Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

JULY 1982/$1.25

Simple Audio Gate Reduces Noise

An EPROM Programmer for Small Computers

Scope Switch Provides Multi-Channel Traces

FORREST MIMS COMPARES

The New Handheld Computers

...d in this Issue:

... V15 Type V Phono Cartridge

... 19" Color TV Receiver

Fox BMP 10/60 Scanner

Right away, you can see a difference.

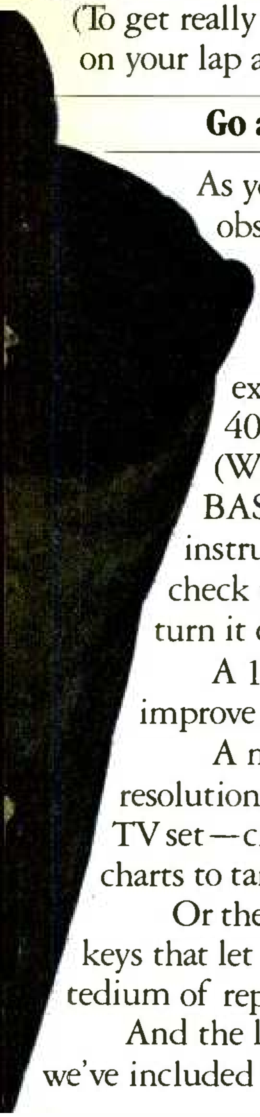
Stop in a store near you. Take a look.

You'll be instantly taken with some of the features that make the IBM Personal Computer so different.

Like the non-glare screen—easy on the eyes during those number-crunching tasks like payroll and general ledger.

80 characters a line—with upper and lower case letters for a quick and easy read.

And the flexibility of a system that lets *you* move the components around at will. (To get really comfortable, try the keyboard on your lap and put your feet up.)



Go ahead, compare.

As you progress from casual observer to comparison shopper, you'll want the inside story of the IBM Personal Computer.

Like user memory expandable up to 256KB. And 40KB of permanent memory. (Which not only includes the BASIC language, but diagnostic instructions that automatically check the system every time you turn it on.)

A 16-bit microprocessor that can improve speed and productivity.

A mix of crisp text and high-resolution color graphics on your own TV set—clearly helpful for creating charts to target forecasts and trends.

Or the 10 programmable function keys that let you bid goodbye to the tedium of repetitious tasks.

And the list goes on. Which is why we've included a box (at right) that tells all.

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Like the instruction manuals that help you set up your system and teach you to use it with the greatest of ease.

IBM PERSONAL COMPUTER SPECIFICATIONS

User Memory
16K-256K bytes*

Microprocessor
16-bit, 8088*

Auxiliary Memory
2 optional internal diskette drives, 5¼", 160K bytes per diskette

Keyboard
83 keys, 6 ft. cord attaches to system unit*
10 function keys*
10-key numeric pad
Tactile feedback*

Diagnostics
Power-on self testing*
Parity checking*

Display Screen
High-resolution*
80 characters x 25 lines
Upper and lower case
Green phosphor screen*

Operating Systems
DOS, UCSD p-System, CP/M-86†

Languages
BASIC, Pascal, FORTRAN, MACRO Assembler, COBOL

Printer
Bidirectional*
80 characters/second
12 character styles, up to 132 characters/line*
9 x 9 character matrix*

Permanent Memory
(ROM) 40K bytes*

Color/Graphics
Text mode:
16 colors*
256 characters and symbols in ROM*
Graphics mode:
4-color resolution: 320h x 200v*
Black & white resolution: 640h x 200v*
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Asynchronous (start/stop) protocol
Up to 9600 bits per second

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CIRCLE NO. 2 ON FREE INFORMATION CARD

JULY 1982 VOLUME 20, NUMBER 7

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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Construction Articles

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COVER GRAPHICS BY JACK WARD COLOR SERVICES INC.

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EDITORIAL

Down With QWERTY

I'm a fairly fast touch-typist. But, then, my motivation for achieving this status was stronger than for most people: "Type more than 40 words-per-minute after deducting for errors and you'll go to EUCOM (European Command); otherwise, it's likely to be FECOM (Far East Command during the Korean War)." The typewriter system I learned in the U.S. Army was developed when Abraham Lincoln was President of the United States. By the turn of the century, this QWERTY keyboard (named for the sequence of the first six characters on the first line of a typewriter's letter keys) was entrenched in our society. It's omnipresent today.

This strange placement of keys was developed to overcome mechanical difficulties. The inventor, Christopher Sholes, placed the most-often-used letters as far apart as possible to prevent jamming of keys as each key arm moved toward one central ribbon-striking opening. Notwithstanding this design, superspeed typists still encounter an occasional jamming problem with a conventional keyboard mechanism. This problem was eliminated by use of a typewriter font ball made popular by IBM. Now manual-input keyboards have evolved into non-ribbon electrical types for use with computers. These are the wiping-contact and capacitance-change designs that don't use moving parts to strike a ribbon; output is displayed on a video screen, while hard copy is produced on a printer without a keyboard through impulses fed to it by electrical signals from a computer.

Without moving parts to jam, why do we need the QWERTY system, whose random placement of letters invites inefficient finger motions as they stroke the keys? Clearly, we do not! Not if we want information input to be speeded up, that is, as the high-speed computer age envelops us.

Other typing systems have been examined for generations now, with at least one, the Dvorak or DSK keyboard, deemed to significantly improve typing speed and reduce fatigue. The DSK system places vowels (A, E, I, O, U) as the leading consecutively placed keys. A more recent keyboard development uses a wipe-activated design in which a "wand" is employed instead of fingers. Here, letters are arranged so that some of them form commonly used words. For example, A N D letters are sequential, as are W I T H E, which form five words.

Whichever system is finally adopted to replace the archaic QWERTY, we had better move toward it with dispatch. If we don't, the full impact of having computers and peripheral equipment that operate at lightning speed will be wasted owing to slow manual inputting. For those of you who might counter this urgent need by pointing out the development of voice-recognition equipment, I say, don't bet on it within the next generation or two for widespread use with all the words in a dictionary.

Art Salsberg

Popular Electronics

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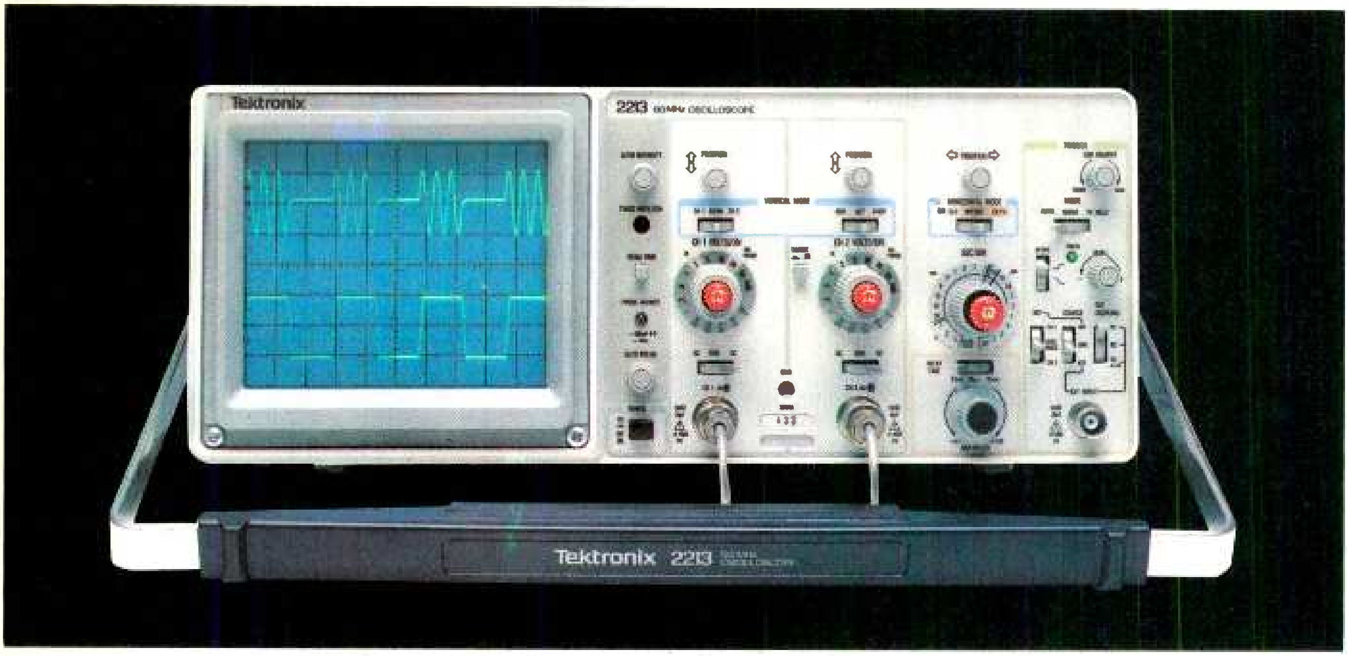

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LETTERS

Waveform Credit

The sidebar on digital storage that accompanied "Add Waveform Storage to Your Oscilloscope" in the April 1982 issue has some information that appears in the Tektronix "The Digital Storage Oscilloscope" primer. It was not credited as such, however.—*Pam Edstrom, Public Relations Supervisor, Tektronix, Inc., Beaverton, OR.*

Thanks for calling the oversight to our attention. Credit for using some information from this fine primer is herewith issued.—Ed.

Fantastic Help

Your magazine is really *fantastic* in the help it gives me in applying electronics to my computer hobby. I really appreciate articles like the one on the r-f modulator in the February issue ("One-Chip R-F Modulator for Crisp Color Signals").—*H.R. Brown, Spirit River, Alberta, Can.*

Lower-Case on Model III

Your review of the Radio Shack TRS-80 Model III Computer was very interesting but one point should be clarified. The author stated that lower case letters could not be directly accessed in Scripsit. This is easily done using Control-Shift. I have been using this word-processing program for reports, spec drawings, and correspondence and it meets all my needs with ease and style.—*W. Barbier, Hazelwood, MO.*

With regard to the availability of lower-case with the Scripsit program on the TRS-80 Model III, I use the "bare-bones" Scripsit and find that "shift-O" gets me into lower case and back with no difficulty.—*A. Kohlber, Jr., New Carrollton, MD.*

Out of Tune

In "Digital Automotive Tune-Up Meter" (May 1982), in Fig. 4, the *C9* shown in the upper part of Fig. 4 should be *C1*. It is shown on both sides of the board because it can be mounted on either side, depending on its size. In the same article, the plug marked ACC on the front panel and shown in the photo, is not used in this project.

In "Experimenting with Fiber Optics" (May 1982), in Fig. 2, the emitters of the two output transistors should be connected together to ground and the collector of the bottom transistor should go to *R1*, not to ground.

In "Build a Synchronous Detector for AM Radio" (April 1982), in Fig. 4, pin 3 of *IC8* should be connected to pin 11 of *IC2* not pin 10.

NEW PRODUCTS

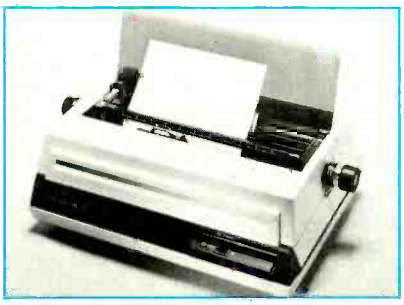
Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Microprocessor-Controlled FM Tuner

The only controls on the front panel of the FM4, the new digital display FM tuner from Quad Electroacoustics, are eight pushbuttons to store and recall stations in memory, a power switch, and a tuning knob. A microprocessor controls all other functions. Once the appropriate preset button is pushed, the microprocessor recalls the required station from memory and automatically adjusts muting and afc. In addition, a bar-graph indicator simultaneously displays signal strength and center tune for the most accurate reception. Specifications include a signal-to-noise ratio of 70 dB (stereo); selectivity, 53 dB; sensitivity (50-dB quieting), 2.7 μV mono; capture ratio, 2.5 dB; and output at 30% modulation, 100 mV. $625.

CIRCLE NO. 86 ON FREE INFORMATION CARD

Daisy Wheel Printer



The Model TP-1 from Smith-Corona is a microprocessor-controlled daisy wheel printer that is reported to deliver letter-quality printout at a speed of 144 WPM. It can be used with word processors, personal computers, and small business sytems. There are few controls on the TP-1, and its drop-in ribbon cassettes are said to be easy to load and replace. The printer is available with either a parallel or serial data interface and offers an 88-character ASCII set in 10 and 12 character/inch (cpi) versions. The 10-cpi model prints a 105-character line, and the 12-cpi expands the line length to 126 characters. Printing output is unidirectional; paper feed is frictional in single sheets or forms. The print impression is operator-selectable at five levels of striking force. $895.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Dual-Output Power Supply

A new power supply, the Model 1652, has been announced by B&K-Precision. It features two variable outputs, each with a rated potential from 0 to 25 V and a current selectable from 0 to 1.5 A. Both outputs can be operated independently of one another or in a tracking mode. In the latter, the B output can be preset to any percentage of the A supply voltage. When the A output is varied, the B output will vary accordingly. The unit is also reported to offer a switching preregulator that reduces internal heat dissipation—permitting operation at full rated output in an environment up to 40°C (104°F). Either supply can be connected with a plus or minus polarity; and either can be floated to an external voltage or connected to a chassis or earth ground. For high voltage or current requirements, the A and B supplies can be connected in series or parallel (with balancing resistors). $465.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Portable VCR

The Panasonic Model PV-5500 video cassette recorder's portable section weighs just over eight lb (with battery) and measures approximately 4" × 9" × 10". Controls include AUDIO DUB and camera remote ON/OFF. The unit can also be activated by a 16-function wireless remote control that directs POWER ON/OFF, CHANNEL UP/DOWN, TV/VCR selection, TAPE SEARCH, STOP, PLAY, RECORD, FAST FORWARD, REWIND, PAUSE/STILL, FRAME ADVANCE, and variable slow motion from ¼ to $\frac{1}{30}$ speed. Its tuner/timer section can be set to record four programs over a two-week period, giving the unit an eight-hour recording capability with the longest-playing VHS tapes. The programmable timer offers 105 channels: 12 vhf, 70 uhf, 9 midband, and 14 superband. It can also record CATV with an optional cable adapter. The LCD indicator shows approximate battery time remaining and functions as a tape counter that retains memory for up to several hours when power is cut off. Audio and video jacks are provided for connection with another VCR. $1350.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Printer Buffer

A 64K printer buffer said to be compatible with all popular microcomputers and parallel printers has been announced by Quadram Corporation. Called MicroFazer, the parallel-in/parallel-out data buffer uses standard Centronics signals and can receive data at rates to 4000 cps. The data is then transferred to the printer as rapidly as the printer can handle it. Power can be drawn either from the printer or from a separate 9-V, 500-mA supply. Standard calculator or battery chargers can also be used. $299.

CIRCLE NO. 90 ON FREE INFORMATION CARD

Alpine Car Stereo

The Model 7146 Bi-Level ETR/PLL is Alpine's in-dash car AM/FM stereo/cassette receiver with electronic digital display. It has light-touch ten-station preset, Dolby NR, auto mute, auto seek, a memory function, separate controls for bass and treble, preamp fader, metal tape capability, a local/DX select, engine noise suppressor, automatic cassette reverse, ignition key-off eject, and loudness contour. Specifications are: frequency response with metal tape, 40 to 16,000 Hz ±3 dB; wow and flutter, 0.1% (Wrms); tape S/N with Dolby, 65 dB; and FM sensitivity, 16.3 dBf/1.8 μV (75 ohms). It measures 7"W × 2"H × 5"D. $500.

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Scanner Converter

A converter that is reported to allow complete coverage of the 225-400-MHz mili-

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MEMOPAK 64k memory extension for $179.95

Give your diminishing memory more byte.

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The Sinclair ZX81 has revolutionized home computing. The MEMOPAK 64K RAM extends the memory of ZX81 by a further 56K to a full 64K. It is neither switched nor paged and is Directly Addressable. The unit is user transparent and accepts such basic commands as 10 DIM A (9000). It plugs directly into the back of ZX81 and does not inhibit the use of the printer or other add-on units. There is no need for an additional power supply or leads.

Description of memory

0-8K . . . Sinclair ROM

8-16K . . . This section of memory switches in or out in 4K blocks to leave space for memory mapping, holds its contents during cassette loads, allows communication between programs, and can be used to run assembly language routines.

16-32K . . . This area can be used for basic programs and assembly language routines.

32-64K . . . 32K of RAM memory for basic variables and large arrays. With the MEMOPAK 64K extension the ZX81 is transformed into a powerful computer, suitable for business, leisure and educational use, at a fraction of the cost of comparable systems.

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Within the first six months, should anything go wrong with your MEMOPAK, return it to us and we will repair or replace it free of charge.

Try MEMOPAK with no obligation

You can use our MEMOPAK in your home without obligation. After 10 days if you are not completely satisfied, simply return it for a full refund.

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A complete range of ZX81 plug-in peripherals:

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- MEMOTECH Digitising Tablets
- RS232 Interface
- Centronic Interface and Software Drivers

All these products are designed to fit "piggy-back" fashion on to each other and use the ZX81 power supply.

Further information forthcoming.

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Memopak 64k RAM	$ 179.95		
Memopak 16k RAM	$ 79.95		
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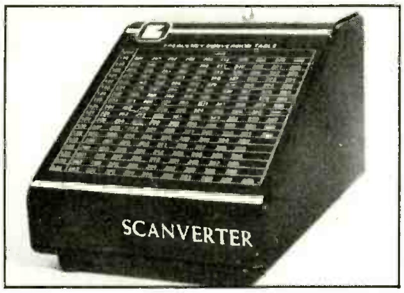
PE07

CIRCLE NO. 30 ON FREE INFORMATION CARD

tary/federal aircraft band has been announced by Grove Enterprises. Called the



Scanverter, it is used in conjunction with a standard aircraft-band scanner and is said to permit eavesdropping on such interesting communications as Tac-air war games, Coast Guard search and rescue missions, military satellites, and space shuttle radio links to earth. A Grove development called "bandstacking" is claimed to compress the entire uhf aircraft band (175 MHz wide) into the 118-136-MHz range tunable on a standard aircraft scanner. Additional tuning and adjustments are said to be unnecessary. Other features include an all-metal cabinet for shielding, an 11-pole filter for suppression of out-of-band interference, and a frequency-conversion chart printed on the cabinet. The unit is powered by 12 V dc. $100. **Address:** Grove Enterprises, Brasstown, NC 28902.

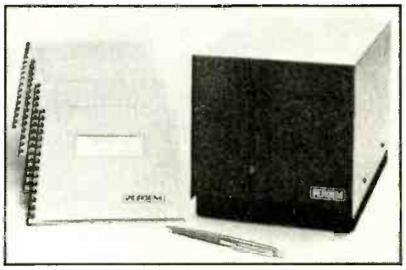
Automatic-Tape-Adjusting Cassette Deck

The AD-3800 is Aiwa's new top-of-the-line cassette deck featuring its microprocessor-controlled Digital Automatic Tape Adaptation (D.A.T.A.). This system is reported to automatically check playback output, adjust bias level, and optimize the Dolby B and C noise-reduction (all within 16 seconds) while retaining, if desired, the same setting for up to 24 hours. An Automatic Demagnetizing System (A.D.M.S.) degausses the heads. A dual-capstan tape transport is said to reduce wow and flutter to 0.025%; and direct-coupled circuitry in the recording amplifier permits signal linearity at levels up to 16 dB. Additional features include a digital electronic display for standard or real-time tape position indication, a memory function, IC logic controls with cue/review operation, switchable MPX filter, auto repeat, timer standby, and a three-color 16-LED per channel peak level display with hold. S/N is given as 75 dB with Dolby C; frequency range is 20 to 20,000 Hz. $595.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Winchesters for Micros

Percom Data Company is now offering 5¼" Winchester disk systems for a variety of personal microcomputers. Called the Percom Hard Disk (PHD), the system features a "smart" microprocessor controller and comes in 5M- and 10M-byte versions. The controller can handle up to four drives, providing 40M bytes of on-line storage capacity.



Backup can be from hard disk to hard disk, or from hard to floppy, with an optional floppy-disk controller. Standard configurations are available for the Apple II, Heath-Zenith 89, IBM Personal Computer, and the TRS-80 Model III. Direct interfacing is possible to the Model III; host system adapters are provided for the other computers mentioned. The PHD system also includes an RS-232-C port, for interfacing to any computer with a data terminal I/O channel. Full buffering permits the host computer to accept data as time allows. $2495.

CIRCLE NO. 93 ON FREE INFORMATION CARD

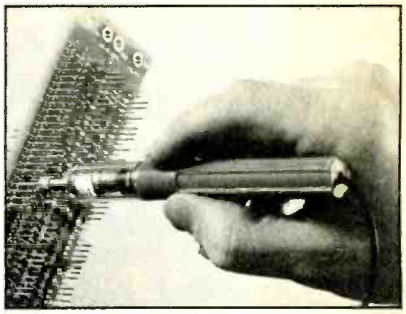
Remote Control for Home Appliances

ECM's Centurian Home Management System is designed to remotely control home appliances via modules that work from ac outlets. The Centurian also offers modules for the control of thermostats and sprinkler water. The master control panel (which plugs into the ac line) has seven-day programmability, auto-snooze alarm clock, back-lit LCD with dimming-level indicator, and control of up to 274 different combinations of time and day when a given command is to be executed. An optional battery back-up takes over in the event of a power failure. The Centurian is said to be compatible with all Sears, Radio Shack, and BSR remote modules. $250.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Wire-Wrap Tester

The Model 120-113 continuity and voltage tester from Desco Industries is designed for use with powered or unpowered Wire-Wrap connections. It comes with standard 12-gauge sockets on each end. The sockets slip over the pins for positive contact without



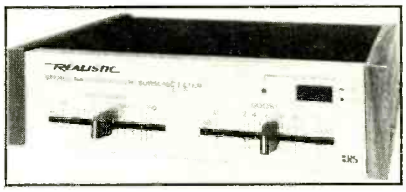
disturbing pins adjacent to the ones being tested. The Model 120-113 is rated for powered connections up to 600 V. It uses its own batteries to test unpowered connections. $23. **Address:** Desco Industries, Inc., 761 Penarth Ave., Walnut, CA 91789.

Desktop Business Computer

Casio announces availability of its new FX-9000P personal computer. Its keyboard and CRT are built into a single housing that is about the size of an electronic typewriter. The computer features 4K slot-in CMOS RAM packs that can store programs for up to three years for easy retrieval. Expansion is to 32K bytes. The 67 keys comprising the keyboard include a calculator section with a capability to compute built-in standard deviation, linear regression, correlation coefficients, and other mathematical functions commonly used in business and scientific analysis. A graphic display can be used to plot these functions; hard copies may be made with an optional graphics printer. The language of the FX-9000P is CASIO BASIC. $1,200.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Bass Enhancer



Radio Shack is offering a stereo-system accessory that is claimed to improve low-end response of any speaker, while also rejecting potentially damaging subsonic signals. Called the Bass Enhancer/Subsonic Filter (Model 42-2106), it uses a slide-control 40-160-Hz center frequency adjustment to help match its performance to characteristics of a

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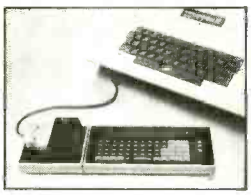

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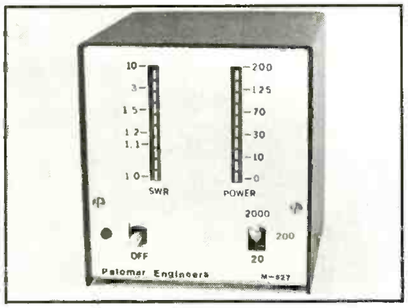

The new M-827 from Palomar Engineers is designed to compute standing wave ratios automatically and display them on a light bar. SWR reading is claimed to be accurate regardless of input power level (which is also displayed on a light bar adjacent to the SWR display). The M-827 has a frequency range rated at 1 to 30 MHz and power range of 20, 200, and 2000 W. The SWR scale is 1 to 10, with logarithmic response. $98.

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The Finney Company has a new addition to its automobile FM Booster line, called the Stereo III. The device is intended for use with any auto AM/FM radio. When the Stereo III is in operation, a gain of 16 times the normal FM signal strength is said to be possible. This is especially useful in fringe areas; but even in strong signal areas, according to Finney, the receiving circuits will not overload. The unit has dual gain-control pushbuttons for local and fringe reception, an antenna trimmer, and dual LED ON indicators. The Stereo III is a one-piece unit designed to mount under the dash. $40.

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The Alpha Magnum Corp. Model TTF temperature probe is designed to work in conjunction with a digital multimeter. With a sensitivity range from −67°F to +302°F, the TTF is claimed to offer an accuracy of

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The new "Steppin' Out 3" Mura is designed to give the owners of personal-size stereo radios and tape players (all brands) the capability of playing them out loud. Designated Model HS-45, it has four speakers consisting of two 5" high-compliance woofers and two 1½" aluminized-dome tweeters. Specifications are: 4 W continuous power output at 1 kHz; a frequency range of 80 to 24,000 Hz; 40 dB channel separation. Features include a LED "on" indicator bass/treble switch and dipole telescoping antenna. Measuring 18" × 8" × 3", and powered by eight "D" batteries, the unit comes wth a 12-V dc adapter input jack, a one-foot audio connecting cable, and adjustable carrying strap with shoulder pad. $80.

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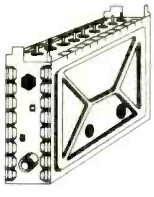

Freq. Range UHF470 - 889MHz
Antenna Input 75 ohms
Channels 14-83 Output Channel 3

KIT NO	PART NO	DESCRIPTION	PRICE
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3	TP7-SW	P.C.B. Potentiometers, 1-20K, 1-1K, and 5-10K ohms, 7-pieces	5.95
4	FR35-SW	Resistor Kit, ¼ Watt, 5% Carbon Film, 32-pieces	4.95
5	PT1-SW	Power Transformer, PRI-117VAC, SEC-24VAC, 250ma	6.95
6	PP2-SW	Panel Mount Potentiometers and Knobs, 1-1KBT and 1-5KAT w/Switch	5.95
7	SS14-SW	IC's 7-pcs, Diodes 4-pcs, Regulators 2-pcs Heat Sink 1-piece	29.95
8	CE9-SW	Electrolytic Capacitor Kit, 9-pieces	5.95
9	CC33-SW	Ceramic Disk Capacitor Kit, 50 W.V., 33-pieces	7.95
10	CT-SW	Varible Ceramic Trimmer Capacitor Kit, 5-65pfd, 6-pieces	5.95
11	L4-SW	Coil Kit, 18mhs 2-pieces, 22µhs 1-piece (prewound inductors) and 1 T37-12 Ferrite Torroid Core with 3 ft. of #26 wire	5.00
12	ICS-SW	I.C. Sockets, Tin inlay, 8-pin 5-pieces and 14-pin 2-pieces	1.95
13	SR-SW	Speaker, 4x6" Oval and Prepunched Wood Enclosure	14.95
14	MISC-SW	Misc. Parts Kit Includes Hardware, (6/32, 8/32 Nuts, & Bolts), Hookup Wire, Ant. Terms, DPDT Ant. Switch, Fuse, Fuseholder, etc.	9.95
		When Ordering All Items, (1 thru 14), Total Price	139.95

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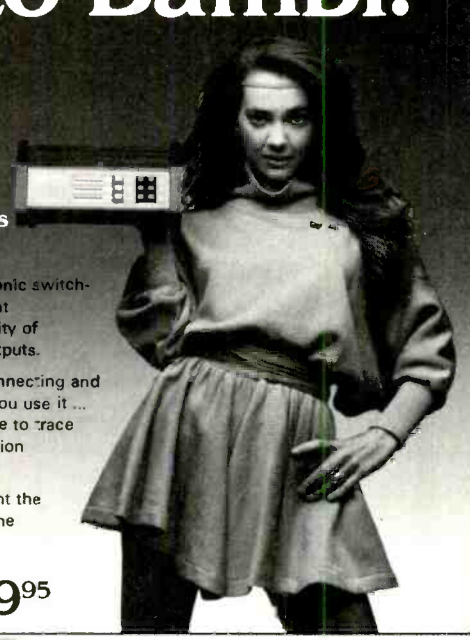
Electronically



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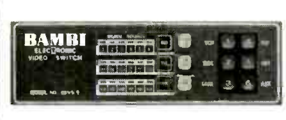
Model BEVS-1 **$129.95**



Bambi's front panel was designed with the user in mind. Computer styled construction, with soft-touch keyboard (rated for over 10 million operations), arranged in matrix form allows easy input/output selection without refering to charts. Functions selected through the keyboard are immediately displayed on the 18 LED status indicators.

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- Weight — 4½ lbs

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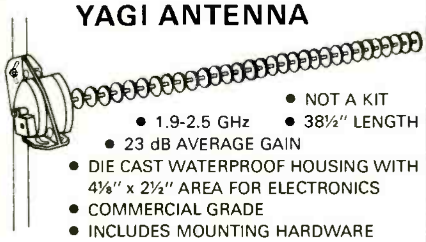

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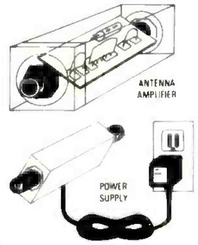

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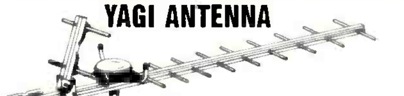

STVA-3 Yagi Antenna, 14.5 dB, 75 ohm, Chan. 60-68 ..... $16.95
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4	4FR-31-PWD	Resistor Kit, ¼W, 5% 29-pcs, ½ W 2-pcs	4.95
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9	9CC20-PWD	Ceramic Disk Capacitor Kit, 50 WV, 20-pcs	7.95
10	10CT5-PWD	Varible Ceramic Trimmer Capacitor, 5-65pfd, 5-pieces	4.95
11	11L5-PWD	Coil Kit, 18mhs 3-pcs., 22µhs 1-piece (prewound inductors) and 2 T37-12 Ferrite Toroid cores with 6 ft. #26 wire	6.00
12	12ICS-PWD	IC Sockets, Tin inlay, 8 pin 4-pcs, 14 pin 1-pc and 16 pin 2-pcs	2.95
13	13SR-PWD	Enclosure with PM Speaker and Pre-drilled Backpanel for mounting PCB and Ant. Terms	14.95
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ENTERTAINMENT ELECTRONICS

The AM Stereo Situation

By Len Feldman

AM STEREO, its proponents maintain, is an idea whose time is overdue. The increasing importance of the listening audience in automobiles has been the driving force behind broadcasters' efforts to bring to the AM band what FM listeners have enjoyed for years—stereo sound.

Most car audio systems include a tuner able to receive FM stereo; but in a moving vehicle this is not always as satisfying as it might be. FM transmission frequencies and low-gain, non-directional mobile antennas limit the range of satisfactory reception to between 20 and 50 miles, while signal reflections, causing distortion, are generally far more severe in a moving vehicle than in a living room. AM stations, by contrast, can be heard at great distances from the transmitter, and groundwave reception is not subject to the audible effects of multipath. (Skywave reception at night is another story.) No wonder, then, that by the mid-1970s, AM broadcasters were crying for stereo capability.

After five years of deliberation, a "false start" almost two years ago, and recent rumors that a single system for stereo AM transmission would be selected, the FCC surprised everyone by handing down what it calls a "marketplace" decision. In fact, this is no decision at all, because it allows any AM broadcast station to transmit stereo programming using any one of *five* systems that have been under study for many years. To many, this non-decision is tantamount to sounding a death knell for stereo AM. Others say that, ultimately, a single system will be favored by the consumer.

It would be nice if a stereo AM receiver could be constructed to automatically detect which of the five broadcast systems it was receiving and then switch in appropriate decoder circuitry. Indeed, such a receiver may be possible some day, but this is almost certain to make its cost prohibitive. That's because the five systems which have been "approved" for trial by the FCC are mutually incompatible, in spite of some superficial similarities.

Here is a brief description of each of the systems, gleaned from the FCC's Report and Order. A look at the associated block diagrams of possible receiving circuits should reveal that there is no single-circuit approach that will decode for all of them.

Frequency and Amplitude Modulation. The Belar system frequency-modulates the r-f carrier with a pre-emphasized, 400-μs, (L − R) signal. The maximum frequency deviation of the carrier varies from 312.5 Hz at low frequencies to 6250 Hz at higher audio frequencies. The (L + R) signal amplitude-modulates the frequency-modulated r-f carrier. The Belar system is therefore called an AM-FM system. It also includes a pilot tone of 10 Hz (for automatic identification or switching from mono to stereo at the receiver). A possible decoder circuit for the Belar system (Fig. 1) has r-f and i-f stages identical to those in a normal AM receiver. Output of the i-f amplifier is divided into two separate detection signal paths. One signal is applied to a conventional envelope detector, where the (L + R) signal is recovered. The other path applies the signal, after appropriate limiting, to an FM detector such as a discriminator. After detection and de-emphasis, the recovered (L − R) signal matrixed with the (L + R) to yield separate left and right outputs.

Variable Phase and Gain. The Harris system modulates two carriers that are separated in phase by up to 90 degrees. They are referred to as the in-phase carrier and the quadrature carrier. The full (L + R) signal modulates the in-phase carrier while a reduced (L − R) signal modulates the quadrature carrier. The two modulated carriers are then combined into one signal whose phase and amplitude are used to modulate the phase and amplitude of the transmitted signal.

An equivalent way of describing the Harris system is to consider it as two car-

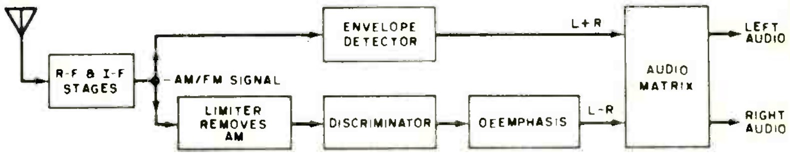

Fig. 1. Belar's system requires separate AM and FM detector circuits.

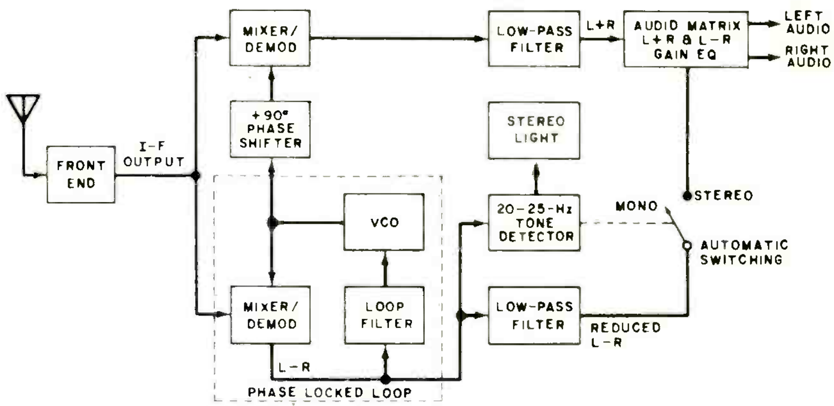

Fig. 2. Basic configuration of an early version of the Harris system.

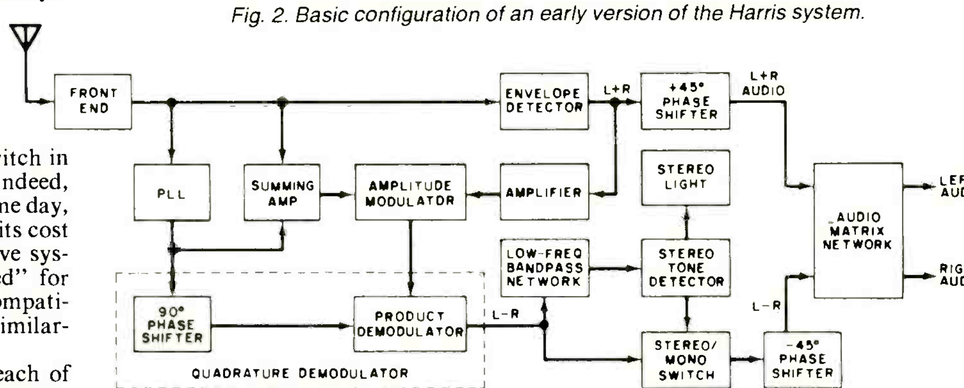

Fig. 3. Single-receiver diagram for Kahn/Hazeltine ISB system.

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riers that are separated by a phase angle that can vary from 90 to 30 degrees. The left channel modulates one of these carriers while the right channel modulates the other. The variable angle between the carriers is directly related to the gain-reduction factor of the (L − R) channel. In order to properly decode the Harris signal, the instantaneous gain used in the (L - R) channel must be transmitted along with the signal. This is done by varying the frequency of an accompanying pilot tone from 55 to 96 Hz, depending on gain reduction of the (L − R) channel. Harris calls it the V-CPM, for Variable Compatible Phase Multiplex.

An early version of a receiving circuit for the Harris system is shown in Fig. 2. A phase-locked loop circuit regenerates unmodulated i-f from the incoming i-f signal. This regenerated i-f is 90 degrees out of phase with the incoming modulated i-f, so the mixer demodulates the quadrature (L - R) signal. A 90-degree phase shift produces unmodulated i-f that is *in phase* with the incoming modulated i-f. This signal, combined with the modulated i-f signal in another mixer, is used to demodulate the (L + R) signal. The two signals are adjusted for equal gain and are then matrixed to yield left and right audio signals.

Independent Sidebands. The Kahn/Hazeltine system phase-modulates the r-f carrier with the (L − R) signal such that amplitude modulation of the carrier places most of the left-channel stereo information in the lower sideband and most of the right-channel stereo information in the upper sideband. The system is called an "independent sideband" (ISB) system. Kahn/Hazeltine uses a pilot tone of 15 Hz which angle-modulates the carrier by approximately 0.1 radian. Interestingly, two ordinary AM radios, placed at the left and right of the listener, can actually be used to recover a stereo effect when the Kahn/Hazeltine system is broadcast. The left-hand radio is tuned slightly *below* center frequency of the ISB transmission, while the other radio is tuned slightly *above* center frequency. Thus adjusted, the two radios will directly demodulate the upper and lower sidebands and will produce left and right audio signals. Kahn has also developed a decoder that will work from the i-f of a single AM receiver (Fig. 3).

Phase and Amplitude Modulation. The Magnavox system uses the (L − R) signal to phase-modulate the r-f carrier and the (L + R) signal to amplitude-modulate the phase-modulated carrier. This type of system is known as an AM-PM system. Magnavox also phase-modulates the r-f carrier with a 5-Hz pilot tone of 4 radians peak deviation.

A receiver suitable for decoding the Magnavox signal has its i-f amplifier output split in two directions (Fig. 4). An envelope detector is used to extract the AM information and to detect the r-f carrier level for automatic gain control. At the same time, i-f output is limited and applied to a PM detector which recovers the (L − R) signal and the 5-Hz pilot tone. The recovered (L − R) and (L + R) signals are then matrixed to derive the left and right stereo signals.

Phase Shift and Forced Compatibility. The Motorola system amplitude-modulates two r-f carriers that are separated by 90 degrees. The (L + R) signal modulates one carrier while the (L − R) signal modulates the other. The two carriers are then added together. At this point, the system is linear; however, the amplitude of the resultant signal is not fully compatible with monophonic envelope-detector type AM receivers. To achieve better compatibility, the combined signal is first hard-limited and then remodulated with the (L + R) signal. This destroys the linearity which the system had previously, but establishes mono compatibility for the system—an absolute requirement for any system being considered. Motorola calls its system C-QUAM, for Compatible Quadrature Amplitude Modulation. Also included is a 25-Hz pilot tone.

A C-QUAM receiver obtains (L + R) information from a gated envelope detector. Two synchronous detectors are used to demodulate the phase-modulated information quadrature component and the cosine of the phase angle. These outputs are fed to an analog divider, which yields the difference signal (L − R). The envelope detector output, (L + R), and the divider output, (L − R), are applied to an audio matrix that provides the desired stereo signals. A fourth demodulator controls the operation of the phase-locked loop and the squelch circuitry.

Which System is Best? Each proponent cites advantages for his system and disadvantages for those of his opponents. If there is, in fact, a "best" system, what likelihood is there that the listening public will really contribute to a decision based on technical merit? FCC Commissioner Abbot Washburn held out little hope for intelligent decision making in his dissenting statement attached to the official FCC Report and Order on AM stereo. His statement said, in part, ". . . whichever system or systems evolve will be based not on true consumer preference resulting from comparisons of the five systems, but rather on the size of promotion and merchandising expenditures and like factors." Commissioner Washburn summed up the feeling of many industry experts by stating, ". . . this type of marketplace referendum is not the way to make an informed choice, if indeed it results in a choice at all . . ." ◇

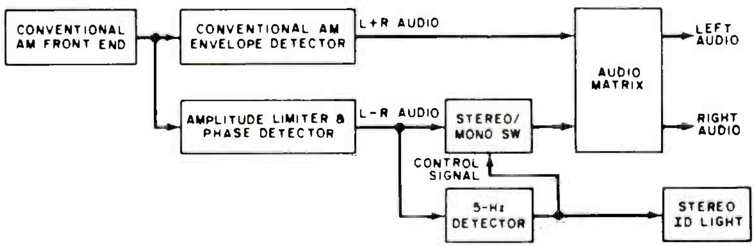


Fig. 4. Basic receiver configuration for Magnavox system.

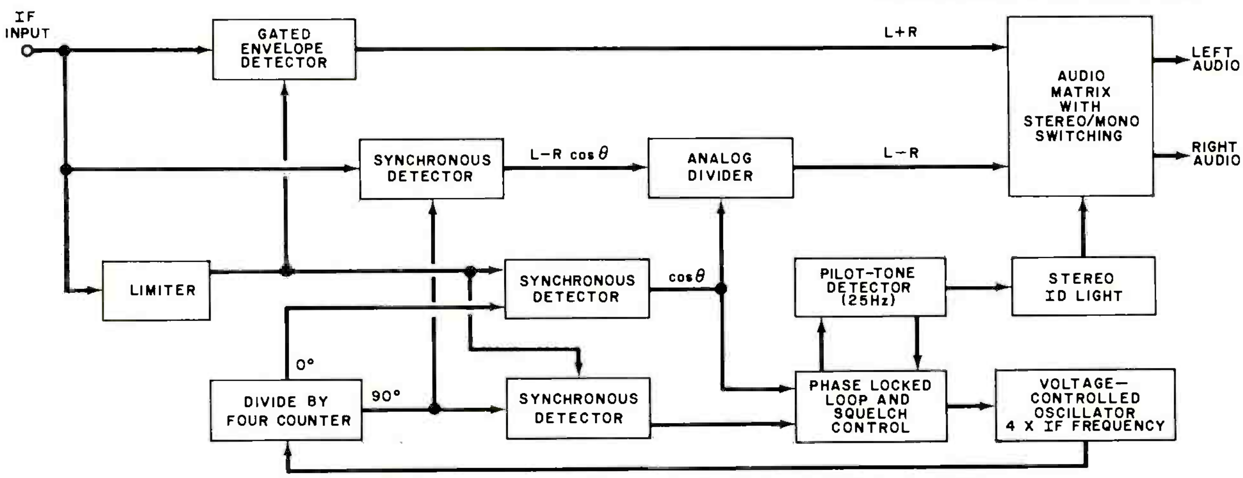


Fig. 5. Block diagram of stereo AM decoder for Motorola C-QUAM system.

Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Shure V15 Type V Phono Cartridge

The V15 Type V is shown above and in tonearm with leveling stylus installed.

THE new V15 Type V phono cartridge succeeds the Type IV as Shure's top-of-the-line cartridge. It features a thin-wall beryllium stylus cantilever that reduces its effective tip mass to half that of the Type IV. This contributes to giving the Type V substantially improved "trackability" at the higher audio frequencies. ("Trackability" is a term coined by Shure to describe the ability of a stylus to follow groove modulation at any frequency or velocity in the audio range, without losing contact with the groove or damaging the record's soft vinyl material.)

The V15 Type V is supplied with a novel mounting and alignment fixture that greatly simplifies its installation. Purchasers of the cartridge are entitled to receive at no charge, a copy of a new test record (the TTR-117, discussed in "Entertainment Electronics" in the June 1982 POPULAR ELECTRONICS) which can be used to establish a single-valued "Total Trackability Index" (TTI) for any cartridge, in addition to checking other aspects of a cartridge's performance.

The price of the Shure V15 Type V is $250. The TTR-117 record is available for $15 (free with cartridge).

General Description. The Type V makes it possible to track any amount of groove modulation that we know to exist on commercial music records, at a playing force of 1 gram. It can track 60 cm/s at 10 kHz, and up to 80 cm/s in the 4-to-5-kHz range. This is made possible principally by Shure's new Microwall/Be™ stylus cantilever.

Shure developed a process for forming a thin sheet of beryllium (0.5 mils thick) into a tube with a diameter of 18 mils. The result is an effective tip mass (exclusive of the diamond tip itself) considerably less than half that of the Type IV stylus shank—increasing its resonance frequency about 50%, to 33 kHz.

Because the Microwall/Be shank is stiffer and lighter, it can be made longer than previous shanks without sacrificing performance. This lowers the vertical tracking angle to 20 degrees (the international standard) when the cartridge is operated at its nominal 1-gram force. Unlike most cartridges, however, the V15 Type V is not rated for operation over a range of forces, but is simply specified for 1 gram.

The diamond tip itself has the hyperelliptical shape (0.2 × 1.5 mils) developed by Shure some years ago and used in many of their better cartridges. It is a modified line-contact shape that gives low tracking distortion and record wear. The contact surfaces of the diamond are MASAR™ polished to an exceptional smoothness, for reduced noise and record wear.

The fixed coils and magnetic structure of the V15 Type V have a lower impedance than previous models, which makes its frequency response less dependent on the load capacitance and resistance. Output level, however, has not been sacrificed, due to the high efficiency of Shure's laminated pole-piece design. The contact pins are gold-plated and the entire body is encapsulated for long, trouble-free life.

Other features of previous Shure cartridges have also been retained. The Dynamic Stabilizer, first used on the Type IV, continues to damp the arm/cartridge resonance. The brush, containing more than 10,000 electrically-conductive fibers, removes dust from the record grooves ahead of the stylus and simultaneously discharges accumulations of static electricity that can cause noise and attract dust. The stabilizer requires an additional 0.5 gram of downward force to overcome its weight, so the arm must be set for 1.5 grams to obtain the rated tracking force of 1 gram on the stylus. Swung all the way down, the stabilizer serves as a stylus guard, and it locks in an upward position when not in use.

In addition, a different type of guard protects the Type V stylus. Called the Side-Guard system, it is a square-cross-section channel surrounding the stylus shank. When the cartridge is subjected to a side thrust, such as scraping the pickup across a record, the entire stylus system is pushed upward into the cartridge body, guided by the angled walls of the Side-Guard tube. This feature has no effect on the normal operation of the stylus, and even offers protection against violent scrubbing motion that would destroy an unprotected stylus.

The final feature of the Type V is not a part of the cartridge at all. Yet in many respects it is the most important consideration from the standpoint of the typical user. Since one of the most critical tasks in setting up a music system involves the correct mounting of the phono cartridge in the headshell, it is vital that the user be able to do this job properly.

If the stylus is not removed during this process, there is a real danger of damaging it. Even if you do remove the stylus, you risk dropping parts used in the mounting assembly.

Shure has simplified this process by providing plastic captive nuts that slide into slots on the cartridge body and are retained there while one inserts the screws from the other side of the headshell. The major innovation, however, is the provision of a precisely machined mounting jig that holds the cartridge body in place (with the stylus removed) while the headshell is being fastened to it.

With the cartridge correctly installed and oriented, a plastic *leveling* stylus is inserted into the cartridge body. This is use to rotate the entire headshell (if necessary), ensuring that the *playing* stylus will be perpendicular to the record surface. When the leveling stylus is removed and the playing stylus inserted, the V15 Type V is fully mounted.

This procedure is much easier (and faster) to do than to describe. It should require no more than a minute or two. It also seems to be at least as accurate as any other alignment system we have used.

Replacement styli for the V15 Type V are the V15V-VN5HE, nude hyperelliptical tip; the V15V-G-VN5G, nude spherical tip; and the VN578E biradial tip optional 78-rpm stylus.

Laboratory Measurements. The Shure V15 Type V was installed in a moderately massive tonearm (about 18 grams). It was operated at its rated 1-gram force, except when we determined its minimum tracking requirements (for which it had to be operated at 0.75 grams or less). At 1 gram, it played every part of the Shure "Audio Obstacle Course" records (ERA III and ERA IV), plus all our other high-level test records. In the test tonearm, the cartridge resonated at 8 to 9 Hz, not far from the ideal 10-Hz range. The Dynamic Stabilizer damped the resonance so effectively that we had to disable it to get a positive indication of any arm resonance. The cartridge output at 3.54 cm/s was 3.4 MV, with the channel levels balanced within 0.4 dB. The vertical stylus angle was the rated 20 degrees.

We measured the frequency response of the cartridge with the CBS STR100 test record, loading the cartridge with its rated 47,000 ohms and a number of capacitance values from 70 to 440 pF. The flattest response was obtained with 280 pF, close to the rated 250 pF, and we used this value for all other tests. The frequency response was flat within +0, −1 dB from 40 to 15,000 or 20,000 Hz, depending on the channel.

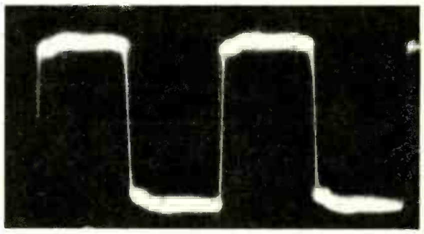
Channel separation was about 26 dB up to 10,000 Hz, and 14 dB at 20,000 Hz. The smooth, wide response of the cartridge was further demonstrated by its response to the 1000-Hz square wave on the CBS STR112 test record. The playback waveform had almost no overshoot and a very slight ringing on its flat portions (mostly from the record, which rings at about 40,000 Hz).

The tracking distortion was measured in the midrange with the Shure TTR-102 test record, and at high frequencies with the TTR-103 record. The TTR-102 has IM distortion test bands with 400 and 4000 Hz signals, at levels from 6.9 to 27.1 cm/s. The output of the cartridge was measured on a standard IM analyzer. The distortion varied randomly between 1 and 1.7% over the full range of levels. These are roughly the residual levels on the record, and they confirm the excellent linearity and trackability of the cartridge at low and middle frequencies.

The TTR-103 record has shaped 10.8-kHz tone bursts at a 270-Hz rate over a range of velocities. The effectiveness of the Microwall/Be shank in improving high-frequency trackability was shown by the negligible distortion reading from the cartridge output—0.7% from 15 to 30 cm/s—probably the residual distortion of the setup.

User Comment. It is difficult to find anything significant in the performance of the V15 Type V to criticize.

With a response flatness rivalling that of some amplifiers, sufficient trackability to cope with any signal it will encounter on today's disc recordings, better channel separation than most records and many FM tuners, and distortions so low that they cannot readily be distinguished from the residual levels on available test records, the Type V would seem to be a virtually ideal cartridge.



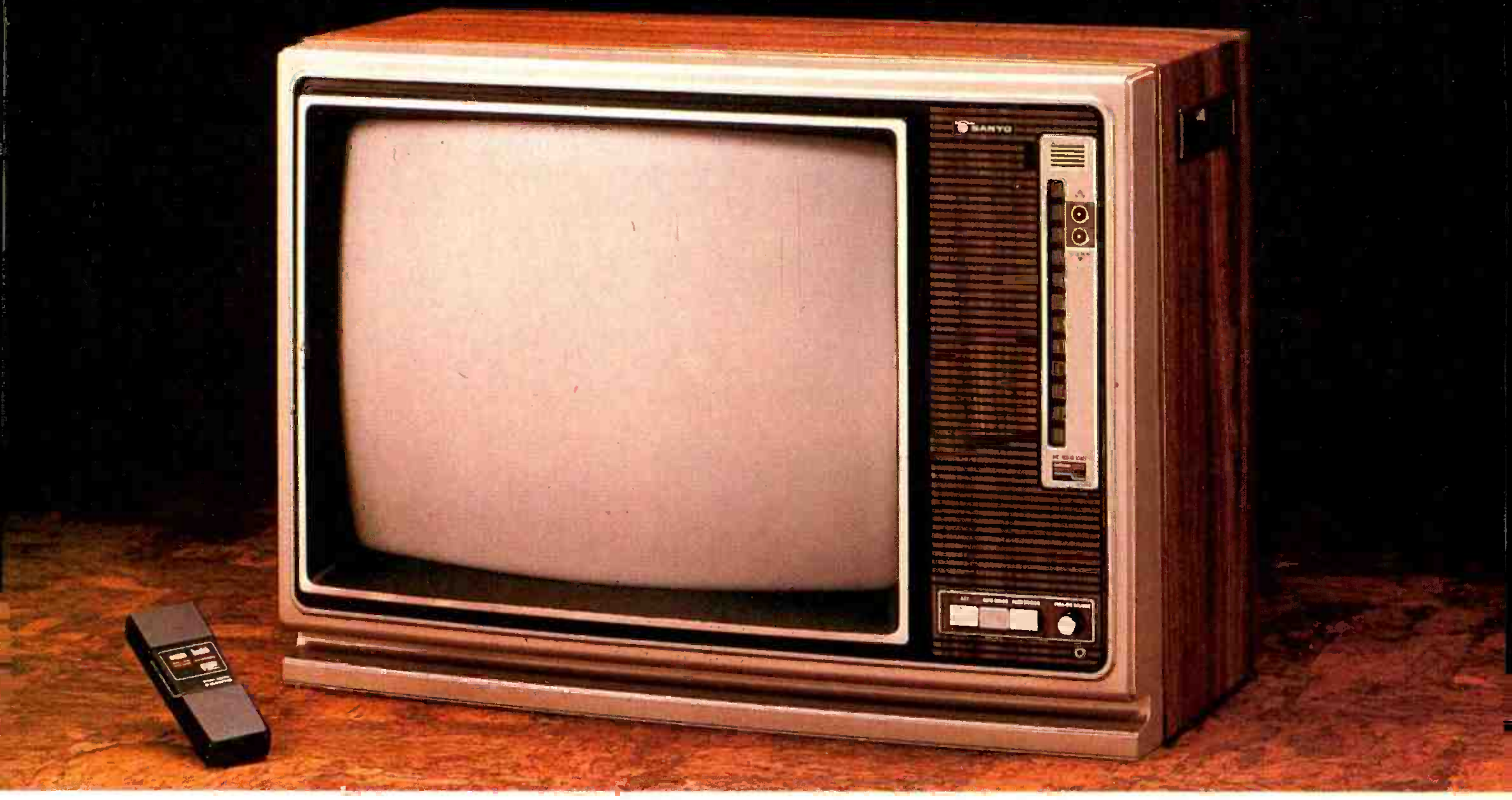
Response to square-wave test.

The playback sound from the V15 Type V had no characteristic coloration or quality that we could detect. What one hears is what is on the record—for better or for worse.

The owner of a V15 Type V can not only be assured that he has purchased one of the finest cartridges that money can buy, but that he has installed it in the optimum manner to deliver its full performance. That is no small achievement, in our view. *—Julian Hirsch*

CIRCLE NO. 101 ON FREE INFORMATION CARD

Popular Electronics Tests



Sanyo Model 91C85 19" Color TV Receiver

The Sanyo 91C85 is a 19" table-top color receiver with an 82-channel varactor-controlled tuner that is simple, yet elegantly designed. With it, the viewer can precisely adjust each channel frequency via a control assembly mounted behind the front panel. Any 12 channels (both uhf and vhf) can be programmed into the illuminated front-panel selector and then accessed directly by UP/DOWN pushbuttons, or with a wireless remote control.

Another front-panel feature is Sanyo's "Trimatic" color control. It consists of three pushbuttons that, respectively, set the TINT/COLOR, BRIGHTNESS/CONTRAST, and automatic fine tuning (AFT). Otherwise, the front panel is sparse—with VOLUME/ON being the only additional control. The 91C85's remote control is similarly clutter-free—containing only one channel selection, VOLUME UP/DOWN, and POWER ON/OFF buttons. The set's dimensions are 17¼"H by 24½"W by 18¼"D. Suggested retail price, including remote control, is $540.

General Description. The Model 91C85 contains five pc boards, two of which are mounted back-to-back—performing the channel selection, remote control, and vhf/uhf tuning. All of the i-f, video, audio, and deflection circuitry is contained on the main signal circuit board, which is mounted horizontally below the picture tube. A small pc board, about 2" by 2", houses the three front-panel pushbutton switches that select manual or automatic control of aft, tint/color, and brightness/contrast. A sixth pc board (part of the picture tube socket assembly) contains all the amplifier adjustments for red, green, and blue video output.

The outer sleeve of the tuner (Fig. 1) controls a three-position switch corresponding to the frequency range of the associated channels, i.e., VHF LOW, VHF HIGH, and UHF. The tuner's inner shaft operates the fine-tuning potentiometer. Next to each display window is a light that illuminates the particular channel you are watching.

The two pushbuttons controlling the UP/DOWN channel selection operate via the Mitsubishi *IC1601* shown in Fig. 2. This chip accepts commands to step its four-bit ring counter up or down. The counter responds with a binary signal, which is then decoded and translated into a precise voltage that tunes in the channel you have selected.

The remote control sends out an ultrasonic signal that is decoded at the receiver by another IC (not shown). The up/down signals coming from this IC are then processed by *IC1601*, just as if they had come from the set's UP/DOWN pushbuttons on the front panel.

Other important technical features include the SAW (Surface Acoustic Wave) filter, which eliminates the need for additional i-f alignment, and the use of automatic control circuits for chrominance phase angle, determination of fleshtones, and proper video levels.

A power IC provides dc regulation for the 123-V B+ line. The three low-voltage dc sources (one 15-V and two independent 12-V sources) are derived from the flyback transformer. Each voltage is regulated by a zener diode. A single IC provides the sync separation, noise cancelling, and the vertical and horizontal sweep signals. Two transistors are used in the horizontal flyback, and three transistors perform the vertical output amplification. The 28-kV high-voltage supply is rectified by a conventional three-diode

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PENTHOUSE . . . "ESCORT's performance stood out like an F-15 in a covey of Sabrajets."

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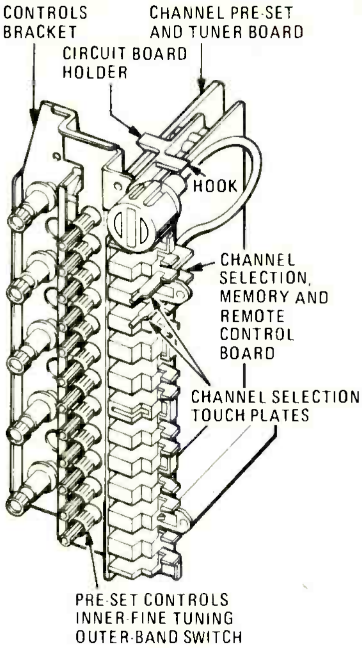

Fig. 1. A cut-away view of the tuning control.

series arrangement on the high-voltage flyback winding.

Laboratory Tests. We tested the unit as we received it—right out of the factory-sealed carton. Test results are summarized in the Table. During testing, all r-f signals were supplied to the set through its 300-ohm antenna input terminals.

Vhf and uhf tuner sensitivity (30 μV at 66.0 dBm, and 38 μV at 63.5 dBm, respectively) reflect the high performance of both the tuners and their r-f-input circuits. Similarly, the noise figures at the video detector (10 dB for vhf and 16 dB for uhf) mean a clear picture without "snow" for the viewer. (Truly excellent noise figures would be somewhat lower—say, 8 dB for vhf; 12 dB for uhf—but this set's performance is about as good as any in its price range.) A video bandwidth of 3.55 MHz, measured at the video detector, is wide enough to give a sharp picture with good detail.

To quantify picture "sharpness" we adjusted the high-frequency portion of the video signal between the video detector and the CRT with the sharpness control. At the maximum sharpness setting (Fig. 3), the video response is rolled off 3 dB at 3.6 MHz, and very little "overshoot" (silhouettes around the image edges) is apparent. By way of comparison, the minimum sharpness setting (Fig. 4) rolls off the video response 3 dB at 3.45 MHz, producing a picture with much softer definition.

A similar, but less subjective test involved the use of a color-bar generator. Figure 5 shows the color-bar pattern at the video input, and Fig. 6 shows its appearance at the first video amplifier, after passing through the vhf tuner and detector section. Not the slight overshoot due to the peak in the high-frequency response. Whereas the pattern appeared virtually undistorted when the sharpness control was set to minimum sharpness, vertical white lines, indicating overshoot, appeared when this control was set for maximum sharpness.

The stability of the tuner's local oscillator was tested over a period of six hours, with line-voltage variations between 105 and 130 V ac, and the set's automatic fine tuning (aft) disabled. Under all conditions, the oscillator response was within 0.35 MHz of the exact frequency needed to receive a particular channel.

Horizontal and vertical nonlinearity were also measured over a six-hour period, using a raster format. We measured the width and height of the squares at the far left, right, top, and bottom of the screen, and compared them with a square at the center. The horizontal discrepancy was 2% on the left, 1% on the right. Vertical discrepancy was 1% at the top, and 0% (undetectable) at the bottom. In other words, image distortion (pin-cushioning) is negligible at the edges of the screen.

Convergence was a comparably excellent 99%. Reds, greens, and blues are clear and undiluted.

The 123 V from the dc power supply was found to vary no more than 4% over the 105 to 130 V ac range.

The regulation of the high-voltage power supply was similarly tested at various line voltages and at different levels of brightness and contrast. We found a drop of approximately 10% when the line voltage was at its minimum and the brightness at its maximum setting. There was, however, no "blooming" of the color picture.

Interference on channel 2 was barely noticeable with a 4-W citizen's band transmitter (28 MHz) radiating just 60 feet away from the TV set. The vhf tuner's 300-ohm input contains a high-pass filter which, together with the 300/75-ohm balun helps to keep such interference to a minimum.

Airplane flutter, too, is minimized by an automatic gain control (agc) that uses a multiple-stage r-c circuit. Thus, when a plane is overhead, amplitude distortions in the r-f and i-f signals are compensated by a stage with a short time constant. As the aircraft reflection fades, the longer time constants compensate.

Dc restoration is close to 98%, and is provided by the same circuit that adds the Y signal to the RGB output. This produces very vivid, pure colors.

Finally, the simple 3" by 5" oval speaker was found to produce adequate, ordinary TV audio.

SANYO MODEL 91C85 19" COLOR TV RECEIVER LABORATORY DATA

Parameter	Measurement
Sensitivity, vhf (Ch. 2):	−17.2 dBmV
Sensitivity, uhf (Ch. 50):	−14.7 dBmV
Noise figure, vhf (Ch. 2):	10 dB
Noise figure, uhf (Ch. 50):	16 dB
Overall video bandwidth:	3.55 MHz
Tuner oscillator frequency stability:	±0.35 MHz; 90%
Horizontal nonlinearity:	2% left, 1% right
Vertical nonlinearity:	1% top, 0% bottom
Voltage regulation, 123 V dc: (105 to 130 V ac)	96%
Voltage regulation, 28.5 kV: (105 to 130 V ac + min./max. brightness and contrast	90%
Dc restoration:	98%

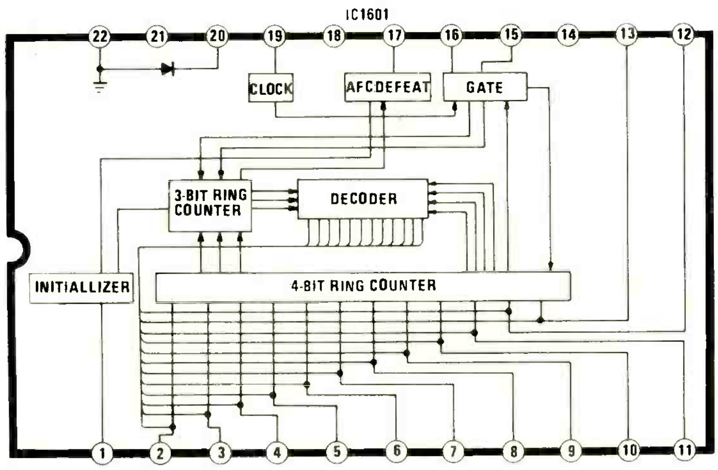

Fig. 2. The Mitsubishi IC1601 controls channel selection.

Comments. The electronic performance tests verified what we saw: The Sanyo Model 91C85 produces excellent color pictures with strong, pure reds, greens, and blues. Depending on the brightness/contrast setting, however, pastel colors were sometimes suppressed, making some nature scenes appear unnaturally bright.

While the varactor tuner in the set we tested may not have been aligned for its maximum sensitivity and noise performance (our measurements of these parameters fell a bit short of Sanyo's specs), the receiver still worked quite well, even in fringe reception areas. We were particularly impressed with the stability and accuracy of the tuner oscillator, and found that the deflection circuits produced a very linear, well-converged color picture.

The electronic tuning section functions as designed, though not including the 23 midband and superband cable channels may be a very minor drawback for some people. (Sanyo's 91C89 includes this feature, as well as a few others for $89 more.)

All-in-all, we found this to be an excellent 19" color set, with a well-engineered chassis, simple, reliable circuitry, and accessible test points for easy servicing. —*Walter Buchsbaum*

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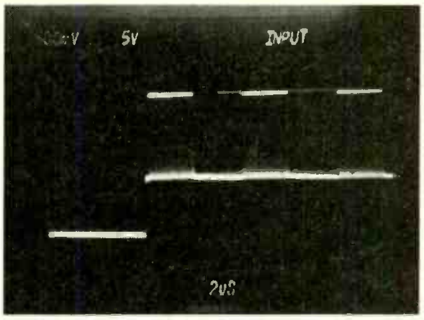


Fig. 5. Color-bar signal at the video input.

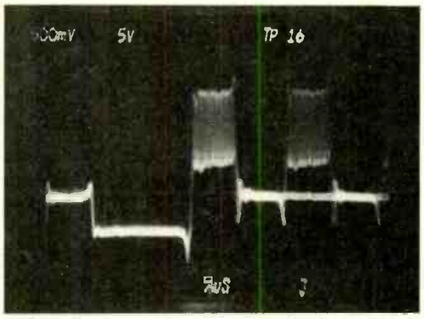


Fig. 6. Color-bar signal at first video amp.

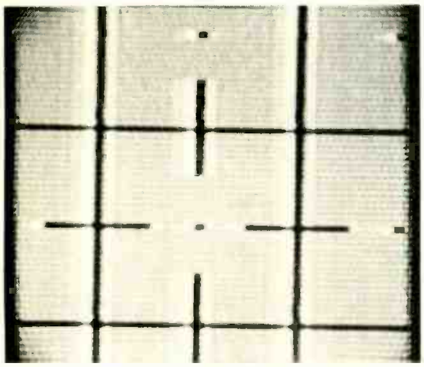


Fig. 3. Max. sharpness shows overshoot.

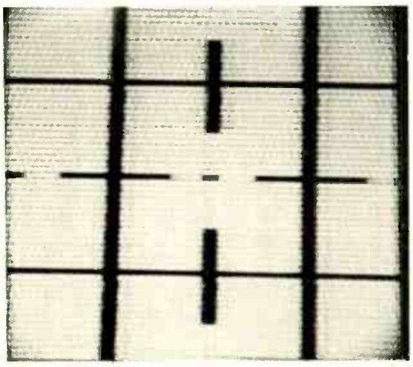
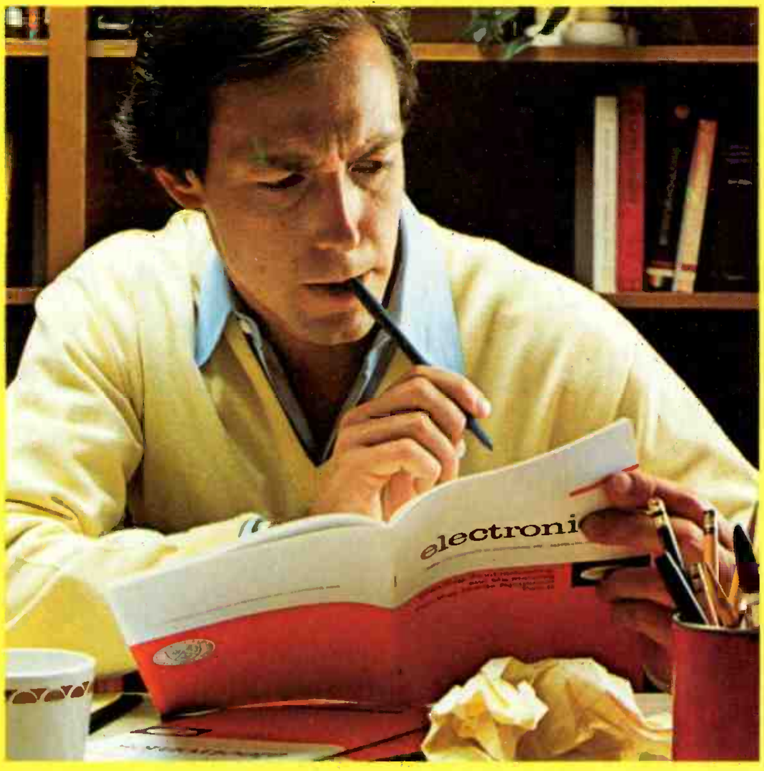


Fig. 4. Min. sharpness shows softer detail.

Learning electronics is no picnic.



At any level it takes work and a few sacrifices. But with CIE, it's worth it.

Popular Electronics Tests

Systems Group Model 2829 Microcomputer

MODERN microcomputer systems are exhibiting great computing power and functionality unimagined only a few years ago. One such product is the Systems Group's Model 2829. Priced at $9565, the basic system comes with 128K bytes of RAM, four serial and two parallel I/O ports, one double-sided floppy, and one 10M-byte hard disk. Among the software available are MP/M 1.1 at $435, MP/M II at $585, and Oasis at $995. CP/M comes as standard equipment.

Characterized by its manufacturer as well-suited for business, industry, and educational needs, the Model 2829 is in many ways the most powerful system we have tested to date. But don't let sheer power fool you: we found some questionable items that have to be considered before an investment in a system like this is justified.

The Micro That's a Mini. The 2829 is unlike any other system we've reviewed since it couples Winchester storage with multi-user/multi-tasking capability. Moreover, the 2829 should be considered a minicomputer simply because it offers the computing functionality of much larger machines.

This computer uses a 4-MHz Z80A microprocessor and is built around an 8-slot, S-100 bus motherboard that meets IEEE 696.1/D2 conventions. Meeting these conventions implies that the system can handle 8-bit and 16-bit processors while allowing master/slave bus operations—something that this particular manufacturer hasn't taken full advantage of.

The heart of the system is the Model CPC-2810 processor board—which includes the Z80A, four serial ports, two parallel ports, a real-time clock, and a vectored interrupt structure. Working in conjunction with the processor board are two Model OM6400, 64K-byte bank-selectable dynamic memory boards for single- or multi-user applications. In addition, the System 2829 includes a Memorex 101 Winchester 10M-byte drive and a Model FD1160 double-density/double-sided floppy capable of 1.2M bytes of storage.

Interestingly, the Memorex drive is being replaced with Fujitsu or Quantum drives. This is because the Memorex drives have exhibited reliability problems, and are of limited capacity. Also, since many system designers experienced difficulties with the original Memorex drive, even Memorex has abandoned the design in favor of the Fujitsu product.

The 2829's floppy disk system is supported by the Model FDC-2800 floppy disk controller, that has onboard sector buffering and full direct memory access (DMA) functionality. This card uses the NEC-765 controller in concert with a Z80A DMA chip. The Model HDC-2800 hard disk controller from Morrow Designs can control up to four daisy-chained Winchesters.

Although the processor board has both serial and parallel ports, all interfacing to the outside world is handled via personality modules that are mounted on the back panel.

The Supply That Protects. In the case of a high-performance microcomputer, the power supply not only provides system power but also serves to protect the system against loss of power due to power-line surges. The 2829 system's supply is a linear design that provides unregulated voltages of 8 V at 16 A, ±16 V at 2.5 A, and exhibits a 20-ms holdup time after removal of ac power. The regulated portion of the supply is 5 V at 5 A, 24 V at 5 A, and − 5 V at 1 A.

The power is tied to the motherboard midway in the bus structure. This is important to ensure that sufficient power is provided to all boards on the bus—a factor frequently forgotten by many S-100 bus system designers.

In conjunction with the power supply, there are two unfused convenience outlets located on the rear panel of the enclosure. These can be used to provide power to printers, terminals, modems, etc. However, care must be taken to ensure that the maximum switched load never exceeds 9 A.

The power-supply system also allows either 115 V ac or 220 V ac to be used, and features a HI/LOW switch for operation with less-than-predictable local power sources.

System cooling is accomplished via a rear-mounted fan. This fan provides a Venturi effect, moving hot air up and away from the lower component areas while circulating air over the card rack and past the disk systems before exhausting it. Fresh cool air is brought in via a filter on the front panel.

What We Tested. The system we evaluated consisted of a 10M-byte Winchester, 1.2M-byte floppy, 128K-byte dynamic memory, and four serial ports with I/O personality cards. There was no parallel port implementation. Everything is housed in a very sturdy metal enclosure that requires only sliders to be added to fit in a standard 19-in. RETMA rack.

As shipped, three ports—0, 1, and 2—came configured at 9600 baud for terminal operation and the fourth port (3) was configured for printer operation at 300 baud. Our model employed the serial ports as dual asynchronous receiver transmitters. We could have requested synchronous I/O (SIO) ports—an option available at additional cost.

To bring the system up, we attached a MicroTerm ACT 1A CRT, configured for 9600 baud on port 0. We then booted CP/M from the distribution diskette, as suggested by the documentation. We used this for initial system checkout to determine if the system did, in fact, sign on—which it did, with a fair amount of speed.

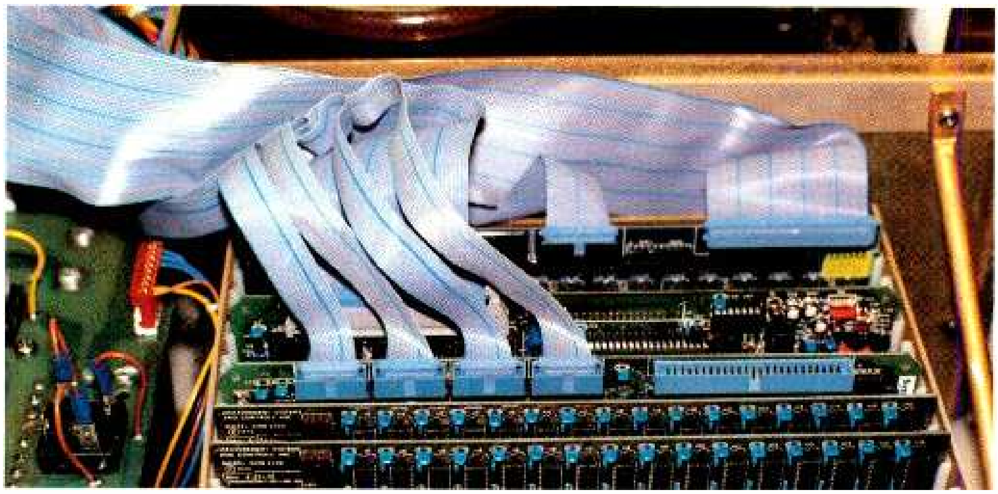
Unlike other formats that store the CP/M system on the reserved tracks of the diskette, the Systems Group stores CP/M as two files—CPSYS.SPR and CBIOS.SPR. The first contains Digital Research's Console Control Processor (CCP) and BASIC Disk Operating System (BDOS) modules in their page-relocatable format. A loader, provided by the manufacturer, is used to load these files and execute them, thus speeding up system operation. This precludes reloading the CCP on warm boots: a jump to location zero is effected instead, and a disk reset is performed.

Using this technique, one version of CP/M fits any memory size. In addition, since reserved tracks aren't used, you can add additional drivers to CP/M without worrying about running out of space to store the system. We liked this since it meant we didn't have to SYSGEN each diskette.

Once we were assured that the system did, in fact, operate, we then re-booted using MP/M 1.1. Booting takes place either at power on or by depressing the front panel RESET switch. When a diskette is placed in the floppy drive, the system boots from it; otherwise a boot takes place off the hard disk system.

Once booted under MP/M, we formatted the hard disk—the operating system takes into account any premapped defects and locates others, mapping them into the BDOS and directing the system to reserved tracks. The version we booted allows the use of both the floppy and the hard disk, and only one console. The system we transferred to the hard disk supports three consoles and a printer. (You can establish up to 14 consoles, but you have to "grow" the system in terms of memory and I/O modules.)

Hardware Evaluation. In the case of the motherboard, the designers followed current conventions by providing passive termination, ground planes between the signal paths, and full power grounds. Scope tests of the board, with the processor performing transfers between the disk controllers and memory, showed no crosstalk or ringing. Other signals were clean square waves without "rounding" or degraded rise time due to board capacitance.



Using an 8-slot motherboard, a hard-disk controller is combined with a floppy controller having DMA capability.

We like the diagnostic LEDs on the CPU and memory boards that advise when a segment is being used and for how long. We "fooled" the machine by partly disabling a segment (a 16K-byte block) to force an error. This error was then easy to locate using the LEDs.

Although the power supply does have fold-back time in case of power failure, the 2829 does not employ this feature to automatically save any data currently in memory. However, fold-back time is used to prevent a hard-disk crash since sufficient time exists to pull the head back from the media.


Apple III

We rated the hardware very good, and found the design conservative and straightforward in its handling of the bus and processor. The only serious hardware fault we found involves the front-panel air filter. For this class (and price) of system we expected a form-fitted, fiber-glass design.

The Software Key. As stated earlier, the system was set up for operation under MP/M 1.1 with three consoles and one serial printer. Implementing MP/M was easy since the Systems Group had done all the work; we merely moved it to the hard disk. Unfortunately, with this implementation you either operate with floppy disk and hard disk, and one console, or have just the hard disk available to several users. This is because MP/M requires that the floppy-driver area be made to support user maps. MP/M II takes care of this problem, and with a properly written BIOS (called an XIOS in MP/M) will give the best of both worlds.

Among the first tests we performed was our obligatory speed test in BASIC. Here we use 10 GOSUB 10, which pushes all the memory contents onto the stack until an error is generated. In the case of the 2829, the time needed to produce an error was 0.1 second (average) out of ten trials.

A real challenge came with the compiling of Digital Research's chess program, written in PL/I. We used three minutes as our benchmark, as measured on an Altos 4-MHz system. In the case of the 2829, we came up with 110.4 seconds for ten trials. This included compiling, linking, and loading the code. The test was also performed using CP/M. At least 56K bytes of memory is required, and MP/M restricts you to 48K.

We performed the first trial using the hard disk system, but also achieved high throughputs on the floppy system. It was slower, but still took only 2.05 minutes. The timing for this task is significant because the compiler first had to be read in, next the code (or segments to be compiled) was read in, then internal comparisons were made to tables and library functions used, and finally the code written back out.

Because the manufacturer touts the 2829 as ideal for multi-users, we attached three terminals and a printer for a full configuration. Our first task was to go in and PIP (move) a 128-entry directory from user-0 to several user areas on the disk (you have a total of 16 user areas per logical disk). By setting up for automatic operation, and causing operations to take place between several areas at the same time, we were able to exercise the hard disk to its maximum. Part of this test included setting the time, using the time-of-day function in MP/M, and printing it out every minute.

Our next step was to perform several tasks on the system simultaneously. We asked console 1 to use user-0 and play chess. Then we instructed console 2 to set up an assembly in user-1, which we then made a background operation by employing the MP/M detach command (invoked by entering a control D from the keyboard). This freed console 2 for other operations. We also set up a spooling operation of a previously large text in user-2 and began a text-editing project in user-3. Meanwhile, console 3 was used as a general purpose utility port to monitor all system operations and slide in and out of the other areas.

We found little or no degradation of operations, except when console 3 invaded another console's user space (this is a shortcoming of MP/M 1.1 that has been taken care of in MP/M II).

Some Critical Thoughts. Undoubtedly the 2829 is powerful. But this power brings some new headaches, requiring that you go through a relearning process. For example, a "console" is different from a "user." The *console* is the physical device connected to a physical port, the *user* is the area on a disk that the console is allowed to use for handling data. These user areas can be public or restricted— making difficult your first implementations of MP/M. *(Continued on page 34)*

Although the system's power supply is quite good, it doesn't fully protect against power surges or dropouts. In one case, for instance, it allowed the floppy disk head to bang, causing a misalignment to which some NEC-type floppies are prone.

We really like the fact that the floppy system didn't care about diskette data density or format—it could read anything except diskettes formatted on a California Computer Systems controller. We would have preferred an MP/M implementation allowing all consoles and the floppy system to be used at the same time. We don't believe the business user will want to change disks to get the system into another configuration.

The documentation supplied is very good. Its technical content is among the best offered by any computer company. Information for reconfiguring is readily available, with sufficient details so that code can be quickly modified. However, there is very little here directed at the casual user (no manual). Most of the information is for the system integrator or computer store. According to company officials, this will be remedied, probably by the time you read this review.

The Systems Group went through a great deal of effort to implement the 2829's operating systems so they would be useful. Unfortunately, by planning to implement operating systems like Oasis, rather than sticking with well-supported systems, their efforts are diffused. And since the 2829 is aimed at business and industrial applications, it would be a plus if the System's Group would offer communications packages such as the Remote Terminal Batch Emulator that Lifeboat Associates provides for IBM communications. (A company spokesman did report that the Systems Group is planning to add networking capability, plus the ability to pool resources from remote locations, later this year.)

Conclusions. The Model 2829 is only one of several 2800-series configurations available from the Systems Group. We found it to be highly reliable, well built, and meeting all the specifications claimed by the manufacturer. We didn't feel, though, that it offered anything unusual relative to other computing systems in its class.

Where software is concerned, Oasis, though a very fine operating system, isn't as heavily supported as CP/M or MP/M. And those Oasis packages that are offered often carry a high price tag. So keep this in mind. We'd advise that you bypass MP/M 1.1 and get MP/M II, but be careful on the implementation.

—Carl Warren

CIRCLE NO. 102 ON FREE INFORMATION CARD

PE COMPARES NEW HANDHELD COMPUTERS

Author discusses results of his "hands on" experience with Sharp, Quasar, and H-P handhelds

BY FORREST M. MIMS

TEN years ago, Hewlett-Packard introduced the HP-35, the world's first scientific calculator. Though some "experts" said its $395 price tag would hold little appeal for consumers, the company sold more than 300,000 units in the first three years. The HP-35 was certainly revolutionary for its time, but it was just another step in the evolution of handheld electronic calculating devices that still continues today.

The most recent (and most impressive) products of this evolutionary process are a new generation of handheld *computers*. These new machines are not merely upgraded calculators. They are sophisticated, fully programmable computers with alphanumeric keyboards and displays. Their memory circuits retain data and programs even when the computer's CPU is powered down. They can be expanded with additional memory modules, and can be connected to peripherals such as printers and cassette-tape storage units.

Handheld computers are much more "personal" than desktop personal computers owing to their small size and battery-powered portability. But are the new handheld computers practical? Are their prices, which can approach those of some desktop machines, justified? To answer these questions, a substantial amount of time was spent working with a handful of these units: Quasar's HHC (same as Panasonic's RLH-1000), Sharp's PC-1500 (same as Radio Shack's TRS-80 Pocket Computer Model PC-2), and Hewlett-Packard's HP-41 Programmable Calculator.

Each of these computers is unique. Here is a close look at their features, capabilities, idiosyncrasies, and peripherals.

Quasar HHC

The Quasar HHC (Hand Held Computer) is a sophisticated portable computer with advanced programming features. A product of the Matsushita Electric Corp. of Japan, the HHC (as well as a Panasonic twin model) is compatible with a wide assortment of peripherals. The computer and its peripherals are distributed in the United States by the Quasar Co. (9401 W. Grand Ave., Franklin Park, IL 60131).

The operating-system language is SNAP (derived from FORTH) or BASIC. The latter's thumb-size plug-in capsules give a choice of 8K Microsoft and 16K Level II BASIC. Moreover, CP/M software is said to be handled in conjunction with an HHC disk system.

The HHC's microprocessor is a 6502 that operates at a clock speed of 1 MHz. The machine's internal ROM capacity is 16K bytes. In addition, a receptacle on the back side of the computer can accept up to three 16K-byte ROM modules. Each module is a plastic carrier containing a 22-pin, dual-in-line ROM.

Information in ROMs cannot be altered or erased, of course, so storage is needed to allow the user to store programs and data. The HHC's internal RAM is either 2K or 4K bytes (depending on the model). This can be expanded with as many as six 8K-byte nonvolatile (continuous storage), external memory units.

The HHC has a typewriter-style (QWERTY) keyboard with 65 keys and two-key rollover. There is no numeric keypad; but an array of a dozen or so function keys, including a handy HELP key, are at the right side of the keyboard.

The keyboard provides an automatic repeat mode and full (up, down, left, right and stop) cursor control. Three keys are user definable. The individual keytops, all of which are colored gray, are *not* marked. Instead, their function or functions are printed in white and orange above each key.

The display is a 26-character (8 × 159 dot matrix) liquid-crystal readout. Status indicators (SHIFT, LOCK, DELETE, etc.) are printed in a row under the display and, when selected, are indicated by a small triangle. The machine is powered by a built-in nickel-cadmium rechargeable power pack. The dimensions of the unit are $8^{15}/_{16}'' \times 3^{3}/_{4}'' \times 1^{3}/_{16}''$.

An important feature of the HHC is its user-accessible bus. Access to the bus is provided by a double-sided edge connector recessed into the left side of the case and containing 22 contacts on each side. A spring-loaded dust cover protects the connector when it is not in use.

A wide range of compact peripherals can be connected to the HHC by means of its bus. Though it can function alone, the HHC can also act as the processor for a powerful computer system that fits in a slim-line attache case. The fully expanded attache-case system is a highly portable personal computing system that can be operated in a car, plane, or hotel room.

For example, the Quasar handheld system reviewed here included the HHC, TV adapter, telephone modem, micro printer, RS-232 interface, and a programmable memory module. All these peripherals and the HHC slide into modular plastic trays attached to each side of the HHC's I/O (input/output) adapter unit. Up to six peripherals can be connected at a single time.

The HHC can be connected via the TV adapter to an external color or B&W tele-

Counterclockwise from upper right: Hewlett-Packard HP-41, Radio Shack TRS-80 PC-2, Quasar HHC, and Sharp PC-1500 with printer.

The Quasar HHC telephone modem can be used in the field to access a network or home-based computer.

vision receiver. This arrangement is particularly handy when developing programs or using the telephone modem to access another computer or one of the computer services.

The HHC provides two video colorgraphics modes that display 64 dots by 32 lines or 64 dots by 48 lines in an assortment of black and eight colors. Sixteen lines up to 32 characters each can be displayed in various color combinations.

Using the HHC. Turn on most personal computers and the display typically shows READY, followed, perhaps, by a cursor. The HHC, however, provides an interactive series of nested menus that allow the user to select any of its various operating modes. When the machine is *initially* turned on, for example, the dis-

A

```
LIST
10 FOR I=1 TO
10
20 PRINT "THE
SQUARE OF
";I;"IS";I*I
30 NEXT I



run
THE SQUARE OF
1 IS 1
THE SQUARE OF
2 IS 4
THE SQUARE OF
3 IS 9
THE SQUARE OF
4 IS 16
THE SQUARE OF
5 IS 25
THE SQUARE OF
6 IS 36
THE SQUARE OF
7 IS 49
THE SQUARE OF
8 IS 64
THE SQUARE OF
9 IS 81
THE SQUARE OF
10 IS 100
```

Shown above, and on the opposite page, are reproductions of tapes from the printers that are peripheral play scrolls through the HHC's primary menu:

1 = CALCULATOR
2 = CLOCK/CONTROLLER
3 = FILE SYSTEM
4 = RUN SNAP PROGRAMS
5 = MICROSOFT BASIC

Pressing 1 converts the HHC into a low-grade, four-function calculator with a fully addressable memory. To return to the primary menu, the CLEAR key is pressed *twice*.

Pressing 2 causes the nested menus for the clock/controller to be scrolled through the display:

1 = SET ALARM
2 = REVIEW
3 = ACKNOWLEDGE
4 = TIME
5 = SET TIME

If the time and date have already been set, select 4; the display will read something like:

A
MON 11:05:21 M JUN 12 1982

The rate at which the HHC scrolls through the selections in its various menus can be controlled by means of the STP/SPD (stop/speed) key. Simply press STP/SPD, followed by any digit from 1 (very slow) to 0 (very fast).

To load a BASIC program into the HHC, press 5 while the primary menu is scrolling through the display. This selects Microsoft BASIC. The display will then present a menu of programs already loaded in the HHC. If none are present, the display will show:

1 = NEW FILE
NO FILES

To enter a new program, press 1. The display will read PROGRAM NAME, followed by a blinking cursor. Type in a name, press ENTER, and the cursor alone will be displayed to indicate that program entry can proceed.

B

```
1000:FOR N=1TO 10
1010:LPRINT N;" S
     QUARED IS ";
     N*N
1020:NEXT N
1030:END
```

```
 1 SQUARED IS  1
 2 SQUARED IS  4
 3 SQUARED IS  9
 4 SQUARED IS  16
 5 SQUARED IS  25
 6 SQUARED IS  36
 7 SQUARED IS  49
 8 SQUARED IS  64
 9 SQUARED IS  81
 10 SQUARED IS  10
0
```

C

```
01♦LBL "SQR"
02 0.01001
03 STO 01
04♦LBL 01
05 CLA
06 RCL 01
07 INT
08 ARCL X
09 ACA
10 " SQUARED IS "
11 ACA
12 CLA
13 X↑2
14 ARCL X
15 ACA
16 ADV
17 ISG 01
18 GTO 01
19 END
```

```
  0.0 SQUARED IS 0.0
  1.0 SQUARED IS 1.0
  2.0 SQUARED IS 4.0
  3.0 SQUARED IS 9.0
  4.0 SQUARED IS 16.0
  5.0 SQUARED IS 25.0
  6.0 SQUARED IS 36.0
  7.0 SQUARED IS 49.0
  8.0 SQUARED IS 64.0
  9.0 SQUARED IS 81.0
 10.0 SQUARED IS 100.0
```

components for the computers: (A) Quasar HHC; (B) Sharp PC-1500; and (C) Hewlett-Packard HP-41.

Your program name has now become part of the Microsoft BASIC menu and you need not assign it to a line number in your program. It is also listed in the file menu selection (key 3 of the primary menu).

After you enter the program, type BYE to load it into the HHC. Should you make a mistake or wish to modify the program, the HHC has a very versatile array of edit functions. If you expand your filed programs to a point where less than 80 characters of storage remain, the display will warn:

ONLY *** BYTES LEFT!

A word of advice to first-time HHC users who know BASIC: The HHC requires an orientation period to fully understand its operation. Be sure to read through the owner's manual and Volume I of the Microsoft BASIC manual to learn the idiosyncrasies of this machine. If you don't, you may have considerable difficulty loading programs.

For example, suppose you've figured out how to title a program, enter the title in the file menu, and write the actual program. Fine, but how do you return to the primary menu to select some other option—or load another program?

Pressing CLEAR seems to be the logical move since this returns the primary menu to the display. But when you try to load a new program, the computer beeps and displays:

NO ROOM, DELETE FILE

Pressing the I/O key will probably reveal a few thousand bytes of free internal RAM, so what went wrong?

I attacked this problem without success until returning to Volume I of the Microsoft BASIC manual. Page 4-8 warns ". . . you may be tempted to return from your program to the BASIC menu by pressing CLEAR, as you would do in most other HHC programs. Resist this temptation at all costs!" Later, on page 7-2, a way to recover from this keyboard gaffe is explained.

So how *should* you return to the BASIC menu? As I noted earlier, just type BYE. Then press CLEAR to return to the primary menu. The lesson, then, is that when the cursor is blinking while the HHC is in program mode, *never* press CLEAR!

First-time users may also run into problems when attempting to use the HHC in its direct-execution or manual mode. The machine does provide a very limited four-function calculator mode, but more advanced operations involving more than simple arithmetic require BASIC. This means naming of a new program file or going to an existing program and using the computer in its direct-execution mode (that is, entering BASIC commands without line numbers). The existing program will be unaffected by what you enter.

I much prefer the former method since it's easy to create (and thereafter select) a programless file named MANUAL MODE. Then you must learn how to enter commands.

Suppose you want to know the square root of 743. You *must* place parentheses around the numerical value and enter PRINT SQR (743). PRINT can be abbreviated?. If you enter ? SQR 743, however, the HHC will beep and display SN ERROR to remind you to insert the missing parentheses.

After figuring out this procedure, which is explained on page 2-2 of Volume II of Microsoft BASIC, I tried to find the sine of 37° by entering ? SIN (37). A beep and a BS error promptly informed me something was wrong. This time the problem was more fundamental. BS is the error code for *bad subscript*, meaning an array element outside the dimensions of an array has been entered.

Since the sine of 37° has nothing to do with arrays, I turned to the section on trigonometric functions in Volume II of Microsoft BASIC and read: "Microsoft Basic on the HHC does not have built-in trigonometric functions." Neither does the HHC have many other functions common to virtually all scientific calculators. Fortunately, appropropriate subroutines for sin, cos, tan, cotan and arctan are provided.

These idiosyncrasies should not be considered deficiencies, for the HHC is apparently designed more as an information processor than as a high-powered mathematical machine. Of course, future ROM modules may add many more BASIC functions to the HHC.

The HHC Micro Printer. Accessing the HHC's peripherals can be both awkward and tricky. For example, to use the miniature thermal printer, press the I/O key to check the printer's status. If *no* peripherals are connected to the bus, the display will show the available number of bytes in internal RAM. Otherwise, the display will identify, in turn, the name and status of each peripheral, as well as the amount of available RAM remaining in the HHC and the programmable memory module (if connected).

If the printer is in place, its status line may intially read:

1 = PRINTER OUT, OFF, SLOT = 3

OUT means the printer is an output peripheral, and OFF means the printer is now off. SLOT = 3 means the printer is plugged into slot 3 of the I/O adapter. (SLOT = 0 means the printer is plugged directly into the HHC's bus socket.)

The printer is turned on by pressing the digit key corresponding to its menu selection number (in this case, 1). The printer status line will then read:

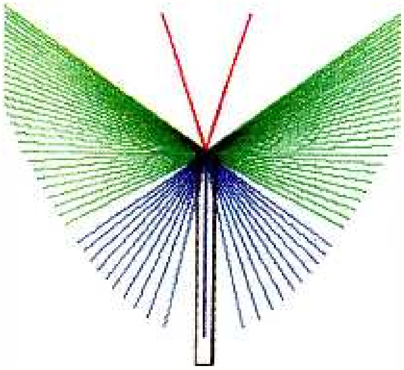
1 = PRINTER OUT, ON, SLOT = 3

Using the printer requires the assignment of a logical unit number—LUN, for short—between the PRINT statement and the data to be printed. For example, in the statement PRINT #2; 123456, #2 is the LUN. Before this statement can be executed, the printer must be referenced via its identification number (68) to LUN #2 with the ATTACH statement ATTACH 68 to #2. Now the printer will operate in response to the instruction PRINT #2; 123456 by printing 123456.

ATTACH is a clumsy barrier to gaining access to the printer. However, it does provide an important advantage in program writing since programs can be peripheral independent. In other words, the same program can be used *without modification* to operate a printer or access some other output device. ATTACH defines which peripheral is accessed.

This advantage notwithstanding, the HHC printer itself is the least sophisticated of the printer models reviewed here. Besides its rather noisy, raspy sound, printed lines are not visible by the user until the paper tape has advanced three or four lines.

Quasar recognizes some of the limitations of the small HHC printer. The manual points out that a serial printer with an 80-character line width can be connected to the HHC by means of a serial-interface adapter.



```
THE BUTTERFLY"

  1:REM  BUTTERFLY
  2:REM  F. MIMS
  3:REM  MARCH 3,
     1982
  5:LPRINT "  THE
     BUTTERFLY"
  7:COLOR 03
 10:GRAPH
 14:GLCURSOR (110,
     100)
 16:SORGN
 17:LINE (0, 100)-(
     25, 175)
 18:LINE (0, 100)-(
     -25, 175)
 19:COLOR 00
 20:LINE (5, 100)-(
     -5, -15), , B
 21.COLOR 01
 22:FOR A=0TO 50
     STEP 5
 25:N=-10*SQR A
 26:COLOR 01
 30:LINE (0, 100)-(
     N, A)
 40:NEXT A
 42:FOR A=60TO 200
     STEP 5
 43.N=-10*SQR A
 44.COLOR 02
 45.LINE (0, 100)-(
     N, A)
 46:NEXT A
 49:COLOR 01
 50.FOR B-0TO 50
     STEP 5
 60:O=10*SQR B
 70:LINE (0, 100)-(
     O, B)
 80:NEXT B
 82:FOR B=60TO 200
     STEP 5
 83.O=10*SQR B
 84:COLOR 02
 85.LINE (0, 100)-(
     O, B)
 86.NEXT B
 90:TEXT
100:END
```

Program and color graphics developed by the author for Sharp PC-1500.

HHC Memory Modules. The plug-in memory modules contain either 8K or 16K of RAM, and batteries to keep the memory alive during power-off periods. There is one main slot for the memory module, though additional memory modules could be plugged into any of the other slots of the bus connector. In fact, an additional bus module could be connected by a cable and an additional six memory modules could be connected. However, the HHC can only address one memory module at a time (either 8K or 16K.) The other memory modules can be used to store programs or data that can be switched into use as required. Total memory capacity of the computer cannot be considered as contiguous blocks of addressable memory. Outside of one 8K or 16K block, the memory is the mass storage of this computer.

Modem Module. The HHC Modem Module looks like any other coupler, but it is an unusual peripheral controlled by a replaceable ROM module. There are two such modules available for the modem unit. The first has a ROM called Telecommunications 1. It controls all of the protocol used in accessing public information networks like The Source or Compuserve. In use, all you have to do is make contact with one of these services and the modem provides all of the answers except your User Number and password. The other ROM is Telecommunications 2, and it contains programs to permit you to download or upload files from the host computer. Either of these ROMS enables a person with little experience to engage in network operation from his home.

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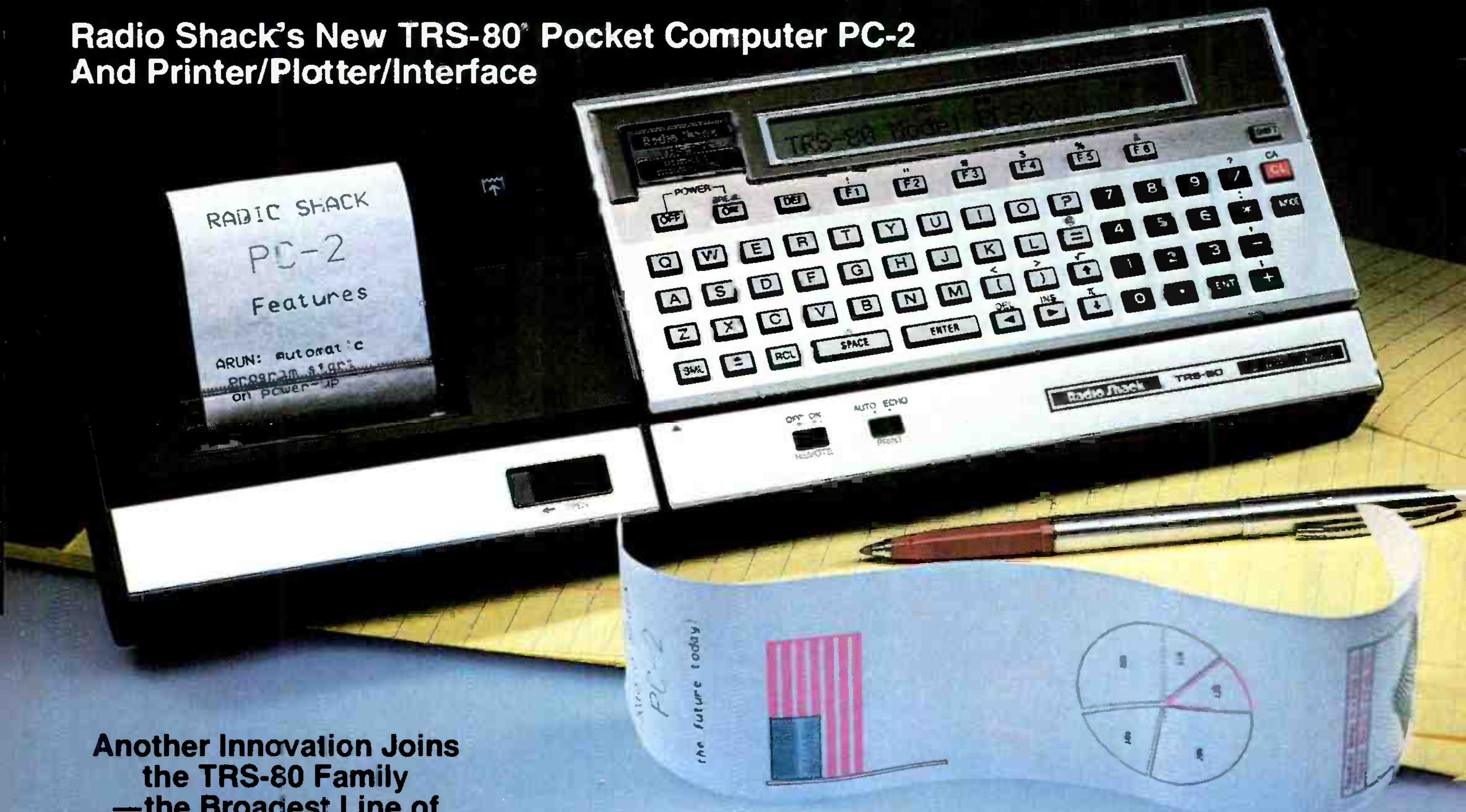

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Retail prices may vary at individual stores and dealers.

Sharp PC-1500

THE Sharp PC-1500, which uses BASIC language, is the successor to the company's PC-1211 Pocket Computer. Manufactured by the Sharp Corp. of Osaka, Japan, the PC-1500 will be distributed in the United States by the Sharp Electronics Corp. (10 Sharp Plaza, P.O. Box 588, Paramus, NJ 07652). Like the PC-1211, the PC-1500 will be available from Radio Shack (TRS-80 Model PC-2) with a slightly modified keyboard layout.

The PC-1500 uses a custom 8-bit microprocessor instead of the two 4-bit CMOS microprocessors used in the PC-1211. The new chip, which is also a CMOS device, is installed in a miniature flatpack having 76 connection pins—enough to handle keyboard, display, and other I/O signals without multiplexing. Its 1.3-MHz clock speed makes for fast, efficient program execution.

Dimensions of the PC-1500 are $7^{11}/_{16}'' \times 3^{3}/_{8}'' \times 1^{1}/_{16}''$, and it weighs 0.83 pounds. The unit is smaller than its more sophisticated cousin, the HHC.

The PC-1500 includes 2.64K bytes of RAM and 16K bytes of ROM. The internal RAM can be expanded an additional 4K by inserting a CE-151 Memory Module in a receptacle on the back of the computer. Higher-capacity RAM and RAM/ROM modules are expected to be announced in coming months.

Other features of this computer are a 26-character display, a 65-key typewriter-like (QWERTY) keyboard, and upper- and lower-case capability. (Note that the PC-1500 will run any programs written for the PC-1211.)

You can develop your own graphics and special characters with the PC-1500 by using the GPRINT command. This permits you to treat the display as a 7 × 156 dot matrix in which any combination of individual dots can be activated. The POINT command allows you to sense dots in any of the 156 columns.

The PC-1500 also provides a very versatile audio output in the form of a self-contained programmable tone generator. The command BEEP n_1, n_2, n_3 specifies a tone sequence having the following characteristics; n_1 specifies the number of beeps (from 0 to 65,535); n_2 specifies the tone frequency (use 0 to 255); and n_3 assigns the duration of each tone (use 0 to 65,279).

These capabilities can be used to create highly specialized tone combinations and even tunes. Let the results of calculations or the machine's random number function be applied to the BEEP command and the PC-1500 makes its own "music."

Using the PC-1500. Unlike the Quasar HHC, the PC-1500 is well suited for calculator-style, direct execution of a wide range of mathematical expressions. Its ten-key numeric pad is particularly handy. Though functions other than square root, pi, and the four basics (+ , − , * and /) must be typed into the keyboard, they can also be entered into one of the six multi-purpose, user-definable, reserve keys.

Normally the reserve keys, which form a row directly under the display, coincide with !, ", #, $, % and &. Up to three functions, program lines, or even complete programs can be assigned to each key with the help of the RESERVE SELECT key.

The reserve keys are made even more versatile by identifying them with labels which can be displayed by pressing RCL. Three strings of characters called *templates*, one for each batch of reserve key assignments, can be stored. A typical identification template for the trigonometric functions might be:

```
TAN  SIN  COS  ATN  ASN  ACS
```

Each of these keys could be assigned two additional functions.

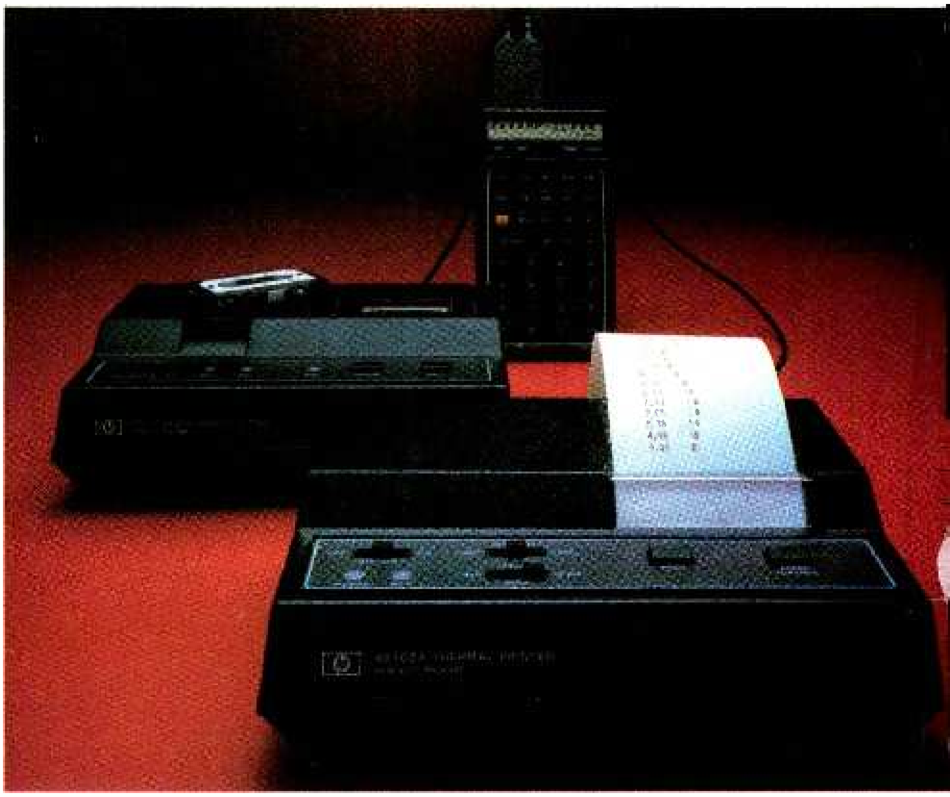
While the PC-1500 has more built-in functions than the HHC, it lacks several useful BASIC commands (such as PEEK and POKE). Its edit capability is slightly less sophisticated than the HHC's and its clock mode is not nearly as versatile. Furthermore, it totally lacks the HHC's sophisticated system of nested menus and files.

The PC-1500 user must keep track of the starting address of each of the programs and always make sure line numbers within the range of existing programs are not used in new programs. Likewise, END commands at the end of each program are imperative if the computer is to avoid inadvertently executing a series of programs when only one was intended to be run.

The PC-1500's array of reserve keys helps to compensate for the lack of a file system. Up to 18 separate programs can be assigned for one- or two-key execution. A typical reserve-key assignment might be RUN 220. When the newly assigned key is pressed, the PC-1500 will run the program beginning at line 220 just as if RUN 220 had been entered.

Editing PC-1500 programs with the aide of the delete, insert and cursor-movement keys is simple and direct. The 46 error codes are a major asset. It's particularly helpful to clear an error code, return to program mode, and immediately see the line with the problem. Often, depending upon the nature of the error, the cursor will be blinking directly over the problem.

Sharp's CE-150 Printer and Cassette Interface. Thus far only a single PC-1500 peripheral is available—the CE-150 Printer and Cassette Interface.



The HP-IL Interface Loop enables the HP-41 to be used with a number of peripherals. Shown are Cassette Drive and Printer.

The cassette interface permits the attachment of two cassette recorders, one for data and programs and the other for their recall.

The CE-150 printer is by far the most sophisticated of the three reviewed here. Since this printer, which is made for Sharp by Alps, is so unusual, let's examine it in some detail.

First, the CE-150 printer is *not* a conventional thermal or impact printer. Instead, it is a four-color, highly miniaturized pen plotter/printer. Four miniature ballpoint pens (black, blue, green and red) are installed in a revolving cylinder that slides back and forth across the paper tape. A small magnet between the black and red pens tells the computer, via a magnet-actuated switch at the left side of the carriage, which pen has been selected for printing or plotting. Pens are selected by the command COLOR n, where n is 0, 1, 2, or 3 (0 = black, 1 = blue, 2 = green and 3 = red).

Printing takes place when the selected pen is pressed against the paper tape by a miniature solenoid. Forward and reverse rotation of the roller causes the paper to move up and down to provide vertical inking. Back-and-forth movements of the pen holder provide horizontal inking. Diagonals are formed by simultaneous movements of the roller (paper) and pen.

The plotter-like operation of the CE-150 gives it amazing versatility. It can, for example, print characters in nine sizes ranging from a tiny 1.2 × 0.8 mm to a huge 10.8 × 7.2 mm ($\frac{1}{16}'' \times \frac{1}{32}''$ to $\frac{7}{16}'' \times \frac{9}{32}''$). The print size is selected by the command CSIZE n, where n is a digit from 1 (smallest) to 9 (largest). When CSIZE 1 is selected, the printing speed is an impressive eleven characters per second.

The CE-150 can generate high-quality, four-color graphics with a resolution of

The fully expanded Quasar HHC computer system fits in an attache case and can be operated in a car, plane, or hotel room.

0.2 mm ($\frac{1}{64}''$)! Thanks to a paper-gripping mechanism, even complex graphics requiring many movements of the paper tape are produced with a very high degree of accuracy.

When the computer is placed in GRAPH mode, the command LINE (0,0)-(100,100) draws a 45°-diagonal, solid line from the leftmost pen position to a point halfway across the tape. The pen color and line format can be changed by adding two additional terms. For example, the command LINE (0,0)-(100,100),4,2, will cause the printer to form a dashed (4), blue (2), diagonal line. The dash width can be varied from 0.4 mm (n = 1) to 1.8 mm (n = 8).

Add ,B to the command and the printer/plotter will form a box or rectangle defined by the diagonal. This provides a handy way of forming borders around graphs, graphic characters, and data. You can even make game boards and calendar grids!

Several other commands simplify the production of graphics. For example, ROTATE n, where n is a digit from 0 to 3, causes the printer to print sideways or upside down. The paper tape can be scrolled forward and backward up to about four inches by the line feed command LF ±n. Since there is no paper detector, the tape can actually be expelled from the roller by an LF command. Should this occur, the printer keeps right on printing, but on the roller instead of the tape.

The set origin command, SORGN, sets as the origin for subsequent x-y pen movements the current pen position. The

COMPARISON OF HANDHELD COMPUTERS

Specification	Quasar HHC	Sharp PC-1500 Radio Shack PC-2	Hewlett-Packard HP-41C/CV
Microprocessor	6502	Custom CMOS	Custom
Clock speed	1 MHz	1.3 MHz	Slow
Internal RAM (bytes)			
Initial	2K	2.6K	448 (HP-41C)
Fully expanded	4K	7.5K	6.4K (HP-41CV)
Internal ROM (bytes)			
Initial	16K	16K	Unknown
Fully expanded	64K	32K	Varies
Display	8 × 159 dot	7 × 156 dot	24 × 14-Segment
Language	BASIC & SNAP	BASIC	RPN/HP-41
Program files?	Yes	No	Yes (Label Names)
Auto line numbering?	No	No	Yes
User definable keys	4/62	6 × 3	34 × 2
Internal clock?	Yes	Yes	Plug-in module
Peripheral bus	44-pin edge con.	60-pin socket	12-pin edge con.
Power	Rechargeable	4 × AA cells	4 × N cells or rechargeable
Dimensions (in.)	$8\frac{15}{16} \times 3\frac{3}{4} \times 1\frac{3}{16}$	$7\frac{11}{16} \times 3\frac{3}{8} \times 1\frac{1}{16}$	5.7 × 3.0 × 1.3
Weight (ounces)	20	13.2	7.4
***Price**	$525	$300 (PC-1500) $280 (PC-2)	$250 (HP-41C) $325 (HP-41CV)

*Suggested retail prices. Actual prices may be lower.

GLCURSOR command moves the pen to any specified x-y coordinate *without* drawing a line. There's even a TEST command that causes the printer/plotter to draw four small boxes in each of its four colors.

First-time users of the PC-1500 should be forewarned that developing original graphics programs can become an entertaining, though time-consuming addiction. The printer's only shortcoming is the time it requires to print long program listings and to form complex graphics.

It took me a couple of hours to develop a program that draws a stylized butterfly in four colors. *Most* of that time was taken by the plotter as it methodically drew various wing configurations until I was satisfied. The actual programming required comparatively little time.

Hewlett-Packard HP-41

THE HP-41 is the oldest of the handheld computers reviewed here. The only domestic handheld machine currently available, it is manufactured by Hewlett-Packard (1000 N.E. Circle Blvd., Corvalis, OR 97330).

When it was first introduced a few years ago, the HP-41 was described by Hewlett-Packard as an alphanumeric, programmable, scientific calculator. But I've owned an HP-41 for nearly two years and am convinced that its programming power and versatility qualify it for designation as a handheld computer.

There are two versions of the HP-41: the HP-41C and the HP-41CV. The self-contained program/data memory (RAM) in the HP-41C can store up to 400 program lines or 63 data registers. The HP-41CV is functionally identical to the HP-41C but has five times the RAM storage capacity (2000 program lines or 319 data registers). The memory for program lines and data registers can be allocated in any desired format by using the SIZE instruction.

The RAM capacity of the HP-41C can be expanded to that of the HP-41CV by inserting a single quad RAM module into one of the four ports on the upper end of the computer. Since both computers are otherwise identical, we will simply use the designation HP-41.

The HP-41 has 58 keyboard functions and a total of some 130 internal functions that can be addressed by typing in the appropriate alphabetic name. Forget a function name not on the keyboard? Just press CATALOG 3 and every internal function will be scrolled through the 12-character position display. Press CATALOG 2 to see the functions provided by plug-in ROM modules. The titles (labels) of user programs are displayed in sequence when CATALOG 1 is pressed.

Programs stored in the HP-41 are run by pressing XEQ (execute) and then typing in the program name. Programs can be keyed in by the user from his own or published software; or factory-programmed ROM modules that plug into the ports above the display can be used.

Why compare the HP-41 to newer machines like the HHC and PC-1500 when it can be operated like a calculator and doesn't have a higher-language capability like BASIC? First, though its keyboard "language" is sometimes clumsy and often more complicated than BASIC, it provides many capabilities not ordinarily found in BASIC. For example, programs are stored and called by names or *labels*. Line numbers are automatically inserted and, during editing, revised. Loops and subroutines can be referenced to a permanent label instead of a line number that might be hard to remember and subject to change. Also many instructions, commands, and functions can be implemented by pressing a single key. The HP-41 is also smaller and lighter than the HHC and the PC-1500. Moreover, it is supported by excellent software, a dynamic users club, and a manufacturer that interacts well with its customers and continues to introduce a growing number of versatile peripherals.

HP-41 Peripherals. In the fast-moving world of computer technology, it's not uncommon for companies to abandon older computer products as they introduce newer ones to take their place. Whether planned or unplanned, this form of technology obsolescence is detrimental and sometimes disastrous to owners of the older systems.

Hewlett-Packard has demonstrated a high degree of product loyalty by continuing to introduce software and peripherals for the HP-41. So far they have made available more than two-dozen solution books and sixteen application pacs. The application pacs include plug-in ROM modules that contain programs in such diverse topics as surveying, engineering, circuit analysis, statistics, mathematics, etc. The modules are accompanied by excellent documentation and, when appropriate, a customized keyboard overlay.

Numerous hardware peripherals are available for the HP-41. The 82180A Extended Functions/Memory Module is a plug-in RAM/ROM cartridge that adds 47 new keyboard functions *and* 889 bytes of continuous memory. This module gives the HP-41 the ability to store programs and data in files and to access an additional 1666 bytes of continuous storage in each of one or two 82181A Extended Memory Modules. These modules give the HP-41 up to 6454 bytes of RAM storage space.

The 82182A Time Module adds a quartz-controlled clock, stopwatch, and calendar capability to the HP-41. The Time Module allows the HP-41 to be programmed to execute a program, signal an alarm, actuate an external device or peripheral, or function as a versatile data logger.

Hewlett-Packard's bar code-reading Optical Wand (HP-82153A) plugs into the HP-41C computer.

Programs and data can be loaded into the HP-41 via the keyboard or with the help of a handheld wand that reads bar code. The wand permits lengthy listings to be loaded quickly and *error free*. Bar-code listings are supplied with HP-41 software. A service for converting commonly used programs into bar code is available.

Programs and data may also be loaded into the HP-41 with the 82104 Magnetic Card Reader, a plug-in attachment that mounts atop the computer. A single card holds up to 224 bytes. Long programs can be stored on multiple cards. An interesting feature of this "smart" card reader is that it can be instructed to disallow alterations of on-card programs or even prevent unauthorized viewing. This provides an important degree of security for programs or data which may have required considerable development time.

Fast, quiet, alphanumeric printing of program listings and data is provided by the 82143A thermal printer. The printer, which has its own rechargeable battery pack and connects to the HP-41 via a short cable, includes built-in firmware that adds 25 new printer instructions.

A 44-register print buffer is included to allow combinations of alpha and numeric characters to be printed in any desired format. With patience, you can design your own graphics and special characters using the BLDSPEC (build special) instruction. There's even a built-in interactive plotting routine, PRPLOT, that prompts you for information about what to plot and then proceeds to graph the results on an x-y axis.

The latest HP-41 peripheral development is the Hewlett-Packard Interface Loop (HP-IL). This is a closed-loop, two-wire link that allows an HP-41 or other compatible computer to access and control any device in a string of up to 96 series-connected peripherals. The cable length between devices can reach 100 meters.

Implementing the HP-IL requires an HP-IL module that plugs into the HP-41. So far, Hewlett-Packard has introduced two HP-41 peripherals that are HP-IL compatible. The 82161A Digital Cassette Drive is a compact, mass-storage unit with a storage capacity of 131,072 bytes per tape—more than fifty times the maximum RAM capacity of the HP-41CV.

All the programs in every HP-41 software book can be stored on about 75% of a single tape! The average file access time is a reasonable 13 seconds, and the total contents of a fully expanded HP-41 can be copied from or written onto tape in under 40 seconds. Program files are easily copied from tape into the HP41's RAM by entering the name of the file and executing the command READP.

The second HP-IL peripheral is the 82162A Thermal Printer/Plotter. Functionally similar to the 82143A, the original HP-41 printer, this new printer includes several new features and an expanded buffer. The 82183A Extended I/O Module permits the new printer to print bar codes.

Hewlett-Packard has also introduced the 3468A Multimeter, the first HP-IL compatible instrument designed to interface with the HP-41. Many sophisticated applications for this new multimeter are possible because its operation can be controlled by the HP-41.

For example, a suitable light detector can be connected to its input to cause it to function as a solar-power meter. With the help of a Time Module, an HP-41 can sample the solar-power level at any desired time interval during the day and resume sampling the next day. The 82162A printer can then produce a plot of available solar power versus time.

While some companies wait to see what Hewlett-Packard will do next, Hand Held Products (6201 Fair Valley Drive, Charlotte, NC 28211) has introduced an HP-41 add-on memory peripheral, the HHP-16K™. This compact unit connects to the HP-41 via a short cable and provides a storage capacity of 4K, 8K, or 16K bytes. Ultraviolet-erasable EPROMs are used in the unit.

HHP provides full customer service for the loading of programs into its memory unit. The introductory cost is $241, with EPROM loading available for an additional fee.

Using the HP-41. The HP-41 has multiple operating modes. Normally it functions as a sophisticated scientific calculator. Placed in USER mode, the keys execute any functions or even complete programs previously assigned to them by the user. In ALPHA mode the keys become letters of the alphabet.

The HP-41 that I own is presently configured as a specialized optical radar and communications calculator when it is in USER mode. One of the programs I've loaded into the machine is called Range R. This program is assigned to a key which has been given the name "R" with the help of a keyboard overlay. Range R can be executed by pressing this R key (in USER mode) or the XEQ (execute) key. In the latter instance, the display will show XEQ___. The program name is typed into the keyboard (in ALPHA mode), and the display then prompts "XMTR POW-

The HP-41C shown here is generating the function sine x. The output, with the curve, is shown on the printer.

ER?" After the transmitter power is entered, a series of prompts for additional information flashes into the display. Finally, the display shows "RANGE = " followed by the range in meters.

The HP-41 utilizes reverse Polish notation (RPN), a highly efficient and logical problem-solving procedure wherein numerical data are processed immediately after they have been entered into the display. This eliminates the traditional equal key found on algebraic-type calculators. Thus, the keystrokes required to add two and three (2/ + /3/ =) becomes 2/ENTER/3/ +.

Developing simple programs for the HP-41 is easy, direct and fast. The program is first assigned a name or *label*, and the steps are then keyed in. There's no need to assign line numbers since they are automatically included by the HP-41. Editing is straightforward, though certainly not as convenient as with the HHC or PC-1500.

Here's a simple timer program that decrements (counts down) in units of one from any positive number initially in the display:

```
01 LBL "TIMER"
02 VIEW X
03 1
04 -
05 X≠0?
06 GTO "TIMER"
07 BEEP
08 END
```

The beeper sounds when the count reaches 1.

This program is straightforward. After the number is decremented (steps 3-4), the program compares it with 0 (step 5). If it does *not* equal 0, then the number is again decremented (step 6). Otherwise the beeper sounds.

While this program is very obvious, it is not elegant. An experienced HP-41 user would simplify it by the apparent contradiction of *adding* an extra step and revising the loop instruction (GTO "TIMER"):

```
01 LBL "TIMER"
02 LBL 01
03 VIEW X
04 1
05 -
06 X≠0?
07 GTO 01
08 BEEP
09 END
```

This program is simpler since the HP-41 need not perform a *global search* through its files to find the program named "TIMER" each time it runs the loop. Instead, it searches for the *local* label 01 *within* the program. This approach is more efficient and it speeds up program execution. Therefore, a larger number must be initially entered into the display to obtain the same time delay.

The most important benefit of adding the extra label is the saving of four bytes: The new GTO instruction is simply GTO 01, not GTO TIMER.

This short example illustrates but one of the many fine points of HP-41 programming. Complicated HP-41 programs can be difficult to develop, but the HP-41 provides a highly versatile, almost assembly-language approach that appeals to some programmers.

HP-41 owners should know about PPC, an international, independent users' club for HP-41 devotees. You can receive information about PPC and a sample issue of its journal by sending a self-addressed 9" by 12" envelope with first-class postage for two ounces to PPC Calculator Journal, 2545 W. Camden Place, Santa Ana, CA 92704.

Conclusion

IN comparison, Quasar's HHC and Sharp's PC-1500 are both considerably faster than the HP-41. When a printed output is required, however, the HP-41 can often hold its own.

To simplify comparisons, I matched the PC-1500 against the slower HP-41 on a time-trial basis. For the first test, both machines were programmed to count from 0 to 1000 and sound their beeper when complete. Both computers were programmed from the keyboard in minutes with little or no editing. The PC-1500 finished in a very fast 1.5 seconds versus a dismal 14 seconds for the HP-41.

For a second test, both machines were programmed to print the square of each digit from 1 to 10 in identical formats (for example, '1 SQUARED IS 1', etc.). The PC-1500 program was composed in a minute or so at the keyboard. The HP-41 program, however, required considerably more time. Though the bulk of the program was trivial, having everything printed on the same line was not. (I was unfamiliar with the use of the accumulator buffer in the 82143A printer and its instruction, ACA.)

Now it was Sharp's turn to eat dust. The PC-1500 needed 45 seconds to print what the HP-41 printer spewed out in 15 seconds. When the PC-1500 printed its smallest character size, it improved its speed to 23 seconds, still 50% slower than the HP-41. (Of course, the PC-1500 could have easily beaten the HP-41 if hard copy were not required.)

My tests can hardly be considered worthy of benchmark status. But at the very least, they illustrate the need to carefully compare *all* the parameters of a handheld computer system before making judgments about which machine is faster than another.

Summing Up. Now that I've had the opportunity to use and evaluate three of the new handheld computers, which represent five brands in the marketplace, I'm convinced they are indeed practical, priced right, and destined to thrive in the highly competitive personal computer market.

But which of the handheld computers examined here is best? Since each of the machines has special characteristics, there is no clear answer. Here are some capsule comments about each model's attributes to help you determine which one best fits *your* applications and requirements.

The Quasar HHC (or Panasonic equivalent) is well-suited for file-structured programming. It has several very useful peripherals and can interface with color-TV receivers and video monitors, as well as other computers, via its optional modem. Of the three machines reviewed here, the HHC most closely resembles what one might expect if a desktop personal computer were reduced to a handheld format.

The Sharp PC-1500 (or Radio Shack equivalent) has a drawback in its lack of a file system, but it has more mathematic and logic functions than the HHC. Though it lacks the HHC's wide range of peripherals, its optional printer/plotter is by far the most impressive and versatile of the three we looked at. Furthermore, its color print provisions give one an added benefit.

The Hewlett-Packard HP-41 has neither the programming ease of BASIC, nor a keyboard that is familiar to typists. It has many single-key functions that speed up program entry, however. Nearly all of its keys are redefinable, and its keyboard "language" generates its own line numbers and automatically files programs by alphanumeric labels. Numerous peripherals are widely available for the HP-41, though given time, the others, which are recent entries on the market, could well catch up. With the HP-41, one cannot interface with other general-purpose computers or use a common high-level language.

The HHC and PC-1500 are further set apart from the HP-41 by their somewhat larger size, which allows for more display characters and a standard keyboard layout. However, the HP-41 is easier to hold in one hand, and its keyboard is simpler to customize.

If you are interested in acquiring a handheld computer, your purchase decision also will be influenced by price and availability of peripherals. You should arrange for a firsthand demonstration and inspection of each machine, of course, and determine which meets your needs best. No matter which you select, you will be impressed by any one of them. ◇

SIMPLE AUDIO GATE EXPANDS DYNAMIC RANGE

Obtain effective noise reduction with this under-$30 circuit

BY JOHN H. DAVIS

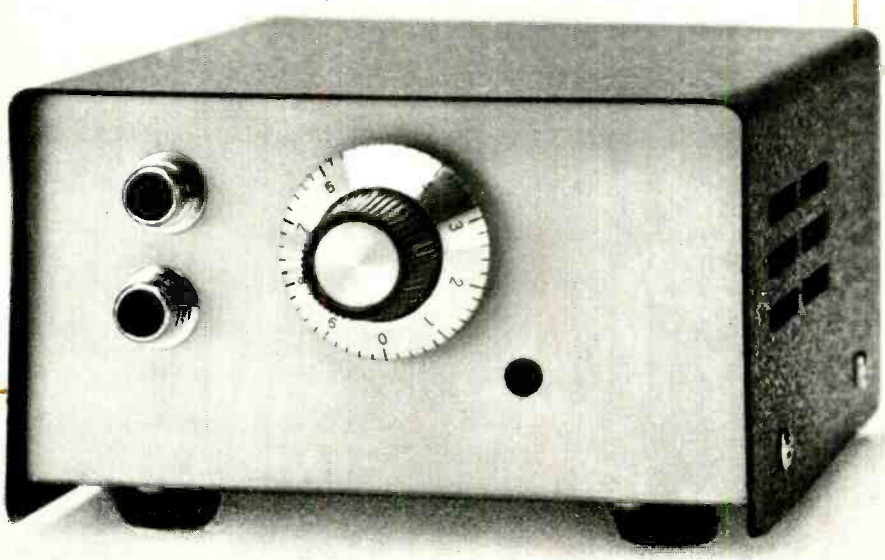
SINGLE-ENDED noise reduction may be all you need to strip background noise from on-location voice recordings, dub "clean" home-movie soundtracks, mute public-address microphones, and improve the audio from video tape recorders. The simple audio gate described here can handle any of these tasks. No encoding is required of the signal source, and with a little practice you should find the gate quite satisfactory for most nonprofessional applications. An investment of less than $30 can buy you a cost-effective alternative to the more sophisticated noise-reduction devices currently available.

Audio gates have been used by professionals for many years—recording studio engineers often refer to them as "noise gates." An audio gate does not constrict and expand the bandwidth of the reproducing system. Instead, it is simply a voltage-controlled attenuator with two states. When a normal signal level is present, the gate operates at unity gain. Below this level, the gain automatically drops, quieting background noises—and the residual signal. This action is comparable to dynamic range expansion, except that the gain reduction is fixed and occurs at a definite, preset threshold.

Circuit Description. In the circuit (Fig. 1), input *IC1A* can be operated as a buffer or a gain stage, depending on input level. Its output is coupled through *C1* to the voltage-controlled attenuator (*R3, R4, Q1*) and the input of a level comparator (*IC1C*). The level comparator is biased with a threshold voltage from *R10*. As long as no signal peaks exceed this threshold voltage, the output of *IC1C* will be positive and no charge will be applied to *C3*. This means the channel resistance of *Q1* will be low, allowing voltage divider *R3-R4* to attenuate the signal applied to the output buffer (*IC1B*).

When positive signal peaks rise above the threshold, the output of *IC1C* will switch negative for a fraction of each cycle, charging *C3* through *D1*. Now the channel resistance of *Q1* rises to several times that of *R3*, effectively disabling the *R3-R4* voltage divider. Attenuation is thus removed from the audio path.

With the component values given, the threshold may be adjusted to begin anywhere from 160 mV rms to less than



10 mV rms. (The maximum possible threshold decreases to about 130 mV rms with 9-V battery operation.) The object, of course, is to find a threshold level that is below the important audio information but above the noise.

As shown in Fig. 1, the audio gate works well for audio input levels from 300 mV to 2 V. Lower input levels should be brought within this range by amplification; higher input levels produce a minor increase in distortion prior to the onset of clipping (8 V rms; 5 V rms for battery operation). However, if high audio levels are accompanied by significant noise, attenuation should be employed to ensure adequate threshold control.

The gating time constants have been chosen so that attack and decay rates are compatible with most speech and music. Of course, these can be varied as special needs dictate.

Construction and Operation. Assembly is straightforward, especially if a pc board is used (Fig.2). The audio path is not overly critical, but the comparator section changes state rapidly, so a short path from the IC to ground through *C4* and *C5* is important. Be sure to observe capacitor polarities. Shield cable is recommended for input and output connections.

After assembly, double check all wiring and component orientations. Before putting *IC1* in its socket, apply power and check that the potential at points *E* and *F* is less than 18 V and of correct polarity. Now remove power, discharge all the capacitors, and insert *IC1* in its socket.

Connect the audio gate between a signal source and an amplifier, and reapply power. (If other noise-reduction equipment is used, it should precede the audio gate.) With an audio signal present, practice adjusting threshold control *R10*. You should hear the gain change when the audio input exceeds the threshold level, and *LED1* should light simultaneously. If *R10* is set too low, the noise may not be attenuated; if *R10* is set too high, the audio level may fluctuate erratically.

AUDIO GATE PERFORMANCE SPECIFICATIONS

Input impedance: 100 kΩ
Output load: 2.5 kΩ or greater
Frequency response: 20 Hz to 20 kHz, +0, −1 dB
Distortion: 0.05% for operation between threshold and 2 V; generally less than 0.25% at other levels, depending on FET *(QI)* characteristics
Recommended line level: 300 mV to 2 V rms
Maximum output: about 8 V rms (5 V rms for battery operation)

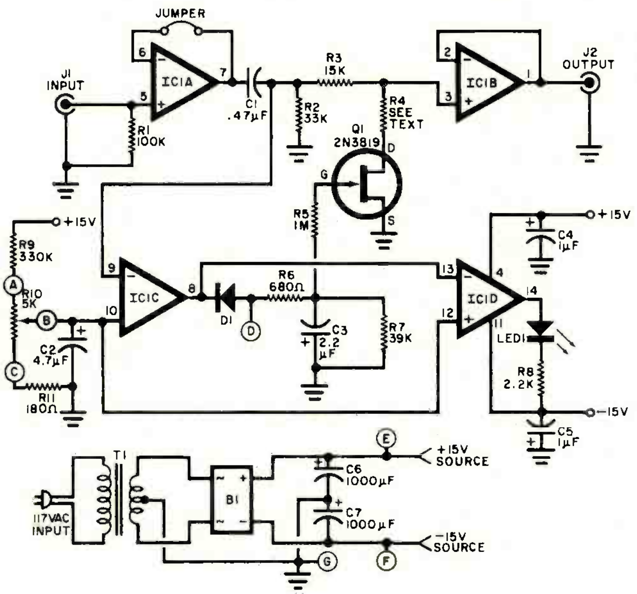


Fig. 1. Schematic of the audio gate circuit, including power supply.

PARTS LIST

B1—Full-wave bridge rectifier module, 1-A, 100-V or more
C1—0.47-μF, 100-V Mylar capacitor
C2—4.7-μF, 16-V electrolytic
C3—2.2-μF, 35-V tantalum or low-leakage electrolytic
C4,C5—1-μF, 35-V electrolytic
C6,C7—1000-μF, 25-V radial-lead electrolytic
C8*#,C9*#—1000-μF, 25-V electrolytic
C10#—2.2-μF, 50-V nonpolarized electrolytic
D1—1N914 diode
IC1—TL074CN quad Bi-FET op amp
J1,J2—RCA-type phono jacks
LED1—Red light-emitting diode
The following resistors are all ¼-W, 5% unless otherwise noted:
R1—100 kΩ
R2—33 kΩ
R3—15 kΩ
R4—see table
R5—1 MΩ
R6—680 Ω
R7—39 kΩ
R8—2.2 kΩ, ½ W
R9*—330 kΩ
R10*—5-kΩ linear-taper potentiometer
R11*—180 Ω
R12#,R13#—47 Ω
R14#—11 kΩ
R15#—100 kΩ
R16#—50-kΩ audio taper potentiometer
Q1—2N3819 or GEFETI transistor
T1—24-V center tap, 100-mA secondary
*Denotes component *not* required in duplicate for stereo version
#Denotes component required for optional features as described in text

Applications. The audio gate was designed for flexibility. Consequently, certain adaptations must be made for specific applications.

For example, the optimum amount of gate attenuation depends on the relative noise content of the incoming signal and how objectionable an abrupt level change would be.

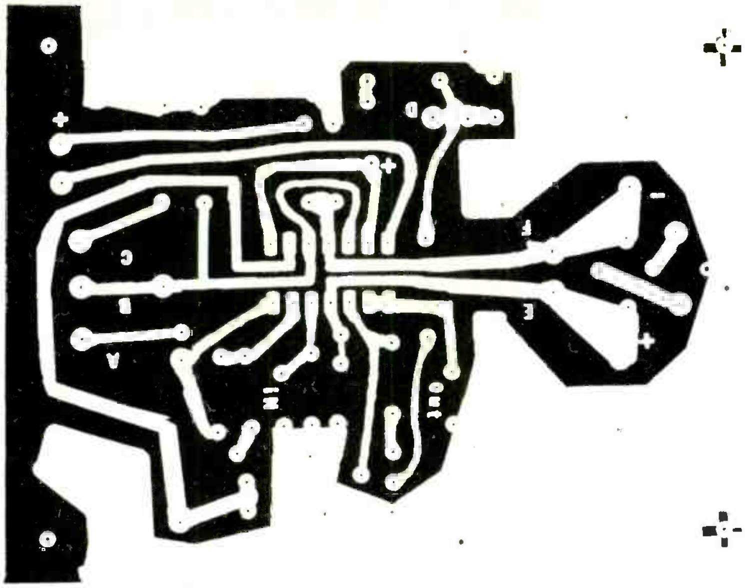
As little as 3 to 6 dB of gating will help in the transfer of old phonograph records to tape or make voices recorded in noisy locations stand out from the background din, enhancing intelligibility. Film soundtrack recording used such methods until the advent of extensive studio re-recording ("looping"). However, it is still common in television, where production budgets are tighter.

The preferred amount of gating in home-music systems ranges from 12 dB for background music down to around 6 dB for more critical listening. On the other hand, 20 dB is not excessive when muting a public-address microphone if the exact threshold is adjusted carefully. The table gives values for *R4* to produce five different gate attenuations between 3 and 20 dB.

Value of *R4*	Audio Gate Attenuation
33 kΩ	3 dB
15 kΩ	6 dB
8.2 kΩ	9 dB
4.7 kΩ	12 dB
1.5 kΩ	20 dB

If gain is needed to bring audio levels up to the specified input range, two modifications to the audio gate's first stage are recommended. Improved signal-to-noise ratio is obtained when the rectifier is moved off the circuit board and additional filtering is added (Fig. 3). The first stage is then set up to provide a voltage gain of 10 (Fig. 4). Increasing *R15* will raise the gain further, but exceeding about 470 kilohms will introduce noise and instability. If input gain is *not* needed, a wire jumper *must* be used in place of *R15*.

The audio gate can be useful in electronic music experiments where a number of audio signals are being mixed together. For example, nearly all synthesizers produce some vaguely musical "noise" at full gain. This is feedthrough from the internal voltage-controlled attenuators. A bank of synthesizers working together—or any other group of sound generators combined in parallel—would exhibit a lower residual output if each input was first



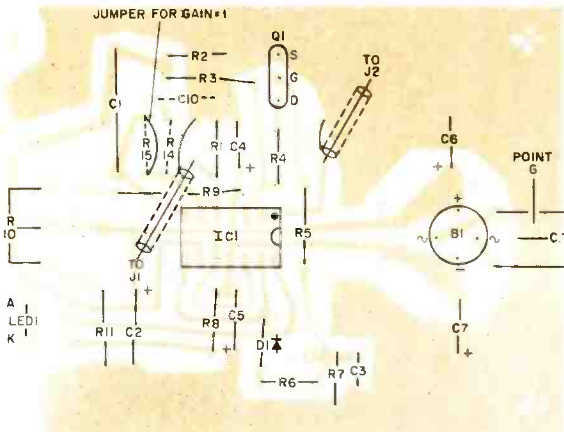


Fig. 2. Use the foil pattern at top to make a printed circuit board and install components as shown.

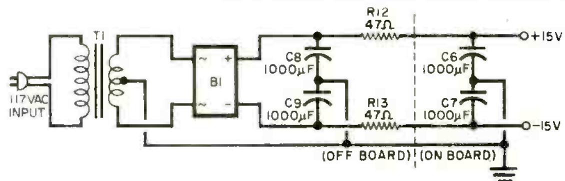
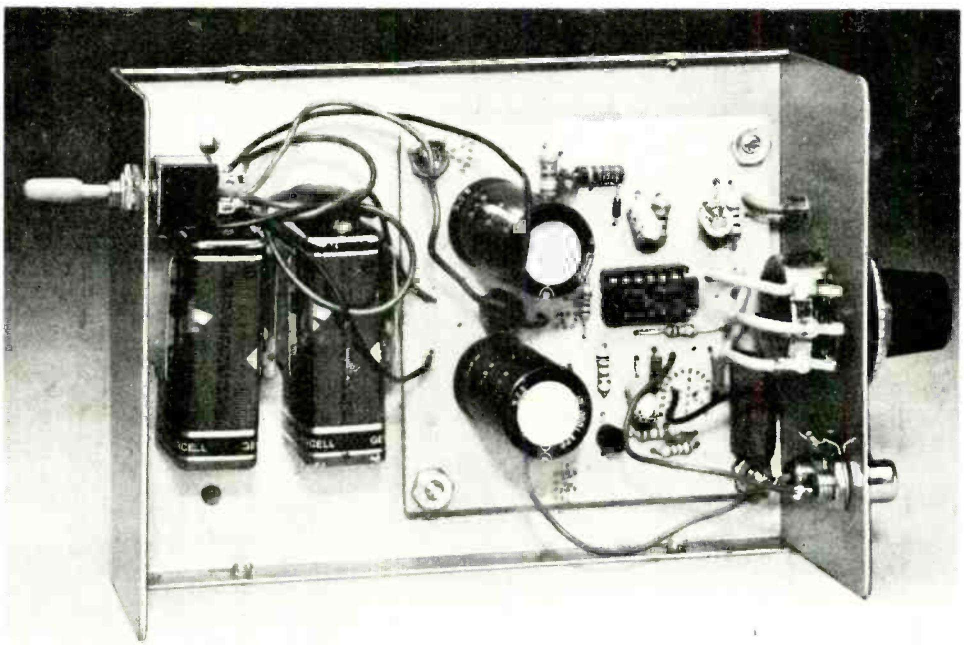


Fig. 3. The S/N can be improved by using extra filtering as shown here.



View of the internal arrangement of the author's prototype.

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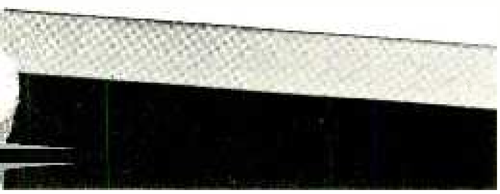

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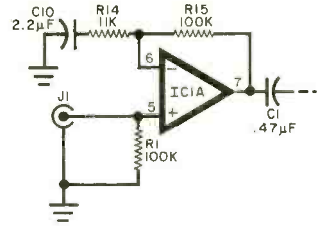


Fig. 4. First stage with gain of 10.

fed through an audio gate.

An alternate application involves modifying the gate's attack and decay rates. Figure 5 shows *R6* and *R7* as potentiometers, permitting the audio gate's attack and decay times to be continuously adjustable. Note that the minimum value of *R7* must not be less than *R6* to ensure full gating.

Portable operation is possible with two 9-V batteries (Fig. 6). Since gate adjustment is largely done by ear, *LED1* can be eliminated in the interest of power conservation.

Stereo Operation. Since many applications for the audio gate involve monophonic signals, this unit was designed accordingly. However, for stereo operation it is only necessary to build a second pc board, duplicating all

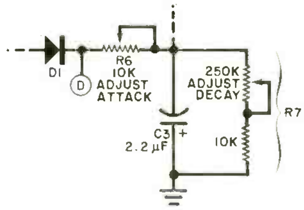


Fig. 5. Using pots for R6 and R7.

the components of Fig. 1 *except* those marked with an asterisk in the parts list. Then tie the boards together electrically with jumper connections between five key points on the two boards (*B*, *D*, *E*, *F*, and *G*). That is, wire left-channel point *B* to right-channel point *B*, *D* to *D*, etc.

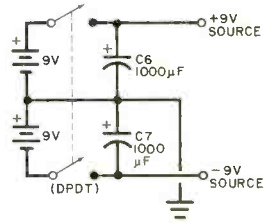


Fig. 6. Power supply for portability.

Both gates will open when either (both) stereo channel(s) is (are) active, and neither gate will attenuate until both channels are inactive. This simultaneous action prevents unwanted stereo-image shift at low-input levels. ◇

4-TRACE CONVERTER FOR OSCILLOSCOPES

Make your single-trace instrument more useful with this low-cost circuit

BY JIM MORGAN

HAVE you ever found yourself staring at the nonworking "innards" of a stereo audio amplifier or a complex digital circuit, wishing you had a multi-channel oscilloscope? Now, for about $70, you can build an oscilloscope switch that can display 2, 3, or 4 channels of inputs on a single-trace scope.

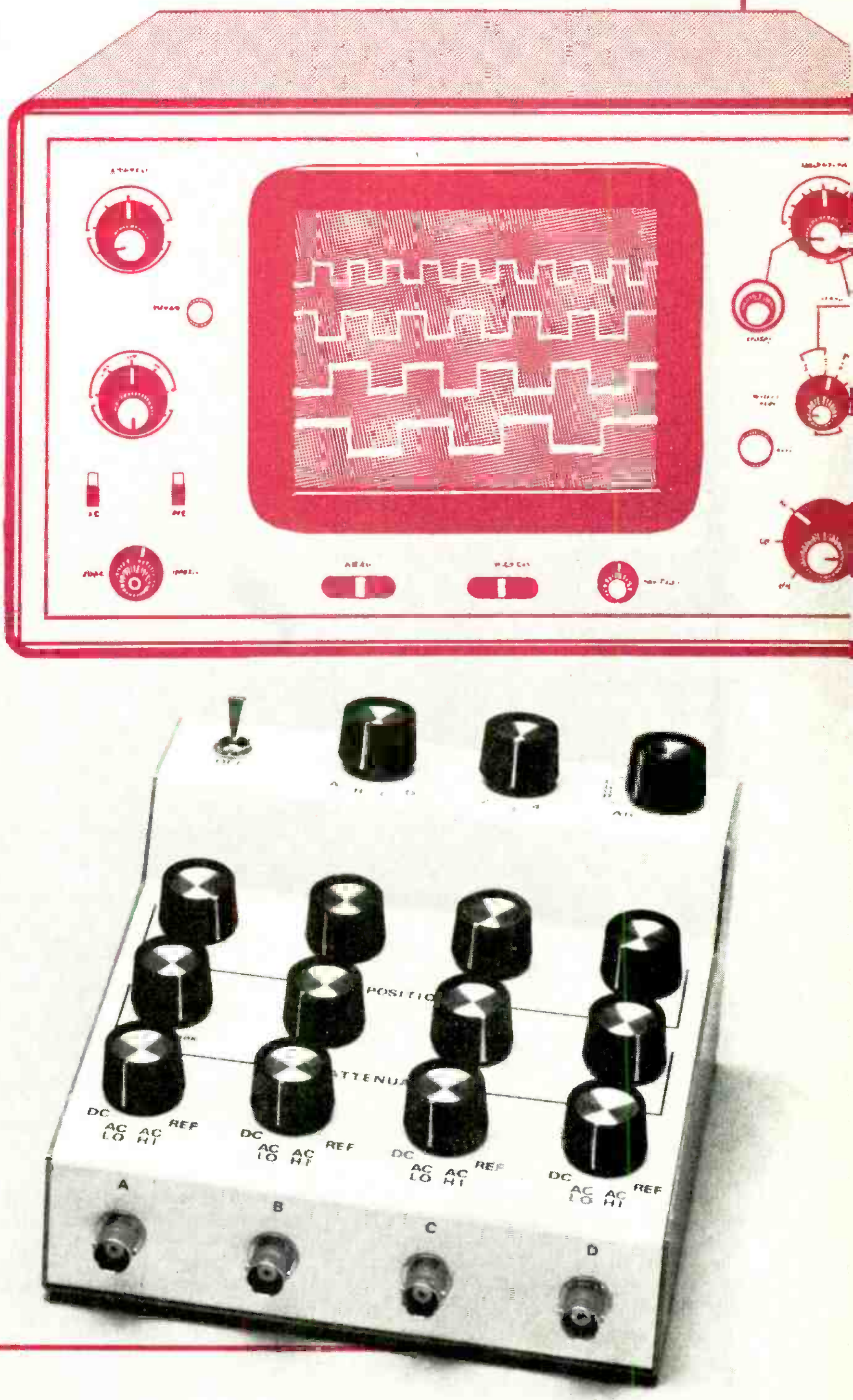
Bandwidth at the 3-dB point is about 4.5 MHz, but the scope switch is usable with signals up to about 20 MHz. Isolation between switches approaches 65 dB, and the input impedance is 98 kilohms (which can be improved if desired). On ac, the switcher will accept signals to 15 V peak-to-peak, while on dc, signals can be ±7.5 V. The display can be chopped at adjustable frequencies from 12 to 210 kHz, and a fixed 200-Hz rate is also available. A built-in trigger processor provides a choice of input channel to do the oscilloscope triggering.

Power requirement is ±9 V from alkaline cells or a simple line-operated power supply.

The switcher can also be used as the staircase generator for a transistor curve tracer, or it can produce four outputs from a single source so that a single audio preamplifier can drive four power amplifiers. A single video source can also be used to drive four video monitors. The complete schematic is shown in Fig. 1.

Circuit Operation. The central element of the oscilloscope switcher is *IC1*, a CMOS quad analog switch. This chip contains four independent spst switches (electronic), each controlled by its own flip-flop. When a CMOS switch is "open," its impedance approaches 2000 megohms, which provides ample isolation between the input and output. In the closed condition the series resistance is approximately 80 ohms, and the attenuation of conducted signals is insignificant.

Since the switcher's four input chan-



nels are similar, we will discuss only channel A. The desired input signal, applied to *J1*, is coupled to DC/LO/HI/REF selector switch *S1*. In the DC position, the input signal is directly coupled to *IC1*, while in the LO or HI positions, the signal is ac-coupled through either *C1* for low frequencies or *C2* for high frequencies. In the REF position, the switch is fed a dc voltage determined by the setting of POSITION control *R5* to allow for trace positioning. The signal at *J1* is also coupled to the trigger-processing circuit to synchronize the scope to the selected signal.

The POSITION control (*R5*) is connected across the positive and negative voltage sources so that each trace can be positioned as desired on the scope CRT display. Capacitor *C3* bypasses the input signal away from the POSITION control and effectively places the lower end of the ATTENUATION potentiometer at ground level. The POSITION control applies a selected dc bias to the switch input to determine trace position.

The four switch outputs (pins 2, 3, 9, and 10 of *IC1*) are connected in parallel and feed the SCOPE VERTICAL INPUT (*J5*).

When CHOP-ALTERNATE switch *S5* (fitted to STABILITY potentiometer *R10*) is in the CHOP (open) position, astable multivibrator *IC2* can be adjusted via STABILITY control *R10* to generate pulses whose frequency ranges from 12 to 210 kHz. When *S5* is in the ALTERNATE (closed) position, the large value of *C13* is placed in the timing circuit, reducing the *IC2* output frequency to approximately 200 Hz.

The CHOP mode of *S5* is used when observing low-frequency signals, while the ALTERNATE mode is used for observing high frequencies. STABILITY control *R10* can be adjusted to remove any flicker or display breakup when the input frequency is similar to the *IC2* pulse frequency or one of its harmonics.

The output of *IC2* drives decade counter *IC3*, whose outputs, in turn, drive the four flip-flops within *IC1*.

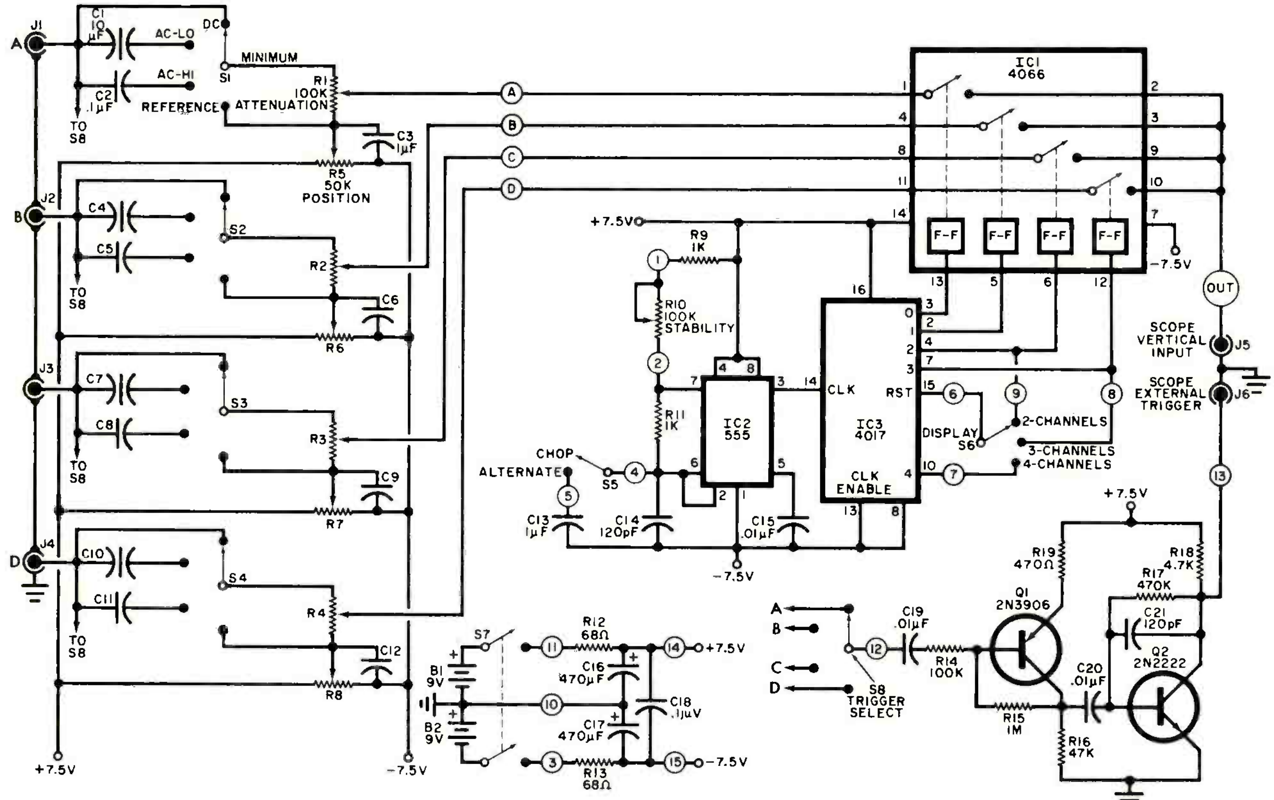


Fig. 1. The heart of the scope switcher is a CMOS quad analog switch.

PARTS LIST

B1,B2—Six 1.5-V alkaline cells
C1,C4,C7,C10—10-μF, 30-V nonpolarized capacitor
C2,C5,C8,C11,C18—0.1-μF, 50-V Mylar capacitor
C3,C6,C9,C12,C13—1-μF, 30-V tantalum capacitor
C14,C21—120-pF, 50-V disc capacitor
C15,C19,C20—0.01-μF, 50-V Mylar capacitor
C16,C17—470-μF, 16-V electrolytic
IC1—4066 quad switch
IC2—555 timer
IC3—4017 decade counter
J1 through J6—BNC connector, UG-1094
Q1—2N3906 pnp transistor
Q2—2N2222 npn transistor
The following are ¼-W, 10% resistors unless otherwise noted:
R1,R2,R3,R4—100-kΩ linear-taper potentiometer
R5,R6,R7,R8—50-kΩ linear-taper potentiometer
R9, R11—1 kΩ
R10—100-kΩ, audio-taper potentiometer with attached switch (S4)
R12,R13—68Ω
R14—100 kΩ
R15—1 MΩ
R16—47 kΩ
R17—470 kΩ
R18—4.7 kΩ
R19—470 Ω
S1,S2,S3,S4,S8—4-position rotary switch
S5—Spst switch (part of R10)
S6—3-position rotary switch
S7—Dpdt slide switch
Misc.—Suitable case (6½" × 6" × 3", Sprague QEP-1715-01 or similar), hook-up wire, battery holders, knobs, press-on type, mounting hardware, etc.

Note: The following is available from Hi-Technology Designs, Box 457, Fairview, OR 97024: etched and drilled pc board for $6.95.

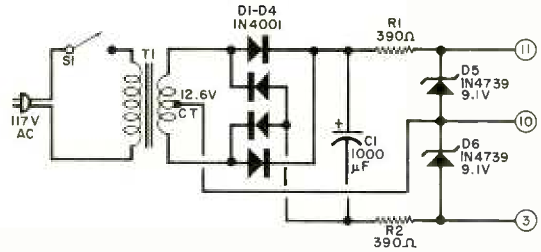


Fig. 2. Optional ac-powered dc supply can be used instead of batteries.

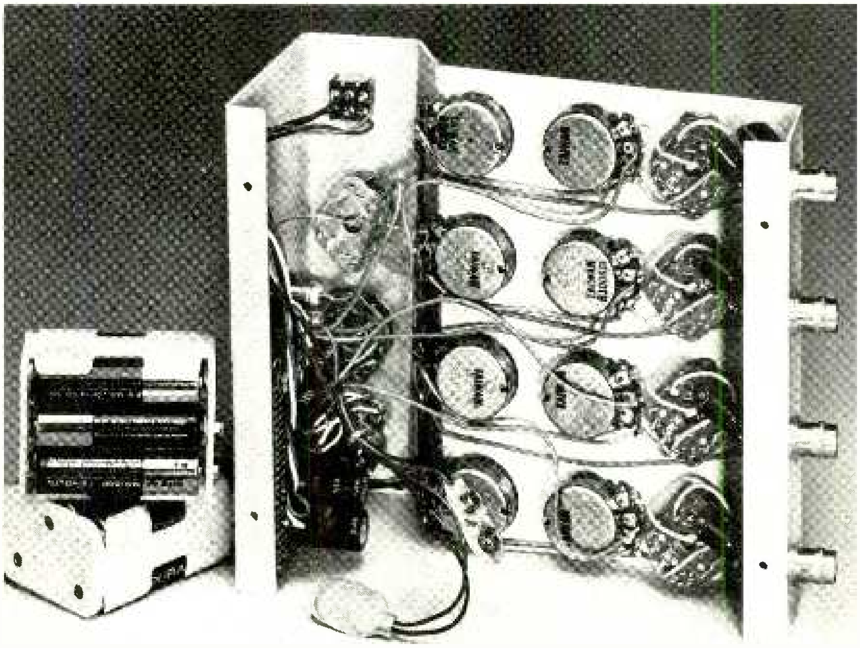
PARTS LIST (Power Supply)

C1—1000-μF, 50-V electrolytic
D1 through D4—1N4001
D5,D6—1N4739, 9.1-V zener
R1,R2—390-Ω, ¼-W resistor
S1—Spst switch
T1—12.6-V, 1.2-A transformer (Radio Shack 273-1505 or similar)
Misc.—Line cord, hook-up wire, tie lugs, etc.

DISPLAY switch *S6* is connected to the reset input of *IC3* and enables selection of three of the *IC3* outputs to allow the display of two, three, or four traces on the scope display. The use of the decade counter ensures that only one flip-flop within *IC1* is enabled at a time.

TRIGGER SELECT switch *S8* selects one of the inputs from *J1* through *J4* and applies the selected signal to the trigger processor formed by *Q1, Q2,* and their associated components. Essentially, the two-transistor circuit forms a high-gain amplifier/shaper whose output is coupled via *J6* to the scope's external trigger input. The two-transistor circuit will operate with inputs as low as 10-mV rms.

Since the current requirement is less than 20 mA, a pair of 9-V batteries can be used for the power supply. If *B1* and *B2* are formed from six 1.5-V alkaline cells in series, up to 80 hours of intermittent duty can be expected. An optional ac-powered dc supply is shown in Fig. 2.



Internal view of the author's prototype.

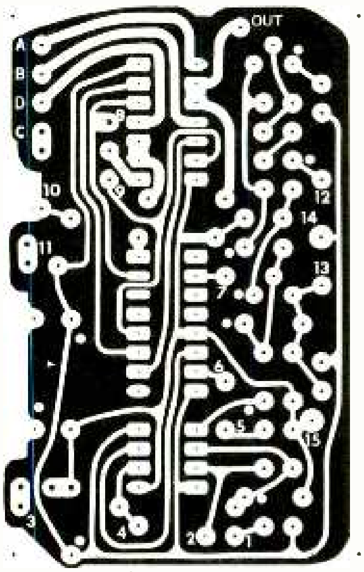


Fig. 3. Exact-size foil pattern.

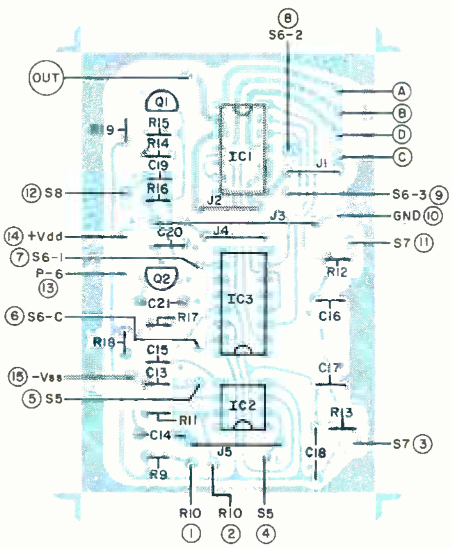


Fig. 4. Component placement diagram.

Construction. The project can be assembled using point-to-point wiring or the pc board shown in Fig. 3. Component installation is shown in Fig. 4. The circled letters in Fig. 1 and Fig. 2 refer to pads on the pc board. Note that some resistors are mounted on end to conserve board space. Note also that input capacitors *C1, C4, C7,* and *C10* are nonpolarized types, while the STABILITY control has an associated switch (*S5*) that closes when this control is at its extreme counterclockwise position. If you take care with lead dress, frequencies up to and beyond 4.5 MHz can be displayed. Use BNC connectors for the inputs, and 20-gauge wire to make the necessary switch/control-to-board connections.

The board is then installed within a suitable enclosure whose front panel can accommodate the various controls and the input and output connectors. Each should be suitably identified as to use. Many components can be directly mounted on the switches and potentiometers. Either the battery pack or the line-powered dc supply can be located within the enclosure. If the supply circuit is used, its power cord can exit via a grommetted hole at the rear of the enclosure. Install fresh alkaline cells if battery operation is desired.

Checkout. Turn on power to the switcher (*S1* in the ac supply or *S7* in the battery version) and measure +7.5 V between pins 14 (+) and 10 (GND), and − 7.5 V between pads 15 (−) and 10 (GND). Also check that the correct dc input voltage appears at the pertinent pads of the three ICs.

Connect a scope between pin 3 of *IC2* and ground. A series of pulses should be displayed. Now, by starting at the maximum clockwise position of STABILITY control *R10*, and rotating this control counterclockwise, the displayed pulse frequency should increase. When the associated switch (*S5*) closes, the pulse frequency should drop to about 200 Hz. You may have to reverse the connections to *R10* to get the desired result.

Set the scope vertical attenuator to 1 V/division, dc input, and position the trace on the center graticule line. On the switcher, set all the POSITION controls fully counterclockwise, DISPLAY (*S6*) switch to 4 CHANNELS, and the ATTENUATION controls to maximum. Connect the scope vertical input to SCOPE VERTICAL INPUT connector *J5*.

Now, with the scope on internal trigger, a straight-line image should appear near the bottom of the screen. Adjust the four POSITION controls on the scope switcher to create a staircase of convenient size with channel A on the bottom, channel B above it, then channel C, and finally channel D on the top. Adjust the scope's vertical attenuator and position controls to center the display. Each step of the staircase should be about a 2-V increment.

Connect the switcher's SCOPE EXTERNAL TRIGGER jack (*J6*) to the scope's external trigger input and set the scope trigger controls accordingly. Using a signal generator, apply analog or digital signals to the four input connectors and note that they appear on the four traces. Use the TRIGGER SELECT switch (*S8*) to select the desired trigger signal and adjust the scope trigger controls for a stable CRT display. You can now adjust the ATTENUATION and POSITION controls on the switcher to position the image as desired.

Other Applications. Besides its application as a four-trace add-on for oscilloscopes, the switcher can also be used as a variable-frequency square-wave generator with a maximum peak-to-peak output of 15 V. To implement this operation, set the input selector switches (*S1* to *S4*) to REFERENCE and the DISPLAY switch (*S6*) to 2 CHANNELS. If the DISPLAY switch is now set to 3 or 4 CHANNELS, and the scope traces are centered, the frequency present at SCOPE VERTICAL INPUT connector *J5* will be lowered by one-third and one-half, respectively. The staircase output can be used as a driver for a transistor curve tracer.

Since *IC1* is bilateral, a signal can be applied to *J5* and then distributed to four different circuits connected to *J1* through *J4*. This setup wil also work with digital signals—you can drive four displays from one computer (or video game).

Some design tradeoffs were made to keep the cost down. For example, the ATTENUATION controls are low-cost 100-kilohm units, which in conjunction with the scope input impedance, produces a 98-kilohm input impedance for the switcher. The input attenuators (*R1-R4*) may be increased to 1-megohm units, but circuit response time will increase because it will take longer to change the input capacitors. This approach could be used when monitoring high-impedance circuits. However, a high input impedance will cause some rolloff on the edges of observed pulses if the ATTENUATION controls are in other than their MINIMUM positions. ◇

PROGRAMMING EPROM's WITH A SMALL COMPUTER

Hardware-software system interfaces with computer for easy, sophisticated programming from keyboard, cassette or disk

BY JOHN DOOLITTLE
AND SLOBODAN TKALCEVIC

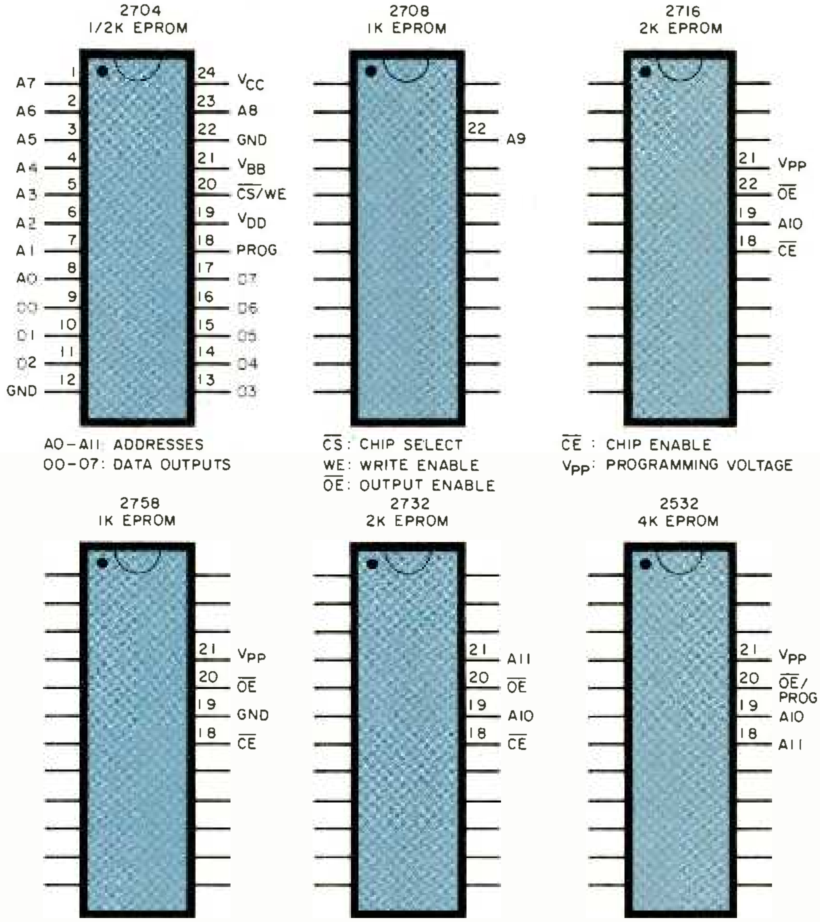
Part 1

WHY pass up advanced digital construction projects because they involve EPROM (Erasable Programmable Read Only Memory) programming? If a small computer such as the TRS-80 is available, then the EPROM programmer described here can expand your digital design work inexpensively. This modest-cost peripheral device can program EPROMs with data loaded from a keyboard, cassette, or diskette. Its other operating modes verify programmed EPROMs against the programming buffer, list the EPROM or programming buffer contents to the monitor screen, copy the contents of one EPROM to another and check that an EPROM is completely erased before re-programming.

EPROMs are most commonly used for storing machine-language programs to control microprocessors or for storing look-up tables where a large number of inputs and outputs are needed (for example, converting one binary code to another, defining mathematical functions, or controlling sequential circuits). Usually, microprocessor control programs that are to be stored in EPROM are written in assembly language and then converted into machine-compatible binary code. While this can be done by manually resolving the necessary op-codes and addresses, a more efficient approach is to use a small computer that supports a text editor and assembler. Once the assembly language text is entered and assembled into binary code, it can then be written directly to EPROM using the peripheral programmer.

An EPROM programmer interfaced with a computer benefits from system software support (such as an editor or assembler), and can use the logic and computational resources of the computer to control its operation. By making address generation and programming-pulse sequencing into software tasks, the hardware component count can be reduced to a bare minimum.

This EPROM programmer can program 2704-, 2708-, 2758-, 2716-, 2732-, and 2532-type EPROMs, giving the user a selection of ½K, 1K, 2K, or 4K by 8-bit devices. The design includes five power supplies to provide the voltages necessary to program all these memory chips. While the printed circuit directly interfaces with the TRS-80 Model I expansion bus using a 40-conductor ribbon cable, its design can be easily adapted for any computer that allows access to the CPU data and address lines.



EPROM	READ				PROGRAM			
PIN	18	19	20	21	18	19	20	21
2704, 2708	0	12	0	−5	25.5	12	12	−5
2758, 2716	0	A10	0	5	5	A10	5	25.5
2732	0	A10	0	A11	5	A10	25.5	A11
2532	A11	A10	0	0	A11	A10	5	25.5

Fig. 1. Pin designations and programming signals for the EPROM chips that are programmable with this project.

Working with EPROMs. There are basically only two operating modes for EPROMS: Read and Program. Most EPROMs are byte-addressable, which means that 8 bits of memory contents can be accessed by specifying a unique byte address. The data lines remain electrically disconnected, or "three-stated," until the chip is enabled. This allows several memories or I/O devices to share the same data bus in turn. Once enabled by supplying a *chip select* signal, data may be read from the device simply by providing the desired address. Valid data becomes available on the output lines a short time after the address is specified. This brief delay, or "access time," allows the address lines to settle to constant values.

Before programming, all bit locations of an EPROM are in the one state as a result of exposure to ultraviolet light. Data is placed in the device by entering zeros at the required bit locations of any byte addressed. The Program mode is activated by supplying a write-enable signal and a programming pulse to the appropriate pins. The duration and amplitude of the programming pulse must be within specified limits. Some EPROMs (2758, 2716, 2732, and 2532) can be programmed in one pass because a relatively long pulse is supplied for each byte addressed. Other types (2704 and 2708) demand that a short programming pulse be repeated many times with a delay inserted between pulses. (This allows for adequate heat dissipation.) Whatever the EPROM type, it is normal to make many passes through the entire memory until each affected bit location has been pulsed for a total time exceeding a specified minimum.

Verification after programming is done by reading back the contents of all programmed bit locations and comparing them with the original data. If modifications to the EPROM data are deemed necessary, and involve changing a 1 to a 0, they are easily made by reprogramming with the altered data. Of course, corrections that involve changing a 0 to a 1 can only be made by first erasing the EPROM.

All of the EPROMs considered here are 24-pin DIP packages which have identical pin configurations except for the assignment of pins 18 through 21. The pin designations and programming signals for all chips programmable with

TABLE I-PORT ADDRESSES

8255 Port	CPU I/O Port Address
A	F8H
B	F9H
C	FAH
Control	FBH

the EPROM programmer are shown in Fig. 1. The similarity in pinouts means that a general circuit can be designed to accommodate the various types with only four lines being unique to each EPROM. The connection of these four lines can be made most conveniently by routing the affected signals through "personality" modules wired specifically for each EPROM type.

Circuit Operation. The schematic diagram of the EPROM programmer appears in Figs. 2 and 3. Computer interfacing is greatly simplified by designing the circuit around a general-purpose programmable I/O device such as the Intel 8255A Programmable Peripheral Interface (PPI), shown logically in Fig. 4. This chip communicates with the CPU through the eight lines of the data bus and provides for 24 I/O lines that can be connected to the computer data bus under program control.

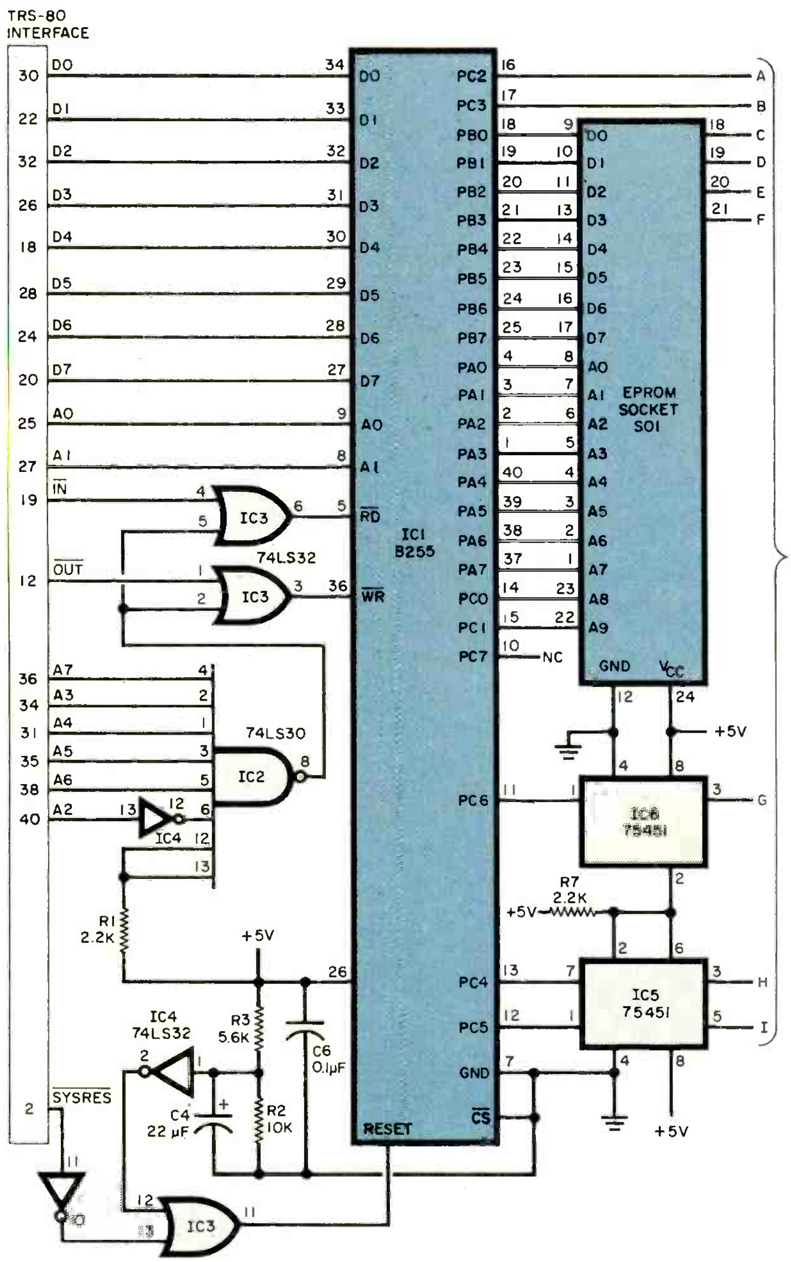


Fig. 2. Interfacing to the computer is provided by a general-purpose programmable I/O device, the 8255A.

PARTS LIST

C1,C2—1000-µF, 16-V electrolytic
C3—1000-µF, 50-V electrolytic
C4—22-µF, 15-V electrolytic
C5,C6,C8—0.1-µF, 20-V disc ceramic
C7—0.1-µF, 50-V disc ceramic
D1 through D6—1N4004 diode
F1—0.5-A fuse and holder
IC1—8255 programmable peripheral interface
IC2—74LS30 8-input NAND gate
IC3—74LS32 quad 2-input OR gate
IC4—74LS04 hex inverter
IC5,IC6—75451 dual peripheral AND driver
IC7,IC8—723 precision voltage regulator
IC9—LM320-5 negative 5-V regulator
IC10—LM340-5 positive 5-V regulator
IC11—LM340-12 positive 12-V regulator
K1—24-V, 700-ohm 4pdt relay (Potter-Brumfield R10-E1-W4-V700, with socket 27E213, or similar)
LED1—Green light-emitting diode
LED2,LED3—Red light-emitting diode
The following are ¼-W, 5% resistors unless otherwise noted:
R1,R4,R6,R7,R10,R17—2200 ohms
R2,R11—10,000 ohms
R3—5600 ohms
R5,R9—10-ohm, ½-W
R8,R12—10,000-ohm potentiometer
R13—220 ohms
R14,R15,R16—330 ohms
S1—Spst switch
SO1—24-pin, zero-insertion-force socket (Textool 224-3344 or similar)
T1—10-20 CT-40 CT, 300-mA transformer (Triad F-91X)
Misc.—Four 16-pin DIP header sockets with covers, suitable enclosure, 40-conductor ribbon cable with connectors, line cord, mounting hardware, etc.

Note: The following are available from Parhelion Inc., Box 3602, Stanford, CA 95405: complete kit including drilled and etched pc board, enclosure, and driver program listing for $134.95, plus $5 for postage and handling. Also available separately are an etched and drilled pc board for $21.95, plus $2 for postage and handling; driver program listing for $10.95; driver program on cassette for $19.95, plus $1 for postage and handling; driver program on diskette for $21.95, plus $1 for postage and handling. California residents, please add 6½% sales tax.

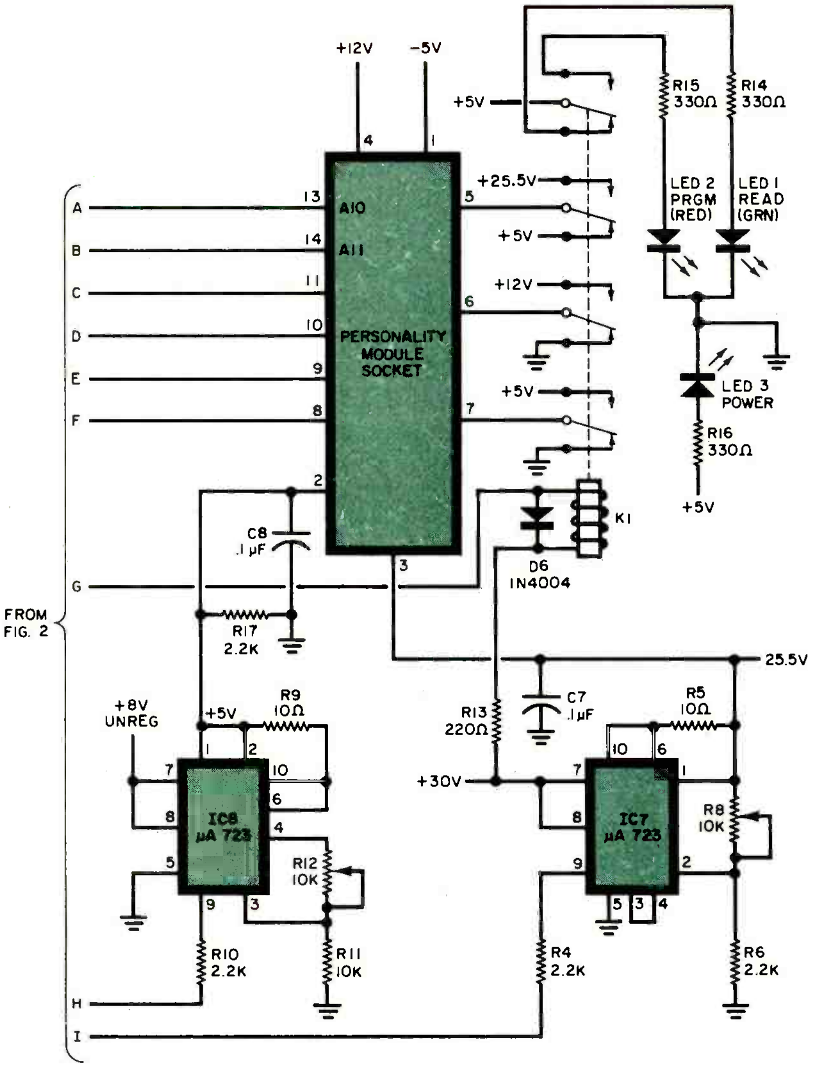


Fig. 3. Precision voltage regulators IC8 and IC9 are used to supply 5- and 25.5-V programming pulses.

TABLE II—CONTROL BYTE FUNCTIONS

Control byte	8255 response	Function
00	reset PC0	reset EPROM add. A8
01	set PC0	set EPROM add. A8
02	reset PC1	reset EPROM add. A9
03	set PC1	set EPROM add. A9
04	reset PC2	reset EPROM add. A10
05	set PC2	set EPROM add. A10
06	reset PC3	reset EPROM add. A11
07	set PC3	set EPROM add. A11
Q8	reset PC4	turn off 25.5V
09	set PC4	turn on 25.5V
0A	reset PC5	turn off 5V
0B	set PC5	turn on 5V
0C	reset PC6	relay PROGRAM mode
0D	set PC6	relay READ mode
0E	reset PC7	not used
0F	set PC7	not used
80	all 8255 ports in output mode	PROGRAM mode
82	8255 ports A&C output, B input	READ mode

In this application, the 8255A's I/O lines are organized into two eight-bit ports (A and B) and a special port (C) with eight lines that can be set or reset independently—without disturbing the other bits of the port. The lower half of port C is used in conjunction with port A to supply up to 12 bits of address information to the EPROM from the CPU data bus. The upper half of port C controls relay *K1* and the switchable power supplies during the programming sequence.

Port B is used for data transfer between the EPROM and the CPU. An additional 8225A port (Control) receives a control byte which configures separately ports A, B, and C for input or output as required. The 8255A remains in a specified configuration until a new control byte is sent by the computer.

Connection of the A, B, C, or Control ports to the computer data bus is accomplished by using "port-addressed I/O." Computer address lines A0 and A1 supply the Port Select signals while addresses A2 through A7 are combined through 8-input NAND gate *IC2*, allowing the $\overline{\text{IN}}$ and $\overline{\text{OUT}}$ control signals from the TRS-80 to pass to *IC1*. Address line A2 is inverted by an element within *IC4* so that unique I/O ports can be specified without conflicting with the TRS-80 assigned port address of FFH for the cassette recorder. The resulting TRS-80 I/O port addresses for the 8255A's A, B, C, and Control ports are listed in Table I.

When power is first applied, the 8255A automatically resets via the $\overline{\text{SYSRES}}$ signal, causing all ports initially to be in the input mode. The reset condition is maintained for about 200 ms by *R2* and *C4*. The 8255A will also be reset whenever the TRS-80 system reset button is operated. This initializes the unit to a known state and protects any EPROM left in the programming socket from inadvertent pulses which might result from an undefined initial state.

As shown in Fig. 5, supply voltages are provided so that several EPROM types are programmable with this circuit. Constant −5, 5, and 12 V are delivered by three-terminal regulators, while 5- and 25.5-V programming pulses, which must be switched under precise control of the software, are supplied by using precision voltage regulators *IC7* and *IC8* (Fig. 3). Frequency compensation (pin 9) is connected through analog switch *IC5* to ground. When a logic 1 is supplied by the 8255A control line (PC4 or PC5), the compensation is allowed to float, turning on the precision regulator. A logic ZERO

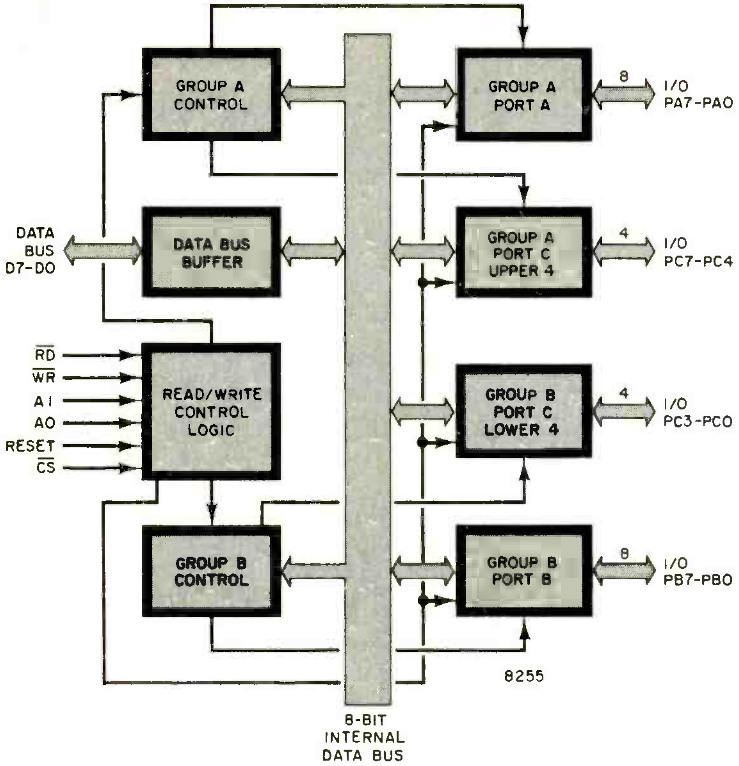


Fig. 4. Internal logic arrangement of the Intel 8255A.

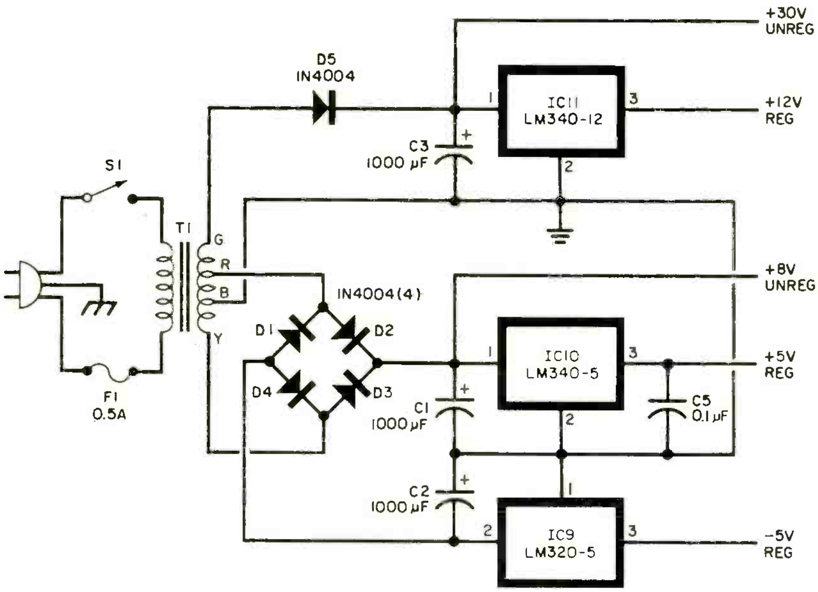


Fig. 5. Power supply provides several voltages.

causes the compensation pin to be grounded, turning the precision regulator off.

Input to the 5- and −5-V regulators is taken from a full-wave rectifier (*D1* through *D4* in Fig. 5), driven by the lower half of the power transformer's secondary winding. The center-tap of that section is grounded, causing the bridge to give both positive and negative outputs of about 8 V. A half-wave rectified input to the 12- and 25.5-V regulators is supplied at about 30 V by the top three quarters of the transformer secondary winding. (All currents are well below the maximum allowed for regulator operation without heat sinks.)

The voltages supplied to some of the EPROM pins depend on whether the device is in the Read or Program mode. Switching between two voltages is done in this case by relay *K1* (Fig. 3), which is activated when a 0 on the 8255A control line (PC6) causes current to flow from the 30-V unregulated supply through voltage-dropping resistor *R13*, the relay coil, and analog switch *IC6* to ground. Diode *D6* protects *IC6* from voltage spikes caused by relay switching. The relay also switches the *LED1* (READ) and *LED2* (PROGRAM) mode indicators.

Personality Modules. Connections to pins 18 through 21 of the different EPROMs are unique to each type and must be routed through appropriate "personality" modules. Wiring diagrams for these personality modules are shown in Fig. 6. These can be made using standard 14-pin headers that will plug directly into the personality module socket of Fig. 3.

In Part 2 of this article, we will present construction plans and software information for the EPROM programmer. ◇

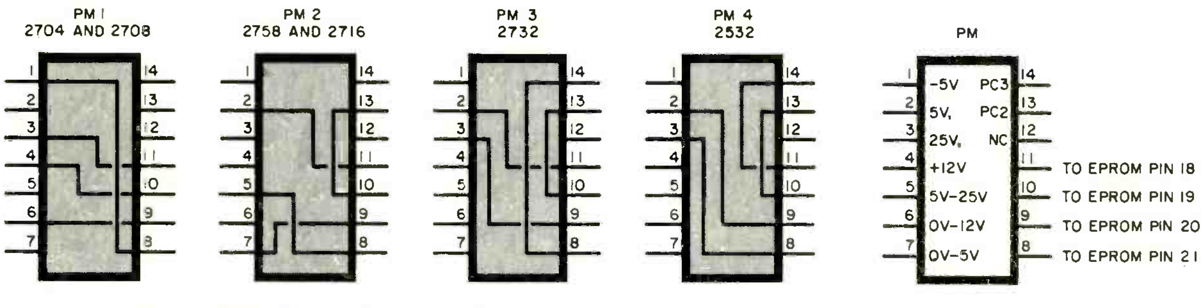


Fig. 6. Wiring diagrams for personality modules to accommodate the various types of EPROMS.

BUILD A TOUCH-CONTROLLED SOLID-STATE SWITCH

Low-cost device can be used for TTL or MOS

BY KEN RAICH

THE touch-controlled switch is a solid-state circuit that can be built for less money than the cost of many of the traditional pushbutton switches. The circuit utilizes the high input impedance of a CMOS gate. Most CMOS gates will work but the 4049 hex inverter was chosen because of its high output current. (It can drive two TTL loads.)

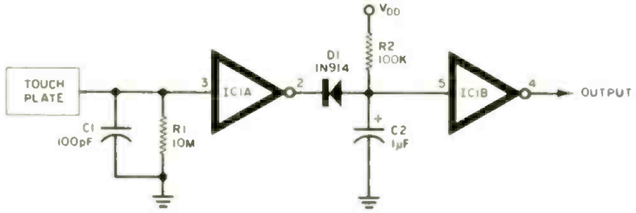
Circuit Operation. Sixty-hertz power, which is present almost everywhere, is transmitted by the body (fingertip) to a small touchplate. Since the bare end of a wire has enough surface area to function as a touch plate, a plate of any convenient size can be attached to the wire.

If the plate is not being touched, *R1* pulls the input of *IC1A* low causing a high to appear at the output of *IC1A*. This reverse-biases *D1* and allows *C2* to remain charged at V_{DD}. Then *IC1B* senses V_{DD} at its input causing a low to appear at the output of *IC1B*.

When the plate is being touched, a 60-Hz square wave ranging in amplitude from V_{DD} to ground appears at the output of *IC1A*. During the time that the output of *IC1A* is low, *D1* becomes forward-biased and allows *C2* to discharge through *D1*. While *C2* is discharging, the input of *IC1B* goes to ground causing a high to appear at the output of *IC1B*. During the time that the output of *IC1A* is high, *D1* will again reverse-bias and *C2* will start to recharge through *R2*, keeping a low at the input of *IC1B*. Therefore, while the plate is being touched, the output of *IC1B* is always high. Capacitor *C1* acts as a filter to eliminate frequencies above 60 Hz, which may also be transmitted by the body.

For circuits which require only a momentary low, such as the snooze alarm of a clock chip, the second stage of this touch switch can be entirely eliminated and the output of *IC1A* can be directly connected to the snooze alarm input of the clock chip. Supply voltages may range from 3 to 15 V making this touch switch practical for anything from TTL to MOS.

Make sure all unused input pins of the 4049 (pins 7, 9, 11, & 14) are connected to V_{DD} or V_{SS}. An open input pin will cause that gate to oscillate and draw a great deal of current from the power supply. ◇



PARTS LIST

IC1—4049 hex inverter
D1—1N914 diode
C1—100-pF capacitor
C2—1-µF, tantalum capacitor
R1—10-MΩ resistor
R2—100-kΩ resistor

Popular Electronics Tests

Fox BMP-10/60 Scanner Receiver

THE Fox BMP 10/60 scanner receiver covers three frequency bands (32-50 MHz, 144-174 MHz, and 420-511 MHz) with quartz synthesized tuning. The compact FM receiver has a built-in speaker, a membrane-type keyboard, and an LED frequency and mode display. It can be operated from a 12-V dc source such as a car battery or the ac converter furnished with the radio. The Fox BMP 10/60 can also be used as a personal portable receiver in its optional "Porta-Pac" that serves as a case for the receiver and a holder for either alkaline or NiCd batteries. (The latter are rechargeable from the receiver's ac converter.)

The receiver, which is in a molded thermoplastic case, measures 6½"W × 9"D × 1⅝"H and weighs 1½ lb. Suggested retail price is $349.95. The optional car mounting bracket is $9.95, and the Porta-Pac is $29.95.

General Description. In addition to being programmable to any frequency in its designed operating range, the Fox BMP 10/60 is pre-programmed with 60 frequencies in six public service bands, at least some of which can be expected to be active in most parts of the country. The pre-programmed frequencies include ten "Police 1" channels in the 460-MHz region, ten "Police 2" channels around 155 MHz, a group of ten "Fire" channels at 154 MHz, ten "Marine/Weather" channels at 156 and 162 MHz (including both NOAA weather channels—162.40 MHz and 162.55 MHz), and two groups of "Mobile Tel" (telephone) channels around 152 MHz. The assumed constant availability of the weather channels is used as a set-up convenience since one will always be heard when the receiver is first turned on.

The BMP 10/60, though simple to operate after some practice, requires careful study of the instructions that accompany the unit.

When the receiver is first turned on by rotating the VOL knob and the SQL knob is turned clockwise to silence interstation noise, one of the ten red LEDs on the front of the receiver will glow to show which of its ten scanning steps is in use. (If the squelch is not set correctly, the receiver will not scan since it interprets the noise to be a received carrier.)

To access any group of pre-programmed channels, the portion of the control panel marked CONTROL is pressed until one long and two short "beeps" are heard and a PR appears in the display window. Then, pressing one of the top panel selector areas (pads) marked with the name of a channel group (such as "Police 1") instantly puts the receiver into that range. It scans the ten pre-programmed frequencies until a signal is received. The scanning rate of ten steps per second ensures rapid interception of any receivable activity.

Pressing the STEP pad stops the scanning action, and each touch of STEP advances the tuning by one channel. Pressing AUTO returns the receiver to its automatic-scanning mode. The three other control pads modify the receiver's scanning action.

ACTION returns the tuning to channel 1 every two seconds to check on its activity. This interrupts the other channel being monitored for only an instant; but if a signal appears on channel 1, the receiver remains there until it leaves. The SKIP mode locks out any selected channels from the scanning/monitor action of the receiver. PAUSE introduces a delay of two seconds after a carrier drops out before scanning is resumed. These three controls can be applied selectively to any channel, and each is disabled by a second operation of its selector pad.

In addition to pre-programmed operation, the BMP 10/60 can be set to any other frequency in its tuning range (resolution is 5 kHz on the two lower bands and 12.5 kHz on the uhf band). Simply place the receiver in a "program" mode by pressing CONTROL until one long beep is heard, enter the desired frequency with the keypad numerics, then press ENT/SEEK. This places the selected frequency in the memory channel that was previously accessed with the STEP pad.

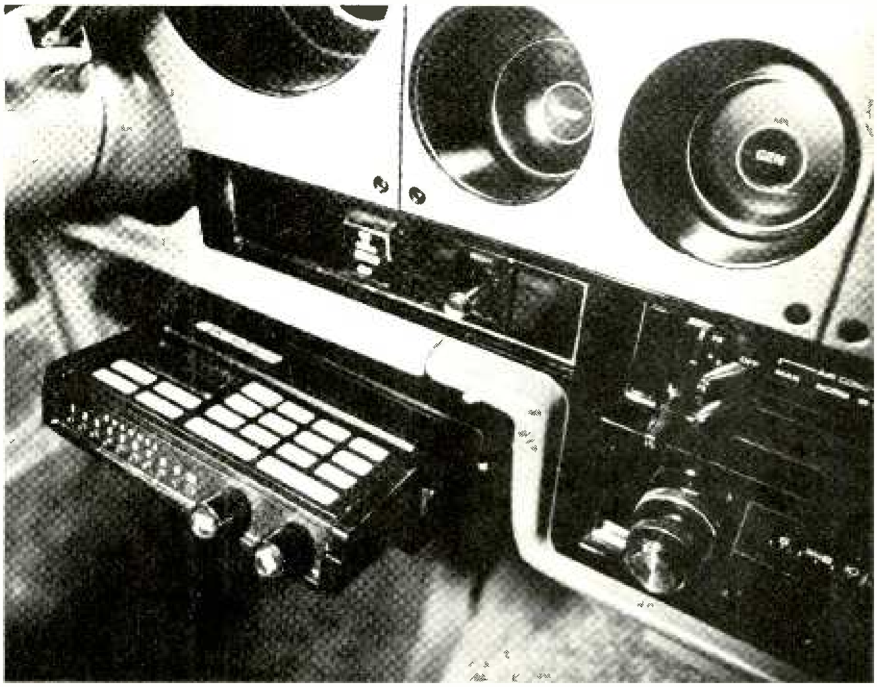
In any mode of operation, the actual received frequency is always displayed on the LED panel, with six-digit precision. To scan the user-programmed channels, the receiver is put into its "program" mode with CONTROL. Now, instead of selecting a pre-programmed frequency group, the numeral 0 is pressed.

Manual tuning in discrete steps of one per second is implemented by pressing and holding ENT/SEEK. An audible "beep" accompanies each frequency step. To reverse the direction of tuning, the pressure on the ENT/SEEK button is released and re-applied. A double "beep" is heard, followed by a normal stepping action, but in the opposite direction. The memories in the receiver are maintained, even with power removed, by a 9-V battery installed in the case.

Laboratory Measurements. Our tests of the BMP 10/60 were made at the edges of the two lower-frequency bands, using an FM signal modulated with 1-kHz to a 5-kHz deviation. Receiver sensitivity is rated by the manufacturer in terms of the input signal required to give a 12-dB (signal + noise)/noise ratio. The rating is 0.5 μV on the vhf bands and 1 μV on the uhf band. In general, our tests confirmed the receiver's ratings, with a sensitivity of 0.49 μV at 144 MHz, 0.27 μV at 174 MHz, and 0.9 μV at both 32 and 50 MHz.

The audio output of the BMP 10/60 into an 8-ohm load (rated at 2 W for 10% distortion) was about 1.5 W at that point and 1.3 W where waveform clipping began to appear (corresponding to about 4.5% distortion). At lower power outputs, the distortion was a constant 3%.

In its scanning mode, the receiver covered about 75 steps per second. All operating modes were checked to confirm their proper action. Everything worked as claimed, and the instruction manual was accurate and complete.



The Fox Scanner Receiver fits neatly in an optional bracket for mounting under the car dashboard.

User Comments. Despite its unusual appearance and method of operation, we found the Fox BMP 10/60 to be a highly effective scanning and monitor receiver. Using only its built-in telescoping antenna (22" long), we were able to receive a large number of stations on all the receiver's bands. In a car, we would expect similar results with a regular whip antenna, and even better performance with a suitable vhf or uhf antenna.

As a personal portable radio, installed in its optional Porta-Pac case and battery holder, the Fox BMP 10/60 offers far more versatility than most "pocket size" scanners, without imposing an unreasonable size or weight penalty.

—*Julian Hirsch*

CIRCLE NO. 105 ON FREE INFORMATION CARD

CHECK YOUR SWR... WHILE YOU TALK

Standing wave ratio can be measured without interrupting SSB transmission or recalibrating

BY PAUL DANZER

AS two-way radio users know, a standing wave ratio (SWR) meter indicates how well the antenna and cable are matched to the transmitter's output. A conventional SWR meter, however, has two distinct shortcomings. It must be calibrated before each SWR reading, and no calibration or reading can be made while the r-f carrier is modulated. (Unmodulated r-f is needed so the meter needle will not fluctuate.) Thus, sideband operators cannot check SWR unless they stop talking and insert an unmodulated carrier. By using the sensing elements of a conventional SWR meter together with a novel display head, as described here, these problems can be overcome.

How It Works. A conventional SWR meter typically contains two sensing elements used to sample voltage levels. These voltages are proportional to the forward (transmitted) and reverse (reflected) power level found in the antenna feed line (Fig. 1). A two-position switch is mounted on the front panel of the SWR meter. When it is in the CALIBRATE position, forward power is sampled and the SWR meter is set to read full scale.

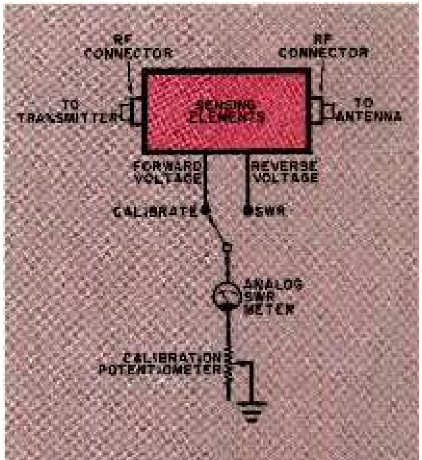


Fig. 1. The typical SWR meter measures ratio of forward to reverse voltages.

Next, the switch is thrown to the SWR position and the reflected power level is sampled. This second meter reading, always relative to the first meter reading, is taken as the measure of SWR. The meter scale is calibrated according to the formula:

$$SWR = (V_f + V_r)/(V_f - V_r)$$

where V_f and V_r are forward and reverse voltages, respectively.

So much for the traditional approach. Now see what happens when LEDs are used to monitor the forward and reverse voltages. The display consists of a simple grid, the horizontal and vertical axes studded with LEDs (Fig. 2). The top (horizontal) row is labeled 1 to 10 and used to measure the forward voltage. The side (vertical) row is also labeled 1 to 10 and used to measure the reverse voltage.

Multiple SWR scales are plotted across the grid. To measure SWR, simply find the highest-numbered LED illuminated in each row, trace horizontally and vertically to the intersection, and read the SWR from the appropriate scale. (Note that a modulated signal will cause identical fluctuations in each LED row, but it will still be easy to identify the highest-numbered LED illuminated in each row and find the intersection.)

Two integrated circuits are used to convert an ordinary SWR bridge to LED readout—allowing SWR measurement while single-sideband or modulated carrier signals are present

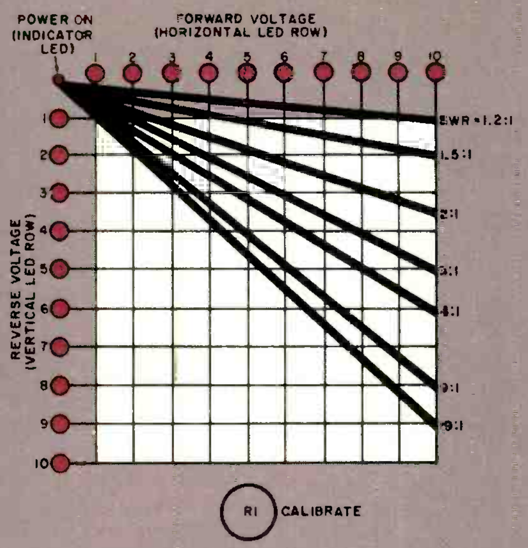


Fig. 2. The display consists of a simple grid whose horizontal (forward voltage) and vertical (reverse voltage) axes are studded with LEDs.

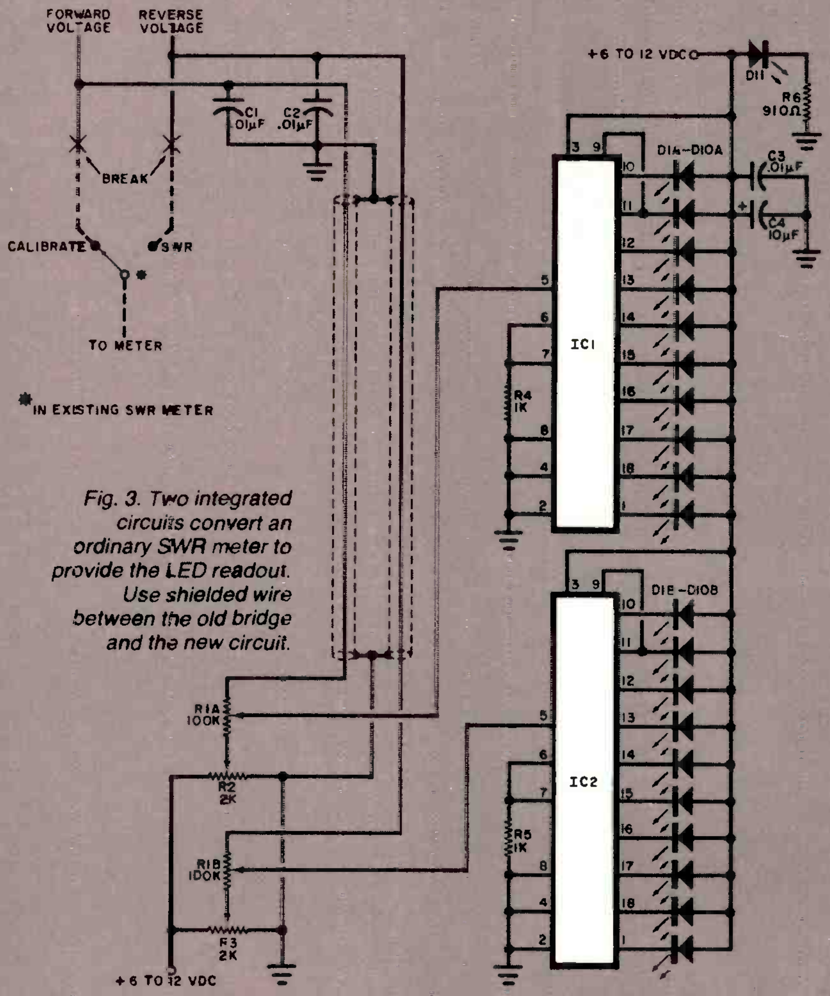


Fig. 3. Two integrated circuits convert an ordinary SWR meter to provide the LED readout. Use shielded wire between the old bridge and the new circuit.

PARTS LIST

C1 to C3—0.01-μF, 50-V dc capacitor
C4—10-μF, 50-V dc capacitor
D1A-D10A—2-V, 20-mA red LED (Radio Shack 276-041)
D1B-D10B—2-V, 20-mA red LED (Radio Shack 276-041)
D11—2-V, 20-mA red LED (Radio Shack 276-041)
IC1, IC2—LM3914 LED driver (Radio Shack 276-1707)
R1—100-kΩ dual potentiometer (Radio Shack 271-1732)
R2, R3—2-kΩ trimmer (Radio Shack 271-218)
R4, R5—1 kΩ, ½ W
R6—910Ω, ½ W
Misc.—Standard SWR meter, shielded wire, 6- to 12-V dc supply, plastic for faceplate, universal breadboard, etc.

(Fig. 3). The SWR meter is modified by breaking the two leads going to the CALIBRATE/SWR switch. These two wires plus a ground lead are brought out. Two bypass capacitors (*C1* and *C2*) are added, and two shielded leads are run to the LED display head, with the shields grounded.

Dual potentiometer *R1* consists of two 100-kilohm sections on one shaft. It is used as the calibrate control for the system. Trimmers *R2* and *R3* are used to provide identical dc offsets for the forward and reverse channels.

Construction Tips. In lieu of a custom printed circuit board, the LED driver can be mounted directly (or with sockets) on a universal breadboard such as the Radio Shack 276-170 (Fig. 4). Two busses are used, one above the ICs for the positive voltage (6 to 12 V) and one below the ICs for ground. LEDs *D1A* through *D10A*, and *D1B* through *D10B* are mounted as shown in Fig. 5. LED *D11* acts as a pilot light and is independent of incident or reflected r-f levels. Capacitors *C3* and *C4* are for power supply bypass. Any 6-to-12-V dc supply can be used for a power source.

A faceplate can be made from a section of rigid plastic, approximately 7″ by 7″. Drill two rows of holes to mount the LEDs on half-inch centers. Then glue graph paper to the faceplate with rubber cement and draw the calibration scale on the graph paper. Now give the faceplate a light spraying with "artist fixitive" to keep it from smudging.

Each SWR calibration line begins at the "zero" point common to both the forward voltage and reverse voltage axes. The Table gives a number of points for constructing the SWR scales shown in Fig. 2, or you can calculate your own SWR scales from the basic relationship involving forward and reverse voltages given earlier.

Checkout and Operation. After construction, ac power is applied to the SWR meter and (with no r-f present) *R2* is rotated so that each of the diodes *D1A* through *D10A* goes on in turn. This test checks out the wiring of the diodes as well as *IC1*. Now rotate *R2* so that *D1A* goes on, then back off until *D1A* is just barely extinguished. Repeat this process for the other string of diodes, using *R3* to set up *D1B*. Checkout and adjustment is now complete.

To use the instrument as an ordinary SWR meter (and assuming it is connected in the antenna feed line), key the transmitter and adjust *R1* so that any one of the horizontal row of diodes is lit. If you chose to have *D10A* lit, make sure it is just barely lit (i.e., close to hav-

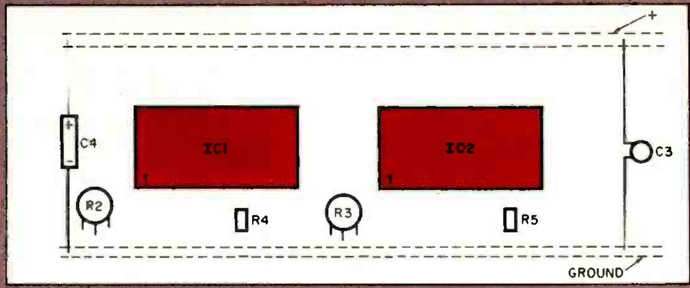


Fig. 4. In lieu of a custom printed circuit board, the LED driver can be mounted on a universal breadboard as shown here.

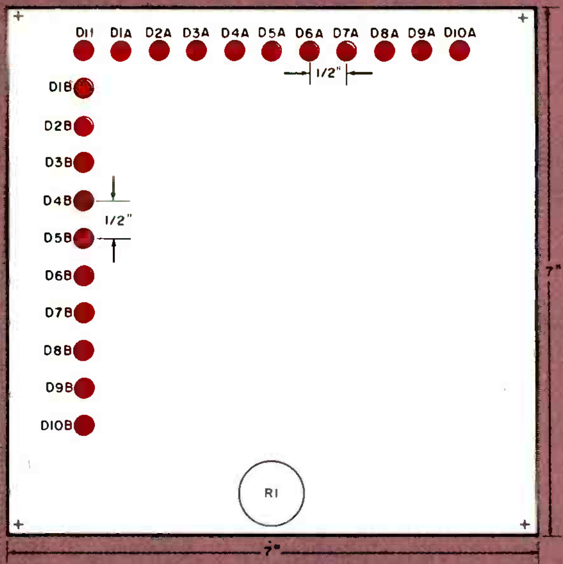


Fig. 5. Mount the LEDs in horizontal and vertical rows on the front panel as shown here.

TABLE—SCALE MEASUREMENTS

Note: Each SWR line starts at origin (*D11*) and extends as shown below.

Diode Intercept	SWR Label
D10A, D1B	1.2:1
D10A, D2B	1.5:1
D10A, Midway between D3B and D4B	2:1
D10A, D5B	3:1
D10A, D6B	4:1
D10A, D7B	5.6:1
D10A, Midway between D7B and D8B	7:1
D10A, D8B	9:1
D10A, D9B	19:1

ing *D9A* lit instead of *D10A*). This keeps the circuit from saturating. Now note which diode in the vertical column is lit, and read the SWR from the calibration line closest to the intersection extrapolated from the lit diodes. For example, if *D10A* is lit in the horizontal row and *D5B* is lit in the vertical row, the intersection lies on the 3:1 SWR calibration line.

To use the instrument with single-sideband, modulate your SSB transmitter and adjust *R1* so that horizontal diode *D10A* never lights (or flickers only occasionally). Again find the highest-number horizontal- and vertical-row diodes which do fully light and extrapolate to find the point of intersection. Read the SWR from the calibration curve closest to the intersection. ◇

SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

New Piezoelectric Products

IN 1880, Pierre and Paul Curie discovered an extraordinary physical phenomenon. They found that if pressure is applied to crystals of quartz, tourmaline, or Rochelle salt, a voltage is produced. They named their discovery the *piezoelectric effect*. A year later they found that this effect is reversible. If an electric field is applied to these particular crystals, they will either expand or contract.

Typical Applications. Nowadays, we are surrounded by devices and gadgets that exploit the century-old piezoelectric effect. Quartz crystals are found in CB radios and scanners, digital watches and clocks, and computers and TV games. The crystals provide an electromechanical resonance so precise that oscillators designed around them have a stability that varies only a few cycles in a million.

Piezoelectric crystals and ceramic elements are used in audio equipment such as phonograph pick-up heads, microphones, high-frequency tweeters, and miniature earphones. Figure 1, for example, shows a magnified view of a piezoelectric wafer that directly drives a tweeter cone. The wafer is a sandwich of two piezoelectric discs separated by a corrugated centervane. When a signal is applied, one disc expands while the other contracts, thus moving the cone to produce a sound.

The ultrasonic sound emitted by electrically stimulated, piezoelectric transducers is used to find fish, measure water depth, agitate jewelry-cleaning solvents, repel certain insects, focus cameras, and guide blind people around obstacles. High-intensity, ultrasonic waves from these transducers can scramble an egg without breaking its shell, set cotton ablaze, shatter gallstones, weld metals, and even kill small animals such as fish, frogs and mice. On the other hand, low-intensity, ultrasonic sound emitted and detected by piezoelectric transducers can be used to safely view on a CRT the outline of a fetus in its mother's womb.

Fig. 1. Piezoceramic sandwich in magnified inset drives a tweeter. (Courtesy Motorola).

The sparks produced by mechanically stimulated, piezoelectric elements are used to light furnaces, hot-air balloon burners, and the fuel in some cigarette lighters. The ionization produced by high-voltage piezoelectricity is used to neutralize the static charge on phonograph records.

A Closer Look at Piezoelectricity. Not all crystals exhibit the piezoelectric effect. Normally a crystal contains an equal number of positive and negative charges and is therefore in a state of equilibrium. In other words, it is electrically neutral. If the shape of a crystal is changed by external mechanical pressure, both the positive and negative charges move. At this point the conditions for the flow of an electrical current are present. If, however, the charges move in the same direction, they neutralize or cancel one another and there is no current flow. For a current flow to exist, the charges must move in *opposite* directions. This happens only in crystals that lack a center of symmetry, and these are the ones that exhibit the piezoelectric effect.

It is important to realize that the piezoelectric effect is always accompanied by the physical movement, via compression or expansion, of the atoms in a crystal. Therefore, a piezoelectric crystal produces a current only when its atoms are in motion. Applying a constant pressure to the crystal will not squeeze out a continuous current!

When a piezoelectric element is struck by a small hammer, a pulse of current is produced while the element is being compressed. When the element springs back to its former shape, a second burst of current having a polarity opposite that of the first is produced. An ac voltage can be elicited by applying a fluctuating pressure to a piezoelectric element.

The dimensions of a piezoelectric crystal change only when the applied voltage changes. The resulting contraction and expansion is of very small magnitude, often on the order of a few mils or less. Yet the velocity at the surface of a piezoelectric crystal vibrating hundreds of thousands of times per second can be substantial. If, for instance, a crystal surface expands 0.01 inch in 0.00001 second (100 kHz), then the surface of the crystal must move at a velocity of no less than 83.3 feet per second or 56.8 mph. It may, in fact, move considerably faster.

Though the current flow produced when a piezoelectric crystal is squeezed is very small, the electromotive force can be on the order of a few hundred or even a few thousand volts. This is sufficient to create a visible arc several millimeters in length.

The converse effect, the physical movement of an electrically stimulated piezoelectric crystal, is not nearly so apparent as a highly visible spark. However, its existence can be demonstrated by an appropriate position-sensing transducer, perhaps one which itself employs the piezoelectric effect to generate an output voltage proportional to an applied movement. Its existence may also be made apparent by secondary effects. For example, a rapidly vibrating piezoelectric wafer produces an audible tone.

Piezoelectric Materials. During the past century many crystals that exhibit the piezoelectric effect have been identified. Only a few, however, have been found suitable for practical applications. Of these, quartz is the unquestioned leader. Though the piezoelectric properties of quartz are not nearly so pronounced as those of Rochelle salt, quartz has excellent mechanical properties and good temperature stability.

Lithium niobate, a crystal with unique optical properties, is used in some piezoelectric applications. However it is more temperature-sensitive than quartz.

Aside from quartz, the most important piezoelectric materials are man-made ferroelectric ceramics such as lead zirconate titanate. These ceramics, unlike quartz and other piezoelectric crystals, are polycrystalline and would therefore seem unsuitable for piezoelectric applications. However, they are given piezoelectric properties during their manufacture by the application of a strong electric field that polarizes the material.

More Applications for Piezoelectricity. We've already mentioned some of the better known applications for piezoelectricity, a few of which have been in use for more than fifty years. For instance, many of the applications that depend

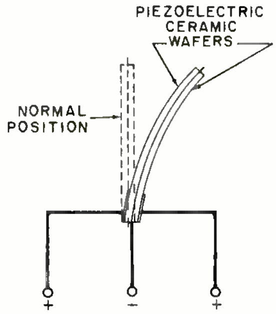


Fig. 2. Piezoelectric bimorph.

upon the electrically triggered motion of a piezoelectric element can be traced to the *bimorph*, the first piezoelectric device invented by the Curie brothers.

The basic bimorph shown in Fig. 2 is a sandwich formed by attaching thin piezoelectric bars to either side of a metal strip. Electrically conductive coatings may be applied to either side of one end of the bimorph to form terminals. A voltage applied to the terminals causes one bar to contract in one dimension and expand in the other, while the opposite occurs to the second bar. The resulting forces cause the bimorph to bend. By changing the polarity of the applied voltage, the bimorph will bend in the opposite direction.

Recently an entirely new array of applications for the piezoelectric effect was announced by Piezo Electric Products, Inc. (186 Massachusetts Ave., Cambridge, MA 02139). Formed in 1980 to develop new piezoelectric devices, the firm has acquired the piezoelectric product manufacturing facilities of Gulton Industries.

So far Piezo Electric Products has announced several new devices developed by Eric and Henry H. Kolm, latter day versions of the Curie bothers and vice-presidents of the new firm. The piezoelectric relay or actuator is a miniature solid-state relay which is faster, longer lived and less noisy than conventional electromechanical relays. Figure 3 shows how a piezoelectric relay is constructed.

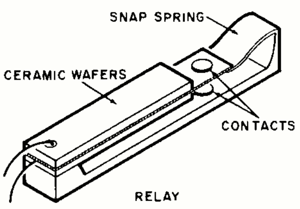


Fig. 3. Piezo Electric Co.'s relay.

The chief drawback of present devices is the requirement of about 40 V for actuation.

The piezoelectric relay technology devloped at Piezo Electric Products has been applied to the design of a new dot-matrix printhead. The new printhead uses piezoelectric bending elements instead of solenoids to drive small pins against a carbon ribbon. If successful, a piezoelectric dot-matrix printer should operate at a high speed with considerably less heat production than a conventional dot-matrix printer.

A third new application involves piezoelectric quadrature motors and fans. Information from Piezo Electric Products about the design and operation of these devices is sketchy, but the fan is described as operating on the principle of the insect wing and using one-hundredth of the power of a conventional blower of similar output. One application is a miniature cooling fan for electronic components.

The inverse of the piezoelectric vibrating fan is a solid-state generator that produces power from moving air or gas. According to Piezo Electric Products, "We have proof-of-concept models of electrical generators which operate off the acoustic energy in the exhaust of internal combustion engines. We anticipate that automobile mufflers of this type would replace the alternator and noticeably improve the fuel economy of the engine."

The firm has also developed a piezoelectric windmill that generates electricity when piezoelectric elements are vibrated by moving air. The company claims such windmills ". . . can be effectively made in the form of small units resembling snowfences, highway barriers, or other structures capable of supporting a number of small vanes resembling the leaves of a tree. Such piezoelectric windmills would operate over a wider range of wind velocities than rotary windmills, and hopefully cost less per watt of installed power."

Another idea from Piezo Electric Products is a bicycle generator expected to enter production this year. It has much less drag than the conventional generators and directly produces the high voltage required for high-brightness, gas-discharge lamps.

Other companies are also developing exotic new applications for piezoelectric technology. Watson Industries (Eau Claire, WI) sells a piezoelectric gyroscope for $295 which (it claims) is superior to laser-ring gyros. The piezoelectric gyro is compact and weighs only about 10 oz. Its sensitivity is sufficient to detect a rotation rate as low as 0.04 degree per second.

National Semiconductor (2900 Semiconductor Dr., Santa Clara, CA 95051) has developed a CMOS chip that is powered by an accompanying piezoelectric element. Developed for Gould Inc., the chip derives its power from a rotating tire, and is designed to transmit a coded signal when tire pressure falls below a certain point.

Many kinds of piezoelectric accelerometers and force transducers have been developed. There is even a piezoelectric micrometer system manufactured by Polytec Optronics, Inc. (22651 Lambert St., Unit 108, El Toro, CA 92630). This system includes a power supply that provides an adjustable voltage to miniature piezoelectric elements mounted on precision micrometers. Model P-252 provides a total excursion of 25 mm with a piezoelectric fine tuning up to 20 microns (at 0.02 microns per volt).

West Germany's Siemens AG has developed a miniature, piezoelectric, isolation transformer. As shown in Fig. 4, a voltage applied to one side of a piezoelectric ceramic wafer induces an acoustic wave that propagates across the wafer to a second pair of electrodes. The voltage produced by the acoustic wave is transferred to the second electrode pair and used to control an external device such as an SCR or TRIAC.

One of the products developed by Siemens is available for only 70¢ in large quantities. It is the PZK 20 Piezo Ignition Coupler, which can be used in appli-

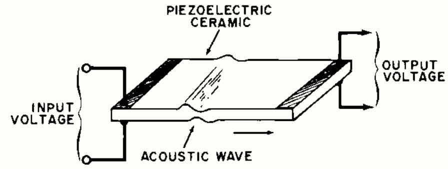


Fig. 4. Isolation transformer from Siemens.

cations that would instantly destroy the LED in an optocoupler. It's very fast (the acoustic wave travels 2 km/s), it provides very high isolation (the piezoelectric element is an insulator), and it produces its own output voltage. The U.S. address for the components division of Siemens is 186 Wood Ave. S, Iselin, NJ 08830. The address for Siemens AG is Frankfurter Ring 152, D-8000, Munich 46, West Germany.

While the recent emphasis in piezoelectric technology has been upon ceramic elements, quartz is still of major importance. The Statek Corporation (512 N. Main, Orange, CA 92668) has made notable advances at both ends of the quartz frequency spectrum. On the low end, Statek has developed a quartz-crystal oscillator that fits within a miniature TO-5 transistor can. A quartz crystal smaller than the point of a sharp pencil provides an oscillation frequency as low as 10 kHz. The crystal and its miniature hybridized circuit can withstand a shock of 1000 g's.

On the high end, Statek has developed what it believes is the smallest 1-MHz microprocessor crystal. The new unit is about one-fourth the size of an 8-pin mini-DIP. Its calibration accuracy of ±0.05% is achieved by a process in which the miniature crystal is etched from a quartz wafer and fine-tuned to the correct dimensions by laser trimming.

Statek's miniature quartz crystal between leads of an HC-33 can.

Learning More. I'm not aware of any recent books on piezoelectricity. Many electronics texts, however, cover the theory in much more detail than I have in this brief column. Some encyclopedias, particularly those dedicated to science topics, cover the subject quite well.

If you want to experiment with piezoelectric crystals of your own making, "Crystals and Crystal Growing" (Alan Holding and Phylis Singer, Anchor Books, Doubleday & Co., 1960) has a chapter containing the recipe for making Rochelle-salt, single crystals larger than a sugar cube. ◇

COMPUTER BITS

By Carl Warren

Add-Ins and Add-Ons Increase System Performance

A NUMBER of established companies are jumping on the microcomputer plug-compatibility bandwagon and are offering a host of goodies to upgrade a system. For example, for the IBM Personal Computer, urged on by an almost limitless market potential, others have developed items ranging from 256K-byte memory boards to expansion chassis for the powerful system—all with the uncharacteristic support of IBM.

Even peripheral equipment manufacturers view the IBM machine as an ideal vehicle for new products. One such company, GTCO Corp. has introduced a digitizing option called the Graphic Analysis Package #1. This package consists of a digitizer pad with 0.001-in. resolution (sizes vary from 11" × 11" to 42" × 60" active area pads), a digitizing stylus, a power supply, a communications interface cable, an operator's manual plus the necessary software on diskette. Prices for the GTCO graphics package range from $1419 for an 11" × 11" tablet to $3025 for a 20" × 20" translucent tablet. The software for the graphics option follows the IBM philosophy of using user-oriented menu systems to display 22 predefined functions with room for 11 user-defined functions.

Like the GTCO offering, other products being introduced are designed to plug directly into the computer backplane. In some cases, such as Tecmar's PC-Mate Expansion Chassis priced at $945 for chassis and adapters with cables, the idea is to extend the working area of the bus.

The Expansion Chassis, is designed to interface to any one of the available expansion slots with a host adapter and extension cables. The bus adapter handles all translation of bus signals and provides buffering and necessary drivers to ensure proper operation of both the primary and expansion bus. Once connected, the expansion bus allows an additional 7 slots for adding memory and peripheral controllers. The chassis comes equipped with a heavy-duty power supply capable of handling an optional 5.25-in. Winchester disk drive. In addition, the chassis provides convenience power outlets for printers or monitors.

Expansion of the bus is only a small part of the offering from Tecmar. The company has developed a total of 20 products, including the expansion chassis, dubbed TecMates. The TecMate series includes a series of RAM cards ranging from a $495 64K-byte card to a $1295 256K-byte card. In addition, you can turn your system into a complete development station by the addition of the E^{3}PROM card ($395) that employs Electrically Erasable Programmable Read Only Memories (EEPROMs). These allow changing ROMable programs under software control so it is not necessary to have an ultraviolet erasing system.

In the same line is an IEEE-488 bus adapter ($395) that permits interfacing to a host of test equipment or the similarly priced Lab Tender that provides complete 16-channel, 8-bit analog-to-digital and digital-to-analog conversion with five timer/counters and three parallel ports.

Should your applications be more futuristic, Tecmar even has cards such as the Speech Master ($395) to give your personal computer a voice. The board has a built-in vocabulary of 143 unique words, letters, and word sounds, and according to Dave Wertman at Tecmar you'll be able to purchase additional personality modules to increase the vocabulary by midyear.

To really turn the system into a futurists dream, you can purchase the $345 Video Digitizer to convert standard NTSC video signals to digital patterns, and add the $495 Stepper Motor Controller to handle the movement of robotic arms. The idea is to use the IBM Personal Computer to develop an artificial intelligence system that not only performs tasks but recognizes images.

No doubt the IBM system will find use in a number of diverse applications, and has wide market potential. However, not all independent design houses are willing to provide as many products as quickly as Tecmar.

Typically, most are planning to jump into the market with two products at most. Data Mac Computer Systems, for example, has a memory board that starts at $499 for a 64K RAM board, with the ability to expand to 256K bytes on the same board, for about $1200.

Microsoft Consumer Products division is planning a 256K memory add-on, designed by Burtronix, also for about $1200. This RAMCard, employs 64 × 1 RAMs and, like the Data Mac card, its parity can be enabled or disabled depending on the operation.

Microsoft is planning to offer more than just the hardware for the price. In the works is a bundled product that will treat the RAM as a solid-state disk system. This board, and possibly the software for it, are expected to be available this month.

Even though Burtronix is best known as an R&D house that develops products for others to market, it is also planning to climb on the IBM bus with an $80 prototyping card and an as yet unpriced extender card.

For one-stop shopping for IBM PC add-ons and tools, there is Applied Business Computer Inc. This company offers everything from the AI-1512, 512K-byte RAM card for $1495 to a $3800 5.25-in. 18M-byte Winchester. They even have an as yet unpriced EPROM programmer, Model AI-7128 that will program 2732s, 2764, and 27128s. If you require CMOS battery-backed memory, they offer the Model AI-1064, 64K board for $850.

Vista Computer on the other hand, is sporting the 576K Multi-Maxicard, that starts out at $1199 for a 256K version and ranges up to $1849 for the full 576K. This board uses just about the entire available memory range permitted without shadowing the system ROM in and out.

Another source of IBM PC memory boards is National Technology Sales. This company offers a 256K version for $1495 and 512K configuration for $1995. Dubbed the PC/RAM Stack, the boards have onboard error checking, an average access time of 250 ns, and a typical cycle time of 410 ns.

If expanding disk storage is important to you, Interface Inc, has double-sided, double-density drives that provide up to 672K bytes of formatted storage. Two models of drives are available and several combinations of internal and external drives can be used to meet storage requirements. The models include: a single-sided drive with 168K of storage and a double-sided drive with 336K of storage. These can be mixed and matched in any manner. Prices for the drives are $470 for an internal single-sided drive, $570 for a single double-sided drive. Add $100 to each price if you want them configured for external operation.

Apple Owners Get Some Too. Should you have an Apple and would like the functionality of the IBM PC, Coprocessor Inc. has just the ticket with the 88CARD. This $899 items uses an 8088 microprocessor, has 64K of RAM and operates at 5 MHz. The board is designed to work in any Apple slot without burdening the power supply. And if you're wondering, the board uses the same operating systems as the PC and enables you to run all the same programs.

Two additional boards that you might want to add to your Apple include: Wesper Microsystems Wizard-BPO, for $179. This card lets you have a printer buffer up to 32K bytes, and is designed to work with all the Apple software, as well as CP/M. What you get is the ability to perform printing while the system is doing something else.

Regardless of what your system is, as

long as you have either a serial RS-232 or 8-bit parallel port available, you can turn the system into an IEEE-488 bus controller simply by plugging in an ICS Electronics Corp's Model 4825, or 4828 Interface Card. All the commands for 488 operation are implemented onboard. Be aware though that ICS offers these cards to OEMs, and they will more than likely be somewhat above $600 in single quantities.

In operation, the card serves as a talker/listener, and your computer thinks it sees either another serial or parallel device. Consequently, writing code to service instruments is a great deal easier since no special 488 drivers are required.

Heath Systems Add-Ins. A few months ago, I happened to call Doug Sauby at Magnolia Microsystems regarding the possibility of adding more than 64K of memory to the Heath/Zenith 89 microcomputer. Doug felt it could be done by employing the memory I/O bit-mapping to gain the extra address bits.

As a result, Magnolia developed the $595 Invisible Disk. This card employs 64K × 1 dynamic RAM, and extends your total memory space to 176K. In the current implementation, 112K of the added board is treated as a very fast disk drive. About the time you read this column, Magnolia plans to have MP/M fully implemented to permit multi-user/multi-tasking operations on the machine.

Implementing the Invisible Disk is easy. All that is necessary is to remove the 89's cpu card, plug in the Magnolia bit-mapping board and the RAM card, and put it back together again. The most difficult part of the process is removing and reinserting the cpu card.

Once you have performed that task, all that is necessary is to link a software module to tell CP/M that the new device is present. You basically set the RAM up as logical device 40; and, using the configuration program, set it to the desired disk name (in our case, drive F:).

In operation, you can use setauto to run a Submit program to load the desired program into the semiconductor disk, and begin immediate operation. Ours is set as follows:

PIP F: = *.*[VO]	put contents of disk on to F:
F:	Log in F: drive
WS	run the program—in this case WordStar.

Due to the paucity of space available on Heath add-in boards, Magnolia wasn't able to implement parity checking. Instead they opted for CRC—Cyclic Redundancy Checking, careful layout of the printed circuit board, and close attention to decoupling capacitors. After about two months of operation, we haven't experienced any soft errors; and surprisingly the 89 hasn't overheated.

I do want to point out, however, that if your 89 is over two years old and you're thinking of adding such niceties as the Magnolia 8-in. controller or the Invisible RAM, chances are you will overtax the power supply. We discovered this in one of our 89s that we have had since 1980. The bridge rectifier broke down due to high current, and the secondary in the transformer burned out. Zenith has taken care of these problems in units produced in the last year. The transformer and rectifiers have higher ratings, and all the regulators have heat sinks. So before adding make sure you have adequate power.

Another enhancement for the 89 comes from DG Electronics. It offers the Super 89 for $800 for a 64K version and $1400 for a 256K configuration. The board completely replaces the Zenith cpu card, and comes with a 4-MHz cpu, real time clock, parity check on RAM, expanded bus structure, on-board serial I/O port, and is CP/M-HDOS compatible. We asked both the DG folks and the Magnolia designers if the new board would work with Magnolia's disk controllers, but as of this March neither was sure since no actual tests were run. Both design groups saw no problems since the DG board is functionally compatible with the Zenith card.

An interesting add-in that you might want to consider for your 89 comes from Artra Inc. The board, called the Housemaster, provides you with a real-time clock, voice recognition, sound synthesizers, BSR X-10 home control, battery backup for the calendar/clock, and dual RS-232 ports. The card, which is available as a kit for $299 or $399 assembled, takes the place of the I/O card. Be aware that things like the RS-232 ports and voice synthesis are options and range in price from $35 to $225 for assembled versions.

Commodore Systems Get CP/M. It seems that everyone wants to have CP/M compatibility, and Small Systems Engineering is providing it with the $895 Z-80 based Softbox. This add-on allows CP/M, RS-232 ports, and an interface to a Corvus hard-disk system, as well as 64K of RAM. The similarly priced Hardbox enhances the Pet disk operating systems allowing one to four Corvus drives to emulate the Commodore floppy-disk system for up to 64 users. It comes with seven utilities including: user reconfiguration, password security, file transfer between hard disk and floppies, diagnostics, and the ability to use a video recorder for data backup.

To speed up Commodore BASIC, SSE has PETspeed priced at $350 to give a 30% increase in compiler operation. ◇

FOR MORE INFORMATION

For more information on the products described in this article, contact the following manufacturers directly:

Applied Business Computer Co.
2883 E. La Palma Ave.
Anaheim, CA 92806
714-630-3821

Artra Inc.
Box 653
Arlington, VA 22216
703-527-0455

Burtronix
18472 Jocotal Lane
Villa Park, CA 92667
714-974-6171

Coprocessors Inc.
50 West Brokaw Road, Suite 64
San Jose, CA 95110
408-947-4616

D-G Electronic Developments Co.
700 South Armstrong
Denison, TX 75020
214-465-7805

Data Mac Computer Systems
680 Alamanor Ave.
Sunnyvale, CA 94086
408-735-0323

GTCO Corp.
1055 First St.
Rockville, MD 20850
301-279-9550

ICS Electronics Corp.
1620 Zanker Road
San Jose, CA 95112
408-298-4844

Interface Inc.
20932 Cantara Street
Canoga Park, CA 91304
213-341-7914

International Business Machines Corp.
Information Systems Div.
Box 1328
Boca Raton, FL 33432
305-998-6007

Magnolia Microsystems Inc.
2264-15th Ave. West
Seattle, WA 98119
206-285-7266

Microsoft Consumer Products Inc.
10700 Northup Way
Bellevue, WA 98004
206-828-8080

National Technology Sales
Box 401782
Garland, TX 75040
214-349-8259

Rana Systems
20620 South Leapwood Ave.
Carson, CA 90746
213-538-2353

Small Systems Engineering Inc.
71 Park Lane
Brisbane, CA 94005
415-468-2900

Sorcim Corp.
405 Aldo Ave.
Santa Clara, CA 95050
408-727-7634

Tecmar Inc.
23600 Mercantile Rd.
Cleveland, OH 44122
216-464-7410

Vista Computer Co.
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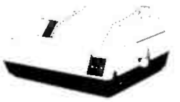

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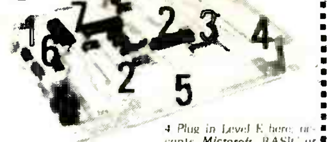

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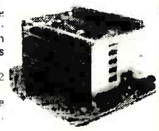

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COMPUTER SOURCES

By Leslie Solomon
Technical Director

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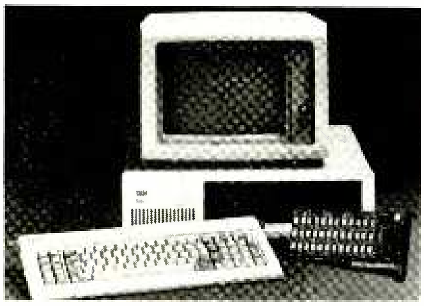

IBM hardware and software, and IBM-like documentations. $395 for 64K, $620 for 128K, $845 for 192K, and $1075 for 256K. There is a 64K expansion kit for $225 which boosts boards already in the field. **Address:** Personal Systems Technology, Inc., 22957 La Cadena, Laguna Hills, CA 92653 (Tel: 714-859-8871).

Green Screen Monitors. The PI-1 is a 9″ (44 sq. inches) green-screen video monitor that can support 64 characters by 16 lines (80 characters by 24 in some applications). $249. The PI-2 is a 12″ (75 sq inches) green-screen video monitor that can support an 80 character by 24 line text display. $275. Both units have 20 MHz bandwidth, with horizontal rate 15.6 kHz. Connection is via SO-239 or RCA phone jack. Both have anti-reflection screen. **Address:** USI International, 71 Park Lane, Brisbane, CA 94005 (Tel: 415-468-4900).

Z80 Board. The PRO/80 is a Z80 based single-board computer featuring the S-100 bus, two parallel ports, cassette interface, 1K of RAM expandable on the board to 2K, 1K of EPROM holding the monitor, hex keypad with 8 extra keys, and six 7-segment displays. Requires external 8-volt, 1-ampere power supply. $169.95. **Address:** ETCO Electronics Corp., Plattsburgh, NY 12901 (Tel: 514-342-1555).

Apple RAM. The DSI 16K RAM Card for the Apple computer is currently available for $99. **Address:** Davong Systems Inc., 1061 Terra Bella Ave., Mountain View, CA 94043. (Tel: 415-965-7130).

CP/M-80 for IBM PC. Baby Blue CPU Plus is a combination of hardware and software that enables IBM Personal Computers to run virtually any software that is CP/M-80 compatible and written for the 8080/Z80 microprocessor. It plugs into an existing slot, adds 64K-bytes of memory to the system, making it a computer within a computer. Baby Blue runs the programs, and passes the task of communicating with the outside world to the IBM machine. $600. **Address:** Xedex Corp., 645 Madison Ave, New York, NY 10022 (Tel: 212-247-1400).

RAM Disk. Designed for the S-100 system or a TRS-80 Model 2 using CP/M 2.2, or the IBM Personal Computer, the SemiDisk is a high capacity memory board that "looks" like a disk drive to the system, except that it is much faster. It does not require extended addressing or bank switching and all data goes through four I/O ports that can be re-addressed to any of 64 locations. Software is supplied on 8″ single-density floppies, 8″ double-density TRS-80, 5″ NorthStar double density, and IBM 5″ formats. 512K-byte SemiDisk is $1995, 1-megabyte SemiDisk is $2995. **Address:** SemiDisk Systems, POB GG, Beaverton, OR 97075 (Tel: 503-642-3100).

Software

French Programs. If French is your language, you should know that there is now a series of French software programs for the Apple computer. The 24 programs include strategic simulations, interactive fantasies, educational programs, etc. Catalog available from Computerre, C.P. 782, St. Laurent, Quebec, Canada H4L 4W2 (Tel: 514-747-9130).

WP Utility. Super Text allows an Apple II to display an 80 column screen with the use of a Videx Board, insert page headers and footers, multi-file search-and-replace, display of disk space available, user defined keys, and the ability to count occurrences of specified words or phrases. It also supports an enhanced math mode, split screen option, advanced block operations, and Autolink of multiple files. $175. **Address:** Muse Software, 347 N. Charles St., Baltimore, MD 21201 (Tel: 301-659-7212).

MAIL Utility. Mail-Base is an inquiry/mailing list that keeps track of up to 32,000 customer records composed of name and address data plus 15 user-defined flags and room for comments. Each customer record is indexed by zip code and user-selectable name key. Each record can be selected by partial or full declaration of any combination of 23 information fields. Selected records may be printed as mailing labels, index and Rolodex cards, user-defined forms, or merged into form letters. For Televideo, Zenith, or any CP/M-based CPU with Zenith Z19 terminal. $199.95 for Microsoft BASIC, $299.95 for compiled version. **Address:** XtraSoft, Inc., 4910 Roman Drive, Louisville, KY 40291 (Tel: 502-499-1533).

VIC20 Software. VICMORSE allows the VIC20 to be used as a cw keyboard keyer and automatic code reader and requires 5K, interface, and I/O connector. $19.95. VICRTTY requires 3K memory expander and is used for radioteletype ham activities. $24.95. The firm also carries numerous game and utility software for the VIC20. **Address:** RAK Electronics, P.O. Box 1585, Orange Park, FL 32073 (Tel: 904-264-0756).

CP/M Utilities. The Disk Utility Package for CP/M works with any single user CP/M 2.x system with any diskette size and format and many hard disks. The menu-driven utilities include DDUMP to examine and patch any byte on any sector, DTEST to test a disk for bad spots which are locked out and reported to printer/terminal, DUSER enables access from one user area to program and/or files stored on other user areas without keeping duplicate copies of disk files, DDUP duplicates disks and is independent of controller, drive, disk size, and format. It will also replace bad sectors on source disk with blank sectors on destination disk. The last utility UNERA recovers from accidentally ERAsed files. $29.95 each or all five $125. Specify format (8″ SS/SD, 5″ HS Heath/Zenith). Include $8 handling/shipping. **Address:** Elektrokonsult AS, Konnerudgaten 3, N-3000, Drammen, Norway.

Apple Adventure. The Adventure game for the Apple II uses hi-res graphics which are compressed, and drawn using over 100 colors. It also uses the Votrax Type'N Talk voice synthesizer, producing both pictures and sound. The game wanders through an enchanted world seeking 13 lost treasures, encountering wild animals, magical beings, and other perils and puzzles. $29.95. **Address:** Adventure International, Dept. G., Box 3435, Longwood, FL 32750 (Tel: 1-800-327-7172).

PROGRAMMER'S NOTEBOOK

By Jim Keogh

Keeping Time

FREQUENTLY, microcomputer software requires the on-screen display of text and/or graphics for specific periods of time. For example, the programmer may want to display a logo, followed by the title of the program, the programmer's name, and the copyright identification, for some short interval. Let's take a look at how display time can be controlled, and then examine a few other interesting BASIC subroutines.

Since there is no way that software, even heavily "bugged," can damage the hardware, the reader can experiment with these programs (or any program) to "see what happens." The worst that can happen is an error message being displayed.

The most common way to control how long an image appears on screen is by using a simple timing loop. Such a loop instructs the computer to perform a series of calculations, without printing the results of the calculations. The following programs, which can be run on a TRS-80 and Apple II, respectively, will illustrate the timing loop. These computers were

TRS-80

```
10 REM TIMING LOOP
20 CLS
30 PRINT "TIMING LOOP HAS
   STARTED"
40 FOR A = 1 to 500
50 B = A+1
60 NEXT A
70 CLS
80 PRINT "TIMING LOOP HAS ENDED"
```

APPLE II

```
10 REM TIMING LOOP
20 CALL-936
30 PRINT "TIMING LOOP HAS
   STARTED"
40 FOR A= 1 TO 500
50 B=A+1
60 NEXT A
70 CALL-936
80 PRINT "TIMING LOOP HAS ENDED"
```

selected because they are two of the most popular machines. However, the programs will run on all computers equipped for BASIC.

Let's examine the timing loop a little closer. Line 20 in both programs clears the screen. Clearing the screen is purely a cosmetic event and is not required for proper operation. Line 30 is the statement which we would like to have displayed on the screen for the duration of the selected timing interval.

The length of time which the statement will be displayed is controlled by line 40, which begins the timing loop. Line 50 instructs the computer to add 1 to the value of "A." Line 50 is not essential and is shown here to illustrate that the computer can "do something" during the timing interval (e.g., print a statement). After the computer completes the "B" calculation, it moves on to the next "A." The loop then cycles around lines 40, 50 and 60 until the value of the 500th "A" is used. If the upper-end value of "A" used in line 40 is relatively low (e.g., 500), the "padding" represented by step 50 is easily accommodated. But when line 40 is re-stated as "FOR A = 1 TO (any very large number)," line 50 may be omitted.

Note that we told the computer to calculate the value for "B." This allows us to keep just the statement we want displayed on the screen without the computer printing the values for "B."

The length of time it takes for the computer to complete the timing loop will depend upon the BASIC used, the computer "clock" speed, and the number of calculation (iterations) the computer has to perform. In the examples shown, we asked the computer to perform 500 calculations. Due to differences in clock speed, this will take about four seconds for the TRS-80 and approximately two seconds for the Apple II.

After the value for the 500th "B" is calculated, the program moves to line 70, which clears the screen. Line 80 then prints "TIMING LOOP HAS ENDED."

The following table can be used to create timing loop programs for six different

	Final Value of A	
Seconds	**TRS-80**	**Apple II**
5	625	1250
10	1250	2500
15	1875	3750
20	2500	5000
25	3125	6250
30	3750	7500

time duratons. Simply change the final value of A in line 40 of the previous programs to the value needed to create the desired timing period. For example, make line 40 read: "FOR A = 1 TO 3750" for a 30-second delay with a TRS-80.

If you require a longer or shorter time interval than those shown, the program below can be used to determine the final value of A (number of approximate calculations to be made). Note that line 40 of this new program shows screen clearing for both the TRS-80 and the Apple. Select the correct version of line 40 depending on the machine you are using.

```
10 REM THIS PROGRAM DETERMINES THE NUMBER OF CALCULATIONS
20 REM REQUIRED BY A TIMING LOOP FOR A CORRESPONDING
30 REM AMOUNT OF TIME FOR WHICH A STATEMENT WILL BE DISPLAYED
40 (TRS-80) CLS
40 (Apple II) CALL -936
50 PRINT "HOW MANY SECONDS WILL YOUR DISPLAY REQUIRE?"
60 INPUT A
70 (TRS-80) B = A* 125
70 (Apple II) B = A*250
80 (clear screen, see line 40)
90 PRINT "THE NUMBER OF CALCULATIONS YOU NEED IS";B
```

A key factor is introduced at line 70, where the desired number of seconds (A) is multiplied by a constant. There are two different constants involved, one for the Z80 CPU used in the TRS-80, and one for the 6502 CPU used in the Apple. That's because these CPUs operate at different clock rates. Again, select the line that matches your machine. ◇

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7411	0.17
7412	0.17
7413	0.24
7414	0.35
7416	0.19
7417	0.19
7420	0.15
7421	0.17
7423	0.18
7425	0.18
7426	0.18
7427	0.18
7430	0.15
7432	0.18
7437	0.18
7438	0.18
7439	0.18
7440	0.15
7441	0.60
7442	0.31
7443	0.50
7444	0.50
7445	0.50
7446	0.46
7447	0.46
7448	0.46
7450	0.15
7451	0.15
7453	0.15
7454	0.15
7459	0.15
7460	0.15
7470	0.21
7472	0.21
7473	0.21
7474	0.21
7475	0.27
7476	0.21
7480	0.22
7482	0.34
7483	0.41
7485	0.50
7486	0.20
7489	0.95
7490	0.30
7491	0.36
7492	0.30
7493	0.30
7494	0.38
7495	0.34
7496	0.38
7497	1.08
74104	0.47
74107	0.20
74109	0.22
74120	0.60
74121	0.24
74122	0.27
74123	0.35
74125	0.30
74126	0.30
74132	0.35
74141	0.53
74145	0.45
74147	$ 0.89
74148	0.62
74150	0.54
74151	0.32
74152	0.32
74153	0.32
74154	0.53
74155	0.32
74156	0.38
74157	0.38
74158	0.38
74160	0.48
74161	0.48
74162	0.48
74163	0.48
74164	0.51
74165	0.51
74166	0.54
74167	1.06
74170	0.84
74173	0.58
74174	0.41
74175	0.40
74176	0.47
74177	0.47
74178	1.00
74179	1.00
74180	0.48
74181	1.02
74182	0.48
74184	1.06
74185	1.06
74188	2.10
74190	0.50
74191	0.50
74192	0.50
74193	0.50
74194	0.48
74195	0.36
74196	0.47
74197	0.47
74198	0.63
74199	0.63
74221	0.40
74251	0.57
74279	0.50
74283	0.99
74290	0.54
74293	0.54
74298	0.50
74365	0.36
74366	0.36
74367	0.36
74368	0.36

74Cxx

74C00	$ 0.20
74C02	0.20
74C04	0.20
74C08	0.20
74C10	0.20
74C14	0.46
74C20	0.20
74C30	0.20
74C32	0.20
74C42	0.72
74C48	0.96
74C73	0.46
74C74	0.46
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74C89	2.15
74C90	0.71
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74C107	0.44
74C151	1.37
74C154	2.04
74C157	1.37
74C160	0.71
74C161	0.71
74C162	0.71
74C163	0.71
74C164	0.71
74C165	0.77
74C173	0.65
74C174	0.65
74C175	0.65
74C192	0.72
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74F157	0.87
74F158	0.87
74F164	1.35
74F175	1.35
74F181	2.90
74F182	1.50
74F190	2.36
74F191	2.36
74F194	1.17
74F241	2.78
74F243	2.78
74F244	1.80
74F251	0.94
74F253	0.94
74F257	0.94
74F350	2.10
74F352	0.94
74F353	0.94
74F373	2.34
74F374	$ 2.34
74F521	2.04
74F533	2.34
74F534	2.34

74LSxx

74LS00	$ 0.15
74LS01	0.15
74LS02	0.15
74LS03	0.15
74LS04	0.17
74LS05	0.17
74LS08	0.16
74LS09	0.16
74LS10	0.15
74LS11	0.17
74LS12	0.17
74LS13	0.21
74LS14	0.35
74LS15	0.15
74LS20	0.15
74LS21	0.15
74LS22	0.15
74LS26	0.18
74LS27	0.16
74LS30	0.15
74LS32	0.17
74LS33	0.32
74LS37	0.18
74LS38	0.18
74LS40	0.15
74LS42	0.37
74LS47	0.60
74LS48	0.51
74LS49	0.54
74LS51	0.15
74LS54	0.15
74LS55	0.15
74LS73	0.21
74LS74	0.21
74LS75	0.29
74LS76	0.23
74LS78	0.24
74LS83	0.40
74LS85	0.54
74LS86	0.24
74LS90	0.33
74LS92	0.33
74LS93	0.33
74LS95	0.40
74LS107	0.22
74LS109	0.22
74LS112	0.24
74LS113	0.24
74LS114	0.24
74LS122	0.41
74LS123	0.47
74LS125	0.33
74LS126	0.33
74LS132	0.42
74LS133	0.26
74LS136	0.26
74LS138	0.45
74LS139	0.45
74LS151	0.36
74LS152	0.36
74LS153	0.36
74LS154	0.72
74LS155	0.41
74LS156	0.41
74LS157	0.41
74LS158	0.41
74LS160	0.51
74LS161	0.51
74LS162	0.51
74LS163	0.51
74LS164	$ 0.51
74LS165	0.51
74LS168	0.57
74LS169	0.57
74LS170	0.84
74LS173	0.54
74LS174	0.35
74LS175	0.35
74LS181	1.36
74LS190	0.58
74LS191	0.56
74LS192	0.56
74LS193	0.56
74LS194	0.64
74LS195	0.40
74LS196	0.56
74LS197	0.56
74LS221	0.58
74LS240	0.63
74LS241	0.63
74LS244	0.63
74LS245	0.63
74LS247	0.59
74LS248	0.59
74LS251	0.40
74LS253	0.49
74LS257	0.41
74LS258	0.41
74LS259	0.94
74LS260	0.21
74LS266	0.27
74LS273	0.88
74LS279	0.29
74LS283	0.47
74LS290	0.58
74LS293	0.58
74LS295	0.54
74LS298	0.54
74LS352	0.58
74LS353	0.58
74LS365	0.33
74LS366	0.33
74LS367	0.33
74LS368	0.33
74LS373	0.80
74LS374	0.80
74LS375	0.56
74LS377	0.80
74LS378	0.70
74LS379	0.70
74LS386	0.28
74LS390	0.68
74LS393	0.68
74LS395	1.05
74LS447	0.37
74LS490	1.02
74LS670	1.14

74Sxx

74S00	$ 0.23
74S01	0.23
74S02	0.23
74S03	0.23
74S04	0.24
74S05	0.24
74S08	0.24
74S09	0.24
74S10	0.23
74S11	0.23
74S15	0.23
74S20	0.23
74S21	0.24
74S22	0.23
74S30	0.23
74S32	$ 0.28
74S40	0.24
74S50	0.24
74S51	0.24
74S60	0.24
74S64	0.24
74S65	0.24
74S74	0.36
74S76	0.36
74S78	0.36
74S86	0.36
74S112	0.36
74S113	0.36
74S114	0.36
74S132	0.52
74S133	0.23
74S134	0.24
74S135	0.42
74S138	0.74
74S139	0.74
74S140	0.26
74S151	0.66
74S153	0.66
74S157	0.66
74S158	0.66
74S161	1.48
74S174	0.87
74S175	0.87
74S181	2.73
74S182	0.82
74S189	1.83
74S194	1.07
74S195	1.07
74S206	2.48
74S240	1.29
74S253	0.63
74S257	0.60
74S258	0.60
74S280	1.14
74S289	3.05
74S387	2.54
93S00	1.08
93S05	1.25
93S10	1.88
93S12	0.74
93S16	1.85
93S41	2.73
93S42	0.82
93S43	3.24
93S46	0.84
93S62	1.44

4xxx

4000	$ 0.20
4001	0.17
4002	0.17
4006	0.61
4007	0.20
4008	0.57
4009	0.27
4010	0.27
4011	0.17
4012	0.17
4013	0.30
4014	0.50
4015	0.50
4016	0.28
4017	0.54
4018	0.49
4019	0.27
4020	0.58
4021	0.48
4022	0.56
4023	0.17
4024	0.40
4025	0.17
4026	1.20
4027	0.36
4028	$ 0.45
4029	0.58
4030	0.23
4031	1.12
4034	1.30
4035	0.65
4040	0.58
4041	0.54
4042	0.51
4043	0.54
4044	0.51
4045	0.64
4046	0.63
4047	0.64
4048	0.28
4049	0.28
4050	0.28
4051	0.54
4052	0.54
4053	0.54
4060	0.59
4066	0.27
4068	0.21
4069	0.17
4070	0.20
4071	0.17
4072	0.17
4073	0.17
4075	0.17
4076	0.53
4077	0.30
4078	0.24
4081	0.17
4085	0.39
4086	0.39
4089	1.07
4093	0.36
4099	0.80
4502	0.27
4503	0.36
4507	0.42
4508	1.49
4510	0.59
4511	0.53
4512	0.53
4516	0.59
4518	0.59
4519	0.30
4520	0.54
4527	0.71
4528	0.63
4539	0.53
4555	0.46
4556	0.46
4582	0.59
4584	0.39
4702	3.87
4703	4.50
4704	3.98
4705	5.04
4706	5.32
4720	5.32
4723	0.78
4724	0.78
4725	2.15
40014	0.39
40085	0.89
40097	0.38
40098	0.38
40106	0.39
40160	0.71
40161	0.71
40162	0.71
40163	0.71
40174	0.65
40175	0.65
40192	0.72
40193	0.72
40194	0.71
40195	0.71

DIODES & TRANSISTORS

DEVICE TYPE	PRICE PER 10	100	1000
1N270	$1.30	$10.80	$90.00
1N914	0.26	2.10	17.50
1N4001	0.49	4.08	34.00
1N4002	0.52	4.32	36.00
1N4003	0.55	4.56	38.00
1N4004	0.58	4.80	40.00
1N4005	0.64	5.28	44.00
1N4006	0.70	5.76	48.00
1N4007	0.80	6.60	55.00
1N4148	0.26	2.10	17.50
2N2218	3.17	26.40	220.00
2N2218A	3.46	28.80	240.00
2N2219	3.17	26.40	220.00
2N2219A	3.46	28.80	240.00
2N2220	2.60	21.60	180.00
2N2221	2.60	21.60	180.00
2N2221A	2.67	22.20	185.00
2N2222	2.60	21.60	180.00
2N2222A	2.67	22.20	185.00
2N2369	2.60	21.60	180.00
2N2369A	2.67	22.20	185.00
2N2484	2.60	21.60	180.00
2N2904	3.17	26.40	220.00
2N2904A	3.46	28.80	240.00
2N2905	3.17	26.40	220.00
2N2905A	3.46	28.80	240.00
2N2906	2.60	21.60	180.00
2N2906A	2.67	22.20	185.00
2N2907	2.60	21.60	180.00
2N2907A	2.67	22.20	185.00
2N3019	3.17	26.40	220.00
2N3704	0.87	7.20	60.00
2N3903	0.87	7.20	60.00
2N3904	0.87	7.20	60.00
2N3905	0.87	7.20	60.00
2N3906	0.87	7.20	60.00
2N4033	4.76	39.60	330.00
2N4123	0.87	7.20	60.00
2N4124	0.87	7.20	60.00
2N4400	0.87	7.20	60.00
2N4401	0.87	7.20	60.00
2N4402	0.87	7.20	60.00
2N4403	0.87	7.20	60.00
MPS2222	0.87	7.20	60.00
MPS2222A	0.94	7.80	65.00
MPS2369	0.87	7.20	60.00
MPS2907	0.87	7.20	60.00
MPS2907A	0.94	7.80	65.00
MPSA42	2.67	22.20	185.00
MPSA43	2.60	21.60	180.00
MPSA92	2.67	22.20	185.00
MPSA93	2.60	21.60	180.00

VOLTAGE REGULATORS

DEVICE TYPE	VREG VOLT	IMAX AMP	PKG. STYLE	PRICE PER 1	10	100	1000
LM317KC	ADJ.	1.5	TO-3	$1.84	$16.64	$151.25	$1,375.00
LM317UC	ADJ.	1.5	TO-220	1.34	12.10	110.00	1,000.00
UA7805KC	5	1	TO-3	1.17	10.59	96.25	875.00
UA7805UC	5	1	TO-220	0.60	5.45	49.50	450.00
UA7806UC	6	1	TO-220	0.60	5.45	49.50	450.00
UA7808KC	8	1	TO-3	1.17	10.59	96.25	875.00
UA7808UC	8	1	TO-220	0.60	5.45	49.50	450.00
UA7812KC	12	1	TO-3	1.17	10.59	96.25	875.00
UA7812UC	12	1	TO-220	0.60	5.45	49.50	450.00
UA7815KC	15	1	TO-3	1.17	10.59	96.25	875.00
UA7815UC	15	1	TO-220	0.60	5.45	49.50	450.00
UA7818KC	18	1	TO-3	1.17	10.59	96.25	875.00
UA7818UC	18	1	TO-220	0.60	5.45	49.50	450.00
UA7824KC	24	1	TO-3	1.17	10.59	96.25	875.00
UA7824UC	24	1	TO-220	0.60	5.45	49.50	450.00
UA78GKC	ADJ.	1	TO-3	1.25	11.35	103.13	937.50
UA78GU1C	ADJ.	1	TO-220	0.84	7.57	68.75	625.00
UA78H05KC	5	5	TO-3	5.00	45.38	412.50	3,750.00
UA78H12KC	12	5	TO-3	5.83	52.94	481.25	4,375.00
UA78HGKC	ADJ.	5	TO-3	5.66	51.43	467.50	4,250.00
UA78P05KC	5	10	TO-3	9.99	90.75	825.00	7,500.00
UA78S40PC*	ADJ.	1.5	16-DIP	1.92	17.40	158.13	1,437.50
UA7905KC	-5	1	TO-3	1.17	10.59	96.25	875.00
UA7905UC	-5	1	TO-220	0.60	5.45	49.50	450.00
UA7908KC	-8	1	TO-3	1.17	10.59	96.25	875.00
UA7908UC	-8	1	TO-220	0.60	5.45	49.50	450.00
UA7912KC	-12	1	TO-3	1.17	10.59	96.25	875.00
UA7912UC	-12	1	TO-220	0.60	5.45	49.50	450.00
UA7915KC	-15	1	TO-3	1.17	10.59	96.25	875.00
UA7915UC	-15	1	TO-220	0.60	5.45	49.50	450.00
UA79GKC	-ADJ.	1	TO-3	1.25	11.35	103.13	937.50
UA79GU1C	-ADJ.	1	TO-220	0.84	7.57	68.75	625.00
UA79HGKC	-ADJ.	5	TO-3	5.66	51.43	467.50	4,250.00

*SWITCHING REGULATOR

MICRO-PROCESSOR & SUPPORT DEVICES

DEVICE TYPE	CLOCK/ SPEED	PRICE PER 1	10	100	1000
Z80A-CPU	4 MHZ	$ 3.20	$ 29.04	$ 264.00	$ 2,400.00
Z80B-CPU	6 MHZ	8.79	79.86	726.00	----
Z80A-DMA	4 MHZ	10.39	94.38	858.00	----
Z80A-PIO	4 MHZ	4.24	38.48	349.80	3,180.00
Z80A-CTC	4 MHZ	4.24	38.48	349.80	3,180.00
Z80A-SIO/1	4 MHZ	17.25	156.82	1,425.60	----
Z80A-SIO/2	4 MHZ	17.25	156.82	1,425.60	----
Z80A-SIO/9	4 MHZ	15.02	136.49	1,240.80	----
Z80A-DART	4 MHZ	7.99	72.60	660.00	----
Z8001-CPU	4 MHZ	94.80	---	---	----
6800	1.0 MHZ	4.80	43.56	396.00	3,600.00
68A00	1.5 MHZ	4.86	44.17	401.50	3,650.00
68B00	2.0 MHZ	5.04	45.74	415.80	3,780.00
6802	1.0 MHZ	4.80	43.56	396.00	3,600.00
6809	1.0 MHZ	14.38	130.68	1,188.00	----
6810	450 NS	1.52	13.80	125.40	1,140.00
68A10	350 NS	1.59	14.40	130.90	1,190.00
68B10	250 NS	1.60	14.52	132.00	1,200.00
6820	1.0 MHZ	2.00	18.15	165.00	1,500.00
6821	1.0 MHZ	2.00	18.15	165.00	1,500.00
68A21	1.5 MHZ	2.24	20.33	184.80	1,680.00
68B21	2.0 MHZ	2.56	23.24	211.20	1,920.00
6840	1.0 MHZ	3.60	32.67	297.00	2,700.00
68A40	1.5 MHZ	3.67	33.28	302.50	2,750.00
68B40	2.0 MHZ	4.00	36.30	330.00	3,000.00
6844	1.0 MHZ	8.79	79.86	726.00	----
6845	1.0 MHZ	8.79	79.86	726.00	----
6847	1.0 MHZ	6.39	58.08	528.00	----
6850	1.0 MHZ	1.92	17.43	158.40	1,440.00
68A50	1.5 MHZ	1.99	18.03	163.90	1,490.00
68B50	2.0 MHZ	2.24	20.33	184.80	1,680.00
6852	1.0 MHZ	2.24	20.33	184.80	1,680.00
68A52	1.5 MHZ	2.56	23.24	211.20	1,920.00
68B52	2.0 MHZ	3.20	29.04	264.00	2,400.00
6854	1.0 MHZ	5.99	54.45	495.00	----
68A54	1.5 MHZ	6.71	60.99	554.40	----
68B54	2.0 MHZ	7.43	67.52	613.80	----
6856	1.0 MHZ	31.95	290.40	---	----
68488	1.0 MHZ	6.39	58.08	528.00	----
2114L	450 NS	1.60	14.52	132.00	1,200.00
2114L-2	200 NS	2.00	18.15	165.00	1,500.00
2114L-1	150 NS	2.50	22.60	205.95	1,872.00
6116-3	150 NS	9.19	83.49	759.00	----
4116-3	200 NS	1.76	15.98	145.20	1,320.00
4116-2	150 NS	1.84	16.70	151.80	1,380.00
2708	450 NS	3.28	29.77	270.60	2,460.00
2716	450 NS	5.20	47.19	429.00	3,900.00
2732	450 NS	14.45	131.34	1,194.00	----

SOLDER-TAB SOCKETS

NO. OF PINS	PRICE PER 1	10	100	1000
8-PIN	$0.09	$0.79	$ 7.15	$ 65.00
14-PIN	0.10	0.91	8.25	75.00
16-PIN	0.11	1.00	9.08	82.50
18-PIN	0.13	1.17	10.59	96.25
20-PIN	0.15	1.29	11.69	106.25
22-PIN	0.16	1.38	12.48	113.45
24-PIN	0.17	1.52	13.75	125.00
28-PIN	0.20	1.82	16.50	150.00
40-PIN	0.29	2.58	23.38	212.50

Hitachi Denshi, Ltd.

OSCILLOSCOPES

MODEL	DESCRIPTION	PRICE
V-151B	15MHZ, SINGLE TRACE	$ 427.50
V-152B	15MHZ, DUAL TRACE	551.25
V-202	20MHZ, DUAL TRACE	637.50
V-301	30MHZ, SINGLE TRACE	558.75
V-302B	30MHZ, DUAL TRACE	746.25
V-352	35MHZ, DUAL TRACE	862.50
V-550B	50MHZ, DUAL TRACE	1,308.75
V-1050	100MHZ, QUAD TRACE	1,792.50

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EXPERIMENTER'S CORNER

By Forrest M. Mims

Experimenting with Piezoelectric Devices

Part 1. Microphones, Pushbuttons, and Ceramic Filters

WHEN certain crystals and ceramics are mechanically flexed, a voltage is produced. This phenomenon is known as the *piezoelectric effect.* The effect is reversible, too. This means that piezoelectric crystals and ceramics will contract or expand when a voltage is applied across them.

In this two-part column, we'll experiment with devices that exploit the electrical output of a mechanically flexed or stressed piezoelectric element. And we'll work with those that depend on the mechanical motion of an electrically excited piezoelectric element.

The Piezoelectric Microphone. The so-called *crystal* microphone is a piezoelectric acoustic transducer. Early crystal microphones used a Rochelle-salt crystal element. Today the piezoelectric element in many of these microphones is a polarized ceramic wafer about the size of a fingernail. The ceramic is easy to mass produce, and is stronger and more moisture resistant than Rochelle salt.

You can learn much about the operation of a piezoelectric microphone with the help of an oscilloscope. Connect the leads of the microphone directly to the scope's probe. Set the vertical sensitivity to about 0.1 V/div. Adjust the sweep speed to about 1 ms/div.

First, speak or whistle into the microphone. The scope's CRT will display a visual analog of the sound; and, depending upon the proximity of the microphone to your mouth, the amplitude will range from about 0.1 to 0.5 V. Since the waveform overlaps the no-signal centerline, it is ac in nature.

Next, rap the microphone with a pencil or thump it with a finger. If the microphone is an economy version, the scope's CRT will display a ringing pulse with an initial peak of perhaps 40 or 50 V. The duration of the initial pulse will be about 0.1 ms.

A better designed, highly damped, piezoelectric microphone will produce only a very low voltage when tapped or thumped. This is because its element is designed to prevent inadvertent high-voltage spikes that might damage the input stage of a preamplifier. This could happen if a microphone were dropped or otherwise given a strong blow.

You can perform a dramatic experiment to demonstrate the high-voltage output of a highly stressed piezolectric microphone element by connecting the leads from the microphone to a neon glow lamp as shown in Fig. 1. Select a very cheap or discarded microphone (perhaps one with a damaged foil diaphragm), since it is necessary to remove the microphone's cover.

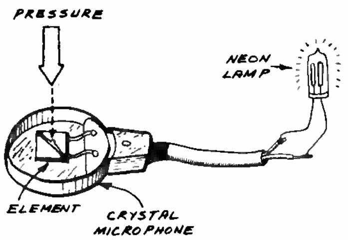


Fig. 1. Flashing a neon lamp with a crystal microphone element.

Tap the center of the foil diaphragm with a pencil or thump it with a finger, and the lamp should flash. The voltage pulse will be up to a millisecond wide and its amplitude may reach a few hundred volts!

It's not necessary to remove the diaphragm to conduct this experiment. However, if you wish to remove the foil, peel it from around the edge of the microphone case first. Then *carefully* pull it away from the central metal support that is attached to the piezoelectric element. Small scissors may help.

If you remove the foil, do not directly strike the element to light the neon lamp. Instead, strike the metal support bar that bridges two opposite corners of the element and provides a mounting point for the diaphragm. Be careful! The sole support for the piezoelectric element is probably a pair of rubber vibration-damping bumpers on two opposite corners of the element. The element is easily detached from these supports. Also, the two leads emerging from one side of the element are very fragile.

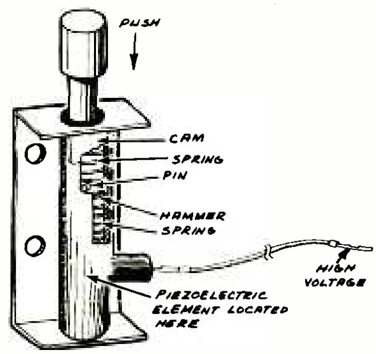


Fig. 2. Vernitron 3652 piezoelectric high-voltage pushbutton.

The Piezoelectric Pushbutton. Piezoelectric pushbuttons are used to ignite the fuel of some cigarette lighters, laboratory burners, and home furnaces. They produce a brief spike of up to 18,000 V and can make an arc up to $^3/_{16}$ in. in length.

For several years I've enjoyed experimenting with a Model 3652 high-voltage pushbutton made by Vernitron Corporation (Piezoelectric Division, 232 Forbes Road, Bedford, OH 44146). A similar device made by Vernitron is used as a solid-state igniter for outdoor cooking grills. The company has also manufactured hundreds of thousands of 0.1-inch, piezoelectric, ceramic cubes used to power the flash in compact cameras.

A pictorial view of the 3652 high-voltage pushbutton is shown in Fig. 2. The piezoelectric element is a compact slug about $^5/_8$ by $^3/_{16}$ in. Most of the unit's size is taken by the spring-loaded trip hammer that strikes the piezoelectric element.

To operate the unit, the pushbutton is pressed downward with a force of a few pounds. This compresses the upper spring and moves the cam toward the pin on the trip hammer. When

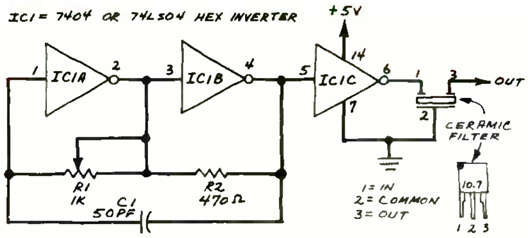


Fig. 3. Test circuit for a ceramic filter.

the cam pushes the pin into the drive slot, the hammer is triggered and slammed with a good deal of force against the piezoelectric element. When the pushbutton is released, the lower spring, which was compressed by the downward motion of the hammer, returns the hammer to its resting position where it is again ready to be driven against the piezoelectric element.

The arc produced by the piezoelectric pushbutton can be viewed by placing the output electrode near the unit's metal frame. For best results, the arc should be viewed in subdued light or against a dark background. Unless you want to feel a potent tingle, keep you fingers away from the output electrode when the button is pressed!

An interesting experiment is to connect a piezoelectric pushbutton to a long xenon flash tube. When the button is pressed, a thin violet arc will immediately appear between the tube's electrodes.

With suitable rectification it should be possible to use a piezoelectric pushbutton to charge a capacitor to a very high voltage. Of course the capacitor would have to be rated for the expected voltage. This might make possible a very simple power supply for Geiger counters and infrared image-converter tubes.

An 18,000-V piezoelectric pushbutton is available for $9.95 plus $2.45 for packing and guaranteed delivery from Edmund Scientific (101 E. Gloucester Pike, Barrington, NJ 08007). Specify catalog number 42,102 when ordering.

The Ceramic Filter. The ceramic filter, a most unusual piezoelectric device, is dependent upon the mechanical resonance of a piezoelectric ceramic wafer. When a signal is applied to its input, a surface wave is induced in the ceramic. If the frequency of the wave matches the resonant frequency of the ceramic, the wave will travel along the surface of the ceramic where it induces a piezoelectric voltage at a second pair of electrodes. Otherwise no signal is passed through the filter. In effect, then, the ceramic filter functions like a frequency-selective, isolation transformer.

Ceramic filters are widely used as 455-kHz intermediate-range filters in AM radio receivers. They are also used as 10.7-MHz filters in FM receivers and television sets. At these frequencies, the size of the filter is much smaller than an equivalent electronic filter. For example, a typical 455-kHz ceramic filter is a disc 0.2 in. across and from 0.1 to 0.4 in. thick. If the signal applied to a center electrode and a common electrode on the back side of the disc is at or very near 455 kHz, then the disk will vibrate and induce an electrical signal at a third electrode around the upper edge of the disk.

Figure 3 is a circuit that demonstrates the operation of a 10.7-

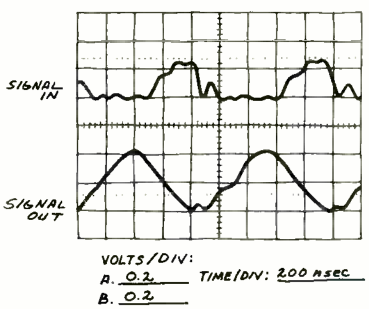


Fig. 4. A 10.7-MHz signal in a ceramic filter.

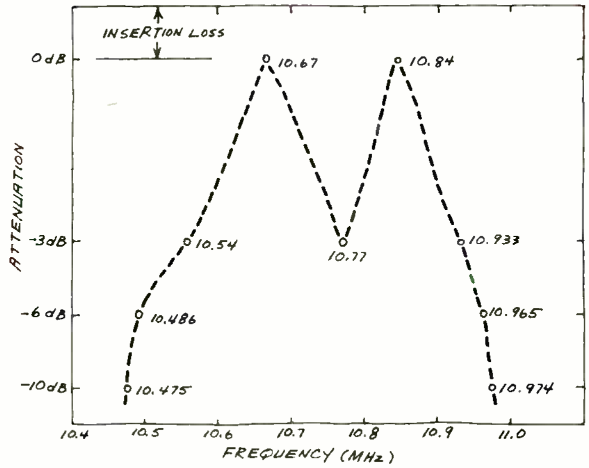


Fig. 5. Measured bandpass of a 10.7-MHz ceramic filter.

MHz ceramic filter such as the SFE 10.7MA5-A made by muRata Corporation of America (1148 Franklin Road, S.E., Marietta, GA 30067) and available for about one dollar from Radio Shack.

In operation, two inverters in a 7404 or 74LS04 hex inverter form a high-frequency oscillator whose output signal is buffered by a third inverter and fed into a ceramic filter. The frequency of the oscillator, which is determined by *R1*, can be adjusted from about 9 to 19 MHz with the component values shown. Much lower frequencies can be produced by increasing the value of *C1*.

Figure 4 shows the signal from the oscillator before and after its passage through the filter, with *R1* adjusted to provide the filter's peak frequency response. Note that the output signal appears to have about twice the amplitude of the input signal. Actually, the output signal is an ac version of the single-polarity input signal, hence the apparent doubling of its amplitude.

Also note that the output signal is phase delayed and is a much smoother, cleaner version of the input signal. The input signal might be cleaned up somewhat by optimizing component placement and using direct, point-to-point wiring instead of a solderless breadboard. Why is the output better shaped than the input? The acoustic wave that travels across the surface of the ceramic dampens imperfections in the input signal.

How effective is a ceramic filter? Figure 5 is a frequency-response plot made with the help of the circuit in Fig. 3 and an oscillocope. Note that the filter has a double peak with almost a − 3-dB valley or ripple at the specified peak response region. Of more significance is the rapid decrease in response beyond the − 6-dB points. The − 3-dB bandwidth is about 390 kHz. At − 10 dB the acceptance window is about 500 kHz.

My measurements do not agree as closely as I would have liked or expected with those given in muRata's published specifications for the SFE 10.7MA5-A. The − 3-dB bandwidth, for example, is given as 280 ± 50 kHz. Though the ripple for this filter is not given, a graph published in muRata's literature suggests a ripple considerably less pronounced than the − 3 dB I measured.

A 10.7-MHz Ceramic Oscillator. Quartz crystals are normally used to regulate precision oscillators. I've found that a ceramic filter will also work, but without nearly the precision quartz provides.

Figure 6 shows a 10.7-MHz ceramic oscillator. The circuit is virtually identical to the one in Fig. 3. The only exception is that *C1* in Fig. 3 has been replaced by the ceramic filter.

The variety of frequencies available with ceramic filters is much less than the vast number of quartz-crystal frequencies.

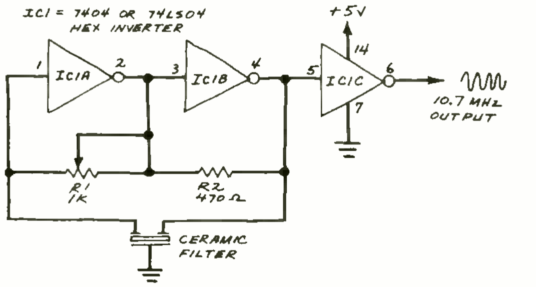


Fig. 6. Schematic diagram of a 10.7-MHz ceramic oscillator.

Nevertheless, the circuits in Figs. 3 and 6 suggest an interesting application: a matched radio-frequency oscillator and frequency-sensitive detector. The signal from the transmitter can be coupled directly or through the air via a fast-rise-time LED or by radio waves. (Additional circuitry will be required to implement this application.) Note that you will have to observe FCC regulations that apply to radio-frequency emissions. If you use a line-powered supply to operate the circuit, a nearby TV set may be subjected to severe video interference.

The chief advantage of this application is the very low cost and compact size of the ceramic filter used in both the oscillator and receiver. The ceramic filter used to produce the plot in Fig. 5 oscillated at 10.71950 MHz when *R1* was 500 ohms. A second filter gave a frequency of 10.72105 MHz. This relatively minor difference is of little consequence since the oscillator can be tuned a few tens of kilohertz in either direction by changing the setting of *R1*. ◇

ENGLISH BROADCASTS AUDIBLE IN No. AMERICA

by GLENN HAUSER

TIME[1] EST	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
4:00-4:15 a.m.	0900-0915	BBC	A	15070, 11955, 11750, 9640, 9510, 6195
4:00-4:30 a.m.	0900-0930	R. Japan[4]	B	15195,9505
4:00-5:30 p.m.	0900-1030	R. Australia	B	15115
4:00-5:00 a.m.	0900-1000	AFRTS, Los Angeles	A	9590, 9530, 6030
4:15-4:45 a.m.	0915-0945	UN Radio	B	15250, 9365, 9350-SSB (Sat.)
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, (21660 Sat. & Sun. and daily from 1030)
4:30-5:20 a.m.	0930-1020	V. of Germany	C	17780, 11850
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12036, 10080
5:00-6:00 a.m.	1000-1100	R. Japan	C	15235, 11875
5:00-6:00 a.m.	1000-1100	R. Korea	B	9570
5:00-6:00 a.m.	1000-1100	All India Radio	C	17875
5:00-6:00 a.m.	1000-1100	AFRTS, Los Angeles	A	11805, 9700, 9590, 9530, 6030
5:00-fade out	1000-	R. Australia	B	6045, 5995
5:00-8:00 a.m.	1000-1300	R. Moscow (via Cuba)	B	9600
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:10-12:00 a.m.	1010-1700	V. of Nigeria	C	15120
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:58-8:00 a.m.	1058-1300	CBC Northern Service	B-C	9625, 6065 (not all Eng.)
6:00-6:30 a.m.	1100-1130	R. Japan	B	15195, 9635, 9505
6:00-6:30 a.m.	1100-1130	R. Finland	B	21475, 15400 (Mon.-Sat.)
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12036, 10080
6:00-6:30 a.m.	1100-1130	R. Mogadishu	D	9585 (irregular)
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535
6:00-7:00 a.m.	1100-1200	V. of Asia, Taiwan	C	5980 (Sun. 1030-1040)
6:00-7:00 a.m.	1100-1200	AFRTS, Los Angeles	C	6030
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977, 9740
6:00-8:00 a.m.	1100-1300	TWR-Bonaire	A	11815 (Sat. & Sun. 1100-1330)
6:00-8:00 a.m.	1100-1300	R. Australia	A	17797, 9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550 11775, 11750, 9740, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	C	11835, 9770
6:00-10:00 a.m.	1100-1500	VOA	B	11715, 9565
6:00-12:00 a.m.	1100-1700	AFRTS, Los Angeles	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)(irreg).
6:30-7:30 a.m.	1130-1230	R. Korea	C	15575, 9870
6:30-7:30 a.m.	1130-1230	R. Thailand	C	11905, 9655
7:00-7:15 a.m.	1200-1215	V. of Kampuchean People	C	11938, 9694 (vary)
7:00-7:20 a.m.	1200-1220	CBC Southern Service	A	17820, 15540, 11955 9650 (Mon.-Fri.)
7:00-7:20 a.m.	1200-1220	Vatican R.	B	21485, 17840 (not Sun.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	21760, 21625, 17630, 15605
7:00-7:30 a.m.	1200-1230	R. Finland	B	15400, 21475
7:00-7:30 a.m.	1200-1230	R. Norway	C	two of: 25730, 25615, 21735, 21730, 21725, 21760, 21555 (Sun.)
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	11785, 15460
7:00-7:30 a.m.	1200-1230	HCJB, Ecuador	A	26020, 15115, 11740
7:00-7:55 a.m.	1200-1255	R. Peking	B	15520
7:00-9:00 a.m.	1200-1400	R. Moscow World Service	B	15150, 15135, 12030, 11720, 9750, 9580
7:00 a.m.-1:00 p.m.	1200-1800	R. Peking	C	11600
7:00-7:35 a.m.	1200-1235	R. Ulan Bator, Mongolia	C	12070, 6383 (not Sun.)
7:15-7:45 a.m.	1215-1245	R. Japan	C	11875, 9675
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11960, 9515
7:30-7:57 a.m.	1230-1257	Austrian R.	B	17880
7:30-8:00 a.m.	1230-1300	R. Bangladesh	D	21670, 15285
7:30-8:15 a.m.	1230-1315	V. of Germany	B	21600
7:30-8:25 a.m.	1230-1325	R. Finland	B	21475, 15400 (Sun.)
7:30-9:30 a.m.	1230-1430	SLBC, Sri Lanka	C	15425, 9720
7:30-10:51 a.m.	1230-1551	WYFR, Family Radio	A	21545, 17785 (Sun. only)
7:35-7:45 a.m.	1235-1245	V. of Greece	C	17555, 15595, 11730 (Mon.-Sat.)
8:00-8:45 a.m.	1300-1345	R. Japan	B	11705, 11815, 9505
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-8:50 a.m.	1300-1350	WYFR, Family Radio	A	11830
8:00-9:00 a.m.	1300-1400	R. Australia	C	9770, 6080
8:00-10:57 a.m.	1300-1557	R. RSA	B	25790, 21535, 15220
8:00-11:00 a.m.	1300-1600	CBC Southern Service	A	17820, 11955, 9579 (Sun.)
8:00 a.m.-5:30 p.m.	1300-2230	CBC Northern Service	B-C	23440, 11720, 9625 (not all Eng.)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520, 17850, 17830
8:30-9:00 a.m.	1330-1400	R. Finland	B	21475, 15400
8:30-9:00 a.m.	1330-1400	NYAB, Bhutan	D	4595 (Wed. & Fri.)
8:30-9:00 a.m.	1330-1400	V. of Vietnam	C	12036, 10080
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605

8:30-9:30 a.m.	1330-1430	R. Korea	C	9720
8:30-9:30 a.m.	1330-1430	V. of Turkey	C	15125
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	25650, 21710, 21660, 21550 21470, 15400 (from 1430), 15070
8:30-11:00 a.m.	1330-1600	R. Malaysia Sabah	C	5980, 4970
8:30 a.m.-fade	1330-	R. Australia	C	6060
8:30 a.m.-5:00 p.m.	1330-2200	R. Moscow World Service (via Cuba)	B	11840
8:57-11:55 a.m.	1357-1655	V. of Philipines	D	9578 (Sun.-1556)(not all Eng.)
9:00-9:30 a.m.	1400-1430	R. Sweden	B	17790
9:00-9:30 a.m.	1400-1430	R. Norway	B	3 of: 26030, 25730, 25615 17840, 15125 (Sun.)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	15460, 11785
9:00-9:45 a.m.	1400-1445	BRT Belgium	B	21810, 21525 (Mon.-Fri.)
9:00-10:00 a.m.	1400-1500	WYFR, Family Radio	A	15215
9:00-10:00 a.m.	1400-1500	R. Moscow World Service	A	30750, 15150, 15135, 12030, 11900, 11720, 9750, 9580
9:00-10:00 a.m.	1400-1500	R. Malaysia Sarawak	C	7160, 4950
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200 or 15150, 11789
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9710
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 17605, 11740
9:30-10:30 a.m.	1430-1530	HCJB, Ecuador	A	26020, 17890, 15115 (Sat. & Sun.1430-1600)
9:30-11:00 a.m.	1430-1600	Burma Br. Ser	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3425, 7105 or 9589
10:00-10:30 a.m.	1500-1530	V. of Asia, Taiwan	D	5980 (not Sun.)
10:00-10:45 a.m.	1500-1545	R. Japan	C	11815, 9505
10:00-10:50 a.m.	1500-1550	V. of Germany	C	21600
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	V. of Nigeria	C	11770 (varies)
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat., Sun.)
10:00-11:00 a.m.	1500-1600	R. Moscow World Service	C	30750, 12050, 12010 11900, 11720, 9580
10:00-12:00 a.m.	1500-1700	WYFR, Family Radio	A	15365, 15215
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:30-11:00 a.m.	1530-1600	R. Afghanistan	D	4775 or 6230
10:30-11:00 a.m.	1530-1600	R. Yugoslavia	C	15415
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570, 17830, 15125
10:30-11:00 a.m.	1530-1600	KTWR, Guam	C	11945
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	15010,10040
10:35-10:45 a.m.	1535-1545	V. of Greece	C	17555, 15595, 11730 (Mon.-Fri.)
10:37-10:45 a.m.	1537-1545	R. Canada International	A	(17820 Mon.-Sat.), 15325
11:00-11:15 a.m.	1600-1615	Vatican R.	C	17730, 15120
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21486, 17660, 17640, 15565, 15530
11:00-11:30 a.m.	1600-1630	R. Norway	B	17875, 15175
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21530 or 21475 (not Sun.)
11:00-12:00 a.m.	1600-1700	R. Korea	C	11830, 9720
11:00-12:00 a.m.	1600-1700	R. Moscow World Service	B	24020, 15240, 15150, 12050, 12030, 11900, 11720
11:00 a.m.-12:45 p.m.	1600-1745	BBC	B	21710, 17830, 15260
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21660, 21485, 17870, (15250 from 1900) 15445, (15410 to 2200)
-11:05 a.m.	-1605	R. Singapore	C	11940, 5052, 5010 (fade-in time varies)
11:05-11:55 a.m.	1605-1655	R. France International	B	25820, 21620, 21580, 21525, 1786(17850, 17720, 15315, 15300
11:15-11:50 a.m.	1615-1650	UAE Radio, Dubai	B	21655, 17710
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820, 15325
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15500, 11672†
12:00-12:30 p.m.	1700-1730	R. Japan	C	9505, 11815
12:00-12:45 p.m.	1700-1745	BBC	C	17695,21470
12:00-1:00 p.m.	1700-1800	R. Moscow World Service	A	15455, 15425, 15240, 15150, 12050, 12030, 11960, 11900
12:00-1:00 p.m.	1700-1800	AFRTS, Los Angeles	A	15430, 15345, 15330, 11805
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 17845, 21510, 15440, 15365, 15215
12:30-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-4:00 p.m.	1700-2100	BSK Saudi Arabia	C	11856 (varies)
12:00-5:00 p.m.	1700-2200	VOA	B	17785, 15205 (15140 from 1830)
12:30-1:00 p.m.	1730-1800	HCJB, Ecuador	B	26020, 21477.5, 17790
12:45-3:00 p.m.	1745-2000	BBC	C	15400, 15070
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-3:00 p.m.	1800-1830	R. Canada International	A	17820, 15260 (Sat. & Sun. 1800-1900)
1:00-1:30 p.m.	1800-1830	R. Norway	C	23615, 21725, 17875,15175 (Sun.)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	10040, 15010
1:00-2:00 p.m.	1800-1900	R. Moscow World Service	A	17700, 15455, 15425, 15240 15150, 12050, 11960, 11900, 11700
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 15440, 15365
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15120, 17800
1:00-3:00 p.m.	1800-2000	R. Australia	C	17795, 9580, 9305
1:00-3:00 p.m.	1800-2000	WRNO, New Orleans	A	15420 (not all English)
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11675
1:00-5:00 p.m.	1800-2200	AFRTS, Los Angeles	A	21570, 17765, 15430, 15345, 15330
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21570 or 21585, 17850, 17830, 15415
1:15-2:00 p.m.	1815-1900	BRT, Belgium	B	17595
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15308, 11767, (both vary)†
1:30-1:37 p.m.	1830-1837	UN Radio	A	18782.5-SSB, 15250, 21710, 15120 (Fri.)
1:30-1:57 p.m.	1830-1857	Austrian Radio	C	17740, 15560 (Sun. from 1806)
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15309 (varies) 9650 (Mon. Wed. and Fri.)(irregular)
2:00-2:30 p.m.	1900-1930	R. Canada International	A	21695, 17875, 15325 (Sat. & Sun. 1900-2000)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15079 (varies), 9665
2:00-2:30 p.m.	1900-1930	UN Radio	A	21710, 15250, 15120 (Fri.)
2:00-2:45 p.m.	1900-1945	R. Japan	C	17755
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21477.5, 17790
2:00-3:00 p.m.	1900-2000	WYFR, Family Radio	A	21615, 15440, 15365, 15215
2:00-3:00 p.m.	1900-2000	R. Moscow World Service	A	17700, 15455, 15150, 12050, 11960
2:30-3:30 p.m.	1930-2030	V. of Iran	D	9022
2:45-4:15 p.m.	1945-2115	R. Free Grenada	C	15104 (time varies and irregular)
3:00-3:30 p.m.	2000-2030	R. Norway	C	25615, 21705, 15205 (Sun.)

3:00-3:30 p.m.	2000-2030	R. Algiers	C	Some of: 25700, 21725, 21635 17745, 15370, 15215, 11810, 9610, 9510
3:00-3:30 p.m.	2000-2030	R. Canada International	A	21695, 17875, 17820, 15325, (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	B	17645, 15585, 11640
3:00-4:00 p.m.	2000-2100	R. Moscow World Service	A	17700, 15425, 15150, 15100, 12050, 11960
3:00-4:00 p.m.	2000-2100	WYFR, Family Radio	A	15215, 21525, 15440, 15365
3:00-4:15 p.m.	2000-2115	BBC	B	21710, 15260, 15070, 12095,
3:00-6:00 p.m.	2000-2300	WRNO, New Orleans	A	17775
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15175
3:15-3:30 p.m.	2015-2030	Sri Lanka Br. Corp.	C	15120, 15115, 11800
3:30-4:15 p.m.	2030-2115	Int. Christ. Radio, Malta	C	9510
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21685, 17695, 17605, 15220, 9715
3:30-4:00 p.m.	2030-2100	V. of Vietnam	C	15010, 10040
3:30-4:30 p.m.	2030-2130	V. Turkey	C	9625
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 9770
4:00-4:30 p.m.	2100-2130	R. Japan	C	17755
4:00-4:45 p.m.	2100-2145	BRT, Belgium	B	17595 (Mon.-Sat.)
4:00-4:50 p.m.	2100-2150	R. RSA	B	11900, 9585
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15120, 17800
4:00-5:00 p.m.	2100-2200	R. Moscow World Service	C	21530, 17720, 15425, 15240, 15100, 12050, 11960, 11750
4:00-5:00 p.m.	2100-2200	WYFR, Family Radio	A	17845, 15440, 15380, 15365
4:15-5:00 p.m.	2115-2200	BBC	A	21710, 15260, 15070
4:15-7:30 p.m.	2115-2430	R. Free Grenada	B	15045 (time varies)(irregular)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 15150, 11945, (17875, 15325 Sat. & Sun. only)
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	21477.5, 26020, 17790†, 15295†
4:30-5:00 p.m.	2130-2200	R. Sofia	B	15315, 11860, 11850
4:30-5:00 p.m.	2130-2200	R. Baghdad	C	9745
4:31-5:00 p.m.	2131-2200	KGEI, San Francisco	C	15280
4:45-5:15 p.m.	2145-2215	Swiss R. International	C	21585, 17830, 17850, 15305
5:00-5:30 a.m.	2200-2230	R. Vilnius	B	17870, 17835, 15100, 11790 11770
5:00-5:30 p.m.	2200-2230	R. Argentina	D	11710 (Mon.-Sat.)
5:00-5:30 p.m.	2200-2230	R. Norway	C	17895, 15345, 15305 (Sun. only)
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	17845, 15440, 11805, 15365, 15380
5:00-6:00 p.m.	2200-2300	CBC Radio	A	17875, 15325 (Mon.-Fri.)
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	9560, 7155
5:00-6:00 p.m.	2200-2300	R. Jamahariyah, Libya	B	11815
5:00-6:00 p.m.	2200-2300	BBC	A	21710, 15420, 15260, 15070, 11750, 9510, 6175, 6120, 5975
5:00-7:00 p.m.	2200-2400	R. Moscow	A	21530, 17720, 15180, 15140, 12060, 12050, 11960, 11900, 11739, 9765, 9710, 9685, 9610,
5:00-7:00 p.m.	2200-2400	CBC Southern Service	A	9755, 5960 (not all English)
5:00-7:00 p.m.	2200-2400	AFRTS, Los Angeles	A	21570, 17765, 15430, 15330
5:00-11:30 p.m.	2200-0430	VOA	A	21460, 17740
5:15-5:30 p.m.	2215-2230	R. Japan	C	17755, 15235, 15195 (11760 via Portugal)
5:15-5:30 p.m.	2215-2230	UN Radio	A	17785, 15305 (Fri.)
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	21710, 17630, 15585, 11640
5:30-6:00 p.m.	2230-2300	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)(Irreg.)
5:30-6:25 p.m.	2230-2325	R. Mexico	B	15430 (Sun.; time varies)
5:30-6:30 p.m.	2230-2330	R. Sofia	B	15330, 15110
5:30 p.m.-12:09 a.m	2230-0509	CBC Northern Service	C	9625, 6195 (not all English)
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755, 15235, 15195
6:00-6:30 p.m.	2300-2330	R. Sweden	C	11705, 15380
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:00 p.m.	2300-2400	WYFR, Family Radio	A	15365, 17845, 15380
6:00-7:00 p.m.	2300-2400	R. Mexico	B	15430 (Thurs.; time varies)
6:00-7:30 p.m.	2300-2430	BBC	A	15420, 15260, 15070, 11910, 9510, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	9977
6:00-8:00 p.m.	2300-0100	WRNO, New Orleans	A	11855
6:00-8:45 p.m.	2300-0145	R. Luxembourg	C	6090 (time varies)
6:30-7:00 p.m.	2330-2400	R. Kiev	A	17870, 17835, 15100, 11790, 11770
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12036, 10080
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 21610
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	R. Canada International	A	9755, 5960
7:00-7:30 p.m.	0000-0030	Kol Israel	A	11640, 17630, 15585
7:00-7:30 p.m.	0000-0030	R. Norway	C	17840, 15205, 15160 (Mon. only)
7:00-7:45 p.m.	0000-0045	R. Berlin International	C	11970, 9730
7:00-7:55 p.m.	0000-0055	R. Peking	B	17855, 17680
7:00-8:00 p.m.	0000-0100	WYFR, Family Radio	A	17845, 11720
7:00-8:00 p.m.	0000-0100	R. Sofia	B	15110, 15330
7:00-8:00 p.m.	0000-0100	AFRTS, Los Angeles	A	21570, 15430, 15330, 11790
7:00-9:00 p.m.	0000-0200	VOA	A	17730, 15205, 11740, 9650, 6130, 5995
7:00-9:00 p.m.	0000-0200	WRNO, New Orleans	A	11965
7:00-10:00 p.m.	0000-0300	R. Moscow	A	17720, 12060, 11960, 9685 9610
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:30-8:00 p.m.	0030-0100	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (Wed. & Sat.)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-8:15 p.m.	0030-0115	BRT, Belgium	B	11695, 15360
7:30-8:30 p.m.	0030-0130	HCJB, Ecuador	A	15175
7:30-9:30 p.m.	0030-0230	SLBC, Sri Lanka	C	15425
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 15070, 11835, 11750 9510, 9410, 7325, 6175 6120, 5975
7:35-9:35 p.m.	0035-0230	HCJB, Ecuador	B	17875, 15155, 9745
8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	15585, 11640, 9815
8:00-8:30 p.m.	0100-0130	R. Japan	C	17755, 17810
8:00-8:30 p.m.	0100-0130	R. Argentina	C	11710, 9690 (not Mon.)
8:00-8:30 p.m.	0100-0130	R. Mexico	C	15430 (Sun.)
8:00-8:30 p.m.	0100-0130	La Voz de la Mosquitia, Honduras	C	4910
8:00-8:30 p.m.	0100-0130	R Canada International	A	9755, 5960
8:00-8:30 p.m.	0100-0130	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (not Mon.)

8:00-8:50 p.m.	0100-0150	V. of Germany	A	15105, 11865, 9590, 9565, 9545, 6145, 6085, 6040
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9740, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17855, 17680
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	R. Zinica, Nicaragua	C	6120.4 (Tue.-Sat.)
8:00-9:00 p.m.	0100-0200	AFRTS, Los Angeles	A	21570, 15430, 15330, 11790
8:00-9:00 p.m.	0100-0200	WYFR, Family Radio	B	9715, 11720
8:00-10:00 p.m.	0100-0300	WRNO, New Orleasn	A	9685
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740
8:00-11:50 p.m.	0100-0450	R. Habana Cuba	B	11930, 11725
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:30-8:40 p.m.	0130-0140	V. of Greece	B	15595, 11730, 9865 (not Sunday)
8:30-8:57 p.m.	0130-0157	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:15 p.m.	0130-0215	R. Berlin International	C	11975, 9730
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 21610, 15195
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:25 p.m.	0200-0225	Kol Israel	A	11585, 11640, 9815
9:00-9:30 p.m.	0200-0230	R. Canada International	A	9755, 5960 (Sat. & Sun. also 15190, 11845, 9535)
9:00-9:30 p.m.	0200-0230	R. Norway	B	15165, 11870, 11740 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Kiev	A	11790, 11770, 9665
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585
9:00-9:40 p.m.	0200-0240	R. Polonia	B	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:50 p.m.	0200-0250	R. RSA	C	11900, 9580, 5980
9:00-9:55 p.m.	0200-0255	R. Bucharest	C	15380, 11940, 11840, 11725, 9570, 5990
9:00-9:55 p.m.	0200-0255	R. Peking	B	17680
9:00-10:00 p.m.	0200-0300	R. Korea	C	15575, 11810
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	17830, 15290
9:00-10:00 p.m.	0200-0300	WYFR, Family Radio	A	11720, 9715
9:00-10:00 p.m.	0200-0300	V. of Free China, Taiwan	A	11740 (via WYFR)
9:00-10:30 p.m.	0200-0330	R. Australia	B	17795
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12000, 9475
9:00-11:00 p.m.	0200-0400	VOA	A	17730, 15205, 9650, 6130, 5995,1580
9:00-11:30 p.m.	0200-0430	AFRTS, Los Angeles	A	11790, 6030
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	17840, 21595
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15752-SSB, 10869 -SSB (Sat.)
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	R. Lebanon	C	11806† (time varies)
9:30-10:00 p.m.	0230-0300	R. Sweden	B	11705, 15420, 17840-SSB
9:30-10:15 p.m.	0230-0315	R. Berlin International	B	11970, 11890, 11840
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165 (Mon. 0230-0320)
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9510, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB Ecuador	A	9745, 15155
9:51-9:58 p.m.	0251-0258	V. of Yerevan	B	17870, 15100
10:00-10:15 p.m.	0300-0315	R. Budapest	B	17710, 15220, 11910, 9835, 9585, (Wed. & Sat; Mon. 0300-0330)
10:00-10:25 p.m.	0300-0325	R. Polonia	B	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:30 p.m.	0300-0330	R. Japan	C	17755, 17810
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 9755, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925
10:00-10:30 p.m.	0300-0330	R. Australia	C	17750 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	15345, 11825, 17800
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9740, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	15120, 17680, 17855
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	21585, 15400, 11935
10:00-11:00 p.m.	0300-0400	WYFR, Family Radio	A	9715, 9660
10:00-11:00 p.m.	0300-0400	V. of Free China	A	5985 (via WYFR)
10:00-11:00 p.m.	0300-0400	R. Uganda	B	15325 (irregular)
10:00-11:26 p.m.	0300-0426	R. RSA	B	11900, 9585, 7270, 5980
10:00-11:30 p.m.	0300-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030-0430)
10:00-12:00 p.m.	0300-0500	HRVC, Honduras	B	4820
10:00-12:00 p.m.	0300-0500	AWR, Guatemala	C	5980
10:00 p.m.-1:00 a.m.	0300-0600	WRNO, New Orleans	A	6155 (not all English)
10:00 p.m.-2:30 a.m.	0300-0730	VOA	A	15240, 9670, 6040, 6035, 5995
10:25 p.m.-fade	0325-	R. One, Zimbabwe	C	3396 (exc. Sun.)
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-11:23 p.m.	0330-0423	U.A.E. Radio, Dubai	B	17775, 15320, (length varies)
10:30-10:57 p.m.	0330-0357	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	R. Australia	B	21680, 17890, 17870, 17795, 17725
10:30-11:00 p.m.	0330-0400	R. Mexico	C	15430 (Mon.)
10:30-11:45 p.m.	0330-0445	BBC	C	15070, 9410, 6175, 5975
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 11725
10:40-10:47 p.m.	0340-0347	V. of Greece	B	15595, 11730, 9865 (not Sun.)
10:50-11:10 p.m.	0350-0410	RAI, Italy	B	21560, 17795, 15330, 11905
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	15380, 11940, 11725, 9570, 5990
11:00-11:30 p.m.	0400-0430	R. Norway	C	17840, 15165, 15125, 11895, 11870 (Mon.)
11:00-11:30 p.m.	0400-0430	R. Mozambique	C	4865, 3265 (vary)
11:00-11:55 p.m.	0400-0455	R. Peking	B	17680, 15120
11:00-12:00 p.m.	0400-0500	R. Sofia	C	11750†
11:00-12:00 p.m.	0400-0500	R. Australia	B	21680, 21650, 21525, 17870, 17795, 17755, 17725 15320, 15240, 15160
11:00-12:00 p.m.	0400-0500	R. Moscow World Service	A	9665, 9610
11:00-12:00 p.m.	0400-0500	WYFR, Family Radio	A	9715, 9660, 6070
11:00 p.m.-2:25 a.m.	0400-0725	TWR, Bonaire	A	9755, 800
11:00 p.m.-3:00 a.m.	0400-0800	R. Moscow	A	12050, 9580
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	11810†, 15200†
11:30-11:57 p.m.	0430-0457	Austrian R.	B	12015
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30 p.m.-1:00 a.m.	0430-0600	AFRTS, Los Angeles	A	11790, 6030
11:45-12:00 p.m.	0445-0500	Vatican R.	C	6208, 9645
11:45 p.m.-12:45 a.m.	0445-0545	BBC	A	15070, 9510, 9410, 6175, 5975
11:55 p.m.-3:00 a.m.	0455-0800	V. of Nigeria	B	11770
12:00-12:15 a.m.	0500-0515	Kol Israel	B	21760, 15105, 11640, 9815
12:00-12:30 a.m.	0500-0530	R. Japan	C	17810, 15325
12:00-12:50 a.m.	0500-0550	V. of Germany	A	11905, 11705, 9690, 9650, 9545, 5960
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17870, 17725, 15240, 15160
12:00-1:00 a.m.	0500-0600	V. of Nigeria	C	15120

12:00-1:00 a.m.	0500-0600	WFYR, Family Radio	A	9705, 9660, 6070
12:00-1:00 a.m.	0500-0600	R. Moscow World Service	C	17880, 12010, 11735, 9530
12:00-2:00 a.m.	0500-0700	HCJB Ecuador	B	11915, 9745, 6095
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	15345
12:00-3:00 a.m.	0500-0800	R. Nigeria, Kaduna	B	4770 (not all Eng.)
12:30-12:40 p.m.	0530-0540	R. Garoua, Cameroon	C	5010
12:30-1:00 a.m.	0530-0600	R. Portugal	A	9575, 6100
12:30-fade	0530-	R. Ghana	C	3366, 4915
12:30-1:25 a.m.	0530-0625	R. Nederland	A	9715, 6165 (Mon. 0530-0620)
12:30-1:30 a.m.	0530-0630	Spanish Foreign R.	B	11880, 9630
12:35-1:30 a.m.	0530-0630	R. Korea	C	15575, 11810, 9870
12:45-1:30 a.m.	0545-0630	R. Berlin International	B	11890
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640 9510, 9410, 7150, 6175
12:55-3:55 a.m.	0555-0855	V. of Malaysia	C	15295, 12350, 9750
1:00-1:30 a.m.	0600-0630	R. Norway	C	21580, 15175 (Mon.)
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 21525, 17870, 17795, 17755, 17725, 15240, 15160
1:00-2:00 a.m.	0600-0700	AFRTS, Los Angeles	B	11790, 6030
1:00-2:30 a.m.	0600-0730	HCJB, Ecuador	C	11810
1:00-2:30 a.m.	0600-0730	R. Kiribati	C	16433-SSB (not all English)
1:00-3:00 a.m.	0600-0800	WRNO, New Orleans	A	9550 (Sun.) (not all English)
1:00-4:00 a.m.	0600-0900	R. Cook Islands	C	11760 or 9695 or 5045 (not all English)
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11960, 11825, 11775, 9760, 9730, 7155, 6140 (Mon-Fri)
1:25-3:00 a.m.	0625-0800	TWR, Monte Carlo	B	9495 (Sunday 0625-0900)
1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15160, 15115, 11820
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-2:30 a.m.	0630-0730	R. RSA	C	21535, 17780, 15220
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11960, 11825, 11775, 9760, 9730, 7155, 6140 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	B	15125, 11740 (Sat.)
1:57-4:55 a.m.	0657-0955	V. of Philipines	C	9578 (not all English)
2:00-2:15 a.m.	0700-0715	R. Japan	C	17810, 15325, (15239 via Portugal)
2:00-2:20 a.m.	0700-0720	R. Nederland	C	21480, 15560, 11720, 9895
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	15305, 9560, 9535, 6165
2:00-3:00 a.m.	0700-0800	Xandir Malta	C	9670 (Sat.)
2:00-3:00 a.m.	0700-0800	V. of Nigeria	C	15120
2:00-3:00 a.m.	0700-0800	ELWA, Liberia	C	11830
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	9840
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 11729, 15115 9570
2:00-6:00 a.m.	0700-1100	HCJB Ecuador	C	11925, 6130 (9745 at 0700-1030)
2:07-2:15 a.m.	0707-0715	UN Radio	A	15125, 11740 (Sat.)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30 a.m.-fade	0730-	GBC-2, Guyana	C	5950
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	9545 or 5020 (not all Eng.)
2:30-9:00 a.m.	0730-1400	NBC, Papua New Guinea	C	4890, 3925 (not all Eng.)
2:30-9:02 a.m.	0730-1402	ABC Melbourne	C	9680
2:37-2:45 a.m.	0737-0745	UN Radio	A	17815, 15195, 15125, 11740 (Sat.)
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
3:00-3:30 a.m.	0800-0830	R. Norway	C	11895, 11870 (Sun.)
3:00-3:15 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11740 (Sat.)
3:00-5:00 a.m.	0800-1000	WRNO, New Orleans	A	6115 (Sun. only; not all English)
3:15-3:30 a.m.	0815-0830	R. Vanuatu	D	7260, 3945
3:30-4:00 a.m.	0830-0900	AWR Portugal	C	9760 or 9665 (Sun.)
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Phillippines	C	11890
24 Hours	24 Hours	CFRX, Toronto	C	6070

ExplanatoryNotes.

1. Times in first column are CDT. For ADT add 2 hours; EDT add 1 hour; MDT subtract 1 hour; DDT subtract 2 hours; Days of week are in GMT.
2. Quality. A—Strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmittersite.
3. The information in the listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "SWL Digest" on R. Canada International for late changes, Saturday at 2135; Sunday at 1930; GMT Mondays at 0106 and 0306.
4. R.—Radio; V.—Voice

† = frequent changes

Popular Electronics

ADVERTISERS INDEX

PROJECT OF THE MONTH

By Forrest M. Mims

A Fully Adjustable Pulse Generator

THE 558 is a quad timer chip with many useful applications. The diagram shows one of the best, a highly versatile, square-pulse generator with fully adjustable pulse rate and pulse duration. The circuit is adapted from Exar's XR-558/559 data sheet.

In operation, the two timers shown are cross-connected so that the output of one timer is directly coupled to the trigger input of the other timer. When the timing cycle of the first timer is complete, the second timer is triggered. When its cycle is complete, the first timer is triggered. The result of this feedback cycle is an astable multivibrator.

The significance of this multivibrator circuit is that the RC time constant of each timer section is independently adjustable. This means that both the pulse rate and duration are independently controllable. Resistor *R1* controls the frequency of the pulses and *R2* controls their duration. Notice that the circuit provides complementary outputs.

The pulse rate of the circuit is given by the reciprocal of $(R1C1) + (R2C2)$. The minimum practical pulse duration is on the order of a microsecond, and the maximum pulse rate is about 100 kHz. The pulses remain very square until their duration falls to a few microseconds. Their amplitude can be altered by varying the power-supply voltage.

The oscillation frequency of each timer in a 558 can be altered by changing the circuit's control voltage. The 558 has a single control voltage pin which is common to all four timers. However, the duty cycle of the circuit is unaffected by application of a control voltage. This means the circuit can be operated as a variable-frequency oscillator having a fixed duty cycle.

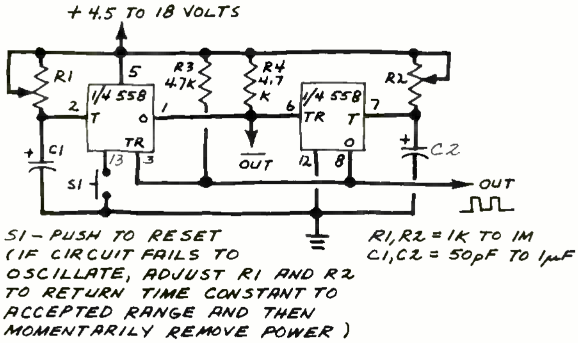
You can add a fixed-duty-cycle frequency control by connecting the rotor of a 10-kilohm potentiometer to pin 4 of the 558. Connect the stator terminals of the pot to V_{CC} and ground, respectively. Adjust the pot to alter the frequency.

Driving External Circuits. The output stage of each timer in the 558 is a normally low, open-collector, npn transistor that can sink up to 100 mA. This means the circuit can directly drive an LED, a small relay, or even a small speaker for audio effects. However, though each timer can sink up to 100 mA, the power dissipation rating of the timer's package limits the maximum current per timer if all four are in use.

For example, the maximum dissipation for the plastic-package 58 is 625 mW. If the circuit is operated at 10 V, 100 mA per output would give a total dissipation of 4 W (from Ohm's law, 10 V × 0.1 A = 1 W per timer). Therefore, the current delivered to each output would have to be reduced or external buffering would be required.

If each output is required to deliver only 10 mA, then the total power dissipation would be 4 × 10 V × 0.01 A = 0.4 W, well within the 625 mW maximum.

Incidentally, this circuit will cease oscillation if an attempt is made to operate it beyond its minimum pulse duration or maximum frequency. Should this occur, adjust the appropriate pot (or capacitor if you prefer) and momentarily disconnect the power to restart the circuit. If the circuit fails to operate when power is first applied, it is possible both RC time constants are out of range and require adjustment to bring the circuit within its operating limits. ◇



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Part	Organization		Each	100 pcs
2101	256 x 4	(450ns)	1.95	1.85
5101	256 x 4	(cmos) (450ns)	4.95	3.95
2102-1	1024 x 1	(450ns)	.89	.85
2102L-2	1024 x 1	(LP) (250ns)	1.69	1.55
2102L-4	1024 x 1	(LP) (450ns)	1.29	1.15
2111	256 x 4	(450ns)	2.99	2.49
2112	256 x 4	(450ns)	2.99	2.79
2114	1024 x 4	(450ns)	8/16.95	1.95
2114L-2	1024 x 4	(LP) (200ns)	8/19.95	2.35
2114L-3	1024 x 4	(LP) (300ns)	8/18.95	2.25
2114L-4	1024 x 4	(LP) (450ns)	8/17.95	2.10
2147	4096 x 1	(55ns)	9.95	call
TMS4044-4	4096 x 1	(450ns)	3.49	3.25
TMS4044-3	4096 x 1	(300ns)	3.99	3.75
TMS40L44-2	4096 x 1	(LP) (200ns)	4.49	4.25
MK4118	1024 x 8	(250ns)	9.95	call
TMM2016	2048 x 8	(150ns)	call	call
HM6116-4	2048 x 8	(cmos) (200ns)	call	call
HM6116-3	2048 x 8	(cmos) (150ns)	call	call
HM6116-2	2048 x 8	(cmos) (120ns)	call	call
HM6116LP-4	2048 x 8	(LP) (cmos) (200ns)	call	call
HM6116LP-3	2048 x 8	(LP) (cmos) (150ns)	call	call
HM6116LP-2	2048 x 8	(LP) (cmos) (120ns)	call	call
Z-6132	4096 x 8	(Qstat) (300ns)	34.95	call

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

Part	Organization		Each	100 pcs
TMS4027	4096 x 1	(250ns)	2.50	2.00
MK4108	8192 x 1	(200ns)	1.95	call
MM5298	8192 x 1	(250ns)	1.85	call
4116-120	16384 x 1	(120ns)	8/29.95	call
4116-150	16384 x 1	(150ns)	8/18.95	1.95
4116-200	16384 x 1	(200ns)	8/13.95	call
4116-250	16384 x 1	(250ns)	8/13.90	call
4116-300	16384 x 1	(300ns)	8/13.80	call
2118	16384 x 1	(5v) (150ns)	4.95	call
MK4816	2048 x 8	(5v) (300ns)	24.95	call
4164-200	65536 x 1	(5v) (200ns)	call	call
4164-150	65536 x 1	(5v) (150ns)	call	call

EPROMS

Part	Organization		Each	8 pcs
1702	256 x 8	(1us)	4.95	4.50
2708	1024 x 8	(450ns)	3.75	3.50
2758	1024 x 8	(5v) (450ns)	9.95	8.95
TMS2516	2048 x 8	(5v) (450ns)	6.95	5.95
2716	2048 x 8	(5v) (450ns)	4.95	3.95
2716-1	2048 x 8	(5v) (350ns)	9.00	8.50
TMS2716	2048 x 8	(450ns)	9.95	8.95
TMS2532	4096 x 8	(5v) (450ns)	9.95	7.95
2732	4096 x 8	(5v) (450ns)	9.95	7.95
2732A-2	4096 x 8	(5v) (200ns)	call	call
2764	8192 x 8	(5v) (450ns)	call	call
TMS2564	8192 x 8	(5v) (450ns)	call	call

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/CM²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320T	X	32	15,000	595.00

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74S287	256x4 TS	14S10	82S129	6301-1	7611	3.25
74S288	32x8 TS	18S030	82S123	6331-1	7603	2.75
74S387	256x4 OC	14SA10	82S126	6300-1	7610	2.95
74S471	256x8 TS	18S22		6309-1		10.95
74S472	512x8 TS	18S42	82S147	6349-1	7649	10.95
74S473	512x8 OC	18SA42	82S146	6348	7648	10.95
74S474	512x8 TS	18S46	82S141	6341	7641	12.95
74S475	512x8 TS	18SA46	82S140	6340	7640	12.95
74S478	1Kx8 TS	28S86				19.95
74S570	512x4 OC	27S12	82S130	6305	7620	5.95
74S571	512x4 TS	27S13	82S131	6306-1	7621	5.95
74S572	1kx4 OC	24SA41	82S136	6352-1	7642	9.95
74S573	1kx4 TS	24S41	82S137	6353-1	7643	9.95
87S180	1kx8 OC	28SA86	82S180	6380-1	7680	19.25
87S181	1kx8 TS	28S86	82S181	6381-1	7681	16.25
87S184	2kx4 OC	24SA81	82S184		7684	17.20
87S185	2kx4 TS	24S81	82S185		7685	16.95
87S190	2kx4 OC	28SA166	82S190		76160	39.95
87S191	2kx8 TS	28S166	82S191		76161	39.95

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74LS00	.25	74LS169	1.75
74LS01	.25	74LS170	1.75
74LS02	.25	74LS173	.80
74LS03	.25	74LS174	.95
74LS04	.25	74LS175	.95
74LS05	.25	74LS181	2.15
74LS08	.35	74LS189	9.95
74LS09	.35	74LS190	1.00
74LS10	.25	74LS191	1.00
74LS11	.35	74LS192	.85
74LS12	.35	74LS193	.95
74LS13	.45	74LS194	1.00
74LS14	1.00	74LS195	.95
74LS15	.35	74LS196	.85
74LS20	.25	74LS197	.85
74LS21	.35	74LS221	1.20
74LS22	.25	74LS240	1.29
74LS26	.35	74LS241	1.29
74LS27	.35	74LS242	1.85
74LS28	.35	74LS243	1.85
74LS30	.25	74LS244	1.29
74LS32	.35	74LS245	1.90
74LS33	.55	74LS247	.75
74LS37	.55	74LS248	1.25
74LS38	.35	74LS249	.99
74LS40	.35	74LS251	1.30
74LS42	.55	74LS253	.85
74LS47	.75	74LS257	.85
74LS48	.75	74LS258	.85
74LS49	.75	74LS259	2.85
74LS51	.25	74LS260	.65
74LS54	.35	74LS266	.55
74LS55	.35	74LS273	1.65
74LS63	1.25	74LS275	3.35
74LS73	.40	74LS279	.55
74LS74	.45	74LS280	1.98
74LS75	.50	74LS283	1.00
74LS76	.40	74LS290	1.25
74LS78	.50	74LS293	1.85
74LS83	.75	74LS295	1.05
74LS85	1.15	74LS298	1.20
74LS86	.40	74LS324	1.75
74LS90	.65	74LS352	1.55
74LS91	.89	74LS353	1.55
74LS92	.70	74LS363	1.35
74LS93	.65	74LS364	1.95
74LS95	.85	74LS365	.95
74LS96	.95	74LS366	.95
74LS107	.40	74LS367	.70
74LS109	.40	74LS368	.70
74LS112	.45	74LS373	1.75
74LS113	.45	74LS374	1.75
74LS114	.50	74LS377	1.45
74LS122	.45	74LS378	1.18
74LS123	.95	74LS379	1.35
74LS124	2.99	74LS385	1.90
74LS125	.95	74LS386	.65
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74LS151	.75	74LS669	1.89
74LS153	.75	74LS670	2.20
74LS154	2.35	74LS674	9.65
74LS155	1.15	74LS682	3.20
74LS156	.95	74LS683	2.30
74LS157	.75	74LS684	2.40
74LS158	.75	74LS685	2.40
74LS160	.90	74LS688	2.40
74LS161	.95	74LS689	2.40
74LS162	.95	74LS783	24.95
74LS163	.95	81LS95	1.69
74LS164	.95	81LS96	1.69
74LS165	.95	81LS97	1.69
74LS166	2.40	81LS98	1.69
74LS168	1.75		

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SN7404N	.25	SN7476N	.35	SN74162N	.89
SN7405N	.29	SN7479N	5.00	SN74163N	.89
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SN7416N	.29	SN7493N	.45	SN74176N	.79
SN7417N	.29	SN7494N	.69	SN74177N	.79
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SN7428N	.49	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
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SN7448N	.79	SN74147N	1.95	SN74284N	3.95
SN7450N	.20	SN74148N	1.29	SN74285N	3.95
SN7451N	.20	SN74150N	1.25	SN74365N	.69
SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.25	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
SN7460N	.20	SN74154N	1.25	SN74390N	1.49
SN7470N	.29	SN74155N	.79	SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.49	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.59	74LS245	2.95
74LS14	.99	74LS126	.59	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.39	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.89
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.69
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.95
74LS33	.59	74LS156	.89	74LS279	.89
74LS37	.45	74LS157	.89	74LS283	.89
74LS38	.39	74LS158	.89	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.35	74LS165	1.15	74LS366	.69
74LS54	.35	74LS168	1.19	74LS367	.69
74LS55	.35	74LS169	1.19	74LS368	.69
74LS73	.45	74LS170	1.95	74LS373	1.95
74LS74	.45	74LS173	.99	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
74LS85	1.25	74LS191	1.25	74LS670	2.49
74LS86	.49			81LS95	1.95
74LS90	.69			81LS97	1.95

74S

74S00	.45	74S124	3.95	74S243	3.25
74S02	.45	74S133	.55	74S244	3.25
74S03	.45	74S134	.69	74S251	1.45
74S04	.55	74S135	1.19	74S253	1.45
74S05	.55	74S136	1.75	74S257	1.35
74S08	.50	74S138	1.35	74S258	1.35
74S09	.50	74S139	1.35	74S260	.79
74S10	.45	74S140	.79	74S280	2.95
74S11	.45	74S151	1.35	74S287	3.25
74S15	.45	74S153	1.35	74S288	2.75
74S20	.45	74S157	1.35	74S373	3.49
74S22	.45	74S158	1.35	74S374	3.49
74S30	.45	74S160	2.95	74S387	2.95
74S32	.55	74S174	1.59	74S471	10.95
74S38	1.25	74S175	1.59	74S472	10.95
74S40	.50	74S188	2.95	74S473	10.95
74S51	.45	74S194	1.95	74S474	12.95
74S64	.50	74S195	1.95	74S475	12.95
74S65	.50	74S196	1.95	74S570	5.95
74S74	.75	74S240	2.95	74S571	5.95
74S86	.79	74S241	2.95	74S572	9.95
74S112	.79	74S242	3.25	74S573	9.95
74S113	.79			74S940	3.15
74S114	.79			74S941	3.15

CA–LINEAR

CA3010H	.99	CA3060N	3.25	CA3089N	3.75
CA3013H	2.15	CA3080H	1.25	CA3096N	3.95
CA3023H	3.25	CA3081N	2.00	CA3130H	1.39
CA3035H	2.49	CA3082N	2.00	CA3140H	1.25
CA3039H	1.35	CA3083N	1.60	CA3160H	1.25
CA3046N	1.30	CA3086N	.85	CA3401N	.59
CA3059N	3.25			CA3600N	3.50

CD–CMOS

CD4000	.39	CD4041	1.49	CD4098	2.49
CD4001	.39	CD4042	.99	CD4506	.75
CD4002	.39	CD4043	.89	CD4507	.99
CD4006	1.19	CD4044	.89	CD4508	3.95
CD4007	.25	CD4046	1.79	CD4510	1.39
CD4009	.49	CD4047	2.50	CD4511	1.29
CD4010	.49	CD4048	1.35	CD4512	1.49
CD4011	.39	CD4049	.49	CD4514	3.95
CD4012	.25	CD4050	.69	CD4515	2.95
CD4013	.49	CD4051	1.19	CD4516	1.49
CD4014	1.39	CD4052	1.19	CD4518	1.79
CD4015	1.19	CD4053	1.19	CD4519	.89
CD4016	.59	CD4056	2.95	CD4520	1.29
CD4017	1.19	CD4059	9.95	CD4526	1.79
CD4018	.99	CD4060	1.49	CD4528	1.79
CD4019	.49	CD4066	.79	CD4529	1.95
CD4020	1.19	CD4068	.39	CD4543	2.79
CD4021	1.39	CD4069	.45	CD4562	11.95
CD4022	1.19	CD4070	.55	CD4566	2.79
CD4023	.29	CD4071	.49	CD4583	2.49
CD4024	.79	CD4072	.49	CD4584	.75
CD4025	.23	CD4073	.39	CD4723	1.95
CD4026	2.95	CD4075	.39	CD4724	1.95
CD4027	.69	CD4076	1.39	MC14409	17.95
CD4028	.89	CD4078	.55	MC14410	18.95
CD4029	1.49	CD4081	.39	MC14411	15.95
CD4030	.49	CD4082	.39	MC14412	15.95
CD4034	3.49	CD4093	.99	MC14419	7.95
CD4035	.99			MC14433	15.95
CD4040	1.49			MC14538	2.49
				MC14541	1.95

A-AMBER R-RED — **LEDS** — G-GREEN Y-YELLOW C-CLEAR

OPTO ELECTRONICS — DISPLAY LEDS

DIFFUSED BI-COLOR/TRI-STATE — 200 (7.5mm) Red Green

POINT SOURCE (RED) — 160 Pointed (Short)

DIFFUSED — 125 (T1)

DIFFUSED — 200 Dia (T1¾) Low Profile

WIDE ANGLE DIFFUSED — 100 Diameter

DIFFUSED — 160 Dia (T Square)

POINT SOURCE — 200 (T1¾)

DIFFUSED — 200 (T1¾)

DIFFUSED TRIANGLE

DIFFUSED RECTANGULAR

Part No.	Size	Color	Description	Price
MAN 1	270	Red	C.A. (LHDP)	$2.95
MAN 2	320	Red	5x7 Alphanumeric (TIL305)	4.95
MAN 52	300	Green	C.A. (LHDP)	.99
MAN 54	300	Green	C.C. (RHDP)	.99
MAN 72	300	Red	C.A. (LHDP)	.99
MAN 74	300	Red	C.C. (RHDP)	1.25
NSN 74L	300	Red	C.C. (LHDP)	.99
MAN 82	300	Yellow	C.A. (LHDP)	.49
MAN 84	300	Yellow	C.C. (RHDP)	.99
MAN 3620	300	Orange	C.A. (LHDP)	.48
MAN 3630	300	Orange	C.A. ±1 Over Flo	.99
MAN 3640	300	Orange	C.C. (RHDP)	.99
MAN 4610	400	Orange	C.A. (LHDP)	.99
MAN 4640	400	Orange	C.C. (RHDP)	.99
MAN 6610	560	Orange	C.A. (RHDP) 2 Digit	.99
MAN 6630	560	Orange	C.A. ±1 1½ Digit	.99
MAN 6640	560	Orange	C.C. (RHDP) 2 Digit	.99
MAN 6650	560	Orange	C.C. ±1 1½ Digit	.99
MAN 6660	560	Orange	C.A. (RHDP)	.99
MAN 6710	560	Red	C.A. (RHDP) 2 Digit	.99
MAN 6740	560	Red	C.C. (RHDP) 2 Digit	.99
MAN 6750	560	Red	C.C. ±1 1½ Digit	.99
DL 34M	110	Red	C.C. (4 Digit Bubble) RHDP	.49
DLO 304	300	Orange	C.C. (RHDP)	1.25
DLO 307	300	Orange	C.A. (LHDP)	1.25
DLG 500	500	Green	C.C. (RHDP)	1.25
DLG 507	500	Green	C.A. (LHDP)	1.25
DL 704	300	Red	C.C. (RHDP)	1.25
DL 707	300	Red	C.A. (LHDP)	1.25
DL 747	630	Red	C.A. (LHDP)	1.49
DL 750	630	Red	C.C. (LHDP)	1.49
FND 350	362	Red	C.A. (LHDP)	.75
FND 357	362	Red	C.C. (RHDP) FND 358	.75
FND 500	500	Red	C.C. (RHDP) FND 503	.99
FND 507	500	Red	C.A. (RHDP) FND 510	.99
TIL 308	270	Red	Numerical Display w/Logic	10.95
TIL 311	270	Red	4x7 Hexadecimal w/Logic	10.95
5082-7300	600	Red	4x7 Numeric (RHDP)	22.00
5082-7302	600	Red	4x7 Numeric (LHDP)	22.00
5082-7304	600	Red	Over Flo ±1	19.95
5082-7340	600	Red	4x7 Hexadecimal (0-9, A-F)	22.50
5082-7432	110	Red	C.C. (2 Digit/3-Bubble)	.25
HDSP-3401	800 20mm	Red	C.A. (RHDP)	1.50
HDSP-3403	800 20mm	Red	C.C. (RHDP)	1.50
HDSP-3406	800 20mm	Red	C.C. (RHDP) ±1 Over Flo	1.50

Many Other Displays Available — Send for New Catalog

LED Mounting Hardware

Mounts in panels up to .125" thick. Drill .257" diameter hole (F Drill). Can be used with XC22, XC111, XC526, XC556 and XC556 Series (from .160" to .200 Dia.). Black plastic clip and ring.

Part No.	8-99	100+
LMH 200	8/$1.00	.08 ea.

OPTO-ISOLATORS

H11C3	SCR Output Opto-Isolators	$1.19
LIT-1	Single Chan 20% CTR, 2500V (MCT 2/4N25)	.69
4N28	Single Chan 10% CTR, 500V (Photo Transistor)	.69
4N33	Single Chan 500% 1500V (Photo Darlington)	1.25
MOC3010	Optically Isolated Triac Driver	1.25

LITRONIX-NATIONAL Stick Display Sale

LIMITED QUANTITY!

LED NUMERIC ARRAYS

PART NO.	DIGIT SIZE (RED)	FORMAT	DRIVE Comm Cathode/Comm Anode	OVERALL SIZE	PRICE	SALE PRICE!
NSA166	100 (9 Bubble Stick)	888888	C.C. 6 Digit Multiplexed	2"L x .72"H x .27"D	$ .69	2/.99
NSA198	100 (9 Bubble Stick)	888888888	C.C. 9 Digit Multiplexed	2"L x .72"H x .27"D	.69	2/.99
NSA298	100 (9 Bubble Stick)	888888888	C.C. 9 Digit Multiplexed	1.98"L x .72"H x .27"D	.69	2/.99
NSA1166	100 (9 Bubble Stick)	8 88 88	C.C. 5 Digit Multiplexed	2"L x .72"H x .27"D	.49	2/.59

MULTI DIGIT LED NUMERIC DISPLAYS

*Standard Spacing Items

PART NO.	DIGIT SIZE (RED)	FORMAT	DRIVE Comm Cathode/Comm Anode	OVERALL SIZE	PRICE	SALE PRICE!
NSN373	3 No Decimal	88	C.C. 2 Digit Direct	.80"L x .80"H x .225"D	$ .69	2/.79
NSN374	.3 No Decimal	88	C.A. 2 Digit Direct	.80"L x .80"H x .225"D	.79	2/.98
NSN582	5 No Decimal	88	C.A. 2 Digit Direct	1.40"L x 1.14"H x .32"D (7/16" pins)	.89	2/1.49
NSN781	7	88	C.C. 2 Digit Multiplexed	1.2"L x 1.25"H x .3"D	1.19	2/1.95
NSB2100	3	88*88=8888	C.C. 8 Digit (10 Spaces)	4"L x .60"H x .260"D	.75	2/.89
NSB3881	3	8888	C.A. 4 Digit Multiplexed	1.88"L x .86"H x .25"D (7/16" pins)	.75	2/.88
NSB3882	3	±:888	C.A. 3½ Digit Multiplexed	1.80"L x .80"H x .225"D	.99	2/1.49
NSB3811	3	88 88	C.C. 4 Digit – Colon/PM Indicator	1-9/16"L x 13/16"H x 3/16"D	.99	2/1.19
NSB3862	3	°88 88 88	C.C. 6 Digit – AM/PM, Failure Ind.	3"L x 1.10"H x 7/32"D	2.95	2/3.95
NSB3864	3	88888888	C.C. 8 Digit Multiplexed	3"L x 1-3/32"H x 3/16"D	2.95	2/3.95
NSB3881*	3	8888	C.C. 4 Digit Multiplexed	1.59"L x .80"H x .225"D	2.95	2/4.95
NSB3882*	3	8888	C.A. 4 Digit Multiplexed	1.59"L x .80"H x .225"D	2.95	2/4.95
NSB5382*	5	±:8.8.8	C.A. 3½ Digit Multiplexed	1.88"L x 1.00"H x .28"D	3.49	2/5.95
NSB5441	5	°88 88	C.C. 4 Digit – AM/PM, Colon Ind.	3.00"L x 1.10"H x .282"D	2.95	2/3.95
NSB5881*	5	888.8	C.C. 4 Digit Multiplexed	1.88"L x 1.00"H x .280"D	3.49	2/5.95
NSB5882*	5	888.8	C.A. 4 Digit Multiplexed	1.88"L x 1.00"H x .280"D	3.49	2/5.95
NSB5918	5	±8888	C.C. 3½ Digit Multiplexed	3.00"L x 1.10"H x .282"D	2.49	2/3.49
NSB5922	5	88888	C.A. 5 Digit Multiplexed	3.00"L x 1.10"H x .282"D	2.95	2/3.49
NSB7923	7	888888	C.C. 6 Digit Multiplexed/Direct	3.60"L x 1.35"H x .282"D (3/8" pins)	3.95	2/4.95
DL2300	3	88	C.C. 2 Digit Multiplexed	13/16" x 7/8" x 1/4"	.79	2/.99
DLG2536	5 (Green)	88	C.A. 2 Digit Multiplexed	1-5/16" x 1 1/2" x 5/16"	.89	2/1.19
DL3130	10	888	C.A. 3 Digit Multiplexed	2-3/4" x 1-13/16" x 5/16"	2.25	2/3.49
DL4600	5	8888	C.C. 4 Digit, MPX, Colon	3-3/16" x 1-1/4" x 5/16"	1.95	2/2.95
DL4607	5	8888	C.C. 4 Digit, MPX, Colon	3-3/16" x 1 x 5/16"	1.75	2/2.95
DLG4607	.5 (Green)	8888	C.C. 4-Digit Non-Multiplexed	3-3/16" x 1 x 5/16"	4.95	2/7.95
DL4608	5	888.8	C.C. 4 Digit Multiplexed	2" x 1-5/16" x 5/16"	1.49	2/1.95
DL4620A	5	8888	C.C. 4 Digit Non-Multiplexed	3-3/16" x 1" x 5/16"	2.49	2/2.95

COMPUTER GRADE CAPACITORS

1¢ SALE!

MFD	WVDC	PRICE	MFD	WVDC	PRICE	MFD	WVDC	PRICE
250	150	1.95	7,000	60	4.95	27,000	10	2.95
500	200	2.49	10,000	15	2.95	32,500	25	4.95
1,250	3	.99	10,000	15	3.95	40,000	25	5.95
1,500	25	1.95	11,000	19	4.95	42,000	10	4.95
1,500	50	2.95	13,000	16	2.95	43,000	10	5.95
2,000	10	2.95	14,000	13	2.95	45,000	5	5.95
2,100	200	2.95	14,000	35	3.95	52,000	20	5.95
2,250	100	3.95	18,000	10	3.95	55,000	15	5.95
2,300	33	2.95	20,000	20	2.95	58,000	20	5.95
2,500	15	2.95	21,000	15	3.95	65,000	10	7.95
3,000	25	1.95	22,000	15	4.95	73,800	5	7.95
3,600	40	3.95	23,000	7	1.95	80,000	15	9.95
4,500	50	3.95	23,000	10	2.95	90,000	10	8.95
5,500	25	4.49	23,000	20	3.95	120,000	15	10.95
6,100	40	2.49	24,000	20	2.95	160,000	10	8.95

1¢ Sale!

OVER 200 OTHER VALUES AVAILABLE — BUY ONE, THE SECOND UNIT IS 1¢ MORE

LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD

	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

JUMPER AND CABLE ASSEMBLIES

Custom Jumpers! *Custom Cables!*

STANDARD DIP JUMPERS

All jumpers use low profile dip plugs with heavy duty pins for repeated disconnect applications.

JAMECO Part No.	AP Cross-Reference	No. Pins	Description	Wire Length	Price
DJ14-1	924102-12	14	single end	12"	$1.79
DJ14-2	924102-24	14	single end	24"	2.05
DJ14-3	924102-36	14	single end	36"	2.35
DJ14-1-14	924106-12	14	double end	12"	3.20
DJ14-2-14	924106-24	14	double end	24"	3.49
DJ14-3-14	924106-36	14	double end	36"	3.79
DJ16-1	924112-12	16	single end	12"	1.85
DJ16-2	924112-24	16	single end	24"	2.19
DJ16-3	924112-36	16	single end	36"	2.59
DJ16-1-16	924116-12	16	double end	12"	3.35
DJ16-2-16	924116-24	16	double end	24"	3.69
DJ16-3-16	924116-36	16	double end	36"	4.05
DJ24-1	924122-12	24	single end	12"	2.69
DJ24-2	924122-24	24	single end	24"	3.39
DJ24-3	924122-36	24	single end	36"	3.95
DJ24-1-24	924126-12	24	double end	12"	4.79
DJ24-2-24	924126-24	24	double end	24"	5.29
DJ24-3-24	924126-36	24	double end	36"	5.89
DJ40-1	924132-12	40	single end	12"	5.89
DJ40-2	924132-24	40	single end	24"	6.79
DJ40-3	924132-36	40	single end	36"	7.69
DJ40-1-40	924136-12	40	double end	12"	10.95
DJ40-2-40	924136-24	40	double end	24"	11.89
DJ40-3-40	924136-36	40	double end	36"	12.79

STANDARD DB25 SERIES CABLES

Now you can order DB25 P or S connectors with the cable necessary to fit your application. Choose from our standard flat cable in 4-foot lengths. **Call today.**

STANDARD CABLES

Part No.	Cable Length	Connectors	Price
DB25P-4	4 feet	1-DB25P	$ 9.95 ea.
DB25S-4	4 feet	1-DB25S	10.95 ea.
DB25P-4-P	4 feet	2-DB25P	16.95 ea.
DB25P-4-S	4 feet	1-DB25P/1-DB25S	17.95 ea.
DB25S-4-S	4 feet	2-DB25S	18.95 ea.

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6% Sales Tax
Postage — Add 5% plus $1.50 Insurance
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7/82

INTERSIL

*Evaluation Kits

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	24.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
72011DR	Low Battery Volt Indicator	2.25
72051PG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	12.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	13.95
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter CA	12.95
7217AIPI	4-Digit LED Up/Down Counter CC	14.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8038CCPD	Waveform Generator	4.95
8048CCPE	Monolithic Logarithmic Amp	21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.95
8212CPA	Volt Ref/Indicator	2.95

74C

74C00	.39	74C95	1.59	74C221	1.95
74C02	.39	74C107	1.89	74C240	2.25
74C04	.39	74C151	2.95	74C244	2.25
74C08	.39	74C154	3.95	74C373	2.49
74C10	.39	74C157	2.25	74C374	2.59
74C14	.75	74C160	1.69	74C901	.69
74C20	.39	74C161	1.60	74C903	.69
74C30	.39	74C162	1.49	74C911	10.95
74C32	.39	74C163	1.69	74C912	10.95
74C42	1.39	74C164	1.59	74C915	1.69
74C48	1.95	74C173	1.39	74C917	10.95
74C73	.79	74C174	1.39	74C922	5.49
74C74	.79	74C175	1.19	74C923	5.75
74C85	1.95	74C192	1.69	74C925	7.50
74C86	.99	74C193	1.69	74C926	7.50
74C89	6.95	74C195	1.59	80C95	.79
74C90	1.29			80C97	.79
74C93	1.29				

LINEAR

LH0002CN	6.85	LM340T-5	1.25	NE571N	3.95
LM10CLH	4.50	LM340T-12	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-15	1.25	LM709N	.29
LH0070-0H	4.95	LM341P-5	.75	LM710N	.79
TL071CP	.79	LM341P-12	.75	LM711N	.79
TL072CP	1.39	LM341P-15	.75	LM723N	.69
TL074CN	2.49	LM342P-5	.69	LM733N	1.00
LH0082CD	35.80	LM342P-12	.69	LM739N	1.19
TL082CP	1.19	LM342P-15	.69	LM741CN	.35
TL084CN	2.19	LM348N	1.25	MC1741SCG	3.00
LH0094CD	36.80	LM350K	5.75	LM747N	.79
LM300H	.99	LF351N	.60	LM748N	.59
LM301CN	.35	LF353N	1.00	LM1014N	2.75
LM302H	1.95	LF355N	1.10	LM1310N	1.95
LM304H	1.95	LF356N	1.10	LM1458CN	.59
LM305H	.99	LM358N	1.00	LM1488N	1.25
LM307CN	.45	LM359N	1.79	LM1489N	1.25
LM308CN	1.00	LM370N	4.49	LM1496N	1.95
LM309H	1.95	LM373N	3.25	LM1556V	1.75
LM309K	1.25	LM377N	2.95	LM1800N	2.95
LM310CN	1.75	LM380N	1.25	LM1871N	5.49
LM311/CN	.90	LM381N	1.95	LM1872N	5.49
LM312H	2.49	LM382N	1.79	LM1877N-9	3.25
LM317MP	1.15	LM384N	1.95	LM1889N	3.20
LM317T	1.75	LM386N-3	1.29	LM1896N	1.75
LM317K	3.95	LM387N	1.45	LM2002T	1.49
LM318CN	1.95	LM389N	1.35	LM2877P	2.05
LM319N	1.95	LM392N	.69	LM2878P	2.25
LM320K-5	1.35	LF398N	4.00	LM2896P-1	2.25
LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
LM320K-15	1.35	TL494CN	4.49	LM3900N	.69
LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.25
LM320T-12	1.25	NE510A	6.00	LM3909N	1.15
LM320T-15	1.25	NE529A	4.95	LM3914N	3.95
LM323K	5.95	NE531H	3.95	LM3915N	3.95
LM324N	.99	NE536H	6.00	LM3916N	3.95
LM329DZ	.65	NE540H	6.00	RC4136N	1.25
LM331N	3.95	NE544N	4.95	RC4151NB	3.95
LM334Z	1.30	NE550A	1.30	RC4194TK	6.95
LM335Z	1.40	NE555V	.39	RC4195TK	5.49
LM336Z	1.75	NE556N	.99	LM4500A	3.25
LM337T	1.95	NE564N	3.95	ICL8038B	4.95
LM337MP	1.15	NE565N	1.25	LM13080N	1.29
LM338K	6.95	LM566CN	1.95	LM13600N	1.49
LM339N	.99	LM567V	1.25	75138N	1.95
LM340K-5	1.35	NE570N	4.95	75450N	.89
LM340K-12	1.35			75451CN	.39
LM340K-15	1.35			75492	.89

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.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	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.16	.14	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.16
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.25	.21	.16
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.89	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

UTIC Mini Stereo AM/FM Receiver

WITH HEADPHONES — For Joggers, Cyclists, Skaters & Sports Events

FEATURES: Lightweight headphones. Left/right balance control. Full fidelity stereo sound. Additional black soft carrying case & shoulder strap. Belt clip (hands free). Operates on 3 AA cell batteries (not incl.). Compact size: 3⅛" x 4⅞" x 1". Wt. 6 oz.

Model 2830 List Price $89.95 .... **$34.95**

SPEAKERS

2¼" Round — 8 Ohm
.25 Watt (4" Leads)
Size: 2¼" x ¾"

Part No.	Price
A0201	$1.25 or 2/1.98

2½" Square — 16 Ohm
.25 Watt (4 mount. holes)
Large Ceramic Magnet
Size: 2⅝" x 2⅝" x ¾"

Part No.	Price
SF-25016	$1.39 or 2/2.98

National Semiconductor

RAM SALE

STATIC RAMS

MM2114N-2 4K (200NS) .... **$2.49 each**
(8 EACH $16.95/lot) (100 EACH $195.95/lot)

MM2114N-2L 4K (200NS) Low Power .... **$2.95 each**
(8 EACH $19.95/lot) (100 EACH $225.00/lot)

MM2147N 4K (70NS) .... **$4.95 each**
(8 EACH $34.95/lot) (100 EACH $419.95/lot)

MM6116P-4 16K (200NS) .... **$9.95 each**
(8 EACH $69.95/lot) (100 EACH $795.00/lot)

DYNAMIC RAMS

MM4164N-20 64K (200NS) .... **$9.95 each**
(8 EACH $69.95/lot) (100 EACH $795.00/lot)

MM5261N 1K (300NS) **8/1.95**

MM5262N 2K (365NS) **8/1.95**

MM5290N-2 16K (150NS) 4116 .... **$2.95 each**
(8 EACH $19.95/lot) (100 EACH $225.00/lot)

MM5290N-4 16K (250NS) 4116 .... **$1.95 each**
(8 EACH $14.95/lot) (100 each $175.00/lot)

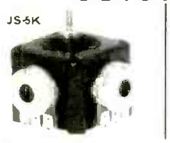
EPROM Erasing Lamp

- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact — only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

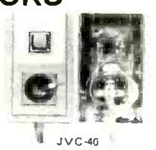
UVS-11EL Replacement Bulb $16.95

UVS-11E $79.95

JOYSTICKS



JS-5K



JVC-40

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JS-150K	150K Linear Taper Pots	$4.75
JVC-40	40K (2) Video Controller in case	$4.95

5¼" Mini-Floppy Disc Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I, III (Industry Standard)

Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6 amps max., 5VDC (±0.25V) 0.8 amps max. Unit as pictured at left (does not incl. case, power supply or cables). 30-page data book included. Weighs 3½ pounds. Size: 5¾"W x 8"D x 3¼"H

Limited Quantity!

Part No.	Price
FD200	$179.95
Single-sided, 40 tracks, 250K bytes capacity	
FD250	$199.95
Double-sided, 35 tracks, 438K bytes capacity	

NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) .. $24.95

(Picture not shown but similar in construction to above)
JE200 Reg. Power Supply Kit (5VDC, 1 amp) .. $14.95
JE205 Adapter Brd. (to JE200) ±5,±9 & ±12V. $12.95
JE210 Var. Pwr. Sply. Kit, 5 15VDC, to 1.5amp. $19.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

INS8080A	CPU	4.95
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	4.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	6.95
DP8253	Prog. Interval Timer	8.95
DP8255	Prog. Peripheral I/O (PPI)	5.95
DP8257	Prog. DMA Control	9.95
DP8259	Prog. Interrupt Control	9.95
DP8275	Prog. CRT Controller	39.95
DP8279	Prog. Keyboard/Display Interface	9.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95
DP8310	Octal Latched Peripheral Driver	5.25
DP8311	Octal Latched Peripheral Driver	5.25

6800/6800 SUPPORT DEVICES

MC6800	MPU	7.95
MC6802CP	MPU with Clock and RAM	14.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	17.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS

Z80 (780C)	CPU (MK3880N) (2MHz)	11.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	13.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901ADC	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MC6S502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	7.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	9.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	9.95
TMS9900JL	MPU—16-Bit	39.95
1173AN-1	30 Tune Musical MPU Chip	8.95

SHIFT REGISTERS

MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402N	256-Bit Dynamic	2.95
MM5013N	1024-Bit Dynamic/Accumulator	1.95
MM5016N	500/512-Bit Dynamic	1.95
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	1.95
2511N	MOS Dual 200-Bit Static	.99
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION

DC10	Mostek DC/DC Convert. +5V to -9V	$2.95
MC3470P	Floppy Disc Read AMP System	4.95
MC1408L7	7-Bit D/A Converter (DAC0807LCN)	4.95
MC1408L8	8-Bit D/A Converter (DAC0808LCN)	5.75
AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Band Filter	19.95
AF122-1CJ	Touch Tone High Band Filter	19.95
LM308CH	Super Gain Op Amp	1.15
LM334Z	Constant Current Source	1.19
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)

ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	6.95

RAM'S

1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	2.25
2114L	1024x4 Static 450ns Low Power	2.49
2114-2	1024x4 Static 200ns	2.49
2114L-2	1024x4 Static 200ns Low Power	2.95
74S200	256x1 Static	6.95
4116N-4 (UPD416)	16K Dynamic 250ns (MM5290N-4)	1.95
4164N-3	64K Dynamic 200ns	14.95
MM2147N	4096x1 Fast 70ns	4.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2K Dynamic	.49
MM5280/2107	4096x1 Dynamic	4.95
MM5290N-2 (4116)	16K Dynamic 150ns (UPD416C-3)	2.95
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	1.95
HM6116-4	16K (2Kx8) Static 200ns	14.95
82S25	64 Bit RAM (16x4OC)	3.49
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	9.95
TMS4045	1024x4 Static	9.95

PROMS/EPROMS

1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	4.95
TMS2716	16K EPROM (-5V, +5V, +12V)	9.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	8.95
2732 Intel TI	32K EPROM	17.95
2758	8K EPROM (450ns) (Single +5V)	7.49
2764Q	64K EPROM (Hitachi HN462764)	49.95
5203	2048 PROM	14.95
82S23 (74S188)	32x8 PROM (Open Collector)	3.95
82S115	4096 Bipolar PROM	14.95
82S123 (74S288)	32x8 Tri-State Bipolar PROM	3.95
82S185	8K PROM	16.95

— Over 30 More PROMS Listed in Our Catalog —

ROM'S

2513 (2140)	Character Generator (Upper Case)	9.95
2513 (3021)	Character Generator (Lower Case)	9.95

NMOS READ ONLY MEMORIES

MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

SPECIAL FUNCTION

DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25

TELEPHONE/KEYBOARD CHIPS

AY-5-9100	Push Button Telephone Dialer	14.95
AY-5-9200	Repertory Dialer	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	11.95
HD0165-5	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.49
74C923	Keyboard Encoder (20 keys)	5.75
MM53190N	Push Button Pulse Dialer	7.95
MM57499N	96/144 Key Serial Keyboard Encoder	8.95

Pee Wee Boxer Fan

- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz
- For Apple users

PWS2107U Cleaned & tested (used) ..... $ 9.95 ea.
PWS2107F New ..... $14.95 ea.

Muffin® Fan

- 105cfm free air delivery
- 4.68" sq. x 1.50" depth.
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

MU2A1-U Cleaned & tested (used) ..... $9.95 ea.
MU2A1-N New ..... $14.95 ea.

KEYBOARDS

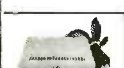
MICRO SWITCH 69-KEY KEYBOARD *Limited Quantity!*
Uses AMI SW20350K Chip. Size: 16⅞"L x 5¼"W x 1⅞"H Metal Frame. Light and dark grey key caps (no data sheet).
Part No. KB69SD12-2 .... **$19.95 each**

DATANETICS 74-KEY KEYBOARD *Limited Quantity!*
Uses EA20134 Chip (Electronic Array). Size: 16¾"L x 5⅛"W x 1⅞"H. White, black, blue, grey key caps. Data sheets not available.
Part No. KB354 .... **$29.95 each**

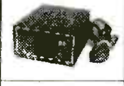
STACKPOLE 62-KEY ASCII KEYBOARD *Standard Stocked Item!*
SPST Switching (Mechanical). Size: 13"L x 3¾"W X 1½"H. Grey key caps. Data sheets are available.
Part No. K-62 .... **$34.95 each**
(ASCII Encloded Keyboard Kit — JE610K .... $79.95)

MICRO SWITCH 88-KEY KEYBOARD
Uses SD 25010K Chip (AMI). Size: 18⅛"L x 5¾"W x 1⅝"H. Dark and light gray key caps. Used in a Diablo 1640 Terminal (schematic avail.)
Part No. 88SD22 .... **$69.95 each**

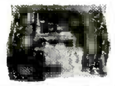
POWER SUPPLIES



POWER SUPPLY — 5VDC @ 1 AMP REGULATED Transaction Tech
Output +5VDC @ 1 amp (also +30VDC) reg. Input 115VAC 60Hz. Two-tone (black/beige) self-enclosed case. 6 foot, 3 conductor black power cord. Size: 6½"W x 7"D x 2¼"H — Wt. 3 lbs.
Part No. PS51194 .... **$19.95 each**



POWER SUPPLY — 5VDC @ 1 AMP REGULATED B Industries
Output +5VDC @ 1 amp, +36-42VDC Adjusted. 400mA or less, 30VAC (isolated) @ 1.5 amp. Input 115VAC 60Hz. Circuit breaker re-set button. Black self-enclosed case with 4 rubber feet. 6 foot, 3 conductor black power cord. On/off switch. Size: 6¼"W x 7¾"D x 3⅞"H — Wt. 7 lbs.
Part No. PS407D .... **$24.95 each**



POWER PAC Heavy Duty Multi-Voltage Power Supply — 5VDC, 12VDC & 24VDC
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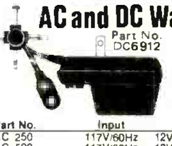
206610	**Intel Peripheral Design Handbook** Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$9.95

AC and DC Wall Transformers



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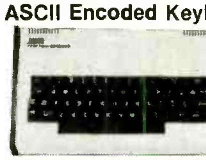
JE610 ASCII Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14½"W x 8¾"D

JE610/DTE-AK (After assembled as pictured above) **$124.95**

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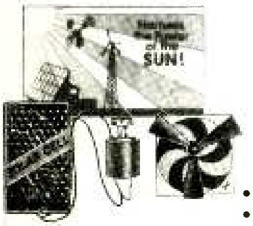

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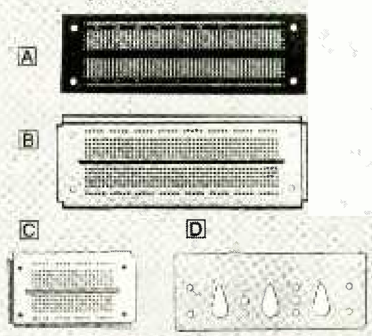

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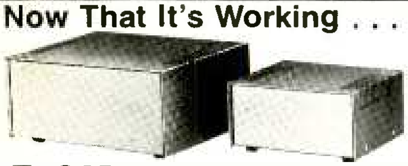

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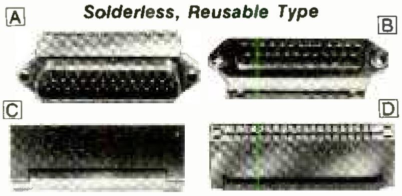

Fig.	Description	Cat. No.	Each
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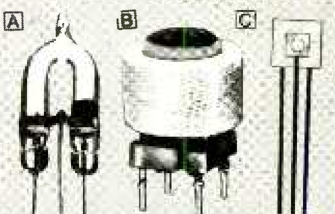

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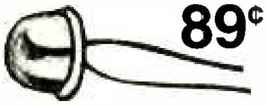

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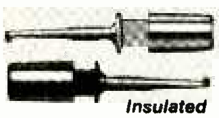

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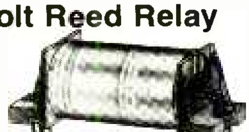

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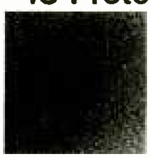

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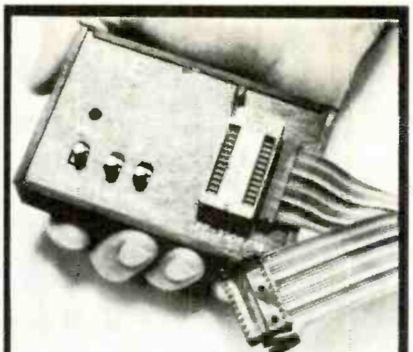

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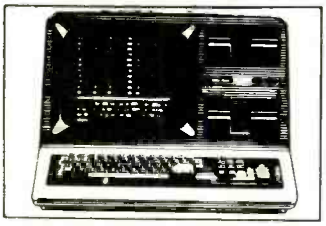

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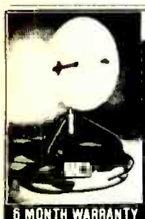

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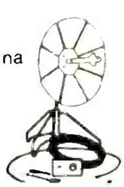

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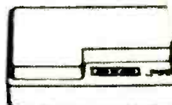

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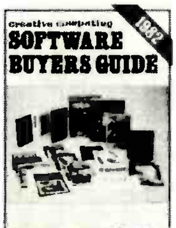

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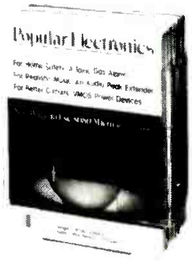

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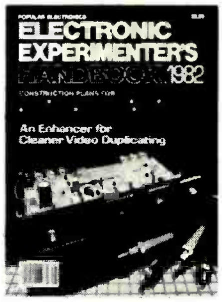

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ELECTRONICS WORLD® Personal Electronics News

CHILDRENS' TV VIEWING can be controlled with a new device from General Electric called "Channel Block-Out". It allows parents to defeat the reception of undesired channels for a period of up to 12 hours by keying in a customer-selected four-digit code, together with the channel numers. A channel can be replaced at any time by re-keying the code number. "Channel Block-Out" is available on 12 different GE receivers for 1983.

AN AUTOMOBILE PHONE from Ford Motor Company uses the capabilities of the computer-controlled Message Center that is standard equipment in the 1982 Lincoln Continental. Unlike a typical hand-held phone, the new system is said to enable a vehicle occupant to place calls by dialing numbers on the Message Center's keyboard, speaking into a microphone concealed in the driver's sun visor. The other party is heard through the rear speakers of the car's audio system. While a call is being made or received, the regular functions of the Message Center (display of time, distance, speed, and fuel economy) are unaffected. Called Commcar, the new technology is being displayed at major 1982 auto shows, though it is not currently planned for production.

A ONE-INCH SQUARE PROM (Programmable ROM) that contains all the information on mail rates found in a U.S. Postal Service Directory is being manufactured by Pitney Bowes. Designed for installation in Pitney Bowes postage meters, it can be quickly replaced should postage rates change. Users of the PROM are thus spared the tedium of cross-referencing shipping weights against mailing costs, and can readily accommodate their operation to the wiles of the Post Office.

PRESTEL COMES TO KNOXVILLE in the first U.S. demonstraton of the British videotex system. The World's Fair pilot project, involving 200 Prestel terminals, is sponsored by Financial Interstate Services and Logica, Inc., which will market the Prestel terminals in cooperation with British Telecom and GEC Computer, Ltd. The terminals have been placed on the site of the World's Fair and in adjacent hotels, banks, and transportation terminals. A special database has been developed for the project that includes event schedules and shopping information as well as banking services.

CELLULAR RADIO is emerging as a hot prospect for investors now that a group of radio common carriers (RCC) has formed a consortium to acquire frequency allocations. The new firm, called Cellular Systems, Inc. (CSI), is an association of 12 RCCs in the Northeast. The stated goal of CSI is to set up a cellular radio system in every major market. For its part, the FCC is granting two licenses in each market: one for the Bell System; the other is the slot CSI hopes to fill. Under the CSI plan, each RCC would lease equipment and share in the profit. Eventually, there could be a national organization, with all cellular systems being compatible within the CSI network.

COMPUTER POWER will be expanded by a factor of six to twelve, according to Cray Research, Inc. (Mendota Hts., MN). Now in the development stage, the CRAY-2 computer will have a 32-million-word memory, and a CPU cycle time (clock speed) of four nanoseconds. This capability represents a considerable improvement over the CRAY-1, now the most powerful computer available. Cray said the advance was made possible by applying liquid immersion technology to remove heat from the system, thereby permitting dense circuit packing in three-dimensional modules. Close packing is important in supercomputers, because at switching speeds of a few nanoseconds, even a signal moving at the speed of light is sluggish over the length of an average wire. Accordingly, the longest wire in the CRAY-2 will be 16″ (compared to four feet in the CRAY-1).

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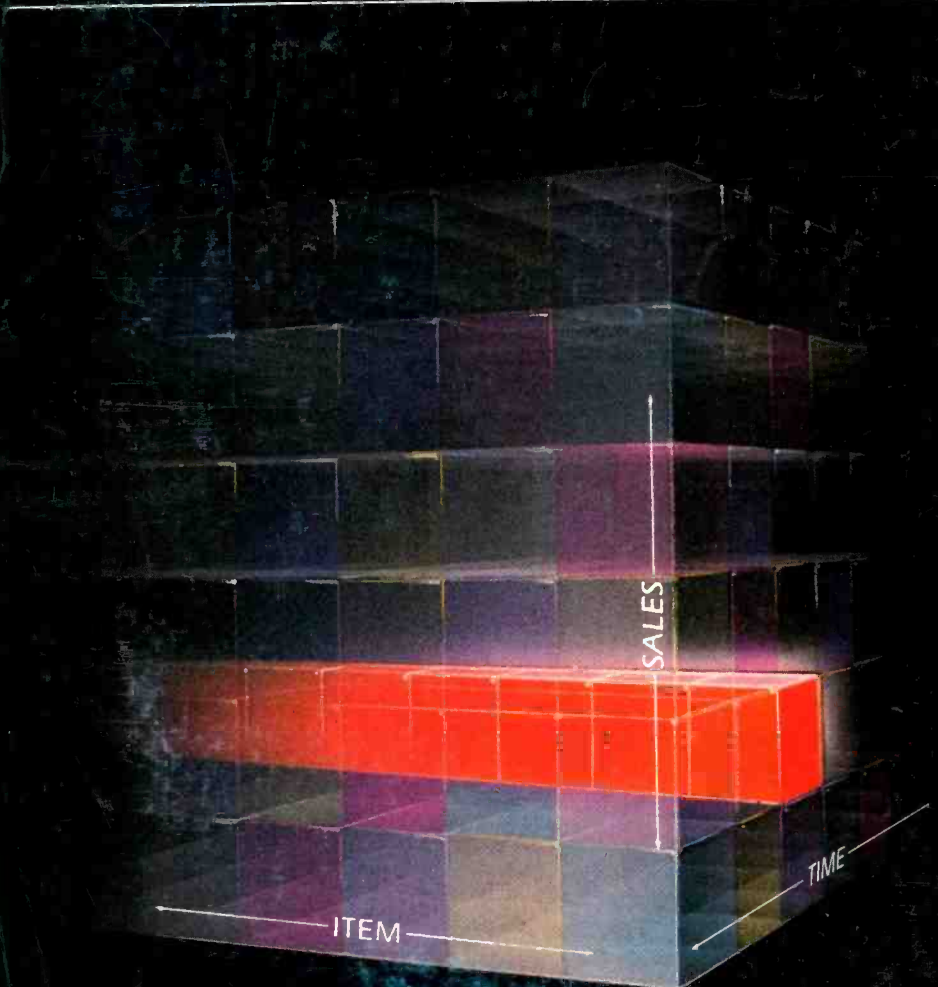

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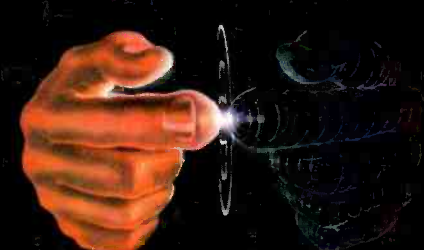

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