.95***

Time/Alarm

Time/Date



Heathkit Exhaust Analyzer Checks Your Car's Tune Up

Make everyone's Christmas whiter and cleaner—be sure your tune up is helping clean up the environment. Big 4½" meter reads relative combustion efficiency, air-fuel ratio and percentage carbon monoxide.

Kit CI-1080, 6 lbs., mailable . . . **59.95***

Exciting new Heathkit Christmas giving

new Heathkit dual-trace DC-15MHz scope

Compare the features:

- Dual-trace with true X-Y capability
- 1 mV/cm vertical sensitivity over the full bandwidth
- Post-deflection accelerated CRT for bright trace, fast writing
- Vertical amplifier delay lines for pulse analysis capability
- Digitally controlled triggering for exceptional stability
  - Typically triggers up to 45 MHz—guaranteed to 30 MHz

It offers a lot more than just a low price

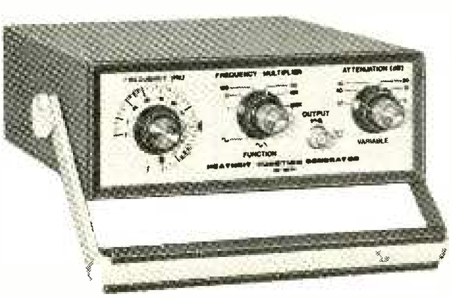
The Heathkit IO-4510 is your best 'scope buy for two good reasons—it does more and it costs less.

Time base sweep up to 100 nsec/cm. There's always a reference baseline, even when there's no trigger signal. The time base can be precisely triggered at any point along the positive or negative slope of the trigger signal. In automatic mode, it triggers at the zero crossing point.

Modes of display. Either channel can be displayed as a function of time or both can be displayed together. In X-Y operation, channel 1 provides horizontal deflection and channel 2 provides vertical deflection. There are 22 calibrated time bases from 0.2 sec/cm to 0.1 μsec/cm. The sweep speed is continuously variable between switch positions. Any speed can be expanded five times by pulling out the control knob.

For easy calibration, a 1 volt peak-to-peak square wave is available on the front panel. The regulated supply operates from 100-280-volt AC power. **Kit IO-4510,** 34 lbs., mailable **549.95***

Assembled SO-4510, factory-wired & calibrated version of the IO-4510, 34 lbs., mailable **750.00***



New Low-Cost Heathkit Function Generator

A true function generator, not an oscillator, delivers sine, square and triangle waveforms from 0.1 Hz to 1 MHz. Short-proof output supplies 10 volts peak-to-peak into 50-ohm load. A calibrated step attenuator adjusts from 0-50 dB (10V to 30 mV) in 10 dB steps. A variable control provides up to 20 dB of additional attenuation at each step. Attenuator accuracy is ±1 dB; frequency accuracy is ±3%. Nonlinearity of the triangle waveform is 5% max., symmetry is within 10%. Sine wave THD is 3% max. from 5-100k Hz. Square wave rise and fall times are 100 nsec max. 105-130 or 210-260 VAC. **Kit IG-1271,** 7 lbs., mailable **99.95***

Assembled SG-1271, factory-wired & calibrated version of IG-1271, 7 lbs., mailable **140.00***

projects-timed for

Coming in December...

A new generation of Heathkit ham radio equipment

New Heathkit SB-104 transceiver

Years ahead in design & features — the SB-104 is a complete rethinking of what a CW/SSB transceiver should be. It utilizes the latest digital & solid-state technologies. The "104" is completely solid-state from the front end to the RF output.

Totally broadbanded. You can switch from 3 to 30 MHz without preselector, load or tune controls.

True digital readout with 6 bright digits to indicate the frequency with accuracy to 100 Hz.

Mobile-ready. The SB-104 operates from 12 VDC, so it's ready to go mobile when you are. Optional features include a plug-in digital noise blanker and 400 Hz crystal filter for CW.

Just about the only things that aren't totally new about the "104" are the quality and easy assembly that have made Heath famous. **Kit SB-104,** 31 lbs., mailable **669.95***

Kit SBA-104-3, 400 Hz CW crystal filter for SB-104, 1 lb., mailable **34.95**

Kit SBA-104-1, digital noise blanker for SB-104, 1 lb., mailable **24.95***

Kit SBA-104-2, mobile mount, 6 lbs., mailable **34.95***

New Heathkit SB-230 1 kW conduction-cooled linear

High-power match for the SB-104. Lowest cost conduction cooled linear on the market. 1200 watts PEP and 1000 watts CW from less than 100 watts input. It's also rated at 400 watts input for slow-scan TV and RTTY. And absolutely silent — no blowers, no fans.

Full metering of relative power, plate current, grid current and plate high voltage. Safety features include microswitch interlocks for top and bottom shells, thermal shutdown, fused cathode, on/off switch with circuit breaker for power transformer.

On the air in 15 to 20 hours. Fast, easy assembly, then check it out with an ohmmeter — no alignment necessary. **Kit SB-230,** 40 lbs., mailable **319.95***

New Heathkit SB-614 station monitor scope

How clean is your signal? The bright 1½ x 2" screen helps you keep your rig in peak condition. Reveals a wide variety of operating problems — nonlinearity, insufficient or excessive drive, carrier or sideband suppression problems, regeneration and key clicks. Monitors AM, SSB and CW signals up to 1 kW from 80 to 6 meters. **Kit SB-614,** 17 lbs., mailable.......... **139.95***

New Heathkit 5-Function SB-634 station console

Five accessories in one — a 24-hour 6-digit electronic clock, a ten-minute digital ID timer with visual and/or audible alarms, RF wattmeter, SWR bridge, hybrid phone patch with manual and VOX controls. **Kit SB-634,** 14 lbs., mailable **179.95***

New Heathkit SB-644 remote VFO

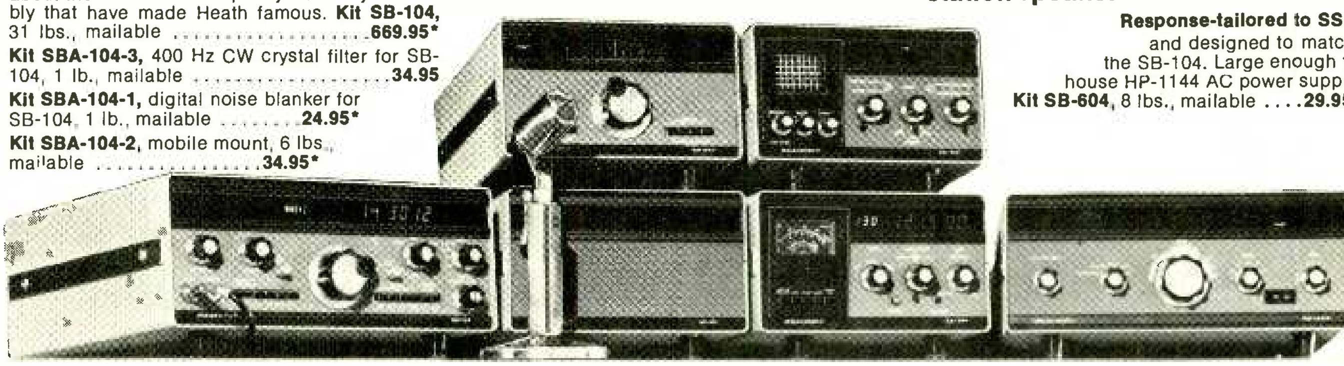
Designed exclusive for SB-104, it provides the ultimate in multi-mode operation with two crystal sockets for fixed frequencies. No modifications — just plug the VFO into the "104" and go — VFO frequency even reads out on the 104's digital display. **Kit SB-644,** 10 lbs., mailable **119.95***

New Heathkit Fixed station AC power supply

Powers the SB-104 from 120 or 240 VAC. Sophisticated regulation assures almost no change in voltage from no load to full load. Entire supply fits inside SB-604 speaker cabinet. **Kit HP-1144,** 28 lbs., mailable **89.95***

New Heathkit SB-604 station speaker

Response-tailored to SSB and designed to match the SB-104. Large enough to house HP-1144 AC power supply. **Kit SB-604,** 8 lbs., mailable **29.95***



HEATHKIT ELECTRONIC CENTERS —
Units of Schlumberger Products Corporation
Retail prices slightly higher.

ARIZ.: Phoenix; CALIF.: Anaheim, El Cerrito, Los Angeles, Pomona, Redwood City, San Diego (La Mesa), Woodland Hills; COLO.: Denver; CONN.: Hartford (Avon); FLA.: Miami (Hialeah), Tampa; GA.: Atlanta; ILL.: Chicago, Downers Grove; IND.: Indianapolis; KANSAS: Kansas City (Mission); KY.: Louisville; LA.: New Orleans (Kenner); MD.: Baltimore, Rockville; MASS.: Boston (Wellesley); MICH.: Detroit; MINN.: Minneapolis (Hopkins); MO.: St. Louis (Bridgeton); NEB.: Omaha; N.J.: Fair Lawn; N.Y.: Buffalo (Amherst), New York City, Jericho, L.I., Rochester, White Plains; OHIO: Cincinnati (Woodlawn), Cleveland, Columbus; PA.: Philadelphia, Pittsburgh; R.I.: Providence (Warwick); TEXAS: Dallas, Houston; WASH.: Seattle; WIS.: Milwaukee.

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Send for your FREE 1975 catalog today.

☐ Please send my free 1975 Heathkit Catalog.
☐ Please send the merchandise checked below. I've enclosed $__________, plus shipping, in payment.

- ☐ GR-2000 Color TV
- ☐ GRA-2000-1 Digital clock module
- ☐ GRA-2000-6 TV remote control
- ☐ IC-2100 Calculator
- ☐ CI-1080 Exhaust analyzer
- ☐ GR-1075 Digital clock radio
- ☐ GC-1093 Digital car clock/timer
- ☐ JK-18A Junior electronics workshop
- ☐ GC-1092A Digital clock with snooze alarm
- ☐ GC-1092D Digital clock with date display
- ☐ IO-4510 Oscilloscope (kit)
- ☐ SO-4510 Oscilloscope (assembled)
- ☐ IG-1271 Function generator (kit)
- ☐ SG-1271 Function generator (assembled)
- ☐ SB-104 Transceiver
- ☐ SB-104-1 Noise blanker
- ☐ SB-104-2 Mobile mount
- ☐ SB-104-3 CW crystal filter
- ☐ SB-230 1 kW linear
- ☐ SB-614 Monitor scope
- ☐ SB-634 Station monitor
- ☐ SB-644 Remote VFO
- ☐ HP-1144 AC power supply
- ☐ SB-604 Station speaker

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CIRCLE NO. 5 ON READERS SERVICE CARD

COMPUTER TERMINALS ARE COMING

BY LESLIE SOLOMON
Technical Editor

THE sales and complexity of electronic calculators seem to be rising exponentially. Practically every month, new models appear with more functions available. Some of the new ones are more like mini-computers than calculators.

Where will it all end? Someday, each of us will probably have his own full-blown computer. For the foreseeable future, however, such a computer would be a trifle large for the average home; and the price would be out of reach for almost everyone. But there is a way of having the use of a full-blown computer without buying your own. All you need is a "computer terminal."

A computer terminal looks like a desk calculator, has a typewriter keyboard with a few extra keys, and is equipped with alphanumeric readout. The terminal shown in the photo is typical of those now being made available at reasonable cost. The input/output connections to the terminal are made through some form of conventional telephone-line coupler. For the unit shown here, the coupling is made by dropping the phone into a special cradle.

To operate a terminal, the user simply dials his local time-shared computer company (usually found in the Yellow Pages) and places the phone in the cradle. The remote computer then "answers" the phone; and after the terminal operator enters his private billing number and the computer verifies it, the operator is signalled to start his entry. What can the operator do? Just about anything of which the expensive computer on the other end is capable—which is quite a bit.

Since the computer is expensive, operating time costs would be very high if it were not for the use of "time-sharing" techniques. This means that a number of terminals are using the same computer but sharing its time. The computer switches from one terminal to another so fast that it appears that each terminal is the only one using the computer. This lowers the user price to between $9 and $30 per month installation fee plus anywhere from $2 to $8 per hour of actual computer time. The user also pays conventional telephone rates for the use of the line, just as he would if he were making a conventional call.

It might appear that the hourly use charge is high. However, if a problem is laid out first, it takes very little time for it to be typed in; and then the answer should return within seconds. A lot of information can pass through such a system in a couple of minutes. Then, the time used is cumulative. That is, the user pays only for the accumulated computer time — a couple of minutes here, a couple of minutes later, etc. The system does not have to be operated for an hour at a time.

What can a computer do for you? Obviously it can provide a complete household or business accounting system in which all purchases, sales, etc., are broken down into various areas for tax purposes. A record of all financial statements, income, expenses, material, etc., is kept in the electronic files. With an available memory of up to 100,000,000 words, quite a bit of information can be stored for future recall by the customer.

How good is security? Can some outsider get a look at your private files? Precautions are generally taken to prevent unauthorized readout. Each customer has a private entry code that he alone can use to gain entry to his portion of the computer. This private code is never displayed on the alphanumeric readout so it remains a secret even if someone is watching the operator at his console.

Some time-sharing companies have special "programs" for their subscribers. Some companies, for example, specialize in engineering areas, supplying subscribers with a list of programs available. The program might be a complete analysis of a particular problem, and all you do is insert your own numbers. You do not have to be familiar with the mathematics involved; the computer takes care of that. For example, assume a transistor amplifier is to be designed or a bandpass filter using an op amp is needed. When you call the program, the terminal readouts will "ask" certain questions regarding input, voltages, stage gain requirements, output desired, and so forth. Once you insert your requirements in answer to the computer, your circuit will be designed in seconds, with all components identified. It is like having an engineering textbook come to life, solving all the problems and supplying all the answers.

There are educational programs for children in which the computer takes on the role of teacher. Children can learn math or other subjects and ask all the questions they want from a teacher having infinite patience. The computer will "talk back" when the student does something wrong, explain the problem, or give the correct answer.

There are also "game" programs in which various sports or games can be played between the computer and the operator. This is a powerful learning tool for students and an intellectual exercise. There will be programs in almost every area; and, as the library is expanded, notification will be sent to each subscriber.

What about cost? The MITS Computer 256 terminal is $595, complete with the acoustic coupler. This particular terminal will store 256 characters with expansion to 1026. Options to expand up to 3 pages are available.

An auto-transmit feature allows the user to transmit data or program material line-by-line instead of typing it directly into the computer, thus saving actual computer use time. The terminal also has a tape play/record feature that gives it a virtually unlimited memory capability. Almost any type of tape recorder can be used.

If you already have a digital computer, a hard wire connector is provided for direct connection to your own computer. If you don't own a computer, this connector will be used for some future add-on features to further expand the terminal. ◈

The MITS Comter 256.

ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR NOVEMBER 1974 TO FEBRUARY 1975

by Roger Legge

TO EASTERN NORTH AMERICA

(If Standard Time is restored, EDT times are one hour earlier than listed except the Melbourne 7:15 a.m. transmission.)

TIME–EDT	TIME–GMT	STATION	QUAL*	FREQUENCIES, MHz
7:00-8:15 a.m.	1100-1215	London, England	G	11.905, 15.07
7:00-9:00 a.m.	1200-1400	**VOA, Washington, U.S.A.	G	6.185, 9.565
7:15-8:45 a.m.	1115-1245	Melbourne, Australia	G	7.295, 9.58
7:30-8:00 a.m.	1130-1200	Jerusalem, Israel	F	12.025, 15.13
8:00-8:15 a.m.	1200-1215	Tokyo, Japan	F	5.99
8:00-8:55 a.m.	1200-1255	Montreal, Canada	G	5.97, 11.825
9:00-9:30 a.m.	1300-1330	**Bucharest, Romania	F	15.25
9:15-9:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
10:00-10:30 a.m.	1400-1430	Helsinki, Finland	G	15.185
		Stockholm, Sweden	G	17.71
10:30 a.m.-12:15 p.m.	1430-1615	London, England	G	17.84 (via Ascension Is.)
4:00-4:45 p.m.	2000-2045	Jerusalem, Israel	F	7.395, 9.495, 9.815
5:15-7:00 p.m.	2115-2300	London, England	G	5.975, 9.58, 15.26
5:30-6:50 p.m.	2130-2250	Hilversum, Holland	F	9.715, 11.73 (Sun.: Dutch)
6:30-8:20 p.m.	2230-0020	Johannesburg, S. Africa	G	9.585, 9.695, 11.90, 11.97
6:55-7:15 p.m.	2255-2315	Brussels, Belgium	F	6.055
7:00-8:30 p.m.	2300-0030	Moscow, U.S.S.R.	G	5.94, 7.15, 7.205, 9.685
7:45-8:45 p.m.	2345-0045	Tokyo, Japan	P	15.27, 15.445
8:00-8:30 p.m.	0000-0030	Tirana, Albania	G	7.065, 9.78
8:00-9:00 p.m.	0000-0100	Peking, China	F	9.94, 11.945
		Sofia, Bulgaria	F	6.07, 9.70
8:00-10:00 p.m.	0000-0200	**VOA, Washington, U.S.A.	G	6.13, 9.65, 11.83
8:30-9:00 p.m.	0030-0100	Stockholm, Sweden	P	6.00
8:30-9:00 p.m. Mo/Th/Sa	0030-0100 Tu/Fr/Su	Kiev, U.S.S.R.	G	5.94, 7.15, 7.205
8:30 p.m.-3:00 a.m.	0030-0700	HCJB, Quito, Ecuador	G	5.965, 9.56, 11.915
8:40-9:00 p.m.	0040-0100	Brussels, Belgium	F	6.055
9:00-9:15 p.m.	0100-0115	Vatican City	F	5.995, 9.605
9:00-9:20 p.m.	0100-0120	Rome, Italy	P	6.01, 9.575
9:00-9:30 p.m.	0100-0130	Budapest, Hungary	P	6.00, 9.833
9:00-9:45 p.m.	0100-0145	Berlin, DDR	P	5.955, 9.73
		Madrid, Spain	F	6.065
9:00-10:00 p.m.	0100-0200	Montreal, Canada	G	6.085, 9.755
		Peking, China	F	7.12, 9.78 (via Tirana)
		Prague, Czechoslovakia	F	5.93, 7.345, 9.54
9:00-11:00 p.m.	0100-0300	Melbourne, Australia	P	11.97, 15.32
9:00-11:30 p.m.	0100-0330	London, England	G	5.975, 7.325, 9.51
9:00-11:30 p.m.	0100-0330	Havana, Cuba	F	11.725, 11.93
9:00 p.m.-1:00 a.m.	0100-0500	Moscow, U.S.S.R.	F	5.94, 7.15, 7.165, 7.205
9:30-9:55 p.m.	0130-0155	Tirana, Albania	F	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
9:30-10:30 p.m.	0130-0230	Bucharest, Romania	P	5.99, 9.57
9:30-10:50 p.m.	0130-0250	Cologne, Germany	F	6.04, 6.075, 9.545, 9.69
9:45-10:15 p.m.	0145-0215	Berne, Switzerland	F	5.98, 6.12, 9.535
10:00-10:45 p.m.	0200-0245	Lisbon, Portugal	F	6.025
10:00-11:20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)
10:00-11:30 p.m.	0200-0330	Cairo, Egypt	P	9.475
10:30-11:00 p.m.	0230-0300	Beirut, Lebanon	P	9.66
11:00 p.m.-12 mdt	0300-0400	Buenos Aires, Argentina	F	9.69 (Mon.-Fri.)
		Peking, China	F	7.12, 9.78 (via Tirana)
		Prague, Czechoslovakia	F	5.93, 7.345, 9.54

TO WESTERN NORTH AMERICA

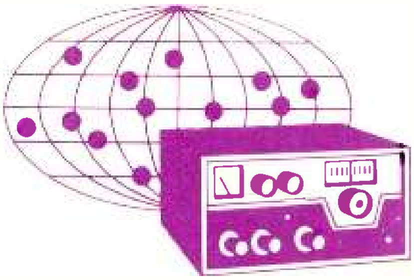
(If Standard Time is restored, PDT times are one hour earlier than listed.)

TIME-PDT	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
7:00-9:00 a.m.	1400-1600	**VOA Washington, U.S.A.	G	6.185, 9.565
8:00-8:15 a.m.	1500-1515	Tokyo, Japan	G	5.99
4:00-5:30 p.m.	2300-0030	London, England	G	6.175, 9.74 (via Canada)
5:00-7:00 p.m.	0000-0200	London, England	F	9.51, 15.26 (via Ascension Is.)
5:30- p.m.-12 mdt	0030-0700	HCJB, Quito, Ecuador	G	9.56, 11.915
6:00-7:00 p.m.	0100-0200	Peking, China	G	9.94, 11.945
6:00-8:00 p.m.	0100-0300	Melbourne, Australia	G	11.97, 15.32, 17.795
6:00-8:00 p.m.	0100-0300	Moscow, U.S.S.R.	G	12.05, 15.18 (via Khabarovsk)
6:30-7:30 p.m.	0130-0230	Tokyo, Japan	G	15.235, 15.445, 17.825
7:00-8:50 p.m.	0200-0350	Taipei, Taiwan	F	11.86, 15.125, 17.72
7:00-9:15 p.m.	0200-0415	London, England	F	9.51, 15.26 (via Ascension Is.)
7:30-8:00 p.m.	0230-0300	Stockholm, Sweden	P	6.045
8:00-8:30 p.m.	0300-0330	Seoul, Korea	F	11.925
8:00-10:00 p.m.	0300-0500	Peking, China	G	15.06, 17.735, 17.825
8:30 p.m.-12:30 a.m.	0330-0730	Moscow, U.S.S.R.	G	11.72, 12.05, 15.18 (via Khabarovsk)
9:00-9:15 p.m.	0400-0415	Tokyo, Japan	G	15.105
9:00-10:55 p.m.	0400-0555	Montreal, Canada	G	6.135, 9655
9:30-10:00 p.m.	0430-0500	Berne, Switzerland	P	5.98, 9.75
9:35-10:55 p.m.	0435-0555	Cologne, Germany	G	6.085, 9.605 (via Canada)
10:00-11:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715 (via Bonaire)
11:00-11:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
11:00 p.m.-12 mdt	0600-0700	Buenos Aires, Argentina	F	9.69 (Mon.-Fri.)
11:30 p.m.-1:00 a.m.	0630-0800	Havana, Cuba	F	9.525

*Reception quality (Virginia location, Collins Communications Receiver, L antenna): G-good, F-fair, P-poor
Reception quality of Western North America broadcasts is expected reception in California.

** Not intended for North America, but receivable satisfactorily.

Reception of many evening broadcasts are expected to be fair or poor during the winter months, due to low MUF's (Maximum Usable Frequencies), associated with the winter low of the 11-year sunspot cycle.



DX Listening

By Glenn Hauser

"SECRET" SW STATIONS

As winter approaches, static on the 2-3-MHz band declines, allowing us to hear some well-known broadcasters. Low-powered stations in Latin America, Africa and the Pacific inhabit the 120-meter tropical band (2300-2495 kHz); high-powered outlets in China and both Koreas spread beyond this range.

Usually closer but offering no less a challenge to DX are the *secret* shortwave stations! So secret are they that even the people operating them are in the dark (or if they are aware, they hope no one will notice).

We're talking about *harmonics* of mediumwave (standard AM broadcast) stations. By combining a good antenna and receiver system with lots of diligent delving into the residual noise level, you too can intercept these secret flea-powered broadcasts.

Even in the central USA, the great majority of harmonics heard originate in Latin America; this speaks highly for the harmonic-suppression standards of the FCC, probably the most rigid in the world.

A harmonic is not just *any* off-frequency reception of a station. It must be an exact integral multiple of the fundamental. Second harmonics (twice the fundamental) are by far the most common, since progressively smaller amounts of power are radiated as harmonic numbers go up.

The way to DX harmonics successfully is to *know* the 1.6-3.2-MHz band—so you can quickly eliminate everything that *isn't* a DX harmonic. If you live near a nighttime MW station, you probably can't help but hear its second and/or third harmonic. Whether transmitted, or the result of receiver overload on the fundamental, local harmonics are of no DX interest.

If you live near two or more nighttime MW stations, their mixing products may be audible. You can predict where most of them will show by summing each pair of fundamental frequencies, and by doubling one, and then subtracting another, in all possible combinations.

You can also eliminate any transmission not consisting of programming, such as hams, LORAN, radiolocation beeps, time signals, ship and shore, military nets, aircraft, RTTY, etc., etc.

This leaves the legit 120-m broadcasters. In the evenings, you'll hear mostly Venezuela, Brazil and Haiti; and Mexico and Guatemala fight it out only on 2390 kHz. Any other programming just about *has* to be harmonic!

When you suspect a harmonic, divide the measured frequency by 2 or 3 to see if its fundamental matches up with a known station. Then tune to the fundamental frequency; chances are you won't hear it there, but if you do, it should be under entirely different conditions of interference, fading and strength. Such a check will prove that you are receiving a transmitted harmonic, propagated on the frequency where you find it.

Don't give up if at first you don't succeed; the selection of harmonics is continually changing as different stations tweak their traps. *Do* report your harmonic DX to other enthusiasts, but *not* to the station! Once they learn their harmonic is getting out, they just might be moved to eliminate it permanently. Let's keep the secret.

DX Monographs. The National Radio Club has become quite a publisher, not only for its members but for a wider readership. Over the past few years, NRC has published many technical articles about antennas suitable for mediumwave reception. Now, they're compiled in the *NRC Antenna Book,* the first of many reprint books to be issued. You'll find everything from the portable ferrite rod to the mile-long Beverage wave antenna, including much ado about loops: direct coupled, degenerate, balanced, unbalanced and box. The 60-page book is $2.25; and many other individual article reprints are available too. For a list, send an SASE to NRC, Box 127, Boonton, NJ 07005.

DX Courtesy. Back in the heyday of radio, many MW stations went on the air in the wee hours with special programs for DX listeners. The practice still continues, thanks to a small band of enthusiasts in the NRC, International Radio Club of America, and Newark News Radio Club—the clubs most involved in MW DX. Each has its own "Courtesy Programs Committee" (CPC), but they coordinate their efforts to avoid duplication. Most CPC broadcasts occur on Monday mornings during the winter season, when 24-hour stations take a few hours off. But the tests are scheduled for the most open "window," as determined from the NRC Log's schedule section and continually revised "condition of frequencies" lists. Each club publishes calendars of upcoming specials. The astute late-night MW DX'er can add stations and states he might never hear any other way. It's all arranged by volunteers, which means there would be more such DX specials if there were more volunteers (hint, hint).

Europe on Your Clock Radio? Trans-Atlantic (TA) MW DX usually peaks during October and November; the exact dates depend on solar variations. Several days of low A-indices (below 10) broadcast on WWV at 18 past the hour signal optimum conditions. You'll have a much better chance to hear Europe on the BCB if you're in the eastern half of the continent. Most European channels are "split" between ours, so powerhouses of 300 to 1200 kW can even come through an 'all-American five' if you tune just right. The band usually opens from the top downward, so check 1586 for West Germany, 1554 for France and 1466 kHz for Monaco just after local sunset and again around midnight. But watch out for buzzes from nearby TV sets which also show up on split frequencies. Later on in November or December the so-called "Midwinter Anomaly" puts a damper on this high-latitude MW DX.

Pings & Bursts. Before we go, some tips for vhf people. November and December are among the best months for meteor scatter DX'ing. High-gain antennas on FM and TV will reveal 'pings' every few minutes on just about any morning; the diurnal peak of MS is at 6 a.m. local mean time. Chances for more strong, long 'bursts' are markedly greater during the meteor showers: Orionids, October 18-23; Leonids, November 14-18; and best of all, the Geminids, December 10-14. If you're lucky enough to catch a burst during a test pattern or ID break, you've bagged a new station—even if the reception only lasts a few seconds. This happens more often than you might think. If you're not equipped for this esoteric signal snatching, you can still look out for winter sporadic E openings; check the lowest open TV channels each evening, especially in December and January. For vhf DX'ers in Gulf coastal states, this is the time for thousand-mile uhf hauls or trans-Gulf Mexican vhf. You'll find much more on television DX'ing in the POPULAR ELECTRONICS 1975 COMMUNICATIONS HANDBOOK, available soon. ◈

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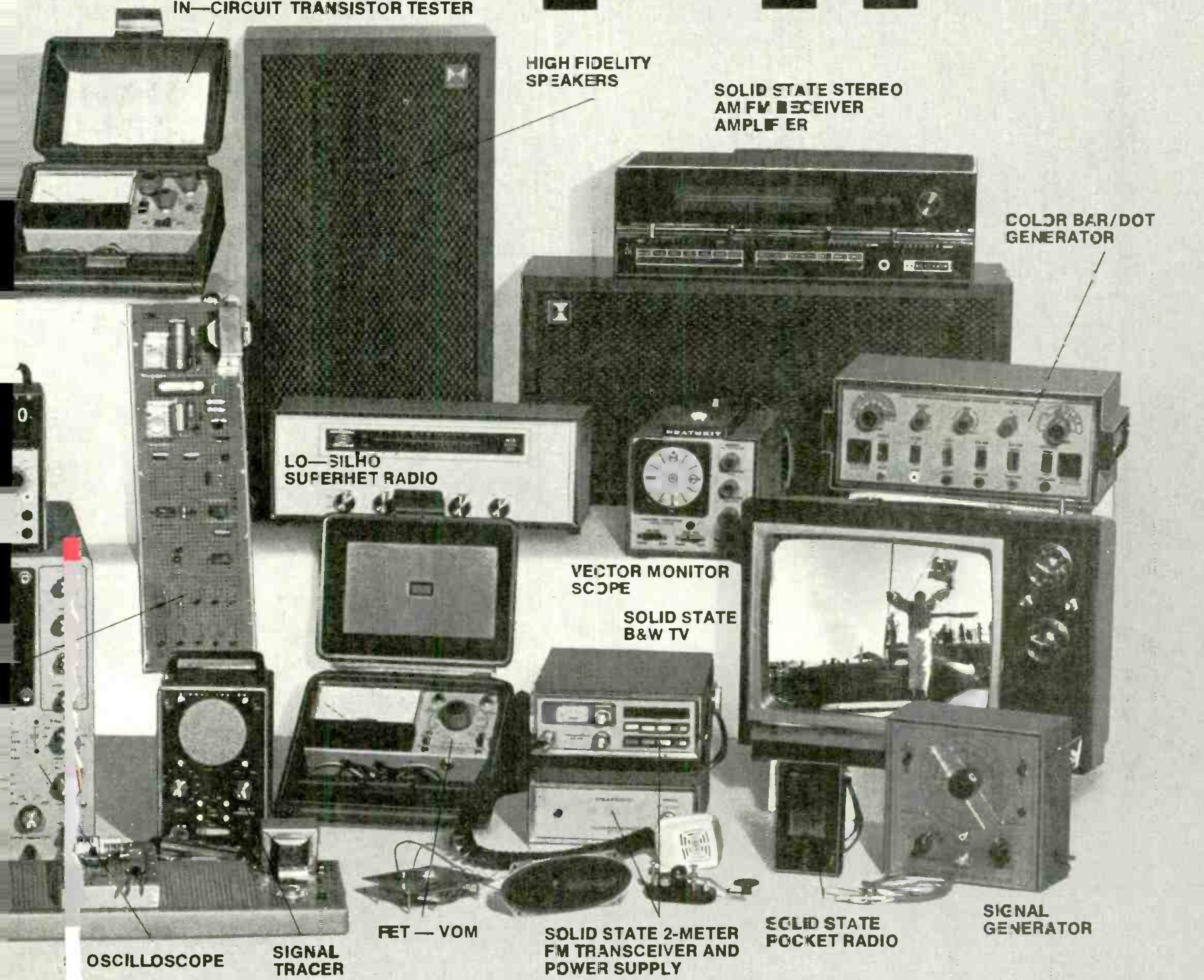

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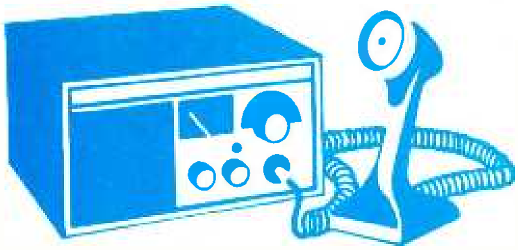


CB Scene

By Len Buckwalter

CB TO THE RESCUE

AFTER holding a license for 16 years it finally happened. I was saved by CB! In a remarkable boating incident last summer, I got a first-hand look at CB's vast power to do good and evil. Good because CB sped to the rescue faster than the U.S. Coast Guard. Evil because of the Neanderthal types who prowl the band tearing up communications, emergencies included. But let's start at the beginning.

It is the end of a hot Sunday in July on Long Island Sound, a body of water east of New York City and between Long Island and Connecticut. After a weekend of cruising aboard a rented 32-foot houseboat, two happy, tired families gather in the bow to witness our arrival in the harbor. The entrance at the breakwater is alive with craft converging on a narrow channel that leads to a crowded anchorage over the next two miles. As the houseboat penetrates a few hundred yards into the harbor the steady rumble of the engines stutters, then weakens. I glance down at the tachometers just in time to see the needle for the starboard engine flicker, then fall over and die on zero. Not much cause for alarm because a twin-diesel boat like ours can easily limp home on one good engine. Ten seconds later the port engine also expires.

Late Sunday afternoon in summer is no time to lose power near the entrance to Stamford harbor, known as the "boating capital of the Sound." It is home for some of the country's most glittering corporations and boasts more Sir Thomas Lipton types than you'd find at the Queen's Tea. Woe betide any craft under 40 feet that's bobbing in the right-of-way. But there was just enough momentum in the houseboat's lumbering hull to swing the craft in a semicircle and pull its prow to the edge of the busy channel. Luckily, the anchor bit the bottom before the wind could smash us against a sailboat moored a few yards away.

Miraculously, within minutes, a flashy cabin cruiser glides alongside and asks what's the matter. High on its flying bridge a lady captain grips the handset of a marine radiotelephone, ready to call the harbor police, the Coast Guard or anyone else we want. We're so awed by this Amazonian Marine that our grateful mumblings are drowned by the sound of her orders barked into the handset. Within a few seconds she triumphantly announces, "The Coast Guard is on its way!" Worried wives breathe easier, children return to their play and the men stand proudly on the deck of the crippled vessel, knowing that everyone will soon be safe at home.

Ten minutes later a rickety putt-putt with "Coast Guard Auxiliary" hand-painted on its side pulls up. It was a far cry from the 40-foot government cutter we were expecting to take us in tow. What's more, the two lads aboard this brave, but hardly adequate, launch were enroute to more serious business offshore. A cruiser had run out of gas and demanded immediate assistance, which meant our rescuers would not return for two hours.

But the surging stream of yachts, hot-rodders and hundreds of other Sunday drivers brushing past our bow was clearly dangerous. In the waning twilight there would be a sharply increased threat of collision. As the houseboat wallowed in the wake of passing boats, I decided to try my hand at the two radios aboard—a marine two-way rig and a CB set—and attempt to reach the owner of the boat. Maybe he could tell me how to restart the engines. We had already poured in 5 gallons of reserve fuel from a jerry can with no luck.

The vhf marine radio was hopeless. The circuits to the New York Marine Operator were jammed with returning boats wanting to call home, forcing the besieged operator to put new callers on standby. It might take hours to reach the owner. I switched off the marine radio and turned the CB transceiver to channel 9. Even as I blindly called for help I knew it was futile. The channel was clobbered with meaningless conversation and interference. Seven pairs of eyes watched me work the radio, expecting some official response that would deliver us from an increasingly threatening situation. I flicked from channel 9 to explore the rest of the band, searching for a strong carrier of any station, but the CB speaker emitted a persistent chorus of squeals, static and fragmented voices. Then, as the selector indented on channel 11, the S-meter shot up the scale. A strong, clear voice filled the cabin. I knew I must land this station or I'd be lost.

"Break-break," I said, then waited.

After monitoring this station a few minutes, it was clear that nothing about its operation was legal. The communications were chit-chat, its callsign just a contrived fake. But the operator answered my break and I suppressed any thought of rules and regulations. The voice, which sounded like that of a 16-year old boy, said he'd gladly help me out of the emergency—but then uttered the words I dreaded. The young man wanted me to stand by while he contacted a volunteer team located closer to me. This was the last thing I'd do. We would almost certainly lose each other in the nightmare of interference washing over the band that evening. Somehow I'd have to convince him of this.

Suddenly a third voice moved on the frequency. "What's the emoigency?" it asked. Some goon had been listening to me describe our plight and committed the cardinal sin of any distress communications; getting on the frequency without being called and interfering with communications. I couldn't hear what the young man replied but the goon didn't like it. He used foul language and held his carrier steadily on to block our signals.

The young man knew what to do, He ignored the carrier and shrewdly said several times, "Switch to channel 12." His powerful signal punched through just enough so I could understand the words. It worked. We rejoined on channel 12 and heard no more interference. Now the only problem was to convince the young man to stay with me and not attempt to raise a closer station. My plan was to give him the phone number of the boat's owner and have him put through a collect call. Somehow he balked at the idea.

By now the sun dipped below the

horizon and boats crossing our bow had switched on their running lights. The gathering darkness was adding yet another problem, I didn't want to dock the houseboat in the dark. Even in daylight, maneuvering this big tub at slow speed called for plenty of engine reversing and bursts of power to keep it from splintering the dock.

"Do *not* turn me over to any other station. I'd like you to make a collect call for me."

I shot those words at the young operator with the sting and authority of an army drill sergeant. It was my only hope. I must have shook up the kid because he came back on, no longer sounding like a NASA space communicator. I assured him several times that a long-distance telephone call placed collect would cost him nothing.

"I have Jim on the line. He says try the lift pump." A wave of excitement flooded over the houseboat. The young man had raised Jim, the boat's owner, on the landline and the first instructions were coming through.

"Where's the lift pump?" I asked. Questions and answers went back and forth over our primitive phone patch. Jim, the owner, would say something to the young man on the phone, and the information was relayed to me via CB radio. It worked well, except for the tense moments when Jim and the young man spoke to each other on the landline and no carrier filled the air. I grew apprehensive at the possibility of some other spoiler getting on the open channel and jamming us. To prevent it, I turned on my carrier during the pauses and made blind announcements about emergency communications in progress. It kept the channel clear.

In the stern of the boat, hatches were raised to expose the two dead Volvo diesels. Following Jim's CB-sent directions, we rammed the lift pump up and down by foot until it forced fuel into the starved engines. I turned the starter key and watched the tachometer. It bounced crazily as the engine fired, but dropped back to zero. I gripped the CB mike, shot my next question at Jim. My words raced over water by radio for a dozen miles, were repeated by the young CB operator on the phone, then travelled by landline over 60 miles to Jim's home.

"Keep pumping while the engine is turning," Jim said. He was right; the houseboat shuddered, made several explosive sounds then throbbed with the steady power of its 310 horses. "Up anchor," I shouted, and within minutes the houseboat melted into the endless stream of other boats heading up the channel to a safe landing.

Later that night I learned what killed the engines. Fifty gallons were in the fuel tank but this boat had a quirk; when the tank was about a quarter full, the fuel line would gobble air and not feed unless the passengers stood at the stern. Those lift pumps purged the trapped air in the lines to get the fuel flowing again and, with the crew herded on the stern, the engines ran perfectly.

I wanted to thank the anonymous young operator. He had done an excellent job of extricating us from a tight situation, especially when he switched us away from the QRM. But I can't express much gratitude because he has no call, no license and no CB status. He legally doesn't exist.

The second hero of this adventure is CB itself. Our lives were not in immediate danger, but each passing minute increased the risk from scores of other craft that careened down the narrow channel in the dimming twilight. CB, in fact, came through when about a half-dozen other resources failed. First, it outdid that vigilante who was first to arrive on the scene. She was a well-meaning Good Samaritan, but she couldn't provide our most immediate need—a tow into port. Then there's the U.S. Coast Guard and its auxiliary. Despite their heroic work in boating areas, our dilemma held too low a priority. Next, the marine telephone system—it, too, was seriously overloaded. Then there was harbor police, but the men in blue never materialized. This is one happy instance where CB outdid them all! ◈

"I need a replacement part. Call 471-3481 in Hong Kong."

MAC'S SERVICE SHOP

The Simplest Test Gear

By John T. Frye, W9EGV

"HEY, Mac, what are you doing with the tattle lights?" Barney asked his employer, who was examining several small objects spread out on the service bench.

"Taking them with me on vacation," Mac replied. "Some of the folks in Florida we visit are sure to say, 'Mac, our electric or electronic whatchamacallit isn't working. Wonder if you'll look at it.' These lights will let me find anything simple, which is all I intend to tackle on vacation. Actually, it's amazing what a fellow can do with some simple, rugged, inexpensive test lights and a little gray matter."

"For instance?"

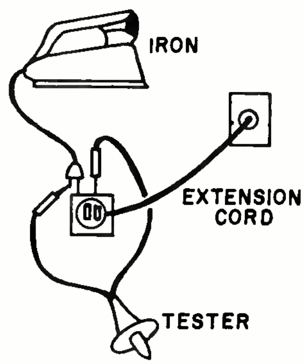
"Well, take this Ne-O-Lite Test Light put out by GC Electronics, a division of Hydrometals, Inc., Rockford, Ill. It carries Audiotex catalogue No. 30-245 or Calectro No. H3-452 and sells for just under a buck. As you can see, it consists of a special two-inch-long, red, high-impact plastic socket carrying a neon bulb protected by a tough clear plastic cone in one end. A current-limiting resistor of—I'd guess—about 200,000 ohms is contained in the socket, and red and black flexible, sharp-pointed leads come out the bottom. The lamp glows with any voltage from 90 to 550 volts, ac or dc. The higher the voltage, the brighter the glow.

"The neon lamp itself has almost infinite resistance until the contained gas is ionized by over 90 volts. Until then, there's no voltage drop across the series resistor, so the full voltage across the test leads is applied to the lamp. Once the gas is ionized by a voltage in excess of 90 V, current through the lamp and series resistor is a function of the voltage across the leads, but it never exceeds 3 mA, even with the full 550 volts applied.

"What can you do with it?"

"A zillion things. If one lead is attached to a spark plug of a running motor, a bright flash will indicate a good plug; a dim flash, a fouled plug; and no flash, a dead plug. Hold on to one test lead and probe the two sides of a 120-volt outlet receptacle with the other. When you touch the 'hot' side of the line, the lamp will glow. If a device controlled by a wall switch will not turn on and you don't know if the trouble lies in the device or the switch, turn the switch on and bridge the test lamp across the switch terminals. If the lamp glows, the switch is bad. Do the same thing to locate a blown fuse. With a device on the fused line switched on, check across the fuse with the lamp. If it glows, the fuse is open. Alternately, you can check from the grounded side of the line or the cabinet of the fuse box to the output sides of the fuses, one at a time. Failure of the lamp to glow with full 120-V brilliance will indicate the bad fuse.

"This little sketch shows how the test lamp can be used for a continuity



indicator. Plug an extension cord into a wall receptacle and locate the hot side of the cube tap on the end of the cord. Plug one lamp lead into this side. Now plug one prong of the cord of the device you want to test for continuity into the other, grounded, side of the cube tap. Touch the free lamp test lead to the free prong of the line cord of the device. A glow of the lamp indicates continuity.

"The test light will indicate the presence of leakage current. As you know, one side of the 117-volt line is grounded. If there's current leakage from the hot side of the line to the case of a device, say a hedge-trimmer, electric drill, refrigerator, dishwasher, etc., a person touching the device while in contact with the ground or a grounded device may receive a severe and perhaps fatal shock. With a clip lead, connect one side of the test lamp to a good ground, such as a water faucet, and touch the other lead to the case of the device being tested while the device is operating. Reverse the plug of the device in the wall socket and test again. If the lamp glows in either case, you know there's *some* leakage. It may not exceed 0.5 mA through 1500 ohms of noninductive resistance shunted by 0.15 μF, which represents the average impedance of the human body and the current is considered permissible for most devices; but if the lamp glows at full 120-V brilliance, you can be suspicious. In all the devices I checked at home, only the electric drill, some fifteen years old, lit the light dimly."

"What's this thing?" Barney asked, picking up a small round plastic object with three prongs on one end to fit a standard 15-A, 120-V grounding receptacle.

"That's a GT-20 'Grounded Outlet' Tester made by Alco Electronic Products, 1551 Osgood Street, North Andover, Mass. 01845. It sells, in single lots, for $7.95 and reveals instantly if a receptacle into which it is plugged has current available and is properly and safely wired. Note the three little round windows in the end. Two of them, labelled NEUTRAL and POWER, are amber, and the bottom one, labelled DANGER, POLARITY is red. When the GT-20 is plugged into a grounding receptacle, one or more of the lights behind the windows light if power is available at the socket. If the socket is correctly wired, the two amber windows glow. Any other combination of lights indicates a potentially dangerous receptacle that is improperly wired or has a broken connection.

"What's inside the thing?"

"Not being like the little boy who cut open his drum to find what made the noise, I didn't take it apart to see; but I'd guess there are three neon lamps with accompanying current-limiting resistors, each wired between a pair of prongs. Can you figure out which lamp is wired between which prongs to produce the conditions shown in the little charts?"

"Child's play!" Barney scoffed. "Will it work on 2-hole outlets?"

"The Code requires that, in all new construction, only grounding receptacles may be installed. If you replace a defective receptacle in an existing installation, the new one must be the grounding type if you can effectively ground it. If this is difficult or impossible, the receptacle may *not* be of the grounding type. You don't want a receptacle with a dummy grounding orifice that seems to promise but does not actually provide grounding of a device with a 3-wire cord plugged into it. You can use the GT-20 as a 2-wire tester by using an adapter plug with the pigtail fastened to the outlet box by placing it under a *metal* screw holding the receptacle plate in place. If the red light of the GT-20 glows when the adapter is plugged in, reverse the position of the two blades. If the red light still glows, a ground fault is indicated and repairs should be made. The only fault the GT-20 will not reveal is switching of the neutral and ground wires, since both are normally at ground potential; but this very rarely occurs.

"How come you've got two neon test lights?"

"I haven't. That one you're holding looks like the H3-452, but it is really a Calectro No H3-454. About the only difference you can see is that the plastic is blue instead of red. It is called a Lo-Volt Test Light and will light with 5 to 50 volts ac or dc. If you look closely, however, you'll see the bulb in the end is a filament type instead of neon. I've found this filament will glow dimly with 3 volts across the test leads while it is drawing 18 mA. At 12 volts the filament is a very bright yellow and draws 45 mA. This goes to 110 mA at 50 volts, and the filament is incandescent white. Filament resistance goes from 80 ohms cold to 550 ohms at 50 volts, which explains the wide range of lighting voltage.

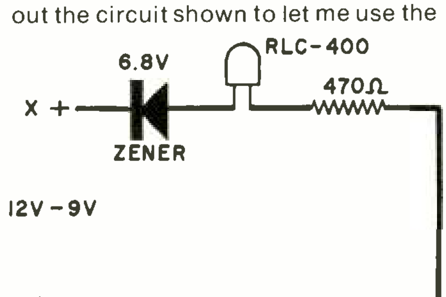
"The Lo-Volt Tester is especially useful in trouble-shooting auto electrical problems. Failure to light across the battery terminals indicates a dead battery. If the battery is OK, you can trace the voltage from it right to an accessory that fails to work. With the accessory turned on, the lamp will light across a defective switch or fuse. It will also light across a high resistance connection, say a battery cable connection or starter solenoid contacts, when the starter is actuated and tries to draw heavy current through the connection. By connecting the lamp between an insulation-piercing darning needle and ground, you can pinpoint a break in a wire. The lamp will indicate generator output. It can be used with the 12-volt battery to indicate continuity, since it will glow with any series resistance from 500 ohms down.

"The Lo-Volt Tester is also useful in the home for checking out low-voltage door-bell circuits, electric trains, and slot cars. With a 9-volt transistor battery, it can be used as a continuity indicator. With a little practice, you can also use it to indicate the condition of 6- and 9-volt batteries."

"Well," Barney said as Mac paused, "that only leaves this little red bulb no bigger than a match head."

"That's a brand new RLC-400 Battery Status Indicator just released by Litronix, Inc., 19000 Homestead Road, Cupertino, Calif. 95014. It sells for a dollar at Litronix representatives all over the country. A GaAsP LED and a voltage-sensing IC are both packed inside that itty-bitty T-1 lamp package designed to warn of imminent battery failure in cameras, tape recorders, calcualtors, and similar battery-powered equipment. The LED lights brightly at 3 V, glows dimly at 2.5 V, and is completely dark at 2 V. It draws about 300 microamperes at 2.5 V, 8 mA at 3 V, and 20 mA at 4 V. Five volts, forward or reverse, is maximum.

"To use the RLC-400 with higher voltage batteries presented a bit of a problem. A series resistor subjected the device to a high turn-on voltage and separated on on-off points too much. A zener took care of the first problem, but the on-off points were only a half-volt apart. I finally worked out the circuit shown to let me use the



RLC-400 with any battery voltage and make the on-off span proportional to that voltage. With the values shown, 3 V appears across the LED with 12 V across points X and Y. There is 2.5 V across the LED with 9 V at X-Y. Other zeners and resistor values can accommodate other battery voltages and provide any desired span between new and discard battery voltage. This little lamp has a lot of exciting possibilities," he concluded.

"You know," Barney mused, "a knowledgeable guy can do a lot with comparatively simple equipment." ◈

Solid State

By Lou Garner

USEFUL CIRCUITS FOR FIELD EFFECT TRANSISTORS

THOUGH more versatile than bipolar types, except in some power applications, field effect transistors —FET's—have never been overly popular with experimenters and hobbyists. True, FET's have been featured in magazine construction articles from time to time, and there have even been several project booklets published featuring FET circuits but, somehow, these devices have never really "caught on."

There are probably several reasons for the FET's lack of popularity. One may be the paucity of application data compared to what is available on bipolar devices. Another reason, perhaps equally important, may be the somewhat confusing situation regarding types. FET's are manufactured in two general categories and six major subcategories, *in addition* to variations relating to electrical specifications. The two broad categories are insulated gate types, or IGFET's, and junction types, or JFET's. Since many insulated gate FET's are manufactured using MOS technology, these are often designated MOS-FET's, while junction FET's frequently are identified simply as FET's (without the J prefix). But there's more. IGFET's may be manufactured for use in either *depletion* or *enhancement* modes, each of which has its own technical advantages, but which may require somewhat different application techniques, depending on the circuit in which it is used. Finally, both IGFET's and junction FET's are available as either n-channel or p-channel devices. These are analogous to npn and pnp bipolar transistors, in that they may be used in similar applications, but require opposite dc polarities.

Poor availability may be another reason for the FET's lack of popularity. The first low-cost experimenter's transistor, the famous Raytheon CK722, was a bipolar device. FET's, on the other hand, were comparatively late arriving on the scene and, by the time inexpensive FET's were available, a mass of application literature and project articles had been published featuring bipolar devices, resulting in a much larger demand by users for these types. As a result, suppliers offering general-purpose semiconductor devices today may list scores of different bipolar transistors but maybe only from one to a half-dozen FET's. As of the present writing, for example, there are only five different FET's listed in Sylvania's ECG line, two types in RCA's SK line, eight in Motorola's HEP line, three in GC Electronic's *Calectro* line, and one in Radio Shack's *Archer* line. There are many other types of FET's in production of course, but the prospective user will not find these in a general line on a self-service sales rack. Instead, he'll have to buy them across the counter, specifying manufacturer's name and type number, and perhaps even seek out a broad line or industrial electronics distributor stocking the units needed. In extreme cases, the user may find it necessary to order specific devices from a large mail-order or semiconductor specialty house.

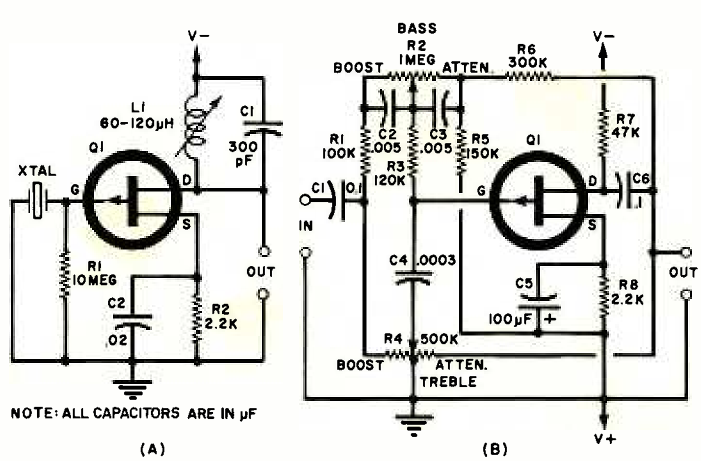
The FET has been called the "semiconductor equivalent of the vacuum tube." This analogy is pretty close to the truth. The FET offers high input and output impedances. It is a voltage, rather than a current, amplifier. It can be self-biased via a source resistor and its characteristics curves are quite similar to those of a pentode vacuum tube.

The basic FET has three terminals—gate (G), source (S) and drain (D). These correspond, generally, to the base, emitter and collector of a bipolar transistor, or to the grid, cathode and plate of a vacuum tube, respectively.

The IGFET (or MOSFET) has an extremely high input impedance. The junction FET also has a high input impedance, although not nearly as great as the IGFET; but, from an experimenter's viewpoint, it is by far the easier device to use in practical circuits. Except for those types with internal protection, the IGFET (MOSFET) requires special treatment. It is particularly susceptible to damage from static charges or transient voltages applied to its gate electrode, even during the simple processes of handling and installation. Some types, in fact, are supplied wrapped in metal foil or with their leads shorted by a metal eyelet or spring to prevent accidental damage. The short can be removed safely only *after* the device is installed in its circuit.

Perhaps the best way to become familiar with the FET is to try the device in a few practical projects. Several useful and easily constructed junction FET circuits are illustrated in Figs. 1 and 2. These were adapted from a FET applications bulletin published several years ago by Siliconix, Inc.

Fig. 1. Useful FET circuits: (A) Crystal oscillator; (B) Tone control.



(2201 Laurelwood Road, Santa Clara, CA 95054). In each circuit, resistors are rated for ¼ or ½ watt, while the capacitors may be ceramic, mica, plastic or tubular paper types, except where a dc polarity is shown, in which case an electrolytic should be used. Capacitor working voltages should be chosen on the basis of the dc supply voltage used, of course, with 50-volt, or better, units adequate for all four circuits. Although p-channel devices are indicated, comparable n-channel FET's may be substituted in each design if dc polarities are reversed and if bias and supply voltages are readjusted for optimum performance.

Suitable for use as the first stage of a transmitter, as a marker generator, and in similar applications, the FET crystal-controlled oscillator shown in Fig. 1A requires relatively few components. The original design specified a type 2N2608 for *Q1*, a 1-MHz crystal, and a 22-volt dc power supply. It may be assembled on a perf board, etched circuit board, or even on a small chassis using point-to-point wiring techniques.

In operation, the drain-gate feedback needed to start and sustain oscillation is provided by stray interelectrode and wiring capacities. Gate bias is established by source resistor *R2,* shunted by bypass capacitor *C2.* Drain tuning is provided by adjustable inductance *L1*, shunted by *C1*. The L and C values specified are for 1-MHz operation but these may be changed, of course, for other frequencies.

Featuring separate treble and bass controls, the tone-control circuit illustrated in Fig. 1B may be used with virtually any audio amplifier—phonographs, tape recorders or playbacks, or PA systems. Depending on application, it can be assembled as a separate control or incorporated as part of more complete amplifiers. Except for the treble control, *R4,* standard components are used throughout the design. As in the previous circuit, a 22-volt dc power supply should be used, and *Q1* is specified as type 2N2843.

In operation, *Q1* serves as a conventional common-source amplifier, with gate bias provided by source resistor *R8,* bypassed by *C5.* Resistor *R7* serves as the drain load and *C1* and *C6* as the input and output coupling capacitors, respectively. A variable frequency response characteristic is achieved by a combination of attenuation and negative feedback techniques. When bass control *R2* is shifted toward its BOOST position, it serves as a shunt across *C2*, increasing the amplitude of the bass portion of the applied signal. When *R2* is set toward its ATTEN position, its shunting effect across *C2* is reduced and, at the same time, a negative feedback signal coupled back from the drain through *R6* serves to reduce effective stage gain at the lower frequencies. A similar technique is used for the treble control. With treble control *R4* in its maximum boost position, *C4* serves as a high-frequency shunt across the bass control network. With *R4* set for maximum attenuation, high-frequency negative feedback from *Q1*'s drain is applied through *C4* to the gate electrode, effectively reducing stage gain.

You can use the phase shifter circuit shown in Fig. 2A in test instruments, such as oscilloscopes, in demonstration projects, and in musical synthesizers. It requires a 12-volt dc supply when 2N2609 FET's are used for *Q1* and *Q2*.

In operation, *Q1* and *Q2* are used as cascaded split-load amplifiers, with *R3* and *R6* serving as the drain loads and *R2* and *R7* as the source loads, respectively. Networks *C1-R4* and *C2-R5* provide a control over the signal phase shifts, with each stage supplying a controllable shift from 0° to 180°.

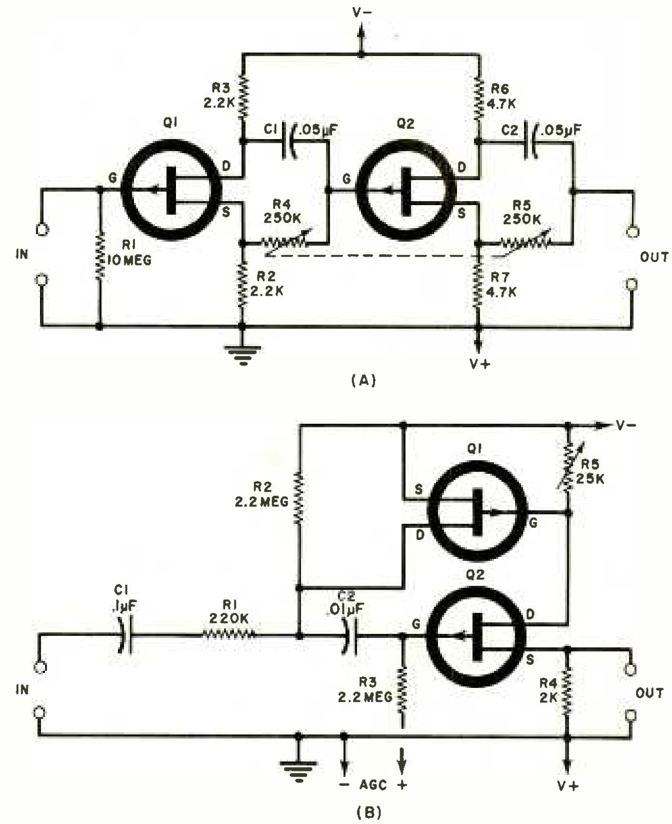


Fig. 2. Phase shifter (A) and automatic gain control (B).

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There are probably many uses you can devise for the audio automatic gain control (agc) circuit illustrated in Fig. 2B. Use it to maintain a constant level in a tape recorder, to prevent overmodulation in a transmitter, or as part of an expander or compressor. According to Siliconix, the circuit will provide an effective agc range of 60 dB and has a frequency response flat to within 1 dB from 1.0 Hz to better than 10 kHz. Type U112 devices are specified for both *Q1* and *Q2*, with a 12-volt dc power supply.

In operation, *Q1* serves as a variable resistance, *Q2* both as a gate bias control for *Q1* and as a source-follower amplifier. Series resistor *R1* and *Q1*'s source-drain resistance, shunted by *R2*, form a simple voltage divider. FET *Q1*'s source-drain resistance, in turn, is determined by its gate bias, which is established by *Q2*'s drain current and the agc voltage applied to *Q2*'s gate. As increasing agc voltage is applied, *Q2*'s drain current is reduced, increasing *Q1*'s negative gate bias and thus reducing *Q1*'s effective source-drain resistance, thus reducing the effective level of the input signal applied through *C2* to *Q2*'s gate and, therefore, the output signal developed across *Q2*'s source load, *R4*. As the agc voltage is reduced, the opposite action takes place, increasing the output signal level.

Although the parameters of the agc circuit are not critical, one simple adjustment is required for optimum performance. With the circuit wiring completed and checked, apply the dc supply voltage, a small input signal, and *zero* agc voltage. Adjust drain load *R5* for a maximum output signal across source load *R4*.

If you've been intrigued by our discussion of the versatile FET and would like to explore the subject in greater detail, we can recommend any (or all) of the following books:

An Introduction to Field Effect Transistors, by J. Watson, published by Siliconix, Inc.

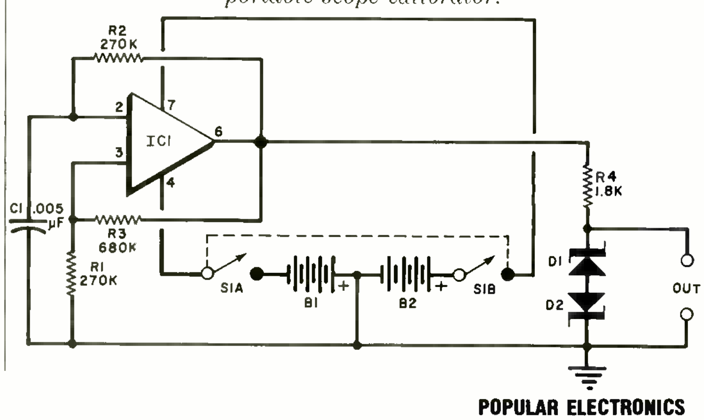
FET Circuits and *abc's of FET's*, both by Rufus P. Turner, published by Howard W. Sams & Co., Inc.

Field Effect Transistor Projects, published by Motorola, Inc., Semiconductor Products Division, and offered through HEP distributors.

Reader's Circuit. Featuring a popular IC op amp and a pair of zener diodes, the portable scope calibrator circuit given in Fig. 3 was submitted by reader Ted Reiter (1442 Brook Drive, Titusville, FL 32780). Layout and lead dress are not critical and the project can be duplicated quite easily in a single evening or on a weekend by the average hobbyist.

In this circuit, *IC1* serves as a simple relaxation oscillator, supplying an output signal which is clipped by zener diodes *D1* and *D2* in conjunction with series resistor *R4*,

Fig. 3. Reader's circuit for portable scope calibrator.



developing a fixed-level square-wave output signal with a peak-to-peak amplitude equal to the total zener voltage. Operating power is supplied by batteries *B1* and *B2* controlled by a dpst switch, *S1*.

Readily available standard components are used in the design. Ted chose a type 741 op amp for *IC1*. The terminal numbers shown are for the "minidip" version used in his original model. The resistors may be either ¼ or ½ watt, while *C1* is a low-voltage ceramic capacitor. Batteries *B1* and *B2* are conventional 9-volt transistor units, with *S1* a toggle, slide or rotary switch. Ideally, the zener diodes should be matched, with a total voltage of 10 volts. Unable to obtain a perfect match, Ted assembled his model using a 5.6-volt zener for *D1*, a 4.5 volt device for *D2*, providing a nominal 10.1-volt output signal. The actual output voltage, of course, will depend on the zener diode voltage tolerances.

If a particular application requires an accurately known output voltage, a simple test will establish this value. Disconnect *R4*'s upper lead (pin 6, *IC1*). Reverse *D2*. Connect *R4*'s free lead to the positive terminal of a 15-18-volt dc source, negative to circuit ground. Finally, measure the dc voltage across the series zeners using an accurate voltmeter. Restore the circuit to its original condition for normal operation.

Device/Product News. We've received a number of inquiries from readers asking what LED's have the lowest current ratings. Actually, most LED's will operate at currents much lower than their maximum ratings, and we've obtained satisfactory light outputs with levels as low as 8 to 10 mA using commercial 50-mA (max) devices. However, the results are not consistent. One LED of a given type may provide a good output at a 7-mA level, while another of the same type may require 10 mA, and still another 12 or 15 mA. At least one firm, however, Data Display Products (5428 W. 104th St., Los Angeles, CA 90045), offers *complete* LED panel-light assemblies designed to be used at a mere 5-mA current level. Available colors are green, yellow, amber and red, at voltages from 1.8 to 28 V. Single unit prices range from $1.58 for a 1.8-volt device (requiring an external current limiting resistor) to $1.76 for a 28-volt type (with built-in resistor). Each unit is supplied with a mounting clip and Neoprene washer.

You can add another name to the roster of firms manufacturing dual 555-type timer IC's: Silicon General, Inc. (2712 McGaw Ave., Irvine, CA 92705). Packaged in 14-pin DIPs, the Silicon General version is identified as the SG556/SG556C.

Perhaps a dual timer is not enough for your application. If this is the case, you might check the new *quad timers* now available from Signetics (811 E. Arques Ave., Sunnyvale, CA 94048). Identified as Models 553 and 554, the new units are supplied in a 16-pin DIP. The 553 and 554 are not exact duplicates of the industry standard, the familiar 555, however. They have no reset control line and a common control voltage pin is provided for all four timers in the package. Basically similar in application, the 553 is rated to sink 100 mA, the 554 to source an equivalent current, compared to the 200 mA ratings of the 555/556 types. Another interesting difference between the 553/554 devices and the 555/556 types is a simplification of their timing equations, from T = 1.1RC to T = RC for the new units.

How many watts in a dollar? If this seems like a silly question, comparable to a mixing of apples and oranges, it is, however, the type of question that a transmitter designer must ask himself. According to Motorola, its new MRF621 uhf power transistor can deliver an output signal in the 406-to-512-MHz band for less than a dollar per watt. Designed for 12.5-V dc operation, the new device can deliver 45 W at 470 MHz with a minimum power gain of 4.8 dB and collector efficiency of 55%. Featuring an internal MOS capacitor chip for "controlled-Q" operation, the MRF621 sells for $39.00 each in unit quantities, even less if you want to buy 25 or more at a time.

RCA's Solid State Division (Box 3200, Somerville, N.J. 08876) has introduced a new linear IC and added another COS/MOS device to its expanding line. Designated type CA3127E, the new linear device consists of 5 independent general-purpose silicon npn transistors constructed on a common monolithic substrate to provide close electrical and thermal matching. Suitable for low-power applications at frequencies up to 500 MHz, the CA3127E, supplied in a 16-lead plastic DIP, can be used in vhf amplifiers, mixers and oscillators, in i-f converters and amplifiers, and in sense amplifiers, synthesizers, and cascade amplifiers. RCA's latest COS/MOS device, identified as the CD4093AE, is a quad 2-input NAND gate consisting of four identical Schmitt trigger circuits, each of which functions as a two-input NAND gate. The CD4093AE, packaged in a 14-pin plastic DIP, is suitable for use in wave-shapers and pulse-shapers, monostable and astable multivibrators, and NAND functional logic circuits. ◈

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7408	.25	7492	.79
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7410	.19	7494	.89
7413	.79	7495	.89
7415	.39	7496	.89
7416	.39	74107	.49
7417	.39	74121	.57
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7438	.39	74154	1.59
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7443	.99	74164	1.89
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7447	1.15	74177	.99
7448	1.15	74180	1.09
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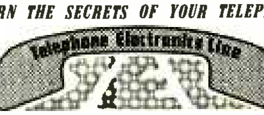

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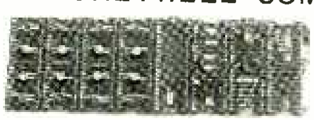
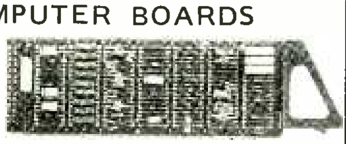


F9121



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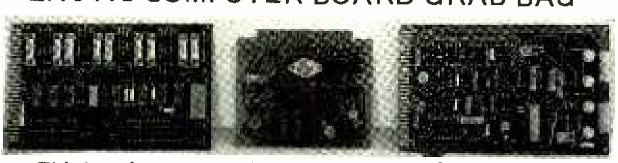

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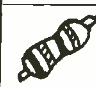

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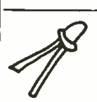

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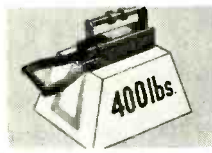

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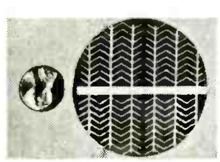

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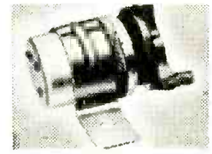

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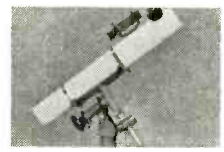

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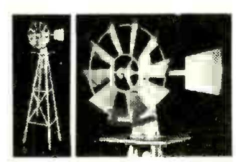

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PLEASE ORDER BY CATALOG NUMBER 03-12241.

DISC CAPACITORS

Solid State Systems offers a complete selection of Ceramic Disc Capacitors for a wide range of applications from high voltage RF to low voltage transistor Circuitry. **PLEASE NOTE: In order to maintain our low prices, we must request that you order in EXACT multiples of 10 per item; you may, however, mix all different types and values of ceramic capacitors for quantity pricing.**

5HK

Sprague type 5HK ceramic disc capacitors offer high capacity in a minimum space. All type 5HK capacitors have a tolerance of −20%, +80%. Voltage rating is 1000WVDC for values up to and including 0.01µF; and 500WVDC for 0.015µF and higher.

Catalog Number	Capacitance	10-90	100-240	250-490	500-990	1000-up	Grouping Code
72-10369	1000 pF	.10	.09	.08	.07	.06	4
72-15369	1500 pF	.10	.09	.08	.07	.06	4
72-20369	2000 pF	.10	.09	.08	.07	.06	4
72-22369	2200 pF	.10	.09	.08	.07	.06	4
72-33369	3300 pF	.10	.09	.08	.07	.06	4
72-47369	4700 pF	.10	.09	.08	.07	.06	4
72-50369	5000 pF	.10	.09	.08	.07	.06	4
72-68369	6800 pF	.10	.09	.08	.07	.06	4
72-10469	0.010 µF	.10	.09	.08	.07	.06	4
72-15463	0.015 µF	.10	.09	.08	.07	.06	4
72-20463	0.020 µF	.12	.11	.10	.09	.08	4
72-25463	0.025 µF	.12	.11	.10	.09	.08	4
72-40463	0.040 µF	.20	.19	.18	.17	.16	4
72-50463	0.050 µF	.20	.19	.18	.17	.16	4
72-10563	0.1 µF	.40	.38	.36	.32	.30	4

TG

Sprague type TG low voltage ceramic disc capacitors with a rating of 100WVDC are ideal for use in transistorized circuits. All units have a ±20% tolerance.

Catalog Number	Capacitance	10-90	100-240	250-490	500-990	1000-up	Grouping Code
73-50342	0.005 µF	.10	.09	.08	.07	.06	4
73-10442	0.01 µF	.15	.14	.13	.11	.10	4
73-20442	0.02 µF	.15	.14	.13	.11	.10	4
73-25442	0.025 µF	.15	.14	.13	.11	.10	4
73-30442	0.03 µF	.15	.14	.13	.11	.10	4
73-50442	0.05 µF	.30	.27	.24	.21	.18	4
73-10542	0.1 µF	.35	.32	.29	.26	.23	4

UK

Centralab type UK miniature ceramic discs offer minimum space occupancy on transistorized boards where large capacitance in a small volume is required. Tolerance: 3WVDC types, Guaranteed Minimum Value; all others −20%, +80%.

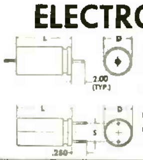
Catalog Number	Capacitance	10-90	100-240	250-490	500-990	1000-up	Grouping Code
84-10415	.01 µF, 16V	.14	.13	.12	.11	.10	4
84-22421	.022 µF, 25V	.16	.15	.14	.12	.11	4
84-10509	.1 µF, 10V	.15	.14	.13	.11	.10	4
84-20509	.2 µF, 10V	.20	.19	.18	.16	.15	4
84-47503	.47 µF, 3V	.25	.23	.21	.19	.17	4
84-10603	1.0 µF, 3V	.28	.26	.24	.22	.20	4
84-22603	2.2 µF, 3V	.35	.32	.29	.26	.23	4

5GA

Sprague type 5GA ceramic disc capacitors have low self-inductance of silvered flat-plate design for high by-pass efficiency. All type 5GA capacitors have a tolerance of ±20%, and 1000WVDC ratings.

Catalog Number	Capacitance	10-90	100-240	250-490	500-990	1000-up	Grouping Code
71-50069	5 pF	.10	.09	.08	.07	.06	4
71-75069	7.5 pF	.10	.09	.08	.07	.06	4
71-10169	10 pF	.10	.09	.08	.07	.06	4
71-12169	12 pF	.10	.09	.08	.07	.06	4
71-15169	15 pF	.10	.09	.08	.07	.06	4
71-20169	20 pF	.10	.09	.08	.07	.06	4
71-22169	22 pF	.10	.09	.08	.07	.06	4
71-25169	25 pF	.10	.09	.08	.07	.06	4
71-27169	27 pF	.10	.09	.08	.07	.06	4
71-30169	30 pF	.10	.09	.08	.07	.06	4
71-33169	33 pF	.10	.09	.08	.07	.06	4
71-39169	39 pF	.10	.09	.08	.07	.06	4
71-50169	50 pF	.10	.09	.08	.07	.06	4
71-56169	56 pF	.10	.09	.08	.07	.06	4
71-68169	68 pF	.10	.09	.08	.07	.06	4
71-75169	75 pF	.10	.09	.08	.07	.06	4
71-82169	82 pF	.10	.09	.08	.07	.06	4
71-10269	100 pF	.10	.09	.08	.07	.06	4
71-12269	120 pF	.10	.09	.08	.07	.06	4
71-15269	150 pF	.10	.09	.08	.07	.06	4
71-18269	180 pF	.10	.09	.08	.07	.06	4
71-20269	200 pF	.10	.09	.08	.07	.06	4
71-22269	220 pF	.10	.09	.08	.07	.06	4
71-25269	250 pF	.10	.09	.08	.07	.06	4
71-27269	270 pF	.10	.09	.08	.07	.06	4
71-30269	300 pF	.10	.09	.08	.07	.06	4
71-33269	330 pF	.10	.09	.08	.07	.06	4
71-36269	360 pF	.10	.09	.08	.07	.06	4
71-39269	390 pF	.10	.09	.08	.07	.06	4
71-47269	470 pF	.10	.09	.08	.07	.06	4
71-50269	500 pF	.10	.09	.08	.07	.06	4
71-56269	560 pF	.10	.09	.08	.07	.06	4
71-68269	680 pF	.10	.09	.08	.07	.06	4
71-75269	750 pF	.10	.09	.08	.07	.06	4
71-82269	820 pF	.10	.09	.08	.07	.06	4
71-10369	1000 pF	.10	.09	.08	.07	.06	4
71-12369	1200 pF	.10	.09	.08	.07	.06	4
71-15369	1500 pF	.10	.09	.08	.07	.06	4
71-18369	1800 pF	.10	.09	.08	.07	.06	4
71-20369	2000 pF	.10	.09	.08	.07	.06	4
71-22369	2200 pF	.10	.09	.08	.07	.06	4
71-25369	2500 pF	.10	.09	.08	.07	.06	4
71-27369	2700 pF	.10	.09	.08	.07	.06	4
71-30369	3000 pF	.10	.09	.08	.07	.06	4
71-33369	3300 pF	.10	.09	.08	.07	.06	4
71-39369	3900 pF	.10	.09	.08	.07	.06	4
71-47369	4700 pF	.10	.09	.08	.07	.06	4
71-50369	5000 pF	.10	.09	.08	.07	.06	4
71-10469	0.01 µF	.12	.11	.10	.09	.08	4
71-20469	0.02 µF	.15	.14	.13	.11	.10	4

ELECTROLYTIC CAPACITORS



These aluminum electrolytic capacitors offer an unexcelled combination of high perfomance, high stability, low leakage current and long shelf life in a package ideally suited for operation in coupling, by-passing and filtering functions with typical operating life of 10 years.

PLEASE NOTE: In order to keep our costs at minimum and maintain our low prices, we must request that you order in **EXACT** multiples of 10 per item. However, you may mix all electrolytic capacitors for quantity pricing.

AXIAL LEADS				RADIAL LEADS					Capacitance	Working	Surge	PRICE EACH					
Catalog Number	Dimensions "D"	Dimensions "L"	Lead Dia.	Catalog Number	Dimensions "D"	Dimensions "L"	Dimensions "S"	Lead Dia.	µFd	DC Volts	DC Volts	10-90	100-240	250-490	500-990	1000-up	Grouping Code
37-10609	.205	0.488	.020	38-10609	.205	0.413	.079	.020	1	10	13	.11	.10	.09	.08	.07	5
37-10621	.205	0.488	.020	38-10621	.205	0.413	.079	.020	1	25	32	.13	.11	.10	.09	.08	5
37-10633	.205	0.488	.020	38-10633	.205	0.413	.079	.020	1	50	63	.14	.13	.11	.10	.09	5
37-22609	.205	0.488	.020	38-22609	.205	0.413	.079	.020	2.2	10	13	.11	.10	.09	.08	.07	5
37-22621	.205	0.488	.020	38-22621	.205	0.413	.079	.020	2.2	25	32	.13	.11	.10	.09	.08	5
37-22633	.244	0.492	.024	38-22633	.244	0.417	.098	.020	2.2	50	63	.14	.13	.11	.10	.09	5
37-33609	.205	0.488	.020	38-33609	.205	0.413	.079	.020	3.3	10	13	.11	.10	.09	.08	.07	5
37-33621	.205	0.488	.020	38-33621	.205	0.413	.079	.020	3.3	25	32	.13	.11	.10	.09	.08	5
37-33633	.244	0.492	.024	38-33633	.283	0.417	.098	.020	3.3	50	63	.14	.13	.11	.10	.09	5
37-47609	.205	0.488	.020	38-47609	.205	0.413	.079	.020	4.7	10	13	.11	.10	.09	.08	.07	5
37-47621	.205	0.488	.020	38-47621	.205	0.413	.079	.020	4.7	25	32	.13	.11	.10	.09	.08	5
37-47633	.323	0.622	.024	38-47633	.283	0.417	.098	.020	4.7	50	63	.14	.13	.11	.10	.09	5
37-10709	.205	0.488	.020	38-10709	.205	0.413	.079	.020	10	10	13	.11	.10	.09	.08	.07	5
37-10721	.244	0.492	.024	38-10721	.244	0.417	.098	.020	10	25	32	.13	.11	.10	.09	.08	5
37-10733	.323	0.622	.024	38-10733	.323	0.512	.138	.020	10	50	63	.14	.13	.11	.10	.09	5
37-22709	.244	0.492	.024	38-22709	.244	0.417	.098	.020	22	10	13	.11	.10	.09	.08	.07	5
37-22721	.323	0.622	.024	38-22721	.323	0.520	.118	.020	22	25	32	.15	.14	.13	.11	.10	5
37-22733	.402	1.024	.024	38-22733	.402	0.768	.197	.024	22	50	63	.20	.19	.18	.17	.16	5
37-33709	.244	0.492	.024	38-33709	.244	0.417	.098	.020	33	10	13	.11	.10	.09	.08	.07	5
37-33721	.323	0.622	.024	38-33721	.323	0.520	.118	.020	33	25	32	.15	.14	.13	.11	.10	5
37-33733	.402	1.024	.024	38-33733	.402	0.787	.197	.024	33	50	63	.22	.21	.19	.18	.16	5
37-47709	.323	0.622	.024	38-47709	.323	0.417	.138	.020	47	10	13	.13	.11	.10	.09	.08	5
37-47721	.402	1.004	.024	38-47721	.402	0.512	.197	.020	47	25	32	.17	.16	.15	.14	.13	5
37-47733	.520	1.240	.031	38-47733	.520	0.807	.236	.024	47	50	63	.21	.20	.19	.18	.16	5
37-10809	.323	0.622	.024	38-10809	.323	0.512	.138	.020	100	10	13	.14	.13	.11	.10	.09	5
37-10821	.402	1.004	.024	38-10821	.402	0.787	.197	.024	100	25	32	.20	.19	.18	.17	.16	5
37-10833	.520	1.240	.031	38-10833	.520	1.240	.236	.031	100	50	63	.30	.28	.26	.24	.21	5
37-15809	.402	1.004	.024	38-15809	.402	0.524	.197	.020	150	10	13	.19	.18	.17	.16	.15	5
37-15821	.402	1.024	.024	38-15821	.520	0.787	.236	.024	150	25	32	.27	.26	.24	.22	.20	5
37-15833	.638	1.260	.031	38-15833	.638	1.260	.295	.031	150	50	63	.40	.38	.36	.33	.31	5
37-22809	.402	1.004	.024	38-22809	.402	0.571	.197	.024	220	10	13	.15	.14	.13	.11	.10	5
37-22821	.520	1.240	.031	38-22821	.520	0.807	.236	.024	220	25	32	.28	.27	.25	.24	.21	5
37-22833	.717	1.240	.031	38-22833	.638	1.555	.295	.031	220	50	63	.41	.39	.36	.33	.30	5
37-33809	.402	1.004	.024	38-33809	.402	0.768	.197	.024	330	10	13	.22	.21	.20	.19	.18	5
37-33821	.520	1.240	.031	38-33821	.520	1.240	.236	.031	330	25	32	.29	.27	.25	.22	.20	5
37-33833	.717	1.811	.031	38-33833	.717	1.772	.295	.031	330	50	63	.60	.55	.51	.47	.42	5
37-47809	.402	1.004	.024	38-47809	.402	0.768	.197	.024	470	10	13	.27	.26	.24	.22	.20	5
37-47815	.520	1.240	.031	38-47815	.520	0.984	.236	.031	470	16	20	.28	.27	.25	.24	.21	5
37-47821	.638	1.240	.031	38-47821	.630	0.984	.295	.031	470	25	32	.29	.27	.25	.22	.20	5
37-47827	.717	1.240	.031	38-47827	.638	1.555	.295	.031	470	35	44	.39	.37	.35	.32	.30	5
37-47833	.717	1.949	.031	38-47833	.717	1.909	.295	.031	470	50	63	.71	.66	.61	.57	.51	5
37-68809	.520	1.240	.031	38-68809	.520	1.004	.236	.031	680	10	13	.35	.32	.30	.28	.26	5
37-68821	.717	1.260	.031	38-68821	.638	1.575	.295	.031	680	25	32	.47	.43	.40	.37	.33	5
37-10909	.520	1.240	.031	38-10909	.638	1.004	.295	.031	1000	10	13	.46	.42	.39	.36	.32	5
37-10915	.638	1.240	.031	38-10915	.638	1.260	.295	.031	1000	16	20	.50	.47	.43	.40	.37	5
37-10921	.717	1.437	.031	38-10921	.717	1.398	.295	.031	1000	25	32	.55	.52	.48	.44	.41	5
37-10927	.717	1.949	.031	38-10927	.717	1.969	.295	.031	1000	35	44	.74	.70	.64	.60	.54	5
37-15915	.717	1.457	.031	38-15915	.638	1.575	.295	.031	1500	16	20	.47	.43	.40	.37	.33	5
37-22915	.717	1.594	.031	38-22915	.717	1.752	.295	.031	2200	16	20	.62	.59	.54	.51	.47	5

Dear Customer:

Are you confused with the wide range of prices you see while reading through this or other hobby magazines? Well, allow us to explain!

We at Solid State Systems are proud to offer our customers ONLY factory FIRST-RUNS, marked and identified with FULL manufacturer's name and part numbers. We have never purchased a single "reject" or "seconds" unit. The best we know, only one other hobby supplier, also in Mid-West, has the same policy. Most others usually buy below-spec, "functional only" units as scraps at a fraction of the price and therefore are able to offer them at lower prices.

The best test of this, is the fact that in the past three years, we have never offered any "Didn't have a chance to check them all" or "For Experimenter's Only" items for sale in any of our advertisements or Catalogs.

So, when shopping for parts, please remember: Manufacturers test all their production units and FACTORY TESTED is NOT the same as FIRST RUN PRIME. Defective units were tested too!

LED'S GET THE 'LED' OUT & SAVE!

The most fantastic prices for 7-Segment and overflow LED displays. These are guaranteed to be BRAND NEW, manufacturer's FIRST RUN, yet thanks to our huge purchasing power, we are able to offer them to you at prices well below what others charge for fall-outs and rejects.

Grouping Code for all displays is "10". Prices good thru December 31, 1974.

Catalog Number	Description	Character Height	Color	Price Each
21-00001	OPCOA SLA-1, 7-Segment, 15mA, left decimal	0.33"	Red	1.50
21-00007	OPCOA SLA-7, 7-Segment, 20mA, left decimal	0.33"	Red	1.10
21-10007	OPCOA SLA-17, 7-Segment, 10mA, left decimal	0.33"	Green	1.10
24-00009	OPCOA SLA-9, ±1 overflow, 20mA, no decimal	0.33"	Red	1.10
16-00704	LITRONIX DL-704, 7-Segment, 20mA, right decimal	0.33"	Red	1.00
16-00007	LITRONIX FBL-7, 7-Segment, 20mA, left decimal	0.33"	Red	1.00

All displays have common anodes except DL-704 which has common cathodes.

SCHOTTKY TTL CLOSE OUT!

We are discontinuing our line of Schottky TTL's and, while the quantities last, they are offered at our cost.

We regret, therefore, that we cannot process back-orders for these items and proper credit will be issued for all items SOLD OUT.

Please note that Schottky's also have a Grouping Code of 1 and, while there are no price breaks for them, they may be combined with your other IC orders to take advantage of price breaks for standard TTL's and Linears!

74S00	QUAD 2-INPUT POS. NAND GATE	50¢
74S01	QUAD 2-INPUT POS. NAND GATE WITH O/C	50¢
74S02	QUAD 2-INPUT POS. NOR GATE	50¢
74S03	QUAD 2-INPUT POS. NAND GATE WITH O/C	50¢
74S04	HEX INVERTER	55¢
74S05	HEX INVERTER WITH O/C	55¢
74S08	QUAD 2-INPUT POS. AND GATE	50¢
74S09	QUAD 2-INPUT POS. AND WITH O/C	50¢
74S10	TRIPLE 3-INPUT POS. NAND GATE	50¢
74S11	TRIPLE 3-INPUT POS. AND GATE	50¢
74S15	TRIPLE 3-INPUT POS. AND WITH O/C	50¢
74S20	DUAL 4-INPUT POS. NAND GATE	50¢
74S21	DUAL 4-INPUT POS. AND GATE	50¢
74S22	DUAL 4-INPUT POS. NAND WITH O/C	50¢
74S40	DUAL 4-INPUT POS. NAND BUFFER	55¢
74S50	EXP. DUAL 2-WIDE 2-INPUT AND-OR-INVERT	50¢
74S51	DUAL 2-WIDE 2-INPUT AND-OR-INVERT	50¢
74S60	DUAL 4-INPUT EXPANDER	50¢
74S64	4-2-3-2-INPUT AND-OR-INVERT GATE	50¢
74S65	4-2-3-2-INPUT AND-OR-INVERT WITH O/C	50¢
74S73	DUAL J-K M-S FLIP-FLOP	99¢
74S74	DUAL D-TYPE EDGE-TRIG. FLIP-FLOP	99¢
74S76	DUAL J-K M-S F-F W/PRESET & CLEAR	99¢
74S78	DUAL J-K M-S F-F W/PRESET & CLEAR	99¢
74S107	DUAL J-K M-S FLIP-FLOP	99¢
74S112	DUAL J-K EDGE-TRIG. F-F W/SEP. CLK. & CLR.	99¢
74S113	DUAL J-K EDGE-TRIG. F-F W/SEP. CLOCK	99¢
74S114	DUAL J-K EDGE-TRIG. F-F W/COM. CLK. & CLR.	99¢
74S140	DUAL 4-INPUT POS. NAND BUFFER/DRIVER	55¢

INTEGRATED CIRCUITS

Catalog Number	Any Quantity Per Item (Mix) 1-99	100-999	1000 Up	Multiples of 10 Per Item (Mix) 100-990	1000-9990	Grouping Code
7400	.34	.32	.30	.28	.26	1
7401	.34	.32	.30	.28	.26	1
7402	.34	.32	.30	.28	.26	1
7403	.34	.32	.30	.28	.26	1
7404	.36	.34	.32	.30	.28	1
7405	.36	.34	.32	.30	.28	1
7406	.56	.53	.50	.47	.44	1
7407	.56	.53	.50	.47	.44	1
7408	.38	.36	.34	.32	.30	1
7409	.38	.36	.34	.32	.30	1
7410	.34	.32	.30	.28	.26	1
7411	.34	.32	.30	.28	.26	1
7413	.60	.57	.54	.51	.48	1
7416	.54	.51	.48	.45	.42	1
7417	.54	.51	.48	.45	.42	1
7418	.38	.36	.34	.32	.30	1
7420	.34	.32	.30	.28	.26	1
7421	.34	.32	.30	.28	.26	1
7423	.84	.80	.76	.72	.68	1
7425	.54	.51	.48	.45	.42	1
7426	.40	.37	.34	.31	.28	1
7430	.34	.32	.30	.28	.26	1
7437	.56	.53	.50	.47	.44	1
7438	.56	.53	.50	.47	.44	1
7440	.34	.32	.30	.28	.26	1
7441	1.73	1.64	1.55	1.46	1.37	1
7442	1.34	1.27	1.20	1.13	1.06	1
7443	1.34	1.27	1.20	1.13	1.06	1
7444	1.34	1.27	1.20	1.13	1.06	1
7445	1.71	1.62	1.53	1.44	1.35	1
7446	1.34	1.27	1.20	1.13	1.06	1
7447	1.30	1.23	1.16	1.09	1.02	1
7448	1.44	1.37	1.29	1.22	1.14	1
7450	.34	.32	.30	.28	.26	1
7451	.34	.32	.30	.28	.26	1
7453	.34	.32	.30	.28	.26	1
7454	.34	.32	.30	.28	.26	1
7459	.34	.32	.30	.28	.26	1
7460	.34	.32	.30	.28	.26	1
7470	.46	.43	.40	.37	.34	1
7472	.40	.38	.36	.34	.32	1
7473	.52	.49	.46	.43	.40	1
7474	.52	.49	.46	.43	.40	1
7475	.80	.76	.72	.68	.64	1
7476	.58	.55	.52	.49	.46	1
7480	.80	.76	.72	.68	.64	1
7482	1.10	1.05	1.00	.95	.90	1
7483	1.72	1.64	1.56	1.48	1.40	1
7485	1.58	1.51	1.44	1.37	1.30	1
7486	.60	.57	.54	.51	.48	1
7489	5.00	4.75	4.50	4.25	4.00	1
7490	.85	.80	.75	.70	.65	1
7491	1.48	1.41	1.34	1.27	1.20	1
7492	.85	.80	.75	.70	.65	1
7493	.85	.80	.75	.70	.65	1
7494	1.32	1.26	1.20	1.14	1.08	1
7495	1.32	1.26	1.20	1.14	1.08	1
7496	1.32	1.26	1.20	1.14	1.08	1
74100	1.80	1.70	1.60	1.50	1.40	1
74104	.70	.67	.64	.61	.58	1
74105	.70	.67	.64	.61	.58	1
74107	.54	.51	.48	.45	.42	1
74121	.60	.57	.54	.51	.48	1
74122	.74	.71	.68	.65	.62	1
74123	1.30	1.20	1.10	1.00	.90	1
74141	1.75	1.66	1.57	1.48	1.39	1
74145	1.50	1.43	1.36	1.29	1.22	1
74150	2.00	1.85	1.70	1.55	1.40	1
74151	1.30	1.24	1.18	1.12	1.06	1
74153	1.70	1.60	1.50	1.40	1.30	1
74154	2.75	2.55	2.35	2.05	1.85	1
74155	1.56	1.49	1.42	1.35	1.28	1
74156	1.46	1.39	1.31	1.23	1.16	1
74157	1.56	1.48	1.39	1.31	1.23	1
74158	1.56	1.48	1.39	1.31	1.23	1
74160	2.10	2.00	1.90	1.80	1.70	1
74161	2.10	2.00	1.90	1.80	1.70	1
74162	2.10	2.00	1.90	1.80	1.70	1
74163	2.10	2.00	1.90	1.80	1.70	1
74164	2.10	2.00	1.90	1.80	1.70	1
74165	2.96	2.82	2.67	2.52	2.37	1
74166	2.20	2.09	1.98	1.87	1.76	1
74170	3.80	3.61	3.42	3.23	3.04	1
74175	2.70	2.57	2.43	2.30	2.16	1
74180	1.30	1.23	1.16	1.09	1.02	1
74181	5.20	4.90	4.60	4.30	4.00	1
74182	1.26	1.19	1.12	1.05	.98	1
74192	2.10	2.00	1.90	1.80	1.70	1
74193	2.10	2.00	1.90	1.80	1.70	1
74198	3.10	2.95	2.80	2.65	2.50	1
74199	3.10	2.95	2.80	2.65	2.50	1

LINEAR IC'S

NE501A	2.99	2.82	2.66	2.49	2.32	1
NE526A	3.59	3.38	3.17	2.95	2.74	1
NE531V	3.20	3.04	2.88	2.72	2.56	1
NE536 T	7.31	6.88	6.45	6.02	5.59	1
NE540 L	2.16	2.04	1.92	1.80	1.68	1
SE540 L	4.48	4.20	3.92	3.64	3.36	1
NE550A	1.30	1.23	1.16	1.09	1.02	1
NE555V	1.10	1.05	1.00	.95	.90	1
NE560B	3.57	3.36	3.15	2.94	2.73	1
NE561B	3.57	3.36	3.15	2.94	2.73	1
NE562B	3.57	3.36	3.15	2.94	2.73	1
NE565A	3.57	3.36	3.15	2.94	2.73	1
NE566V	3.57	3.36	3.15	2.94	2.73	1
NE567V	3.57	3.36	3.15	2.94	2.73	1
N5111A	.90	.86	.82	.78	.74	1
N5556V	2.10	1.95	1.80	1.65	1.50	1
N5558V	1.00	.95	.90	.85	.80	1
N5596A	1.87	1.77	1.66	1.56	1.46	1
µA709CV	.50	.47	.44	.41	.38	1
µA710CA	.50	.47	.44	.41	.38	1
µA711CA	.55	.52	.49	.46	.43	1
µA723CA	1.00	.95	.90	.85	.80	1
µA733CA	1.90	1.80	1.70	1.60	1.50	1
µA741CV	.80	.75	.70	.65	.60	1
µA747CA	1.10	1.04	.98	.92	.86	1
µA748CV	.80	.75	.70	.65	.60	1
SI-3554M	8.25	7.75	7.25	6.75	6.25	1
SI-3120E	3.75	3.60	3.45	3.30	3.15	1
SI-3150E	3.90	3.75	3.60	3.45	3.30	1
SI-3240E	3.90	3.75	3.60	3.45	3.30	1

DIODES

1N270	.15	.14	.13	.12	.11	2
1N4001	.10	.09	.08	.07	.06	2
1N4002	.11	.10	.09	.08	.07	2
1N4003	.13	.12	.11	.10	.09	2
1N4004	.14	.13	.12	.11	.10	2
1N4005	.15	.14	.13	.12	.11	2
1N4006	.17	.16	.14	.13	.12	2
1N4007	.20	.18	.16	.14	.12	2
1N4148	.10	.09	.08	.07	.06	2
1N746A	.25	.22	.19	.16	.13	2
1N747A	.25	.22	.19	.16	.13	2
1N748A	.25	.22	.19	.16	.13	2
1N749A	.25	.22	.19	.16	.13	2
1N750A	.25	.22	.19	.16	.13	2
1N751A	.25	.22	.19	.16	.13	2
1N752A	.25	.22	.19	.16	.13	2
1N753A	.25	.22	.19	.16	.13	2
1N754A	.25	.22	.19	.16	.13	2
1N755A	.25	.22	.19	.16	.13	2
1N756A	.25	.22	.19	.16	.13	2
1N757A	.25	.22	.19	.16	.13	2
1N758A	.25	.22	.19	.16	.13	2
1N759A	.25	.22	.19	.16	.13	2
2N3860	.25	.23	.21	.19	.17	2

All IC's are supplied in 8-, 14-, or 24-pin DIP (Dual-in line) plastic or ceramic package except for NE536, NE540, and SE540, which come in TO-5 package. Voltage Regulators SI-3554M, SI-3120E, SI-3150E, and SI-3240E are supplied in TO-3 (Diamond) package.

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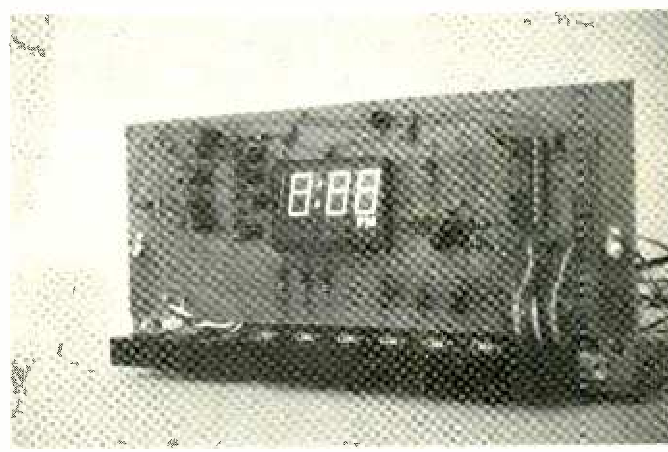

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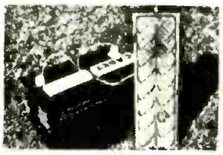

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