14278

STARTING THIS ISSUE! "EXPERIMENTER'S" COLUMN

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE OCTOBER 1975 / 75¢

HOW TO DESIGN SOLID-STATE OSCILLATORS

Experimenting with Phase-Lock-Loop IC's

Build an Electronic Wheel of Fortune

Rhombic Antenna Plans for TV

How to Interface Mechanical Switches to Digital Logic

What's New For HI-FI in 1976

HIRSCH-HOUCK TESTS

Sony's New V-FET Power Amplifier & Koss' Quadraphonic Headphones

PLUS REPORTS ON

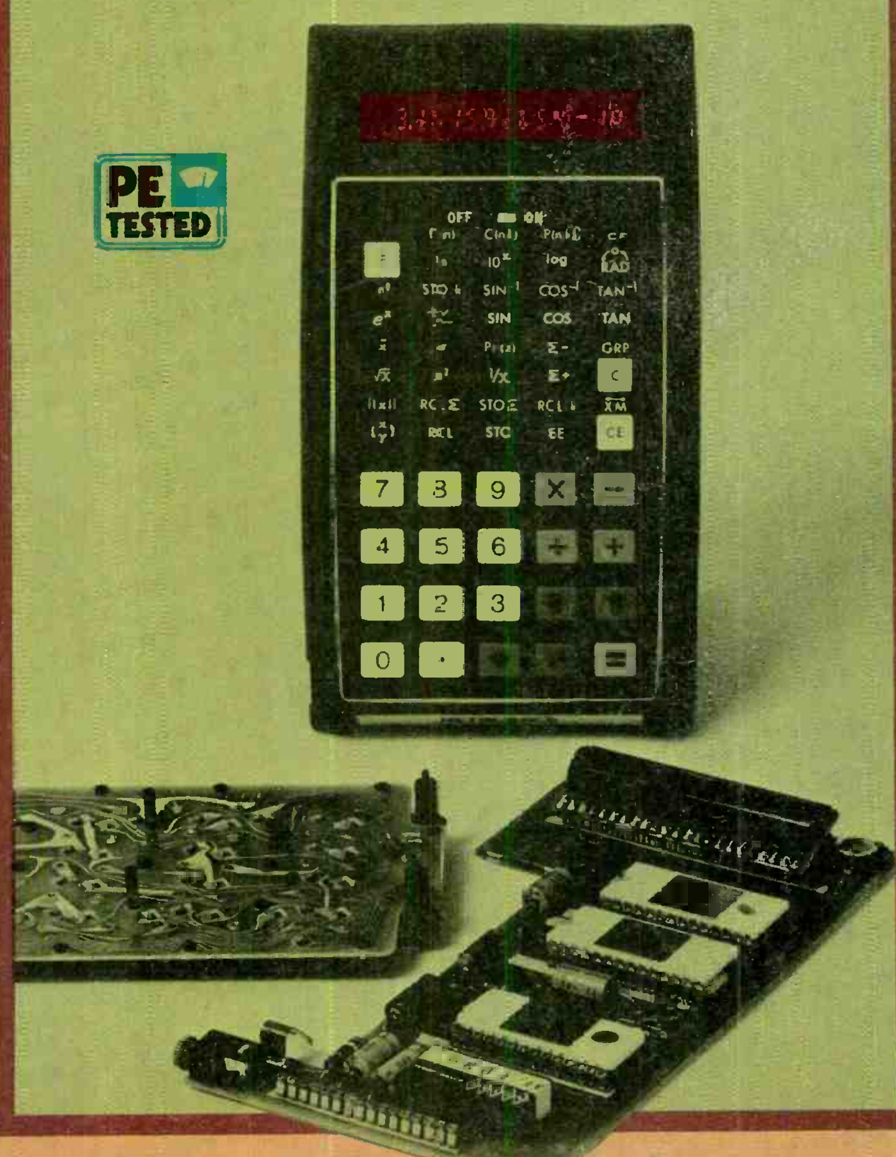
B&K's Transistor Tester & SBE's Digital Mobile CB Transceiver

BUILD THE

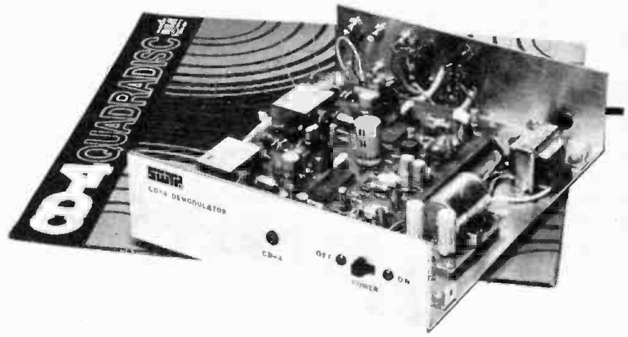
"Senior Scientist" Calculator

10 LEVELS OF ADDRESSABLE MEMORY

PE TESTED



SWTPC



CD-4

DEMODULATOR

TRUE FOUR CHANNEL SOUND

Southwest Technical Products is proud to offer the most advanced CD-4 demodulator available. Our new CD-4 has characteristics superior to anything previously available thanks to the QSI-5022 integrated circuit used in the unit. This IC and the balance of the circuit was designed by Quadracast Systems Inc. under the direction of Mr. Lou Dorren. The QSI-5022 contains all the sub-system functions needed to demodulate a CD-4 disc, from the phono cartridge input to the output drive for the four power amplifiers. It may be used with either an RIAA equalized magnetic cartridge, or a semiconductor cartridge with flat equalization.

INEXPENSIVE

Now anyone can afford to add discrete true 4 channel sound to their system. You no longer need be satisfied with matrix techniques that produce acoustrical enhancement, but not true 4 channel sound. The Southwest Technical Products CD-4 demodulator when added to your system will produce four channel sound from a CD-4 encoded disc that will equal, or surpass anything you can buy—no matter what the price.

EASY INSTALLATION

The SWTPC demodulator connects between the cartridge and the volume-tone control portion of your system. If you did not want tone controls, actually all that would be needed in addition to our CD-4 demodulator would be volume controls for the front and rear amplifiers. The demodulator is self powered from any 115 Volt 60 Cycle line. When normal stereo discs are played on your system a muting system automatically turns off the rear channels. A manual override 2 or 4 channel selector switch is provided on the rear panel.

SIMPLE CONSTRUCTION

As shown in the photograph, the vast majority of the parts mount on the epoxy-fibreglass circuit board. Part numbers and package outlines printed on the top of the board make proper assembly quite simple. Anyone with a minimum of electronic experience should be able to assemble this project without any problems. A copy of the article describing the CD-4 demodulator and assembly instructions are supplied in the kit.

CD-4 Demodulator Kit...........$50.00 ppd

CD-4 CARTRIDGE

For those who do not already own a CD-4 cartridge, we are offering the "Technics" EPC-451C semiconductor strain-gauge cartridge at a special low price when purchased with our new CD-4 demodulator kit. This cartridge features a Shibata-type stylus and excellent response out to 50 kHz. This eliminates any chance of "carrier drop-out", or "carrier crosstalk" which result in abnormal noise or distorted sound. The EPC-451C produces a high output (about 30 times that of an average magnetic cartridge) and does not pick up hum from magnetic, or electrostatic fields. Easily replaced stylus.

EPC-451C CD-4 Cartridge........$25.00 ppd

TEST RECORD

Lou Dorren has recorded a special test record for Southwest Technical Products Corp. that will allow you to properly adjust your CD-4 demodulator for the best possible sound. This special test and demonstration record is yours for only $5.00 when purchased with the CD-4 demodulator kit.

CD-4 Test Record...................... $5.00 ppd

WANT MORE INFORMATION?

Send the coupon below and $0.50 and we will send you by return mail a copy of the article describing our new CD-4 kit along with our catalog of other kit projects.

CD-4 DEMODULATOR

MAIL THIS COUPON TODAY

☐ Enclosed is $ __________ or BAC # __________

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☐ CD-4 Demodulator Kit ☐ Cartridge ☐ Test Record

NAME __________

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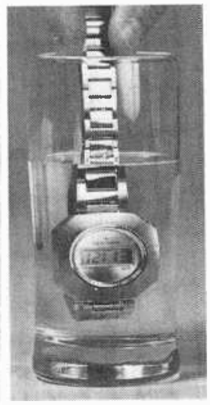
☐ $0.50 Enclosed for catalog & CD-4 Data

Southwest Technical Products Corp., Box 32040, San Antonio, Texas 78284

At night or during the day, the Sensor's large, constantly "alive" CDR display is clear and easy to read.

Digital Watch Breakthrough!



The new CDR display dramatically increases legibility and battery life and opens a new era of watch technology.

Would you do this with your solid-state watch? Of course not. Practically all solid-state watches require care and pampering. Not the Sensor 770. You can dunk it, drop it and abuse it without fear during its unprecedented five year parts and labor warranty.

A glance at your solid-state watch won't give you the time. Sound incredible? If it's an LED (light-emitting diode) watch, you've got to press the button first. If it's an LCD (liquid crystal display) watch, you must have plenty of light at just the right angle.

Now there's a new solid-state display technology called CDR (crystal diffusion reflection) incorporating the best features of the LED and the LCD displays. You can easily and constantly read your watch under any light conditions without strain or inconvenience.

The new CDR display takes the properties of the field-effect liquid crystal display, puts a strong reflective substance behind two closely-alligned polarization lenses, and the resulting large digits can be read clearly from practically any angle. When engaged, an integrated light source illuminates the display at night. The Sensor's constantly "alive" high-contrast display makes legibility outstanding under all light conditions.

Press the button on the Sensor 770 and the date and seconds appear in large black numerals—easy to read in any light.

A WORRY-FREE WATCH

Solid-state watches pose their own problems. They're fragile, they must be pampered, and they require frequent service. Not Sensor! Here are just five common solid-state watch problems you can forget about with this advanced space-age timepiece:

1. **Forget about batteries** Sensor is powered by a single EverReady battery that will actually last years without replacement. In fact, if your battery fails during the first five years, we will replace it free of charge. A low-power indicator tells you when to change the battery one month in advance and you simply open the hatch at the back of your watch and replace the battery yourself.

2. **Forget about water** Take a shower or go swimming. The Sensor is so water-resistant that it withstands depths of up to 100 feet.

3. **Forget about shocks** A three foot drop onto a solid hardwood floor or a sudden jar. Sensor's solid case construction, dual strata crystal, and cushioned quartz timing circuit make it the most rugged solid-state quartz watch ever produced.

4. **Forget about service** The Sensor 770 has an unprecedented five-year parts and labor unconditional warranty. Each watch goes through weeks of aging, testing and quality control before assembly and final inspection. Service should never be required, but if it should anytime during the five year warranty period, we will pick up your Sensor at your door and send you a loaner watch while yours is repaired—all at our expense.

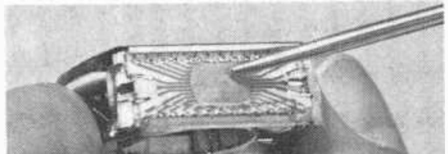
5. **Forget about changing technology** The Sensor is literally years ahead of every other watch in durability and technology. But should Sensor's technology improve anytime during the next five years, you may trade in your watch for Sensor's newer model under JS&A's liberal trade-in policy.

COMPARED TO EVERY OTHER

The $275 Pulsar uses the LED technology which requires pressing a button each time you want to review the time. Even the $500 solar-powered Synchronar watch, in our opinion, can't compare with the Sensor and its 5-year warranty. And no solid-state watch can compare to Sensor's quality, accuracy, ruggedness and exceptional value.

PLENTY OF ADVANCED FUNCTIONS

Sensor's five functions give you everything you really need in a solid-state watch. Your watch displays the hours and minutes constantly. Depress a button and your watch displays the seconds and date constantly. There's also an AM/PM indicator. To adjust the time, insert a ball-point pen into the four-channel time-control switch. Each channel independently controls one time function. In short, you can change the hours without affecting the date, and the minutes without affecting the hours.



A pin points to the new decoder/driver integrated circuit which takes the input from the oscillator countdown integrated circuit and computes the time while driving the display. This single space-age device replaces thousands of solid-state circuits and provides the utmost reliability—all unique to Sensor.

Sensor's accuracy is unparalleled. All solid-state digitals incorporate a quartz crystal. So does the Sensor. But crystals change frequency from aging and shock. And to reset them, the watch case must be opened and an air-tight seal broken which may affect the performance. In the Sensor, the crystal is first aged before it is installed, and secondly, it is actually cushioned in the case to absorb tremendous shock. The quartz crystal can also be adjusted through the battery compartment without opening the case. In short, your watch should be accurate to within 5 seconds per month and maintain that accuracy for years without adjustment and without ever opening the watch case.

STANDING BEHIND A PRODUCT

JS&A is America's largest single source of electronic calculators, digital watches and other space-age products. We have selected the Sensor as the most advanced American-made, solid-state timepiece ever produced. And we put our company and its full resources behind that selection. JS&A will unconditionally guarantee the Sensor—even the battery—for five years. We'll even send you a loaner watch to use while your watch is being repaired should it ever require repair. And our liberal trade-in policy guarantees that new watch technology will never leave you behind.

Wear the Sensor for one full month. If you are not convinced that the Sensor is the most rugged, precise, dependable and the finest quality solid-state watch in the world, return it for a prompt and courteous refund.

To order your Sensor, credit card buyers may simply call our toll-free number below or mail us a check in the amount indicated below plus $2.50 for postage, insurance and handling. (Illinois residents add 5% sales tax) We urge you, however, to act promptly and reserve your Sensor 770 today.

Stainless steel w/leather strap $99.95
Stainless steel w/metal band $109.95
Gold plated w/leather strap. $119.95
Gold plated w/metal band. $129.95

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OCTOBER 1975 VOLUME 8, NUMBER 4

Popular Electronics®

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PRODUCT TEST REPORTS

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Editorial

THE NEW PRODUCT WARRANTY LAW

Hallelujah! Did you know that we have a wonderful (?) new product warranty law to protect buyers from those terrible ogres, the manufacturers? With this law, unleashed by the Federal Trade Commission and effective for products made after July 4, 1975, the buyer will probably enjoy warranties that offer less protection than ever before. He will also probably pay more and watch our Federal bureaucracy (and hence his taxes) grow even larger.

In a giant step backward, the consumer will now have a choice of buying products carrying one of two types of warranties: "Limited" or "Full," depending on which one the manufacturer wishes to declare. Some gutsy manufacturers will doubtlessly choose the Full one, hoping to gain a competitive advantage. But they'll also run the risk of having to abide by very vague Federal standards—which could be interpreted differently at a later time and expose them to legal damages. (By vague we mean such things as the FTC's partiality for the word "reasonable," as in "repair within a reasonable time," "full refund after a reasonable number of repair attempts," etc.)

Though the law is now in effect, the FTC has not yet clearly defined the rules (and may not for years to come), leaving manufacturers in a quandary. How do they interpret "reasonable"? Who is responsible for sending a defective product to the company? What about house service calls for portable TV receivers? The auto tire maker wants to know if he can still deduct depreciation when a refund is in order. As a result of all this confusion, many manufacturers will take the conservative route rather than risk a financial bath. The loser, I think, will be the consumer. For example, *Bisiness Week* reports that Wright & McGill Co. will drop the "lifetime guarantee" from all of its "Eagle Claw" line of fishing rods and reels. This decision has been reached, it seems, because a Full warranty under the new law is frought with legal uncertainties, and the company doesn't want to fall back on a Limited warranty.

Certainly, product warranties have been a source of anguish to some consumers over the years. More often than not, however, this has not been due to the wording of the warranty. In most instances, dissatisfaction was caused by the actual intent and action of the manufacturer, dealer or authorized service company. The new Warranty/FTC Improvement Law won't change this! As in the past, the dealer or manufacturer who treats a buyer fairly will retain him or her as a customer—and as a good-will ambassador to attract other buyers. The manufacturer who doesn't pursue this policy soon loses out in the marketplace.

The new warranty law is only the tip of the iceberg, as one might expect. There are proposed rules requiring pre-sale availability of retailers' complete written warranties, with products carrying a printed message inviting consumers to ask to see a copy of the warranty.

Interestingly, the FTC's Director of the Bureau of Consumer Protection admits that the FTC could only police this at enormous cost. One member of the FTC warned that the rule could cost consumers millions of dollars a year. While acknowledging that he supports the principle that people who make and sell products ought to stand behind them, he added, "There are some things the citizen must learn to do for himself. . ." Amen!

Art Salsberg

New Mallory Ni-Cad Batteries. Rechargeable 1000 times.

Economical recharging —
Mallory BC-1 Charger draws only two watts.

Team these long-life nickel-cadmium cells with an automatic Mallory Charger, and you can recharge them 1000 times, or more.

You'll be sure of having fresh D, C, and AA batteries, while saving money, time and trouble. Mallory Rechargeable Nickel-Cadmium Batteries keep on coming back for more in electronic calculators, tape recorders, radios, cameras, toys, other battery-powered products.

Keep a spare set of Mallory Ni-Cads on hand, and you'll never run out of battery power again. They recharge to full strength, two or four at a time. And unlike ordinary dry cells that lose voltage during discharge, Mallory Ni-Cads with a full charge maintain operating voltage during the entire work cycle. You get maximum power, continuously, for top product performance.

For the long run, Mallory Rechargeable Ni-Cads . . . the 1000-time batteries. Get them now at your Mallory Distributor.

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CIRCLE NO. 37 ON FREE INFORMATION CARD

Letters

VARIABLE AUDIO FILTER

In the article "Active Filter Sharpens CW Reception" (June 1975), the author alludes to difficulty in tuning in CW signals when the 100-Hz filter is switched into the circuit. Autek Research (Box 1494, Canoga Park, CA 91304) markets an audio filter which is continuously variable from 30 Hz to approximately 2 kHz, with a center frequency of 800 kHz. The "Q-Box" is priced at $17.95 plus $1 for shipping. I have been using one for over a year and find it a great help in digging through the clutter of the Novice bands.—*Thomas R. Sundstrom, Willingboro, NJ*

ORDERING STETHOSCOPE KITS

Due to a slip-up at the Post Office, the first few orders for the stethoscope kit ("Listen to Your Heart with Doppler Ultrasound," August 1975, p 60) were unfortunately returned to the senders. I apologize for the mix-up. The situation has now been corrected and readers who wish to return their orders to the same address will receive the kit.—*Joseph Jaffe*

WANTS SHORTWAVE UV LIGHT

"Build a Blacklight Lantern" (April 1975) was a project I have been waiting to see in print for some time. However, I was disappointed that the Parts List did not include a source for a shortwave fluorescent tube and its associated cobalt glass filter. Working in the underground zinc mine here in the Fluorescent Mineral Capital of the World and being a rock collector for years, I know that most minerals that fluoresce at all will be more appealing under shortwave UV light. As long as one uses a shortwave UV light with a reasonable amount of caution and does not look directly into the light source, he need not be concerned with "sun-burned" eyes.—*Joseph Williams, Franklin, N.J.*

We wanted to keep the project as safe as possible for even an uninformed user, which precluded the inclusion of eye-damaging (if improperly used) shortwave UV light. However, if you really want a shortwave UV light, you might try looking through the latest Edmund Scientific Co. (300 Edscorp Bldg., Barrington, NJ 08007) catalog for ready-to-use shortwave UV lights starting at about $40.

CHECK YOUR CMOS

I have had several letters telling of problems involving the CMOS oscillator in my article "Build a Versatile Digital LED Thermometer" (November 1974). I have double-checked the schematic to determine that it is correct. One thing to remember is that a TTL NAND will not work in the place of the CMOS NAND because the resistances used are too high for TTL. Also, CMOS circuits are notoriously tricky if rejects are used. I would advise trying several prime CMOS units before rejecting the circuit.—*Thomas R. Fox.*

EQUIPMENT FOR AM BCB DX'ING

In "How to Listen to Out-of-State AM Broadcasts" (April 1975), the author failed to mention the type of equipment needed to get started in this hobby. I am a sports fan and would like to receive broadcasts of sporting events outside of the Connecticut area. Just what type of equipment would I need to get started in AM broadcast band DX'ing?—*Daniel Protas, Stamford, Conn.*

First of all, you need a sensitive AM broadcast band receiver or tuner. Then, you need a good antenna system that will pull in those weak signals originating out of state. One such antenna is the McKay Dymek Model DA-3.

IC FOR THE VR12 VOLTAGE REGULATOR

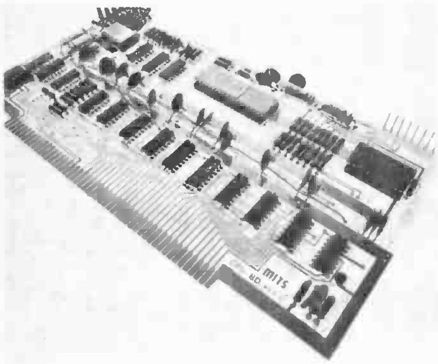
General Electric has discontinued the manufacture of the PA230 IC which was originally used for the Beco VR12 voltage regulator. The VR12 has been redesigned around the UA741 (full temperature range) IC.—*C. R. Ball, Jr., Beco Inc., Salem, VA.*

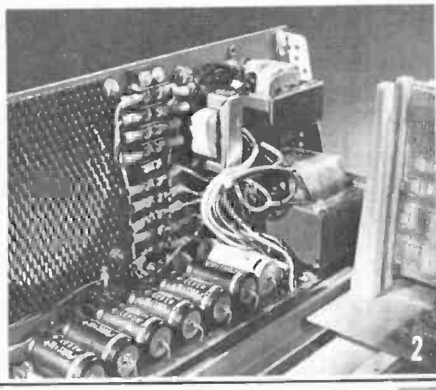
ELECTRONICS UNLIMITED ORDERS

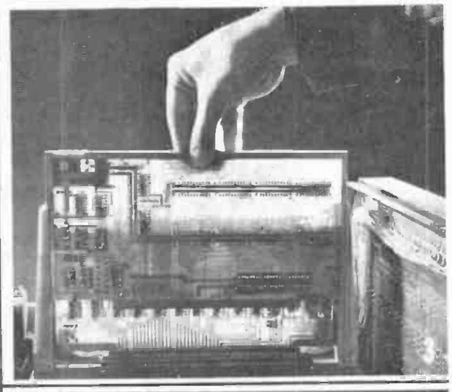
On March 14, I ordered the LED kit from Electronics Unlimited, Inc., as described in Lou Garner's March "Solid State" column. So far, I have not received the kit. After getting my cancelled check from the bank, I wrote E.U.I. I have still heard nothing from them. This is the first time I have had any difficulty ordering from your advertisers.
—*P.A. Shackelford, Paducah, Ky.*

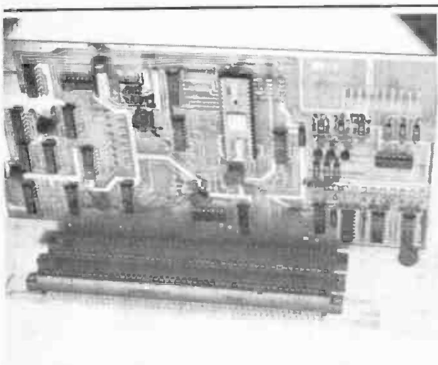
This is one of many letters we have received concerning nondelivery of paid-for parts from E.U.I. First, E.U.I. is not an advertiser. Lou Garner simply gave the company a free plug for what he thought was an unusual $8.95 kit that readers would welcome. He had been assured by E.U.I. (before mentioning it in the column) that they would be happy to fill orders on the kit. A number of phone calls from Lou to E.U.I. elicited a host of reasons for shipment delay, including waiting two weeks for checks to clear and back-ordered perf boards. If any reader experiences difficulty in reaching the company through its P.O. Box number, please let us know (enclosing a stamped, self-addressed envelope) and we will send you a more complete address.

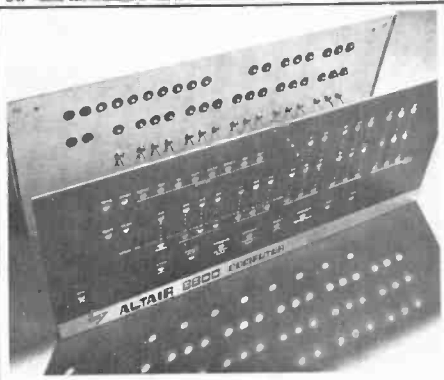
INSIDE the Altair® Computer

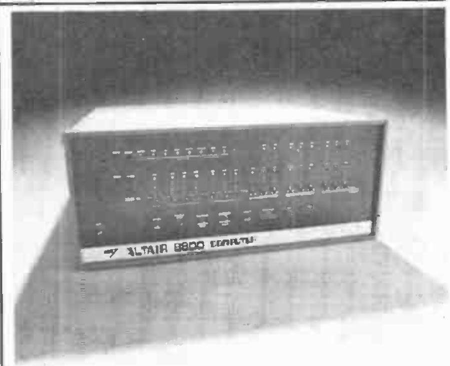












1. Central Processing Unit (CPU) Board. This double-sided board is the heart of the Altair 8800. It was designed around a powerful, byte oriented, variable word length processor—a complete central processing unit on a single LSI chip using n-channel, silicon gate MOS technology. The CPU board also contains the Altair System Clock—a standard TTL oscillator with a 2.000 MHz crystal as the feedback element.

2. Power Supply. The Altair Power Supply provides two +8, a +16 and a −16 volts. These voltages are unregulated until they reach the individual boards (CPU, Front Panel, Memory, I/O, etc.). Each board has all the necessary regulation for its own operation.
The Altair Power Supply allows you to expand your computer by adding up to 16 boards inside the main case. Provisions for the addition of a cooling fan are part of the Altair design.

3. Expandability and custom designing. The Altair has been designed to be easily expanded and easily adapted to thousands of applications. The basic Altair comes with one expander board capable of holding four vertical boards. Three additional expander boards can be added inside the main case.

4. Altair Options. Memory boards now available include a 1024 word memory board, a 2048 word memory board, and a 4096 word memory board. Interface boards include a parallel board and 3 serial boards (RS232, TTL and Teletype). Note: Interface boards allow you to connect the Altair Computer to computer terminals, teletypewriters, line printers, plotters and other devices.

Other Altair Options include additional expander boards, computer terminals, audio-cassette interface board, line printers, ASCII keyboards, floppy disc system, alpha-numeric display and more.

5. All aluminum case and dress panel. The Altair Computer has been designed both for the hobbyist and for industrial use. It comes in an all aluminum case complete with sub-panel and dress panel.

6. It all adds up to one fantastic computer. The Altair is comparable to mini-computers costing 10-20 thousand dollars. It can be connected to 256 input/output devices and can directly address up to 65,000 words of memory. It has over 200 machine instructions and a cycle time of 2 microseconds.
You can order the Altair Computer by simply filling out the coupon in this ad or by calling us at 505/265-7553. Or you can ask for free technical consultation or for one of our free Altair System Catalogues.

PRICES:

Altair Computer kit with complete assembly instructions $439.00
Assembled and tested Altair Computer $621.00
1,024 word memory board $97.00 kit and $139.00 assembled
2,048 word memory board $145.00 kit and $195.00 assembled
4,096 word memory board $264.00 kit and $338.00 assembled.
Full Parallel Interface board $92.00 kit and $114.00 assembled.
Serial Interface board (RS232) $119.00 kit and $138.00 assembled.
Serial Interface board (TTL or teletype) $124.00 kit and $146.00 assembled
Audio Cassette Record Interface $128.00 kit and $174.00 assembled
Expander Board (adds 4 slots to 8800) $16.00 kit and $31.00 assembled

NOTE: Altair Computers come with complete documentation and operating instructions. Altair customers receive software and general computer information through free membership to the Altair User's Club. Software now available includes a resident assembler, system monitor, text editor and BASIC language.

MITS/6328 Linn NE, Albuquerque, NM, 87108 505/265-7553

MITS

"Creative Electronics"

Prices and specifications subject to change without notice. Warranty: 90 days on parts for kits and 90 days on parts and labor for assembled units.

MAIL THIS COUPON TODAY!

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☐ or Master Charge #________
☐ Credit Card Expiration Date ________
☐ Altair Computer ☐ Kit ☐ Assembled
☐ Options (list on separate sheet)
Include $8.00 for postage and handling.
☐ **PLEASE SEND FREE ALTAIR SYSTEM CATALOGUE**

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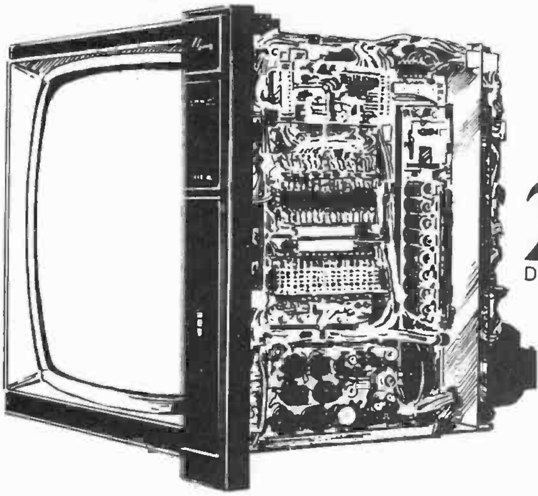
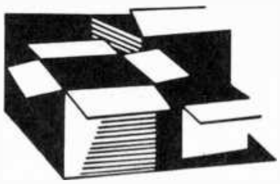


You get the same 25" DIAGONAL hobby-kit color TV from three different schools.

You get this designed-for-learning 25" DIAGONAL color TV only with NRI training.

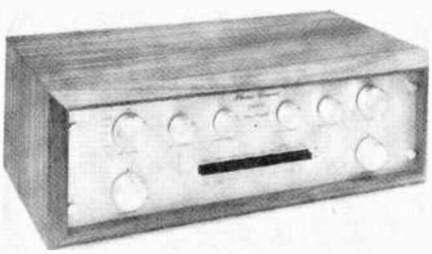


New Products

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

PHASE LINEAR STEREO PREAMP

Phase Linear's new stereo preamplifier, Model 2000, features low-noise IC designs, individual detented bass and treble controls for each channel, and a choice of four



tone turnover points. Two tape monitors and a low-frequency active equalizer are included. "Variable Ambience Injection" is said to enhance the dimensions of stereo reproduction. THD is rated at less than 0.1%, and phono S/N at 74 dB below 10 mV. $299.

CIRCLE NO. 70 ON FREE INFORMATION CARD

BEARCAT WEATHER-PROOF SPEAKER

The Bearcat speaker by the Electra Company is weather-proof (made of white heavy-duty plastic), making it well suited for patio, garden, or marine installation. It can handle 5 watts rms (12 watts peak), and its response is 500 to 5000 Hz. Shipping weight is 1.4 lb. $16.95.

CIRCLE NO. 71 ON FREE INFORMATION CARD

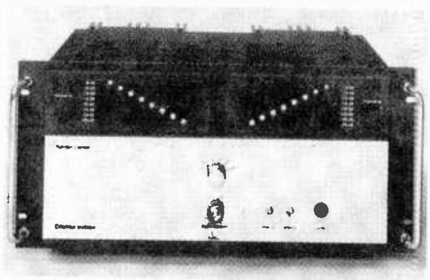
EICO DIGITAL LOGIC PROBE

The Model DLP-6 Digital Logic Memory Probe can be used with DTL and TTL systems, and provides detection capabilities for pulse durations as short as 50 nanoseconds. The indicator system consists of three LED's. The bottom LED lights green for logic 1, the center LED lights red for logic 0, and the top LED lights yellow to indicate a positive- or negative-going transition. Each LED remains in the "on" stage for 200 nanoseconds regardless of pulse duration. A memory switch causes the LED to remain on permanently after a positive or negative pulse occurs. Available in either kit ($19.95) or factory-assembled ($29.95) form.

CIRCLE NO. 72 ON FREE INFORMATION CARD

HARMAN/KARDON STEREO POWER AMPLIFIER

The Citation 16 is a new stereo amp from Harman/Kardon with a power rating (as per FTC rules) of 150 W/channel, and twin power level indicators using a series of



LED's whose sensitivity is switchable for 4- and 8-ohm loads. It is said that the amplifier offers a wide power bandwidth, and incorporates a design which deals effectively with transient intermodulation distortion (TID). Also included is a test switch for checking the readouts. The Citation 16 can be operated in a "bridged" one-channel mode with higher output capacity. $795.

CIRCLE NO. 73 ON FREE INFORMATION CARD

HEATHKIT ELECTRONIC WORKSHOP

Budding scientists can build up to 35 different experiments while learning electronics basics with the new Heathkit Jr. JK-18A Electronic Workshop. Connections are solderless spring terminals and power is supplied by four "D" cells. Each experiment is accompanied by a simple schematic to help teach circuit and component identification. Circuits which can be built with the kit include code flasher, continuity tester, battery and diode testers, rain alarm, timing relay, and intercoms. $34.95 (mail order, less batteries)

CIRCLE NO. 5 ON FREE INFORMATION CARD

TRAM/DIAMOND MINI-MOBILE CB RIG

The Tram XL, a new mini-mobile unit from Tram/Diamond, features PA/CB operation, switchable ANL, illuminated S/r-f meter,

squelch, 23-channel operation, 13.8-volt (positive or negative ground) supply voltage, front-panel plug-in mike, and mounting bracket with tamper-proof bolts (wrench included). Rated frequency tolerance is −0.005%, sensitivity 0.6 μV for 10 dB S+N/N (1-kHz sine wave, 30% modulation), and selectivity at 6 dB at 4 kHz, 60 dB at 20 kHz. Included are spare fuses, instruction manual, and FCC license application. Measures 6.3"D × 5.5"W × 1.97"H (16 cm × 14 cm × 5 cm) and weighs 2.5 lb. (1.1 kg). $159.95.

CIRCLE NO. 74 ON FREE INFORMATION CARD

RF/AF ANALYST

The Nikoltronix RF/AF Analyst is a solid-state, battery-powered servicing test instrument that combines a crystal-controlled r-f generator, a 400-Hz sine-wave generator (which can modulate the r-f unit), and an r-f and a-f signal tracer. The r-f generator contains a crystal tester with LED readout, covering the 3.5- to 90-MHz range. The r-f module is also available with built-in crystals providing up to 12 fixed frequencies spanning the same frequency range. The signal tracer section has a high-input-impedance probe and can trace signals riding on dc levels up to 500 V, according to Nikoltronix. $129.45.

CIRCLE NO. 75 ON FREE INFORMATION CARD

BURWEN LOW-NOISE PREAMPLIFIER

The Model SP5200 Low-Noise Stereo Preamplifier by Burwen Laboratories has a claimed dynamic range of 115 dB at 0 dB gain, a small-signal frequency response of

20 to 20,000 Hz ± 0.1 dB, and a THD of 0.05% max. from 20 to 10,000 Hz. Output is dc coupled, delivering 2.5 V (rated), 8 V max. Burwen states that the use of FET input circuitry and selectable feedback loop provides quiet (90 dB below 10-mV input) performance in the open 47k phono input mode. A monitor is provided, as well as a turn-on/turn-off silencer and short-circuit protection. A total of 33 input and output jacks are available, including a center channel output. One unswitched and four switched ac outlets are built-in, which can handle a total of 1000 W. Matched slide pots form the volume control.

CIRCLE NO. 76 ON FREE INFORMATION CARD

PANAVISE "THIRD HAND"

Builders of projects involving pc boards and other small, fragile components will find PanaVise's Model 396 the equivalent of a "third hand" at their workbenches. Offered with various bases and heads, all interchangeable, the basic unit tilts, turns, and rotates to any position while holding delicate parts gently yet firmly.

CIRCLE NO. 77 ON FREE INFORMATION CARD

PIONEER "PRO" TURNTABLE

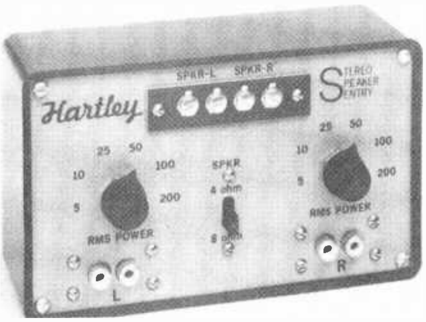
A professional direct-drive turntable featuring an automatic tonearm return and an S-shaped low-mass tonearm with low-capacity cable has been introduced by Pioneer as its Model PL-55X. The platter is driven by a brushless dc servo-controlled motor and operates at 33⅓ and 45 rpm (changed electronically). Speed can be adjusted to ±2%. Wow and flutter are 0.05%

Wrms and S/N ratio exceeds 58 dB, according to the manufacturer. It accommodates cartridges weighing 4 grams (min.) to 14 grams (max.). In addition, the turntable includes an anti-skating device, lateral balancer, plug-in headshell, and stylus-pressure direct-readout counterweight. Wood base measures 18 29/32" W x 16 5/32" D x 7 9/32" H (48 x 41 x 18 cm). $249.95

CIRCLE NO. 78 ON FREE INFORMATION CARD

HARTLEY STEREO SPEAKER SENTRY

The latest version of the Hartley Stereo Speaker Sentry is an electronic control that



limits power applied to a speaker at a preset level between 5 and 200 W rms. If the power limit is exceeded, the input signal to the amplifier is automatically reduced to bring the output to the desired level. According to Hartley, it is self-powered, expends milliwatts of the amplifier output, and acts faster than a common fuse, responding to an overload in a fraction of a millisecond. $35.00.

CIRCLE NO. 79 ON FREE INFORMATION CARD

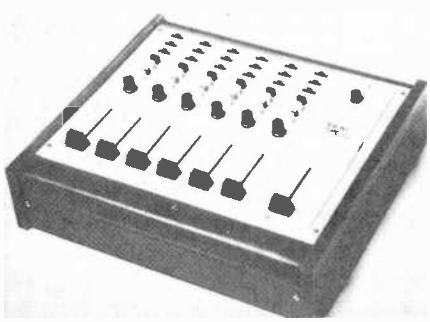
UNGAR SOLDERING STATION

A portable, rechargeable soldering station (No. 194), made by Ungar, incorporates a rechargeable nickel-cadmium battery. The lightweight pencil iron features an indicator light, operating trigger control with interlock "off" switch, and built-in lamp. It accepts two interchangeable tips. The high-impact plastic charging holder has a tip-cleaning sponge receptacle and is rated at 120-V ac input: 3.2-V ac at 120 mA output.

CIRCLE NO. 80 ON FREE INFORMATION CARD

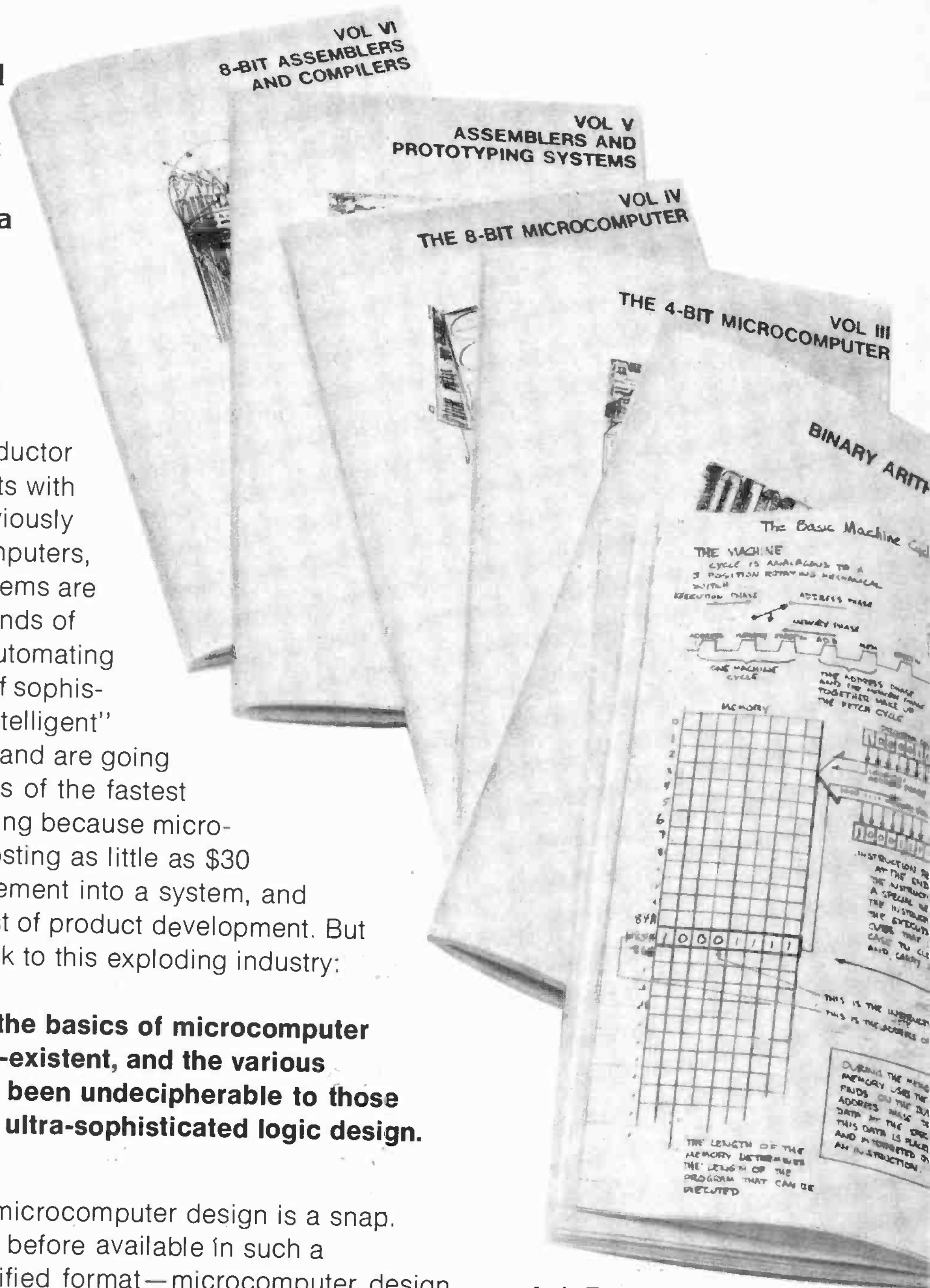
TEAC MULTICHANNEL MIXER

Teac's new multichannel (6-in, 4-out) mixer, Model 2, has low- and high-cut fil-



Microcomputer

A new six-volume programmed learning course from Iasis tells you EVERYTHING about what microcomputers are and how you can design and implement a microprocessor-based system.



Since the transistor was invented, no single electronics innovation has made such an impact as the microcomputer. Powered by tiny semiconductor chips containing computing elements with the same powers and functions previously found only in large scale digital computers, these dedicated microcomputer systems are now being applied to literally thousands of applications. Microcomputers are automating assembly lines, providing the heart of sophisticated electronic games, making "intelligent" computer peripherals even smarter, and are going so far as streamlining the operations of the fastest food chains. This revolution is occuring because microcomputers are very inexpensive—costing as little as $30 in production volume—easy to implement into a system, and significantly reduce the time and cost of product development. But there has been one serious drawback to this exploding industry:

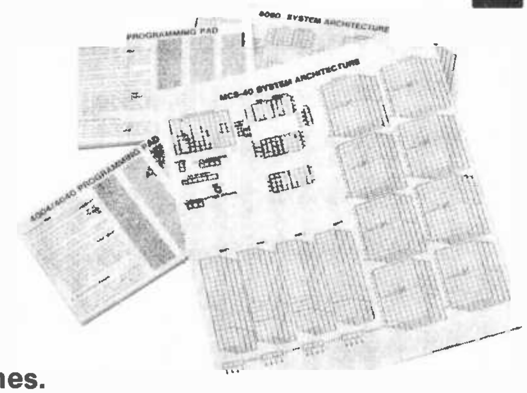
Training materials and courses in the basics of microcomputer technology have been virtually non-existent, and the various published manuals and texts have been undecipherable to those not already intimately familiar with ultra-sophisticated logic design.

Once a designer has the hang of it, microcomputer design is a snap. But without the fundamentals—never before available in such a readable, understandable and simplified format—microcomputer design has been unbelievably difficult. The comprehensive, step-by-step six-volume Programmed Learning Course on Microcomputers from Iasis makes the unbelievably difficult almost ridiculously simple. The authors of these texts have been involved on a professional level in the microcomputer industry since it became an industry. Their direct, first-hand experience in the whys, hows, wherefores and potentials of microcomputers

Iasis Texts:
1. Binary Arithmetic
2. Microcomputer Architecture
3. The 4-Bit Microcomputer
4. The 8-Bit Microcomputer
5. Assemblers and Prototyping Systems
6. 8-Bit Assemblers and Compilers

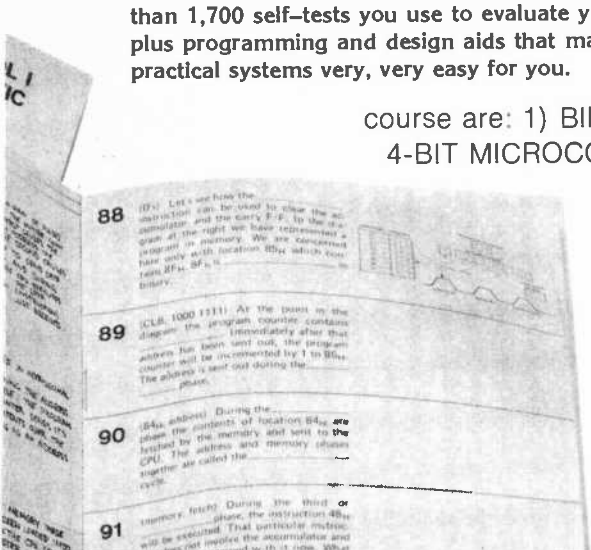
Finally, you can get a comprehensive training course on microcomputers that puts all the hard-to-get information at your fingertips in an easy-to-read, easy-to-understand and even easier-to-implement manner. You can get it here... now.

design is a snap.



have made this six-volume collection the most valuable and meaningful series ever published on microcomputer design. The books combine the most effective methods of programmed instruction with the entire gamut of essential information vital to the designer of a micro-based system. You begin with the ABC's of microcomputers and go through a virtual post-doctoral course... **and the unique, self-testing programmed learning Iasis course enables you to understand and absorb every bit of the information every step of the way through the six volumes.**

The Iasis course gives you more than 700 pages of detailed, illustrated microcomputer information—including more than 1,700 self-tests you use to evaluate your progress—plus programming and design aids that make the design of practical systems very, very easy for you.



Specific details are provided on four of the industry's most versatile microcomputers—the 4004, 4040, 8008 and 8080 from Intel Corporation—but the basic design information will apply to any and all microprocessors. The six volumes you receive with the course are: 1) BINARY ARITHMETIC; 2) MICROCOMPUTER ARCHITECTURE; 3) THE 4-BIT MICROCOMPUTER; 4) THE 8-BIT MICROCOMPUTER; 5) ASSEMBLERS AND PROTOTYPING SYSTEMS; and 6) 8-BIT ASSEMBLERS AND COMPILERS. Plus, this detailed course provides you with two programming pads and two simplified design aids so you may quickly and easily develop both 4-bit and 8-bit microcomputer systems. Use the coupon below to order your course from Iasis, Inc., 110 First St., Suite PE Los Altos, California 94022

Special introductory price on this remarkable new course is just $99.50 . . . and if it isn't everything we say it is or even more, return it within 15 days for a full refund!

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Order before Nov. 30, and you'll save a full $25 on the Programmed Learning Course on Microcomputers! In addition, all introductory orders will include a bonus seventh volume, the Microcomputer Applications Handbook!

(After Nov. 30, 1975 price for the complete Iasis course will be $124.50, plus $2.50 for postage and handling.)

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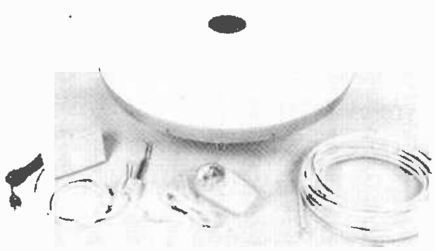
CITY/STATE/ZIP ____________

ters plus panning on each input, as well as cue out, bus in, and accessory send/receive patch points. Push/push channel assignment buttons are color-coded to correspond to the output buses. A signal from any input channel can be assigned to any or all output channels. When more than one channel is assigned, Pan is engaged, giving the recordist the ability to shift around the acoustic image. The Model 2 features a straight line fader as the level controls for the input channels, while a master fader controls the output levels. The MIC IN accepts a ¼-inch phone plug, and LINE IN accepts a standard phono plug. LINE OUT serves as the program bus out, and AUX OUT acts as an additional line output in parallel with the main line output. $299.50.

CIRCLE NO. 81 ON FREE INFORMATION CARD

RCA MINI-STATE TV ANTENNA

RCA's new Mini-State TV Antenna System includes a 60-ft. length of 75-ohm coaxial cable and three rotor wires within a single outer jacket. The system's built-in rotor

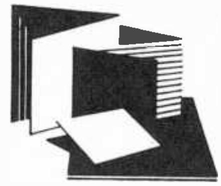


and amplifier enable it to pick up signals from stations up to 35 miles away, according to RCA. A hand-held remote control with lighted direction indicator lets the viewer adjust the antenna's directivity for best reception. The Mini-State is housed in a compact plastic case measuring 21" (53.3 cm) in diameter and 6" (15.2 cm) thick. The antenna system can be mounted outdoors or indoors. $79.95.

CIRCLE NO. 82 ON FREE INFORMATION CARD

WIK-IT DESOLDERING WICK

"Wik-It," developed by the Wik-It Electronics Corp., is a chemically treated wire braid, which draws up molten solder through capillary action. After the solder has been removed from the connection, the user snips off the saturated piece of Wik-It, and draws out another length from its spool. Wik-It comes in various diameters to suit small IC and pc-board work, as well as tube and chassis applications. The wick is packaged in lengths from 5 to 100 feet. Price of a 5-foot roll of Wik-It varies from $1.59 to $1.79 according to braid diameter. Address: Wik-It Electronics Corp., 140 Commercial St., Sunnyvale, CA 94086



New Literature

LAFAYETTE 1976 CATALOG

"The Electronics Shopping Center" is the title of Lafayette's catalog for 1976, and it does contain listings of just about every electronic item imaginable. Included are hi-fi components and accessories, CB and other communication equipment, antennas, tools, musical instruments, calculators, watches, vacuum tubes, solid-state devices, etc. Also, the Lafayette and Criterion brands of their own products. Address: Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, NY 11791.

JENSEN LOUDSPEAKER SYSTEM CATALOGS

A new series of catalogs is available from Jensen Sound Laboratories. The catalog for Models 1 through 6 contains specifications, illustrations, and features of the Jensen high-fidelity line. A separate full-color catalog describes the Jensen Serenata™ sound system. Various catalog sheets describe the Dynamount™ mobile high-fidelity unit, the full mobile speaker line, and the professional sound line. Address: Jensen Sound Laboratories, 4310 Trans World Road, Schiller Park, IL 60176.

MOBILE COMMUNICATIONS BROCHURE

A new 16-page, full-line brochure from Motorola Communications describes mobile communications equipment. "Vehicular Communications" covers the latest Motorola offerings in the mobile two-way field, including car telephones, data communications equipment, and mobile radios. Among the equipment highlighted are MICOR/Systems 90 group which provides selective signalling, multi-channel monitoring, and voice scrambling; the MCR-100 motorcycle radio; and the PULSAR mobile telephone. Address: Motorola Communications and Electronics, Inc., 1301 E. Algonquin Road, Room 4420, Schaumburg, IL 60172.

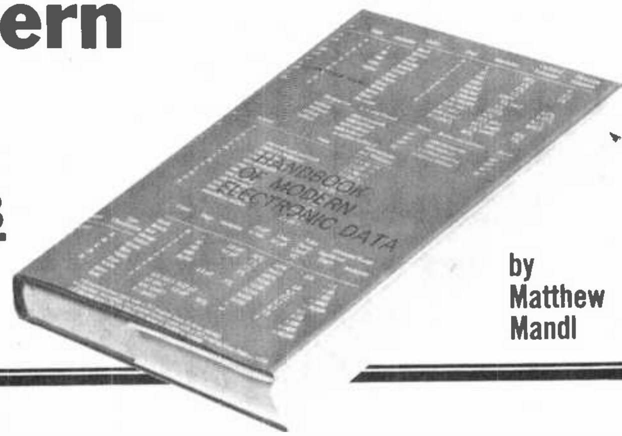
TAB BOOKS CATALOG

More than 340 current and forthcoming technical books are listed in Tab Books' new 1975 catalog. Among the areas covered are amateur radio, audio, broadcasting CB and mobile radio, FCC license study guides, equipment servicing, electronic devices, and hobby and experimentation. Address: Tab Books, Blue Ridge Summit, PA 17214.

Now—solve your workbench problems faster with the help of this comprehensive, fully illustrated

Handbook of Modern Electronic Data

This $14.95 volume is yours for just $1.98 when you enroll in an obligation-free trial membership in the Electronics Book Service. And there's no obligation to ever buy a minimum number of books!



by Matthew Mandl

This book—truly a volume no electronics workbench should be without—is typical of the practical selections offered to members of the *Electronics Book Service.* Although it is selling actively at its list price of $14.95, we have arranged for you to receive a copy for just $1.98, together with an obligation-free, trial membership in this unusual book club.

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With this book on your workbench, you'll save hours by letting it serve as your main reference. All the information you need is there. Just look in the index, flip to the subject you want, and you're guaranteed of finding the techniques you need for faster, easier design and analysis of circuits, switches, relays and many other electronic units.

Here are 274 pages of accurate, up-to-date data that the practicing technician/engineer uses constantly—BASIC EQUATION, EXPLANATIONS OF CIRCUITRY, TABLES, GRAPHS, SOLID-STATE THEORY, and many other informational items—including data on LASERS, HOLOGRAMS, ANTENNAS, COLOR CODES, SYMBOLS, VECTORS, PHASE FACTORS, UNIT SYSTEMS and the INTERNATIONAL SYSTEM OF UNITS.

And it's all indexed and cross-indexed so that you can find what you're looking for *in seconds!*

To make this vital information *easy for you to find*, the author has grouped the topics in related categories. For example, in the first chapter Matthew Mandl groups descriptions of fundamental units, terms and their appropriate mathematics.

Here, you'll quickly find what you need to know about capacitance, prefix values, hertz, units of current and voltage, wavelength, the coulomb, Ohm's Law, magnetic properties, inductance, rectangular notation, resonance, dynes, and Basic SI Units and Symbols—to name but a few of this chapter's items.

And Chapter Two brings together various series-parallel circuit combinations—and their mathematics.

In each of these two chapters, you'll find over 80 electronic and electric equations. These equations aptly illustrate the applied mathematics required in electronics and circuitry.

In the third chapter, Mandl takes up the fundamentals of transistors and tubes—including parameters for both junction transistors and field-effect transistors. Chapter Four covers transmission line and antennas.

The next two chapters put at your fingertips such essential information as common logarithms, trigonometric ratios, international atomic weights, exponential functions, Bessel functions, conversion and comparison tables, UHF television station allocations, television signal data, antenna gain and Z factors, thermal units, binary math—and even important data on lasers, masers, holograms and cryogenics.

And Chapter Seven gives you a wealth of ready-reference information on *basic circuitry*—including functional aspects, typical configurations and applications.

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5. You have at least 10 days to decide whether you want the selection or not. Return the card so we receive it no later than the date specified. If you don't have 10 days to answer and receive an unwanted selection, return it *at our expense.*
6. Each bulletin also describes a number of alternate or additional selections, also available to you at the special discount price for members.

The meter ranges, color codes and symbols frequently used by technicians and engineers make up the contents of Chapter Eight. The last chapter discusses and illustrates vectors and three-phase fundamentals in full detail.

Yes, in this one comprehensive, fully illustrated handbook are the answers to practically every question you might have about the circuitry and applications, ratings and characteristics of transistors, semiconductors, IC's, antennas, amplifiers and just about any other piece of equipment.

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CIRCLE NO. 46 ON FREE INFORMATION CARO


Build this set...
CAUTION
HIGH VOLTAGE

Stereo Scene

By Ralph Hodges

WHAT'S NEW FOR HI-FI IN 1976

NOW THAT the summer Consumer Electronics Show (CES) has come and gone, I've had a leisurely month or so to reflect on the new audio products seen there. In retrospect, I'm surprised at the emergence of a few trends I was scarcely conscious of noting as I toured the show.

Integrated Amplifiers. It's been years since anyone asked me for a recommendation on integrated stereo amplifiers, and I had made up my mind that this type of component was pretty much eclipsed by the ever-popular receiver (except for high-power aficionados, who would, of course, choose separate preamp and power amp). What, then, were all those new integrated amplifiers doing at the CES? The answer to this question comes in several parts, gleaned from several sources. First, a few West Coast manufacturers, notably Marantz and SAE, are said to have discovered lively regional markets for integrated amps.

Second, for various good reasons the integrated amplifier enjoys much greater acceptance abroad; and, with few exceptions, almost all the major new units are of overseas origin.

Third, by design, the integrated amplifier seems to be eking out a new image for itself as a poor man's Phase Linear 700 or Marantz 500. Since the real beginning of the transistor era, an integrated amp was simply the control and power-output sections of the corresponding model in the manufacturer's receiver line, abstracted from the larger unit for the convenience of buyers with special needs or budgetary considerations. Today, more and more, integrated amplifier's are being marketed as the direct offspring of heftier preamp/power-amp ensembles, which they tend to resemble closely in features, construction, and styling. For example, Pioneer's SA-9900 integrated unit (110 watts per channel) actually preceded the introduction of the company's SPEC 1 preamplifier and SPEC 2 power amplifier (250 watts per channel) at the CES, although the three products obviously share a common design philosophy. Now Pioneer has three smaller integrated amps descended from the larger model.

Sansui's new amplifier line sprang up fully grown at the show. It comprises, in descending order, the BA 5000 power amplifier (300 watts per channel), the somewhat less powerful BA 3000, the CA 3000 preamplifier, and then the integrated amplifiers: the AU-20000 (170 watts per), AU-11000 (110 watts), and AU-9900 (80 watts). All these follow a common styling scheme that is distinct from the manufacturer's receivers and other product lines. Likewise, JVC, with a new 180-watt-per-channel power amplifier (the JM-S1000) and four-channel preamplifier (the JP-V1000), has combined the essential characteristics of the two into the JA-S20 integrated amplifier (120 watts per channel). Also, Fisher now has a large power amplifier, the BA-4500 at 150 watts per channel, a new preamplifier (the CA 4500), and three new integrated amplifiers to bask in their reflected glory.

The Rotel line lacks separate power amplifiers and preamplifiers, but it now includes an integrated amp, the 110-watt RA-1412, that looks like it logically might have evolved from larger units. On the other hand, the Luxman line, currently being reintroduced to the U.S., includes no receivers, but has four power amplifiers (300 down to 75 watts per channel), two preamplifiers, and three integrated amplifiers ranging from 110 to 75 watts per channel, as well as several separate tuners.

A little apart from this trend are the Pilot 225, a 25-watt-per-channel inte-

grated model with no super-power brethren, the modest but handsome Harman/Kardon A-401 (20 watts), and the 85-watt Sherwood SEL-400, which was reportedly conceived as a companion to the SEL-300 digital-readout tuner. As for the rest of the new integrated amps, they look like an attempt to provide caviar on a salmon-roe budget, and as such they should be welcome to those with moderate power requirements who have felt technologically disenfranchised by the super-power stir.

Moving-Coil Cartridges. Do you remember how happy everyone was when moving-coil phono cartridges virtually disappeared more than ten years ago? Well, they're back, and with most of the same old practical problems. Stylus replacement still necessitates a factory return, and output voltages are still discouragingly low (although not quite so low as before), requiring the use of step-up transformers or special gain stages ahead of the preamplifier and causing no end of worry about hum and other forms of noise.

All the current crop of moving-coil pickups is made abroad; and when this new wave materialized a few years ago, it was easy to believe that it merely reflected the foreign manufacturers' difficulties in selling moving-magnet (or moving-iron or whatever) cartridges in the U.S., where Shure, Pickering, Stanton, Empire, and ADC hold strong basic patents on the design. However, Ortofon, which offers both types of pickup, has kept the faith over the years, continuing to offer moving-coil models for what are said to be good sonic reasons (in fact, a CD-4 moving-coil cartridge from Ortofon is working its way past the prototype stage). Best-known of the newer moving-coil manufacturers are Supex, Fidelity Research, and Denon, all of which are Japanese companies, with their products handled by only a few small distributors in this country.

Considering the short supply of these cartridges, their inconveniences, and their substantial prices, they seemed destined to remain exclusively esoteric products for the most passionately involved audiophiles. And that may still be the greatest notoriety they'll achieve, but be it noted that such comparative heavyweights as Yamaha, Sony and Great American Sound have acknowledged the existence of these cartridges by providing amplifier gain to boost their outputs to usable levels. In particular, the CES brought the debuts of the Thaedra preamplifier from G.A.S. and Yamaha's new C-1 all-FET preamplifier, both with what are becoming called "head amps"—highly sensitive phono preamplifiers such as were heretofore only available as separate "pre-preamplifiers" from such small outfits as Mark Levinson Audio and one or two others. ("Head" is a name for a phono cartridge that is somewhat archaic in the U.S., but is still seen occasionally in British publications.) The Yamaha C-1, incidentally, is one of the most elaborate stereo preamplifiers now offered—a fitting companion to the B-1 FET power amplifier introduced earlier this year. Also, kit versions of Dynaco's new PAT-5 preamplifier can be wired to give an additional 6 dB of gain to the phono preamp—enough, it is said, to be usable with the higher-output moving coil pickups.

Sub-Woofers. You may recall sub-woofers from the last time they were in vogue, when hobbyists were busily converting spare garage and basement space into monster speaker enclosures with openings onto one wall (often occupying the entire wall) of the listening room. The latest sub-woofers are nowhere near as large. The offering from Dahlquist, in fact, is little larger than a bookshelf speaker system.

The sub-woofer concept is simple. It is a speaker system for low frequencies only, with high power-handling and output capability. It is intended to be simply a supplement to an existing, complete sound system and to augment the reproduction of frequencies below about 50 Hz, where the low-frequency resonance of many fine speaker systems occurs. Connection into the system is by means of a passive crossover network or an electronic crossover (requiring additional amplification facilities for the sub-woofer). The point is to thoroughly maul the listener with a deep, loud bass that his otherwise preferred loudspeakers (especially electrostatics or other dipole film-diaphragm types) might not be capable of generating without severe distortion. A convenience feature is also involved. Because low bass is non-directional (one way of saying that it's difficult to localize the source of low-frequency energy), the main speakers can be small and placed according to the requirements of good stereo imaging. Then the sub-woofer can be located anywhere in the room (compatible with good acoustic practice) and still "join up" satisfactorily with the stereo image.

Besides Dahlquist, Hegeman offers a sub-woofer, and so does a new company called Bottom End. Others are becoming available on special order from several manufacturers. Note that two such units are not necessarily required. Low frequencies can be electronically "summed" and directed to one sub-woofer, which should be adequate for smaller rooms.

Automatic Turntables. Automatic turntables a new trend? Yes, considering that manual turntables have been the going thing for the past two years. Actually, automatic turntables with manual features are the big news, the important features being a belt-driven (offered by B.I.C. last year) or direct-drive platter (as in Technics' Model 1350). Technics still has the only direct-drive automatic, but Garrard has come up with two units that are belt-driven through an intermediate idler pulley. One of these units, the Z2000B, has the Zero Tracking Error tone arm. Also, there are two belt-driven automatics from BSR, and the striking Model 1249 of Dual.

Three-Head Cassette Decks. The surprising thing about three-head cassette decks is that there haven't been more of them since the successful introduction of the Nakamichi 1000 and 700 some time ago. So now welcome the Akai GXC-760D, with three motors as well as three heads, and a dual-capstan drive system to create a closed tape loop around the head nest. Akai will also offer several less expensive models, as will Fisher, which claims to have a three-head machine selling for less than $250.

The one new three-head machine I've had a chance to examine in some detail is the Hitachi D-3500, which may be a genuine winner. A tricky problem with three-headers has been alignment between record and playback heads, which are generally spaced (because of the limited number of openings in the cassette housing) so that the tape is free to twist and skew between them enough to upset any hope of accurate

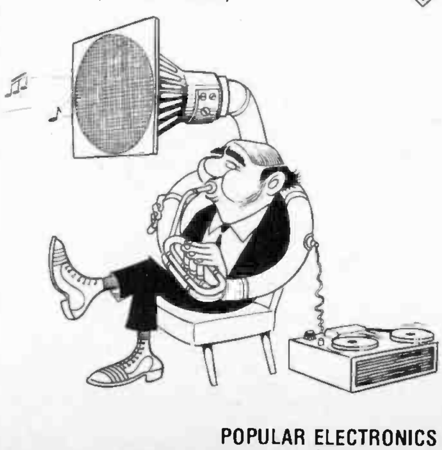
azimuth. Nakamichi freely admits that tape skew can be serious enough to require realignment when a cassette is merely turned over. Thus the company provides an alignment control for the record head that can be set in a matter of moments using built-in indicators. Hitachi, however, has managed to create record and playback heads that nest together so closely that the two gaps can share the cassette's pressure pad, without any obvious signs of mutual interference, and no suggestion of azimuth problems.

Four Channel. Now that four-channel stereo is not quite so involved in the rush for patents and exclusives as in years past, some thoughtful, time-consuming work is being done in decoder/demodulator design. JVC has introduced the CD4-1000 demodulator, which is at least as flexible as the so-called "professional" units, and probably on a par with them in performance. Sansui's QSD-1 is the first separate QS decoder to be seen in a long, long time. It incorporates Vario-Matrix (operating independently in three frequency bands) and provides audible separation that I've never heard equalled by any matrix system. CBS Labs (now CBS Technology Center) does not have any immediate plans for selling the superb Paramatrix SQ decoder to consumers, but is urging on other designers such as Audionics. The latter demonstrated a prototype of the so-called Shadow Vector SQ decoder—a good, if potentially expensive device, with excellent image stability as far as I could hear.

There is really nothing surprising about the emergence of high-ticket decoders and demodulators. Serious audiophiles *are* interested in four-channel stereo, but they intend to have it their own way, just as they did when stereo came along.

Small Trends. A scant year or so ago, Pioneer introduced a stereo headset employing what was called a "high-polymer" film diaphragm. The diaphragm itself was the transducer, exhibiting piezoelectric properties when voltage was applied; the material was coated with a thin metallic deposit to provide electrodes. At that time, it was suggested that there were many other applications beyond headphones in which the material could be used. This lead directly to the HPM-200 speaker system introduced this year, with tweeter and super-tweeter constructed of the same high-polymer material. The diaphragms now are formed into a cannister shape, providing a radiation pattern that covers a full 360 degrees laterally.

V-FET power amplifiers are still a small trend, but with some potential for growing larger. So far only Sony, Yamaha, and Kenwood are prepared to sell equipment containing V-FET output devices, but next year there will probably be more. (For more on this subject, see this month's Product Test Reports.—Ed.) ◈



news HIGHLIGHTS

Digital Watch Developments

Brown Boveri SA of Switzerland has introduced a new field-effect liquid crystal display with permanent readout of hours, minutes and seconds (the latter by groups of ten) with calendar readout on demand. Other models have permanent readout of hours and minutes, with seconds and date on command. The readouts require 1.5-to-5.0-volt power sources.

Also in Switzerland, Heuer-Leonidas SA has announced the Chronosplit, a digital timepiece that shows conventional and elapsed time simultaneously. An LCD gives the time of day in hours, minutes, and seconds and the date. A light-emitting diode display shows the elapsed time up to 9:59:59.9 in tenths of a second increments. The LED's light up only on demand and stay on for two seconds. Both displays operate on the same time base without interference. Two silver-oxide batteries, with an estimated one-year lifetime, supply the power.

RFI Bill Introduced

Rep. Charles Vanik of Ohio has introduced a bill that would deal with the problems of RFI (radio frequency interference) and electronic equipment. The bill, H.R. 7052, would give the FCC the right to regulate the manufacture of electronic home-entertainment devices with respect to their susceptibility to interference from nearby radio transmitters. Since over 90% of RFI is caused by inadequate shielding and/or filtering, the bill would attempt to solve the problem at its major source—audio and visual consumer products. The RFI problem is increasing with the growing number of active broadcast, amateur, CB, commercial, and public-service transmitters. Comments on the bill can be directed to your local Congressman.

New TV Components

Hitachi, Ltd., has developed a new color TV picture tube which reportedly produces pictures 50% brighter than those from conventional tubes. It has a black matrix screen, a high-performance gun, dot screen structure, high matrix transparency, and a large electron lens. An HV of 12.1 kV is applied to the shadow mask, and a 25-kV phosphor screen voltage is maintained. Therefore, electrons experience increased acceleration after passing through the shadow mask, not before. This is said to help reduce electron deflection by 30%, and brighten the picture.

In another development, the General Instrument Corp. introduced Project Omega, a solid-state tuning system for TV receivers. It incorporates a nonvolatile memory, which stores information after power has been turned off. Omega will allow the viewer to "fine tune" all channels once, with identical results each time the channel is selected. The system will cover all 82 vhf and uhf channels, and will incorporate remote control options. Its basic four-chip format provides for manual address systems, last-channel-viewed recall, sequential search for all on-air channels, and remote control. Additional chips now under development will provide on-screen displays of channel number and time, and complete programming for a week's worth of viewing.

Cable TV Growth Projected

About 8.7 million homes now subscribe to cable television, representing 13% of the viewing total. By 1983, that number will more than double to 22 million, according to market researchers at Frost & Sullivan, Inc., NYC. To support this growth, cable TV operators will spend almost $5 billion on goods and services over the 10-year period. Subscribers will pay more than $16 billion in fees during the same interval. The study reports that, in 1975, 281,000 subscribers will take this option, increasing to 1,492,000 in 1979 and 5,968,000 in 1984.

Voice-Controlled Wheelchair

NASA has demonstrated a voice-controlled wheelchair with attached manipulator. The chair, developed by engineers at NASA's Jet Propulsion Laboratory, responds to 32 one-word voice commands, such as ready, go, stop, left, right, backward, etc. The voice-command analyzer, actually a minicomputer, learns the commands when the patient repeats them several times. It recognizes the commands only in the patient's own speech pattern, even if he has an accent. The chair also has a manipulator arm which can grasp objects from one to four feet away. The voice-command analyzer and chair are activated when the patient presses the back of his head or chin against either of two switches, and receives information from a microphone worn by him. Additional memory space would allow the chair to contain a number of pretrained sequences, such as moving a fork or spoon between a plate and the patient's mouth.

REACT Reorganized

REACT, the national CB emergency service, has been reorganized into an independent, nonprofit public service organization called REACT International, Inc. As a result, it is receiving recognition and support from new sources, as well as a new grant from General Motors, its most recent commercial sponsor. Under the new structure, REACT is applying for exemption from U.S. Federal Income Tax. If approved, contributions to REACT teams may be deducted by the donor as allowed by IRS regulations. Since 1962, REACT teams have handled about 55 million emergency calls, including approximately 12 million highway accidents. Members have assisted relief efforts in such natural disasters as hurricane Camille, the Rapid City (South Dakota) flood, the Southern California earthquake, etc.

The better the training the better you'll

(Simulated TV Reception)

As an NTS student you'll acquire the know-how that comes with first-hand training on NTS professional equipment. **Equipment you'll build and keep.** Our courses include equipment like the **NTS/Heath Digital GR-2000 Solid State color TV** with first-ever features like silent varactor diode tuning; digital channel selection, (with optional digital clock), and big 315 sq. in. ultra-rectangular screen.

Also pictured above are other units — 5" solid state oscilloscope, vector monitor scope, solid-state stereo AM-FM receiver with twin speakers, digital multimeter, and more. It's the kind of better equipment that gets you better equipped for the electronics industry.

This electronic gear is not only designed for training; it's field-type — like you'll meet on the job, or when you're making service calls. And with NTS easy-to-read, profusely illustrated lessons you learn the theory behind these tools of the trade.

Choose from 12 NTS courses covering a wide range of fields in electronics, each complete with equipment, lessons, and manuals to make your training more practical and interesting.

Compare our training; compare our lower tuition. We employ no salesmen, pay no commissions. You receive all home-study information by mail only. All Kits, lessons, and experiments are described in full color. Most liberal refund policy and cancella-

You can't experience today's high fidelity with yesterday's record changer.

Most high fidelity manufacturers watch each other to find out what's new. At Pioneer, we keep our eye on the audio enthusiast to find out what he wants. That's what keeps us ahead of all the others who are watching all of the others.

If you look at the sale of record playing devices — and we have — you'll see that sales of manual turntables are increasing four times faster than the sale of record changers. The reasons are clear: Record changers were designed a generation ago — for another generation. Designed for hours of uninterrupted background music at cocktail parties.

Today, your needs are probably different. When you listen to music, you listen to music. You're involved with the sound — and with your equipment. And only a manual turntable can offer you this level of involvement.

It's part of Pioneer's responsibility to understand and anticipate your changing needs. As a result, we now offer you the most complete line of professional manual turntables available. Each one of them delivers the highest level of performance, the most sophisticated features and the greatest value in its price category. And all of them have the precision engineering and quality that are part of the Pioneer legend.

When you buy your next record player, shop smart. Consider what you want — and what you need. If you need performance, precision and quality — and want the involvement that only a professional turntable can provide — you'll get a Pioneer.

It's as simple as that.

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074.
West: 13300 S. Estrella, Los Angeles 90248 / Midwest: 1500 Greenleaf, Elk Grove Village, Ill. 60007 / Canada: S. H. Parker Co.

PIONEER
when you want something better

PL-71 Direct-Drive Turntable

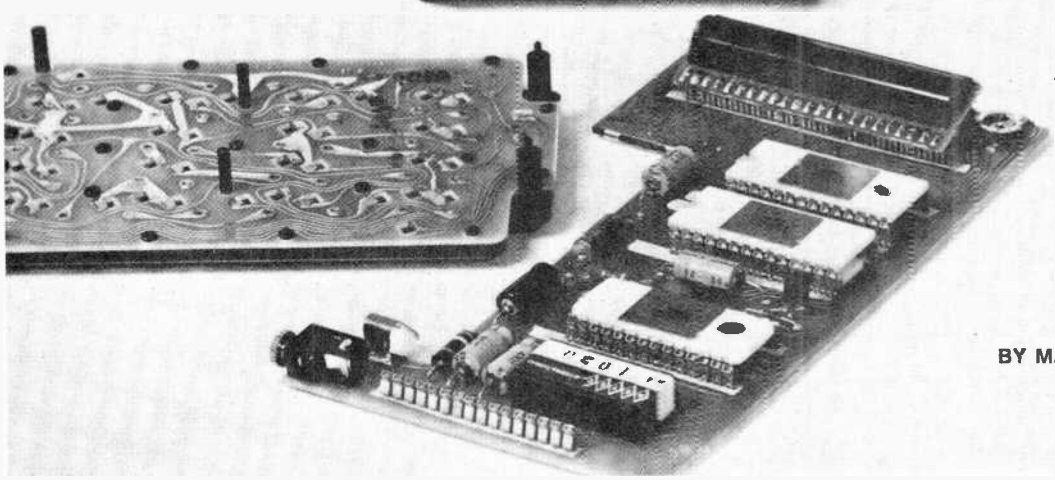
CIRCLE NO. 61 ON FREE INFORMATION CARD

Popular Electronics®
October 1975

PE TESTED

This new-generation scientific calculator features combinatorial, statistical, and probability functions, plus ten levels of addressable memory.

NOW... BUILD THE 'SENIOR SCIENTIST' CALCULATOR



BY MARTIN MEYER

THE simple four-banger electronic calculator can do little more than add, subtract, multiply, and divide. Since it was first introduced, however, we have welcomed at least two other "generations" of calculators—each with added capabilities. Now, we've taken another quantum jump in calculator capability with the "Senior Scientist." In addition to the functions that most scientific calculators can perform, (roots, powers, trigonometrics, summations, factorials, various conversions, nested parentheses, etc.) the Senior Scientist makes available combinatorial, statistical, and probability functions. Furthermore, it has 10 levels of storage memory that can be addressed independently in any order desirable. And it's a snap to build this advanced hand calculator, whose kit price is just $115.

The Specifics. There are 40 keys on the Senior Scientist's keyboard, divided into two groups of 20 keys each. The lower 20 keys are assigned the numbers 0 through 9, decimal point, arithmetic functions (+, −, ×, ÷, =), π, exponentiation (x^y), and two-level parentheses functions. These are all single-function keys. Of the remaining 20 keys, 19 are assigned double-function status, while the remaining key (labelled F) serves the single function of shifting the dual-function keys to their alternate functions.

The calculator's LED display consists of a 12-place arrangement. The left-most place is reserved for indicating mantissa sign, calculation error, degrees/radians status (degrees implied, bar segment on for radians), and low-battery condition. Ten digits of the display are for the mantissa, while two are for the exponent. The sign for the exponent is located between the mantissa and exponent displays. (Only the − sign is displayed for both mantissa and exponent; + is implied.) The calculator has a built-in battery saver feature that blanks the display after a preset (adjustable) time when no operations are being performed; this is indicated by the − sign for the exponent coming on. For easy identification, the exponent displays are half the size of the displays used for the mantissa and are shown as superscripts at the right.

The ability to solve complex and

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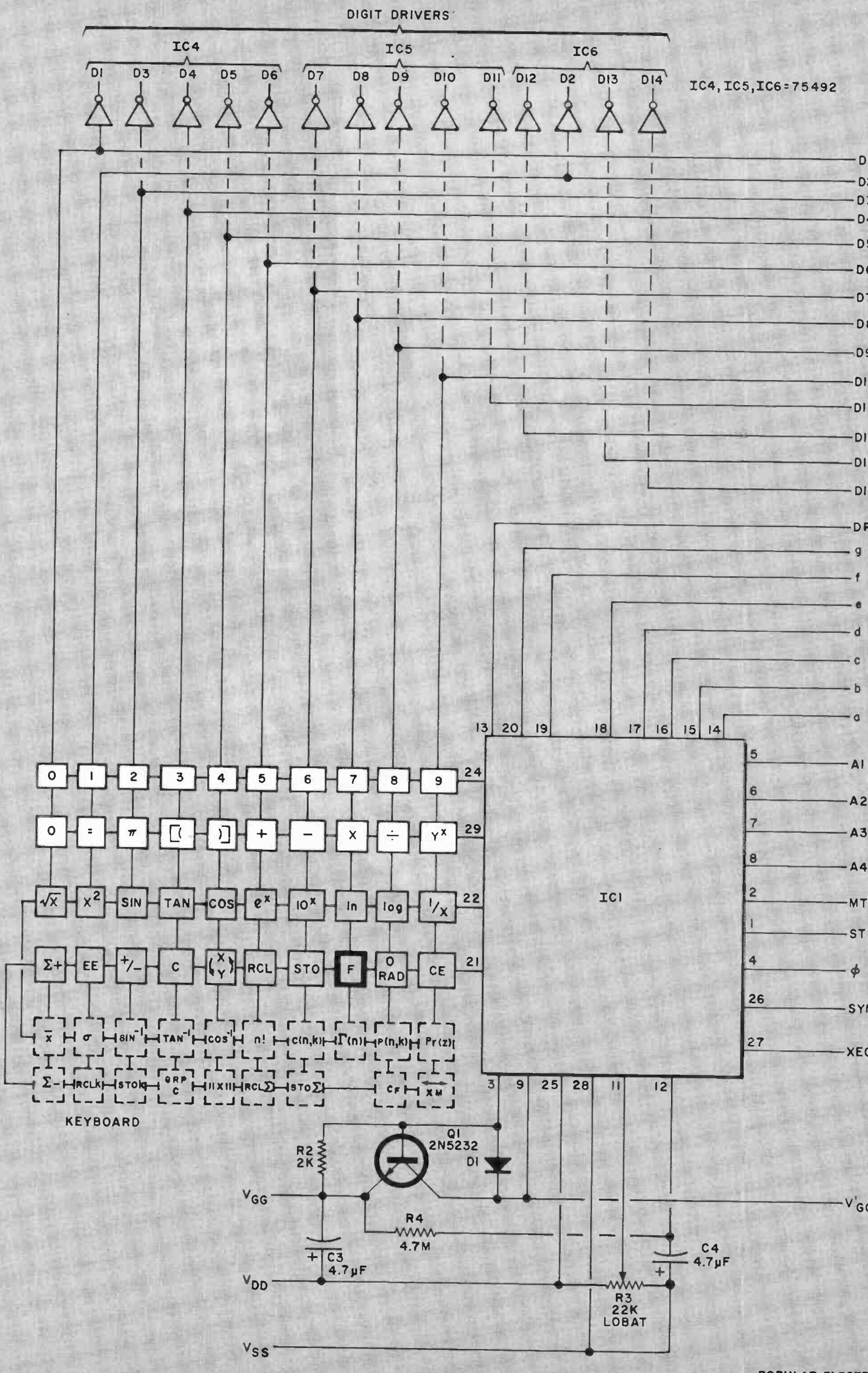

DIGIT DRIVERS
IC4
IC5
IC6
D1 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D2 D13 D14
IC4, IC5, IC6 = 75492
D1
D2
D3
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
D14
DP
g
f
e
d
c
b
a
13 20 19 18 17 16 15 14
IC1
5 A1
6 A2
7 A3
8 A4
2 MT
1 ST
4 ϕ
26 SYNC
27 XEC
24
29
22
21
0 1 2 3 4 5 6 7 8 9
0 = π [( )] + − X ÷ Yˣ
√X X² SIN TAN COS eˣ 10ˣ ln log 1/x
Σ+ EE +/− C X Y RCL STO F 0 RAD CE
x̄ σ SIN⁻¹ TAN⁻¹ COS⁻¹ n! C(n,k) Γ(n) P(n,k) Pr(z)
Σ− RCLk STOk GRP C IIXII RCLΣ STOΣ CF XM
KEYBOARD
3 9 25 28 11 12
Q1
2N5232
R2
2K
D1
VGG
V'GG
R4
4.7M
C3
4.7μF
C4
4.7μF
VDD
R3
22K
LOBAT
VSS

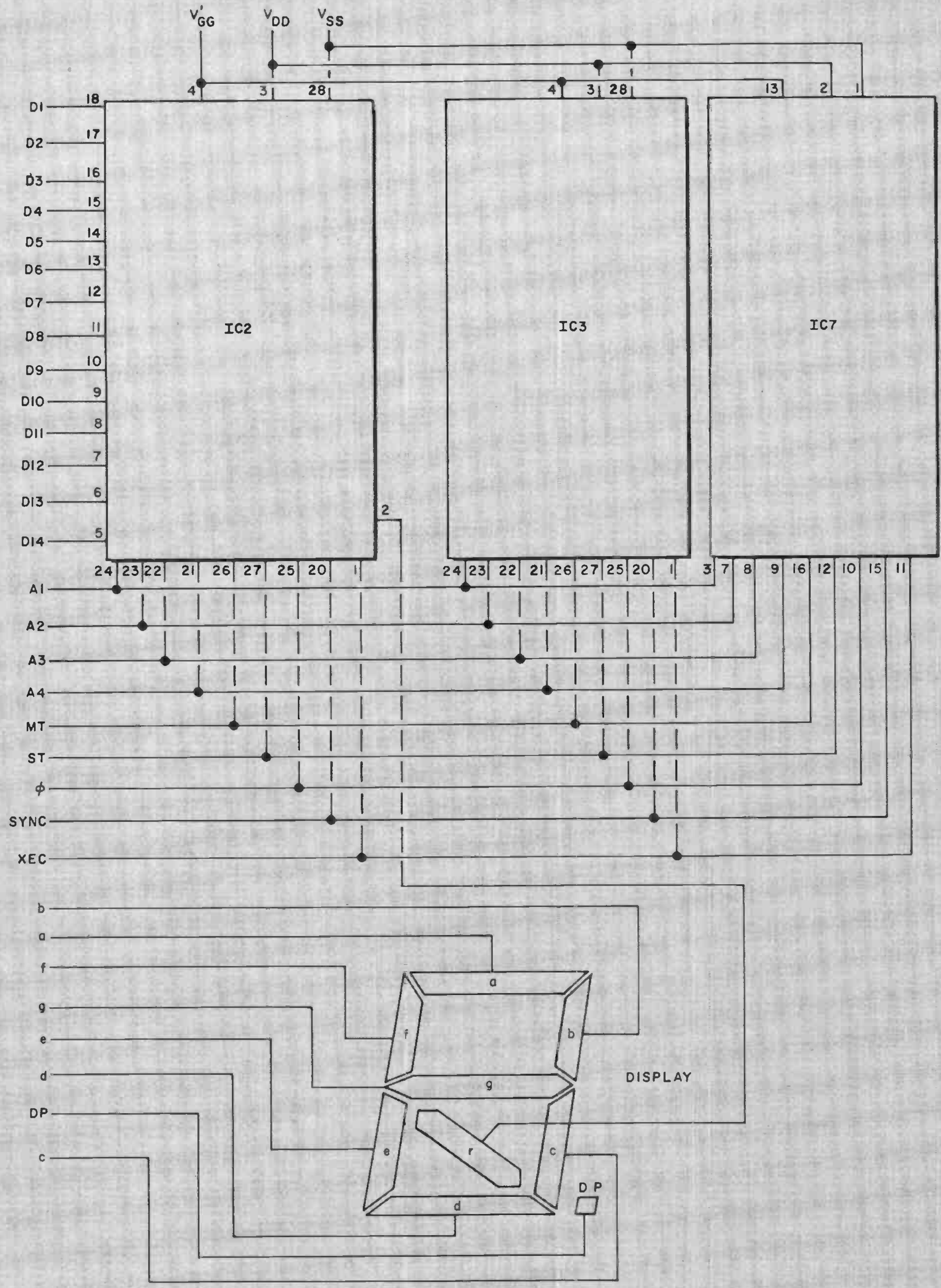

Fig. 1. Schematic of calculator is shown above and opposite. Unshaded keys are primary functions. Others are dual-function keys. Arrangement here is electrical—actual layout shown in photograph.

time-consuming mathematical problems is greatly enhanced by the calculator's two-level parenthetical capability. In stating an equation, information contained within the parentheses defines a specific variable. The solution of this variable is computed and retained. This allows a problem to be entered as it is written or stated.

The 10 levels of memory greatly enhance the calculator's power, giving

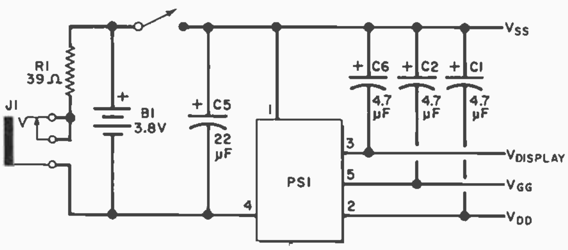

Fig. 2. Power supply uses a dc/dc converter to step up voltage.

a simple programming capability. Without the 10-level memory, the calculator has three memory levels (sum, sum-of-the-squares, index). The 10-level memory is a single IC that can be added at any time. It "plugs" into the holes provided for it on the pc board; no board changes are required. Entry into the 10 levels is accomplished by pressing STO and then the numeral (0 to 9) key that corresponds to the memory location desired. To recall a number from memory, simply press RCL and then the appropriate numeral key.

The Senior Scientist operates up to five hours on its built-in nickel-cadmium battery. The battery can be fully recharged in about nine hours, using the ac adapter/recharger supplied with the kit.

PARTS LIST

B1—3.8-volt rechargeable nickel-cadmium battery
C1, C2, C3, C6—4.7-µF, 20-volt electrolytic capacitor
C4—56-µF, 6-volt electrolytic capacitor
C5—22-µF, 10-volt electrolytic capacitor
D1—1N914 silicon diode
IC1, IC2, IC3—Mathematical integrated circuit set
IC4, IC5, IC6—75492 hex inverter integrated circuit
IC7—10-level memory integrated circuit
J1—Miniature phone jack
PS1—Dc/dc converter assembly
Q1—2N5232 npn transistor
R1—39-ohm, 1/8-watt resistor
R2—2000-ohm, 1/8-watt resistor
R3—20,000-ohm, linear-taper miniature pc potentiometer
Misc.—Keyboard; 14-digit LED display assembly; printed circuit board; case; ac adapter/recharger; Molex Soldercons (124); masking tape; solder; etc.
Note: The following items are available from Netronics Research & Development Ltd., 27 Eagle St., Spring Valley, NY 10977: complete kit of parts, including assembly/instruction manual; battery; ac adapter/recharger, soft carrying case, and 10-level memory IC (N2000MX) for $114.95; same kit minus memory IC (N2000X) for $99.95; keyboard (N201) for $12; double-sided pc board with plated-through holes (N202) for $5.50; 47A026 memory IC (IC8) for $15; 75492 IC's for $1.50 each; dc/dc converter assembly (N203) for $5.80; mathematics IC set (IC1, IC2, IC3) (N204) for $65 per set; 14-digit LED display assembly (N205) for $19.50. New York state residents please add sales tax.

Special Functions. The standard arithmetic and scientific functions incorporated into the Senior Scientist need not be detailed here. Anyone who has used a second-generation calculator will be familiar with their use. However, the special advanced math functions in this calculator require a few words of explanation. These functions include the gamma [Γ(n)]; combinatorial (n!); permutation [P(n,k)] and combinations and binomial coefficient [C(n,k)]; normal probability [Pr(z)]; statistical group operation (such as the summations Σ+ and Σ−), arithmetic mean ($\bar{x}$), standard deviation (σ), square-root-of-the-sum-of-the-squares (‖ × ‖); and factor reversal (transposing x and y terms) functions, and such group operations as STO k, RCL k, RCL Σ, and group (GRP) clear.

Combinatorial analysis is a powerful tool for obtaining the probabilities of complex events, binomial coefficients, combinations, and permutations. With the Senior Scientist, a few simple keystrokes let you evaluate the number of combinations of n different objects taken k at a time where the order of the resulting subsets does not distinguish one subset from another. The number of possible combinations of size k from group n is given by C(n,k) = n/[k! (n−k)!], where k is the number stored in the group index and n is the number in the display.

The function C(n,k) also gives the binomial coefficients for the binomial expansion $(a + b)^n = \sum_{k=1}^{n} C(n,k)a^{n-k}b^k$ and allows the binomial distribution functions where P is the probability that an event will occur in a single trial and q is the probability that the event will not occur in a single trial (q = 1 − P). The probability that the event will occur exactly k times in n repeated trials is given as $C(n,k)P^kq^{n-k}$. This is known as the binomial probability function, since its terms for k = 0,1,2,3 . . . n correspond to the successive terms for the binomial expansion.

The Senior Scientist also evaluates the number of permutations of n different objects taken k at a time where, from a group of n items, k items are selected under conditions where the order of the resulting subgroups *does* distinguish one subgroup from another.

As one example of using combinatorial functions, evaluate the condition C(n,k), where n is 7 and k is 4. Six keystrokes on the calculator give the solution as 35. Another example: how many different five-man teams can be formed from a pool of 16 people? Again, six keystrokes provide an answer of 4368. If you were to perform these problems with pencil and paper, even with the aid of a less advanced calculator, it would take you considerable time to reach the solutions. With the Senior Scientist, you can have the answer within seconds of stating the problem. (Note: We are not going into the details of the keystroke sequence to use here, as the instruction manual that comes with the IC's and calculator kit fully covers this subject.)

Normal probability functions are a thing unto themselves. Besides permitting you to determine the area of a Gaussian distribution curve, the probability functions in the calculator let you do some mundane things. For example, if you have an installation containing 4000 light bulbs, each of which has an average life of 1000 hours and a standard deviation of 200 hours, you can quickly calculate how many lamps can be expected to fail in the first 700 hours.

The Senior Scientist is capable of evaluating the arithmetic mean, standard deviation, and square root of the sum of the squares of any data. The data need be entered only once; thereafter, only single keystrokes are required to complete the calculations. Besides providing the arithmetic mean, the calculator can solve geometric mean, which is the type of average that is applied in situations that approximate a geometric progression, geometric growth, or exponential law (for example, population growth).

Solution of the harmonic mean is also simple. This mean is the measure of the central tendency to employ when dealing with rates or prices, such as mph, dollars/gallon, etc. An example of this type of problem is the old school math question that requires the student to determine the average speed of an airplane flying a square course that is 100 miles long on each side and where the speed is

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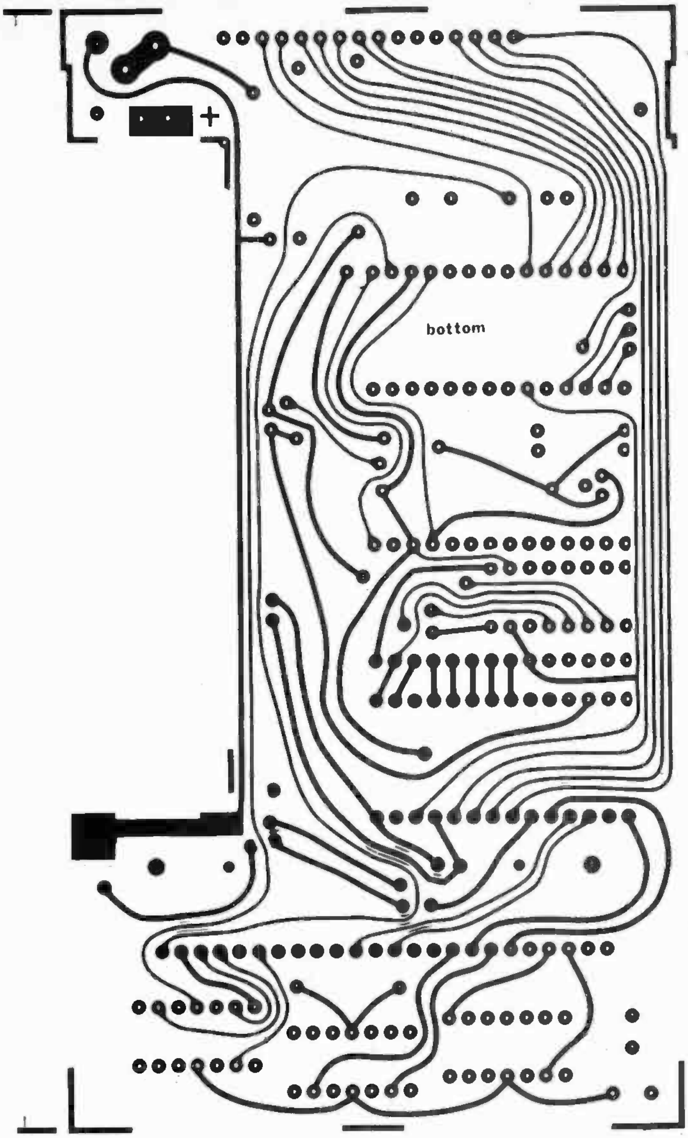


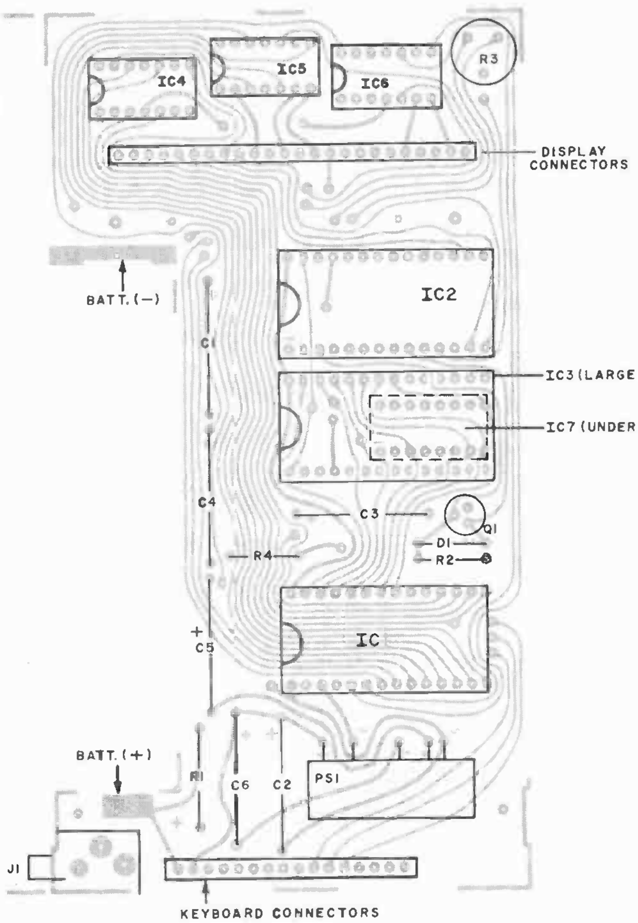
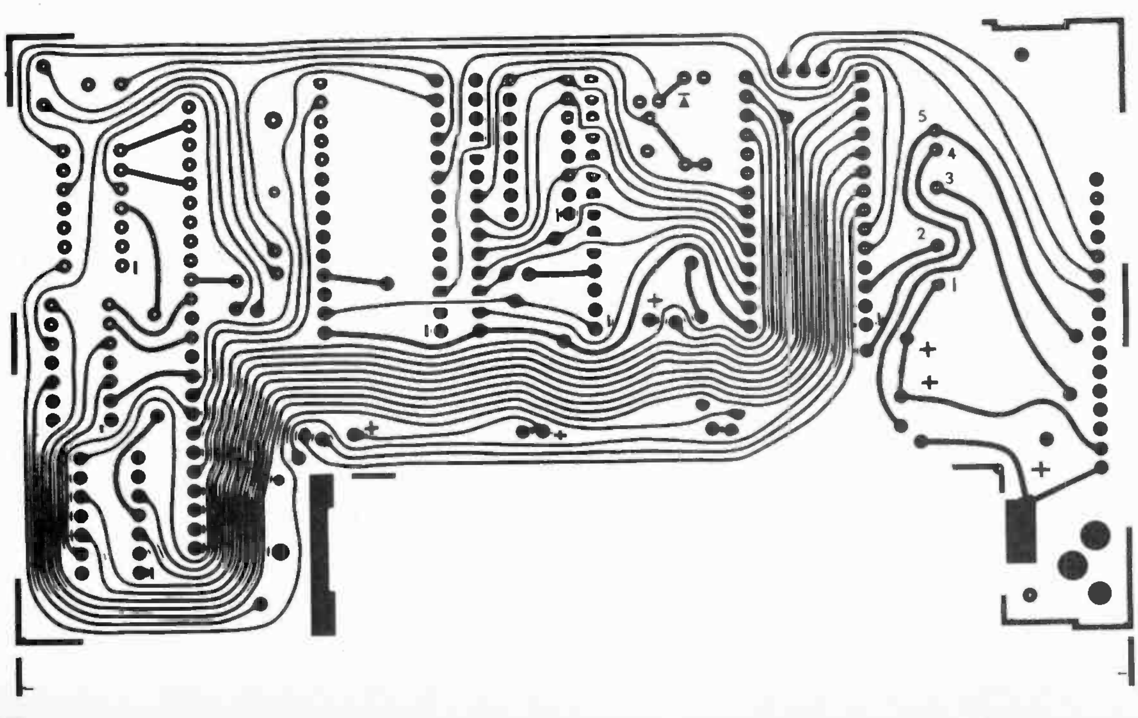


Fig. 3. Etching and drilling guides for the two sides of the printed circuit board are shown at left and below. Component placement is made as shown above on the top side of the board (below). Be sure to observe polarities and placement of IC's.



100 mph on the first leg, 200 mph on the second, 300 mph on the third, and 400 mph on the fourth. With a few simple keystrokes, the Senior Scientist provides an answer of 192 mph.

Last but not least, the calculator can evaluate the gamma function of all positive values of n where n ≤ 2. The gamma function can be considered as a type of interpolation of the factorial function of nonintegral values of n.

With the features and functions incorporated into the Senior Scientist, it is not difficult to see that this is a calculator that will be highly useful for any science, technology, and mathematics major right on through college and beyond.

About the Circuit. The schematic diagram of the Senior Scientist's basic circuit is shown in Fig. 1. It would be pointless to attempt a stage-by-stage analysis of this circuit, especially since what goes on inside of mathematical integrated circuits *IC1* through *IC3* would require a manual to explain. Consequently, only the highlights are presented here.

The schematic shows a 40-key matrix for the keyboard. The unshaded boxes in the upper two rows are the single-function keys. The shaded boxes in the second two rows are the dual-function keys and are labelled with their primary functions. The secondary functions of these keys are illustrated by the phantomed boxes in the last two rows. The F key, shown with a heavy outline box is responsible for shifting the two-function keys to their secondary functions.

Integrated circuits *IC1*, *IC2* and *IC3* form the special mathematics system that is responsible for all of the arithmetic and mathematics functions in the calculator. Integrated circuits *IC4*, *IC5*, and *IC6* isolate the display system from the low-power math IC's and provide the necessary drive current for the display. Last but not least, *IC7* is the 10-level memory system.

The power supply circuit for the calculator is shown in Fig. 2. This circuit employs an ingenious dc-to-dc converter that boosts the voltage available from battery *B1* to the level required by the calculator circuit. By employing this scheme, physical battery requirements are minimized and the calculator is kept to hand-held size.

Construction. There is no practical way to assemble the calculator without using a printed circuit board. The board requires conductors on both sides. You can make your own board by using the actual-size etching guide shown in Fig. 3, but you will not be able to plate-through the holes as required. So, don't forget to solder component leads to both sides of the board.

Start assembly by soldering the battery clips (see Fig. 3 for component placement) to both sides of the board. Next, install *IC4*, *IC5*, and *IC6*. Solder their pins directly to the pads on the board. Do *not* use sockets. (The pin-1 pads for all IC's are indicated by short bars on the top of the board near the respective pads.) Install the capacitors, dc/dc converter, diode, power jack, potentiometer, and resistors.

Cut six 1½" (3.8-cm) lengths of ⅛" (3.2-cm) wide masking tape and press them onto the top of the board over the lead holes for *IC1*, *IC2*, and *IC3*. Press a 2½" (6.4-cm) length of the tape over the display board connector holes and a 2" (5.1-cm) length over the keyboard connector holes.

Break off a strip of 23 Soldercons and force their pointed ends through the tape and into the display connector holes. (Note: The hole at the far right is not used.) Solder the Soldercons to the pads on the board and carefully break away the connecting strip. Similarly, install 16 Soldercons at the bottom of the board for the keyboard and six sets of 14 Soldercons in the *IC1*, *IC2*, and *IC3* holes.

Before you remove the remaining IC's from their protective carrier, you must familiarize yourself with the following procedures to avoid damaging them by static electricity:

- Wear only anti-static clothing, such as cotton, when working with MOS devices. (Synthetics readily build up static charges.)
- Ground your work surface.
- Ground yourself; wrap a length of wire mesh around your wrist and terminate it at a cold water pipe or the grounding screw of an electrical outlet.
- Ground your soldering tip in a similar manner, but use heavy solid wire—not mesh—around the tip.
- Always install a MOS device immediately into its circuit after removal from its protective carrier and replace it in the carrier immediately after removal from the circuit.
- NEVER install a MOS device in, or remove it from, a circuit to which power is applied.
- Always install MOS devices last.

Once you have familiarized yourself with the proper procedures to use, remove *IC7* from its carrier and install it into place on the board, without using Soldercons. This done, install the remaining IC's.

Plug the display and keyboard assemblies (they come ready to use), into their respective connectors. When the keyboard is properly seated, two plastic posts on it drop into small holes in the pc board. The foam plastic on the back of the display board should be compressed against *IC4*, *IC5*, and *IC6*.

At this point, you can check out the calculator. Slip the battery into its connectors and turn over the calculator. Turn on the power; a 0, followed by a decimal point should come on. If not, the battery needs to be charged. Charge it, with the battery charger, for about an hour. (Note: If you operate the calculator at any time, *the battery must be installed*.)

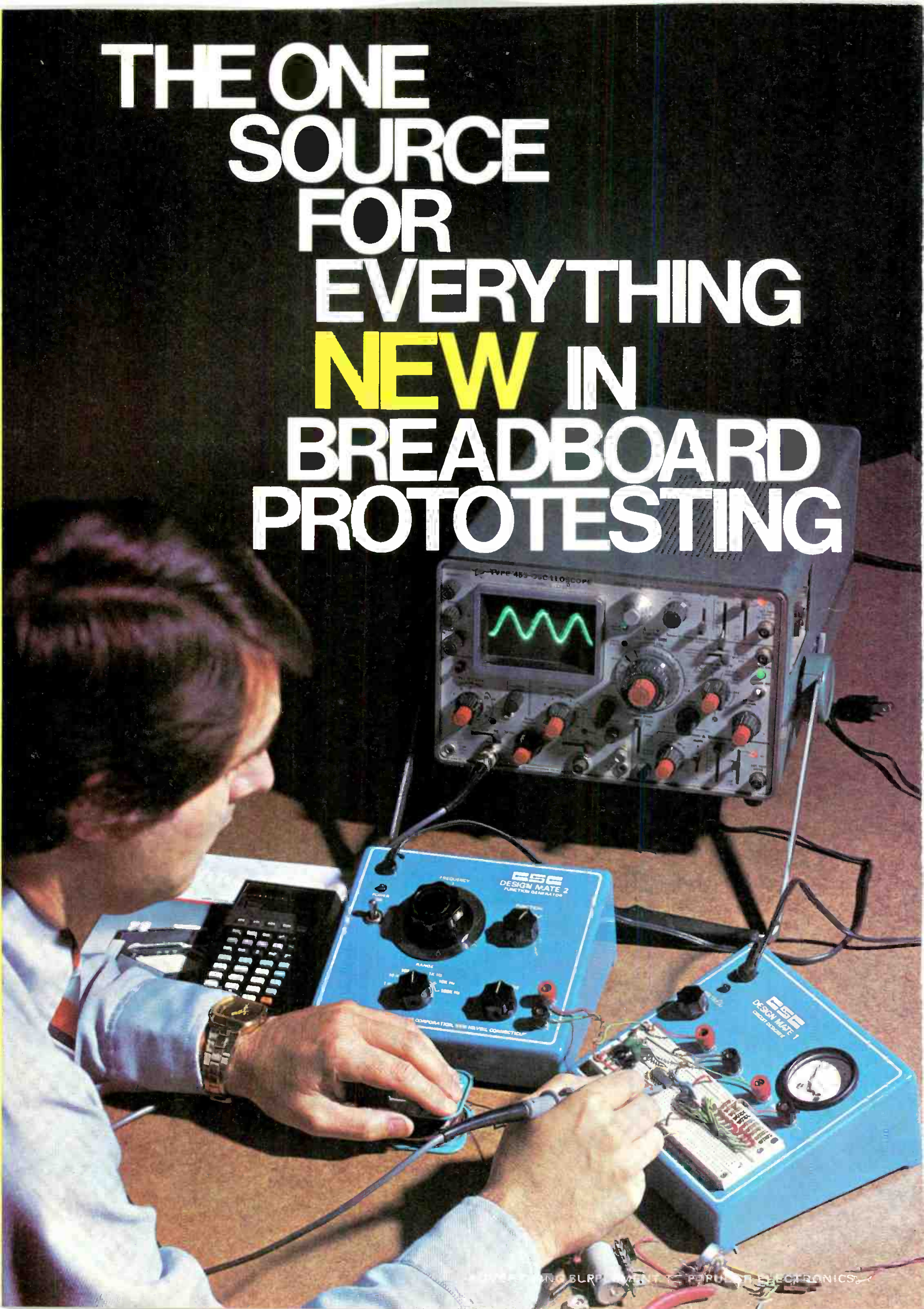
Press C, 9, STO, 1, C, 5, STO, 5. The number 9 should now be stored in the second level of memory (0 is the first level) and 5 in the sixth level of memory. Now, press C, RCL, 1 (9 displayed), +, RCL, 5 (5 displayed), =; the display should now read 14.

Finally, press C, 8, Σ+, 5, Σ+, 3, Σ+, F, RCL; the answer displayed should be 16, which is the sum of 8 + 5 + 3. Set the power switch to OFF.

Potentiometer *R3* sets the point in the battery's charge condition at which the battery-low indicator (L) is displayed in the left-most digit. Set the pot to the center of its rotation initially. Then if you find that the L comes on too soon or doesn't come on soon enough, you can readjust the pot's setting.

To complete assembly, insert the bottom of the calculator assembly into the top half of the case and swing the assembly into place. It is properly positioned when the keyboard fits snugly into the case surround and a pair of plastic posts protrude through the bottom of the pc board. Thread a pair of small nuts onto the plastic posts to hold the assembly firmly in place. (It may be necessary to prethread the posts.) Insert the two lugs on the bottom of the back half of the case into the slots in the top half and snap the halves together.

Plug the adapter/charger into the jack on the side of the Senior Scientist and the plug into a wall outlet and let the battery charge for at least nine hours. ◈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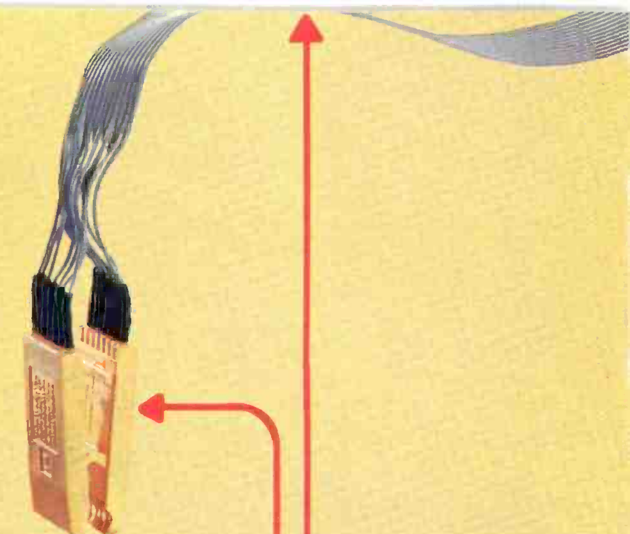

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PC-16-	18	8.50	16.00
PC-16-	24	8.75	16.25
PC-16-	30	9.00	16.50
PC-16-	36	9.25	10.75

NOTE: S=Single Clip
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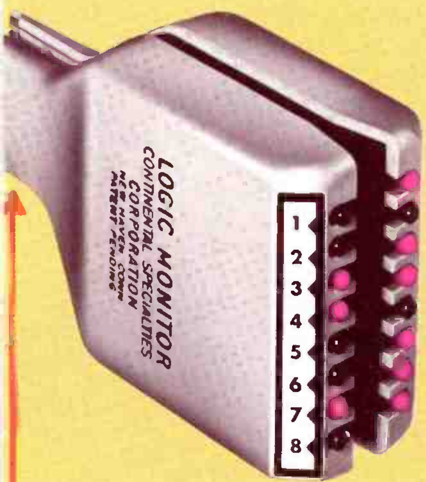

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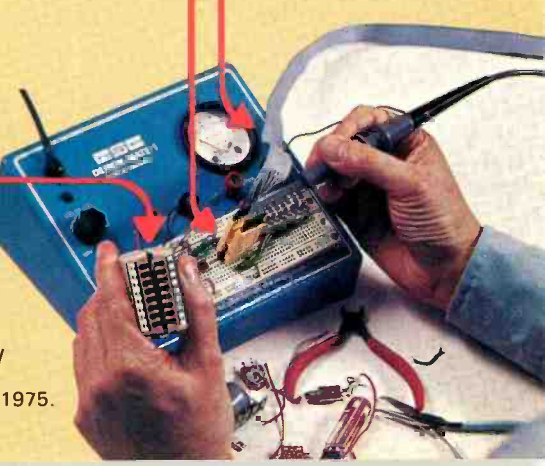

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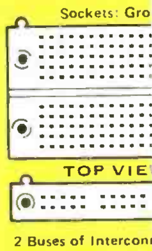

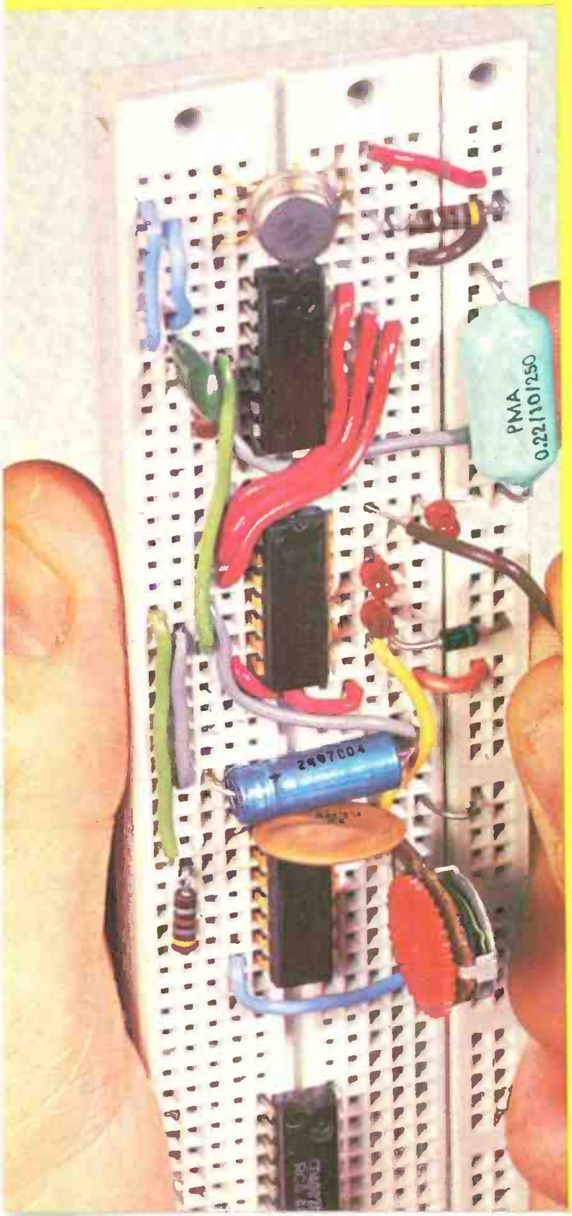

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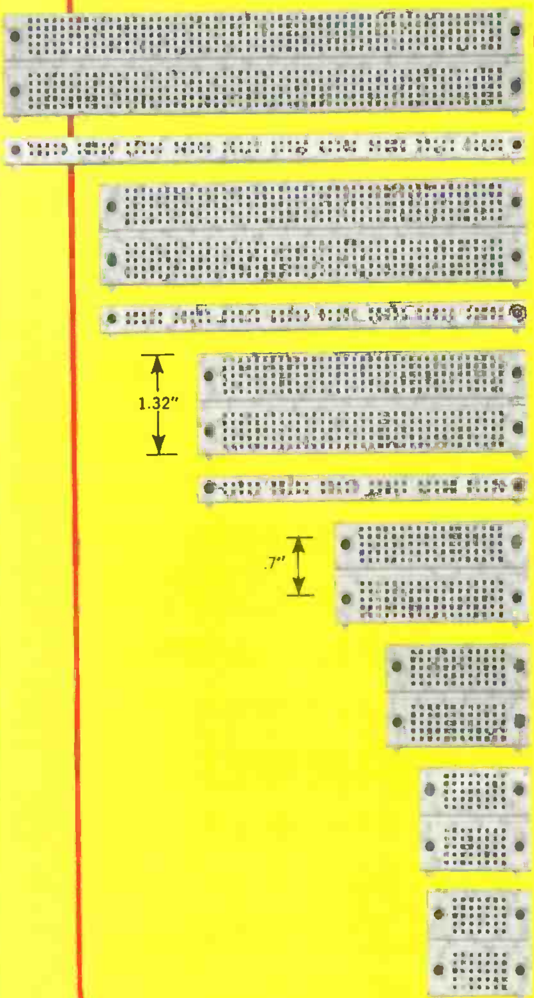

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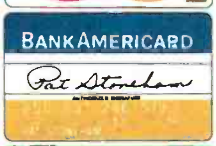

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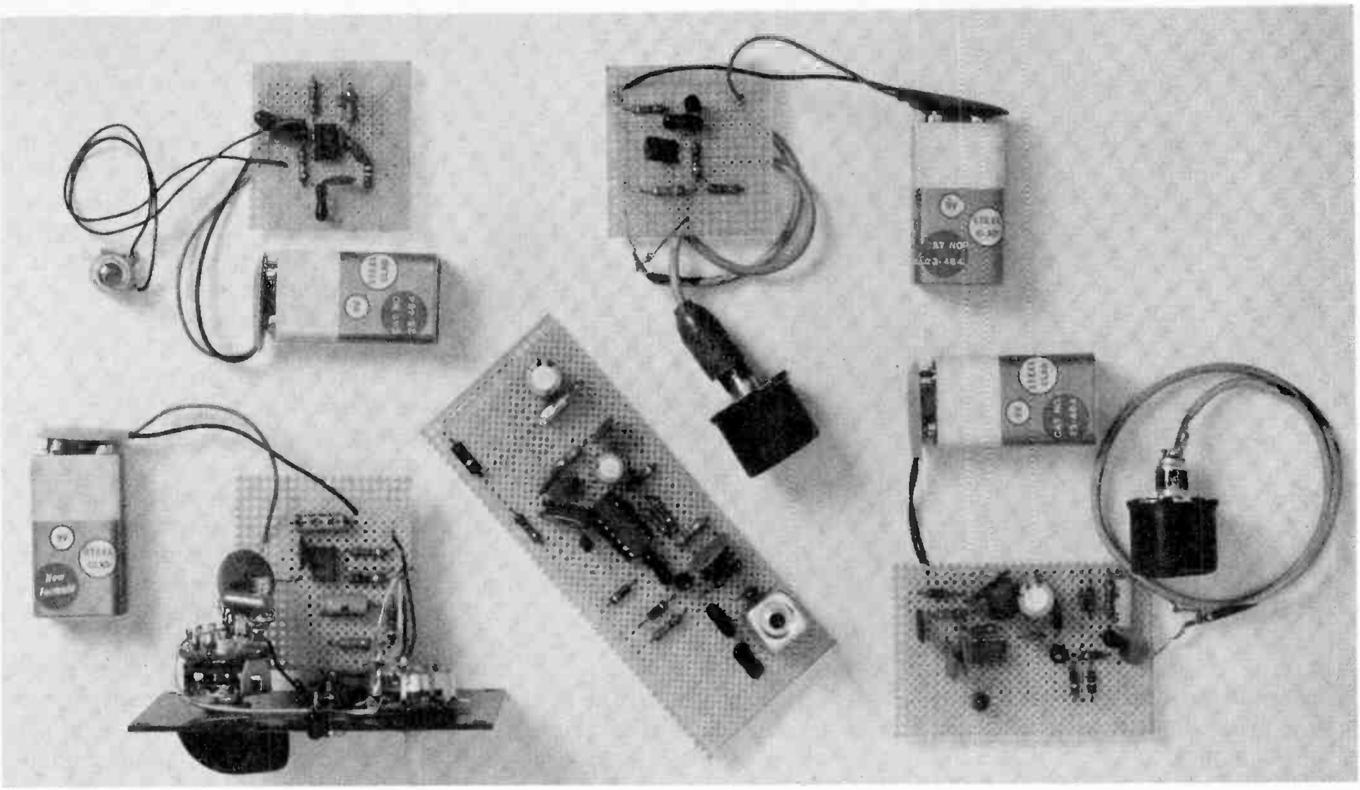


EXPERIMENTING WITH PHASE-LOCKED LOOPS

Four simple but useful circuits that will increase your understanding of these versatile 565 and 567 IC's.

BY HERB COHEN

WHEN phase-locked-loop (PLL) integrated circuits began to appear on the hobby market, the experimenter was faced with the same problem always encountered with new devices: what to do with it. If he tried to understand the theory—usually available in abundance—he was clouted with terms like rads/second, capture ratio, lock range, and lag networks. Needless to say, there was an urge to slam shut the book and treat the IC as a "black box"—not really such a bad idea.

Although there have been a number of articles published in various magazines explaining the basics of PLL theory (see "How Phase-Locked Loops Work," February 1975), a "hands-on" session with these IC's will tell you more about them than all the reading you're likely to do. As an example, the 565 and 567 PLL's are so simple to work with and require so few external components that you don't need a stage-by-stage understanding of what goes on inside them to put them to use.

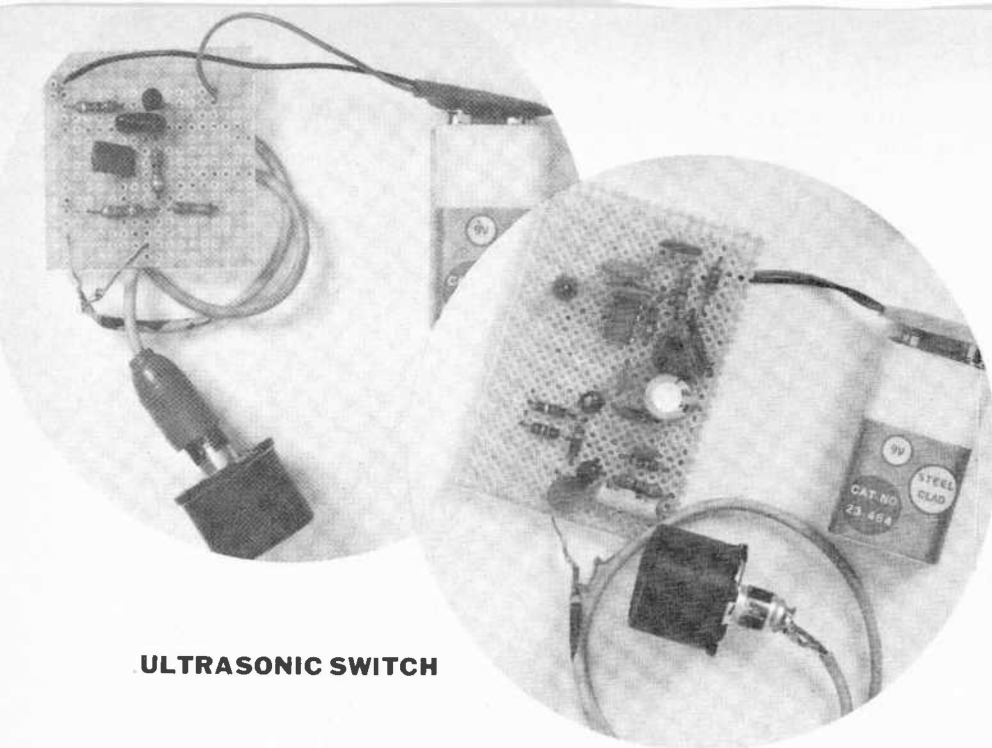
In this article, we describe four simple projects you can build around a pair of commonly available PLL's to give a "feel" for how they perform. Each project illustrates a different aspect of phase-locked-loop technology, and each is a practical circuit you can put to immediate use. Before proceeding to the projects themselves, however, let us first discuss the specific PLL's used in our projects.

Two PLL's. Of the many phase-locked-loop IC's available, the 567 is the only one that is designed primarily for switching applications. When this PLL goes into lock, its output transistor, driven from a quadrature detector, is capable of passing 100 mA of current. This makes the 567 ideal as an SCR or relay driver.

Another unique feature of the 567 PLL is its ability to be driven from a low-voltage (4.5 to 10 volts) power supply at a nominal 10-mA drain. This means that the IC can be powered by a 9-volt transistor battery with good life expectancy. So, although it doesn't have the bandwidth or sensitivity of other PLL's, the 567 is ideal for hundreds of tone-decoder applications in the range from 1 Hz to 100 kHz.

The 565 is a general-purpose PLL IC and is by far the most popular now being used. It exhibits a very wide ±60% locking range and a 1-mV input sensitivity. This PLL is ideal for use as an SCA decoder, which will let you receive the hidden subchannels on FM.

The following four projects are examples of the simplicity and versatility of the PLL IC. The first three are built around the 567, while the fourth—an SCA decoder—employs the 565 PLL. The circuits can be assembled easily on perforated boards or pc boards.



ULTRASONIC SWITCH

Ultrasonic Switch. The simple transmit/receive system shown in Fig. 1 can receive a signal from distances of up to 40′ (12 m) and more in hallways and enclosed areas where the acoustical properties are good. The transmitter is shown in B, while the receiver is shown in A.

Transducers *TR1* and *TR2* in the receiver and transmitter are 40-kHz barium-titanate ultrasonic transducers. Transducer *TR1* in the receiver picks up the sound waves from transmitter transducer *TR2* and passes them to the amplifier consisting of transistors *Q1* and *Q2*. The PLL (*IC1*) then accepts the amplified signal and rejects any spurious responses and out-of-band noise pulses.

Light-emitting diode *LED1* and limiting resistor *R9* are installed in the circuit only temporarily to assist in tuning the system. Once the system has been properly tuned, these components are removed and replaced with the load to be driven (relay, lamp, etc.).

The transmitter shown in B is a Colpitts oscillator configuration that uses transducer *TR2* in the resonance circuit. This circuit puts out a minimum of 2 volts rms across *TR2*, which develops more than enough sound power for the system.

To tune the receiver, place the transmitter about 5′ (1.5 m) away from the receiver with both transducers facing each other. Adjust potentiometer *R10* until *LED1* comes on. Turn off the power to the transmitter; *LED1* should immediately extinguish. (Note *LED1* may light up when *R10* tunes the system to a submultiple or harmonic of the transducer frequency, so make sure you're tuned to the fundamental frequency.)

Once the receiver has been properly tuned, the range you can obtain with this system is dependent mainly on room acoustics. However, you should be able to obtain a minimum of 20′ (6.1 m) of range.

The ultrasonic relay system can be used as an intruder alarm, garage door opener, or remote relay. It can even be made to operate as a simple motion detector. To do this, place the transmitter and receiver about 10′ (3 m) apart and with their transducers facing the same wall in a room. The LED in the receiver should come on; if it doesn't, move the transmitter closer to the receiver until it does. Then, move it away until the LED just extinguishes. Now, walk along the side of the room that the transmitter and receiver are facing. As you move, the LED will blink on and off.

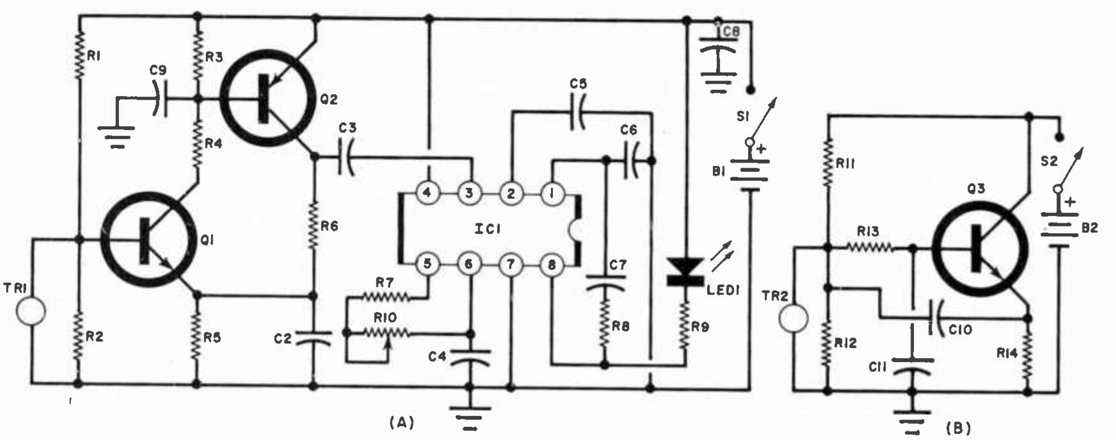
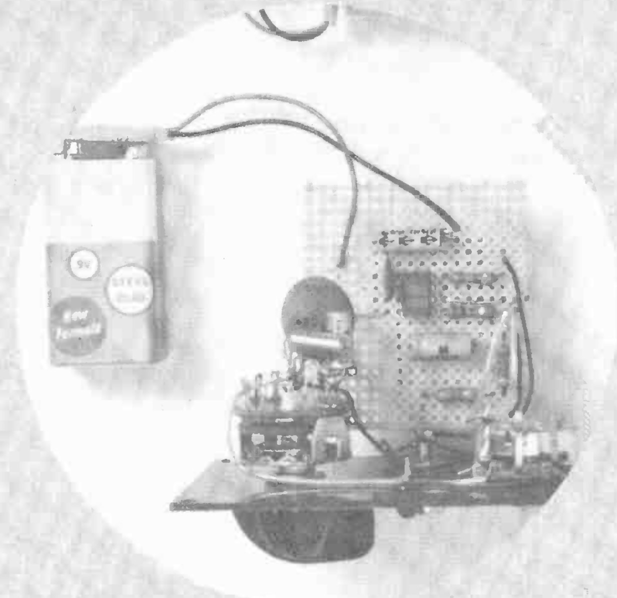


Fig. 1. A simple transmit/receive ultrasonic relay.

PARTS LIST

B1,B2—9-volt battery
C1,C6—0.04-μF disc capacitor
C2—5-μF, 10-volt electrolytic capacitor
C3,C4—0.0047-μF disc capacitor
C5—0.1-μF disc capacitor
C7,C10—0.02-μF disc capacitor
C8—100-μF, 10-volt electrolytic capacitor
C9—0.001-μF disc capacitor
C11—330-pF disc capacitor
IC1—567 PLL IC
LED1—Light-emitting diode
TR1,TR2—Ultrasonic transducer (Detectron No. HC1)
Q1—2N4946 pnp transitor
Q2—2N4917 npn transistor
Q3—HEP S0007 npn transistor
The following are ¼-watt, 10% resistors:
R1—180,000 ohms
R2—43,000 ohms
R3,R4—2200 ohms
R5,R13,R14—1000 ohms
R8,R7—2700 ohms
R9—330 ohms
R11—22,000 ohms
R12—47,000 ohms
R10—10,000-ohm miniature potentiometer
S1,S2—Spst switch
Misc.—Battery clips; hookup wire; solder; etc.



LED starts to flash at a rate that is the difference between the two signals. This is called the capture state. Once the PLL is locked in, the LED glows steadily.

This circuit has a tendency to lock onto odd harmonics and subharmonics of the input signal. To overcome this problem, simply limit the amplitude of the incoming signal to less than 1 volt.

TUNABLE FILTER

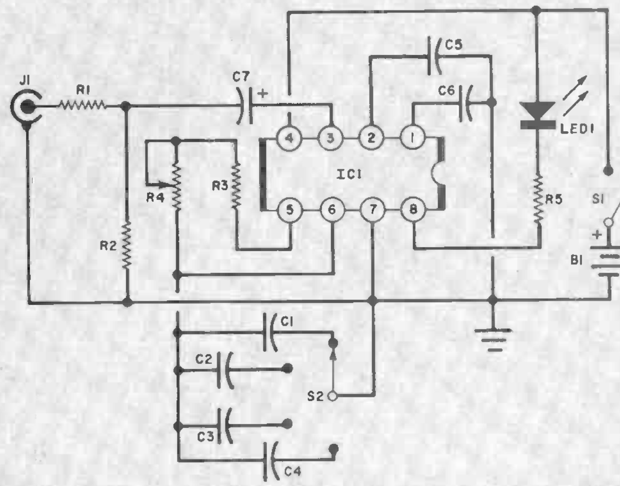


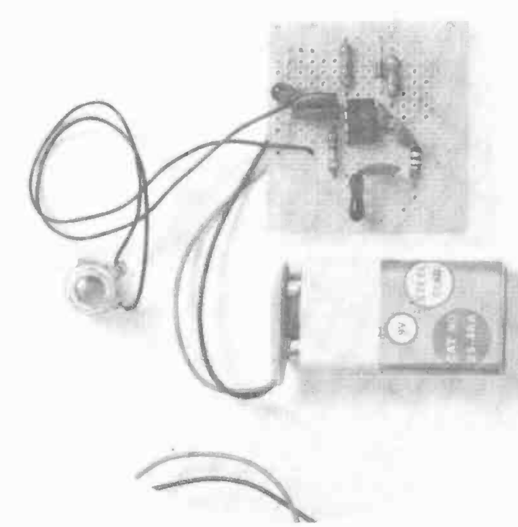
Fig. 2. Tunable filter circuit can be used as a tone decoder.

Tunable Filter. The circuit shown in Fig. 2 illustrates the use of the 567 PLL as a wideband (10-to-100-kHz) tunable filter. Potentiometer *R4* is the fine-tuning control. If its dial is accurately calibrated, the knob pointer can indicate to better than 5% accuracy, the frequency of any incoming signal within the filter's range. This circuit can be used for stereo tuning and tape bias oscillator adjustments. As a tone decoder, it would be hard to beat.

The circuit has several interesting features. First, the bandpass of the filter is proportional to the input voltage, from 1% to about 14% of the bandwidth. Second, when the PLL starts to lock onto the incoming signal, the

PARTS LIST

B1—9-volt battery
C1—0.01-μF disc capacitor
C2—0.1-μF disc capacitor
C3—1-μF, 15-volt electrolytic capacitor
C4—10-μF, 10-volt elctrolytic capacitor
C5—0.05-μF disc capacitor
C6,C7—5-μF, 15-volt electrolytic capacitor
C8—100-μF, 15-volt electrolytic capacitor
IC1—567K PLL IC
J1—Phono jack
LED1—Light-emitting diode
R1—4700-ohm, ¼-watt resistor
R2—2200-ohm, ¼-watt resistor
R3—1000-ohm, ¼-watt resistor
R4—10,000-ohm, linear-taper potentiometer
R5—330-ohm, ¼-watt resistor
S1—Spst switch
S2—4-position non-shorting rotary switch
Misc.—Battery clip; hookup wire; solder; etc.



TOUCH SWITCH

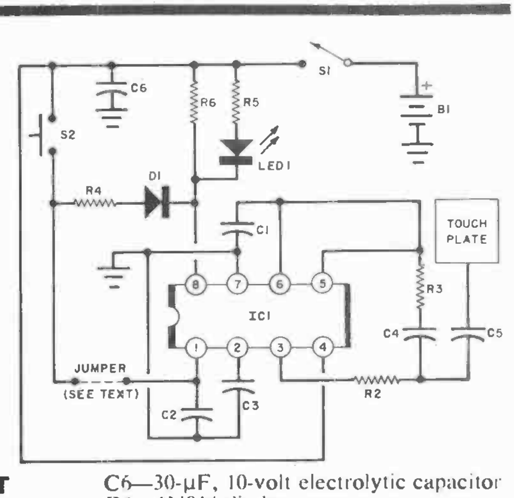


Fig. 3. Touch switch can be made to latch in by adding the jumper.

PARTS LIST

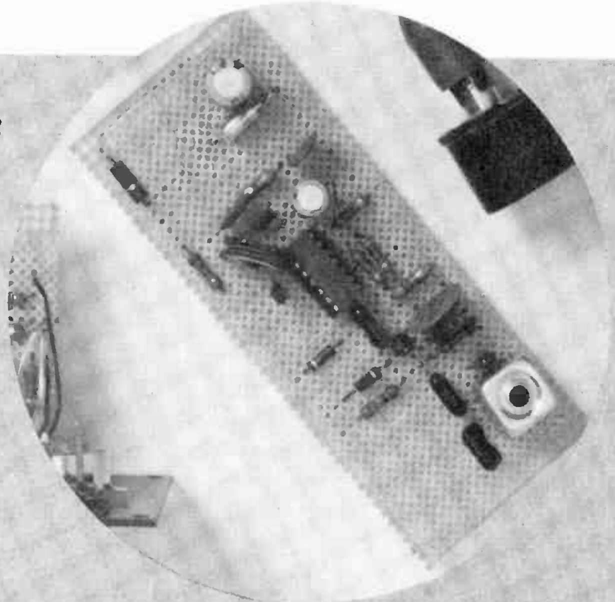
B1—9-volt battery
C1—0.005-μF disc capacitor
C2,C3,C4—0.04-μF disc capacitor
C5—33-pF disc capacitor
C6—30-μF, 10-volt electrolytic capacitor
D1—1N914 diode
IC1—567 PLL IC
S1—Spst normally open, monentary-action switch
Misc.—3" × 3" solderable metal for touch plate; hookup wire; solder; etc.

Touch Switch. As a convenience feature in a home, the touch switch, shown in Fig. 3, is hard to beat. Just by touching the plate, body capacitance unbalances the circuit and pulls *IC1* into lock. An external signal is normally fed into the PLL *(IC1)* via pin 3 and *C1* and *R1* are used to tune the voltage-controlled oscillator to the input frequency. When lock occurs, the vco adjusts itself to be 90° out-of-phase with the input signal.

With the input signal at pin 3 coming from the output of the vco (pin 5 of *IC1*) through *C4*, *R2*, and *R3*, the two signals are in-phase with each other and the circuit cannot lock. However, when the touch plate is approached, enough capacitive phase shift is introduced to allow the circuit to lock.

Wiring the jumper into the circuit as shown allows the system to latch in the on position even after your hand is removed from the touch plate. To reset the system to off requires *S1* to be closed momentarily.

SCA DECODER



SCA Decoder. Our final PLL project is an SCA decoder built around the 565 phase-locked-loop IC. This is essentially a 67-kHz FM detector. However, a PLL is a better detector for FM than any of the traditional detector designs because it has the ability to dive 6 dB below the noise level and still lock onto a signal.

In the case of an SCA subchannel where the information is only 10% of the total program power (most of that lost in the audio filtering), the 565 IC's ability to reject noise is an important factor in building a simple and effective SCA decoder.

Capacitors *C1*, *C2*, and *C3* and coil *L1* (Fig. 4) form a bandpass filter that peaks at 67 kHz and rejects all low-frequency components of the audio signal in an FM tuner. Transistor *Q1* amplifies this signal and passes it to *IC1*. The PLL IC is tuned by *C7*, *R6*, and *R10*. Since the tuning frequency is also a function of the supply voltage, the IC should be zener-diode regulated.

The demodulated audio signal comes out of the decoder at a 50-mV level. It has a 7,000-Hz audio bandwidth that can hardly be considered hi-fi. This bandwidth, however, is more than sufficient for background music.

The tuning procedure is simple. Connect the output of your FM tuner to the input of the SCA decoder and the output of the decoder to your audio amplifier. Set *R10* to the center of rotation. Scan the FM dial; all you should be able to hear at this point is noise and no stations. An SCA subchannel will appear as a sharp drop in the noise level, accompanied by a distorted music program. Now, adjust *R10* for the best signal-to-noise (S/N) ratio and highest fidelity.

Tune to the weakest SCA subchannel you can find. Adjust *L1* for the lowest possible noise level. The SCA decoder is now ready to use.

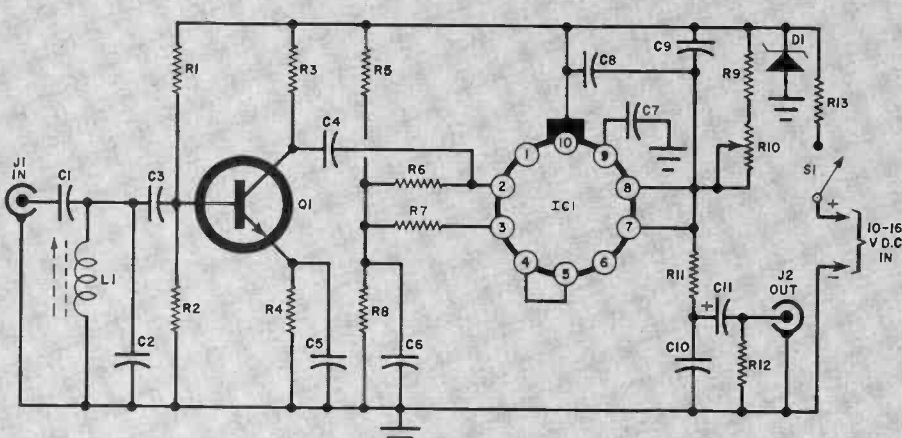


Fig. 4. SCA decoder.

PARTS LIST

C1—220-pF disc capacitor
C2—0.002-µF disc capacitor
C3—330-pF disc capacitor
C4—560-pF disc capacitor
C5,C9,C10—0.04-µF disc capacitor
C6—0.1-µF disc capacitor
C7—0.001-µF disc capacitor
C8—0.001-µF disc capacitor
C11—30-µF, 15-volt electrolytic capacitor
D1—12-volt zener diode
IC1—565 PLL IC
J1,J2—Phono jack
L1—10-mH slug-tuned inductor (Miller No. 9060)
Q1—2N2926 npn transistor

The following are ¼-watt, 10% resistors:
R1—100,000 ohms
R2—22,000 ohms
R3—8200 ohms
R4—1500 ohms
R5—15,000 ohms
R6,R7,R11—4700 ohms
R8—6800 ohms
R9—1000 ohms
R12—47,000 ohms
R10—10,000-ohm, linear-taper potentiometer
R13—47,000-ohm, ½-watt, 10% resistor
S1—Spst switch
Misc.—Battery clip; hookup wire; solder; etc.

Closing Comment. The preceding four projects illustrate only a small portion of the possible applications to which the versatile phase-locked-loop IC can be put. A couple of the projects should be able to suggest other projects of your own. ◈

How to "DEBOUNCE" Mechanical Switches for Digital Logic Use

Interface circuitry eliminates false pulses.

BY E. W. GRAY

MANY projects involving digital logic require the use of one or more mechanical switches. These can take the form of toggle switches, relays, pushbuttons, or keyboards. Two characteristics of these devices, switching noise and timing, require special consideration when connecting them to a digital logic system.

All mechanical switches, regardless of type, normally generate some electrical noise when the contacts transfer from one position to the other. This is due to bouncing of the contacts for several milliseconds after actuation. They actually make, break, and remake several times before finally coming to rest in the new position. This bounce period is called settling time. Digital logic elements, being much faster in their operation than mechanical switches, respond to each transition during the bounce period if the logic is connected directly to the switch. Thus false signals are produced. For this reason, "debouncing" circuits are used between the mechanical switch and the driven logic.

Contact Bounce in Spdt Switches. A single-pole, double-throw (form-C) switch and an idealized timing diagram of its action during transfer from normally closed to normally open are shown in Fig. 1. Initially, the movable arm (operating strap) is in contact with the normally closed contact. As transfer begins, the arm moves away from the normally closed side, opening the contact. The slightly springy, normally closed contact attempts to follow the arm and bounce occurs. This is called "break bounce;" the multiple openings and closings of the normally closed contact and the arm as the switch transfer is initiated.

As transfer continues, break bounce ceases. At this time the arm is not in contact with either side of the switch, but is "in transit" to the opposite side. Both normally closed and normally open contacts are now open. (Note: "Make-before-break," or shorting, switches are available; similar bounce conditions can occur, however.)

When the arm reaches the normally open contact, the two collide, and "make bounce" begins. The arm and the normally open contact close, open, and close again until the mechanical movement ceases. The switch transfer is then complete. In most switches, make bounce is much more severe than break bounce.

When the form-C switch is released from the transferred position, the reverse of the above actions occur. Break bounce takes place at the normally open contact and make bounce occurs at the normally closed contact.

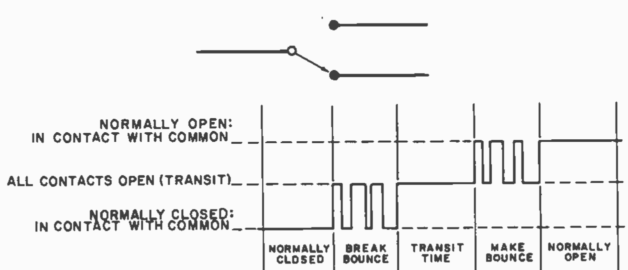
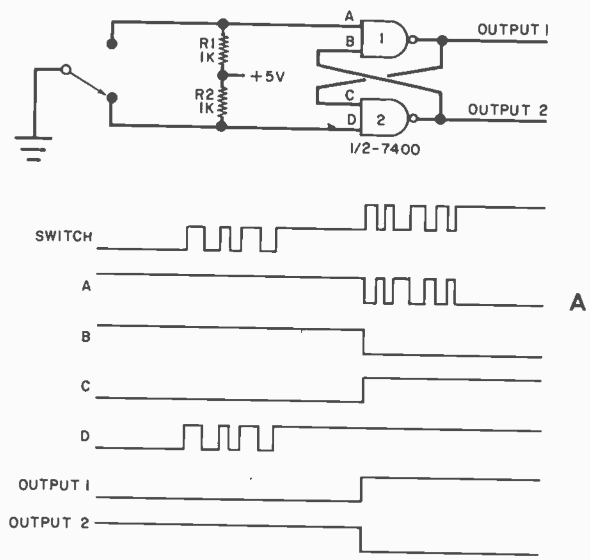


Fig. 1. During the few milliseconds it takes a switch to operate, erroneous pulses can confuse digital logic.

Debouncing Spdt Switches. To use the form-C switch successfully in digital logic, the debounce circuit must mask both break and make



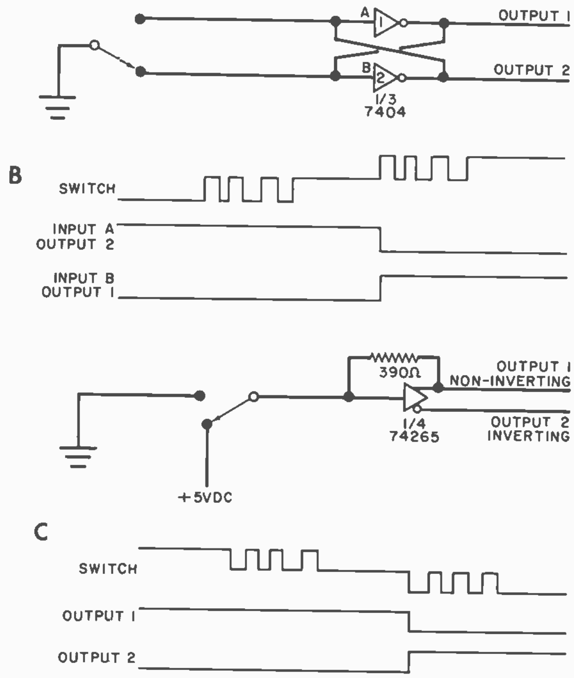


Fig. 2. Debouncing circuits: (A) simple NAND gate; (B) inverter configuration; (C) circuit used in a recently announced complementary device.

bounce and produce a single, noise-free transition at its output each time the switch is operated or released.

Three circuits to accomplish this are shown in Fig. 2. TTL devices and positive logic are used. (High voltage equals logic one; low voltage equals logic zero.)

In the circuit of Fig. 2A, two cross-coupled NAND gates are used to form a latching circuit. With the switch not operated, the ground (logic zero) applied to input D, gate 2, holds output 2 at logic one. Output 2 is applied to input B, gate 1. This high voltage level, and the high voltage level on input A, gate 1 (through R1 to +5 volts) cause output 1 to be logic zero.

When the switch is operated, input D, gate 2, changes in step with the break bounce. However, outputs 1 and 2 do not change state since the movable arm has not yet grounded input A, gate 1, and the logic zero on output 1 (fed back to input C, gate 2) maintains output 2 at logic one. Thus break bounce is ignored at the outputs.

As mechanical action continues, break bounce ceases and the arm makes its first contact with the normally open side. This applies ground (logic zero) to input A. With input A low, output 1 and input C switch to logic one. Inputs C and D are now both at logic one and output 2 goes to logic zero. Fed back to input B, output 2 now latches output 1 high and the circuit is stable.

This switching action between outputs 1 and 2 requires very little time: a maximum of 52 nanoseconds if 7400 NAND gates are used. Thus, the switching is complete long before the first bounce during make occurs. Input A will continue to follow the make bounce transitions but no output changes will occur. When the switch is released, the action is reversed, with output 2 reverting to logic one and output 1 to logic zero.

A somewhat simpler circuit is shown in Fig. 2B. The 7400 NAND gates are replaced by 7404 inverters. Pullup resistors are not required for this circuit. The switching operation is similar to that of Fig. 2A, except that one gate output will be short-circuited for about 37 nanoseconds each time the switch is activated. Device operation is not affected by the short-circuited output; the manufacturer's specification allows a single output in the logic one state to be grounded temporarily.

Note that switch bounce can be observed with an oscilloscope at inputs A and D of Fig. 2A. It cannot be observed at the inputs of the circuit of Fig. 2B due to the direct coupling of input and output.

Both of the above circuits provide complementary outputs, and both require two input lines from the switch. If both ground and +5 volts are available at the switch, debouncing can be ac-

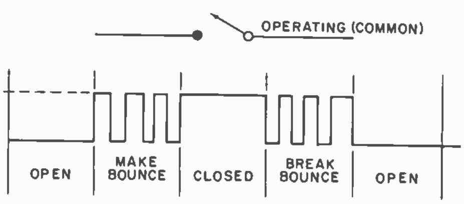
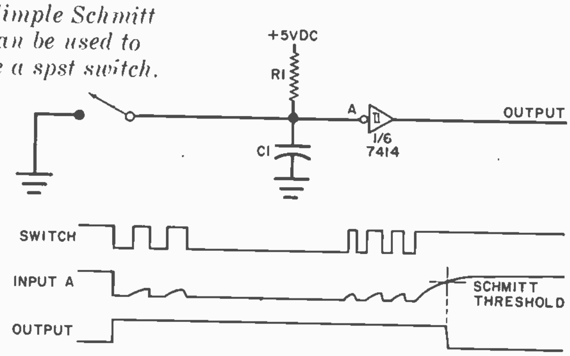


Fig. 3. Bounce pattern of a single-pole-single-throw switch.

Fig. 4. Simple Schmitt trigger can be used to debounce a spst switch.



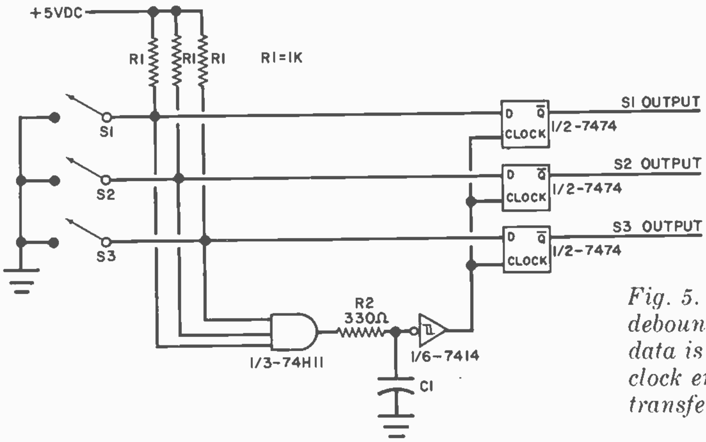


Fig. 5. In keyboard debouncing, switch data is stored until clock enable transfers the data.

complished with only a single input line as illustrated in Fig. 2C. The integrated circuit used is the 74265, a recently announced complementary output device. Here, the noninverting output is fed back to the input, providing stabilizing action much like the 7404 latch of Fig. 2B.

Contact Bounce in Spst Switches. A single-pole, single-throw (form-A) switch and its idealized timing diagram are shown in Fig. 3. This switch is equivalent to a single side of the form-C switch. When a spst switch is operated, break bounce occurs between the movable arm and the normally closed contact. No further action occurs until the switch is released. Following release, the operating strap remakes with the normally closed contact, bounces, and make bounce occurs. As in the form-C switch, make bounce is usually more severe than break bounce. The time required for make bounce to subside is an important factor in debouncing the form-A contact.

Debouncing Spst Switches. Since only a single output is available from the form-A switch, the latching method of debouncing previously described cannot be used. Instead, a delay circuit is normally used to mask the contact bounce. The debounce circuit must: (1) detect the switch transition; (2) delay response for a sufficient amount of time to allow all bounce to cease, and (3) produce an output defining the new switch position. A simple circuit to accomplish this is shown in Fig. 4.

The gate used is a Schmitt trigger device such as 7413 or 7414. With the switch contacts open as shown, input A will be approximately 5 volts, and the output will be logic zero. When the switch is operated, input A goes low and the output switches from low to high. Each time the switch bounces open, point A starts to return to the 5-volt level at a rate determined by the time constant of *R1* and *C1*. As long as input A does not reach its positive-going threshold voltage of about 1.7 volts, the output will remain at logic one. Therefore, the time constant of *R1* and *C1* should be sufficiently long to allow all bounce to subside before this threshold is reached. Usually about 5 to 10 milliseconds is satisfactory.

Keyboard Debouncing. Keyboards, having many switches, pose a special problem when debouncing is considered. Building a debounce circuit for each switch is impractical. Many keyboards include a strobe, or gating, contact which is activated whenever any key is operated. In such keyboards, this common switch should be debounced and its output used to test the state of the remaining switches. Where a common switch is not available, the individual switches can be logically "OR'ed" and the resultant output used as input to the debounce circuit. A typical circuit is shown in Fig. 5. Note that this is an application of the circuit of Fig. 4. Each time a switch is operated, the output of the debounce circuit clocks a flip-flop register which stores the switch information until another switch is operated.

Note that only Schmitt trigger gates should be used with RC networks as shown, since such networks on the input of an ordinary gate can cause oscillation at the gate's output. Series resistance such as *R2* in Fig. 5 should not exceed 330 ohms. ◈

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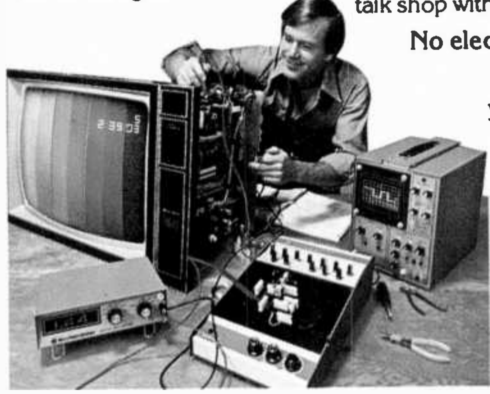

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This easy-to-build antenna offers high gain, good directivity, wide bandwidth–and costs less than $10 for parts.

BY GEORGE L. MONSER

THE rhombic is a nearly ideal TV antenna. It's easy to build and install, provides good reception, and costs less than $10 in materials. If you live in a house with a nonmetallic roof and are located in a medium signal-strength area (with a rather clear "shot" to the transmitter), it can be installed without support masts. The rhombic can also be shaped to the roof contour so it will not detract from the house's appearance. High gain (up to 14 dB), broad bandwidth, and good directionality are characteristic of the rhombic's performance.

About the Rhombic. The rhombic is a long-wire antenna in the shape of a rhombus, with sides usually greater than three halves of a wavelength (Fig. 1). In this configuration, it is a non-resonant antenna with a resistive termination. The presence of the resistor converts the rhombic into a unidirectional antenna with the favored direction looking toward the termination. (Unterminated rhombics are bidirectional). This is desirable in most situations since many viewers want to receive signals which are all transmitted from the same high antenna site. The legs of the antenna are formed from foam-filled 300-ohm twinlead, because the use of multiple conductors increases the gain and bandwidth of the antenna.

Both the leg length l and the "tilt angle" θ are variables, and the rhombic's overall gain depends on this combination and the angle at which the signal approaches the antenna. The dimensions (l and θ) can be chosen either to give maximum gain and directivity or to fit certain physical constraints (like the shape and size of your roof!). In general, maximum gain is found as θ increases. The gain of a diamond-shaped rhombic ($\theta = 65°$) is

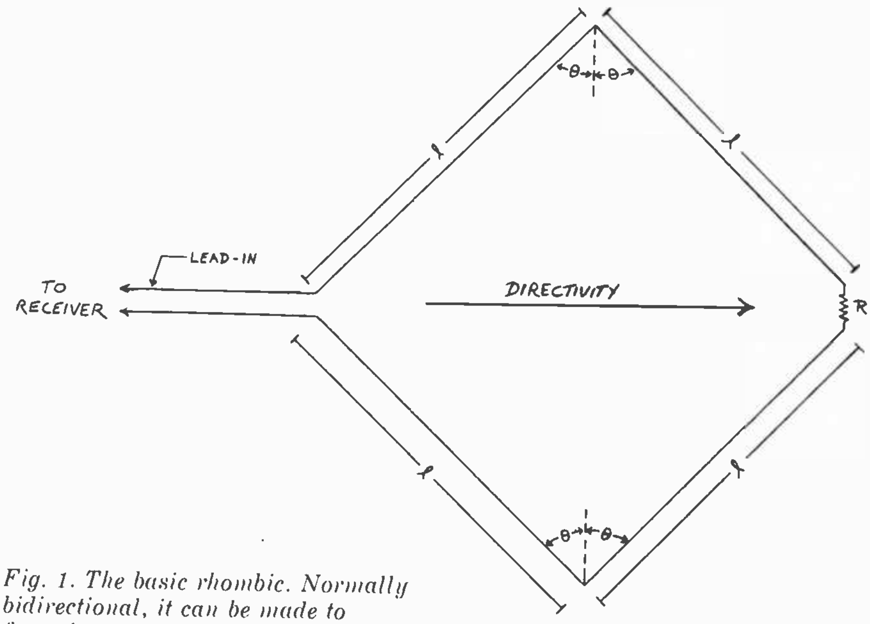
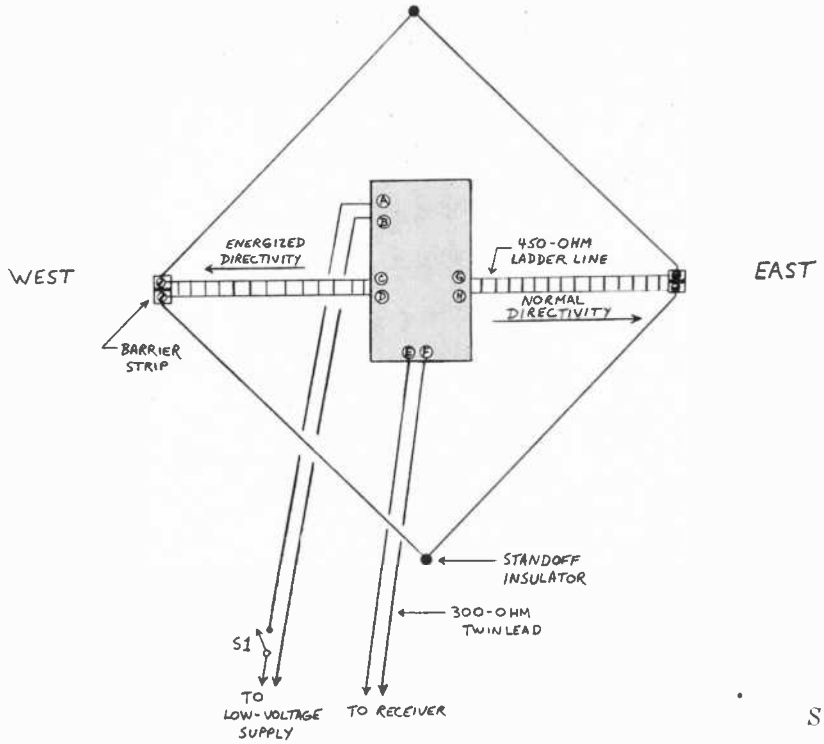


Fig. 1. The basic rhombic. Normally bidirectional, it can be made to focus in one direction by adding the resistive termination.



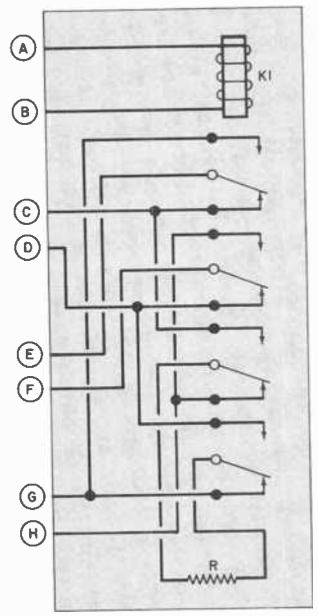


Fig. 2. At left is switchable rhombic antenna. Shaded area is relay switching circuit above. Switching feed and termination changes direction.

about twice that of a square antenna (θ = 45°).

Feedpoint impedance poses an important question—what type of transmission line should be used with the rhombic? The antenna's impedance is not a constant value over variations in frequency, and the physical dimensions have some effect. A square antenna has an impedance of 600 to 800 ohms, while smaller values of θ mean it will generally lie between 450 and 600 ohms.

Most TV receivers, on the other hand, have an input impedance of 300 ohms, and most TV transmission line is of the 300-ohm twinlead variety. This means that, if 300-ohm line is used to bring the signals down to the receiver, an SWR will develop on the line. Some signal loss will exist because of the reflections induced by the impedance mismatch. It's not all that bad, since the greatest SWR you're likely to encounter is 2.7:1. This corresponds to a signal loss of about 25%, or 1.25 dB—which will not really be noticed.

Multidirectional Rhombics. If you want to receive stations from more than one direction, you will either have to put up a few unidirectional rhombics or resort to a switching scheme such as that shown in Fig. 2. In this case, we want to receive signals coming along one axis of the rhombic (see arrows). Most of the time, we listen to station X, whose broadcasts come in from the east. So, we leave *S1* open and relay *K1* de-energized. The antenna favors signals facing east, since that's where the termination (*R*) is with respect to the feedpoint.

Now, let's say that there's a good program on station Y's channel, whose signals come in from the west. Closing *S1* will energize the relay coil, reversing the feed and termination points. The antenna thus "looks" west. Although only two directions are realized in this design, it's possible to use a more complex switching system to include the other two corners of the rhombic. This would allow selection of each of the four cardinal directions (with respect to the antenna). If you want to use this relay switching technique, it's advisable to have a low-capacitance relay mounted in a weather-sealed box to avoid excessive signal loss. Also, for safety's sake, use a low-voltage ac or dc relay coil and good outdoor wire between the coil and voltage source.

Antenna Design. The first step in designing the rhombic is to decide what channels you want to receive, the relative location of their transmitting antennas with respect to your home, and the physical layout of the installation site. (In this article, we assume the antenna is mounted horizontally on

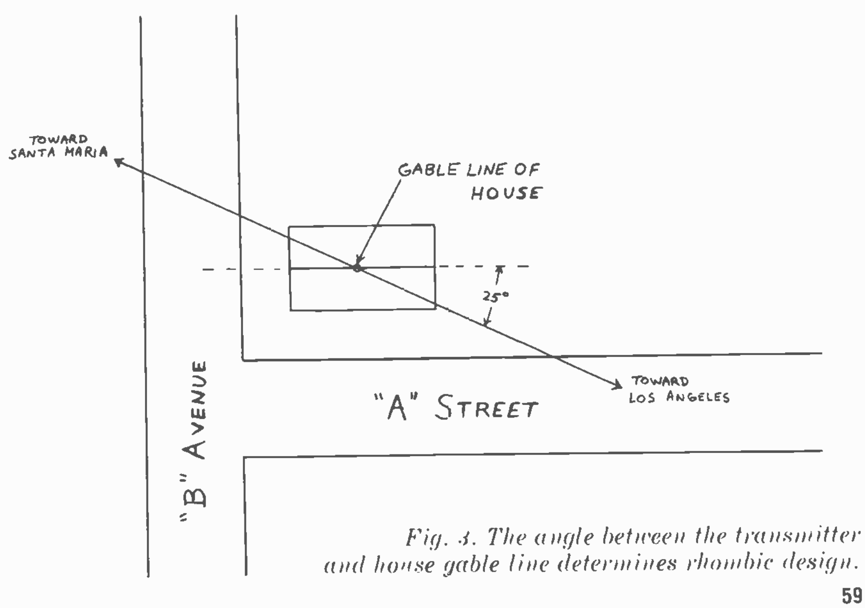


Fig. 3. The angle between the transmitter and house gable line determines rhombic design.

the pitched roof of a wood-frame house.)

For optimum results, three basic designs are described, covering the vhf LO, vhf HI, and uhf bands. The vhf LO antenna measures 25 feet (7.6 m) on a side, and covers channels 2 through 6 and the FM broadcast band. The vhf HI design, spanning channels 7 through 13, has legs one-third the length of those for vhf LO. For the uhf channels (14 through 83), a rhombic that is 55 inches (139.7 cm) on each side is recommended. One rhombic can be installed within another with a different cant to receive higher channels from another direction.

Once you have chosen which size(s) you want to use, locate your reception site and the transmitting antenna on a state or city map. Determine the alignment of your house with respect to the station locations as shown in Fig. 3. In our example, we want to receive stations in Los Angeles and Santa Maria. These roughly lie along the same line, at a 25-degree angle from the gable line of the house. If the angle to the station exceeds 30°, it's best to use the square rhombic (θ = 45°). But we are within the limit for a diamond-shaped antenna, and we'll take advantage of its higher gain to get the distant (100 miles) signals. A vhf LO band antenna will be set up.

Construction. First, we cut a 100-ft. (30.5-m) length of foam-filled 300-ohm TV twinlead in half. A few inches of the insulation are removed at each end of the twinlead segments, and the bared

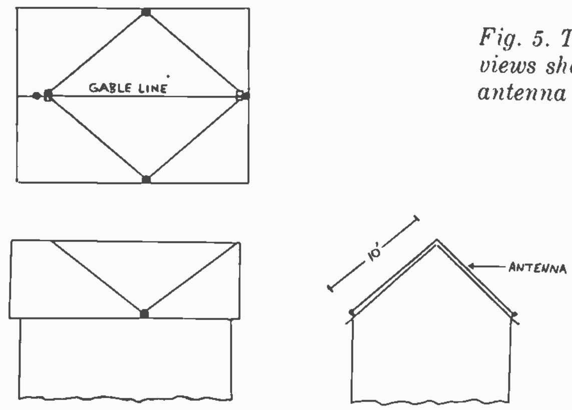


Fig. 5. Top, side, and edge views show how to install antenna on a pitched roof.

wires are twisted together and soldered. Then, install 3½-inch (not critical, larger units can be used) standoff insulators at the four corners of the rhombic design. Slip the twinlead segments through standoffs 1 and 3 until they are halfway through. The free ends of the twinlead are now connected to individual terminals on two barrier terminal strips, which are secured with nylon rope to standoffs 2 and 4. Install relay *K1* and the terminating resistor in a small weatherproof box near the center of the antenna. Weatherproof all connections with epoxy or a commercial preparation made for this purpose. The terminating resistor should be either 470- or 680-ohm, half-watt carbon types. Experiment with the two values and choose the one that gives best reception.

The geometry and physical installation of the rhombic may have to be tailored to your location. Use Figs. 4 and 5 as guides—but by all means experiment. Try to keep all leads to the relay short, and have the 300-ohm line take off at right angles to the gable line.

Performance. How well the rhombic performs is pretty much a function of the leg length and the tilt angle. For the antenna described, about 6 dB of gain is realized on channel 2, rising to about 14 dB on channel 6 and the FM broadcast band. If the vhf HI-band rhombic is built along the same lines, the gain would be 6 dB on channel 7 and increase to 11 dB on channel 13. The uhf model would deliver about 7 dB gain on channel 14, rising to 12 dB on channel 83. (These figures are referenced to a dipole, and are approximate.) With the rhombic aimed toward the channel(s) of interest, the antenna should yield better results than a 5-element yagi beam mounted at the same height. While reception won't be quite as good as that experienced with the multi-element, long-boom commercial antennas, the rhombic will deliver amazing results—considering that it was built for less than $10!

Other Uses for the Rhombic. Though we have described a rhombic for the TV bands, there's no reason why it can't be adapted for SWL, CB, amateur and vhf monitor use. The only major modifications would be in size. At lower frequencies, a larger antenna (and mounting area) would be needed. Remember though, that hf rhombics (14 MHz and below) can be unwieldy. A matching network would also be required to step down the high impedance of the rhombic feedpoint to the low-impedance, unbalanced inputs and outputs of communications receivers, transceivers, and transmitters. For more design information on this high-performance antenna, see "The ARRL Antenna Handbook" or other reference works on antennas. ◈

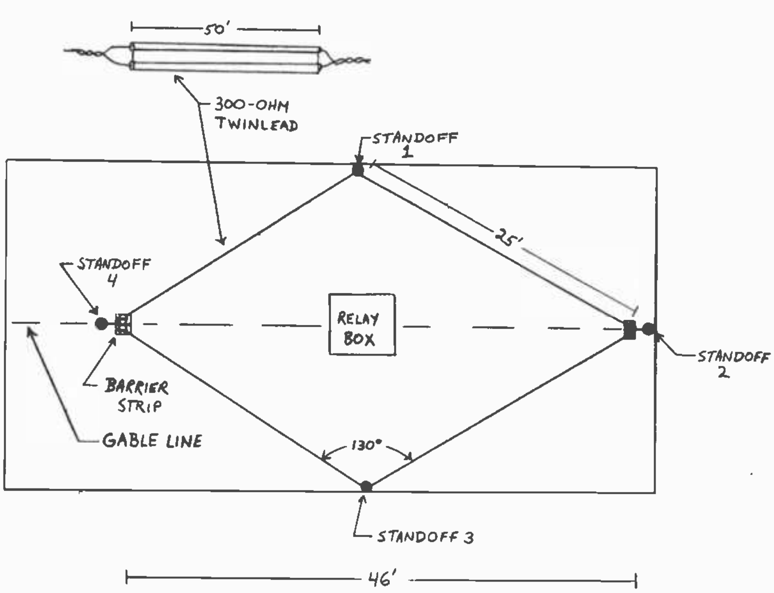


Fig. 4. Installation on a pitched wooden roof. TV insulators support the rhombic about 3" off the roof.

HOW TO DESIGN SOLID-STATE OSCILLATORS

An easy-to-follow approach to basic design of this important part of electronic systems.

BY JIM HUFFMAN

THE oscillator is one of the major building blocks of electronic systems. As differentiated from an amplifier, which merely applies gain to any signal fed to its input, the oscillator converts dc applied to its input to an ac signal at its output. Many people who know how to design an amplifier are stymied when it comes to designing oscillators.

There are many types of oscillators. They can be all-electrical or electromechanical. In this article, our concern is with the former, which includes the negative-resistance, Hartley, Colpitts, RC, Armstrong, avalanche, etc., oscillators commonly found in everyday electronic equipment. We will limit our discussion to oscillators that are most practical for the experimenter to use.

Preliminary Information. The configuration of the basic feedback-type oscillator is shown in Fig. 1. It is simply an amplifier to which has been added a feedback network. This type of oscillator goes by various names (Hartley, Colpitts, Armstrong, etc.), but the operation is the same no matter what the name given to it.

If the output of the feedback network is in phase with the input of the amplifier and the output signal of the network is of sufficient level, the amplified output will return to the input and be reamplified. This signal, made even greater in amplitude through double amplification, goes back around to the input of the amplifier continuously, causing the output of the amplifier to alternate in such a manner that the dc power supply voltage to the amplifier is changed to an ac signal at the output of the amplifier. If the feedback network is frequency sensitive, as well as being phase-shifted, the frequency of the oscillator's output signal can be accurately predicted.

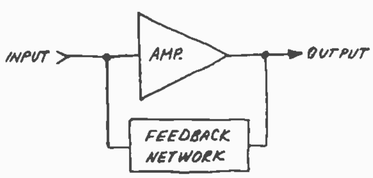


Fig. 1. Basic oscillator is amplifier with feedback.

The obvious problem to the foregoing is that if the feedback energy keeps building each time it is amplified, the ac signal's amplitude will attempt to exceed the dc supply voltage, which is an impossibility. Instead, clipping results and the waveform becomes distorted. In some cases, the distortion is acceptable, but if the oscillator is used in an application such as the vfo (variable-frequency oscillator) in a transmitter, it will cause unacceptable spurious outputs. So, the feedback network must be prevented from feeding too high a signal amplitude to the input of the amplifier. Alternatively, you can reduce amplifier gain. In fact, maximum stability and cleanest waveform occurs when overall gain (including losses in the feedback network) is just slightly greater than unity. If gain is too low, however, there will not be enough feedback to initiate oscillation in the first place and you will end up with an amplifier with frequency-selective positive feedback.

Five basic feedback oscillators are shown in Fig. 2. Each feedback network (tuned circuit) provides the proper phase shift to make the network output in phase with the amplifier's input. In the case of the RC (resistive-capacitive) oscillator, the phase shift in each RC network adds to those of the other networks to produce the total phase shift in the amplifer. Since the proper amount of phase shift occurs at only one frequency, the output frequency of the oscillator is predictable.

The real design problems come in deciding, for example, where to tap the Hartley oscillator's coil, determining the ratios of the capacitors in the Colpitts oscillator, and making sure that the losses in the RC oscillator do not exceed the amplifier's gain so that oscillation can occur.

In the following, we will deal mainly with the Colpitts oscillator, since it is representative of the others and is commonly used in vfo's and other exacting applications where stability must be very good. Another reason for focusing on the Colpitts oscillator is that it is capable of some rather high power levels and it makes a good crystal oscillator simply by replacing the coil with a crystal.

In approaching the design phase, we have three options. First, we can design for maximum stability and little output power. Or, we can forget about stability and go for a lot of power. Finally, we can compromise and design for as much as possible of both stability and output power. Our option will be dictated by the application in which the oscillator is to be used. Whichever option is decided upon, we will use the common-emitter circuit configuration because it yields good power and voltage gain.

Designing the Oscillator. Let us assume we want an oscillator for the vfo in a transmitter. This means that stability must be excellent and the waveform must be clean. Furthermore, the oscillator should be capable of delivering a clean 30-mW signal, which should hardly prove difficult, while maintaining a high degree of stability.

Figure a power supply potential of 9 volts, which can be obtained from an ordinary battery or a zener-diode or IC regulator. Plan on operating the oscillator class A for best stability with an output frequency in the 80-meter (3.5-to-4-MHz) band.

Begin your design by drawing a rough schematic of the oscillator circuit as shown in Fig. 3. Now, determine some of the basic parameters. Start with the load resistance, which is equal to the supply voltage squared divided by two times the output power ($R_L = V_{cc}^2/2P_o$). In your calculations, let V_{cc} be 7 volts to allow some margin of safety. Then, using 7 volts, R_L comes out to 817 ohms, which you can round off to 800 ohms. Pencil in these figures in the appropriate places on your schematic.

The next step is to determine the value of inductance needed. For this, you will have to refresh your memory on Q—the figure of merit for a coil—which is a ratio between the dc resistance of the winding and the winding's reactance at some specific frequency. Most coils have a reasonable enough Q as long as the wire in the winding is not so thin that it inherently exhibits a high dc resistance. Note that our concern here is with the Q that is imposed on the coil by paralleling it with the 800-ohm load. This "loaded Q," or Q_L, is the ratio of the coil's reactance to the load resistance.

If your oscillator used a coil with 800 ohms of reactance and then powered up to 30 mW with an 800-ohm R_L, the ratio would be 800:800 (1:1), which would yield a 3.5-MHz bandwith (output frequency/Q=3.5 MHz/1=3.5 MHz). Remember that bandwidth has a direct bearing on the Q; so, the narrower the bandwidth, the better the Q. (Of course, too high a Q would be detrimental.) A Q of 10 to 20 would be acceptable in our oscillator circuit.

Since the oscillator is to be used as the vfo in a transmitter, where we want the cleanest and most stable signal possible, we will settle for a Q of 20. Now, we must design our coil to have a reactance of 40 ohms.

Choosing a capacitor is a relatively simple task. Rearranging the capacitive-reactance formula $X_C = 1/(2\pi FC)$, we obtain $C = 1/(2\pi FX_C) = 1/(6.28 \times 3.5 \times 10^6 \times 40) = 1.12$ nF. Round this off to 0.001 μF (1000 pF). This would be the total capacitance in the circuit, which means that each of the two capacitors across the coil would have a value of approximately 0.002 μF penciled in on your schematic. Total capacitance $C_T = C1C2/(C1+C2) = 0.002^2/(0.002 + 0.002) = 0.001$ μF.

Feedback Selection. So far, we have done only the easy work. Now we have to start the design of the oscillator itself. First, find a transistor that will give satisfactory performance at 3.5 MHz. A quick look through the manuals reveals that the Motorola HEP-50 transistor has plenty of gain at 3.5 MHz. But let's go a step further to insure that we obtain a stable vfo design.

It is time to identify the components in your schematic, and this time don't forget to draw in tuning capacitor *C5*. You should end up with a circuit like that shown in Fig. 4. Note that single battery biasing would be used for maximum stability.

It would seem that all you have to do is plug in 0.002-μF capacitors for *C1* and *C2* to obtain the required 0.001-μF

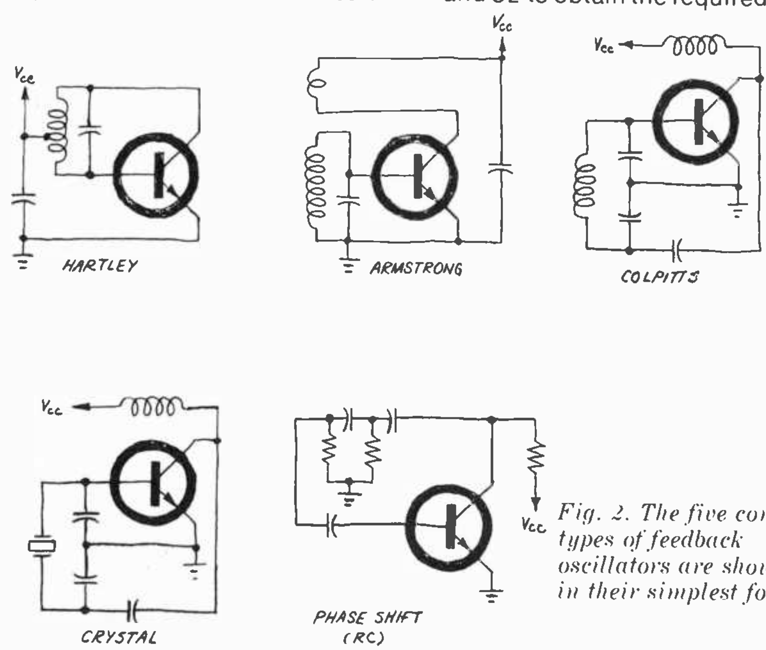


Fig. 2. The five common types of feedback oscillators are shown in their simplest forms.

figure. Make tuning capacitor *C5* small in value—say, a few picofarads—and tweak the slug in coil *L1* a little to lower the inductance to make up for the extra capacitance in the circuit. Then put in the correct biasing resistors.

We mentioned earlier the danger of having the feedback network deliver too much energy to the input of the amplifier. One way to keep the energy down is to add the resistor shown in phantom to reduce stage gain. In many cases, this would be valid. But if you go a step further, your approach will work in all cases.

You can find detailed information on how to design basic amplifier circuits in "Solid-State Circuits for the

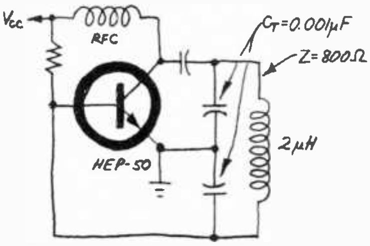


Fig. 3. Start with this basic Colpitts oscillator circuit.

Experimenter" (September 1972 POPULAR ELECTRONICS or 1975 Winter ELECTRONIC EXPERIMENTER'S HANDBOOK). If you can obtain a copy of either, refer to the box to help you fill in the values for the components in Fig. 4.

Use the information given in the box to determine the gain of the amplifier. We know that R_L is 800 ohms. From the information listed on the back of the transistor's box, we know that its β is 85. If you bias the transistor for class A operation, it will be in the middle of its operating range. From Ohm's Law, the maximum current the stage will draw will be: I = E/R = 9 volts/800 ohms = 11 mA. If the stage is in the middle of its operating range, bias it for 5 mA with no signal. From the box, you can see that input impedance Z_{in} is about 400 ohms and stage gain is 160. Divide the gain by 4, which yields a gain of 40. (This is a handy rule of thumb for oscillators.) In designing a Hartley oscillator, you would now select a coil tap that would transform at a 40:1 ratio, and your design would be complete.

We now have a gain of 40. Using the two 0.002-μF capacitors in series would divide the gain by 2 to yield an effective gain of 20. For maximum stability of the oscillator, however, we want the gain to be roughly unity. It would seem logical to allow *C1/C2* equal 20 as in the Hartley oscillator design. However, we want power as well as stability from our oscillator. So, let us pursue another optimum approach to design: impedance matching. This means to obtain maximum power transfer within the oscillator and then adjust the amplifier's gain to obtain a clean output signal. We can assume that matching the impedances is the best approach when power is required from the oscillator.

The capacitive divider provides the impedance match. Impedance ratios in tuned circuits vary as the square of the turns ratio (in this case, the capacitive divider). Now, the object is to find two capacitors whose series capacitance equals about 900 pF, which allows 100 pF for the tuning capacitor *(C5)*. Gain in the amplifier is reduced as necessary by the unbypassed phantomed resistor.

Getting back to the design again, we must sift through a few simple algebra equations. First, the formula for total series capacitance (C_T) is: $C_T = C1C2/(C1 + C2)$. The value of C_T in our example is 900 pF. Next, the ratio of R_{in} to R_{out} is $R_{in}/R_{out} = (n_{in}/n_{out})^2 = [C1/(C1+C2)]^2$, which translates to the simple formula for determining the value of *C2*: $C2 = C_T\sqrt{R_{out}/R_{in}}$. In our case, C_T = 900 pF, R_{out} = 800 ohms, and R_{in} = 400 ohms. So, $C2 = 900\sqrt{800/400}$ = 1270 pF. The value of *C1* can be determined from the formula: $C1 = C_T/[1 - (C_T/C2)]$ = 3100 pF. Rounding out the two values, we obtain: *C1* = 1200 pF (0.0012 μF) and *C2* = 0.003 μF.

With the oscillator set for maximum power gain, you must now add some negative feedback to obtain the cleanest output signal. The phantomed resistor's value is easy to determine. When it comes time to assemble the circuit, temporarily connect a 500-ohm potentiometer between the transistor's emitter and ground. Adjust the pot, while observing the oscillator's output on an oscilloscope, for the cleanest possible waveform. Then, without touching the setting, remove the pot from the circuit and measure its resistance. Use a fixed resistor of the same or approximately the same value as that measured across the pot in the circuit.

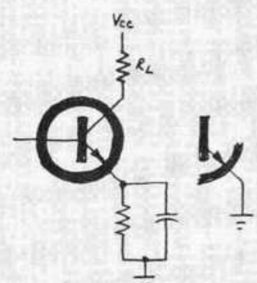
From this point on, it is just finishing touches. The reactance of *C3* should be roughly $R_L/10$ = 800/10 = 80 ohms. Using the formula $C = 1/(2\pi FX_C)$, we obtain a figure of roughly 570 pF, which can be rounded out to a more common 0.001-μF value. The reactance of *C4* should be at least $R_{in}/5\beta$ or about 1 ohm in this case. (This value can be adjusted to prevent quenching.) The formula used for *C3*, when applied to *C4*, yields a value of about 0.05 μF. To prevent the r-f choke's (*RFC1*'s) dc resistance from limiting the output of the oscillator, it should be considerably less than the 800-ohm value of R_L. A 2.5-mH choke would look like 55,000 ohms at 3.5 MHz, which should be very effective in comparison to the 800 ohms for R_L.

All that is left now is to assemble the circuit, using the calculated component values, and measure the parameters to determine if all is well with the design.

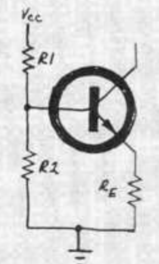
Design Checkout. The next step is to breadboard your design, preferably with perforated phenolic board and

QUICK AMPLIFIER STAGE DESIGN

Shown below are some rules-of-thumb formulas you can use to design your own common-emitter amplifier stages. Combining this information with the design details given in the text, you can design a complete oscillator stage.



V_G (VOLTAGE GAIN) ≈ $\beta(R_L/Z_{in})$
Z_{in} (INPUT IMPEDANCE) ≈ $\beta(26/I_E^*)$
* I_E IS IN mA
I_G (CURRENT GAIN) ≈ 0.9β
Z_{out} (OUTPUT IMPEDANCE) ≈ R_L



I_C (COLLECTOR CURRENT) ≈ I_E
I_E (EMITTER CURRENT) ≈ V_E/R_E
V_E (EMITTER VOLTAGE) ≈ $V_{CC}[R2/(R1+R2)]$
$R1 = [(R2V_{CC})/V_E] - R2$
$R2 = 5R_E$
V_E = VOLTAGE DROP ACROSS R_E

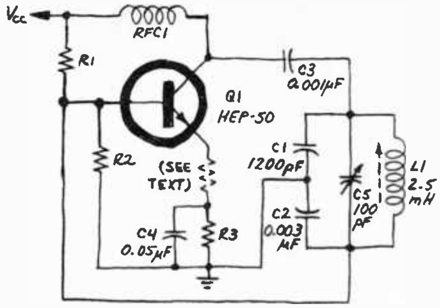


Fig. 4. Here we have added some values and a tuning capacitor.

solderless clips. This will permit you to adjust component values as needed before proceeding to final assembly. Test equipment that will be handy to have during checkout includes a variable power supply, a frequency counter for checking that the oscillator is on-frequency, an oscilloscope to view the output waveform, and a good general-coverage communication receiver to listen for signal purity and check for harmonics.

None of the above test equipment is essential. For example, you could use an ordinary 9-volt battery in lieu of a variable power supply. However, you will need at least a VOM (set to ac volts) or, better yet, an oscilloscope to check for the presence of oscillation.

You can check for instability, in the form of drift, by beating the oscillator's output signal against a known reference signal of good stability, such as from a crystal oscillator. Some of the sources of drift and instability are the input and output capacitances of the transistor itself, which can vary with bias, temperature, supply voltage, etc. There are also coil dimension changes that occur with changes in temperature and instabilities caused by capacitance changes with heating and cooling. All of these can be minimized or limited in some or all of the following ways.

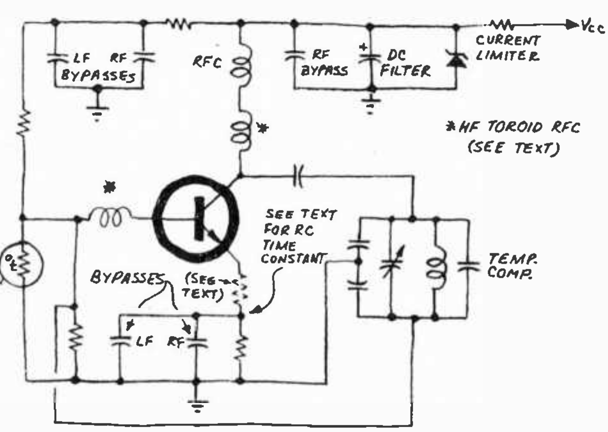
Since transistor parameters vary with changes in bias, single-battery (or regulated-dc) bias systems should be used when stability is a critical factor. To keep the transistor's parameters from changing with variations in the supply voltage, regulate the V_{cc} line with a zener diode or IC regulator. Also, to keep capacitance changes in the transistor junctions at a minimum, use a high-Q, high-LC-ratio tuned circuit. (The major advantage of the Colpitts design is that *C1* and *C2*, whose values we took so much pains to calculate, tend to swamp out the variations in input and output capacitances.) The high LC ratios demand a coil of fewer number of turns, and the wire should be firmly wound on the coil form and held in place with coil dope to minimize dimension changes due to temperature changes.

High-quality capacitors, such as the silver-mica variety, will not be as susceptible to thermal drift as are other types of capacitors. The oscillator should be well ventilated, component leads should be kept short, and all components should be firmly mounted in place to minimize vibrational effects.

Final Touches. Under final touches, we rid our oscillator of spurious oscillations that are common in transistor designs. We will cover only a few of the problems likely to be encountered and their solutions. Most of the problems can be avoided at the time the circuit is still on paper.

One problem is "quenching" or "squegging." This is a lower-frequency oscillation often caused by too high a time constant in the emitter circuit bypass. It allows the emitter bypass capacitor to charge up to a voltage that eventually cuts off the transistor. This occurs repeatedly at some lower frequency and superimposes itself on the oscillator's output signal. The output signal is then loaded with spurious outputs that may occur every few kilohertz on the radio dial. When quenching occurs, reduce the time constant by making the values of *R3* and *C4* as low as possible and readjusting the bias circuits to compensate for the lower resistance.

Fig. 5. A completed oscillator circuit which may contain more refinements than you need.



Another problem is that of an additional high-frequency oscillation in the circuit. There can also be low-frequency oscillations caused by such things as the inductance of the r-f chokes. The lower frequencies can be minimized by bypassing both r-f and audio frequencies. Higher-frequency parasitics can be minimized by adding r-f chokes that act as high impedances at the parasitic and short circuits at the operating frequency. One such choke can be fabricated by slipping ferrite beads over component leads. You can make your own by winding a turn or two of enameled wire on a toroid core made from a tuning slug of a tunable coil. The hole runs lengthwise along the slug so that a few turns of No. 28 enameled wire wound through the hole makes an excellent parasitic choke.

The schematic diagram shown in Fig. 5 illustrates all design techniques that can be employed in an oscillator. It is doubtful, however, that all of these techniques will be needed in any given oscillator.

Once you've debugged your oscillator design, you can proceed to final assembly. The preferable medium would be printed-circuit board construction, but perforated board and solder clips will serve equally well.

In Conclusion. We've covered one basic type of oscillator here. Obviously, there are many more. The oscillator and approaches used in its design in these pages are very simple and extremely dependable. Using the guidelines, you can design your own oscillator circuits. Special requirements, such as working at temperature extremes, super-high stability, etc., can all be achieved by starting with our modest approach.

You can design crystal oscillators that operate in the series mode by replacing the coil with a crystal in the Colpitts design. You can use pre-tapped coils in Hartley circuits and still design system gain for optimum oscillator performance by adding negative feedback. We can go on and on *ad infinitum*, but you get the idea. ◈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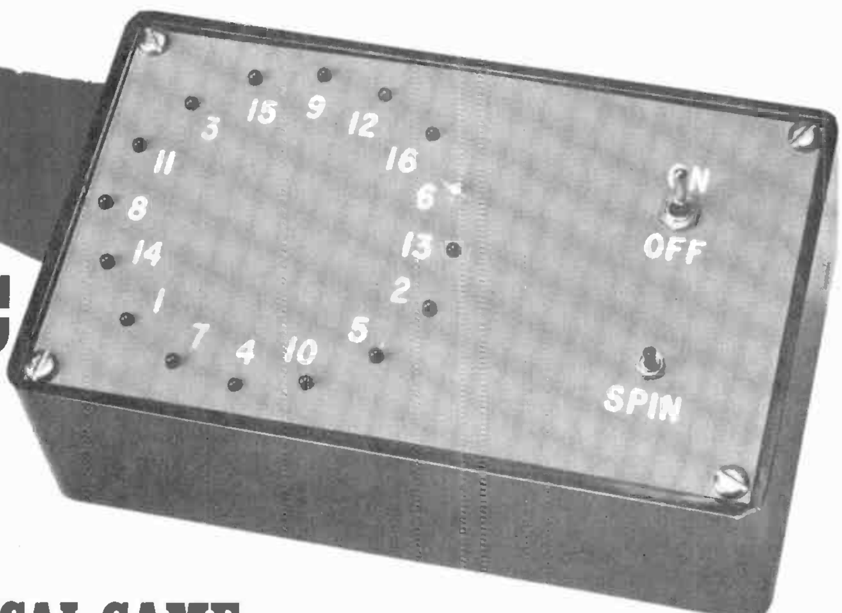
Form no. 1C65 0875 EXP 150M

Solid-state version uses LED's as the spinning ball.

BY ROBERT D. PASCOE



ELECTRONIC WHEEL OF FORTUNE

SIMULATES MECHANICAL GAME

THE WHEEL of fortune has always been one of the favorite games of chance. Perhaps it is because of the fascination of watching the wheel go around and around and not knowing where it will stop. You can build an electronic roulette which has little red lights going around and around, stopping eventually at a completely randomly selected number between 1 and 16. Players can select their number for each spin of the wheel, watch the lights, and collect their winnings if the light stops on their number. Like a mechanical wheel, the lights go fast at first and then slow down gradually before stopping at the winning number.

Circuit Operation. As shown in Fig. 1, a clock oscillator (*IC1*) operates at about 100 Hz when the SPIN pushbutton is depressed. When the switch is released, a time constant in the circuit causes the oscillator to slow down to a stop in about 10 seconds. The output of the clock is conditioned for the TTL logic by transistor *Q1*.

To understand how the 16 LED's are operated, note that the combinations of numbers 1 and 9, 2 and 10, through 8 and 16 are driven by the output of the first flip-flop and the 8-bit shift register. However, the selection of which of the eight combinations is in the circuit at one time is made by the state of the second flip-flop. As the clock delivers pulses to the first flip-flop, the digital one level is propagated from 1 through 8 on the LED's.

At the eighth clock pulse, the output of *IC3* operates a one-shot (*IC2*). This causes the output flip-flop to change states, so that the second eight LED's are selected. Simultaneously, the first flip-flop and the shift register are

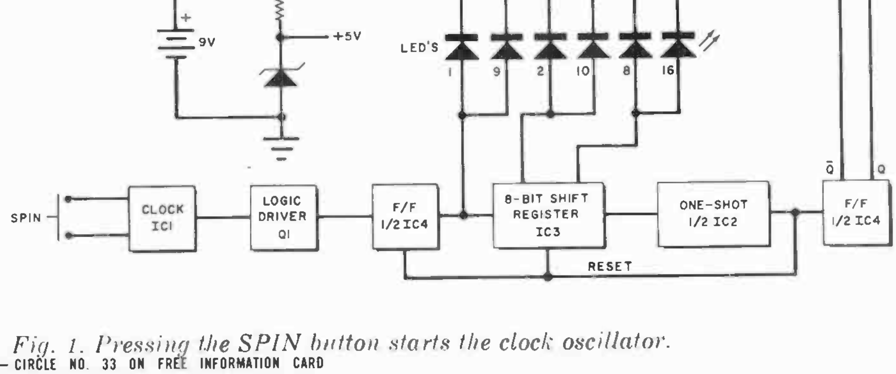


Fig. 1. Pressing the SPIN button starts the clock oscillator.

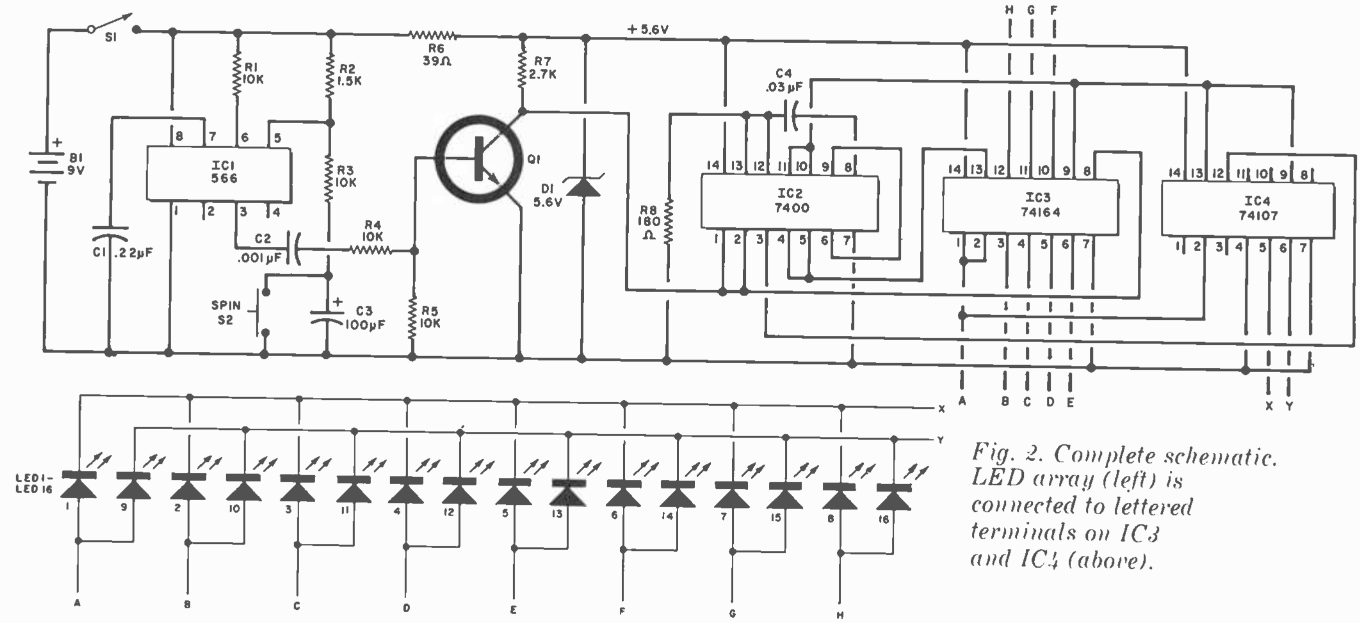


Fig. 2. Complete schematic. LED array (left) is connected to lettered terminals on IC3 and IC4 (above).

PARTS LIST

B1—9-volt battery (6 C cells)
C1—0.22-µF capacitor
C2—0.001-µF capacitor
C3—100-µF, 15-V electrolytic capacitor
C4—0.03-µF capacitor
D1—5.6-V zener diode
IC1—Function generator (566)
IC2—Quad 2-input NAND gate (7400)
IC3—8-bit shift register (74164)
IC4—Dual JK flip-flop (74107)
LED1 to LED16—Light emitting diode
Q1—Silicon npn transistor
R1,R3-R5—10,000-ohm, ¼-W resistor
R2—1500-ohm, ¼-W resistor
R6—39-ohm,¼-W resistor
R7—2700-ohm, ¼-W resistor
R8—180-ohm, ¼-W resistor
S1—Spst switch
S2—Normally open spst pushbutton switch
Misc.—Suitable enclosure, press-on type, C-cell holders, insulated wire, mounting hardware, etc.
Note—The following are available from Hosfelt Electronics, 224 Opal Blvd., Steubenville, OH 43952: etched and drilled printed circuit board at $5.00; case and engraved front panel at $5.00; complete kit of parts at $24.95.

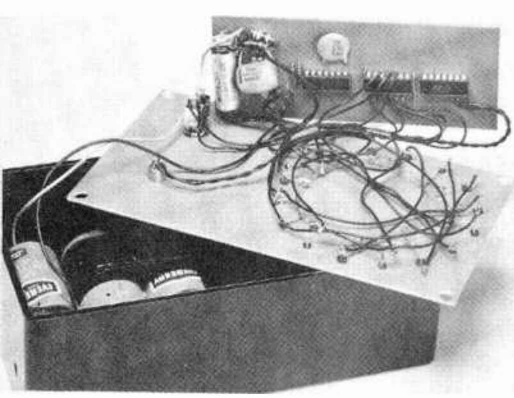


Photo shows how LED's were arranged on top of the enclosure.

reset. In this way, the same logic is used for all 16 LED's. The complete schematic is shown in Fig. 2.

Construction. The circuit can be assembled on perforated board or on a pc board such as that shown in Fig. 3. Be sure to observe the polarities and coding on all components and use a low-power soldering iron. Note that there are three jumpers on the board.

The prototype was housed in a plastic enclosure 6½" × 3¾" × 2". As shown in the photo, the cover of the box was drilled for the 16 LED's arranged in a circle. The holes should be just large enough to fit the tops of the LED's. The lights can be identified at random using press-on type. The two switches can be mounted on the cover as shown.

Since the project has a current drain of about 100 mA, six C cells, in holders mounted on the bottom of the enclosure, can be used. This allows about 10 mA for the LED's. Any color can be used for the LED's, but it is advisable to have a few extras so that they can be selected to have all 16 glow with about the same brilliance. ◈

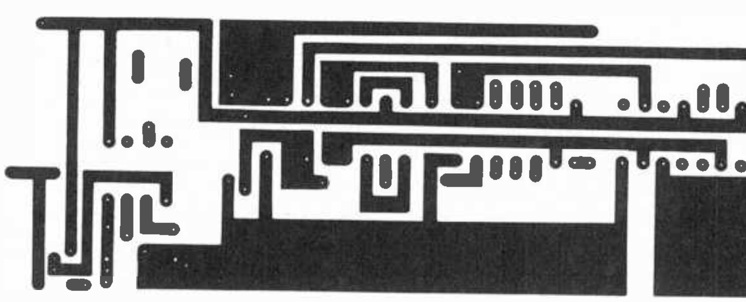
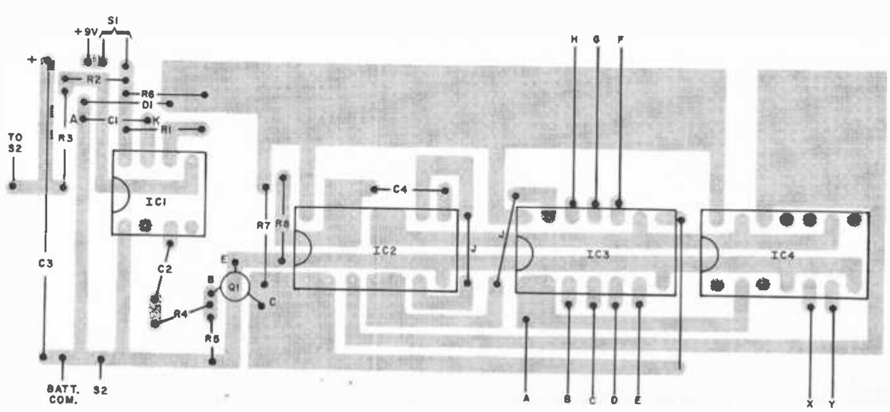
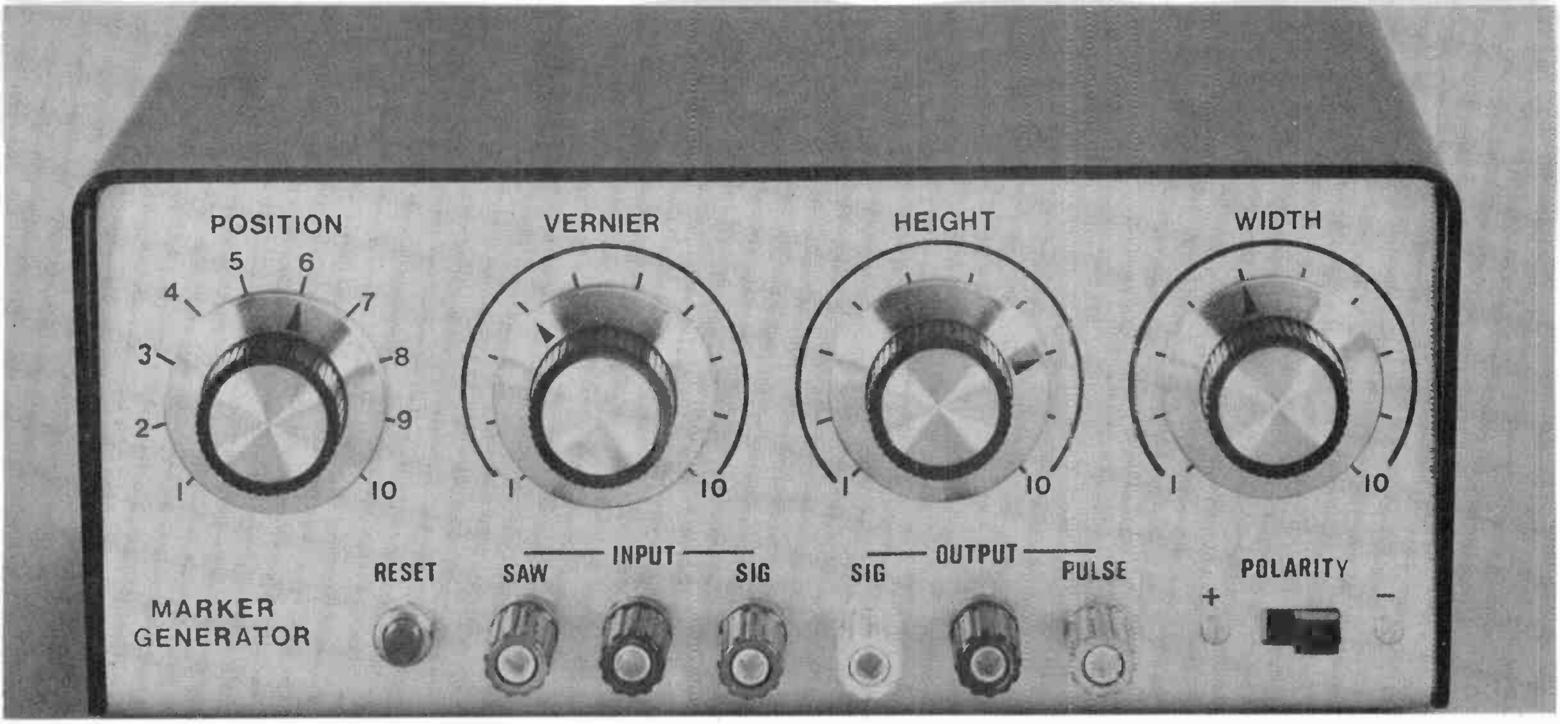


Fig. 3. Etching and drilling guide above; component layout below.





BUILD AN

AUDIO SWEEP MARKER GENERATOR

Now you can easily identify any frequency on an audio swept waveform display.

BY JON PAUL

THE USE of a sweep generator is practically a necessity in any serious testing of audio equipment. Some sweep generators are not sufficiently calibrated however (especially for a logarithmic sweep) to provide an easy identification of an unusual response at a particular frequency. This can be easily remedied by mixing the output of a marker generator with the sweeper's output. Then, when the signal is displayed on a scope, a particular frequency can be identified.

The audio sweep marker generator described here provides two approaches to marker display. One is a sharp vertical pulse as shown in Fig. 1, which can be positioned on the scope at the frequency of interest. Or the pulse can be fed through the scope's intensity axis to generate a bright spot on the display. The marker automatically covers the same range as the sweeper being used, and the only condition required is that the sweeper's main sawtooth be available.

How It Works. The sawtooth output from the audio sweeper (the waveform within the sweeper that is performing the actual frequency sweep—not a sawtooth audio output) is coupled to the marker generator through *BP1* as shown in Fig. 2. This signal is buffered in *IC1* and fed to *IC2* and *IC3*, which form a peak detector.

As the input rises in voltage, *IC2* places a charge on *C2* through *D1*. When a peak value is reached and the signal drops to zero, the output of *IC2* goes negative and *D1* is reverse biased. However, *C2* remains charged at the peak value of the sawtooth (V_{peak}). When RESET pushbutton *S1* is depressed, *C2* discharges through *R3* so that, on the next sweep, a new value of V_{peak} is detected. Integrated circuit *IC3* is a unity gain buffer that prevents succeeding circuitry from loading *C2*. The output of *IC3* goes to *IC2* to supply the feedback necessary for the peak detection process. It is also applied to two adjustable voltage dividers—*R4*, which is used as a VERNIER control, and the resistor network associated with *S2*.

The voltages selected by *S2* and *R4* are mixed in *R14* and *R15* so that the input to *IC4* can be selected to be between 0 and 90% of V_{peak} in 10% steps with the vernier providing smooth adjustment between steps.

The output of *IC4* is applied to two comparators—*IC5* and *IC6*. Transistor *Q1* develops a constant current (I) in *R21* to produce an offset at the input to *IC5*. Thus one input to *IC4* is V_{ref} (from *IC4*) + (R21xI). The other input is V_{sweep} from *IC1*. The output of *IC6* switches when V_{sweep} equals V_{ref} and the output of *IC5* switches slightly later due to the offset provided by *R21*.

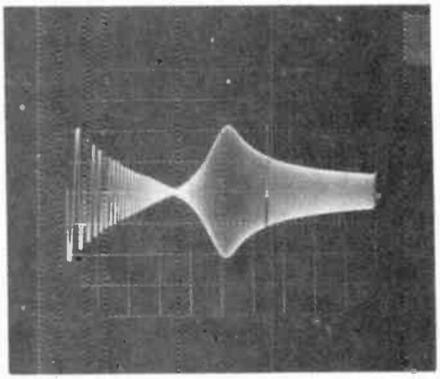


Fig. 1 Photo of marker "pip" on a typical scope display.

Diodes *D5* and *D6* and resistor *R27* form an AND gate whose output is negative only when *IC5* and *IC6* have negative outputs. This generates a

PARTS LIST

BP1 to BP6—Five-way binding post
C1,C6—0.001-μF ceramic capacitor
C2—47-μF, 20-volt tantalum capacitor
C3,C5—33-pF ceramic capacitor
C4—3.3-pF ceramic capacitor
C7,C8—150-pF ceramic capacitor
D1 to D9—1N914 diode
IC1—741 op amp
IC2 to IC6—301A op amp
Q1—2N4250 transistor
Q2—2N3642 transistor
Following resistors are ¼W, 10% unless otherwise noted
R1,R30—4700 ohms
R2,R18—8200 ohms
R3—10,000 ohms
R4—10,000-ohm linear potentiometer
R5 to R13—1000-ohm, 1% carbon-film
R14—2-megohm, 1% carbon-film
R15—221,000-ohm, 1% carbon-film
R16—200,000 ohms
R17,R27—2200 ohms
R19—2-megohm linear potentiometer
R20—160,000 ohms
R21 to R24, R34—22,000 ohms
R25,R26—10 megohms
R28,R29—27,000 ohms
R31—6800 ohms
R32—20,000-ohm linear potentiometer
R33—100,000 ohms
S1—Spst normally open pushbutton
S2—10-position, single-pole rotary switch
S3—Spdt switch
Misc.—Suitable enclosure, knob (4), dry transfer lettering, mounting hardware, etc.
Note—The following is available from MITS Inc., 6328 Linn, N.E., Albuquerque, NM 87108: complete kit including prepunched board and cabinet (MG-1K) at $98; complete kit without cabinet and hardware (MG-1P) at $71; pc board alone (MG-PC) at $8; assembled unit, with 90-day warrantee (MG-1A) at $138. Add $5 for postage and handling on all items except for pc board alone.

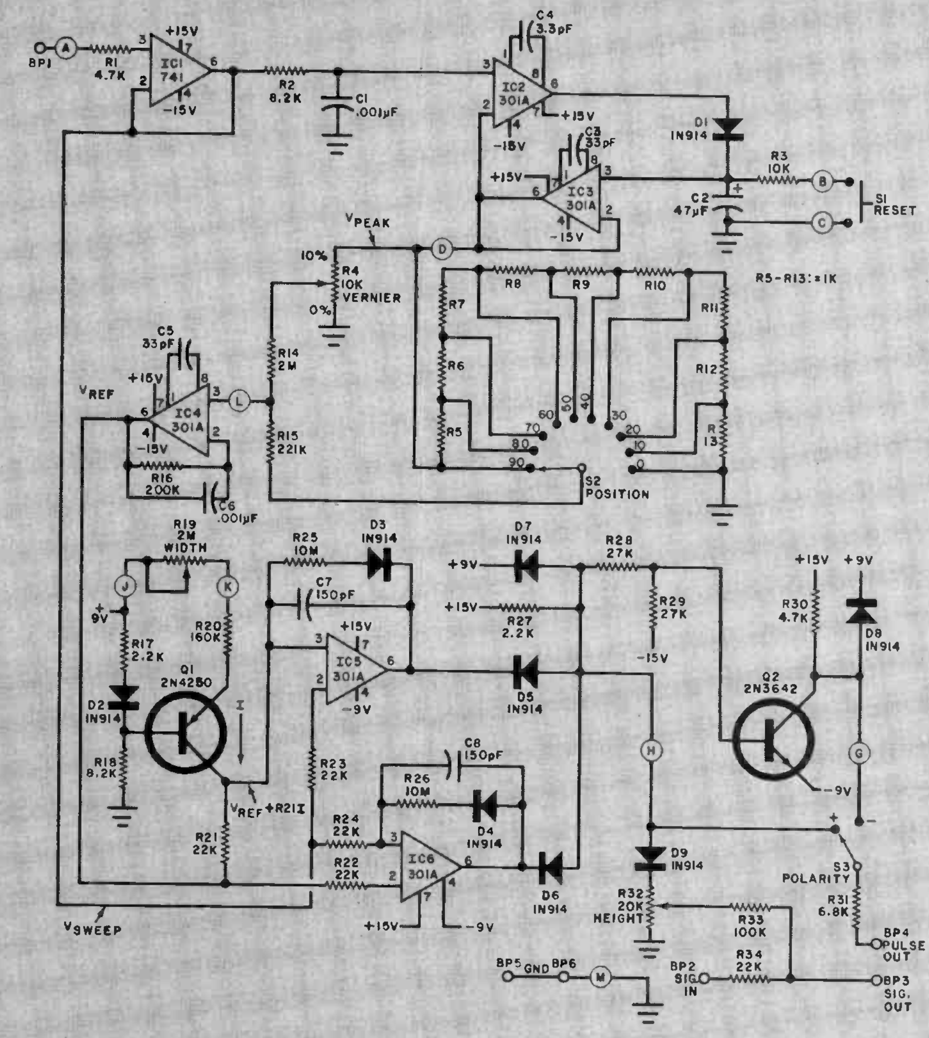


Fig. 2. Position of marker pulse is determined by S2 and R4, while width and height are controlled by R19 and R32.

pulse which is negative only when V_{sweep} is greater than V_{ref} but less than V_{ref} plus the offset. The width of the pulse is proportional to I. Since the current is determined by the setting of *R19*, the setting controls the width of the pulse. The various waveforms involved are shown in Fig. 3.

The pulse from the AND gate is applied to the base of *Q2*, which is an inverter. POLARITY switch *S3* can then select either a positive or an inverted pulse. The mixed marker is formed by adding a variable-amplitude pulse (from *R32*) to the swept audio signal connected to *BP2*.

Construction. The circuit can be built on a pc board such as that shown in Fig. 4. Be sure to obtain proper orientation of the diodes, the IC's and *C2*.

The marker generator requires four power sources: ±9 and ±15 volts. These may be available in the sweep generator (as they are in the unit described in the October 1973 issue of POPULAR ELECTRONICS). Or small separate supplies can be constructed. The two 15-V sources can be unregulated and any value between 13 and 17 V. The 9-V sources should be regulated (using zener diodes) and can be derived from the 15-V supply.

The front panel of the chassis should be large enough to accommodate the POSITION switch *(S2)*, the VERNIER potentiometer *(R4)*, the HEIGHT control (*R32*), the WIDTH control, (*R19*), the RESET switch (*S1*), the POLARITY switch (*S3*), and six input and output connectors.

The vernier potentiometer should be calibrated for 1% increments by measuring its resistance in 10% steps. The switches and connectors should also be marked as shown in the photograph.

Operation and Use. No calibration of the circuit is necessary since the peak detector works automatically.

Connect the sweep and marker generators to the unit being tested and the scope as shown in Fig. 5. The marker's POLARITY switch determines the type of intensity modulation (bright or dark marker), while the HEIGHT control varies the marker am-

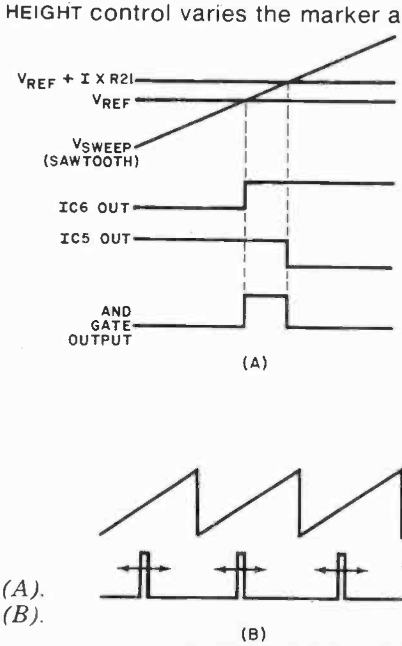


Fig. 3. Pulse is generated as shown at (A). Position can be varied as shown at (B).

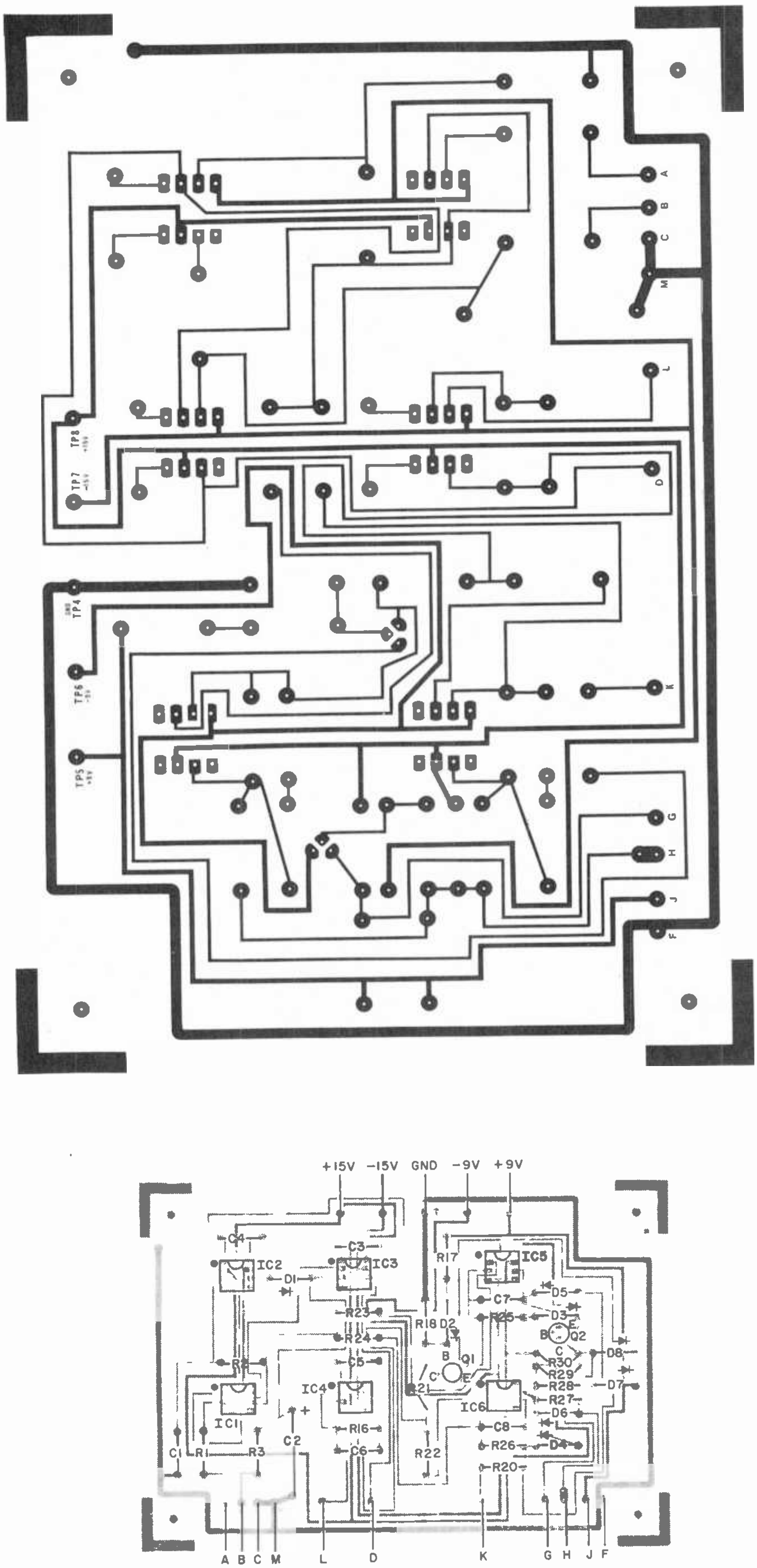


Fig. 4. Actual-size foil pattern is at top; component layout below. Lettered pads correspond to those on schematic and are used for interconnections.

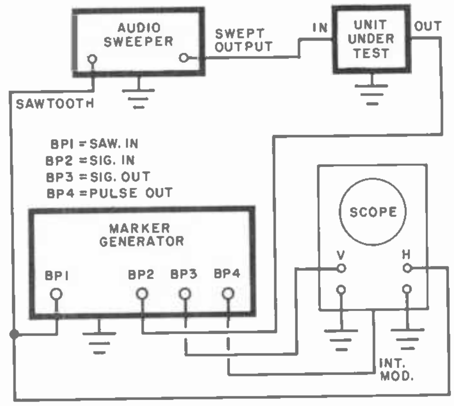


Fig. 5. Interconnections for setting up a test.

plitude. Three types of display are shown in Fig. 6.

The accuracy of the marker generator is determined by the matching of *R5* through *R13* (all 1% resistors). The sweep linearity of the scope, however, will rarely be better than 2%.

RESET pushbutton *S1* is rarely used. If the marker suddenly shifts position on the display, or if high-value markers cannot be displayed, a noise pulse

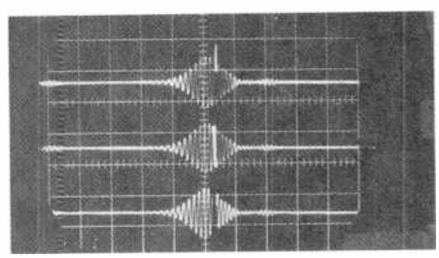


Fig. 6. Pip marker is at top. Bright and dark intensity markers in display at center and bottom.

has probably disturbed the peak detector. In this case, depress *S1* so that the circuit will automatically recalibrate itself on the next peak.

Assuming that the sweep generator is set to operate in the linear mode between 0 and 10,000 Hz and you want to determine the frequency of a "glitch" near the center of the display, proceed as follows. Set the marker generator for the type and amplitude of marker desired and adjust the POSITION switch until the marker is just below the frequency of interest. Then adjust the VERNIER to refine the position. If the POSITION switch is at 5 and the VERNIER at 7, the marker frequency is 57% of the swept frequency, or 5700 Hz.

Note that there are no "frequency" dials on the marker generator—only percentages of swept frequency. ◈

Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

The truly novel aspects of Sony's new Model TA-4650 integrated stereo amplifier, reviewed here, are not readily obvious. This is one of the first consumer audio products to use the recently developed "Vertical FET," or V-FET, in its power output stages. The V-FET has been heralded for its electrical characteristics (similar to those of a triode vacuum tube) and its exceptional power-dissipation capability and ruggedness.

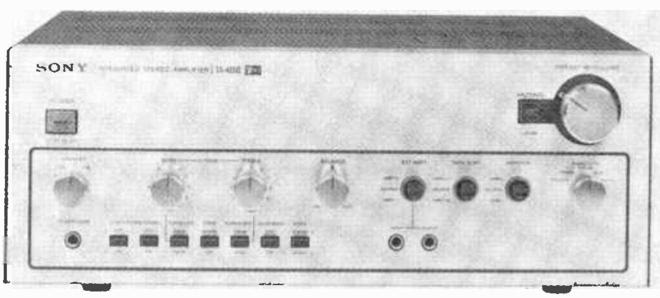
Since Koss is one of the leaders in the development of stereo headphones, we would expect it to come up with something out of the ordinary in 4-channel phones. On testing the company's new Phase/2 + 2 phones, we have not been disappointed. They offer some surprises—such as "rear" drivers located in front of the "front" drivers—and one of the most unusual features is an integral "Programmer" control box that lets the listener adjust sound quality to his personal taste, making available 127 different combinations. Even if you do not yet own a 4-channel system, the Phase/2 + 2 phones can simulate an excellent "surround-sound" effect from ordinary stereo programs, and they are almost as much fun to experiment with as to listen to seriously.

Audioanalyst's new Model A-200X speaker system, with five drivers, is priced to compete with some very fine systems. Judging by its many attributes—unusually high accuracy, moderately high efficiency, and excellent listenability—it should be a formidable competitor.

—Julian D. Hirsch

SONY MODEL TA-4650 V-FET STEREO AMPLIFIER

Versatile control amplifier features no crossover distortion.



HIRSCH-HOUCK LABS REPORT

Several Japanese manufacturers have recently begun to market audio amplifiers using the vertical field-effect transistor. The V-FET has characteristics that closely match those of an ideal triode vacuum tube. It is inherently immune to thermal runaway which can destroy a bipolar transistor, has the high input impedance of low-power FET's, and is capable of dissipating very large amounts of power.

The Sony Model TA-4650 is the first V-FET amplifier we have had an opportunity to test. It is an integrated stereo amplifier, rated at 30 watts/channel into 8-ohm loads with less than 0.1% distortion over a frequency range of 20 to 20,000 Hz. In addition to its technical circuit innovations, this is a highly versatile control amplifier.

The amplifier measures 16 7/8"W × 12 3/4"D × 6 5/8"H (43 × 32 × 17 cm) and weighs about 25.5 pounds (11.5 kg). Its retail price is $400.

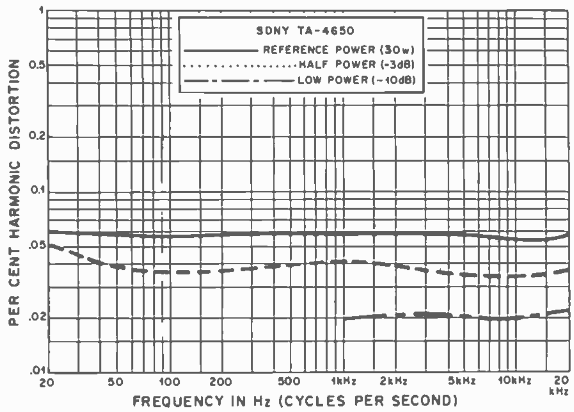
General Description. The styling of this amplifier differs from that of previous Sony hi-fi products, but it matches that of the company's new Model ST-4950 tuner. The lower portion of the satin gold panel has most of the operating controls, including the bass and treble, balance, and speaker selector controls, as well as the source selector switch. The amplifier can handle two pairs of speaker systems and has two magnetic phono-cartridge and three high-level inputs. There is also a stereo headphone jack on the front panel.

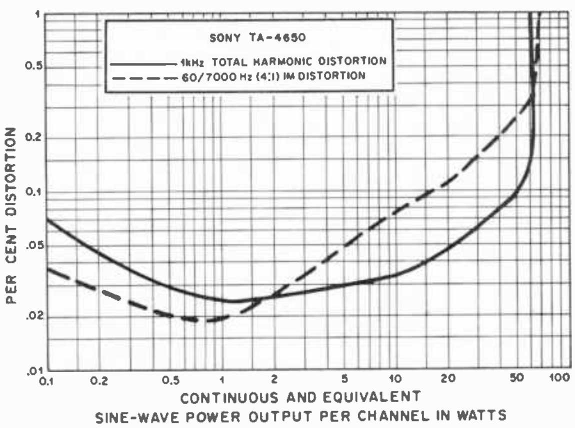
A row of small pushbutton switches provide for operating the low- and high-cut filters, loudness compensation, and stereo/mono selection. One switch permits the tone controls to be bypassed, and two other switches provide a choice of turnover frequencies of 250 or 500 Hz in the bass and 2500 or 5000 Hz in the treble ranges. The tone controls each have 11 detented positions.

Three-position lever switches give the amplifier much of its flexibility. One is a tape-monitor switch for controlling two tape decks; in its center position, the normal program is heard. Another is the tape-copy switch that connects the two decks to copy tapes from either one to the other. Finally, there is the EXT ADPT switch that is similar to the monitor switch except that it is intended for connecting into the circuit (following the tape recorders) such accessories as an equalizer or a quadraphonic adapter. In one of the EXT ADPT switch's positions, two adjacent stereo phone jacks on the front panel are used to connect the accessory device, while the connectors are on the rear apron when the switch is in its alternate position. The EXT ADPT feature can also be used with one or two more tape decks, but it does not offer the tape-copying feature.

At the upper right of the front panel is the large VOLUME control knob. A concentric PRESET ring can be set to provide a light detent at any position of the VOLUME control's rotation for conveniently returning to a previous setting. A small lever to the left of the VOLUME control can be used to reduce the volume by 20 dB for temporary interruptions or while lowering the pickup onto a record surface.

The input and output connectors are located on the rear apron of the amplifier. They include a DIN socket for duplicating the functions of the





TAPE 1 inputs and outputs. Insulated springloaded clips are used for the speaker system connectors. The preamplifier outputs and power amplifier inputs are brought out to separate jacks that are normally joined by jumper plugs.

The rear apron also has three accessory ac outlets on it. One of these is unswitched.

Laboratory Measurements. When we put the amplifier through its one-hour preconditioning period at 10 watts output power, it became quite warm. However, it displayed no signs of distress. Driving both channels into 8-ohm loads at 1000 Hz, the outputs clipped at 64.4 watts/channel. With 4- and 16-ohm loads, clipping occurred at 75.7 and 39 watts/channel, respectively. It is interesting to note that, when both pairs of speakers are driven simultaneously, they are connected in series so that the amplifier will never have to drive an impedance of less than 4 ohms even if two 4-ohm speaker systems are used.

The 1000-Hz THD, which was below the noise level at outputs of less than 1 watt, measured 0.024% at that level. It increased smoothly to 0.062% at the rated 30 watts and to 0.14% at 60 watts just before clipping occurred. The IM distortion was less than 0.02% at about 1 watt and rose to 0.11% at 30 watts and to 0.36% at 60 watts.

Clearly, Sony has very conservatively rated this amplifier. At the rated 30 watts/channel into 8-ohm loads, the THD was an almost constant 0.06% from 20 to 20,000 Hz. At lower power levels, it was also constant with frequency and measured slightly less than at full power.

The amplifier has a fast-acting relay that disconnects the speaker systems in the event of severe overdriving or an internal malfunction. We tripped it a number of times without causing any damage. The amplifier came on automatically a few seconds after the fault was removed. The relay also provides a turn-on time delay of 5 or 6 seconds to keep transients away from the speaker systems.

An input of 60 mV at the high-level input jacks or 1 mV at the phono jacks drove the amplifier to a reference 10-watt output. The respective noise levels measured −73 and −76 dB. The fact that the phono noise was actually less than the high-level noise probably reflects Sony's use of special low-noise transistors of the company's own design in the phono preamp section. The phono input overloaded at the very high input level of 380 mV.

The tone controls had a rather moderate range of ±10 dB at the frequency extremes, but the choice of turnover frequencies gives them better than average flexibility for a bass/treble configuration. The filters had gentle

6-dB/octave slopes with the −3-dB response points at 30 and 7500 Hz. The loudness compensation boosted the lows, and to a lesser degree the highs, at low volume settings. The RIAA phono equalization accuracy was within ±0.5 dB from 100 to 20,000 Hz. It rose to +1.5 dB between 20 and 40 Hz. The equalization was virtually unaffected by cartridge inductance since the equalization components are almost completely isolated from the phono circuits.

User Comment. The Model TA-4650 is a notable amplifier both for what it does and for what it does not do. First of all, it obviously has just about all of the operating versatility one could desire. Certainly, one could hardly ask for better electrical performance than our laboratory tests revealed. What this amplifier does *not* have (and in this respect, it lives up to the advance publicity for V-FET devices) is crossover distortion or any other higher-order harmonics in its output. At normal listening levels of up to 10 or 20 watts output, the distortion is almost pure second harmonic in nature, with a little third harmonic appearing at power levels above 30 watts.

If you are a true believer in the mystical properties of "vacuum-tube" sound, perhaps you will find the sound of this amplifier comparable to that of a very good tube-type amplifier. For our part, we see and hear it simply as a first-rate amplifier, devoid of any identifiable distortion or other sonic properties. It has no flaws or operating vices we could discover. Its sound quality is certainly as good as there is, and its construction is superior to most other amplifiers on the market.

Judging from the fairly warm idling temperature, the two V-FET devices in each channel operate at a relatively high quiescent current, which lets them avoid the problem of crossover distortion. The exceptional ruggedness and heat dissipation ability of the V-FET is obviously one of its strong points, and Sony has apparently made good use of these characteristics.

Whatever reason Sony might have had in rating this amplifier at 30 watts/channel, it is plain to us that it is really more appropriate to call it a 60-watt/channel amplifier. Therefore, it is certainly a lot of amplifier, even at its moderately high price.

CIRCLE NO. 65 ON FREE INFORMATION CARD

KOSS PHASE/2 + 2 QUADRAFONE 4-CHANNEL HEADPHONES

Unusual design, with programmer, provides variable listening characteristics.

Most 4-channel headphones have two drivers in each earcup, one located ahead of and the other behind the listener's ear. Sometimes the two drivers in each earcup have different response characteristics to help the listener to distinguish between the front and rear channel sounds. Unfortunately, most attempts at making true quadraphonic sounds in headphones have been unsuccessful, but a few notable exceptions have recently emerged. One is the new Koss Phase/2 + 2 Quadrafone, with phones and control box as part of an integrated system. It comes close to providing a relatively realistic 4-channel sound effect by employing a radically different design approach than is found in other quadraphonic phone systems, as will be described later.

The Koss phones are only slightly bulkier than stereo phones. This is due to the small size of the forward earcup extensions. The large areas of the ear cushions make these phones comfortable to wear for extended listening periods. The phones are designed to be driven from sources with impedance ratings between 3.2 and 600 ohms. They are also designed to produce a 90-dB sound-pressure level (SPL) with a 1-volt, 1000-Hz drive signal. The maximum input signal rating is 10 volts. When delivering a 100-dB SPL at 1000 Hz, the phones' THD (total harmonic distortion) is specified at less than 1%.

The Koss Phase/2 + 2 Quadrafone is list priced at $145.00, which includes the control box.

General Description. The front channels of the phones consist of 2" (5.1-cm) dynamic drivers that are positioned directly over the listener's ears. The rear-channel drivers are 1½" (3.8 cm) in diameter and are located in *front* of the drivers for the front channels, in forward extensions of the earcups.

The outsides of the molded plastic earcups are perforated to provide the correct loading to the rear of the drivers. The foam plastic ear cushions provide only slight isolation from outside sounds, giving these phones much of the "open" sound quality of good nonisolating phones.

The 4' (1.22-meter) cords from the earcups terminate in the small control box that comes with the phones. The box is about the size and shape of a pocket calculator. Exiting from the box is a 10' (3-meter) long coiled cord that goes to the front- and rear-channel phone plugs of an amplifier or receiver. The controller (Koss calls it a "Programmer") contains eight slide switches that permit the listener to alter the spatial and frequency response characteristics of the system over a wide range. There are, in fact, 127 different combinations of switch settings available.

Koss engineers have determined that much of the front-to-rear sound resolution of the human ear depends on the different characteristics of the sound arriving from two directions. (Don't confuse this with the more general concept of directional localization, which is the basis for the various 4-channel matrix systems.) Since the sound from the front carries the primary program information, the front drivers were placed where their full frequency range would be most effective—directly over the ears. Locating the rear-channel drivers behind the ears caused the listener's external earlobes to adversely affect the sound quality. So, putting the drivers forward of the ears and carefully tailoring their frequency response, the subjective effect of a sound source to the rear was achieved in the new phones.

The Programmer has a QUAD COMPARATOR switch whose CH4 position connects the drivers in the phones directly to the corresponding signal inputs. The other switch position, labelled ϕ 2 + 2, is intended primarily for synthesizing 4-channel effects from ordinary 2-channel stereo programs. It can also be used to modify 4-channel programs. In the ϕ 2 + 2 mode, two BINAURALATOR switches permit partial blending of the left and right signals, with independent control of the front and rear channels. A QUAD FIELD switch is provided for altering the relative contributions of the front and rear drivers to simulate a basically front-located source (2π) or a full surround sound (4π). Four AMBIENCE EXPANDER switches that can be used in either the CH4 or the ϕ 2 + 2 mode permit reversing the phase of each driver individually.

Laboratory Measurements. Our measurements of these phones were limited to evaluating their performance and to verifying the actual circuit functions of the Programmer switches. Using a Koss-designed coupler, we measured a frequency response of 20 to 20,000 Hz ±5 dB, with a slight dip at 2500 Hz. The rear drivers had a similar frequency response but with somewhat lower output level at frequencies above 5000 Hz. They also had a 6-dB rise at 300 Hz, with the curve exhibiting a rapid decline in output at lower frequencies. With a 3-volt drive signal applied, the front drivers generated between 90 and 100 dB SPL over most of the audio range.

The QUAD FIELD and BINAURALATOR switches had little effect on the frequency response, but they made a great difference in the sound. The phase reversal introduced by the AMBIENCE EXPANDER switches had the predictable effect of almost cancelling out the midrange sound in either earcup when its two drivers were operated out-of-phase with each other and had little effect at low frequencies, where the two drivers had dissimilar output levels.

The impedance of the phone system measured a constant 300 ohms. When the BINAURALATOR switch was set to the ϕ 2 + 2 mode, the impedance rose to 500 ohms. At a 100-dB SPL output and a test signal frequency of 1000 Hz, the THD from the front-channel drivers measured a mere 0.6%.

User Comment. These are very good headphones, with a quality —apart from any 4-channel considerations—that compares favorably with the best dynamic phones we have tested. Their smooth response, wide frequency range, and low distortion figures would earn them a place in the top ranks of headphones solely on the basis of listening quality. Their one major disadvantage is their high impedance, which precludes their use with most preamplifiers and tape decks. These phones must be driven from the outputs of a power amplifier. When we used a low-power receiver to drive them, we had to crank the volume up to near its maximum setting. Thus, we conclude that the driving amplifier should be capable of delivering some 30 or more watts per channel.

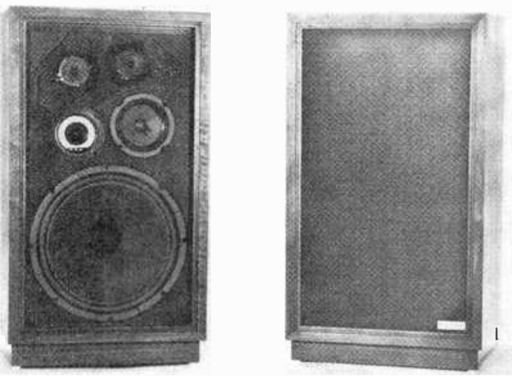
We listened to a number of CD-4 records that were chosen for their exaggerated separation and movement of sounds around the listener to judge just how discrete the sound would be from the phones. It was apparent that the front-to-rear directionality of the phones was not nearly as positive as that of the program itself. Although we were able to detect the difference between the front and rear sound, it was not always obvious which was which. However, most 4-channel programs (particularly from matrix-encoded discs) are not sharply directional. Consequently, when we listened to these records, we were very impressed with the spaciousness and "surround-sound" effect obtained. Better still, the phones delivered much the same effect with ordinary stereo programs. The effect was analogous to that obtained from the Dynaquad® and basic SQ and RM matrix decoders on stereo programs.

By and large, we feel that the subjective quadraphonic effect imparted by these phones was superior to that of a four-speaker system on the same program material—with a few exceptions. There was often little difference between the sounds of ϕ 2 + 2 enhanced stereo and discrete 4-channel programs. Both had the same sense of "liveliness" and ambience that, in our opinion, represent the most important contribution of quadraphonic sound to subjective realism. We must emphasize, however, that these phones (nor any other 4-channel phones) do not sound like a 4-speaker system, any more than stereo phones sound like a stereo speaker system setup.

The vast number of control switch combinations available on the Programmer invites the listener to try his hand at creating the sound that best suits his tastes. In this respect, the Programmer is more versatile than any other type of program modifier we have used. Not only can it shift the ambience characteristic, from a spacious to a constricted sound, but it can move instruments closer to and farther away from the listener, shift them around the listening area, and even make them disappear altogether.

AUDIOANALYST MODEL A-200X SPEAKER SYSTEM

Five drivers with switchable level adjustments.



HIRSCH-HOUCK LABS REPORT

The Model A-200X floor-standing, sealed-enclosure system is at the top of Audio Analyst's speaker system line. It contains five drivers: a 12" (30.5-cm) woofer, 5" (12.7-cm) midrange driver, 2" (5.1-cm) cone-type tweeter, and two 1½" (3.8-cm) cone-type tweeters.

The crossovers are at 800, 2000, and 7500 Hz, respectively. The pair of 1½" tweeters is angled for better dispersion than is usually the case in both the horizontal and vertical planes. System resonance is 46 Hz, while impedance is nominally 8 ohms.

Two toggle switches on the rear of the system's oiled-walnut cabinet permit separate level adjustments in the middle- and high-frequency ranges. The speaker system is recommended for use with amplifiers capable of delivering a minimum of 10 watts/channel of power. Consequently, this is a relatively high-efficiency acoustic-suspension speaker system. There is no need for protective fuses when the system is driven by medium- and high-power (up to 100 watts/channel) amplifiers.

Audioanalyst is one of the few speaker system manufacturers to supply a specific frequency response rating for its speaker systems. In the case of the Model A-200X, the response is stated at 38 to 20,000 Hz ±3 dB, with the bass response down 10 dB at 28 Hz in a free-air field, where it is not reinforced by room boundaries.

The system measures 27"H × 15"W × 12 3/4"D (69 × 38 × 32 cm) and weighs approximately 45 pounds (20.5 kg). Backed by a six-year warranty, it retails for $259.

Laboratory Measurements. We created a frequency-response curve by measuring the averaged smoothed output of the speaker system in a reverberant field (about 12', or some 3.7 m, from the system in a "live" room) at frequencies above a few hundred hertz. At the same time, we measured the woofer response with a microphone placed very close to this driver to eliminate room effects. Splicing together the two curves gave us a composite frequency response curve that closely matched Audioanalyst's specifications when we made allowances for the characteristics of our microphone and test room acoustics.

The bass response matched the rated free-field response almost exactly, with a drop to −10 dB at about 30 Hz. Except for a slight peak at 12,000 Hz (near our microphone resonance), the frequency response of the system was ±3 dB from 38 to 18,000 Hz, which is excellent for a live room measurement. This response was measured with both level switches in their up positions for maximum output, which corresponded to the flattest power response. The midrange switch was able to drop the output in the 800-to-2000-Hz range by a couple of decibels, while the tweeter switch reduced the output above 2000 Hz by about 5 dB.

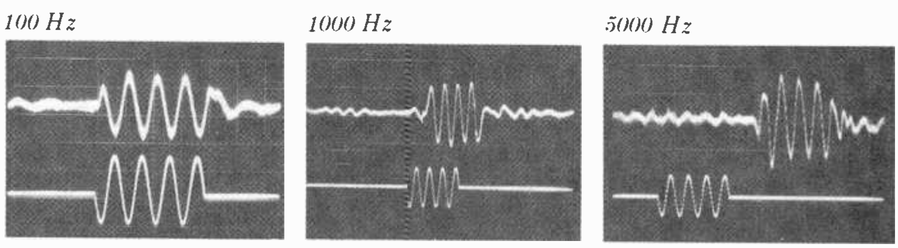
The low-frequency distortion, measured at a 1-watt input, was very low—less than 1% from 100 to below 50 Hz, and only 6% at 20 Hz. Increasing the drive to 10 watts had only a minor effect on distortion, which was about 2% down to 50 Hz and 9% at 20 Hz. The tone-burst response was good, exhibiting no signs of ringing or spurious outputs.

As claimed, the system's efficiency was relatively high. An input of 1 watt of random noise in the octave centered at 1000 Hz produced a 92-dB SPL at a distance of 1 meter. The system impedance measured 8 ohms or higher—and was 20 ohms at bass resonance—from 20 to 20,000 Hz with both rear-panel switches in their down positions. In their up positions, the impedance dropped above 3000 Hz, to a minimum of about 5 ohms at 13,000 Hz.

User Comment. As its wide, smooth frequency response and low distortion suggest, the Model A-200X is a very accurate, as well as a highly listenable, speaker system. We confirmed this by subjecting it to our "live-versus-recorded" listening test, which evaluates speaker system accuracy principally in the frequency range above a few hundred hertz. The Model A-200X proved to be one of the most accurate speaker systems we have ever tested in this manner, with essentially 100% perfect imitation of the "live" sound source. The only part of the test where a difference could be heard was in the reproduction of wire brush sounds that involve the highest audible frequencies. A boost of 2 or 3 dB in the 10,000-to-20,000-Hz range resulted in accurate reproduction of these sounds, which proved to be the nemesis of many other speaker systems we have tested.

When we listened to a variety of recorded music through the speaker

Tone-burst responses.



system, making side-by-side comparisons against other fine systems, the essential sound character of the Model A-200X became quite apparent. Because of its excellent overall balance, one is never aware that this is a four-way, five-driver speaker system. The sound is thoroughly integrated and dispersed, with no coloration over most of the audible range.

The chief difference between the Model A-200X and some systems to which we compared it was in bass response. Even with the speaker system in a free-standing position several feet from a room boundary, the deep bass could often be felt as well as heard.

In general, we would describe the sound of this speaker system as "warm," with a healthy but not excessive output from the lowest bass through the midrange. Since this was balanced nicely by the smooth output at higher frequencies, the system did not sound at all "bottom heavy," except possibly by comparison with some speaker systems that are less well endowed in the bass registers.

The Audioanalyst Model A-200X is priced to compete with some very fine speaker systems. Judging by its measured performance and audible listening quality, it should be a formidable competitor indeed.

CIRCLE NO. 67 ON FREE INFORMATION CARD

SBE "FORMULA D" TYPE 26 CB TRANSCEIVER

Mobile unit employs digital frequency synthesis to eliminate extra crystals.

THE USE of digital frequency synthesis appears to be the coming thing for multi-channel coverage in CB transceivers. Already, several CB rigs with digital frequency synthesis can be found on the market. One of these is the Linear Systems SBE "Formula D" Type 26 transceiver in which all 23 transmit and receive channels are controlled from a single crystal. This eliminates the need for as many as 14 crystals normally required in traditional CB synthesizers.

The Formula D is an AM transceiver designed for mobile operation. It can operate from any 11.7-to-15.9-volt, positive- or negative-ground mobile electrical system. Built in are reverse-polarity protection, voltage regulation, and line-filter circuits.

The transceiver measures 9 3/8"D × 6 3/4"W × 2 1/2"H (24 × 17 × 6.4 cm). Supplied with a microphone and mobile mounting hardware, it retails for $199.95.

The Receiver. Aside from the frequency synthesizer, the transceiver's design is quite straightforward. A double-conversion scheme is used in the receiver to derive 10.695-MHz and 455-kHz i-f's. The grounded-base r-f amplifier is diode protected, a dual-gate MOSFET is used as the first mixer. A 455-kHz ceramic filter, located ahead of the i-f stages, provides the selectivity. The voltage-doubling detector is followed by a switchable series-gate automatic noise limiter (anl), two audio stages, and a push-pull power output stage. Designed into the audio system is an a-f tone control.

Measurements indicated a high 0.3-μV receiver sensitivity for 10 dB (S + N)/N with 30% modulation at 1000 Hz. Image, i-f, spurious-response, and adjacent-channel rejection measured 90, 66, 46, and 50 dB, respectively.

The overall 6-dB audio response was from 275 to between 2600 and 4000 Hz, depending on the setting of the tone control. Audio output at the start of clipping measured 3 watts at 7% distortion with a 1000-Hz test signal and an 8-ohm load. A 0.5-μV r-f input signal produced full output, and the same full output was also available on PA. Two jacks are provided for external speakers.

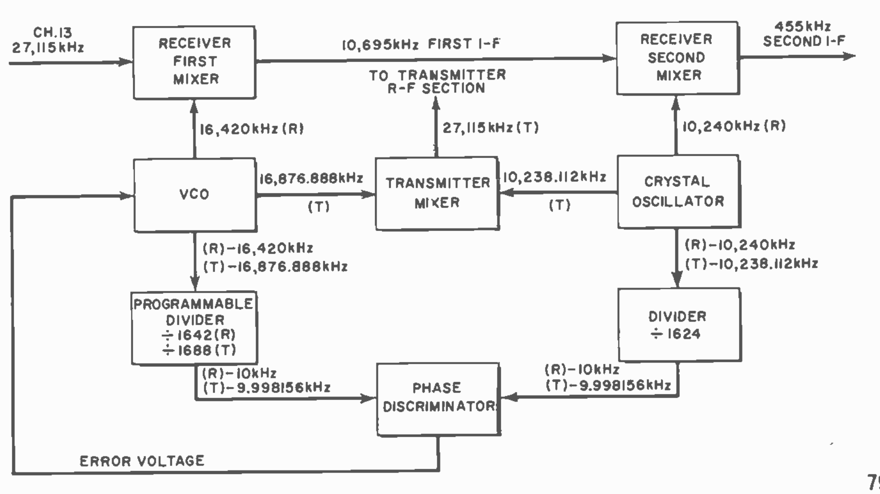
The voltage-doubling agc held the audio output to within 7 dB with a 20-dB r-f input change at 1 to 10 μV and to 3 dB with an input change of 60 dB at 10 to 10,000 μV. The S meter, which doubles as an r-f output indicator on transmit, indicated S9 with only 10 μV of input signal. The squelch system was adjustable for 0.3- to 1000-μV thresholds.

Frequency Synthesizer. The frequency synthesizer consists of digital-counter dividers and a crystal-controlled master clock oscillator that works with a phase-locked loop (PLL). Space does not permit a description of how the complex system functions; so, we will just cover what it does.

As shown in the diagram, the receiver heterodyning signals for the first conversion are obtained from a voltage-controlled oscillator (vco) operating in the range from 16,270 to 16,560 kHz. For example, the 27,115-kHz signal of channel 13 minus the vco frequency of 16,420 kHz yields a first i-f signal frequency of 10,695 kilohertz.

The second conversion is accomplished by using a 10,240-kHz crystal-controlled oscillator so that the 10,695-kHz first i-f minus the

Diagram shows how digital frequency synthesis works.



10,240-kHz oscillator signal yields a 455-kHz second i-f. This crystal signal is also divided by a factor of 1024 to produce a standard reference frequency of 10 kHz (10,240/1024 = 10 kilohertz).

In addition, the vco frequency is divided to a second 10-kHz comparison signal by a factor in the range between 1627 and 1656, depending on the channel in use. This is accomplished with the aid of a programmable divider by which the required division for a particular channel is obtained from the channel-selector switch. For example, 16,420 kHz, the frequency of the vco on channel 13, divided by 1642, the channel-13 divisor, equals 10 kHz.

The two 10-kHz signals are compared in a phase discriminator where any frequency or phase difference between them produces an error voltage that corrects the vco frequency in the direction that shifts its derived 10-kHz comparison signal until it is locked in phase with the standard reference. This places the vco on the proper heterodyning frequency for the specific channel.

Suppose that, when the selector switch is set for channel 13, the initial vco frequency is 16,424.926 kHz. Dividing this number by the channel-13 divisor of 1642 yields 10.003 kHz, or 3 Hz above the 10-kHz reference. This causes the error voltage at the discriminator that now shifts the vco frequency to the point where its frequency is divisible by 1642 to exactly 10 kHz (16,420 kHz). A phase-locked condition then takes place and holds the vco on-frequency.

On transmit, the vco and crystal oscillator signals are sum-mixed. For this to result in an on-channel carrier, the vco frequency must be increased by 455 kHz. To demonstrate, 16,420 kHz (vco frequency on channel 13) + 455 kHz = 16,875 kHz. Then 16,875 kHz + 10,240 kHz (crystal oscillator frequency) = 27,115 kHz on channel 13. It is readily apparent that there is no whole-number factor that will divide the new vco frequencies to yield exactly 10 kHz. Now, by shifting the crystal oscillator's frequency downward by 1.888 kHz—to 10,238.112 kHz—and again dividing by 1024, a new standard reference of 9.998156 kHz is obtained. Then, by allowing the new vco frequencies to increase an additional amount in the range of 1.861 to 1.914 kHz (according to the channel) and programming its divider for a factor in the range of 1646 to 1702, the vco comparison signal will also be 9.998156 kHz, again producing a phase-locked condition. In addition, the mixing sum of the vco and crystal oscillator signal frequencies will still come out to the channel frequency.

As a safety precaution, provisions are included for preventing out-of-lock operation. With channel 13 set "on the nose" (done during production by adjustment of the crystal oscillator), the accuracy of the other channels will progressively deviate by up to a maximum of +26 Hz on channel 1 to −27 Hz on channel 23 due to the added variations in the vco frequency required to produce the correct vco comparison signal for the particular channel.

These conditions were verified at an ambient temperature of 75° F. After the transceiver was operating for a while or at ambient temperatures in the 85° to 90° F range, the frequency on all channels decreased by 200 to 250 Hz, well within the legal tolerance.

The Transmitter. The carrier goes to two r-f amplifiers and the power amplifier. The latter has a double-pi output network for matching to 50-ohm loads. Included is a 54-MHz TVI trap. The last two stages are conventionally modulated by the receiver's audio output amplifier with automatic modulation control (amc).

The output power from the transmitter measured 4 watts, using a 13.8-volt dc power source. Modulation (producing a sine-wave signal) limited to 90% to 95% at 5% distortion with a 1000-Hz test signal. With a 6-dB increase in input signal level both positive *and* negative peaks limited with some clipping at the 100% points, with distortion at 10%. Adjacent-channel splatter was down 40 dB with a 2500-Hz test tone and down 50 dB with a 1000-Hz tone. The overall a-f response was nominally 275 to 7500 Hz.

User Comment. The Formula D transceiver's Delta tune system varies the crystal oscillator frequency on receive. The DELTA TUNE has a range of ±700 Hz, which is hardly enough to make any practical audible or visual difference in slightly off-frequency signals. The back-lighted r-f/S meter is a reasonably good size, but its calibrations are blue on a black background, making them a bit difficult to distinguish under some conditions. On the other hand, the red meter pointer shows up well against the dark background.

A DISTANCE/LOCAL switch on the transceiver allows the front-end gain to be reduced by almost 30 dB for strong-signal overload protection. When the anl is switched on, impulse noise 60 dB above 0.3 μV was attenuated to virtual inaudibility in the presence of the signal. We found it extremely effective in our exceptionally noisy test car.

The very high receiver sensitivity and the fine performance of the anl, coupled with the good audio response and the built-in loudspeaker characteristics that provide very good intelligibility, make this transceiver ideal for use in weak-signal areas and where electrical noise is a problem. In addition, the amc setup during voice modulation ensures a signal of high *average* power without undue splatter.

CIRCLE NO. 68 ON FREE INFORMATION CARD

B&K MODEL 520 TRANSISTOR TESTER

Tests and identifies devices in or out of circuit.

THERE are a great many in/out-of-circuit transistor testers on the market for troubleshooting modern solid-state equipment and devices. One of the best we have encountered is the latest B&K Model 250 transistor tester that sells for $150. Using either three clip leads or a front-panel transistor socket, this transistor tester can be used to determine if a transistor is good or bad, identify the device's basing, determine its composition (silicon or germanium) and its polarity (npn or pnp), and test for leakage.

The tester can also measure the I_{CES} and I_{BES} of bipolar transistors, the I_{DSS} and gate leakage of FET's, and the reverse current leakage of diodes. Furthermore, it can be used to determine if a device under test is bipolar, FET, or SCR. If this last feature does not appear to be much, keep in mind that package styling is similar among these types of semiconductors.

Using the Tester. Operation of the transistor tester is simplicity itself, owing to the fact that there are only two switches (and no controls) that need be touched. One switch is for identifying whether the semiconductor under test is silicon or germanium in its IDENTIFY position and to measure current leakage in its LEAKAGE position. The TEST switch is a six-position affair that is used to identify the device's basing.

In use, you simply connect the three color-coded test leads to the three leads of the semiconductor under test in any order whatever for in-circuit tests or plug the device into the front-panel socket for out-of-circuit tests. Then operate the large six-position TEST switch until the tester emits a loud audio tone. At this point, a front-panel LED will come on to identify the device type.

Once the semiconductor is identified according to type, you set the second switch to IDENTIFY whether it is silicon or germanium. Moving this switch to the LEAKAGE position gives a meter indication of the amount of leakage current in the device under test. The meter scale and ballistics are logarithmic so that leakage currents can be indicated over a range of 0.1 μA to 5 mA. The meter also indicates the limits for silicon signal and power and germanium signal and power transistors so that you can see at a glance if the indicated leakage is within tolerance for that particular device.

Unlike other transistor testers, the Model 520 uses an exclusive high-current, low-duty-cycle (5%) pulse technique to make its test. For a good/bad test, the limiting values connected to the device under test is greater than 10 ohms, while the capacitance is up to 5 μF for low-beta and 15 μF for high-beta transistors.

The Model 520 is housed in an attractive metal cabinet that measures 8″W × 7″H × 3½″D (20 × 18 × 9 cm). The instrument weighs 5 pounds (2.3 kg). Rubber feet are attached to the housing for upright use, while a handle/tilt stand can be used on the bench. The color coding is clear and unambiguous. A yellow LED is used for silicon and a green LED for germanium device types. A pair of red LED's are used as NPN and PNP indicators. The B/C/E indicators on the TEST switch are brightly colored and keyed to the coding of the test clips.

User Comment. During a period of several weeks on our workbench, we used the Model 520 to test a number of densely packed printed circuit board assemblies. In an A/B comparison between a run-of-the-mill in/out-of-circuit tester and the Model 520, we noted quite a difference in setup and operation. With the B&K tester, there was no need to properly orient the test leads, and the loud "beep" we heard as we hit the correct lead basing left no doubt about the connections.

With both testers, we were able to isolate bad transistors from the good ones on the pc assemblies and to identify silicon and germanium devices according to whether they were npn or pnp transistors. The Model 520, however, also uncovered a leaky transistor that our other tester failed to catch. Our other tester could not check out FET's, which the B&K tester can.

CIRCLE NO. 69 ON FREE INFORMATION CARD

Solid State

By Lou Garner

THE GOODFLASHER—PART II

WHEN a motion picture is a box-office smash, there's a fine opportuntiy for a sequel. For example, the resounding success of "The Godfather" resulted in "The Godfather, Part II." But, whereas a few motion picture sequels are planned before the initial film is released, I truly planned—and promised—to present additional applications for the amazingly versatile LM3909 LED flasher/oscillator first discussed in this column last July. (That was a smash hit!)

In fulfillment of that promise, "Solid-State Productions" proudly presents another super-colossal epic in breathtaking black and white: "Goodflasher, Part II," starring LM3909. As customary in Show Biz, credits are in order. I am indebted to Mr. Peter Lefferts, an engineer with the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051), who designed, bench-tested and contributed the circuits shown in Figs. 1 through 4.

The LM3909, you may recall, is a monolithic oscillator specifically designed to flash light emitting diodes. Consisting of one pnp double collector and three npn transistors, a zener diode, and nine resistors, the device is packaged in an 8-lead plastic mini-DIP. With a maximum power dissipation rating of 500 mW and a maximum supply rating of 6.4 volts, the LM3909 can deliver current pulses of up to 200 mA. It is available through franchised National Semiconductor electronic components distributors and from some mail order supply houses.

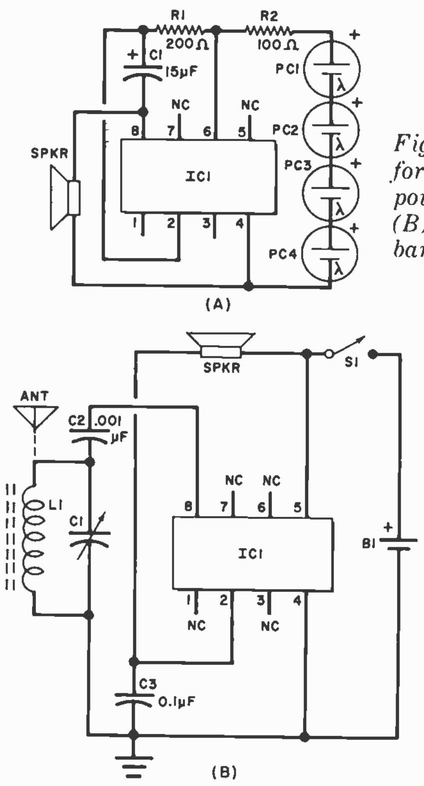


Fig. 1. Applications for LM3909: (A) solar powered oscillator; (B) AM broadcast band receiver.

Designed to demonstrate the LM3909's high efficiency and low power requirements, the solar powered oscillator circuit in Fig. 1A may be used as part of a science fair display, as an interesting lab experiment, or simply as a "fun" project. In direct sunlight, the oscillator will deliver a piercing screech, while average daylight will produce a more moderate tone. A low buzz is emitted when the circuit is activated by a 75-watt incandescent bulb placed two or three feet from the solar-cell power supply. With practice, one may be able to "guesstimate" light intensity by the tone of the output signal.

In addition to the LM3909 (*IC1*), the circuit requires two ¼- or ½-watt resistors (*R1* and *R2*) and a low-voltage, 15-μF electrolytic capacitor (*C1*). The output device is a standard PM loudspeaker with a 25-ohm (or more) voice coil, while the power supply consists of four to six single-junction silicon solar cells (*PC1* to *PC4*), connected in series.

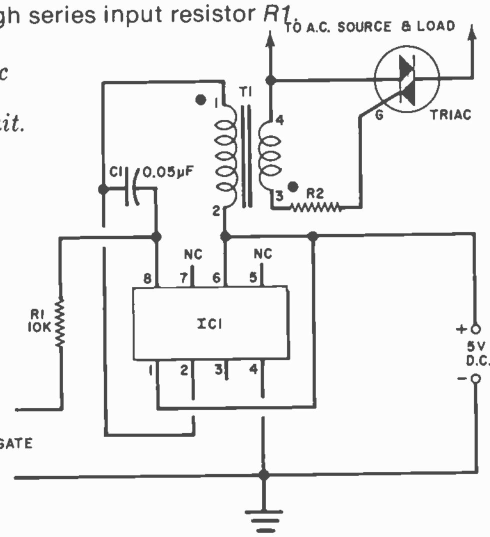
A simple AM broadcast band receiver circuit featuring the LM3909 is illustrated in Fig. 1B. Here, the IC serves as a detector/amplifier rather than in its customary role as a pulse oscillator. Suitable for listening to stronger local stations, the receiver has better sensitivity and greater power output than conventional crystal sets but, of course, can not be compared to multistage superheterodyne designs. It is an excellent project for the novice, however, who has tried crystal and one or two transistor circuits and wants to experiment with IC devices.

Operating power is supplied by a single penlight or flashlight cell (*B1*), controlled by a spst toggle, slide, or rotary switch (*S1*). The PM loudspeaker should have a 40-ohm (or better) voice coil. (If you have trouble finding one, use a 4- or 8-ohm coil and a step-down impedance transformer.) Capacitors *C2* and *C3* may be ceramics, plastic film, or tubular paper types. The single tuned circuit consists of a standard ferrite core broadcast band antenna coil (*L1*) and a matching variable capacitor (*C1*).

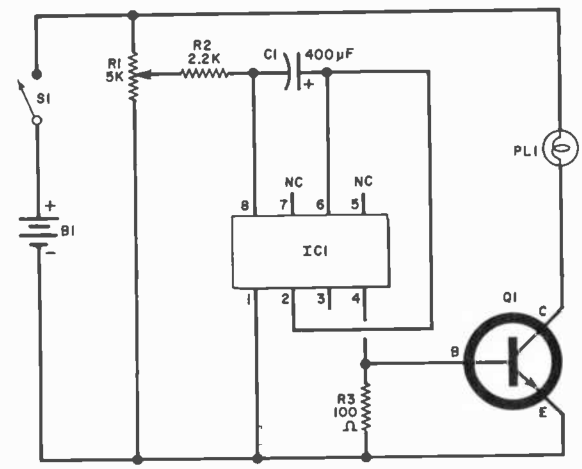
If desired, a short antenna can be connected to the "high" end of the coil, as shown. Overall sensitivity and selectivity will be improved with a longer antenna, but this should be connected to a tap near *L1*'s "cold" (ground) terminal. If the coil used does not have a separate antenna tap, simply wind a few turns of fine-gauge enamelled wire around the lower end of the coil, attaching one end to ground and the other to the long antenna.

Requiring fewer components than an equivalent UJT configuration, the triac trigger circuit illustrated in Fig. 2A is designed as an interface between TTL logic circuitry and a power triac. The circuit delivers a train of 7-kHz, high-current pulses to the triac's gate through isolation transformer *T1* when its input is driven "low" by a lightly loaded TTL gate through series input resistor *R1*.

Fig. 2. (A) Triac trigger and (B) ministrobe circuit.



(A)



(B)

Other than the LM3909 (*IC1*), the circuit requires a standard pulse transformer, *T1* (Sprague 11Z2003), a small 0.05-µF ceramic or plastic film capacitor (*C1*) and a ½-watt resistor (*R1*) at 10,000 ohms or less. A ½-watt gate current limiting resistor (*R2*) will be needed for low-to-medium-power triacs, with its value determined by the device's maximum gate current specification. If a high-power triac capable of handling a 200-mA gate current is used, *R2* will be 1 ohm or less (or can be omitted). As indicated, the circuit is designed for operation on a standard 5-volt dc supply.

Battery operated and thus shockfree, the mini-strobe circuit given in Fig. 2B is ideal for a youngster's toy, but also could be used for advertising displays or caution and warning signal applications. With an effective flashing rate of up to 7 Hz, the unit can provide a strobelike "flicker" effect in a darkened room. The rate control, *R1*, has a range from "off" to beyond the response time of the incandescent lamp bulb, *PL1*, causing it to appear "on" continuously.

For optimum results, the lamp, a type 1767 bulb (chosen for its rapid response characteristic), should be provided with a reflector. Control *R1* is a 5,000-ohm linear potentiometer. Timing capacitor C1 is a 3-volt electrolytic. The lamp driver (*Q1*) is a National Semiconductor type U01 npn transistor or similar general-purpose device. Operating

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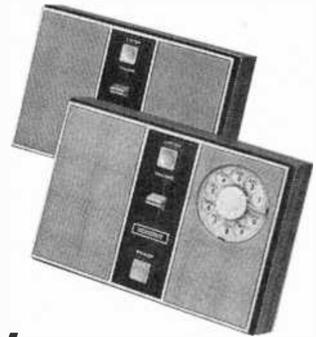

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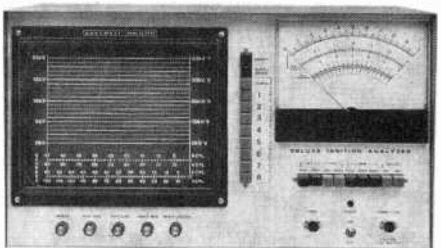

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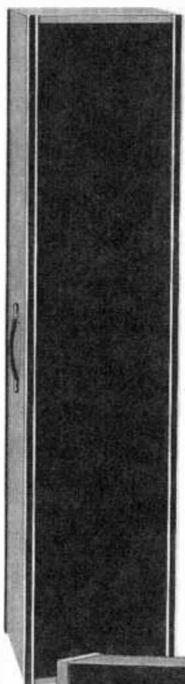

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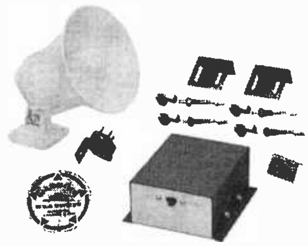

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Unique. Two big, bright digits show wind speed to 99 mph. As you build, choose 2 readout modes: miles, knots, or kilometers per hour; front panel light shows mode in use. 8 incandescent lights show wind direction at principal compass points; adjacent lighted bulbs give 16 point resolution. Remote transmitter boom clamps to TV mast. Styled in black plastic to match Heathkit GC-1005 Digital Clock and ID-1390A Digital Thermometer. Kit ID-1590, $69.95 less cable.

power is supplied by two series-connected flashlight cells, B1, furnishing 3 volts, controlled by *S1*.

Delivering a rapidly rising wail when activated, followed by a slower "coasting down" when its control button is released, the fire siren shown in Fig. 3A may be used in toys or as a sound effects generator. As in the previous circuits, the active device is an LM3909. The capacitors are low-voltage electrolytics. A momentary contact, NO, spst pushbutton type is used as the control switch, *S2*. A single flashlight cell (*B1*) serves as the power source. The PM loudspeaker should have at least a 25-ohm voice coil. If the operator prefers that the output tone stop sometime after the pushbutton is released, an 18,000-ohm, ½-watt resistor should be connected between IC pins 6 and 8.

A whooper siren circuit is illustrated in Fig. 3B. Generating a sound similar to that of the electronic sirens used on many ambulances, police cars and rescue trucks, the design employs a pair of LM3909's. In operation, *IC1* produces a high-pitched signal which is modulated at a low rate by a sawtooth waveform developed by *IC2*. Again, a high-impedance (25-ohm or more) loudspeaker (or transformer) is used. The capacitors are low-voltage electrolytics, and a single flashlight cell serves as the power source. Diode *D1* is type 1N4002. Since this circuit provides continuous operation, a single control switch is adequate.

Suitable for operation at distances of up to 200 feet when used with standard 22-gauge intercom or hookup wire, the dual-station code practice set shown in Fig. 4A is a dandy project for beginners or even for old-timers wishing to improve their skills at "pounding the brass." The two units may be operated room-to-room, room-to-garage or basement, apartment-to-apartment, or even house-to-house in some suburban areas. In addition to its obvious application for code practice, the system could be used in lieu of an intercom for simple communication by means of a pre-established private code. For example, one short buzz could mean "dinner's ready," a long and short "you're wanted on the phone," and so on.

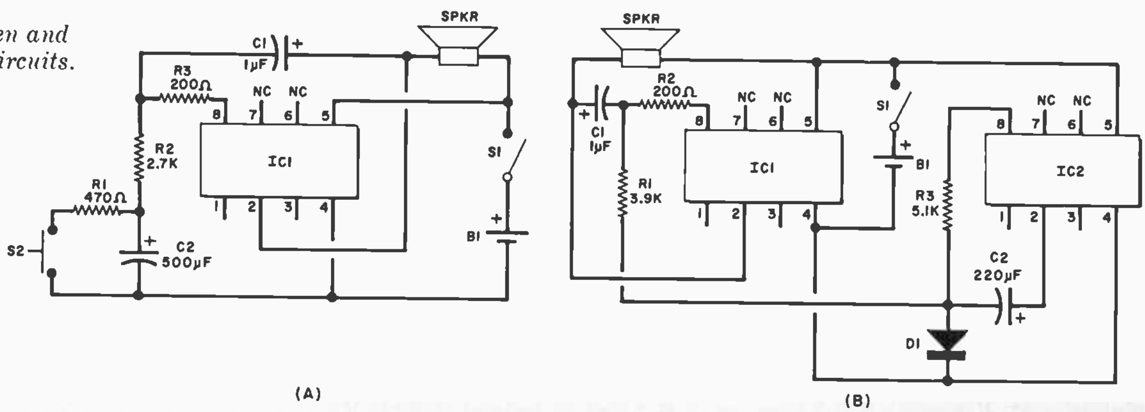
In operation, the LM3909 serves as a simple relaxation oscillator to drive both loudspeakers, which are effectively in series. Its normal narrow pulse output is modified by series resistor *R2*, lengthening capacitor *C1*'s discharge time and developing a rectangular waveform.

With the two loudspeaker voice coils in series electrically, inexpensive 8-ohm types may be used in this application. The capacitor is a low-voltage electrolytic. Either a penlight or flashlight cell may be used as the power source. On-off switch S1 is optional, for the battery drain is virtually nil until one of the handkeys is closed.

For maximum audio output at minimum current drain, the entire system can be operated in a resonant mode. This may be accomplished by adjusting both the oscillator output frequency and the acoustic characteristics of the enclosures (or cases) to match the natural resonant frequencies of the loudspeakers. The oscillator output frequency may be changed by selecting different values for timing capacitor *C1*. The acoustic characteristics of the cases may be modified by adding additional holes (other than the openings for the speaker grill). Both hole size and capacitor value must be determined experimentally for maximum output and stability.

Another interesting linear application for the LM3909 is given in Fig. 4B—a low power unidirectional intercom or "remote listener." Here, the device serves as a simple audio amplifier between a remote microphone and a local loudspeaker. Although the circuit's overall gain and audio output are relatively low, so is the power drain, assuring long battery life, even under continuous operating conditions.

Fig. 3. (A) Fire siren and (B) whooper siren circuits.



Referring to the schematic, the remote microphone consists of a 3.2-ohm PM loudspeaker and a 3.2-ohm-to-15K matching transformer, *T1*. This can be a small tube-type output transformer used "in reverse." The microphone assembly is connected to the amplifier, *IC1*, through a standard twisted pair up to 50-feet in length. The local loudspeaker should have a high impedance (40-ohm) voice coil (or use a transformer). Capacitors *C1* and *C2* are small ceramic or plastic film types. Operating power is supplied by a single flashlight cell, *B1*.

The additional circuits we've reviewed (Figs. 1 through 4) will hopefully spark *your* imagination, leading to even more exciting applications in the future.

Reader's Circuit. In a letter commenting on the LED flasher circuits discussed in a previous column, reader Edwin C. Hadden (Oakland Park, FL) asks if I know of a circuit capable of flashing two LED's at *different* rates.

A suitable circuit is illustrated in Fig. 5. Featuring discrete devices, this design was developed several years ago, long before inexpensive timer and flasher IC's, such as the 555, 556, and LM3909, were introduced. Despite the limitations imposed by its early design, the circuit requires but four transistors, four resistors, and two capacitors in addition to its dc power source, yet is capable of flashing two LED's at widely different rates and includes an optional circuit interlock.

Transistors *Q1* and *Q2* form a complementary relaxation oscillator, with *LED1* serving as *Q2*'s collector load and capacitor *C1* providing the feedback needed to start and sustain oscillation. The circuit's operating rate (frequency) depends upon a number of factors, including the dc source voltage and individual transistor characteristics, but principally upon the *R1-C1* time constant. Similarly, *Q3* and *Q4* form a second complementary relaxation oscillator, with feedback provided by *C2*, and *LED2* serving as *Q3*'s collector load. Operating power is furnished by a common dc source, *B1*, controlled by *S1*. Series resistor *R3* serves a dual role, acting to limit current and thus to protect the LED's. It also introduces a common source impedance to "interlock" the two complementary oscillators.

Different flashing rates for the two LED's may be achieved simply by establishing different operating frequencies for the complementary oscillators, using different values for either the feedback capacitors (*C1* and *C2*) or the corresponding base bias resistors (*R1* and *R4*). If a variable flashing rate is needed, either base bias resistor can be replaced with a fixed resistor in series with a suitable potentiometer. Typically, *R1* could be replaced by a 100K resistor in series with a 500K potentiometer.

The circuit interlock feature provided by *R3* is most effective when one

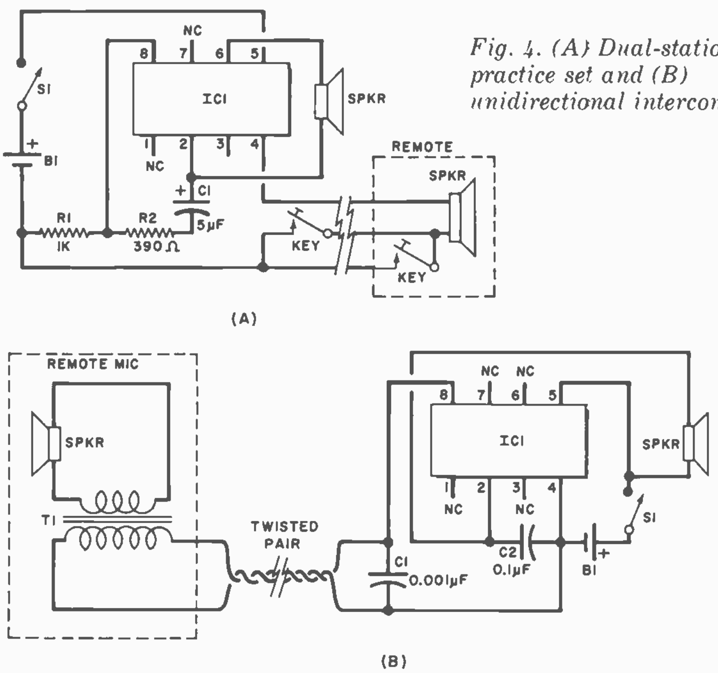


Fig. 4. (A) Dual-station code practice set and (B) unidirectional intercom circuit.

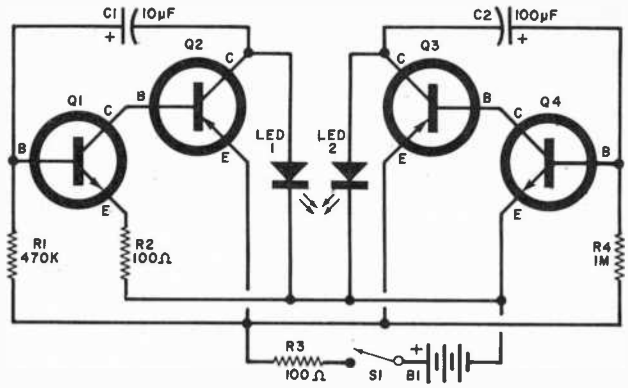


Fig. 5. Simple double-flasher circuit design.

LED is flashed at a rate which is a multiple of the other. With the values specified in Fig. 5, *LED1* is flashed at (approximately) a 1-Hz rate. Then *LED2* flashes at a 0.1-Hz rate—once in ten seconds. If the interlock feature is not needed, *R3* may be omitted, but fixed small resistors should be connected in series with each LED to limit their respective maximum currents.

While the design is not overly critical, best results are obtained when low-leakage, moderate- to high-gain transistors are used. Small-signal (low-power) types are adequate. In the original model, the npn types, *Q1* and *Q4*, were similar to type 2N170, while the pnp devices, *Q2* and *Q3*, were equivalent to the 2N109. Both LED's were type MV50. The two capacitors were 10-volt electrolytics. A standard 9-volt transistor battery was used.

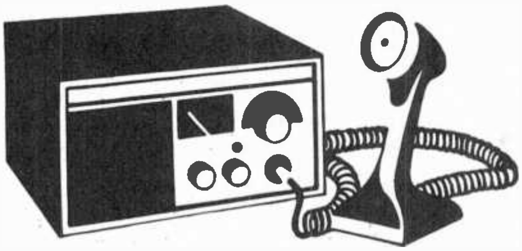
The double-flasher circuit may be assembled using perf board, point-to-point wiring, or a suitably designed PC board, as preferred, for neither layout nor lead dress are critical. However, some experimentation with component values may be needed to achieve optimum performance and to establish desired flashing rates due to component tolerances and differences in transistor characteristics.

Device/Product News. RCA's Solid State Division (Box 3200, Somerville, NJ 08876) has introduced a number of new IC's which are said to offer the performance and reliability characteristics of hermetically sealed devices in low-cost plastic packages. Identified by a "G" suffix, a number of standard circuits are now available in the new "hermetic-in-plastic" packages, including the CA741CG and CA747G op amps, the CA324G quad op amp, the CA339G quad voltage comparator, and the CA3724G and CA3725G high-current npn transistor arrays.

Also from RCA comes news of substantial price reductions of from 15 to 40 percent on over 100 types of IC's in the firm's extensive COS/MOS line and the addition of 30 new modules, IC's and power devices to the popular "SK" general replacement line. The new "SK" devices include four hi-fi audio modules ranging from 10 to 20 watts, a Darlington preamp, some 16 linear IC's designed for AM and FM radio, stereo, and TV receiver applications, power transistors, op amps, and SCR's.

A family of solid-state current sensors designed to protect highly sensitive electronic equipment against over-current conditions has been announced by the Micro Switch division of Honeywell (11 W. Spring St., Freeport, IL 61032). Designated type ES, the devices use coils which have resistances of a few milliohms to operate Hall-effect sensors. The solid-state sensor is triggered when coil current exceeds a specified level in the 1-to-3 amp range, producing a logic-level digital output signal which, in turn, can be used to actuate "crowbar" circuits or other protective devices. The sensors are designed to respond to over-current conditions in approximately 100 µs, independently of ambient temperature conditions and pre-existing current levels.

Suitable for use in a variety of timing, control and logic applications, a new series of pulse generator modules has been introduced by the Engineered Components Company (3580 Sacramento Drive, San Luis Obispo, CA 93401). Designed to provide precise output pulse widths when triggered by variable width inputs, the new devices are supplied in standard 16-pin DIP's. Twelve models are available, supplying output pulse widths from 5 ns to 100 ns at maximum pulse rates of from 100 MHz (for the 5-ns version) to 5 MHz (for the 100-ns model). All twelve devices operate on a standard 5-volt dc power supply. ◈



CB Scene

By Len Buckwalter, K1ODH

HARMONIC TV INTERFERENCE

In a previous column, we dealt with a type of television interference called "fundamental blocking." This time, let's look at another source of TVI—"harmonic interference."

All efficient transmitters produce harmonics, which are signals at integral multiples of the desired or "fundamental" frequency. Thus CB rigs, which have a fundamental of 27 MHz, also produce energy at 54 MHz, 81 MHz, 108 MHz, etc. — the second, third and fourth harmonics.

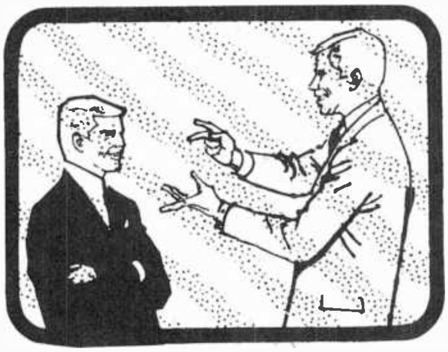


Fig. 1. Cross-hatch interference.

Harmonics are a problem because they become interfering signals on frequencies which are used by other services. For example, CB's second harmonic (54 MHz) could affect the picture carrier of television's channel 2 whose video information starts at 54 MHz. The third harmonic (81 MHz) could zonk the upper end of channel 5, which occupies the frequencies between 76 and 82 MHz.

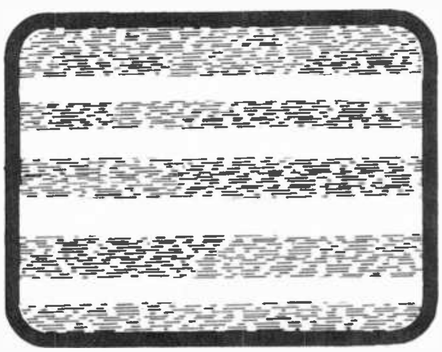


Fig. 2. Sound-bar interference.

TV isn't the only service susceptible to harmonic interference from CB transmissions. The fourth harmonic on 108 MHz elbows into the top of the FM broadcast band. Although CB signals use amplitude modulation (to which FM receivers are immune), it's still possible for your voice to be heard on the FM sound systems of both TV and radio receivers through "incidental rectification."

CB's fifth and sixth harmonics fall on 135 and 162 MHz, which are not allocated to TV stations. However, these frequencies are assigned to commercial and government two-way radio services, which should not be interfered with. Further, the seventh and eighth CB harmonics—on 189 MHz and 216 MHz—are potential causes of TVI because they fall within channels 9 and 13.

The biggest source of TV interference, however, is the second harmonic, followed by the third. This is so because the power of a harmonic falls rapidly as its frequency grows higher, and the effects of higher-order harmonics are negligible unless a receiver is extremely close to the CB set.

There are several clues to look for if you suspect TVI is caused by harmonics. They are easy to examine, thanks to the greatest test instrument since the oscilloscope—the TV screen—which, after all, is an oscilloscope of sorts. The most effective

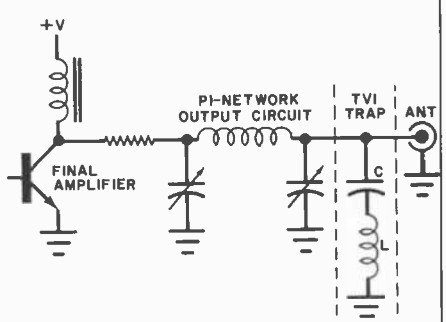


Fig. 3. An LC series wavetrap.

way of identifying harmonic interference is to note which channels are affected. Only those channels which have a harmonic relationship to the Citizens Band could present problems. If ALL the channels, or one not harmonically related to 27 MHz, show symptoms of TVI, the problem lies elsewhere (most likely in the TV receiver itself). Because the second harmonic falls on 54 MHz, and is the most powerful multiple, TV channel 2 is the one most commonly affected.

Another important sign is the visual pattern of the interference. If the harmonic is potent and the TV receiver and the transmitter are very close, complete picture "blackout" may occur. Weaker harmonics might cause the picture to be broken up, leaving a jumble of light and dark lines, or cause a "negative" (light and dark areas reversed) to appear. More often though, "cross-hatching" —diagonal bars or lines in the picture—is experienced (Fig. 1). This pattern is caused by heterodyning between the harmonic frequency and the carrier picture frequency. They are wide and few in number if the frequency difference is small, and very fine and plentiful if the harmonic and video carrier are farther apart.

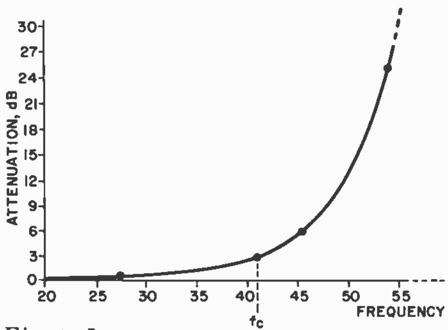


Fig. 4. Low-pass filter response.

Harmonics can also cause "modulation bars" or "sound bars," a series of dark and light horizontal bands across the screen that step with the syllabic rate of the CB'er's voice. (Fig.2). It's possible that sound bars may appear when the carrier is modulated even if no cross-hatching is produced by a "dead" carrier.

While it is sometimes possible to treat an individual receiver to eliminate the harmonic-caused interference, this is *not* the course to take. You are merely treating an isolated symptom, and not the source of the disease—the *transmitter*. The FCC clearly specifies that a transmitter output should be as "clean" of harmonics as possible. The minimum figure to shoot for is 50 dB below power output. In this case, the 4-watt output from a CB transceiver should contain no more than 40 microwatts of harmonic energy.

Harmonic Suppression. There are several ways to obtain a high degree of harmonic suppression.

First, manufacturers usually provide an internal trap tuned to 54 MHz to cope with the second harmonic. As shown in Figure 3, it's an LC series trap across the r-f output. The trap offers very low impedance to any 54-MHz output and, in effect, short-circuits them to ground. The fundamental on 27 MHz is virtually unaffected.

If you're causing TVI on channel 2, the trap could be misadjusted or defective. Check your owner's manual—some manufacturers give a standard procedure for tuning the trap. One technique is to watch the interference on a TV set tuned to channel 2 close to the CB rig. As you tune through an access hole on the chassis, adjust the trap for minimum interference to the picture. Some traps use a coil slug which should be adjusted with a plastic tuning tool. Others have a trimmer capacitor that should be tuned with an insulated screwdriver.

The FCC, incidentally, refers to this procedure in its regulations. They state that brief transmissions can be made (with the antenna connected), "when necessary for the detection, measurement, and suppression of harmonics. . . Test transmissions using a radiating antenna shall not exceed a total of 1 minute during any 5-minute period . . ." That's time enough to tweak a tuning trap.

A series-tuned trap can only handle one harmonic, the one to which it is tuned. There's another, more flexible approach — an outboard low-pass filter.

Low pass filters as the name implies, are designed to allow all energy below the "cut-off" frequency to flow unimpeded, while frequencies above that frequency are not allowed to pass. Low-pass filters for CB should have a cut-off frequency of about 43 MHz, leaving the CB signal virtually unaffected. The insertion loss, or the amount of desired signal lost in the filter, is often below 0.5 dB (which is negligible).

As we move farther above cut-off, higher frequency signals have an even more difficult route through the filter. A typical low-pass filter has a frequency response shown in Figure 4. Note that the cut-off frequency (f_c), at which the amplitude is reduced by 3 dB (one-half), is 41 MHz. A signal on 54 MHz, on the other hand, is attenuated by a whopping 25 dB to 3/1000 of its original strength). Add that to the harmonic suppression provided internally by the CB manufacturer and almost all interference will vanish.

Making Filters. Low-pass filters can either be made at home or bought assembled. There are a large number of commercially available models. They are rather simple, though, and the schematic of a good one is shown in Figure 5. All capacitors (use 100 and 70 pF in parallel to get 170 pF) should be 500-V silver mica components. Given in the schematic are the number of turns for each coil. Wind them with 12 or 14 gauge wire on half-inch (1.3-cm) ID forms, at 8 turns per inch. The dashed lines are metal shields. The entire assembly can be mounted in a 6" × 4" × 2" (15.2 × 10.2 ×5.1 cm) enclosure.

The low-pass filter that you install (whether home-made or a commercial unit) should be inserted in the line close to the transceiver output via a

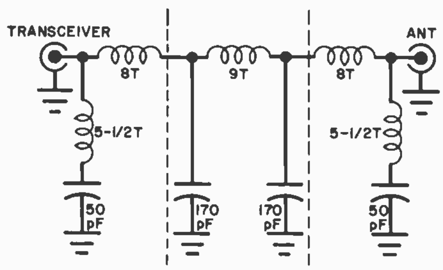


Fig. 5. Typical low-pass filter.

short coaxial jumper. Then connect the antenna feedline to the ANT jack on the filter. Bond the chassis to a good earth ground.

Another solution to the harmonic problem is to use an antenna matchbox. These devices, while designed to provide the correct output impedance for the transceiver, also add a degree of selectivity and harmonic suppression. In fact, a well-designed antenna-matching network can attenuate the harmonics by as much as 40 or 50 dB—all by itself! In many cases, they will clear up the interference, with the added bonus of allowing the final to work into a purely resistive load—the preferred order of things. ◈

Amateur Radio

By Herbert S. Brier, W9EGQ

MORE ON RESTRUCTURING LICENSING

THE COMMENTS and counter proposals made by the American Radio Relay League, Inc. (ARRL) in response to the proposals of the Federal Communications Commission Docket No. 20282 (issuing a new no-code vhf amateur license and reshaping the entire amateur license structure) turned out to be as surprising as the FCC proposals. The ARRL approved of the new vhf license to authorize phone and code operation on 145 to 145.5 MHz and 222 to 225 MHZ with a maximum transmitter power input of 50 watts and a license term of five years. However, it could not quite bring itself to vote for the complete elimination of the code test. Instead, it recommended that applicants for the new license be required to identify the code characters with no speed requirement and to pass the standard Novice written examination.

ARRL also recommended that Novice licensees be given the new vhf privileges in addition to their lower-frequency code privileges. The Novice requirements would still include a 5-wpm code test and an elementary written examination. The FCC and ARRL agree that the vhf and Novice exams should be supervised by two volunteer examiners and that their privileges should be renewable. But that is about as far as their agreement goes.

ARRL wants Technician licensees to enjoy all amateur privileges above 29 MHz and Novice privileges below 29 MHZ. The FCC goes along with the Novice privileges but wants a new Experimenter's license which would grant all vhf/uhf privileges. ARRL wants the General class requirements reduced from 13 wpm to 10 wpm and a 15-wpm code test added to the Advanced class exam for future licensees. It wants the General, Advanced, and Extra class privileges to remain essentially unchanged, however. In contrast, the FCC would leave the code tests for the General and Advanced licenses unchanged, but cut their privileges off at 29 MHz for new licensees.

The ARRL and the FCC differ even more widely in their proposed treatment of Conditional and "by-mail" Technician class licensees. The ARRL proposes to freeze them into their present status. The FCC proposes that, except for the physically handicapped, they would be required to pass an appropriate examination before an FCC representative to renew their privileges. I personally feel the FCC proposal is too harsh; while the ARRL proposal would perpetuate privileges that some acquired by chicanery. A more just approach would be that all (except the physically handicapped) who hold conditional-type licenses when the new regulations go into effect shall have five years to pass the new examination. They would not be deemed to have failed it, however, even if they have failed to achieve a passing grade in one or more attempts, until the grace period expires. At that time, their privileges would be reduced one grade. I also oppose any code test for the new vhf license and recommend that its written examination be concerned solely with amateur regulations and operating procedures.

What Next? Optimists are hoping that the FCC will wade through the many, many comments it received on these matters and come up with a series of decisions before the end of 1975. If this happens, it will be months after that before the new regulations can be implemented; but it is not too soon now for prospective new licensees and the amateur world to make preparations. The Chicago FM Club (WR9ABY), for example, is actively working on a new repeater to be located in the new 222-MHz sub-band; so that the newcomers will be able to

use it. Based on the performance of the existing repeater, of which the new one will be a copy, 25-watt mobile stations within a radius of 25 miles of the repeater will be able to work each other with "solid" signals. Therefore, mobile stations on opposite sides of Chicago, 50 miles apart, will be able to communicate with each other easily.

Until the scope of the new vhf examination is announced, it is difficult to tell a prospective licensee exactly what to study. If ARRL's suggestion prevails, however, the written test will be the same for the Novice license. It certainly will not be more comprehensive. If one studies for a Novice license and learns the code at 5 wpm, he will be ahead of the game when the regulations do come into effect.

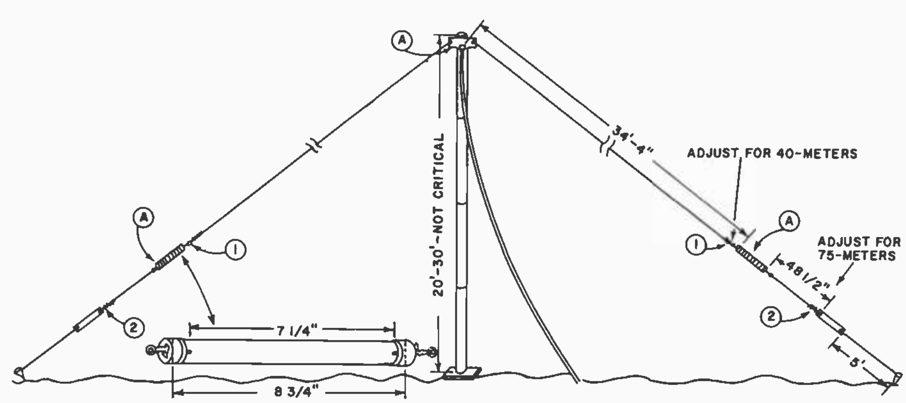
New Study Guide. The spiral-bound *From 5 Watts to 1000 Watts,* a new programmed course in amateur radio recently introduced by Radio Shack, will be useful to a person with no knowledge of electronics who wants to pass a Technician or General class written examination. The book provides the neophyte with an understanding of resistance, conductance, Ohm's Law, horizontal and vertical antennas, capacitance, inductance, frequency, transistors, vacuum tubes, etc. The components are identified by photographs, and their schematic symbols. Their functions are explained with the aid of drawings and schematic diagrams. While *5 Watts to 1000 Watts* is not the equivalent of a full-fledged electronics course, diligent study of it will make it easy to pass the Novice class written test and take the student a long way toward passing the Technician/General written test. For those who are not necessarily studying for an amateur license test, the book might be a good investment if they are a little hazy on some of the fundamentals.

Compact 80/40-Meter Inverted V. The antenna shown in the diagram is for the 80- and 40-meter bands. It is only 10 feet (30.15 m) longer than a conventional 40-meter dipole, but gives good 2-band coverage. The dimensions were suggested by Art Smith, W6INI. The coils at A are made of #18 wire wound on 1.125" (2.86-cm) OD PVC pipe forms. Cut two 8 3/4" (22.22-cm) pieces of the pipe for the forms and drill two rows of three #42 holes 7¼" (18.42 cm) apart in each. Measure two 50′ (15.24-m) lengths of the #18 wire for the coils.

Thread one end of one length of wire through one of the rows of holes in one form, allowing 1½" (3.8 cm) of wire to protrude from the form. Close-wind the wire on the form and thread the remaining end through the holes at the other end of the form. Mount a #10 brass or stainless steel eye bolt in each of two PVC pipe caps used to cover the ends of the form. Then insert a #10 solder lug under each outside nut. Drill a #42 hole in each cap adjacent to the lugs. Coat the insides of the caps and the ends of the forms with PVC cement. Position the caps on the ends of the forms so that the ends of the wire protrude through the #42 holes near the solder lugs. Tamp the caps firmly into place and allow the cement to set. Scrape the enamel from the ends of the wire and solder them to the lugs. Use a hot iron, make the connections rapidly, and immediately cool them.

The center insulator can be fabricated from a 5/16" (0.8-cm) piece of plexiglass, an SO-239 coaxial chassis jack and a U clamp to fasten the assembly to the mast. The ends of the antenna can be insulated by lengths of

Design for a compact 80/40-meter inverted-V antenna. Leadin is RG-58 or RG-8 depending on length and power.



plexiglass or standard antenna insulators.

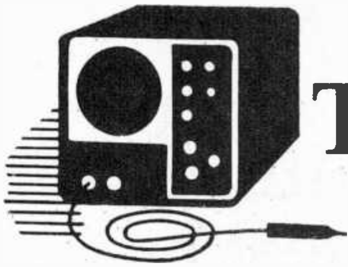
The dimensions in the diagram are approximately correct for the 7.2- and 3.8-MHz phone bands. Assemble the antenna using these dimensions, allowing another 12" (28.5 cm) of wire at points 1 and 2. For the lead-in, use RG-58 for short runs and low power; RG-8 for long runs and high power.

Feed r-f power through an SWR bridge into the antenna at intervals across the 7-MHz band to find the frequency of minimum SWR. Take measurements in smaller frequency increments as the SWR approaches its minimum value, which should be about 1:1 at the resonant frequency of the antenna. If the minimum SWR occurs at a lower frequency than desired, shorten the 7-MHz section of the antenna at points 1. If minimum SWR occurs at too high a frequency, lengthen the antenna. Make the adjustments two or three inches at a time. After 40-meter resonance is established, transfer operations to the 3.5-4-MHz band and adjust lengths at points 2 for minimum SWR at the desired frequency on that band.

After the resonant frequencies of the antenna have been established on both bands, point 1 can be soldered. Proximity to large objects changes the resonant frequency on the 80-meter band, however. Therefore, it is advisable to make it easy to change the lengths at points 2, if the antenna is going to be used in different locations. The center of the antenna should be as high as possible; but if the center height is increased, raise the heights of the ends, too, so that the apex angle does not become too acute.

CQ World-Wide DX Test. CW: October 25-26. Phone: November 29-30. Exchange serial numbers and reports with foreign stations on each band. This contest separates the men from the boys. Rules and score sheets from CQ Magazine, 14 Vanderventer Ave., Port Washington, NY 11050.

ARRL Section Sweepstates (SS). CW: November 8-9. Phone: November 22-23. Work as many U.S. and Canadian stations as possible on all bands. Official rules and score sheets from ARRL, 225 Main St., Newington, CN. 06111. IMPORTANT: Include large, stamped return envelope with your requests for data on either contest. Two units of first class postage are suggested. ◈



Test Equipment Scene

By Leslie Solomon

USING DIODES IN POWER SUPPLIES

ACCORDING to my mail, the piece of equipment that most people want to build for their test bench is a power supply. They usually want a supply that is well-filtered, regulated, has a variable output voltage level, and can be used to power a wide variety of equipment.

Questions most often asked about designing a supply involve the rectifier diodes and how to keep them from burning out. The confusion seems to lie in interpreting the diode specifications—particularly the peak inverse voltage (PIV).

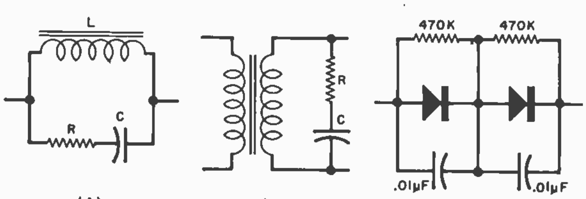
There are two ways to apply voltage to a diode—the right way (forward) and the wrong way (reverse). The right way is what is normally seen in a circuit and the wrong way is hardly ever seen, but is important to take it into consideration. For example, if we want a positive output from a simple half-wave rectifier, we would connect the diode anode to one end of the transformer secondary and the diode cathode to the positive lead of the filter capacitor. The other end of the transformer is then the common and is connected to the negative terminal of the filter capacitor. Now, when power is applied, the diode conducts on the positive half cycles and is reverse biased on the negative halves. But there is more to the story than that.

When the diode is properly biased, it conducts and allows the positive half cycles to put a charge on the filter capacitor, making the positive end more and more positive. On the negative half cycle, the diode anode is reverse biased, but the cathode is also reverse biased by the positive voltage on the capacitor. Therefore, the *total* voltage across the diode is not just the transformer voltage, but the transformer voltage plus the capacitor voltage. In fact, this voltage is 2.828 times the actual rms value. If the transformer supplies 35 volts rms, then the actual voltage across the diode can reach about 99 volts. If a center-tapped transformer and two diodes are used in a conventional full-wave rectifier/filter circuit, the voltage across the diode would be 1.414 times the rms (50 volts in our example).

So, it can be seen that the PIV rating of the diode must be carefully observed. (It is given in the specifications.) Using just any silicon rectifier is providing an invitation to disaster.

Choke-Input Filters. If a choke-input filter is used, it must be kept in mind that, when the diode switches through the zero point of the voltage cycle, the current in the inductor goes to zero. This sudden drop in current causes a large back emf across the diode. (This is how ignition and horizontal-sweep circuits work.) In this case, you must use a diode having a higher PIV and also use the circuit shown at A across the inductor. The approximate value of the transient-suppressing capacitor can be found from $C = (L \times I^2)/10E^2$, where C is in microfarads, L is the maximum choke inductance in henries, I is the maximum current through the choke in amperes, and E is the maximum dc supply in kilovolts. The series resistor should be equal to the load impedance connected across the supply.

Another source of damaging transients is the power transformer itself. Power-line transients and the result-



(A) (B) (C)

ing abrupt changes in the magnetizing current in the transformer can cause damage in voltage-sensitive solid-state components. The circuit shown at B is one way to reduce these transients. The approximate value of the capacitor can be found from $C = (15 \times E \times I)/e^2$, where C is in microfarads, E is the maximum dc supply voltage, I is the maximum current of the supply in amperes, and e is the rms voltage of the transformer secondary. Here again, the resistor should be equivalent to the load impedance on the supply. (If there is any doubt about this, use 100 ohms.) For transient suppression, it is also possible to use a commercial suppressor such as those in the GE MOV line.

Current-limiting Resistors. It is wise to use series current limiting resistors with silicon rectifiers. Knowing the voltage on the transformer secondary and the maximum allowable diode current (from its specifications), you can calculate the value of resistance that will safely limit the current if a direct short were to occur across the rectifier (which happens when the supply is first turned on and the filter capacitors are not charged). Calculate the power and use a resistor of sufficient size to prevent rapid burnout.

If the secondary voltage of the transformer is too high for the PIV of the diodes you have on hand, put two or more diodes in series. To equalize the PIV, connect a resistor of about 470,000 ohms across each diode. To reduce possible transient damage, connect a 0.01-μF, 1-kV capacitor across each diode as shown at C. There is another good reason for using these shunt capacitors, which can be explained as follows.

Silicon diodes, such as those used as rectifiers, do not conduct until the applied forward voltage reaches about 0.6 volt. As the input reaches this value, the diode junction suddenly snaps into conduction, producing a small, but steep, waveform. The waveform can have harmonics that go far up into the r-f spectrum, producing signals that can interfere with a radio receiver. Using capacitors across the rectifier diodes suppresses this r-f generation.

If you have a receiver that uses solid-state diodes in the rectifier and you are troubled by strange signals that don't seem to make sense, try connecting a capacitor across each rectifier diode. ◈

Experimenter's Corner

By Forrest M. Mims

A PROGRAMMABLE TIMER/COUNTER

A FEW years ago, Signetics overwhelmed us all with the introduction of the 555 timer. That chip, as you probably know, is one of the most versatile IC's around, and literally scores of applications for it have been published in POPULAR ELECTRONICS and other magazines.

More recently, Exar capitalized on the 555's popularity by pairing it with a binary counter and putting the whole thing in a 16-pin DIP. They called it the XR-2240 and it is a fully programmable timer/counter with all kinds of fascinating applications. I'm going to describe a few that I've come up with—you will probably think of many others.

With just a few external parts, you can connect the XR-2240 in a free-running mode as shown in Fig. 1. Use anything from 4 to 15 volts for the supply. Current drain is fairly low—about 10 mA for a 9-volt battery. The combination of R and C determines the oscillation period (T = RC) of the XR-2240's internal time base. The binary counter outputs (pins 1 through 8) increase T (or reduce the frequency, depending on how you look at it) by factors of 1, 2, 4, 8, 16, 32, 64, and 128. The result is eight quare waves with harmonically related frequencies from a single RC timing combination. Figure 2 is a scope photo showing six of the counter outputs from an XR-2240 in its free-running mode (R = 1.5 kilohms and C = 0.022 µF). Of course, this is impressive, but you haven't seen anything yet!

You can get some really interesting waveforms by connecting the binary counter outputs together. Some of the possible results are shown in Fig. 3. Exar calls the circuit configuration a binary pattern generator, but I call it a super-deluxe audio "chirper." Just connect a crystal or high-impedance magnetic earphone to the output to hear the chirps. By experimenting with the binary counter output interconnections and installing resistors of various values between some of the outputs, you will be able to obtain a variety of chirps, buzzes, warbles, and other strange sounds. For even more variations, change values of R and C.

If weird-sounding electronic music doesn't interest you, you can always use the pattern generator in more conventional applications. For example, it makes a nifty marker tone generator for a communications system (such as a long-range laser communicator). While a monotone audio oscillator would do the job, it's hard to miss a chirping marker or mistake it for a heterodyne.

Waveform Generator. Another possibility is to use the circuit as a complex waveform generator. I really mean complex, because the XR-2240 can generate all kinds of stepped waveforms. The photo in Fig. 4 shows part of a repetitive, stepped waveform generated by connecting several resistors of different values between the binary counter outputs and the circuit output.

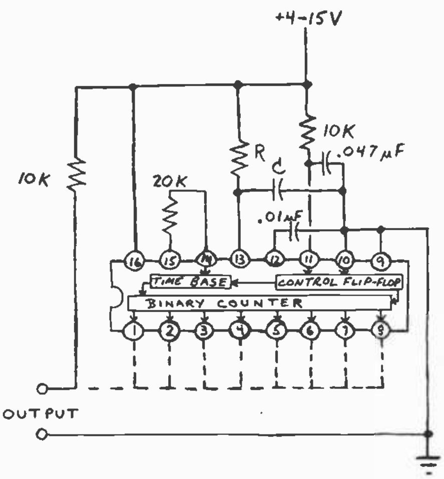


Fig. 1. Schematic of XR-2240 in free-running (astable) mode.

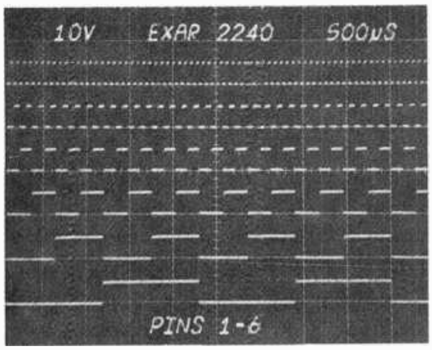


Fig. 2. Output on pins 1 to 6. Scope photos taken with C-59 camera on a Tektronix 7603 scope with 7M13 plug-in readout unit.

If you don't need far-out waveforms like the one in Fig. 4, you can generate more conventional staircases, For a staircase with 256 steps, connect a resistor with a value of about 1000 ohms from pin 8 to the output. Then connect resistors 2, 4, 8, 16, 32, 64, and 128 times that value from pins 7, 6, 5, 4, 3,

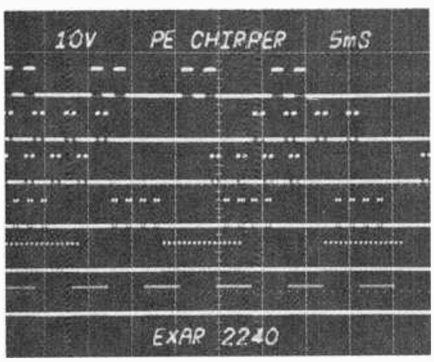


Fig. 3. Six different "chirp" (tone burst) outputs from XR-2240.

2, and 1 (respectively) to the output. You'll have to use precision resistors to get a uniformly spaced staircase. If some values are slightly off, the waveform will be somewhat distorted.

There are lots of other uses for the XR-2240 and they include analog-to-digital conversion, sample-and-hold,

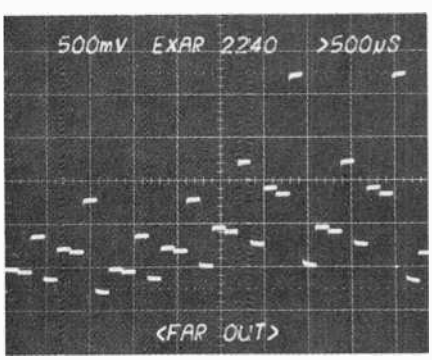
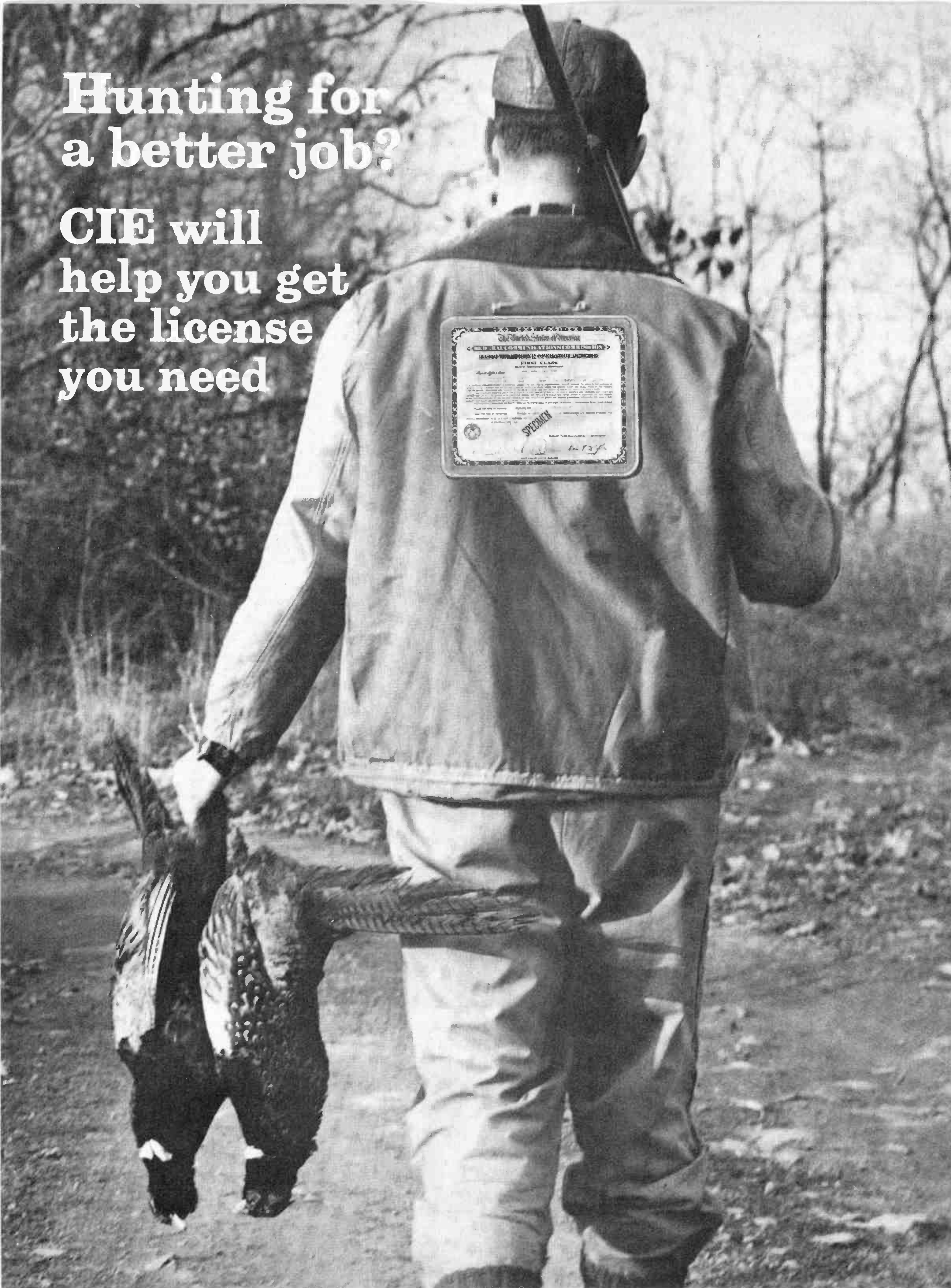


Fig. 4. Complex waveform obtained by connecting resistors to outputs.

harmonic synchronization, and ultra-long "timing" circuits (not true one-shots, but useful nonetheless). The timing properties of the chip are really impressive. For example, the values of R and C in Fig. 1 can be set to provide just one pulse every 10 or 15 minutes. Since pin 8 has a period of 128T, an RC combination which gives a period of 12 minutes would provide an output square wave with a period of 128 × 12 or 1536 minutes. That's more than a whole day. You can get longer delays by connecting more counter outputs to the output bus. The total time delay will equal the sum of the delays available at each counter output pin.

For truly incredible delays of up to 3 years (!), you can cascade two XR-2240's in series. The delays available from the combination can be used to remind you of birthdays and anniversaries, limit your offsprings' phone calls, and dream up assorted science fiction gadgets.

We'll take a closer look at some of the XR-2240 timing applications in a future column. Meanwhile, latch on to a couple of XR-2240's (see the ads in the back of this magazine), and warm up your soldering iron. ◈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200	.70	1.10	1.75	.60	.70	1.60
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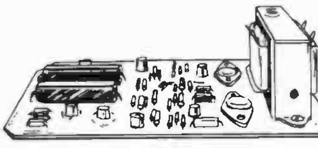

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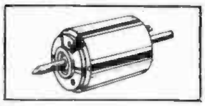

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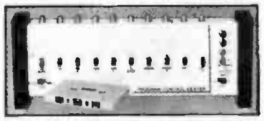

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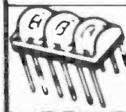

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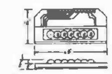

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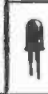

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7408-16c	7475-65c	74161-99c
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7427-24c	7492-75c	74174-1.29
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7438-35c	7496-75c	74192-1.25
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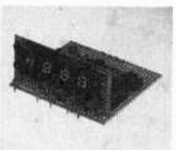
DIGITAL VOLTMETER

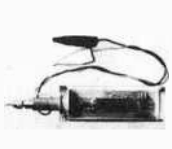


This is a 3½ digit, 0.2 volt Digital Voltmeter, with a .5% full scale accuracy. It is based around the Siliconix LD110, LD111 DVM chip set. The voltmeter uses MAN7 readouts (.3" high) to provide a highly readable display. The unit requires the following supply voltages: 12, -12, 5. The unit comes complete with all components to build the unit pictured at the left, that is a complete DVM less power supply.

$39.95 Per Kit

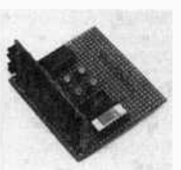
LOGIC PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families: TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols. (HI)—1 (LOW)—o (PULSE)—P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.



$9.95 Per Kit

DIGITAL COUNTER



This is a 4 digit counter unit which will count up to 9999 and then provide an overflow pulse. It is based around the Mostek MK5007 digital counter chip. The unit performs the following functions: Count Input, RESET, Latch, Overflow. The counter operates up to 250 kHz. The counter is an ideal unit to be used as a frequency counter, where the only extra components needed would be a timebase, divider chain and gate. The unit requires 5V, and -12V. The unit comes complete as shown on the left less power supply.

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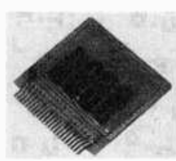

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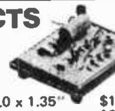

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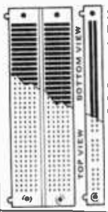

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7408N	.18	7453N	.16	74122N	.45	74180N	.73
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74H00N	$.33	74H20N	.33	74H53N	.36	74H73N	.90
74H01N	.25	74H21N	.33	74H54N	.36	74H74N	.87
74H02N	.30	74H22N	.33	74H55N	.36	74H76N	.90
74H04N	.33	74H30N	.33	74H60N	.36	74H101N	.80
74H05N	.33	74H40N	.36	74H61N	.36	74H102N	.80
74H08N	.40	74H50N	.36	74H62N	.36	74H103N	1.10
74H10N	.33	74H51N	.36	74H71N	.80	74H106N	.95
74H11N	.33	74H52N	.36	74H72N	.74		

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74L00N	$.31	74L10N	.33	74L51N	.34	74L90N	1.62
74L02N	.33	74L20N	.33	74L73N	.69	74L93N	1.74
74L03N	.39	74L42N	1.49	74L74N	.90	74L95N	1.62
74L04N	.33						

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74LS00	$.50	74LS21	.58	74LS76	.92	74LS157	2.10
74LS01	.58	74LS22	.58	74LS78	.92	74LS158	2.40
74LS02	.58	74LS27	.64	74LS100	.92	74LS160	2.70
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74LS04	.60	74LS32	.64	74LS112	.92	74LS170	5.92
74LS05	.63	74LS38	.65	74LS113	.92	74LS174	3.02
74LS08	.58	74LS51	.58	74LS114	.92	74LS175	2.90
74LS09	.58	74LS54	.58	74LS138	2.38	74LS181	3.72
74LS10	.58	74LS55	.58	74LS139	2.38	74LS251	2.55
74LS11	.58	74LS73	.92	74LS151	2.10	74LS253	3.05
74LS15	.58	74LS74	.92	74LS153	2.38	74LS260	.58
74LS20	.58						

SCHOTTKY TTL

74S00N	$.44	74S51N	.80	74S140N	.80	74S189N	4.40
74S02N	.60	74S64N	.80	74S151N	2.20	74S194N	3.30
74S03N	.75	74S74N	1.20	74S153N	3.40	74S195N	3.30
74S04N	.55	74S85N	6.10	74S157N	2.40	74S251N	2.20
74S08N	.80	74S86N	2.50	74S158N	2.20	74S253N	2.40
74S10N	.55	74S112N	1.00	74S160N	3.90	74S257N	2.40
74S11N	.65	74S113N	1.50	74S161N	4.70	74S258N	2.40
74S20N	.65	74S132N	3.60	74S174N	3.30	74S260N	1.20
74S30N	.80	74S133N	.80	74S175N	2.90	74S280N	5.70
74S32N	.80	74S138N	2.20	74S181N	8.40	74S289N	4.00
74S40N	.65	74S139N	2.20				

9300 SERIES

9300PC	$1.00	9318PC	2.30	9366PC	1.75	93L18	3.50
9301PC	1.20	9321PC	1.20	93L00	1.50	93L21	1.50
9304PC	1.50	9322PC	1.30	93L01	1.60	93L22	1.80
9306PC	6.90	9324PC	2.00	93L08	3.20	93L24	2.80
9308PC	2.50	9328PC	2.50	93L09	1.80	93L28	3.70
9309PC	1.60	9334PC	2.95	93L10	2.80	93L34	4.00
9310PC	1.50	9338PC	3.30	93L11	4.20	93L38	4.20
9311PC	2.30	9340PC	5.00	93L12	1.80	93L40	6.50
9312PC	1.20	9341PC	4.10	93L14	1.70	93L41	6.50
9314PC	1.30	9342PC	1.15	93L16	3.20	93L60	3.00
9316PC	1.50	9360PC	1.75	93L18	3.50	93L66	2.70

AUDIO AMPS

TYPE	V	W	Ω	PRICE
LM352	6-15	1.15	8	1.60
LM354A	6-27	2.80	8	2.50
TAA611B12	6-15	1.15	8	1.60
TAA621A12	6-27	1.40	8	2.00
TAA641B11	6-18	2.20	4	3.00
TBA800	5-30	4.70	8	2.20
TBA810AS	4-20	2.50	4	3.00
TBA820	3-16	0.75	4	1.70
TCA830	5-20	2.00	4	2.20
TCA940	6-24	6.50	8	4.40

IC SOCKETS

SOLDER-TIN DIP

PIN	1-24	25	100
8	.21	.19	.17
14	.25	.22	.20
16	.28	.25	.23
24	.67	.61	.55
28	.88	.80	.72
36	1.09	.98	.89
40	1.24	1.12	.92

WIRE-WRAP GOLD

PIN	1-24	25	100
14	.45	.41	.37
16	.54	.49	.44

SOLDER - GOLD

14	.34	.28
16	.37	.31

TEFLON TO-5

3 PIN	.55 EA
4 PIN	.65 EA
6 PIN	.90 EA
8 PIN	1.10 EA
10 PIN	1.40 EA

LEDs

.125" dia.		.160" dia.		.200" dia.	
209 RED	$.25	216 RED	$.25	220 RED	$.25
209 YELLOW	.35	216 YELLOW	.30	220 YELLOW	.30
209 GREEN	.35	216 GREEN	.30	220 GREEN	.30

LOW PROFILE

226 RED	$.25	5053 RED	$.35	MV50 RED	$.30
226 YELLOW	.30	5053 YELLOW	.40		
226 GREEN	.30	5053 GREEN	.40		
226 ORANGE	.30	5053 ORANGE	.40		

216 = MV5024
5053 = MV5053

DISPLAYS

LITRONIX

DL80	RED	6.00
DL81	RED	6.00
DL10	RED	6.00
DL10A	RED	4.00
DL101	RED	4.90
DL57	RED	9.90
DL61	RED	12.00
DL33	RED	4.00
DL44	RED	6.00
DL402	RED	4.00
DL701	RED	3.40
DL704	RED	2.25
DL707	RED	2.35
DL747	RED	2.50
IL1		1.30
IL12		1.40
IL16		1.80
IL74		1.35
ILD74		1.75
ILQ74		3.40

EP 9125 9-DIGIT DISPLAY $7.90
1/8" Character Ht. Compact, Thin PC Pkg., Wide Viewing Angle

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SLA11 GREEN 3.50

XCITON
XAN72 RED 2.00
XAN52 GREEN 2.00

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1-24 $16.00
25 14.40
100 12.00

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9602PC	2.10
9614PC	2.30
9615PC	2.40
9616PC	5.00
9617PC	3.50
9620PC	4.00
9621PC	4.00

75107

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75108BN	2.30
75109N	2.20
75110N	2.20
75115N	2.25
75138N	2.95
75150N	3.10
75154N	4.10
75208N	2.70
75234N	2.50
75450N	1.25
75451N	1.00
75452N	1.00
75453N	1.00

7520 SERIES SENSE AMPS

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7523N	1.75
7524N	2.00
7525N	4.50

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1404AN	5.40
1405A	4.10
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1602	33.00
1702	33.00
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2602-2	5.50
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4034	5.50
4035	4.95
4102	4.95
7562	4.95
7552-1	5.40
7552-2	5.50
8102	4.90
8102-2	5.10
9102PC	5.50
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2601-21	11.40
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2602-2B	8.00
MK4102P	11.40
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Recirculating 512 Bit Dynamic Shift Register
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LM114H	$3.00	LM311H	$1.70	LM711CN	$.90
LM300H	1.20	LM311D	1.90	LM715CH	3.50
LM300N	1.20	LM311M	1.75	LM715CD	4.60
LM301AH	.80	LM311N	2.00	LM723CH	.90
LM301AM	.80	LM312H	2.70	LM723N	.70
LM301AN	1.10	LM318H	1.70	LM725CH	4.50
LM301M	.90	LM324N	1.90	LM725CD	5.00
LM301H	.90	LM331N	2.20	LM733CH	1.40
LM302D	3.50	LM339N	2.90	LM733CD	3.50
LM302N	1.30	LM320-5K	2.90	LM733CN	1.30
LM302H	1.40	LM320-5T	2.50	LM741CH	.45
LM304H	1.40	LM320-12K	2.90	LM741CD	1.25
LM305H	.85	LM320-12T	2.50	LM741CM	.40
LM305AH	1.05	LM340-05K	2.60	LM741CN	.70
LM305N	1.00	LM340-06K	2.60	LM747CH	1.60
LM306H	.95	LM340-08K	2.60	LM747CN	.90
LM307H	.75	LM340-12K	2.60	LM747CD	2.50
LM307M	.95	LM340-15K	2.60	LM748CM	.55
LM307N	1.50	LM340-18K	2.60	LM748CN	.55
LM308H	1.00	LM340-24K	2.60	LM777CH	2.15
LM308AH	5.00	LM555CM	.90	LM777CM	2.10
LM308D	2.00	LM556CN	1.30	LM3046CN	.95
LM308M	1.20	LM709CH	.45	LM3054CN	1.50
LM309H	1.75	LM709CN	.45	SG4501T	2.40
LM309K	1.50	LM710CH	.90	SG4501N	2.40
LM310H	1.60	LM710CN	.90	LM5000K	7.50
LM310M	1.80	LM711CH	.90		

C-MOS

	1-9	10up		1-9	10up		1-9	10up
4000AE	.26	.22	4022AE	1.11	1.00	4051AE	1.34	1.13
4001AE	.26	.22	4023AE	.26	.22	4052AE	1.34	1.33
4002AE	.26	.22	4024AE	.90	.88	4053AE	1.34	1.33
4004AE	5.83	5.82	4025AE	.26	.22	4055AE	2.68	2.00
4006AE	1.35	1.34	4026AE	3.72	3.70	4056AE	2.43	1.86
4007AE	.26	.22	4027AE	.60	.50	4060AE	1.50	1.25
4008AE	1.79	1.78	4028AE	.98	.90	4066AE	.90	.72
4009AE	.60	.50	4029AE	1.27	1.16	4069AE	.38	.34
4010AE	.59	.50	4030AE	.44	.37	4071AE	.26	.22
4011AE	.26	.22	4033AE	3.01	3.00	4076AE	1.68	1.48
4012AE	.26	.22	4035AE	1.27	1.16	4081AE	.26	.25
4013AE	.47	.40	4040AE	1.49	1.25	4508AE	2.30	2.20
4014AE	1.49	1.25	4041AE	4.06	4.05	4510AE	1.98	1.46
4015AE	1.26	.90	4042AE	.75	.64	4516AE	1.98	1.46
4016AE	.56	.45	4043AE	.60	.50	4518AE	1.28	.98
4017AE	1.20	1.00	4044AE	.60	.50	4520AE	1.28	.98
4018AE	1.49	1.25	4047AE	3.54	3.53	4528AE	2.30	2.20
4019AE	.52	.44	4048AE	1.43	1.42	4901AE	.43	.36
4020AE	1.49	1.25	4049AE	.52	.50	4911AE	.43	.36
4021AE	1.34	1.25	4050AE	.52	.50			

SPECIALS

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LM335K: 5V, 600mA 2.40
LM336K: 12V, 500mA 2.90
LM337K: 15V, 450mA 2.90

DUAL LOW NOISE OP AMP

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

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LM567CM Mini-dip $1.70 ea.

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XR-215	$6.56	$5.74

For FM or FSK demodulation, freq. synthesis and tracking filter applications. 5 to 26V from 0.5Hz to 35MHz. Accepts analog signals 300mV to 3V. Interfaces with DTL TTL & ECL.

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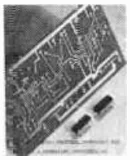

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Here's a highly versatile lab instrument at a fraction of the cost of conventional unit. Kit includes two XR205 IC's, data & applications, PC board (etched & drilled, ready for assembly) and detailed instructions.

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1N4001	1.00	7.00	60.00
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1N4003	1.20	9.00	80.00
1N4004	1.30	10.00	90.00
1N4005	1.40	11.00	100.00
1N4006	1.50	12.00	110.00
1N4007	1.60	13.00	120.00

INTERSIL 8038 PRECISION WAVEFORM GENERATOR & VCO

For simultaneous sine, square and triangular waveforms <001 Hz to 1MHz.

Part No.	1-9	10 up
8038CCPD	$3.90	$3.70

XR-2206KA/XR-2206B

The Function Generator Kit features sine, triangle and square wave, THD 0.5% typ., AM/FM capability.

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Includes monolithic function generator IC, PC board, and assembly instruction manual.

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Same as XR-2206KA above and includes external components for PC board.

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SI-1010G	10W	$6.40
SI-1020G	20W	9.90
SI-1030G	30W	18.70
SI-1050E	50W	24.90
SI-1050G	50W	24.90

HIGH VOLTAGE TRANSISTORS

BU204	3A	1300V	$4.14
BU205	3A	1500V	4.95
BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

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10	100
12	90
15	70
18	50
20	35
22	25
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APS5-3	5	3.0	$26.95	$25.60
APS12-1.6	12	1.6		
APS15-1.5	15	1.5		
APS24-1	24	1.0		
APS28-0.8	28	0.8		
APS5-6	5	6	$48.45	$46.05
APS12-4	12	4		
APS15-3	15	3		
APS24-2.2	24	2.2		
APS28-2	28	2		
APS5-10	5	10	$72.25	$68.65
APS12-7	12	7		
APS15-6	15	6		
APS24-5	24	5		
APS28-4	28	4		

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CDM2502	$13.20	$10.60	$ 8.80
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COM2017	13.20	10.60	8.80
COM2017P	8.00	6.85	5.95
COM2502H	25.00	20.00	16.00
COM2017H	25.00	20.00	16.00
COM2601	30.00	24.00	20.50
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KR2376-ST	20.00	17.50	15.00
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☐SN7403	.16	☐SN7472	.29	☐SN74126	.59
☐SN7404	.19	☐SN7473	.36	☐SN74132	1.75
☐SN7405	.19	☐SN7474	.36	☐SN74140	2.10
☐SN7406	.35	☐SN7475	.59	☐SN74145	1.05
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☐SN7414	1.65	☐SN7485	1.25	☐SN74156	.95
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☐SN7417	.34	☐SN7488	3.95	☐SN74158	.95
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☐SN7450	.16			☐SN74193	1.25
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☐ **$4.95 6-VOLT NICAD POWER PAK**

Includes 4 "A" cell nicad batteries hooked up to give you 6-volts for all types of energy uses. The best batteries made. Rechargeable.

9-FUNCTION, 8-DIGIT MEMORY CALCULATOR KIT

It's the easiest multi-function kit today!

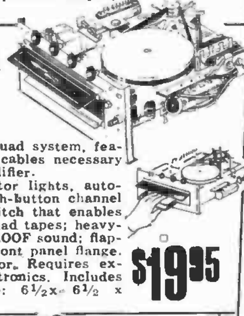
Lightweight, 5¼ x 3 x (2" at back side) x 1¼" front side of angular display panel black case. Nifty unit for business, school, home, and for the youngsters. Slips into any pocket, briefcase with ease. Easy-to-understand pictoral instruction booklet and how-to-use-book. **AC/DC too!**

KIT INCLUDES: case, 22-key keyboard kit, ON-OFF switch (part of keyboard) PC board, driver and memory calculator chips, 9-digit "bubble" magnifier LED array, array cable, AC adapter jack & wires, battery case, 6 battery card display, instruction and pictoral step-by-step construction booklet.

- DOUBLE MEMORY
- Percent, Constant, Display Restore

$16.95 ☐

- 4-Function Arithmetic
- 22 KEYS!



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JUST IN. The "QUA[D]" a complete Quad system, featuring 4-channel preamp . . . all the cables necessary to just plug into any stereo quad amplifier.

Other features: 4-program indicator lights, automatic or manual program change, push-button channel selector switch, built-in triggering switch that enables you to automatically use 8-track or quad tapes; heavy-duty flywheel for WOW & FLUTTER PROOF sound; flapping front panel tape door mounting front panel flange. Heavy duty cool-proof 115 VAC motor. Requires external 12 VDC supply, for all electronics. Includes schematic, hookups, all cables. Size: 6½x 6½ x 3½". IT'S READY TO GO!

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"PANEL OPTICS"

YOU ASKED FOR IT! Found only at Poly Paks at this l-o-w price! It's ONLY 1 3/4 x 1 3/16 x 3/8" deep panel. Designed specifically for our MM-5316 fluorescent driving clock chip. Indicates 4-digits, AM-PM, pulsating second indicator, requires minimum of parts to build. Color: BLUE-GREEN; you can use RED or GREEN filters. Character height: 0.5". Filament voltage is 1.75 VAC or DC @ 160 mils. Anode voltage 25V @ 250 microamps per segment. With spec sheets, clock construction diagrams, P.C. board layouts, specs. A DIGITAL CLOCK BUILDER'S SPECIAL.

Made By TUNG-SOL D2004

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State 1st, 2nd, 3rd Choices of Case Styles
*State Voltages 5 thru 24
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☐ LM301	.29	☐ LM567	2.50
☐ LM302	.69	☐ LM702	.49
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☐ LM305	.89	☐ LM703M	.41
☐ LM308	1.05	☐ LM709	.25
☐ LM309H	1.05	☐ LM710	.29
☐ LM309K	1.50	☐ LM711	.29
☐ LM310	1.10	☐ LM723	.61
☐ LM311	.99	☐ LM733	1.75
☐ LM318	1.75	☐ LM741	.31
☐ LM319	1.19	☐ LM741CV	.31
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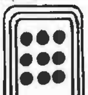
		☐ LM7535	.59



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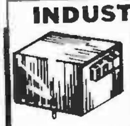

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- TO-220 Case • 1 Amp
- POSITIVE VOLTAGE

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☐ LM-340-12T	12 v
☐ LM-340-15T	15 v
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Type	PIV	Sale
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☐ 1N4003	200	10 for 65c
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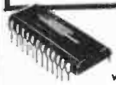
Micro	.210x.125
☐ Red	☐ Yellow
☐ Green	☐ Amber

Micro (Axial) MV-50 style
☐ MV-50 Clear ..... 10 for $1.
☐ MV-55 Red ..... 6 for $1.



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☐ MM5313	6-digit 28-Pin	5.50
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Timer ☐555 2 for $1

OR

☐558 Dual 741 3 for $1

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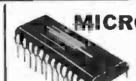

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- Up to 20 mils per seg. at 5V.
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ALL ABOVE BY MONSANTO

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☐ SLA-1	.33	Yellow	1.95	5.00
☐ SLA-3	.7	Green	4.95	12.00
☐ SLA-3	.7	Yellow	4.95	12.00
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☐ 704A	.33	Red	1.95	5.00
☐ 701C	.33	Red	1.50	3.00
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A—Common Cathode, others Common Anode
B—With bubble magnifier
C—Plus or Minus 1

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- Duals size: .8 x .9 x .29
- 7-Segment, 25-mils per segment

Type	Size	Color	Sale	3 for
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☐ 727E	.5	Red	5.95	15.00
☐ 746F	.6	Red	3.95	11.00
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SN7404N	.21	SN7460N	.22	SN74156N	1.30
SN7405N	.24	SN7470N	.45	SN74157N	1.30
SN7406N	.45	SN7472N	.39	SN74160N	1.75
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SN7444N	1.10	SN74142N	6.50	SN74198N	2.25
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CD4017	1.35	CD4051	2.98	74C157	2.15
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CD4020	1.49	CD4060	3.25	74C161	3.25
CD4022	1.25	CD4066	1.75	74C163	3.00
CD4023	.25	CD4069	.45	74C164	3.25
CD4024	1.50	CD4071	.45	74C173	2.60
CD4025	.25	CD4081	.45	74C193	2.75
CD4027	.69	74C00N	.39	74C195	2.75
CD4028	1.65	74C02N	.55	80C97	1.50
CD4029	2.90	74C04N	.75		

LINEAR

LM100H	15.00			LM1310N	2.95
LM106H	2.50			LM1351N	1.65
LM171H	3.75	LM373N	3.25	LM1414N	1.75
LM212H	7.00	LM377N	4.00	LM1458C	.65
LM300H	.80	LM380N	1.39	LM1496N	.95
LM301H	3/1.00	LM380CN	1.05	LM1556V	1.85
LM301CN	3/1.00	LM381N	1.79	LM2111N	1.95
LM302H	.75	LM382N	1.79	LM2901N	2.95
LM304H	1.00	NE501K	8.00	LM3065N	.69
LM305H	.95	NE510A	6.00	LM3900N	.55
LM307CN	.35	NE531H	3.00	LM3905N	.60
LM308H	1.00	NE536T	6.00	LM5556N	1.85
LM308CN	1.00	NE540L	6.00	MC5558V	1.00
LM309H	1.10	NE550N	.79	LM7525N	.90
LM309K	1.25	NE553	2.50	LM7528N	2.20
LM310CN	1.15	NE555V	.75	LM7534N	2.20
LM311H	.90	NE565H	1.25	LM7535N	1.25
LM311N	.90	NE565N	1.95	8038B	4.95
LM318CN	1.50	NE566CN	1.95	LM75450	.49
LM319N	1.30	NE567H	1.25	75451CN	.39
LM319D	9.00	NE567V	1.95	75452CN	.39
LM320K-5	1.35	LM703CN	.45	75453CN	.39
LM320K-5.2	1.35	LM709H	.29	75454CN	.39
LM320K-12	1.35	LM709N	.29	75491CN	.79
LM320K-15	1.35	LM710N	.79	75492CN	.89
LM323K-5	10.50	LM711N	.39	75494CN	.89
LM324N	1.80	LM723H	.55	RCA LINEAR	
LM339N	1.70	LM723N	.55	CA3013	1.70
LM340K-5	1.95	LM733N	1.00	CA3023	2.15
LM340K-12	1.95	LM739N	1.29	CA3035	2.25
LM340K-15	1.95	LM741CH	3/1.00	CA3039	1.35
LM340K-24	1.95	LM741CN	3/1.00	CA3046	1.15
LM340To-5	1.75	LM741-14N	.39	CA3059	2.46
LM340To-6	1.75	LM747H	.79	CA3060	2.80
LM340To-12	1.75	LM747N	.79	CA3080	.85
LM340To-15	1.75	LM748H	.39	CA3083	1.60
LM340To-24	1.75	LM748N	.39	CA3086	.59
LM350N	1.00	LM1303N	.90	CA3089	3.25
LM351CN	.65	LM1304N	1.19	CA3091	8.25
LM370N	1.15	LM1305N	1.40	CA3123	1.85
LM370H	1.15	LM1307N	.85	CA3600	1.75

DATA HANDBOOKS

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

MICROPROCESSOR COMPONENTS

8008 CPU	$24.95	8111	1024 RAM	$ 7.95	
8080 CPU	149.95	1702A	2K PROM	19.95	
7489 64B RAM	2.95	5203Q	2K PROM	19.95	
8599 Tri State 7489	3.50	8223	PROM	3.00	
1101 256B RAM	2.25	2401	2K SR	9.95	
2102 1K RAM	2.95	2533	1K SSR	7.95	
8101 1024 RAM	7.95	AY-5-1013	UART	6.95	
91L02-1 1024 RAM	3.95	93410	256B-RAM	3.25	
7010 1K	NMOS	RAM	Retains data w/o Power	29.95	
2107 4K	RAM	450NS	Access time-22 pin DIP	19.95	

91L02 — 1K Static RAM Direct Replacement for 2102-1 with 40% Less Current Drawn. — 3.95

.Vector General Purpose Logic CARD Board 14.95
*Very High Noise Immunity * Holds 12 ea. 14 pin DIPS
*44 pin Edge Connection

THE KILOBYTE RAM CARD — Per Kit 69.95
*Complete 1Kx8 Memory * High Noise Immunity Components
*Single 5v supply *500NS Access Time &Kit includes sockets, ICS & Board

FREE $12.00 Value — With each $75. order of Microprocessor components, get a one year subscription to BYTE the magazine for computer PHREAKS FREE FREE FREE

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IN4001	50V @ 1 Amp	15/$1.00
IN4002	100V @ 1 Amp	15/$1.00
IN4003	200V @ 1 Amp	15/$1.00
IN4004	400V @ 1 Amp	15/$1.00
IN4148	Switching	20/$1.00

TRANSISTORS

2N2907A	PNP Switching	6/$1.00
2N2222A	NPN Switching	6/$1.00
2N3904	NPN Amp	6/$1.00
2N3906	PNP Amp	6/$1.00
2N918	NPN RF	6/$1.00
2N5951	NJ Fet	6/$1.00
C10681	3.6 Amp SCR	2/$1.00

TTL/LINEAR

7400	Gate	7/$1.00
7447	Decoder	.79
7490	Counter	.49
74100	8 Bit Latch	.99
74154	Decoder	.99
74197	Counter	.75
LM301H—LM741H		4/$1.00
LM324N—Quad 741		1.19
LM309H	5V Reg TO-5	.79
LM309K	5V Reg TO-3	.99

DYNAMIC SHIFT REGISTERS
MM500H MM504H MM510H 2 FOR
MM503H MM506H-MM5016H $1.00

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MM5311N	6 Digit	$3.95
MM5312N	4-Digit	3.95
MM5313N	6 Digit	3.95
MM5314N	6 Digit	3.95
MM5316N	6 Digit Alarm	4.95
MM5725N	8 Digit-4 Funt.	1.98
MM5736N	6 Digit-4 Funt.	3.95
MM5738N	8 Digit-5 Funt.	4.95

26 Awg RIBBON CABLE

1 Ft. Minimum	1-9 ft.	10 ft.
4 Cond.	.49 ft.	.39 ft.
8 Cond.	.89 ft.	.69 ft.
16 Cond.	1.49 ft.	1.19 ft.
32 Cond.	2.49 ft.	1.99 ft.

4' POWER SUPPLY CORDS ....

Black — SPECIAL 3/$1.00

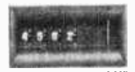
THUMBWHEEL SWITCHES

THUMBWHEEL SWITCH ONLY — SF – Front Mount, SR – Rear Mount

Part No.	Description	Price
SF-12	Single Pole 10 Position	$2.50
SR-12	Decimal	3.00
SF-21	10 Position BCD only	2.50
SR-21		3.00

Snap together – No Hardware

SERIES SF Front Mount Assembly ($11.70)

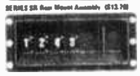


Note: Picture to the left has the following: 4 ea. SF 12, 1 ea. SF EP, 1 ea. SF BB, 1 ea. SF DP and 1 ea. SF HB

ACCESSORIES

Part No.	Description	Price
SF-EP	End Plate (Pair)	.50
SF-DP	Divider Plate (each)	.40
SF-BB	Blank Body (each)	.40
SF-HB	Half Body (each)	.40

SERIES SR Rear Mount Assembly ($13.70)



Note: Picture to the left has the following: 4 ea. SR 12, 1 ea. SR-EP, 1 ea. SR BB, 1 ea. SR DP and 1 ea. SR HB

ACCESSORIES

Part No.	Description	Price
SR-EP	End Plates (pair)	$ .50
SR-DP	Divider Plate (each)	.40
SR-BB	Blank Body (each)	.40
SR-HB	Half Body (each)	.40

Ordering: Order desired switch or switches and add necessary accessories for your particular application.

POCKET CALCULATOR KIT

5 function plus constant – addressable memory with individual recall – 8 digit display plus overflow – battery saver – uses standard or rechargeable batteries – all necessary parts in ready to assemble form – instructions included. 3" x 5¼" SPECIAL $12.95 each
OPTIONS –
115VAC Transformer .... 4.95 each
6 each "N" Alkaline Batteries ..... 1.95 lot

.394" DIAM. TRIMMER

STANDARD RESISTANCE VALUES
MODEL 100Ω 500Ω 1K 2K 5K 10K 20K 100K 200K 1Meg

SPECIAL Model TR II

RESISTANCES (OHMS)	1–9	10–24
STD 100Ω – 1 MEGΩ	4/$1.00	

1/16 VECTOR BOARD

P-Pattern, 0.1" Hole Spacing

MATERIAL	STOCK NO	LONG	WIDE	PRICES 1	10
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.88	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.27	8.25
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

NEW PROTO BOARD-100

Here's a low cost, big 10 IC capacity breadboard kit with all the quality of QT Sockets and the best of the Proto Board series . . . complete down to the last nut, bolt and screw. Includes 2 QT 35S Sockets, 1 QT-35B Bus Strip, 2 5-way binding posts; 4 rubber feet; screws, nuts, bolts, and easy assembly instructions.

COMPLETE KIT... *Special $17.95

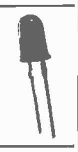
WALL or T.V. DIGITAL CLOCK

12 or 24 Hour — 115 Vac
25' VIEWING DISTANCE
Walnut Case-6" x 3" x 1"
Hr. & Min.-6" High
Seconds-3" High
KIT - All Comp. & Case $34.95
Wired & Assembled $39.95

DISPLAY LEDS

FND70	Com. Cath.	.250	.69
MAN 1	Com. Ano.	.270	$1.95
MAN 2	5x7 Matrix	.300	3.95
MAN 3	Com. Cath.	.125	.39
MAN 4	Com. Cath.	.187	1.95
MAN 7	Com. Ano.	.30	1.50
DL33	Com. Cath.	.125	1.95
DL747	Com. Ano.	.625	2.50

DISCRETE LEDS



MV 10	Red	5/$1.00
MV 50	Red	6/$1.00
MV 5024	Red	5/$1.00
MV 5024	Green	4/$1.00
MV 5024	Yellow	4/$1.00
MV 5024	Orange	4/$1.00
MV 50*	Red 1¼" Leads	5/$1.00

IC SOLDERTAIL – LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.23	.22	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.36	.37	.36				

SOLDERTAIL STANDARD (TIN)

14 pin	$.30	.28	.26	28 pin	$.99	.90	.81
16 pin	.33	.31	.29	36 pin	1.39	1.26	1.15
18 pin	.42	.39	.37	40 pin	1.59	1.45	1.30
24 pin	.59	.54	.49				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.55	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

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

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST 8	3 ea	SN7400 7401 7402 7403 7404 SN7410 7430 7438 7440 7472	SSI/TTL	$5.95 ASST
ASST 9	2 ea	SN7447 7490 7491 74100 74121 SN74145 74175 74180 74191 74193	MSI/TTL	$9.95 ASST
ASST 10	2 ea	CD4001 4002 4011 4012 4013 CD4016 4017 4019 4023 4030	CMOS	$7.95 ASST
ASST 11	2 ea	LM301T 301N 302T 307T 309K LM311T 565T 567T 741T 741N	LINEAR	$14.95 ASST

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
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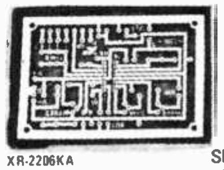
IC'S EXAR KITS

FUNCTION GENERATOR KIT



features sine, triangle and square wave; THD 0.5% typ., AM/FM capability

XR-2206KA — SPECIAL $17.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB — SPECIAL $27.95
Same as XR-2206KA above and includes external components for PC board.

TIMERS		
XR-555CP	Monolithic Timer	SPECIAL $ .69
XR-320P	Precision Timer	1.55
XR-556CP	Dual-555 Timer	1.85
XR-2556CP	Dual Timing Circuit	3.20
XR-2240CP	Programmable Counter/Timer	SPECIAL 3.25
PHASE LOCKED LOOPS		
XR-210	FSK Demodulator	5.20
XR-215	High Frequency PLL	6.60
XR-567CP	Tone Decoder (mini DIP)	1.95
XR-567CT	Tone Decoder (TO-5)	SPECIAL .99
STEREO DECODERS		
XR-1310P	PLL Stereo Decoder	3.20
XR-1310EP	PLL Stereo Decoder	3.20
XR-1800P	PLL Stereo Decoder	3.20
WAVEFORM GENERATORS		
XR-205	Waveform Generator	8.40
XR-2206CP	Monolithic Function Generator	SPECIAL 4.49
XR-2207CP	Voltage-Controlled Oscillator	3.85
OTHER EXAR IC'S		
XR-1468CN	Dual + 15V Tracking Regulator	SPECIAL 2.95
XR-1488N	Quad Line Driver	5.80
XR-1489AN	Quad Line Receiver	4.80
XR-2208CP	Operational Multiplier	5.20
XR-2211 CP	FSK Demodulator/Tone Decoder	6.70
XR-2261	Monolithic Proportional Servo IC System w/4 ea. Driver Transistor	3.79

Special Requested Items

RC4194	Dual Track V Reg	$5.95	N8T97	$3.00	2533	$7.95
RC4195	±15V Track Reg	3.25	4024P	2.25	8263	5.95
F9368	Decoder	3.95	2513	11.00	8267	2.75
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00
MC1408L7	A/O	9.95	2525	6.00	8880	1.35
F3341	FIFO	8.95	2527	5.00	7497	5.00

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	IN4003	200 PIV	1 AMP	.10
IN751A	5.1	400m	4/1.00	IN4004	400 PIV	1 AMP	10
IN752	5.6	400m	4/1.00	IN3600	50	200m	6/1.00
IN753	6.2	400m	4/1.00	IN4148	75	10m	15/1.00
IN754	6.8	400m	4/1.00	IN4154	35	10m	12/1.00
N965B	15	400m	4/1.00	IN4734	5.6	1w	.28
IN5232	5.6	500m	28	IN4735	6.2	1w	.28
IN5234	6.2	500m	.28	IN4736	6.8	1w	.28
IN5235	6.8	500m	.28	IN4738	8.2	1w	.28
IN5236	7.5	500m	.28	IN4742	12	1w	28
IN456	25	40m	6/1.00	IN4744	15	1w	.28
IN458	150	7m	6/1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5/1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	.09	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	10	IN1188	400 PIV	35 AMP	3.00

TRANSISTORS

MPS-A05	5/1.00			PN4249	4/$1.00
MPS-A06	5/$1.00	PN3567	3/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3568	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3569	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3204	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3700	5/$1.00	2N4409	5/$1.00
FN2415	5/$1.00	2N3707	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3724	$.65	2N5088	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3905	4/$1.00	2N5139	5/$1.00
MJE3055	$.89	2N3906	4/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	C10681 SCR	2/$1.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

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

100 VOLT MYLAR FILM CAPACITORS

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

± 20% DIPPED TANTALUMS (SOLID) CAPACITORS

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

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead					Radial Lead				
47	50	15	.13	10	.47	25	15	13	.10
1	50	16	14	11	47	50	16	14	.11
3.3	50	15	13	10	1	16	15	13	.10
4.7	25	16	14	12	1	25	16	14	11
10	25	15	13	10	1	50	16	14	.11
10	50	16	14	12	4.7	16	15	13	10
22	25	17	15	12	4.7	25	15	13	10
22	50	24	20	18	4.7	50	16	14	11
47	25	19	17	15	10	16	14	12	09
47	50	25	21	19	10	25	15	13	10
100	25	24	20	18	10	50	16	14	.12
100	50	35	30	28	47	50	24	21	.19
220	25	32	.28	25	100	16	19	15	14
220	50	45	41	38	100	25	24	20	18
470	25	33	29	27	100	50	35	30	28
1000	16	55	50	45	220	16	23	17	.16
2200	16	70	62	55	470	25	.31	28	.26

CIRCLE NO. 31 ON FREE INFORMATION CARD

RADIATION DETECTOR

Brand new VICTOREEN Model 710 B. Reads gamma radiation from 0.1 to 50 roentgens / hour. Complete with service and instruction manual. Meter is a 20 ua movement, worth twice the price of the whole unit. Also contains matched multi plier resistors of 1000 meg., 10,000 meg. & 100,000 meg. plus VX86 (5886) electrometer tube. Wt. 3lbs. 5"x4"x8½".

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ULTRA SONIC TRANSDUCERS

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2SA473	.75	2SB303	.65	2SC478	.80	2SC828	.75	2SC1756	1.25
2SA483	1.95	2SB324	1.00	2SC491	2.50	2SC829	.75		
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2SA490	.70	2SB367	1.60	2SC497	1.60	2SC839	.85	2SD45	2.00
2SA505	.70	2SB370	.65	2SC515	.80	2SC945	.65	2SD65	.75
2SA564	.50	2SB405	.85	2SC535	.95	2SC1010	.80	2SD68	.90
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2SA643	.85	2SB415	.85	2SC537	.70	2SC1051	2.50	2SD88	1.50
2SA647	2.75	2SB461	1.25	2SC563	2.50	2SC1061	1.65	2SD151	2.25
2SA673	.85	2SB463	1.65	2SC605	1.00	2SC1079	3.75	2SD170	2.00
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2SA699A	1.75	2SB481	2.10	2SC643	3.75	2SC1166	.70	2SD300	2.50
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1N914	.10	2N962	.40	2N2221	.20	2N2914	1.20	2N3771	1.75	2N4402	.20
		2N967	.40	2N2221A	.20	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N173	1.75	2N1136	1.15	2N2222	.20	2N3019	1.20	2N3773	2.10	2N4409	.20
2N178	.90	2N1142	1.85	2N2222A	.20	2N3053	.30	2N3819	.25	2N4410	.25
2N327A	1.15	2N1302	.25	2N2270	.30	2N3054	.70	2N3823	.55	2N4416	.75
2N334	1.20	2N1305	.30	2N2322	1.45	2N3055	.75	2N3856	.20	2N4441	.85
2N336	.90	2N1377	1.15	2N2323	1.50	2N3227	1.90	2N3866	.85	2N4442	.90
2N338A	1.05	2N1420	.20	2N2324	1.85	2N3247	3.40	2N3903	.20	2N4443	1.20
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.40	2N3904	.20	2N4852	.55
2N404	.20	2N1540	.90	2N2326	2.85	2N3375	4.80	2N3905	.20	2N5061	.25
2N443	1.00	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.40
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.20	2N3925	4.25	2N5130	.20
2N501A	3.00	2N1549	.95	2N2329	5.75	2N3414	.20	2N3954	4.35	2N5133	.15
2N508A	.30	2N1551	3.20	2N2368	.25	2N3415	.25	2N3954A	4.80	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.20	2N3416	.30	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.70	2N2484	.20	2N3417	.30	2N3957	1.25	2N5294	.60
2N677C	4.85	2N1557	1.50	2N2712	.25	2N3442	1.85	2N3958	1.20	2N5296	.40
2N706	.20	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20
2N706B	.35	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.25
2N711	.35	2N1613	.30	2N2904	.20	2N3565	.20	2N4124	.20	2N5369	.25
2N711B	.50	2N1711	.30	2N2904A	.25	2N3638	.20	2N4126	.20	2N5400	.50
2N718	.20	2N1907	4.10	2N2905	.20	2N3642	.20	2N4141	.20	2N5401	.50
2N718A	.25	2N2060	1.85	2N2905A	.25	2N3643	.15	2N4142	.20	2N5457	.35
2N720A	1.30	2N2102	.40	2N2906	.20	2N3645	.15	2N4143	.20	2N5458	.35
2N918	.20	2N2218	.25	2N2906A	.25	2N3646	.10	2N4220A	.95		
2N930	.20	2N2218A	.30	2N2907	.20	2N3730	1.10	2N4234	1.20		
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87-20021	2.0"	Red	100	2.60
87-25001	2.5"	Black	100	2.65
87-25021	2.5"	Red	100	2.65
87-30001	3.0"	Black	100	2.70
87-30021	3.0"	Red	100	2.70
87-35001	3.5"	Black	100	2.75
87-35021	3.5"	Red	100	2.75
87-40001	4.0"	Black	100	2.80
87-40021	4.0"	Red	100	2.80
87-45001	4.5"	Black	100	2.90
87-45021	4.5"	Red	100	2.90
87-50001	5.0"	Black	100	3.00
87-50021	5.0"	Red	100	3.00
87-60001	6.0"	Black	50	1.60
87-60021	6.0"	Red	50	1.60
87-70001	7.0"	Black	50	1.70
87-70021	7.0"	Red	50	1.70
87-80001	8.0"	Black	50	1.80
87-80021	8.0"	Red	50	1.80
87-90001	9.0"	Black	50	1.90
87-90021	9.0"	Red	50	1.90
87-10101	10.0"	Black	50	2.00
87-10121	10.0"	Red	50	2.00
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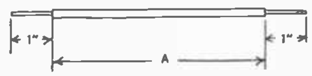

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Resistance	Carbon Comp Resistor Catalog Number		Carbon Film Resistor Catalog Number		
	1/4 Watt	1/2 Watt	1/8 Watt	1/4 Watt	1/2 Watt
10	26-10107	27-10120	30-10105	31-10107	32-10120
11	26-11107	27-11120	30-11105	31-11107	32-11120
12	26-12107	27-12120	30-12105	31-12107	32-12120
13	26-13107	27-13120	30-13105	31-13107	32-13120
15	26-15107	27-15120	30-15105	31-15107	32-15120
16	26-16107	27-16120	30-16105	31-16107	32-16120
18	26-18107	27-18120	30-18105	31-18107	32-18120
20	26-20107	27-20120	30-20105	31-20107	32-20120
22	26-22107	27-22120	30-22105	31-22107	32-22120
24	26-24107	27-24120	30-24105	31-24107	32-24120
27	26-27107	27-27120	30-27105	31-27107	32-27120
30	26-30107	27-30120	30-30105	31-30107	32-30120
33	26-33107	27-33120	30-33105	31-33107	32-33120
36	26-36107	27-36120	30-36105	31-36107	32-36120
39	26-39107	27-39120	30-39105	31-39107	32-39120
43	26-43107	27-43120	30-43105	31-43107	32-43120
47	26-47107	27-47120	30-47105	31-47107	32-47120
51	26-51107	27-51120	30-51105	31-51107	32-51120
56	26-56107	27-56120	30-56105	31-56107	32-56120
62	26-62107	27-62120	30-62105	31-62107	32-62120
68	26-68107	27-68120	30-68105	31-68107	32-68120
75	26-75107	27-75120	30-75105	31-75107	32-75120
82	26-82107	27-82120	30-82105	31-82107	32-82120
91	26-91107	27-91120	30-91105	31-91107	32-91120
100	26-10207	27-10220	30-10205	31-10207	32-10220
110	26-11207	27-11220	30-11205	31-11207	32-11220
120	26-12207	27-12220	30-12205	31-12207	32-12220
130	26-13207	27-13220	30-13205	31-13207	32-13220
150	26-15207	27-15220	30-15205	31-15207	32-15220
160	26-16207	27-16220	30-16205	31-16207	32-16220
180	26-18207	27-18220	30-18205	31-18207	32-18220
200	26-20207	27-20220	30-20205	31-20207	32-20220
220	26-22207	27-22220	30-22205	31-22207	32-22220
240	26-24207	27-24220	30-24205	31-24207	32-24220
270	26-27207	27-27220	30-27205	31-27207	32-27220
300	26-30207	27-30220	30-30205	31-30207	32-30220
330	26-33207	27-33220	30-33205	31-33207	32-33220
360	26-36207	27-36220	30-36205	31-36207	32-36220
390	26-39207	27-39220	30-39205	31-39207	32-39220
430	26-43207	27-43220	30-43205	31-43207	32-43220
470	26-47207	27-47220	30-47205	31-47207	32-47220
510	26-51207	27-51220	30-51205	31-51207	32-51220
560	26-56207	27-56220	30-56205	31-56207	32-56220
620	26-62207	27-62220	30-62205	31-62207	32-62220
680	26-68207	27-68220	30-68205	31-68207	32-68220
750	26-75207	27-75220	30-75205	31-75207	32-75220
820	26-82207	27-82220	30-82205	31-82207	32-82220
910	26-91207	27-91220	30-91205	31-91207	32-91220

Resistance	Carbon Comp Resistor Catalog Number		Carbon Film Resistor Catalog Number		
	1/4 Watt	1/2 Watt	1/8 Watt	1/4 Watt	1/2 Watt
1000	26-10307	27-10320	30-10305	31-10307	32-10320
1100	26-11307	27-11320	30-11305	31-11307	32-11320
1200	26-12307	27-12320	30-12305	31-12307	32-12320
1300	26-13307	27-13320	30-13305	31-13307	32-13320
1500	26-15307	27-15320	30-15305	31-15307	32-15320
1600	26-16307	27-16320	30-16305	31-16307	32-16320
1800	26-18307	27-18320	30-18305	31-18307	32-18320
2000	26-20307	27-20320	30-20305	31-20307	32-20320
2200	26-22307	27-22320	30-22305	31-22307	32-22320
2400	26-24307	27-24320	30-24305	31-24307	32-24320
2700	26-27307	27-27320	30-27305	31-27307	32-27320
3000	26-30307	27-30320	30-30305	31-30307	32-30320
3300	26-33307	27-33320	30-33305	31-33307	32-33320
3600	26-36307	27-36320	30-36305	31-36307	32-36320
3900	26-39307	27-39320	30-39305	31 39307	32-39320
4300	26-43307	27-43320	30-43305	31 43307	32-43320
4700	26-47307	27-47320	30-47305	31 47307	32-47320
5100	26-51307	27-51320	30-51305	31 51307	32-51320
5600	26-56307	27-56320	30-56305	31 56307	32-56320
6200	26-62307	27-62320	30-62305	31 62307	32-62320
6800	26-68307	27-68320	30-68305	31-68307	32-68320
7500	26-75307	27-75320	30-75305	31-75307	32-75320
8200	26-82307	27-82320	30-82305	31-82307	32-82320
9100	26-91307	27-91320	30-91305	31-91307	32-91320
10K	26-10407	27-10420	30-10405	31-10407	32-10420
11K	26-11407	27-11420	30-11405	31-11407	32-11420
12K	26-12407	27-12420	30-12405	31-12407	32-12420
13K	26-13407	27-13420	30-13405	31-13407	32-13420
15K	26-15407	27-15420	30-15405	31-15407	32-15420
16K	26-16407	27-16420	30-16405	31-16407	32-16420
18K	26-18407	27-18420	30-18405	31-18407	32-18420
20K	26-20407	27-20420	30-20405	31-20407	32-20420
22K	26-22407	27-22420	30-22405	31-22407	32-22420
24K	26-24407	27-24420	30-24405	31-24407	32-24420
27K	26-27407	27-27420	30-27405	31-27407	32-27420
30K	26-30407	27-30420	30-30405	31-30407	32-30420
33K	26-33407	27-33420	30-33405	31-33407	32-33420
36K	26-36407	27-36420	30-36405	31-36407	32-36420
39K	26-39407	27-39420	30-39405	31-39407	32-39420
43K	26-43407	27-43420	30-43405	31-43407	32-43420
47K	26-47407	27-47420	30-47405	31-47407	32-47420
51K	26-51407	27-51420	30-51405	31-51407	32-51420
56K	26-56407	27-56420	30-56405	31-56407	32-56420
62K	26-62407	27-62420	30-62405	31-62407	32-62420
68K	26-68407	27-68420	30-68405	31-68407	32-68420
75K	26-75407	27-75420	30-75405	31-75407	32-75420
82K	26-82407	27-82420	30-82405	31-82407	32-82420
91K	26-91407	27-91420	30-91405	31-91407	32-91420

Resistance	Carbon Comp Resistor Catalog Number		Carbon Film Resistor Catalog Number		
	1/4 Watt	1/2 Watt	1/8 Watt	1/4 Watt	1/2 Watt
100K	26-10507	27-10520	30-10505	31-10507	32-10520
110K	26-11507	27-11520	30-11505	31-11507	32-11520
120K	26-12507	27-12520	30-12505	31-12507	32-12520
130K	26-13507	27-13520	30-13505	31-13507	32-13520
150K	26-15507	27-15520	30-15505	31-15507	32-15520
160K	26-16507	27-16520	30-16505	31-16507	32-16520
180K	26-18507	27-18520	30-18505	31-18507	32-18520
200K	26-20507	27-20520	30-20505	31-20507	32-20520
220K	26-22507	27-22520	30-22505	31-22507	32-22520
240K	26-24507	27-24520	30-24505	31-24507	32-24520
270K	26-27507	27-27520	30-27505	31-27507	32-27520
300K	26-30507	27-30520	30-30505	31-30507	32-30520
330K	26-33507	27-33520	30-33505	31-33507	32-33520
360K	26-36507	27-36520	30-36505	31-36507	32-36520
390K	26-39507	27-39520	30-39505	31-39507	32-39520
430K	26-43507	27-43520	30-43505	31-43507	32-43520
470K	26-47507	27-47520	30-47505	31-47507	32-47520
510K	26-51507	27-51520	30-51505	31-51507	32-51520
560K	26-56507	27-56520	30-56505	31-56507	32-56520
620K	26-62507	27-62520	30-62505	31-62507	32-62520
680K	26-68507	27-68520	30-68505	31-68507	32-68520
750K	26-75507	27-75520	30-75505	31-75507	32-75520
820K	26-82507	27-82520	30-82505	31-82507	32-82520
910K	26-91507	27-91520	30-91505	31-91507	32-91520
1.0M	26-10607	27-10620	30-10605	31-10607	32-10620

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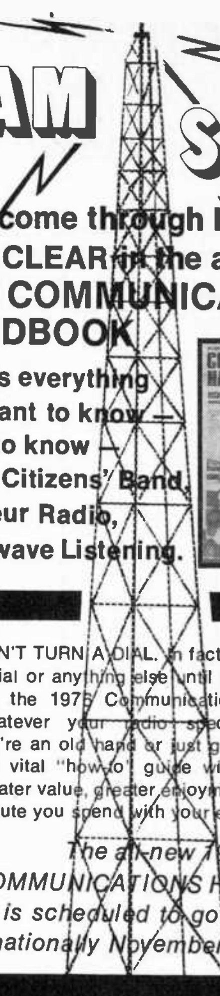

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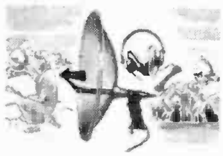

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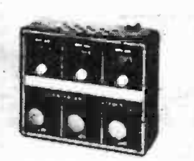

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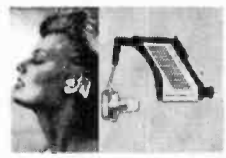

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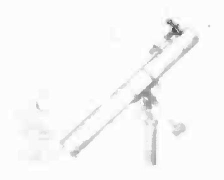

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