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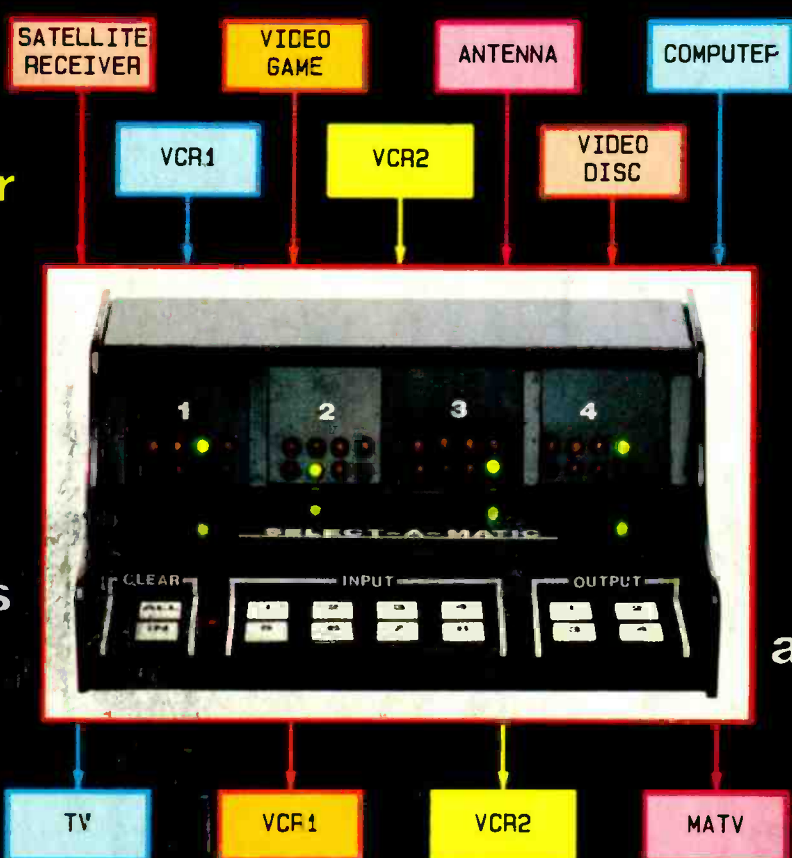

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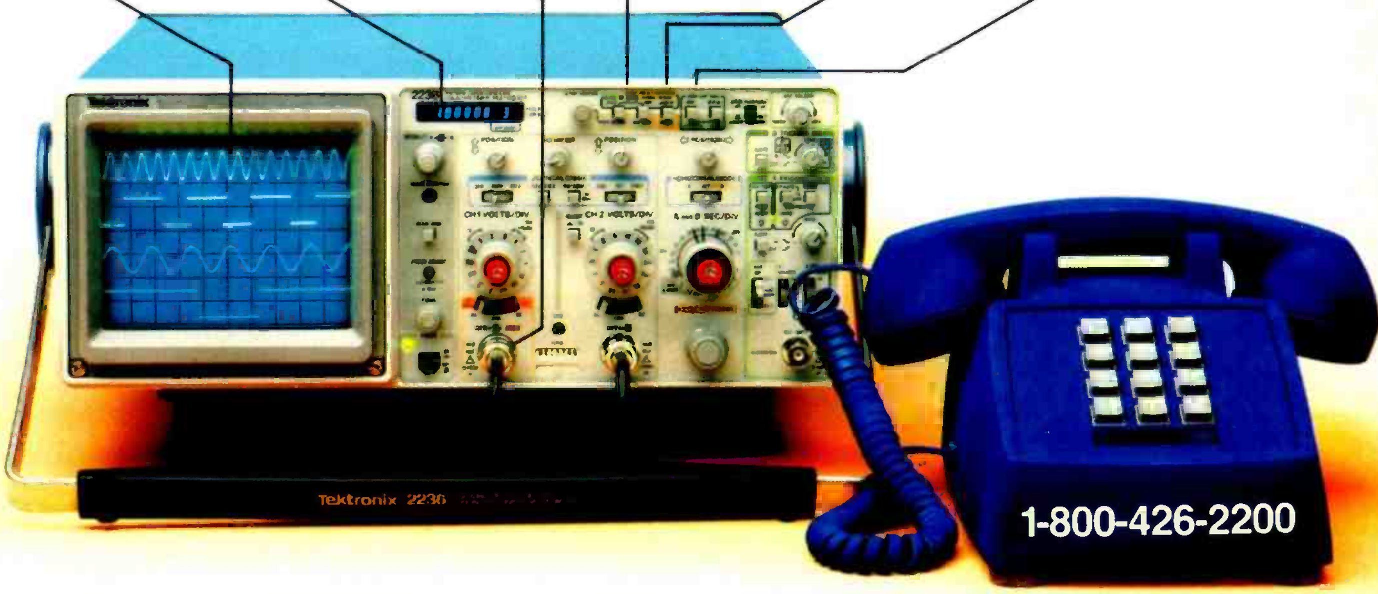

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If you don't need the extended coverage, there's the HX1000. It let's you cover your choice of over 15,000 frequencies on 30 channels at the touch of your finger. No crystals are necessary. Six band coverage, search and scan, priority control, and a liquid crystal display with special programming messages and clock are all part of the package. And with the sealed rubber keyboard and die-cast aluminum chassis, the HX1000 is the most rugged and durable hand held on the market.

CRYSTAL-CLEAR

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CIRCLE 261 ON FREE INFORMATION CARD

NEW! uniden® Bearcat® Products

Communications Electronics,™ the world's largest distributor of radio scanners, is pleased to announce that *Bearcat* brand scanner radios have been acquired by Uniden Corporation of America. Because of this acquisition, Communications Electronics will now carry the complete line of Uniden *Bearcat* scanners, CB radios and Uniden *Bandit™* radar detectors. To celebrate this acquisition, we have special pricing on the Uniden line of electronic products.

Bearcat®† 300-E

List price $549.95/**CE price $339.00**
7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC
Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz.
The *Bearcat* 300 is the most advanced automatic scanning radio that has ever been offered to the public. The *Bearcat* 300 uses a bright green fluorescent digital display, so it's ideal for mobile applications. The *Bearcat* 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys, Separate Band keys to permit lock-in/lock-out of any band for more efficient service search.

Bearcat® 20/20-E

List price $449.95/**CE price $269.00**
7-Band, 40 Channel • Crystalless • Searches AM Aircraft and Public Service bands • AC/DC Priority Channel • Direct Channel Access • Delay
Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz.
Find an easy chair. Turn on your *Bearcat* 20/20 and you're in an airplane cockpit. Listening to all the air-to-ground conversations. Maybe you'll pick up an exciting search and rescue mission on the Coast Guard channel. In a flash, you're back on the ground listening as news crews report a fast breaking story. Or hearing police and fire calls in your own neighborhood, in plenty of time so you can take precautions. You can even hear ham radio transmission, business phone calls and government intelligence agencies. Without leaving your easy chair. Because you've got a *Bearcat* 20/20 right beside it.

The *Bearcat* 20/20 monitors 40 frequencies from 7 bands, including aircraft. A two-position switch, located on the front panel, allows monitoring of 20 channels at a time.

Bearcat® 210XL-E

List price $349.95/**CE price $209.00**
6-Band, 18 Channel • Crystalless • AC/DC
Frequency range 32-50, 144-174, 421-512 MHz.
The *Bearcat* 210XL scanning radio is the second generation scanner that replaces the popular *Bearcat* 210 and 211. It has almost twice the scanning capacity of the *Bearcat* 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display. Automatic search finds new frequencies. Features scan delay, single antenna, patented track tuning and more.

Bearcat® 260-E

List price $399.95/**CE price $249.00**
8-Band, 16 Channel • Priority • AC/DC
Frequency range 30-50, 138-174, 406-512 MHz.
Keep up with police and fire calls, ham radio operators and other transmission while you're on the road with a *Bearcat* 260 scanner. Designed with police and fire department cooperation, its unique, practical shape and special two-position mounting bracket makes hump mounted or under dash installation possible in any vehicle. The *Bearcat* 260 is so ruggedly built for mobile use that it meets military standard 810c, curve y for vibration rating. Incorporated in its rugged, all metal case is a specially positioned speaker delivering 3 watts of crisp, clear audio.

NEW! Bearcat® 201-E

List price $279.95/**CE price $179.00**
9-Band, 16 Channel • Crystalless • AC only Priority • Scan Delay • One Key Weather
Frequency range 30-50, 118-136 AM, 146-174, 420-512 MHz.
The *Bearcat* 201 performs any scanning function you could possibly want. With push button ease, you can program up to 16 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear.

NEW! Bearcat® 180-E

List price $249.95/**CE price $149.00**
8-Band, 16 Channel • Priority • AC only
Frequency range: 30-50, 138-174, 406-512 MHz.
Police and fire calls. Ham radio transmissions. Business and government undercover operations. You can hear it all on a *Bearcat* 180 scanner radio. Imagine the thrill of hearing a major news event unfold even before the news organizations can report it. And the security of knowing what's happening in your neighborhood by hearing police and fire calls in time to take precautions. There's nothing like scanning to keep you in-the-know, and no better way to get scanner radio performance at a value price than with the *Bearcat* 180.

Bearcat® 100-E

The first no-crystal programmable handheld scanner.
List price $449.95/**CE price $234.00/*SPECIAL!***
8-Band, 16 Channel • Liquid Crystal Display Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 138-174, 406-512 MHz.
The world's first no-crystal handheld scanner has compressed into a 3" x 7" x 1¼" case more scanning power than is found in many base or mobile scanners. The *Bearcat* 100 has a full 16 channels with frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the 2-Meter and 70 cm. Amateur bands, *plus* Military and Federal Government frequencies. It has chrome-plated keys for functions that are user controlled, such as lockout, manual and automatic scan. Even search is provided, both manual and automatic. Wow...what a scanner!

The *Bearcat* 100 produces audio power output of 300 milliwatts, is track-tuned and has selectivity of better than 50 dB down and sensitivity of 0.6 microvolts on VHF and 1.0 microvolts on UHF. Power consumption is kept extremely low by using a liquid crystal display and exclusive low power integrated circuits.

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. The *Bearcat* 100 is in stock for quick shipment, so order your scanner today.

Bearcat® DX1000-E

List price $649.95/**CE price $489.00**
Frequency range 10 kHz to 30 MHz.
The *Bearcat* DX1000 shortwave radio makes tuning in London as easy as dialing a phone. It features PLL synthesized accuracy, two time zone 24-hour digital quartz clock and a built-in timer to wake you to your favorite shortwave station. It can be programmed to activate peripheral equipment like a tape recorder to record up to five different broadcasts, any frequency, any mode, while you are asleep or at work. It will receive AM, LSB, USB, CW and FM broadcasts.

There's never been an easier way to hear what the world has to say. With the *Bearcat* DX1000 shortwave receiver, you now have direct access to the world.

Uniden® PC22-E

List price $159.95/**CE price $99.00**
The *Uniden* PC22 is a 40 channel AM remote mobile CB radio. It's the answer for today's smaller cars which don't always provide adequate space for mounting. Since all the controls are on the microphone, you can stash the "guts" in the trunk. The microphone has up/down channel selector, digital display, TX/RX indicator and external speaker jack. Dimensions: 5¾" W x 7⅞" D x 1½" H. 13.8 VDC, positive or negative ground.

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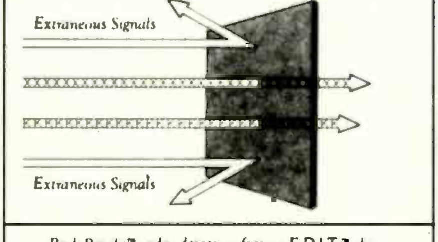

Both Bandit™ radar detectors feature E.D.I.T.™ the Electronic Data Interference Terminator that edits-out false alarm signals.

CIRCLE 79 ON FREE INFORMATION CARD

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List price $59.95/**CE price $44.00**
The *Uniden* PC33 boasts a super-compact case and front-panel mike connector to fit comfortably in today's smaller cars. *Controls:* Power & Volume, Squelch; *Switches:* ANL. Other features of the PC33 include Graduated LED "S"/RF Meter, Digital channel indicator. Dimensions: 6" W x 6" D x 1⅞" H. ±13.8 VDC.

Uniden® PC55-E

List price $89.95/**CE price $59.00**
The full featured *Uniden* PC55 front-panel mike connector makes installation easier when space is a factor. It has ANL, PA-CB, Channel 9 and RF Gain switches. LED "S"/RF meter, TX lite, PA & external speaker jacks. Dimensions: 6" W x 6" D x 1⅞" H. ±13.8 VDC.

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Vol. 56 No. 1

ANNUAL INDEX
JANUARY—DECEMBER 1984

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COVER 1

These days, the home TV has become much more than a device for viewing broadcast TV. Cable-TV, pay-TV, videocassette recorders, videodisc players, videogames, and personal computers all make use of the TV for display. That means a tangle of wires, and a constant hooking up and unhooking of connectors—unless you have a device like our RF switcher. To learn more about the switcher, including how to build it, turn to page 41.

NEXT MONTH

ON SALE JANUARY 17

STEREO-TV
Stereo TV is here at last! Next month, we'll look at the technical standards that have been adopted to make it all possible.

OSCILLOSCOPE UPGRADE
Add a video-sync separator to your oscilloscope.

UNIVERSAL CASSETTE INTERFACE
Record your programs on cassette tape via your computer's RS-232 port.

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All about the many different types of resistors and capacitors, and when and where each type should be used.

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ADVANCE ELECTRONICS

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Super VCR.** Although some firms are now introducing VCR's in the new 8mm video format, many Japanese video companies have lost their enthusiasm for the new small tape and instead are working to develop ½-inch recorders of vastly improved quality, while retaining compatibility with existing formats. While the original thought behind 8mm was to develop miniaturized units that will provide quality equal to ½-inch, those companies instead are seeking to apply the new 8mm specifications to ½-inch tapes and come up with vastly better quality in the older compatible formats.

Those projects are still closely guarded secrets, but they are aiming at a home machine capable of 400 lines of horizontal resolution, as compared with about 250 on today's VCR's, and a 50–55 dB signal-to-noise ratio, up from 40–45 today. Being explored is the use of high-band color, similar to that used in broadcast VTR's, along with metal tape, new heads, and highly integrated electronics. Both the VHS and Beta groups are working toward these super VCR's, which could be ready in about two years. One of the goals is to make the new system far superior to anything that could be accomplished within the 8mm video format, thereby calming any fears that 8mm will take over as the standard for home decks and keeping it relegated to the status of a system for portable use only.

The key to any improved ½-inch system must be compatibility, according to Shizuo Takano, Managing Director of Video Products for JVC, who is known as the "father of VHS." Takano envisions the current ½-inch formats existing for many years, and being flexible enough to encompass many signal improvements. Takano recently told us: "If a completely new format is ever necessary, it should be when the broadcasting system is changed"—for example, to a widescreen high-definition system.

• **Cassettes that communicate.** Borrowing a page from 8mm, the *Video 2000* VCR system developed by Philips and Grundig in Europe uses a notched cassette to let the recorder know how much tape it contains, so that the display panel on the VCR can show the time remaining in the cassette. The 8mm videocassette specifications, developed by a 122-company committee in Japan, provides for similar "recognition holes which make an automatic detection of such parameters as kind of tape and tape thickness possible."

The use of notched videocassettes may soon become universal. The VHS group is now exploring whether to add such notches to standard ½-inch cassettes, and undoubtedly the Beta proponents are working on a similar project. Such a notched cassette could tell the VCR of the future whether the tape is of an oxide or metal type and direct it to make automatic adjustments in bias and signal processing, retaining compatibility of any future "super VCR" with current tape types.

A new VHS recorder developed by Grundig for the European market uses a somewhat similar cassette identification system to cue a tape-remaining indicator on the VCR. Instead of notches, that system involves stick-on bar-code symbols, which are read by the machine as the tape is loaded. The Grundig VCR also contains a special security system—the user punches in any four-digit code on the keypad. After the cassette is loaded, the machine won't play unless the code is re-entered—as a matter of fact, unless the code is re-entered the cassette can't even be removed from the recorder. A user who forgets his security code can have the machine unlocked only by taking it to an authorized Grundig service station with proof of purchase. A sticker on the recorder notifies prospective burglars that the VCR is totally useless without the four-digit security code.

The Grundig recorder, which is compatible with other VHS machines but uses a "U"-type wrap—around the head drum instead of the standard VHS "M"-wrap—is expected to be available eventually in the U.S. **R-E**

WHAT'S NEWS

Library of Congress receives Compact Discs

The Compact Disc Group—in a special presentation last July 25—presented more than a thousand compact digital-audio discs to the Library of Congress. The presentation included every compact disc released in the United States to that date.

The Compact Disc Group is composed of leading equipment and record manufacturers, united to educate the public and create further awareness of the distortion-free sound of the laser-read Compact Disc.

The discs were officially presented to Deputy Librarian William J. Welsh by Leslie Rosen, Director of the Compact Disc Group. An 1897 Berliner recording of John Philip Sousa's "Stars and Strips Forever," recorded just 13 days after Sousa composed the work, was compared with later renditions, the finale being a Compact Disc recording.

WILLIAM J. WELSH, DEPUTY LIBRARIAN of the Library of Congress, receives a Compact Disc from Leslie Rosen, Director of the Compact Disc Group. Toward the rear, from left to right, are: John L. Broderick, Deputy Librarian for Research Services, Roger Nichols, recording engineer and producer, Robert Saudek, Chief of the Motion Picture, Broadcasting and Recorded Sound Division of the Library, and RCA recording artist Larry Elgart.

ARRL wants volunteers as Amateur examiners

With the decision by the FCC to discontinue administering licensing exams to radio amateurs it becomes necessary to develop an organization of Voluntary Examination Coordinators (VEC's) and examiners to administer amateur license exams.

The American Radio Relay League will serve as a VEC in all the 13 FCC call areas of the United States. (More than one VEC may serve in a given call area.) The League is, accordingly, calling for volunteer examiners. Those must hold advanced or extra class licenses. Advanced class license holders may administer only the exam elements required for the technical license; Extra class licensees may administer all written element and international code tests. (Novice licenses will continue to be given by novice examiners under the new novice rules.)

Applicants need not be members of the ARRL. They must be at least 18 years old, hold advanced or extra class licenses, and have no record of license suspension or revocation.

If you qualify and would like to be a volunteer examiner in ARRL's VEC program, you may request an application by writing to Volunteer Examiner Accreditation, American Radio Relay League, 225 Main St., Newington, CT 06111.

Semiconductor shortage eases up in 1984

The year-long semiconductor shortage, which peaked in January 1984—when orders overran shipments by more than 50 percent—was reported to be dropping off by early Fall 1984. Some parts, such as microprocessors, were still reported in short supply but the shortage of older products had declined sharply.

Part of the greater availability of many types of semiconductors may have been due to the seasonal summer slowdown in sales, especially of personal and home computers. In June, 1984, orders outstripped shipments by 15 percent—in July the difference was down to 6 percent. R-E

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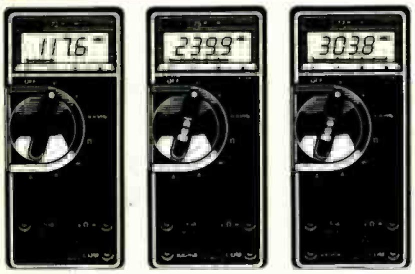

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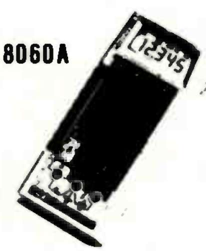

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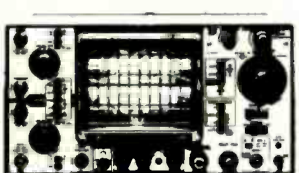

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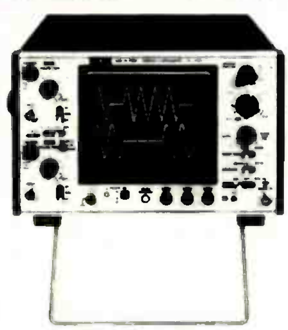

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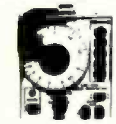

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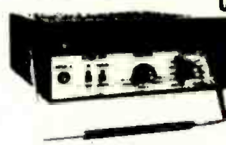

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SATELLITE TV

Changes in the TVRO industry

BOB COOPER, JR.*
SATELLITE EDITOR

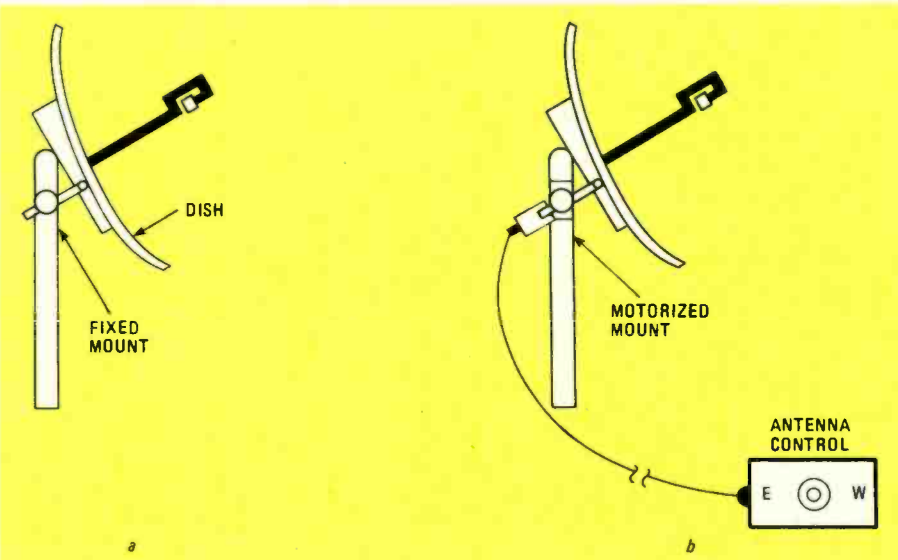

FIG. 1

IN THE LAST INSTALLMENT OF THIS COLumn, we looked at the business opportunities presented by the home-TVRO industry today. We also took a backward look at the basic hardware contained in the system with a sort of "then-and-now" comparison of how hardware developments have paced rapidly expanding equipment sales. This time we'll look at the individual components that make up those systems.

TVRO components

The first home-TVRO systems, bought by *genuine* consumers (not "technology buffs" who'd purchase *anything* new and exciting) were extremely cumbersome to operate. Not only that, one segment of the system was missing from the equipment line-up: the "dish mover" or motor-drive unit. (It had not yet been invented, nor would it be until late in 1980.)

* Publisher, CSD magazine

Early enthusiasts who built or assembled their own systems were seldom satisfied to watch programming from a single satellite for long. After all, part of the fun and excitement was being able to "cruise the skies" looking for action. With cable programming concentrated on a single satellite (F1 in 1980), the 20 or so channels emanating from its transponders were entertaining, but were hardly all that was in the sky.

Those early TVRO owners talked glibly about picking up 30 or 40 channels as if they were all easily accessible from an easy chair. Of course, they were not. In fact, to receive programming beyond the first 20 or so channels, somebody had to go out in the yard and "wrestle" with the antenna because the original mount was of the fixed variety, as shown in Fig. 1-a (not exactly a "consumer friendly" product!).

Motor drives have been troublesome parts of TVRO systems since they first appeared commercially in the fall of 1980. The earliest drives (available as retrofit devices for virtually any polar-mount style dish) were simple devices that had a three-positions switch (OFF, EAST, and WEST).

The switch connected to a motorized jack-screw actuator (see Fig. 1-b) that mounted between the dish and the post portion of the polar mount. The post was stationary (they hoped!), while the dish would pivot when pushed or pulled by the motor-driven jack screw. If the dish and mount were capable of tracking the *Clarke orbital belt*, the motor would provide the remote-controlled push/pull action to drive the dish through the belt. Simple enough, but there were many problems.

The earliest motorized mounts were not designed for frequent use—moving the dish on the mount quickly proved they weren't. Poor calculation of weights and loads resulted in extremely heavy strains on the small motors chosen to rotate the jack-screw actuators. The jack screws, in turn, proved too lightweight and they soon bound-up under the strain.

Needless to say, the first year of motorized dish-mounts was a disaster and those who purchased those units probably junked them within a few months. It took a mul-

continued on page 20

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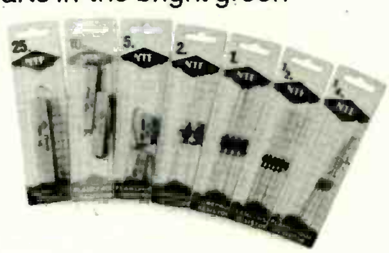

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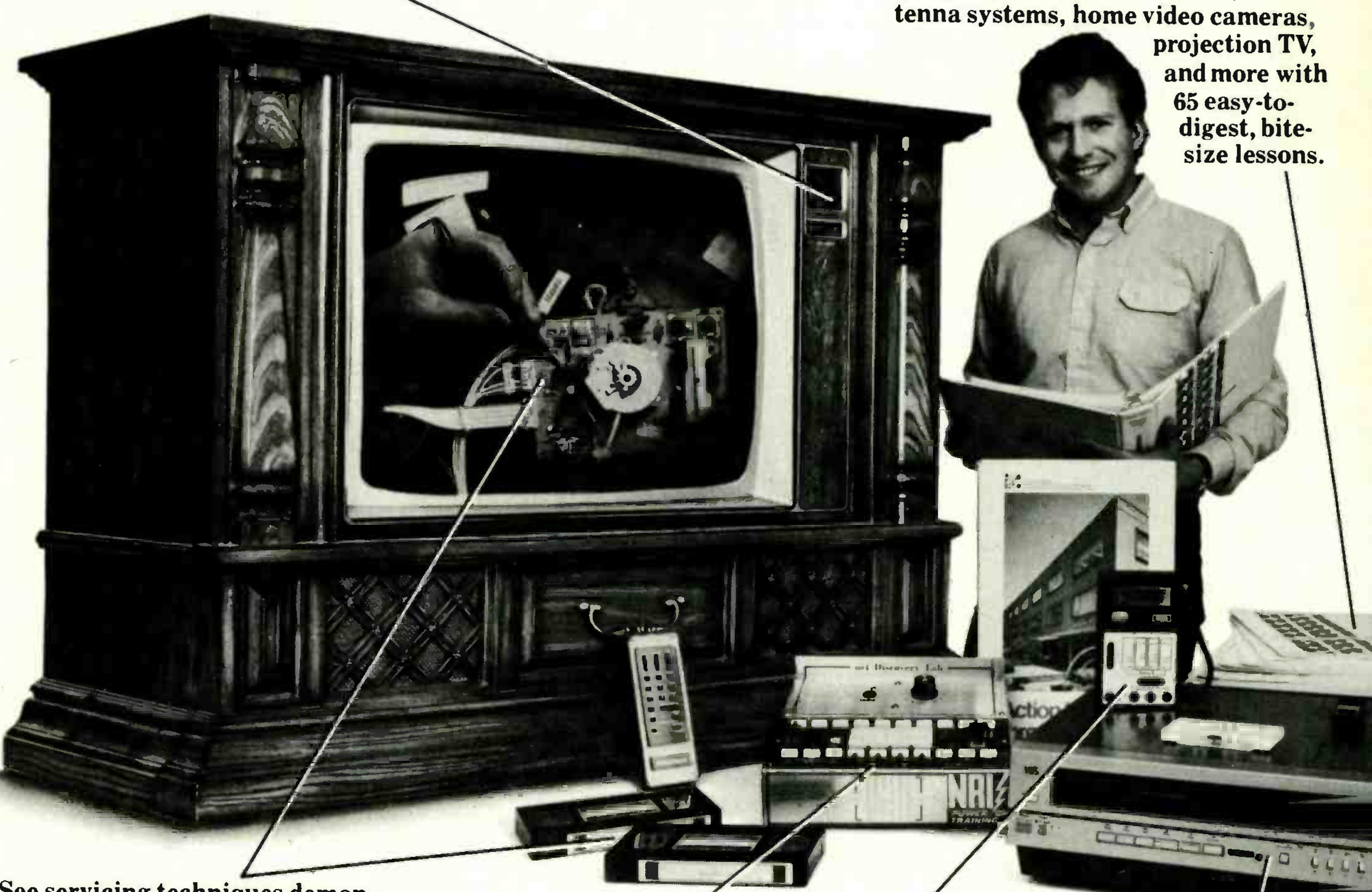

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SATELLITE TV

continued from page 14

titude of field failures to get suppliers thinking about the strains being placed on the system.

To complicate things, just as the mechanics of the system were being ironed out, a firm in Tulsa, Oklahoma introduced a drive system with a built-in programmable memory. The user simply programmed several satellite locations into the unit using a two- or three-digit code and the control box "remembered" where the satellites were.

As you might expect, that development brought with it an entire new wave of problems. Memories would fail (forget) when there was a power failure or glitch. Dish positioning would be knocked off by a degree or two by a glitch. Power surges would wipe out memory entirely, and the user would be forced to re-program the memory. The problems seemed endless.

Fortunately, virtually all those early problems are now behind us. Modern drives have memories that remember, infrared or UHF wireless remote-controls, and "floating" gimbel-type brackets that transfer the load of the dish away from the motor-driven jack screw. They also have the ability to interface to fully remote-controlled receivers, as well.

As recently as 1983, dealers were reporting in annual TVRO-dealer surveys that "dish movers" were their most frequent problem causers. That's not true anymore. However, pricing still continues to be surprisingly high for that portion of the system.

At dealer pricing levels, simple "east-west" systems with a single switch control run in the $300 and up range. More elaborate systems with memories can cost twice that amount, while those with full remote-control capabilities may cost a dealer.

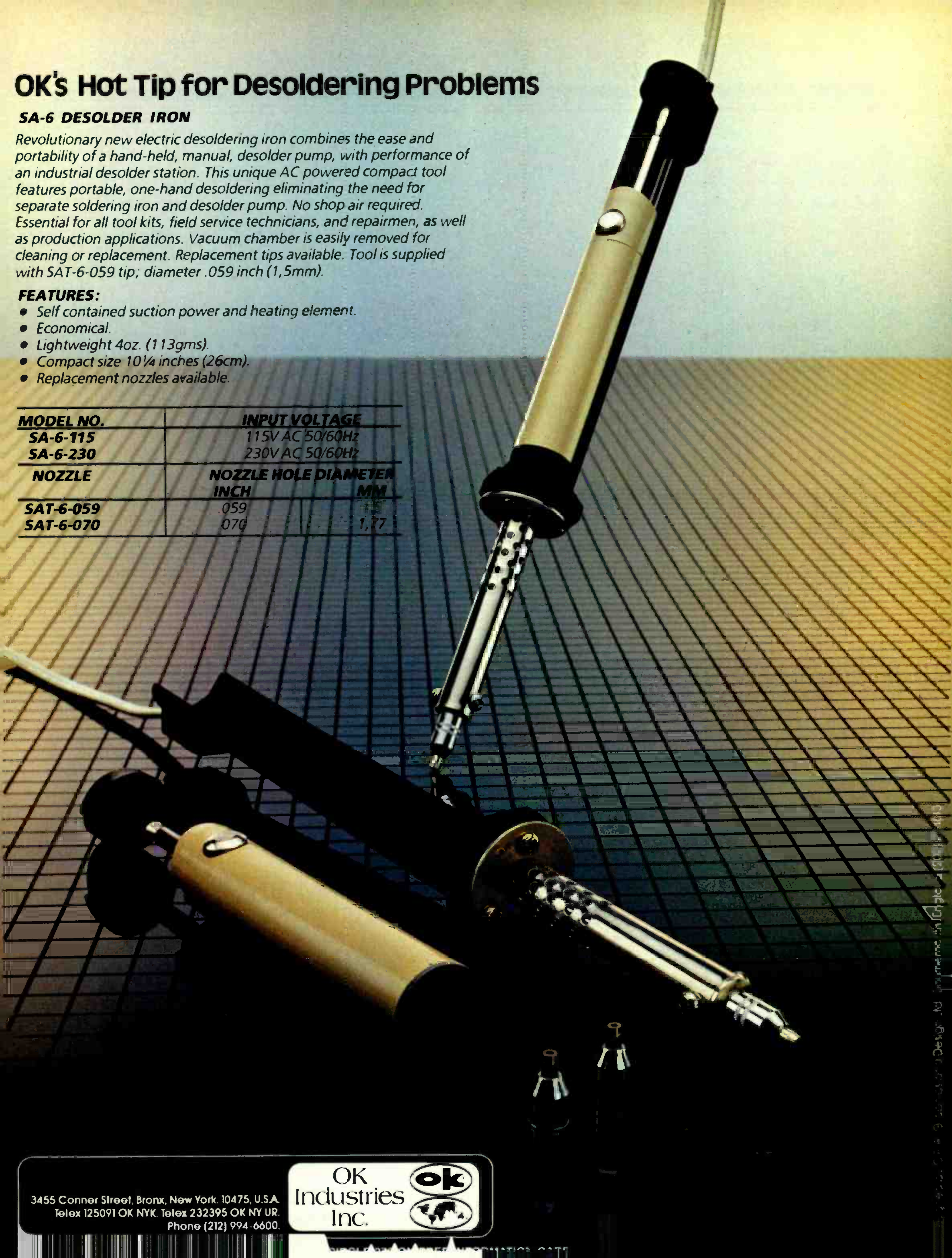
Perhaps the most significant signs of maturity in the TVRO industry are the warranties now attached to motor-drive and control systems. One year is standard, and some offer even longer full-coverage protection.

Next month, we'll look at more component changes. **R-E**

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer, in addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.



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LETTERS

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New York, NY 10003

CORRECTION

In "All About Power Supply Circuits", **Radio-Electronics**, July 1984, I believe an error exists in the schematic shown in Fig.4. The caption for that figure states that Figs. 3 and 4 are equivalent. Please note that diodes D1 and D2 are connected "across" the whole secondary of T1, whereas diodes D3 and D4 are "across" only one-half the winding. Therefore, −V out will be one-half that of +V out, supposedly. However the circuit shown in Fig. 4 would not work well because the cathode of D3 is grounded.

I enjoy your magazine very much, as long as you do not go "computer happy." I was a fan of *Popular Electronics*, but they went crazy over computers and that turned me right off (I'd rather switch than fight)! Please, minimize your articles on computers. Let's continue to have good material on phone accessories, control circuits, timer circuits, and such, along with explanations of how various circuits function. For example, the "All About Power Supply Circuits" article was great.
EDWARD BALASKI
Torrington, CT

An error certainly does exist in Fig. 4. The caption describes what was supposed to be there. But, as you indicate, diode D3 is shown incorrectly. Its cathode should be connected to the bottom of the transformer.—Editor

SERVICE MANUAL NEEDED

I enjoy your magazine very much and I eagerly await the first of the month for the latest issue so that I can see what new projects I can build and find what new information I can use.

Perhaps some of your readers can help me. I have a Sansui *AU*

3900 amplifier that is not operating. I need a schematic or, better yet, a service manual for the unit, but the Sansui distributors are unable to get it for me. In addition, neither Sam's Photofact nor the Radio College of Canada list the appropriate schematic. I am hoping someone can help me.
BRIAN COLLINS
3179-138th Ave.
Edmonton, Alberta, Canada T5Y 1R1

EXPANDING THE ZX81

I was working on a project in which an output line is turned alternately high and low under computer control using a Timex/Sinclair *1000*. When Neil Bungard's article on interfacing the *ZX81* appeared in the July 1984 issue of **Radio-Electronics**, I felt a modification of his circuit was just what I needed.

I sat down at my computer to test the program I wrote to accomplish the task. Immediately I ran into trouble. In spite of using only even-numbered addresses as Neil has advised, my program crashed. Experimentation finally revealed that the program ran fine using odd-numbered addresses. Had Neil mislead his readers? No! The problem arose because he only told half the story.

There exists somewhere in the innards of the *ZX81* an NMI (non-maskable interrupt) generator. That generator must be on in the slow mode, but off in the fast mode. Evidently Sinclair uses the address line AØ to turn that generator on and off. I was operating in the fast mode, so every time the computer executed an OUT instruction to an even address, it turned *on* the NMI generator, causing a crash. Neil must have been operating in a slow mode, so every time his computer executed an OUT instruction to an odd address, it turned *off* the NMI generator, causing a crash.

The rule then is: In the fast mode, OUT instructions should use only odd addresses, but in the slow mode, OUT instructions should only use even addresses.

Another caution: The monitor uses hexadecimal output addresses FF, FE, and FD, and hexadecimal input address FE. That means that it will activate output 8 on IC3 and IC4. That could result in undesired outputs and inputs by the normal running of the monitor. Neil has guarded against that by the decoder circuit using IC9 and IC1-c. He also has left open output 8 on IC3 and IC4.
WALTER E. STYLES
Richmond Area Timex/Sinclair Users Group
Chester, VA

MANUAL NEEDED

I received some old equipment from friends, but they did not have the operating manual. Perhaps there are some **Radio-Electronics** readers who know where I can get a manual and hopefully a schematic for an Electronic Measurement Corp. tube and transistor Tester, model *215*.
TOM BRACLETT
22258 Gregory
Dearborn, MI 48124

SATELLITE STEREO DEMODULATOR

The correct telephone number of Video Control, who is offering kits of parts for the satellite stereo demodulator described in the October issue of **Radio-Electronics**, is (206) 693-3834.

ANTIQUE RADIO CLASSIFIED

There is now a publication that may interest the growing number of antique-radio collectors. Beginning in September, 1984 *Antique Radio Classified* will feature free classified ads for buyers, sellers, and traders of old radios and related items.

Antique Radio Classified will be published nationally each month and will also contain coverage of upcoming radio conventions, meetings, and flea markets for the antique-radio collector.

GARY B. SCHNEIDER
Publisher
Antique Radio Classified
9951 Sunrise Blvd.
Cleveland, OH 44133

INFORMATION EXCHANGE

The Data Processing Amateurs Society of Quebec is the oldest such association in Eastern Canada.

The goal of the association is to have an interesting hobby, and together to increase our knowledge and experience. We do our best to help beginners with meetings, courses, demonstrations, etc.

Our members asked us to try contacting other clubs or associations in Quebec and surrounding areas to exchange experiences, information, and friendship. As over 30% of our members are using modems, we succeeded in organizing our own telecommunication system: TELESAIQ II. We are learning a lot with this project, and it is not over, because we do not have full services.

We are negotiating with other systems and networks to exchange services.

Since yours is one of the most popular publications in the field, we thought of turning to you for assistance. We would appreciate if you could help us by publishing our address so that other similar organizations could contact us.

GERALD BOULET
SIAQ
Societe D'Informatique Amateur du Quebec
C.P. 9242
Sainte Foy, Quebec, Canada G1V 4B1

SCHEMATIC NEEDED

I recently acquired a B&K model 1075 TV Analyst in need of repair. I know it needs a horizontal width/frequency coil, but I have no other information on the unit itself. I would hope that one of your readers has a schematic and parts list for that older device. I am a student in electronics and would greatly appreciate any and all help other readers could provide.

TERRY B. SCHWARTZ
1864 Eleanor Ave.
St. Paul, MN 55116

POWER-SUPPLY CORRECTIONS

The article, "All About Power-Supply Circuits," (**Radio-Elec-**

tronics, July, 1984) contained several significant errors and omissions:

1. The VA rating calculation for a power-supply transformer is not correct for the circuits shown. It should be: Secondary RMS voltage × DC current × 1.2 (CT) or 1.8 (bridge). Also, the transformer regulation factor for the typical small hobbyist transformer is 15-20%, not the 10% stated.

2. The PIV rating for the rectifiers is at least twice the secondary voltage, allowing for a safety factor.

3. 3-terminal regulators can rarely be used for their rated current unless "bolted to an anvil sitting on a block of ice." Without any heat sink, those popular 1-amp "tab" regulators are only good for about 100–200 mA. The heat sink is what really determines the rating of most regulators.

4. A good-quality filter capacitor is important. Audio-grade capacitors, identified by their flimsy leads, are not suited for output currents above ½ amp.

5. Allow adequate ventilation, especially around the power transformer. Keep the filter capacitor and regulator away from it.

6. To prevent current surges from blowing the rectifiers, put a very small resistor in series with one side of the transformer secondary (or center-tap, if you are using it). The value to use is approximately: (secondary RMS voltage)/(20 × rectifier current rating).

7. Safety first! Use a fuse, and locate it *before* any switch. Ideally, use a grounded power cord, and put the fuse and switch on the "hot" side of the line.

Finally, a construction tip: for low-current supplies, a wall-plug transformer is the safest and usually the cheapest approach.

ALVIN H. NICHTER
New York, NY

ZX81 DESIGN—OKAY!

I've just built the ZX81 Interface, (**Radio-Electronics**, July, 1984).

It's an excellent design, but there is an error in the schematic. For address inputs through IC8 (74LS373), A2 comes in on pin 7, and should leave via pin 6, not pin 5, as shown.

Thank you for the article on the ZX81. Let's have many more, please!

MERLIN TINKER
Casper, CA

MORE MEDICAL ELECTRONICS

Since you have started printing articles about medical electronics, I'd appreciate some more about the repair of the instruments used in that field. There seems to be a dearth of information about their repair as I have, to this point, only been able to locate one book on the subject. Any articles that could enlighten me further about the care and repair of electronic medical instruments, or even just a suggested reading list, would be most helpful.

ALBERT SHUGZDIS
Arkadelphia, AR

BACKWARD X-RAY

I have read the article by Dr. Fish, "Electronic Measurement in Medicine," (**Radio-Electronics**, September 1984) with interest. On the whole someone outside medicine might not find the article interesting. It is, however very informative. There is one error of note in Fig. 5, page 57. The radiograph (X-ray), is printed backward, making some of the labeling incorrect.

I mention that because I am a Radiographer by profession and things like backward X-rays really stick out.

Keep up the good work. I really enjoy your magazine.

RONALD J. BOHLAND, R.T.(R)
Toledo, OH

EDITORIAL "AMEN"

I saw your editorial in **Radio-Electronics**, September 1984, "When is a Change not a Change?", and I say AMEN! There are plenty of magazines that tell about computers—seems like they all do—and that is the sole reason I changed to **Radio-Electronics** a few months ago from another similar magazine. I am a circuit guy, not a button pusher. I realize that computers are great for the non-technical, but there are a lot of us who are technical. Anyhow you get the point.

That particular issue really rang the bell on articles. I liked "Sonic Motion Detector," (I have been looking for years for this), "Electronic Measurements in Medicine," "What's New in Batteries," "Squarewave Generator Circuits," and the departments were also of interest.

Congratulations! I think your courage will pay off!

CHARLES DEMING
Mariposa, CA

AMPLIFIER SCHEMATIC NEEDED

A few years ago, I brought a Lafayette *LA-324A* stereo amplifier from a friend. Last week it burned up due to a power overload. I am interested in rebuilding that amplifier, but the schematic diagram is missing from my records. Is there any reader that can help? I need a copy of the service manual or the schematic diagram. I'd appreciate any help from any source.

ARTURO OTERO BRACERO
P.O. Box 2821-S,
San Juan, Puerto Rico, 00903

R-E

EQUIPMENT REPORTS

Radio Shack Model 4 Computer

An 8-bit, Z80-based personal computer

CIRCLE 5 ON FREE INFORMATION CARD

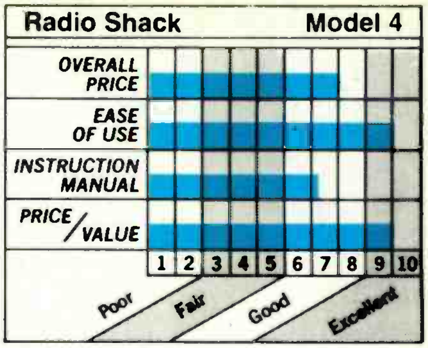
THE RADIO SHACK (ONE TANDY CENTER, Ft. Worth, TX 76102) *Model 4* is a personal computer that will run both TRSDOS and CP/M programs without the need to get into the guts of the computer and attempt some rather hairy and complex circuit retrofits. As such, essentially the *Model 4* is a merger of the best features of Radio Shack's *Model III* and *Model II* computers.

The computer is available in three configurations: tape-based at $799; one disk drive for $1099; and two disk drives plus the optional RS-232 I/O for $1299. We will concern ourselves only with the

two-disk model because that offers the user the best value; the others are but way-stations on the way to two disk drives.

Highlights of the two-disk *Model 4* include 64K of RAM that can be user-upgraded to 128K, automatic operation in the *Model III* mode by simply using *Model III* disks, and a *Model 4* mode that features an 80-column × 24-line screen with normal and reverse video, a 4-MHz Z80 CPU, and the ability to run CP/M. Also, the computer will read and write tapes for the *Model 100* "briefcase" computer.

The *Model 4* is very similar in appearance to the *Model III* except for color and minor, though important, keyboard improvements. Replacing the "Mercedes gray" color of the previous models—which looks great on a car but awful on a plastic cabinet—is the light beige color common to most



modern "high-tech" equipment. The keyboard, though similar to the earlier computers, now features a real CONTROL key—there is no longer a need to hold down the SHIFT key simultaneously with an UP-ARROW or DOWN-ARROW key in order to simulate the function of the CONTROL key. Also, there are three software-definable function keys, labeled F1, F2, and F3.

The two-disk configuration consists of the basic computer with TRSDOS Version 6.0 and TRSDOS 6.0 BASIC, two double-density 5¼ inch disk drives, 64K of RAM (an additional 64K of RAM can be added), and the ROM set from the *Model III*.

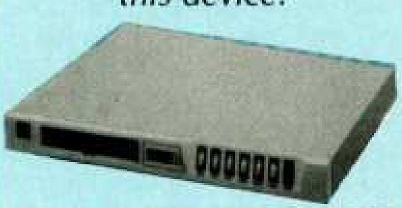
If you are wondering about the *Model III* ROM set, it's there to let the *Model 4* act like a *Model III* computer. It works this way: The *Model 4* is meant to handle both the new TRSDOS Version 6.0 and the CP/M disk-operating systems, both of which require that the full RAM be available from memory address 0000H. Earlier Radio Shack computers, on the other hand, located their operating (driver) routines and BASIC, in ROM, in the first 16K of memory; thus the user-available RAM was located only in the upper 48K of memory. When the user inserts a *Model III* disk, the *Model 4* senses the fact and automatically switches out the first 16K of RAM and switches in the *Model III* ROM's, causing the *Model 4* computer to function as a *Model III*. In that way, Radio Shack has retained complete compatability with the software for their earlier computer. When the computer is run in the *Model 4* mode, the full 64K of RAM is available.

Since the Z80 microprocessor can only address 64K of memory at a time the 64K RAM upgrade (for a total of 128K) is bank-switched in and out by the software. It can be used as straight additional memory, or all or part can be used to function as a simulated disk (RAM disk), or as a printer spooler. If you don't install the optional 64K RAM expansion, the computer's TRSDOS operating system can use part of the basic 64K of memory for both RAM disk and spooling. (Spooling is a way to print and use the computer at the same time; it avoids tying up the computer when printing.)

By itself the *Model 4* is a formidable machine, but a complete package consisting of the *Model 4*, CP/M (from Montezuma Micro, Box 32027, Dallas, TX 75232), and Newdos 80 (for those who use *Model III* and *Model I* software) is hard to beat. Newdos 80 is available from Apparat Inc. (4401 South Tamarac Pkwy, Denver, CO 80237). The complete package is ideal for schools, small businesses, or anyone who needs a lot of computing power at a reasonable price. **R-E**

Computer Accessories P12 Power Director

End powerline woes, add powerline conditioning, and centralize control of your computer system with this device.



CIRCLE 6 ON FREE INFORMATION CARD

IF YOUR COMPUTER SYSTEM IS LIKE most, one of its most apparent "features" is a maze of powerlines. Likewise, powering up your system might be a task worthy of a contortionist, what with all of the reaching and stretching required to hit all of the power switches. If so, you may be a candidate for a product like the *P12* power director from Computer Accessories (7696 Formula Place, San Diego, CA 92121). In addition to alleviating the above conditions, the unit provides line conditioning to guard against powerline glitches.

The power director

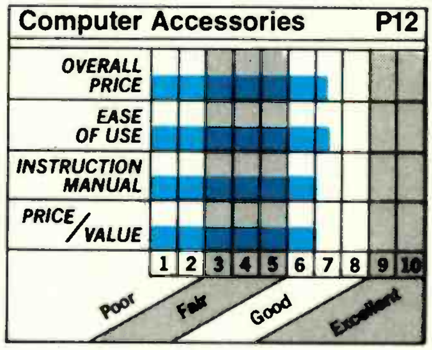
The power director provides three functions. First of all, it is a six-outlet power strip. Most computer installations have a common problem—the number of power cords exceeds the number of available power outlets. The power director allows your computer and all of its peripherals to be plugged into one central location, eliminating powerline tangles in the process. A single line leads from the unit and is to be plugged into a grounded outlet.

Each of the outlets is individually controlled by front-panel mounted rocker switches. If you leave the computer's and/or peripherals' power switches permanently on, you can use those rocker switches to turn any device connected to the power director on or off. Each of the rocker switches has a pilot light to help you quickly identify which switches are on or off. Finally, there is a master switch that can be used to turn on or off the entire system.

Last, and perhaps most important, the power director contains line-conditioning circuitry. The level of protection afforded by the unit exceeds that specified by the 1983 IEEE industry guide for surge voltages in low-voltage AC circuits (IEEE-587). The surge-suppression device used in the power director is General Semiconductor's TranZorb. That device responds in less than a nanosecond to suppress transients. An RF filter is used to handle RF noise. Each outlet has line-to-line and line-to-ground protection against voltage spikes, surges, RF noise, etc.

Other features of the unit include a digital clock and a media (5¼-inch floppy disk) storage slot. An option available is a *Data Director* switch box. That switch box can direct the data from your computer's serial or parallel port to any of up to 3 peripherals.

The unit is rated for a maximum current of 15 amps and a maximum power capacity of 1800 watts. A circuit breaker is used to protect against problems caused by equipment overloads. The line-conditioning circuitry is rated for a maximum transient peak-current of 4500 amps. The RF filter has a frequency response (stop band) of 0.15 to 30 MHz. The peak-to-peak power dissipation of the the unit is rated at 10,000 watts. Maximum transient voltage is 6000. Clamp voltage is 276 volts, maximum, at 102 amps. Clamping time, as indicated earlier is less than one nanosecond.



The *P12* power director measures 19½ × 2¼ × 13½. It is sized to fit atop an IBM *PC* system. Other models of the power director, sized to be stacked with disk drives, or to serve as a monitor stand, are available. Those units have fewer outlets and differing specifications however. No weight was specified for the unit, but it is heavy, as the beige cabinet is made primarily of steel.

The one major complaint we had about the unit was the stiffness of the switches. Because of that stiffness, they were exceptionally difficult to operate. Perhaps that stiffness will ease with time and use, but we would have liked to have seen better quality switches used.

The "manual" that accompanied the unit was also quite skimpy, offering little besides some basic operating instructions, specifications, and warranty information.

The *P12* power director certainly does make your computer setup more attractive and easier to use, and it has a suggested retail price of $199. **R-E**

NEW IDEAS

Multiple-outlet control circuit

ALMOST EVERY ELECTRONIC DEVICE IS used with one or more different accessories. For example, an AM/FM receiver might have a tape deck, equalizer, and turntable connected to it. Or you may have a video system consisting of a TV set, VCR, video enhancer/stabilizer, and so on.

Each of those units has its own power-on switch, which means that if you want use one or more of those components in conjunction with the main unit (receiver or TV set), you'll have to turn on each component individually. That means that there is always the possibility that one or more components will be accidentally left on when you're finished.

There are many ways to get around that problem—for instance, you could use one of several commercially available switched outlet-strips, which can cost $15 and up. Those products (often containing a surge suppressor) are fine for things like computers; but for other electronic devices, like stereos or TVs, they're simply not needed. There is, however, another way to go about it and save some bucks in the process.

Outlet control circuit

Figure 1 shows a circuit that can be use to turn on several components of an audio or video system at the same time. The beauty of that scheme is that it can be built using a handful of easy-to-get parts. But that's not all: With a little imagination and some experimenting, it can be made to do the same things that the commercial products do, making it more than worth the parts cost and time spent building it.

First you should note that the circuit draws no standby current; in other words, when a device plugged into socket SO1 is turned off, no power is supplied to SO2. You may be wondering why no switch is included in the 110-volt AC line. Well, the answer to that question will become clear as we discuss the circuit's operation.

One more point: T1 is a 6-volt transformer with its primary and secondary connected in reverse (i.e. the secondary in parallel with R1 and the primary feeding the Triac gate). Resistor R1 is chosen according to the load connected to SO1: If the SO1 load is 125–150 watts, R1 should be a 1-ohm, 10-watt unit. For loads of 250–300

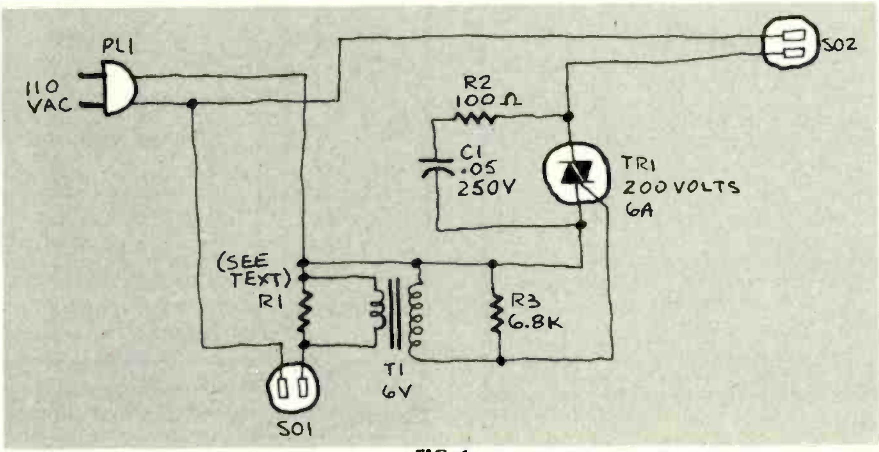
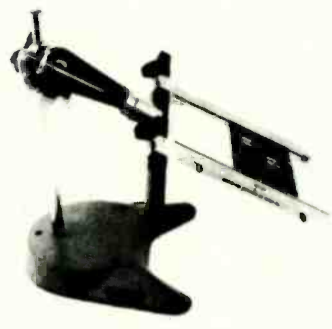


FIG. 1

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.



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Mail your idea along with this coupon to: **New Ideas Radio-Electronics, 200 Park Ave. South, New York, NY 10003** watts, use a .5-ohm, 10-watt resistor or you can parallel two 1-ohm, 10-watt units if desired.

When the device connected to SO1 is turned off, no current will flow because that leg of the circuit is open and therefore, there is no voltage developed across R1. (Remember the power switch on any device is used to complete a circuit.) Because there is no voltage drop across resistor R1, no voltage is fed to transformer T1. When the device plugged into SO1 is turned on, current flows to SO1 through resistor R1 causing a small voltage to be developed across the resistor.

The voltage across R1 is then applied to the secondary of T1 (which is used as a step-up transformer), resulting in a higher output voltage at its primary. The output from T1 is fed to the gate of Triac TR1. When TR1 is turned on, power is supplied to the load at SO2. That means that the on-off function of any device connected to SO2 is controlled by the power switch of the SO1 load. Therefore, it is not necessary to include one in the AC power line.

Additional sockets may be placed in parallel with SO2 so that any other device that you may want to use in conjunction with the main unit at SO1 may be powered up in the same manner. Just keep the 6-amp limitation of the Triac and the total current requirements of the load in mind when adding extra sockets. Also, the current rating of the Triac assumes proper heat sinking. If the 6-amp limit is a problem, you may want to check into some of the higher rated Triacs, like those listed in the *ECG Replacement Guide*.

Although it is not necessary, you may want to add switches in series with the extra sockets, so that any device connected to those sockets may be turned off from a central location as needed. A final note: The circuit should be mounted in a case for safety's sake. —*Theodore Stern*

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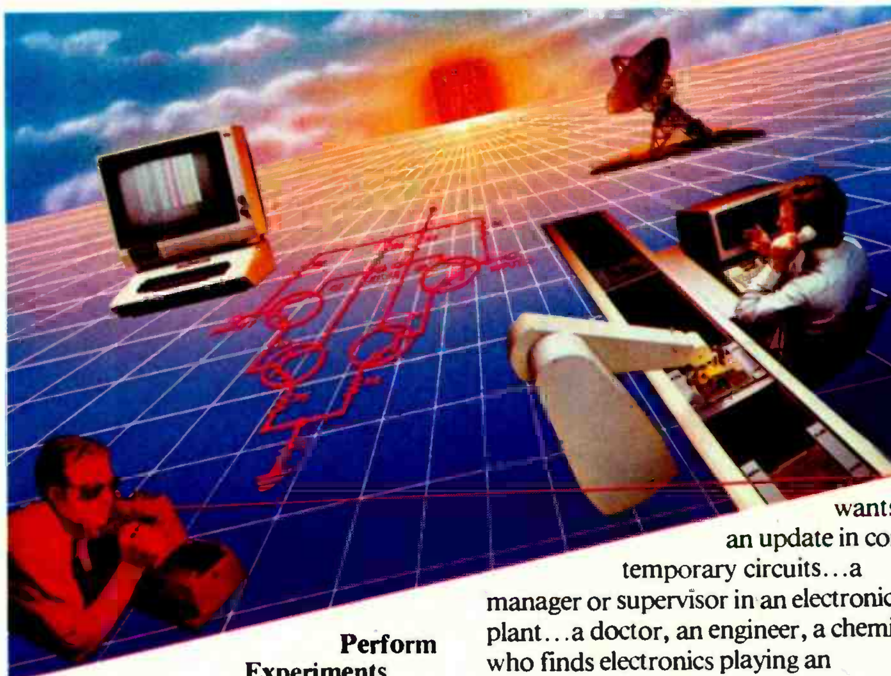

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NEW PRODUCTS

CIRCLE 11 ON FREE INFORMATION CARD

AUDIO/VIDEO CONTROL CENTER, NEC model *AV-200E*, performs its audio functions via a 12-watt-per-channel, built-in stereo amplifier with tone control, headphone jack, and inputs for a tape deck, tuner, and auxiliary sources such as a CD player. A sophisticated synthetic-stereo circuit uses a bucket-brigade device to synthesize a stereo signal from any mono source.

Video signals are processed through a full complement of inputs and outputs, including inputs/outputs for two VCR's (one front-panel set; one rear-panel set), and two AUX inputs—all with stereo audio capabilities. Monitor output and a set of inputs and outputs for an audio tape deck are also provided. A switchable image enhancer improves contrast and sharpness for either playback or dubbing purposes.

The NEC model *AV-200E* is priced at $199.00.—**NEC Home Electronics (USA) Inc.,** 1401 Estes Avenue, Elk Grove Village, IL 60007.

SCANNER, model *HX750*, is a six-channel hand-held scanner that can monitor activity in six popular bands—including such services as police, fire, public safety, aircraft, business, and amateur 2-meter bands. Channels can be scanned automatically at about 15-per-second, or stepped manually.

Individual channel lock-out switches temporarily skip over unwanted channels. LED's indicate which channel is being monitored.

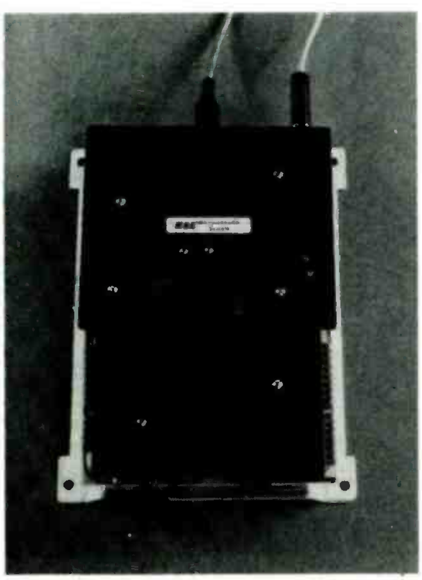
The model *HX750* comes with an AC adapter/charger, a flexible ("rubber ducky") antenna, and a wire antenna. It offers both a built-in speaker and an earphone jack for private listening. It can be operated from a 6-volt external DC power-supply, or four standard or rechargeable AA batteries (not included). Current drain is 16 mA (stand-by, squelch on) to 70 mA at full audio output. The unit is FCC-certified (part 15, subpart C); it measures 3¼ × 5½ × 1 inches and

CIRCLE 12 ON FREE INFORMATION CARD

weighs approximately nine ounces (without batteries). It is priced at $159.95.—**Regency Electronics, Inc.,** 7707 Records St., Indianapolis, IN 46226-9989.

MICROCONTROLLER, the model *R8E* is an enclosed, stand-alone programmable-control system that features real-world inputs and outputs. It is configured as a programmable controller, data logger, or interface device; both transducers and AC devices may be connected directly. Included are high and low level A/D inputs (8 channels), numerous digital-control lines, parallel and serial ports, and solid-state power relays. The controller is programmed in its resident BASIC interpreter through any terminal or CRT; no "programmer" or host system is needed. Sockets for up to 16K of ROM/EPROM or RAM are provided.

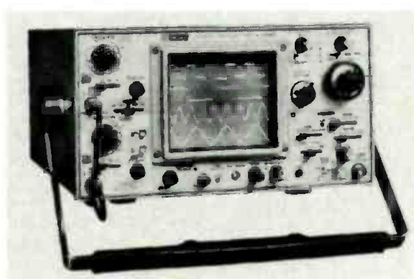
The model *R8E* runs on 2-volts DC or 24-volts DC and is priced at $599.00.—**HHS Microcontrollers,** 5876 Old State Road, Edinboro, PA 16412.



CIRCLE 13 ON FREE INFORMATION CARD

100-MHz OSCILLOSCOPE, model *1580* features dual time-base circuitry and 5 mV/div vertical sensitivity over the 100-MHz bandwidth with 1-mV/div vertical sensitivity to 50 MHz in the ×5 mode. The V mode can be used to display two signals unrelated in frequency. Other features include Z-axis input; Channel-1 output; calibrated delayed sweep; X-Y operation; Channel-2 invert; 20-MHz bandwidth limiter, and a variable trigger hold-off that permits stable observation of complex pulse trains.

The user can select from 23 calibrated sweep-time ranges from 0.5 s/div to 20 ns/div in a 1-2-5 sequence. Sweep time is fully adjustable between calibrated ranges. To allow closer examination of waveforms, a ×10 sweep-magnification feature is provided.



CIRCLE 14 ON FREE INFORMATION CARD

The triggering circuitry offers five trigger sources: CH1, CH2, EXTernal, LINE, and V MODE. In the V MODE, each waveform displayed becomes its own trigger, thereby allowing steady display of two signals unrelated in frequency. Signals are displayed on an 8×10 div (1 div = 10mm) rectangular CRT with internal graticule and 16-kilovolt accelerating potential.

The model *1580* is priced at $1,595.00.—**B&K Precision/Dynascan Corporation,** 6460 West Cortland Street, Chicago, IL 60635. **R-E**

CIRCLE 99 ON FREE INFORMATION CARD

BUILD THIS

Get rid of switching woes, and that "pile of spaghetti" in back of your TV set, with the "Select-A-Matic" RF switcher.

RF SWITCHER

ROBERT GROSBLATT

IN THE DIM PRE-HISTORY OF THE ELECTronic age, just after the disappearance of the dinosaurs, the family television set had but one simple job—displaying broadcast TV signals (although many of you probably thought that it was to keep your children from doing their homework).

Not any more.

Today's family television set has a whole new set of functions. And it sometimes seems that not a day goes by without the development of yet another device that uses the tube for a display. Computers, videodiscs, VCR's, and videogames all compete with the simple antenna for access to the back of the set. But since the input on most televisions is limited to the two little screw terminals for the antenna, you can find yourself doing a lot of wire swapping anytime you decide to watch a tape or blast a few aliens.

That is, unless you build the Select-A-Matic. That device can take any one of eight inputs and assign it to any one of four outputs. Not only will that make it much easier to organize things, it will also help eliminate the usual pile of "spaghetti" found at the back of the set. Keyboard entry and a visual display make operation of the Select-A-Matic a snap. And even if you don't have a lot of interest in RF switching, the theory and design can easily be incorporated into audio, appliance control, or just about any area where you need to choose among several devices.

The theory behind the Select-A-Matic is evident when you take a look at Fig. 1, the block diagram of the circuit. One input and one output are selected from a keyboard, and the control signal that results is stored in a latch at the selected part of the circuit. It's really that simple. There's nothing exotic in the parts list and the basic design of the Select-A-Matic is easy to adapt to a whole host of other uses.

The simplicity of the circuit can be seen further in Fig. 2, the schematic. Since we're dealing with eight inputs and four outputs, there are 32 possible combinations we have to be able to select. Although there are several ways to handle it, the most straightforward approach is to arrange the I/O in a matrix with the inputs on the columns and the outputs on the rows as shown in Fig. 3. Selecting an input turns on the whole column and selecting an output turns on a whole row. That scheme routes the selected input exclusively to the selected output.

The easiest way to see how that theory is translated from ink to electrons is to go

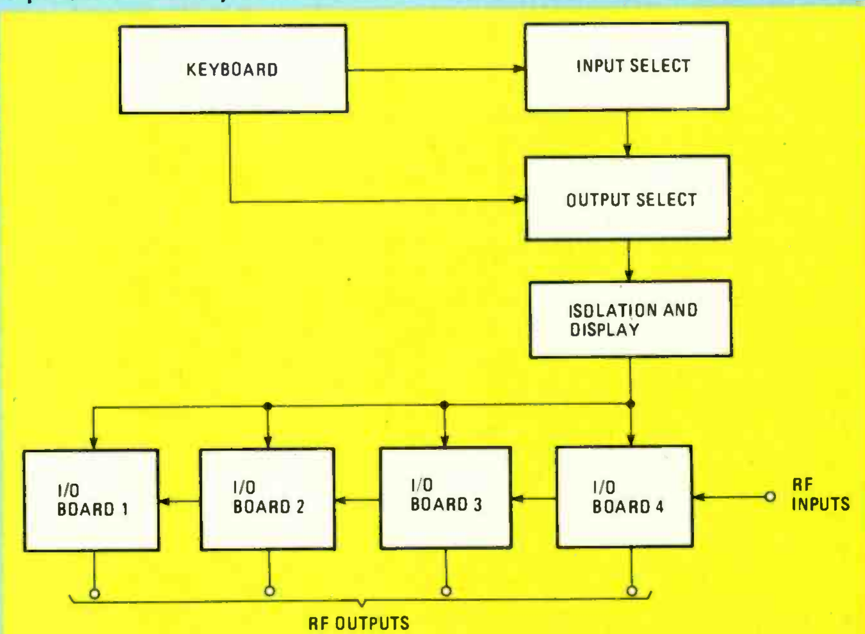
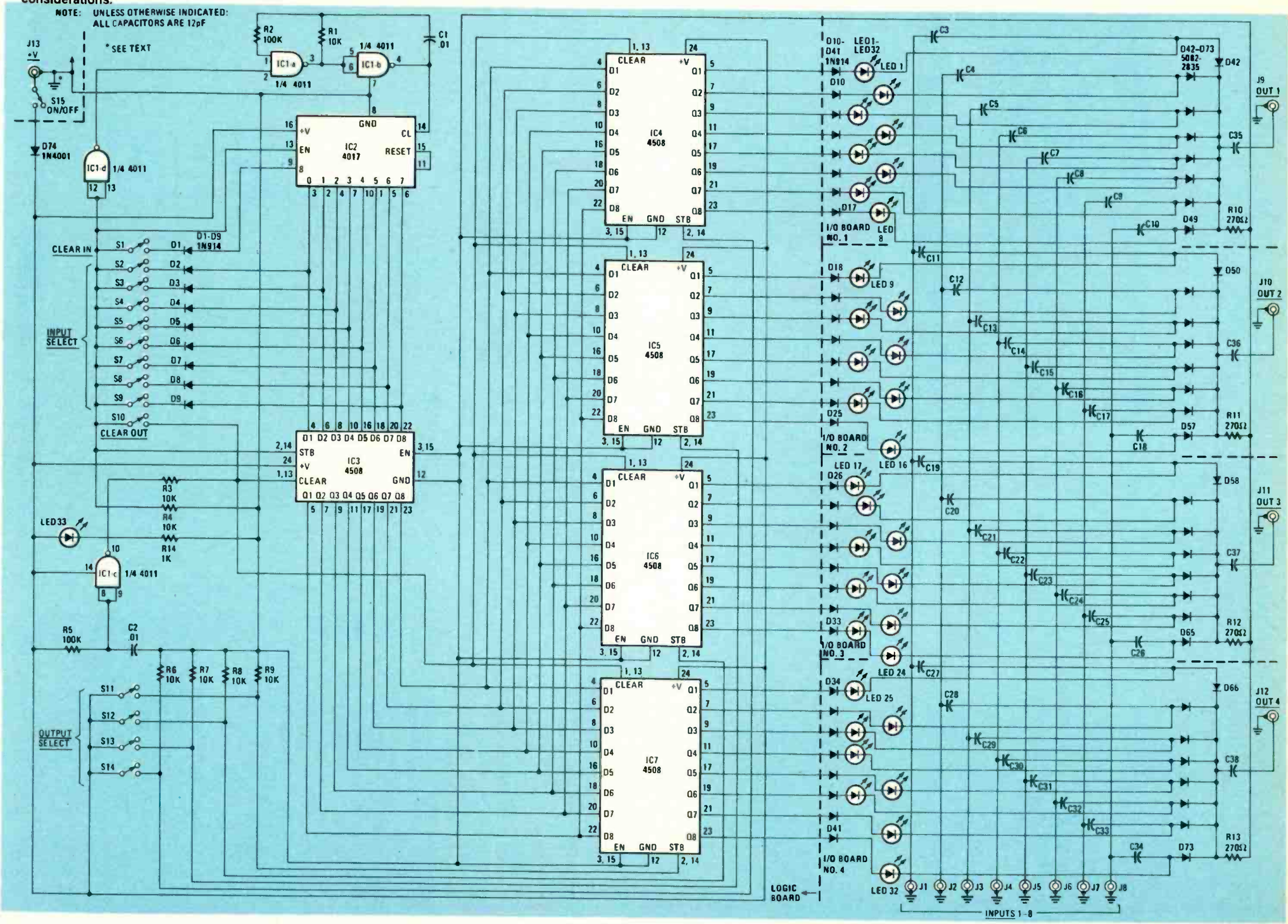


FIG. 1—BLOCK DIAGRAM of the Select-A-Matic. The unit can switch things other than RF signals by modifying the I/O boards to suit the particular application.

FIG. 2—SCHEMATIC DIAGRAM of the unit. Note that the unit is built on five PC boards; which components mount on which boards is clearly noted in this illustration. Refer to the text for grounding considerations.



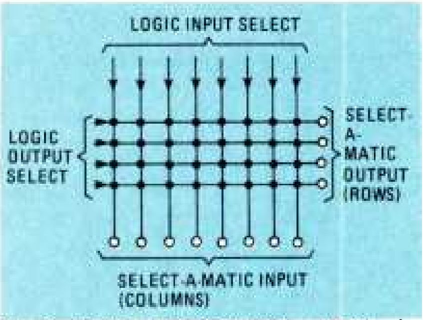


FIG. 3—IN THE SELECT-A-MATIC, switching is handled using a matrix arrangement.

back to the schematic and follow the operation of the circuit. IC1-a and IC1-b are half a 4011 quad NAND gate set up as a gated oscillator running at about 8 kHz. That simply means that a high on pin 2 turns the oscillator on, and a low turns it off. The output is connected to the clock input of IC2, a 4017 decade counter. That IC sequentially turns each of its outputs high as long as pin 13, the $\overline{\text{ENABLE}}$ input, is held low. When one of the INPUT SELECT switches, S1 to S9, is closed, nothing happens until that particular output of the 4017 goes high. As soon as it does, one of the corresponding keyboard diodes, D1 to D9, is forward biased; that disables both the clock (through IC1-d) and IC2 (by presenting a high to its $\overline{\text{ENABLE}}$ input).

That same high also stores the selected column information in IC3, a 4508 dual quad latch. Although that IC has two separate quad latches, we've set it up—and shown it in the schematic—as an octal latch by connecting the control pins of each side in parallel. Pins 2 and 14 control the IC's inputs. When they're high, data presented to the inputs will be stored, and when they're low, the inputs are ignored. Closing one of the input switches, therefore, selects one of the inputs and stores it in the "column" latch. You should also notice that we're able to get an input-clear function for free by selecting one of the 4017 outputs that's not connected to IC3. That's taken care of by connecting the CLEAR IN switch to pin 9, an unused output of the 4017. When it's pressed, eight lows are stored in IC3, overwriting any other data that was stored there.

Pins 3 and 15 of the 4508 are the output control pins. Bringing them low will enable the outputs, and making them high will put the IC in its high-impedance mode. Since there's no need for that in the circuit all these pins are connected together and tied low, permanently enabling the outputs of all the 4508's in the circuit. The importance of that can be seen by looking at the row selectors, IC4 to IC7. The inputs of those IC's are all in parallel and are connected to the outputs of IC3. If IC3 was allowed to go to its high-impedance state, the inputs of IC4 to IC7 would be able to float and, since we're dealing with CMOS, that is a definite no-no.

The operation of the row selector is much the same as the column selector. Closing one of the OUTPUT SELECT switches, S11 to S14, causes the selected IC to store whatever information is presented at its inputs. Since the outputs are always enabled, they follow the inputs, and the selected control signals are available on the appropriate line of the 32-bit-wide output bus. Selecting one input and one output, therefore, will turn on one of the output, control lines. Since the outputs are grouped in four rows of eight lines, selecting an output for IC4, for example, won't change the information stored in IC5 to IC7, the other output latches.

Turning off the outputs can be done one of two ways. You can press the CLEAR IN key and then select the output you want to turn off. That will store a low in each cell of the output latch and turn off everything controlled by it. Closing switch S10 will turn off all the outputs as well as clearing the input latch, IC3. That happens because all the CLEAR pins of the 4508's are tied together and pressing S10 brings them all high. Ordinarily they're controlled by IC1-c. That gate is set up as a power-on reset to make sure that all the latches are cleared when the Select-A-Matic is first turned on. Resistor R5 and capacitor C2 generate a negative pulse at power up. The pulse is cleaned up and inverted by IC1-c, causing a short positive pulse to be sent through R3 to all the clear pins of all the latches. After that, the clear pin is held low unless S10 is closed.

Each of the output control lines go through a 1N914 diode and an LED. Both of those devices help isolate the digital control circuitry from the things they're controlling. The LED's also serve to show which outputs are turned on, but it's interesting to note that they're also used as old fashioned diodes. The great majority of the circuits that have LED's in them use them only as status indicators of one kind or another and it's easy to forget that they're really diodes, not some kind of long lasting light bulb. One side benefit of using them like this is they don't have to have their own current limiting resistors. You can't forget about that altogether because some other part of the circuit can take care of it.

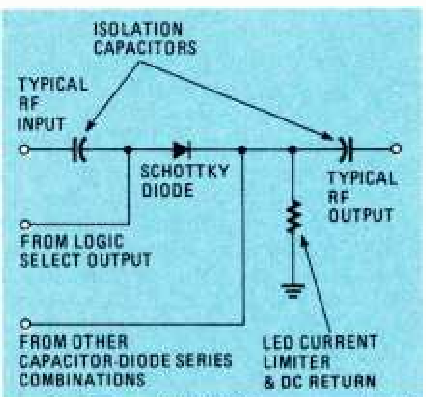


FIG. 4—DIODE SWITCHING is used to handle the RF switching in the Select-A-Matic. Because they can handle the frequencies involved, Schottky diodes are used.

The RF switching of the Select-A-Matic is a straightforward application of diode switching. Figure 4 makes it a lot easier to see what's going on. The input signal passes through a capacitor to isolate the source of the signal from the DC control voltages generated by the Select-A-Matic. The next thing the signal sees is a Schottky diode that does the actual switching in the circuit. As long as the Select-A-Matic has the output turned off, the diode is turned off. When the output is turned on, the diode is forward biased and starts conducting. The input RF passes through the diode, the output capacitor, and shows up at the output connector of the Select-A-Matic. The resistor not only provides the DC return for the Schottky diode, it also serves as the current limiter for the LED.

The layout

As you can see, the basic operation of the Select-A-Matic is easy to understand and, although we're using it to switch RF, the same approach can be used to switch just about anything. The PC layout (the foil patterns for the boards are shown in Figs. 5, 6, and 7) was designed with the aim of making the Select-A-Matic as versatile as possible. All the digital control circuitry is located on the main logic board (see Figs. 5 and 6). The output bus shows up at the far end of that board and is grouped conveniently in four groups of nine solder pads—the ninth connection is system ground. If you want to switch audio signals, for example, you only have to design your analog I/O (to replace the RF I/O used by this project) and connect it to the logic I/O on the logic board of the Select-A-Matic.

The I/O boards of the Select-A-Matic (see Fig. 7) have female connectors (see Fig. 8) to mate with right-angle male connectors on the logic board making the assembly of the whole unit a plug-in operation. The connectors used are header strips with 0.1-inch spacing. Of course you can replace the board connectors with wire, but since we're switching RF, you'll have to be really careful about length, layout, and shielding. The frequencies being switched by the Select-A-Matic can go up as high as 800 MHz., (the top of UHF), and signal behavior can get really strange when you get up in that kind of rarefied atmosphere. Stray capacitance, leakage, and some unplanned-for resonance are only a few of the pitfalls that can completely foul up the operation of the circuit. If you take a look at the foil pattern for the I/O boards, you'll see that component leads are kept as short as possible and several options are provided for handling

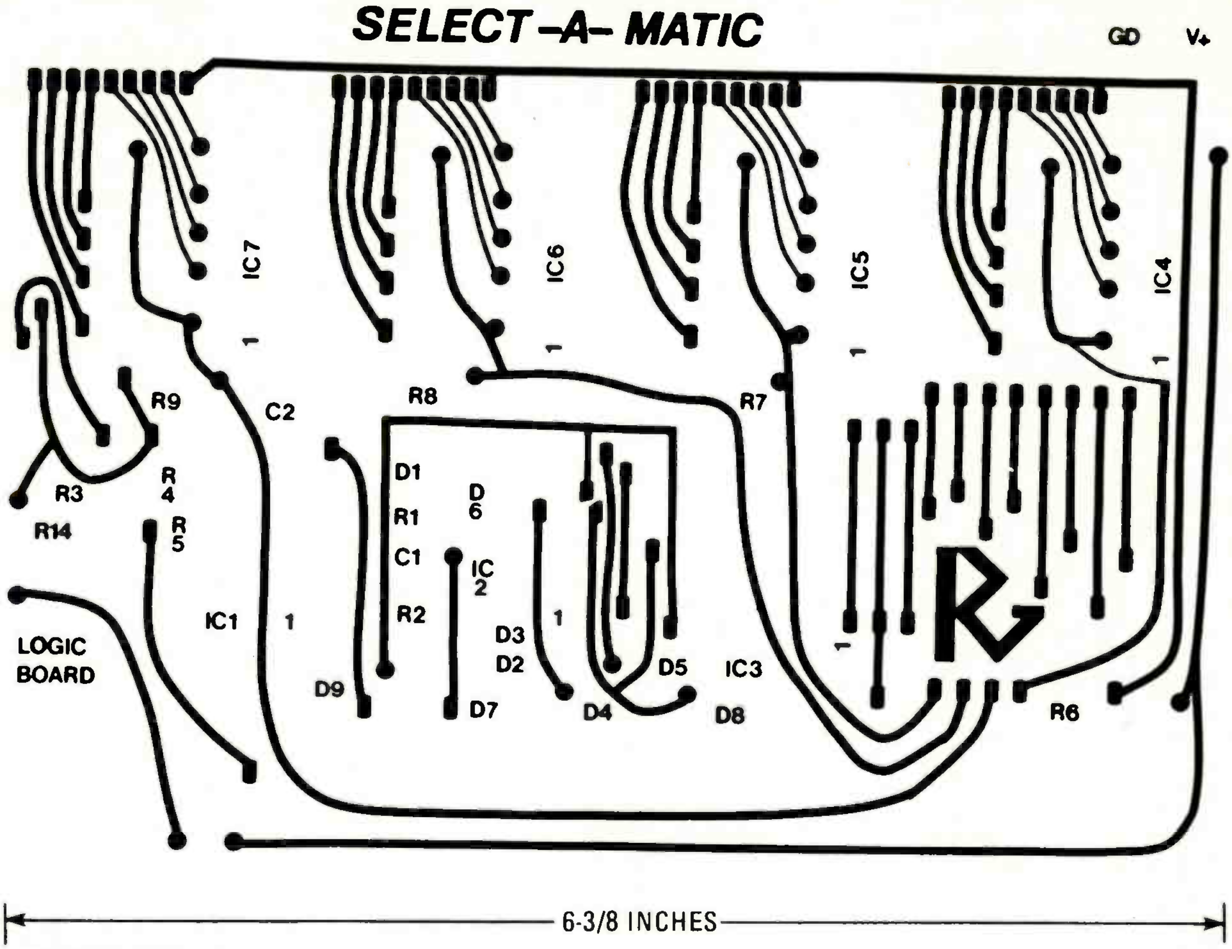


FIG. 5—COMPONENT SIDE of the double-sided logic board. The board is shown full sized.

ground.

A ground plane is provided for both the RF ground, (at the top of the board), and logic ground, (at the bottom of the board). The answer to how you should handle this is a resoundingly unsatisfying "it depends." There are as many theories about grounding as there are about why the dinosaurs disappeared. The best approach is to try various things and decide what works best. It pains us to say this, but as far as this problem is concerned, a logical approach is no help whatsoever. Anyone who uses a simple dipole antenna for FM knows that there is a prescribed way to orient it. They also know that the best orientation is usually found by bunching it up and throwing it on the floor!

Pads are provided on the I/O board to connect RF and logic ground as well as mounting holes if you want to surround all the components on the RF circuit with a metal shield. You should use shielded cable to go from the chassis-mounted F-connectors at the back of the unit to the I/O boards. There are places on the I/O board to connect the cable shield (see Fig. 9). But whether connecting the shield there, elsewhere, or nowhere works best is something you'll have to find out by experiment.

For what it's worth, here's what happened in our case. We had a lot of trouble with crosstalk when we first assembled the Select-A-Matic. We got rid of it completely by lining the inside of the case with aluminum foil (see Fig. 10). That tied together all the RF grounds at the chassis-mounted F-connectors. We connected the shield of the cable on the case side but left it unconnected at the I/O boards. Jumpers on the I/O boards were used to connect the RF and logic ground. That eliminated all of our crosstalk problems. If it had not, the next step would have been to build shields for the I/O boards—probably with aluminum foil at first and then with copper foil so we could solder a connection from the shield to the board. Fortunately that nightmare was unnecessary in our case.

Since signal strength in our location is very good, the slight loss of signal through the Schottky diodes didn't present us with any problem. You may find that to be different—it all depends where you live. In general, signals that come in well won't be degraded much by putting the Select-A-Matic in the signal path. If, however, you're looking at reception that's marginal even on a good day, you've got a problem. You can use the Select-A-Matic to handle home-grown RF from such things such as VCR's, videogames, and the like, but broadcast signals are probably out of the question unless you add an RF amplifier to the Select-A-Matic output lines. That can be a one-transistor circuit or anything you need to get the job done.

Construction

There's nothing especially difficult about constructing the Select-A-Matic if you use PC boards. As previously mentioned, the foil patterns for that board, one of which is double-sided, are shown in Figs. 5, 6, and 7: the parts placement diagrams are shown in Figs. 9 and 11. Wirewrapping or breadboarding are unsuitable because of the frequencies running around the circuit. The breadboarded version we built worked, but the performance of the circuit was terrible. When it was put on PC boards, noise, crosstalk, rejection, and all the other things that had been a problem completely disappeared. Remember, CMOS digital signals are just about noise immune—even if you grind the wires into the ground with your heel. Look cockeyed at RF and the whole circuit can go bananas.

The power supply for the Select-A-Matic is designed to be located elsewhere. All you've got is a jack for a small wall unit that puts out more than 5- but less

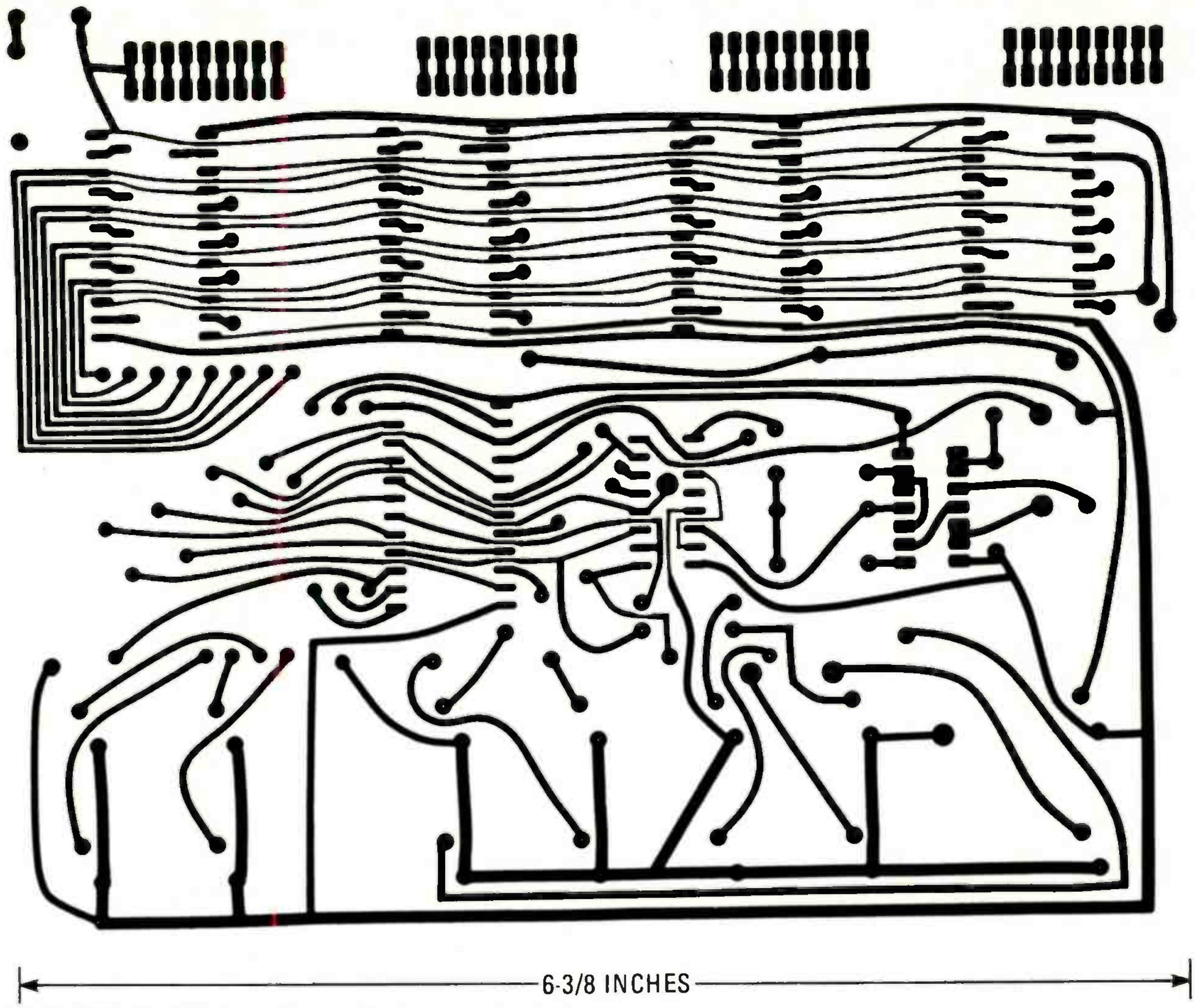


FIG. 6—FOIL SIDE of the logic board. The board is shown here full sized.

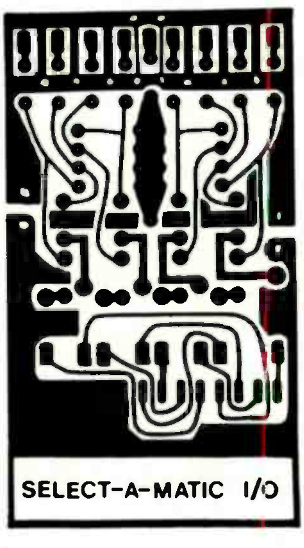


FIG. 7—FOIL SIDE of the I/O board. Four of these single-sided boards are required.

than 7-volts DC with a reasonably small amount of ripple. If you use one that's really noisy, you can put a nice chunky capacitor across the pins of the jack on the chassis. If it's really a problem isolate the circuit by putting a resistor in series between the power supply and the Select-A-Matic—you can use the power jack for that as well. Since the whole circuit draws less than 20 mA, a value around 200 ohms should be in the ballpark. You can also leave out the protection diode on the +V line, but it's always better to be safe than sorry.

The switches used in the Select-A-Matic are soldered directly to the logic circuit board. They're made by Oak Switches and the pin spacing on the board was designed to accommodate them.

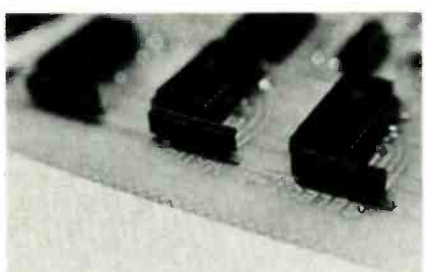


FIG. 8—HEADER STRIPS are used to make the connections between the I/O boards and the logic board.

Those switches are brand new (and a special thank you to Henry Richter, Inc. for providing them to us for use in this project), but should be available from most Oak distributors by the time you read this. If you have a hard time finding them, you can make up a wiring harness and locate the switches off the board. The same is true of LED33, the power pilot-light. Just make sure you keep the leads straight and remember that the current limiter for that LED, R14, is located on the board.

When you're assembling the board, watch the polarity of all the diodes, especially the Schottky diodes. These are a lot more expensive than your garden-variety diodes and it's distressing, to say the least, to break one when you solder it. We used those diodes because they're fast enough and have a low enough turn on voltage to be perfect for UHF mixing. Although we haven't tried it, 1N914 or 1N34A germanium diodes could be used as well, but we don't know how far up the spectrum you'll be able to go before signal loss gets excessive. All we can tell you is they work for channel three but we don't know if they can even make the frequency jump found around Channel 6. If you want to try them, go ahead.

Since the logic board is double-sided, you'll have to solder feedthroughs from one side of the board to the other. Thread hookup wire back and forth through the indicated holes (marked with an asterisk in Fig. 11), solder on both sides and then cut it off. We tried to do all the side jumping on component legs, but there aren't a lot of components on the board so there are quite a few stand alone feedthroughs.

Use IC sockets, caution, and common sense to keep potential problems from the board. And make sure you use a low-wattage iron when you're soldering the diodes—glass-cased diodes are really fragile.

One note on the I/O board. While there are four such boards required, only one is shown in the interest of space. All four boards are identical. In other words, where board 1 (shown) uses eight 12-pF capacitors (C3–C10), board 2 (not shown) uses eight 12-pF capacitors (C11–C18) and so on. A quick look at the schematic (Fig. 2) should help remove any confusion; which components go on which board is clearly shown there.

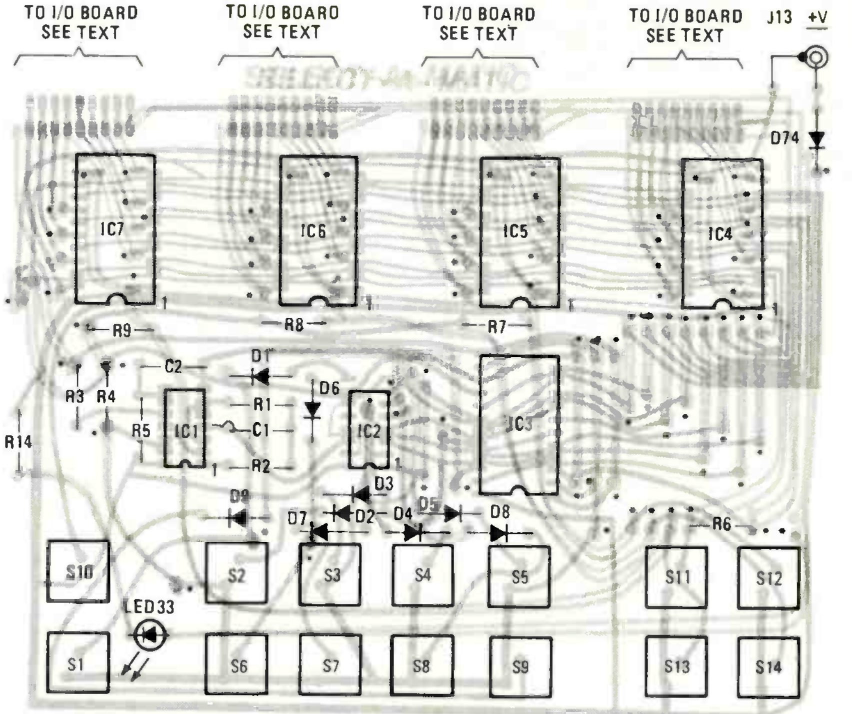


FIG. 11—PARTS PLACEMENT diagram for the main logic board. Note that—although not marked by an asterisk—feed throughs are required at the I/O connections.

PARTS LIST

All resistors ¼ watt, 5%, unless otherwise noted
R1, R3, R4, R6–R9—10,000 ohms
R2, R5—100,000 ohms
R14—1000 ohms
R10—R13—270 ohms
Capacitors
C1, C2—.01µF, ceramic disc
C3–C38—12pF, ceramic disc
Semiconductors
IC1—4011 quad NAND gate
IC2—4017 decade counter
IC3–IC7—4508 dual quad Latch
D1–D41—1N914 diodes
D42–D73—5082-2835 Schottky diodes
D74—1N4001 diode
LED1–LED34—miniature LED's
S1–S14—SPST switch, momentary pushbutton (Oak 225)
S15—SPST switch, toggle
J1–J12—F-type connectors, chassis mount
J13—miniature jack
Miscellaneous: PC boards, aluminum foil for shield, case, wire, solder, male header strips, right angle (AP products 929835 or equivalent), female header strips (AP products 929974 or equivalent), etc.

A set of the five PC boards, etched and drilled, but not plated through, is available from Hal-Tronix, PO Box 1101, Southgate, MI 48195. The price is $39.95. Please add $2.00 for shipping and handling. MI residents add 4% tax.

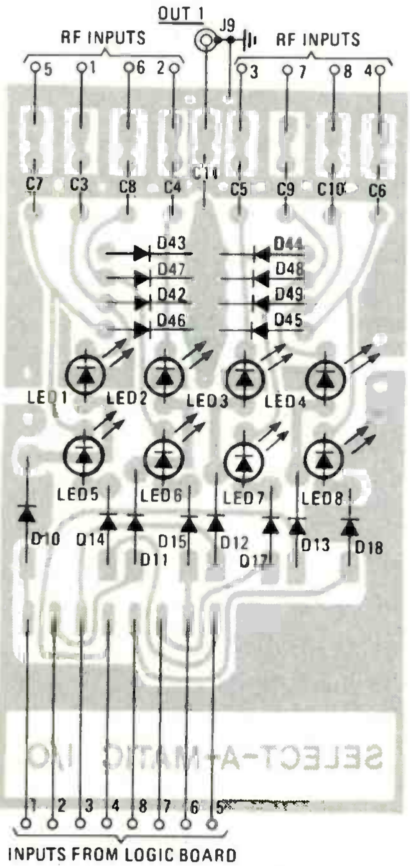


FIG. 9—PARTS PLACEMENT DIAGRAM for the I/O boards. Note that only board 1 is shown; four I/O boards in all are used by the project (see text).

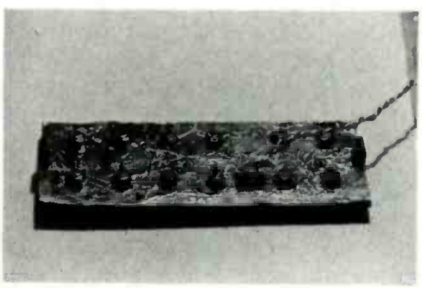


FIG. 10—TO ELIMINATE CROSSTALK, the inside of the case was lined with aluminum foil.

Troubleshooting

If the unit doesn't work when you get it all assembled, and it probably won't the first time, use all the standard troubleshooting techniques. The most suspect things are mechanical—solder bridges, bad joints, components in backwards, and all of the rest of the usual stuff. If everything seems OK as far as that goes, then start suspecting the components. Is the clock clocking? Are signals showing up where they should?—but you've heard all of that before. Exercise simple caution and you shouldn't have any major problems (famous last words). Actually, though, the circuit is simple enough to severely limit the number of problems you can have. Save all your energy for figuring out how to take care of the ground.

If you find that nothing you do will solve the kinds of RF problems we talked about before, you always have the option of substituting small relays for the Schottky diodes and capacitors (RF). That kind of last resort solution should work no matter what the problem is. And you'll be able to switch anything—including audio and video. Another benefit you'll get is that the coil resistance of the relay will probably be great enough to work as a current limiter for the LED's. **R-E**

ALL ABOUT THERMISTORS

HARRY L. TRIETLEY

Here's an article designed to make you feel at ease with thermistors. This month, we'll look at thermistor basics.

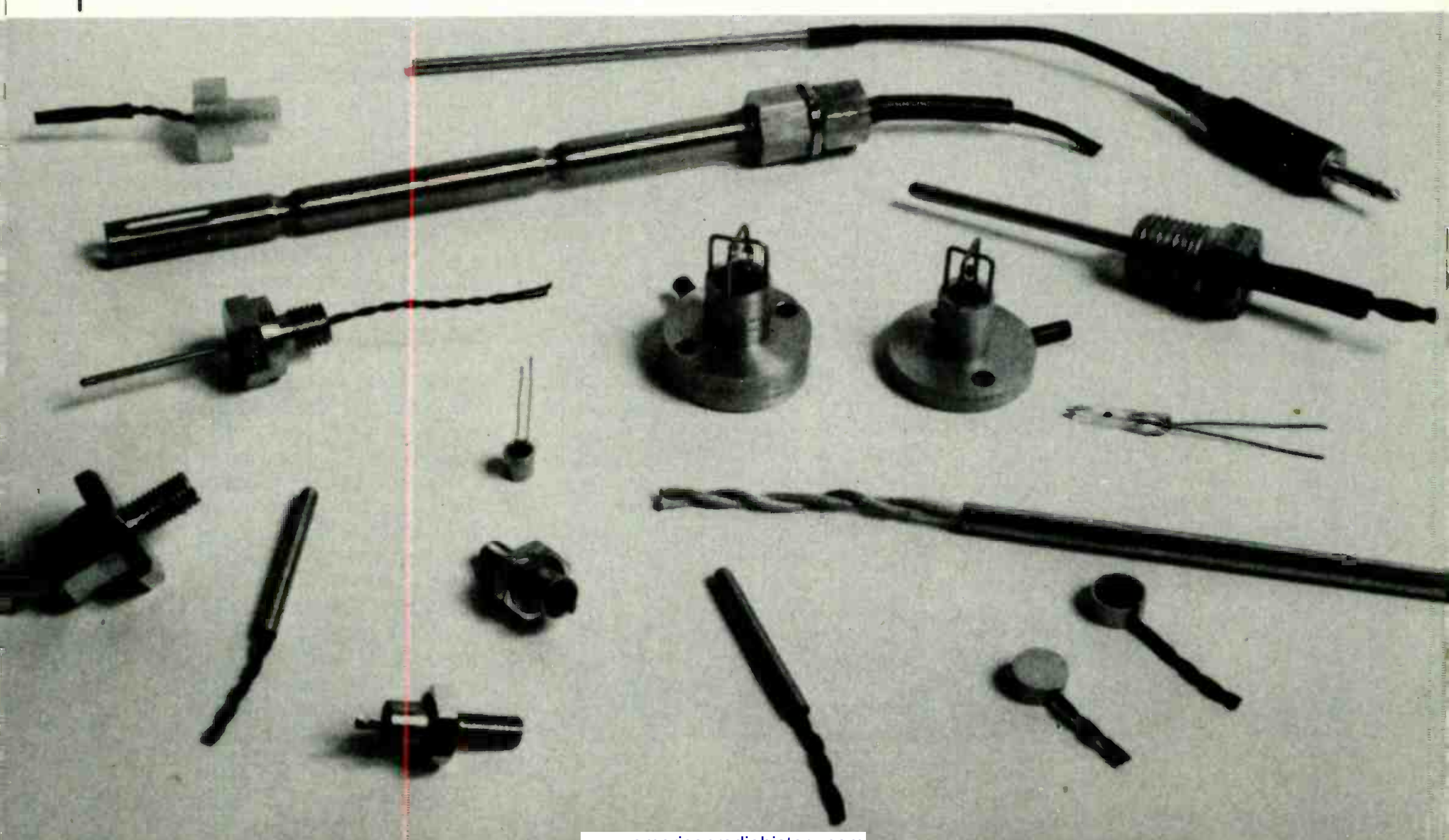
WE ALL KNOW WHAT THERMISTORS ARE. The name "thermistor" itself gives us a good idea: *THERM*al res*ISTOR*—a device whose resistance changes with temperature. While you might be familiar with those devices from building one of the projects you've seen in **Radio-Electronics** that used them, do you really know how to design with them?

Thermistors are highly nonlinear—and often only loosely defined—devices. That's the reason why even many experienced engineers and circuit designers do not feel at ease with them. But once you get familiar with them, you'll find that thermistors are actually quite straightforward. That's what this article is for: to help you become familiar with thermistors. This month, we'll study the basics of thermistors—how they're made, what types are available, the equations and specifications that describe them, and how they typically behave. After we go through the basics, we'll present design techniques, circuit examples, and applications ideas.

Thermistor basics

We should start off by saying that not all devices that change resistance with temperature are called thermistors. For example, *resistance thermometers* are made from small, wirewound coils or from deposited metal films. While they are temperature dependent, they don't behave like thermistors. The term thermistor is generally reserved for thermally sensitive *semiconducting* devices.

There are two general classes of thermistors: NTC (*N*egative *T*emperature *C*oefficient) and PTC (*P*ositive *T*emperature *C*oefficient). There are two distinctly different types of PTC thermistors manufactured. One is produced by means similar to NTC thermistors, the other is made of silicon. We will cover PTC's only briefly, reserving most of the space for the much more common NTC's. In fact, from this point on, unless we specify otherwise, we will be talking about NTC-type thermistors.



NTC thermistors are narrow-range, highly sensitive, nonlinear devices whose resistances decrease with increasing temperature. Figure 1—a curve relating resistance change to temperature—shows typical *resistance-temperature characteristics*. The sensitivity is about 4–5%/°C (1°C = 2.5°F). A wide range of resistance is available, and resistance changes may be many ohms or even kilohms per degree.

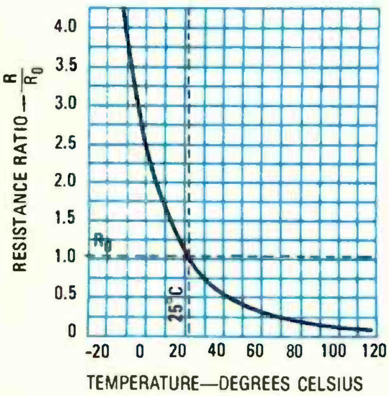


FIG. 1—NEGATIVE TEMPERATURE COEFFICIENT thermistors are very sensitive and highly nonlinear. Ro may be ohms, kilohms, or megohms.

TABLE 1— RESISTANCE-TEMPERATURE CHARACTERISTICS OF TYPICAL NTC THERMISTORS

Temperature	100Ω @ 25°C	1K @ 25°C	10K @ 25°C	1MEG @ 25°C
−80°C (−1112°F)	14.47K	278.80K	3558K	
−70°C (−94°F)	7475	132.60K	1694K	
−60°C (−76°F)	4066	66.78K	845.9K	
−50°C (−58°F)	2315	35.39K	441.3K	
−40°C (−40°C)	1374	19.64K	239.8K	
−30°C (−22°F)	846.0	11.35K	135.2K	
−20°C (−4°F)	538.9	6815	78.91K	
−10°C (14°F)	354.1	4232	47.54K	
0°C (32°F)	239.2	2710	29.49K	3966K
10°C (50°F)	165.9	1785	18.79K	2238K
20°C (68°C)	117.7	1206	12.26K	1299K
30°C (86°F)	85.4	834.0	8194	774.5K
40°C (104°F)	63.1	589.5	5592	473.2K
50°F (122°F)	47.5	424.8	3893	295.9K
60°C (140°F)	36.4	311.9	2760	189.1K
70°C (158°F)	28.3	233.0	1990	123.3K
80°C (176°F)	22.3	176.9	1458	81.98K
90°C (194°F)	17.8	136.2	1084	55.48K
100°C (212°F)	14.3	106.4	816.8	38.20K
110°C (230°F)			623.5	26.76K
120°C (248°F)			481.8	19.03K
130°C (266°F)			376.4	13.74K
140°C (284°F)			297.2	10.05K
150°C (302°F)			237.0	7447

Basically, thermistors are semiconducting ceramics. They are formed from powdered metal oxides (usually nickel and manganese oxides), sometimes with small amounts of other oxides added. The powdered oxides are mixed with water and various binders to form a slurry, which is formed into the desired shape and sintered (fired) at temperatures above 1000°C (1832°F). A conductive metal coating (generally silver) is fired on, and leads are added. The finished thermistor is usually coated with epoxy or glass, or otherwise packaged.

As you can see from Fig. 2, there is a wide variety of thermistor styles available. Those styles include discs and washers from under 0.1 inch to an inch or so in diameter, and rods of various dimensions. Some thermistors are formed first as large, flat sheets, then diced to form squares. Very small bead thermistors are made by firing a drop of the slurry directly on a pair of high-temperature platinum alloy lead wires, then dipping the thermistor in glass to coat it.

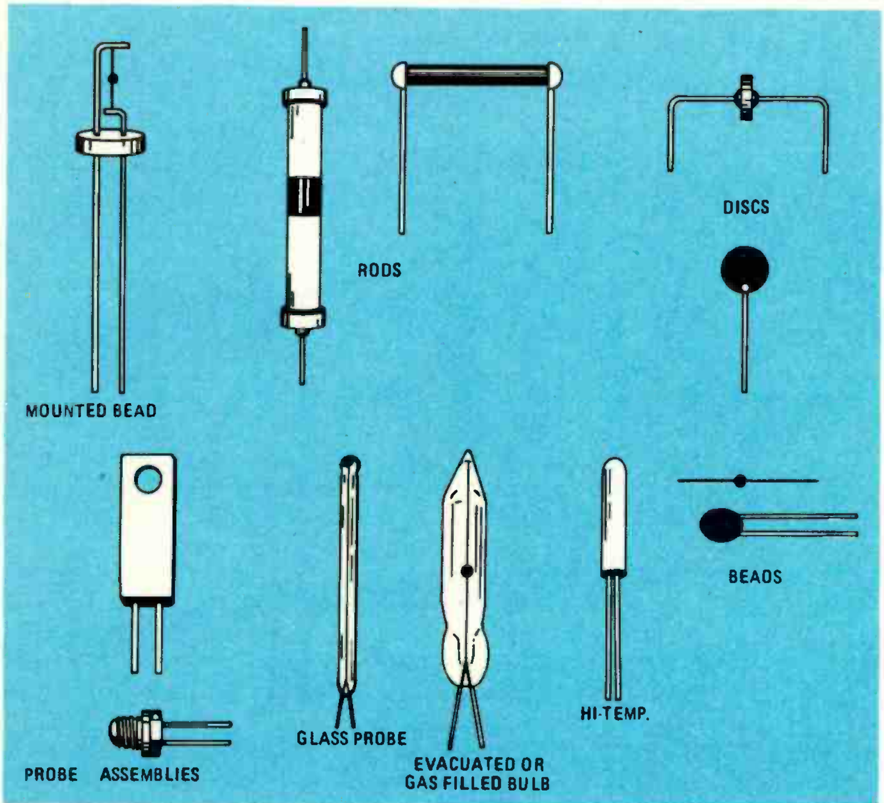


FIG. 2—A BROAD VARIETY OF thermistor styles and assemblies are available. Shown here are some of the more common.

Typical specifications

To say "typical specifications" is misleading—there are very few typical specifications for thermistors. The wide variety of thermistor styles, sizes, shapes, resistances, and tolerances that are available creates an equally wide variety of specifications. What's more, thermistors offered by different manufacturers often are not interchangeable with one another.

Table 1 lists resistance versus temperature for a few commercially available devices. You can buy thermistors with resistances (at 25°C—which is how a thermistor's resistance is normally specified) as low as one ohm and as high as ten megohms or more. A thermistor's size and shape influence its resistance, but for any given style the manufacturer can provide a five- or six-decade range of resistance values simply by changing the oxide mixture. Changing the mixture also changes the shape of the resistance-temperature (R-T) curve and influences the stability at high temperatures. Fortunately, thermistors that have resistances high enough to be useful at high temperatures also tend to be more stable.

Inexpensive thermistors usually have fairly loose specifications. For example, resistance tolerances (again at 25°C) range from ±20% down to ±5%. At higher or lower temperatures, those specifications loosen further. For a typical thermistor with a sensitivity of 4% per degree C, the corresponding temperature measurement tolerances are around ±5 to ±1.25°C (±9 to ±2.2°F) at 25°C. Much higher precision is available at costs generally ranging from $2.00 on up, depending on specifications. We will explore high-precision thermistors later in this article.

We stated earlier that thermistors are narrow-range devices. That should be clarified: Most thermistors operate from −80° to +150°C (112 to +302°F), and units are available (generally glass coated) which work to 400°C (752°F) and beyond. For practical purposes, however, the high sensitivity of thermistors limits their useful temperature range. A typical thermistor's resistance may change by 10,000 or 20,000 to one between −80 and +150°C. You can imagine the difficulty of trying to design a circuit that will accurately measure both ends of such a range (unless you use range switching). A thermistor having a useful resistance at zero degrees will be no more than a few ohms at 400°C.

Most thermistors use solder to attach their leads internally. Obviously, you can't use such a thermistor to measure temperatures higher than the melting point of solder. Even without solder, their epoxy coatings are good only to around 200°C (392°F). For higher temperatures it is necessary to use glass-coated thermistors with welded or fired-in lead wires.

Stability considerations also limit high-temperature use. Thermistor structures tend to change when left at high temperatures, and the rate and type of change is greatly affected by the oxide mix and the way that the thermistor is manufactured. Epoxy-coated thermistors begin to drift a bit at temperatures above 100°C (212°F) or so. If such a thermistor is operated continuously near 150°C, it may drift by several degrees in a year. Low-resistance thermistors (below, say, 1000 ohms at 25°C) often are worse—they can drift noticeably when used at about 70°C (158°C) and become unreliable by 100°C.

Inexpensive, loosely specified devices are produced with less attention to detail and can give even worse results. On the other hand, some properly constructed glass-coated thermistors have excellent stability at even higher temperatures. Glass-coated bead thermistors show excellent stability as do the glass-coated disc thermistors that have recently become available. Remember that drift depends on time as well as temperature. So, for example, you can generally use an epoxy-coated thermistor for brief times at 150°C without significant shifts.

When using thermistors you must be aware of the specification for *dissipation constant*. A small epoxy-coated thermistor, for example, will have a dissipation constant around one milliwatt per degree C in still air. In other words, one milliwatt of power in the thermistor will raise its internal temperature by one degree C; two milliwatts will raise it by two degrees, etc. If you apply one volt to a 1K thermistor with a dissipation constant of 1 mW/°C, you will produce a measurement error of 1°C. Thermistors will dissipate more power if they are immersed in liquids. The same small epoxy-coated thermistor we used in our example will dissipate 8 mW/°C in well-stirred oil. Larger thermistors have better dissipation constants than smaller devices. For example, a one-inch disc or washer may dissipate 20 or 30 milliwatts per °C in air. Keep in mind that as the thermistor's resistance changes with temperature, so does its power dissipation.

Thermistor equations

There is no such thing as an exact equation to describe a thermistor's behavior: there are only approximations. We will look at two commonly used approximations.

The first approximation, an exponential, is reasonably good over limited temperature ranges, especially when using non-precision thermistors. The second, known as the Steinhart and Hart equation, provides excellent precision over ranges as wide as 100°C.

The resistance of an NTC thermistor decreases *approximately* exponentially with increasing temperature. Over limited temperature ranges its R-T curve is described reasonably well by:

$$R_{T2} = R_{T1} e^{\beta\left(\frac{1}{T2} - \frac{1}{T1}\right)}$$

where T1 and T2 are absolute temperatures in degrees Kelvin (°C + 273); R_{T1} and R_{T2} are the thermistor's resistances at T1 and T2, and β is a constant, determined by measuring the thermistor at two known temperatures.

If beta and R_{T1} are known, this equation can be rearranged and used to calculate temperature by measuring the resistance:

$$\frac{1}{T2} = \frac{1}{T1} + \frac{1}{\beta} \ln \frac{R_{T2}}{R_{T1}}$$

Beta is a large, positive number whose units are degrees Kelvin. Typical values run from 3000 to 5000°K. Manufacturers often include a value for beta in their specifications but, since the exponential equation is only an approximation, the value of beta depends on the two temperatures used to calculate it. Some manufacturers use 0 and 50°C; others, 25 and 75°C.

Other temperatures may be used: you can compute your own values for beta from the manufacturer's resistance-temperature tables. The equation will typically agree with measured values to within ±1°C over a span of 100°C. The equation should not be trusted very far beyond the temperatures used to find beta.

Before going on to the Steinhart and Hart equation let us look at two other terms often used to specify thermistors: alpha (α) and ratio. Alpha is simply the slope of the R-T curve—the sensitivity, at some particular temperature. Alpha is usually specified as a "percent per degree." Typical values run between 3% and 5%/°C. Like beta, alpha depends on the temperatures at which it is measured. Its value decreases somewhat at higher temperatures.

The ratio term is simply the ratio of the resistance at one temperature (usually 0 to 25°C) to the resistance at a second, higher temperature. For example, the 0°/50°C ratio of the 10-kilohm thermistor shown in Table 1 is 7.58. Beta may be computed from this ratio and vice versa. Typical values of the 0°/50°C ratio are between 5 and 10.

When using precision thermistors, you generally will have a degree-by-degree chart of resistance versus temperature furnished in the manufacturer's data. Sometimes, however, it is handy to have a precise equation when doing design calculations or (especially) when using a computer to convert the thermistor's resistance to temperature. Except for very narrow temperature spans, the single-term exponential is not good enough: more terms are needed.

The best approximation in common use today is known as the Steinhart and Hart equation:

$$\frac{1}{T} = a + b \ln R + C (\ln R)^3$$

where T is the absolute temperature (in degrees Kelvin), R is the thermistor's resistance, and a, b, and c are experimentally determined constants.

Rewriting the equation to show resistance as a function of temperature results in a rather messy-looking equation. However, it is easily handled using a computer or programmable calculator:

$$R = \exp\left[\left[-\frac{\alpha}{2} + \left(\frac{\alpha^2}{4} + \frac{\beta^3}{27}\right)^{1/2}\right]^{1/3} + \left[-\frac{\alpha}{2} - \left(\frac{\alpha^2}{4} + \frac{\beta^3}{27}\right)^{1/2}\right]^{1/3}\right]$$

$$\text{where } \alpha = \frac{a - \frac{1}{T}}{c} \text{ and } \beta = \frac{b}{c}$$

We should point out that these values of alpha and beta are *not* related to the alpha and beta used with the single-term exponential equation.

Although the Steinhart and Hart equation is more complex, it generally agrees with the actual thermistor to within a few thousandths of a degree over spans as wide as 1000°C. Of course, it can be that good only if the experimental thermistor data is equally accurate. Temperatures accurate to thousandths of a degree can be provided only in top-grade laboratories. You will probably want to rely on the manufacturer's tables rather than try to provide your own measurements.

To find a, b, and c it is necessary to know the thermistor's resistance precisely at three temperatures and substitute each set of data (R and T) into the Steinhart and Hart equation, in three unknowns. (The unknowns are a, b and c.) Algebra must then be used to simultaneously solve the three equations to find the three constants. Using the manufacturer's tables, choose R versus T data at each end and at the middle of the temperature range you plan to use. Manufacturer's generally do not provide specified values of a, b and c, since they vary depending on your temperature range.

Precision thermistors

Ordinary thermistors are specified only to between ±5% and ±20% at 25°C, with looser tolerances at other temperatures. With proper manufacturing control and measurement, however, much better precision is possible. Three types of precision thermistors are available: precision interchangeable discs, precision beads, and matched-curve bead pairs. Precision thermistors allow readout instruments to be electronically calibrated without the need for precise temperature sources. Interchangeable thermistors also allow replacement of the thermistor without recalibrating the electronics.

Precision interchangeable disc thermistors are manufactured with careful control and measurement of the R-T characteristics and stability of the oxide mixture. Mixes that don't conform to precise specifications are discarded. The thermistors are mixed, shaped and fired using normal techniques. Then, in a fluid bath at a carefully controlled temperature, each thermistor is ground to bring its resistance to a specified value. Before shipment, each thermistor is measured at two or three temperatures and discarded if it does not meet specifications.

You can buy stocked, cataloged tolerances between 0 and 70°C of ± 0.2°C or ±0.1°C, with accuracies loosening to about +1°C at −80 and +150°C. Special high-stability glass-coated disc thermistors are offered with tolerances as tight as 0.05°C. Figure 3 shows the resistance-and temperature-tolerance characteristics

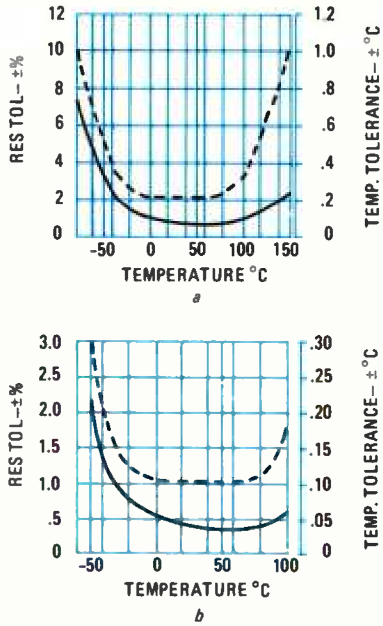


FIG. 3—TEMPERATURE AND RESISTANCE TOLERANCE for precision interchangeable thermistors. The dotted lines show temperature tolerance (±°C) and the solid lines show resistance tolerance (±%). In *a*, we see the curves for a ±0.2°C thermistor, while in *b* we see the curves for a ±0.1°C thermistor.

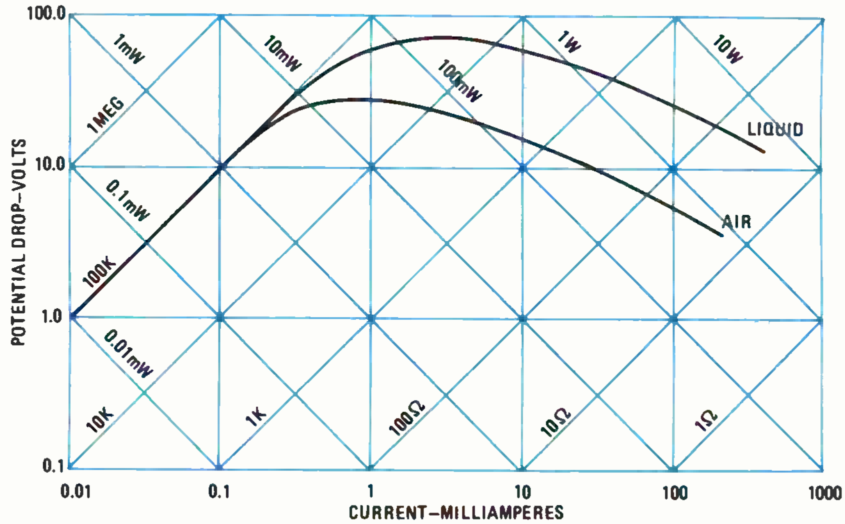


FIG. 4—THE RESISTANCE OF AN NTC thermistor drops as it is heated by high currents until it eventually enters a negative-resistance mode.

for typical interchangeable thermistors.

Those high-precision, interchangeable thermistors are available only as small size discs or squares coated with epoxy or (for higher stability) glass. Several manufacturers offer some or all of the following resistances at 25°C: 100, 300 and 500 ohms, 1.0, 2.252, 3.0, 5.0, 10.0, 30.0, 50.0, 100.0, and 300.0 kilohms and 1.0 megohm. The 2.252, 3.0 and 5.0K thermistors are interchangeable among manufacturers, the other generally are not. A variety of temperature probes that use 2.252K thermistors are available.

Bead thermistors can be very precise and very stable, but their small size and methods of construction make it impossible to grind them to an exact value. If you need to make precision measurements with beads (which offer the ultimate in small size and high-temperature operation), you can ask the manufacturer to provide a measurement and printout of each thermistor's R-T curve. Or, you can specify thermistors selected to a specific resistance and tolerance at one temperature.

Another way in which bead manufacturers provide precision and interchangeability is to routinely measure each thermistor, then connect selected matched pairs in series or parallel to match a specific curve.

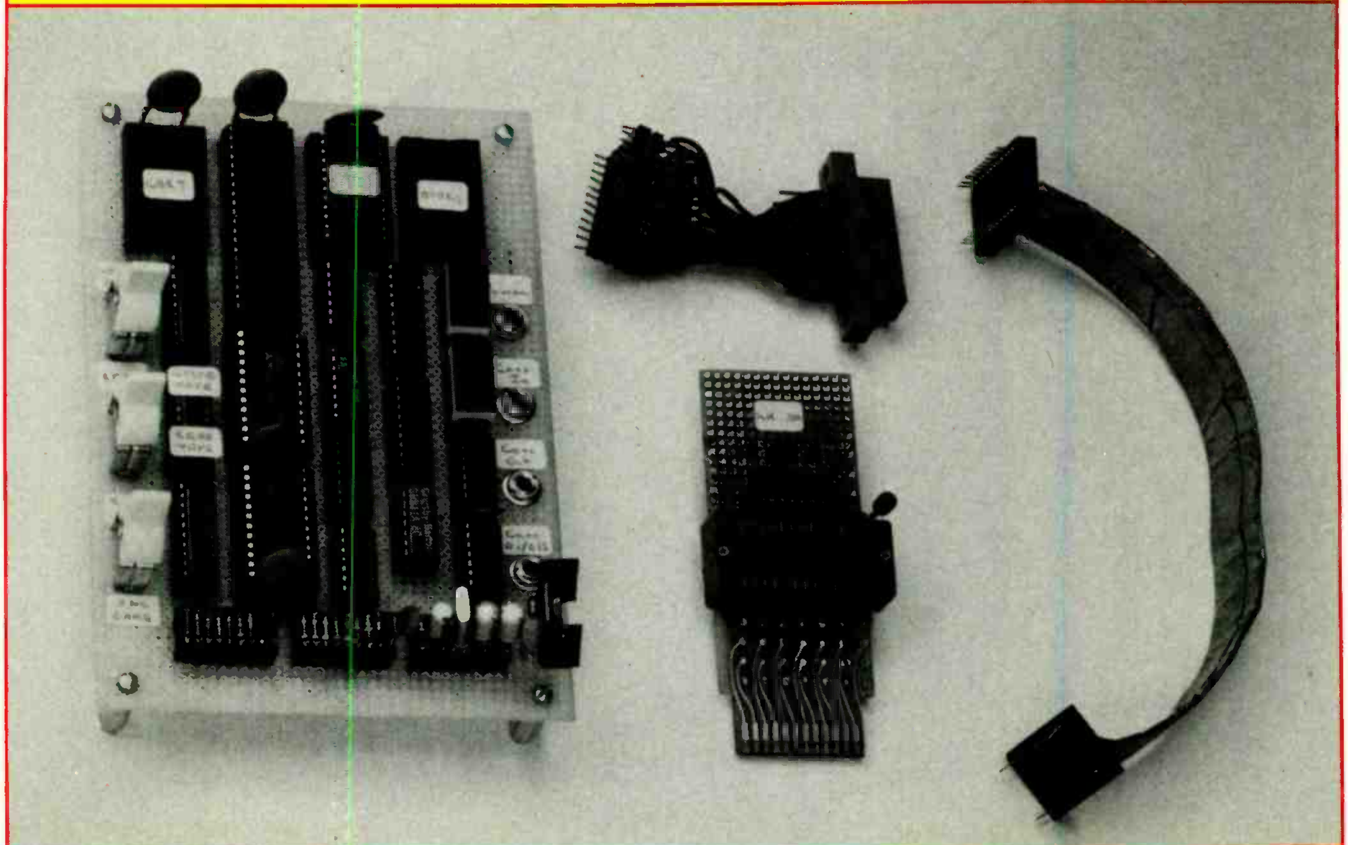
Thermal behavior

Thermistors are resistors. They obey Ohm's law (E = I × R)—until you change their temperature. Remember that it takes only a few milliwatts to raise a thermistor's temperature by one degree or more and that the resistance will drop by about 4% per degree C. If you connect a current source to a thermistor, and slowly increase the current, you will see the voltage rise more and more slowly as the thermistor's resistance decreases. Eventually the voltage will stop rising altogether, then actually drop as the current is increased further. The graph of Fig. 4 shows typical voltage-versus-current curves. Also on the graph are lines indicating constant resistance and constant power dissipation. At low current and low power, the curve follows a line of constant resistance, showing that the thermistor is not being heated very much. As the power increases, you can see that its resistance begins to drop. At the high-power end of the curve, the thermistor, in a sense, acts as a negative resistance in that its voltage goes down as the current goes up.

That's all we have room for now. Next time, we'll continue with our look at thermistor basics and then turn our attention to some practical applications. **R-E**

ATARI Game Recorder

GUY VACHON and DAVID A. CHAN



You can record the contents of your Atari 208 videogame cartridges on audio cassette tape! This month, we'll take a look at the software that's needed.

Part 2 LAST MONTH, WE looked at the basic approach we'll follow to store the contents of Atari *2600* game cartridges on audio cassette tape. We also looked at the hardware that's required, and briefly studied how cassette I/O is handled. This time, we'll look at the software in more depth. Then we'll see how we can build the game recorder and put it to use.

Game-recorder software

The complete software listing for the game recorder's operating system appears in Table 1. Note that it is written in Z80 mnemonics. Although we won't be discussing the software line by line, you might want to study Table 1 to get the details.

When we left off last time, we were discussing cassette I/O. Figure 5 showed a flowchart that described the cassette-read algorithm. Let's look at the software in more detail to see how it's used to detect the data and sync pulses. (Remember that sync pulses are sent out every 2 milliseconds. Data pulses are sent between the sync pulses—a pulse represents a 1 bit, while the lack of a pulse represents a zero bit.)

When the contents of a game cartridge is written to a cassette tape, a header of 2000 zero bits preceeds the actual beginning of the program bits. After the header, the game recorder also writes a (user-selected) label before each game. When the game recorder reads the contents of a cassette tape, its software looks for fifty consecutive zeros to decide that it has found the beginning of a game program. You might wonder why we write 2000 zero bits and look for only 50. There's a very practical reason: It allows the automatic gain control (AGC) of most recorders enough time to settle down.

After the recorder finds 50 consecutive zero bits, it keeps on looking until it finds a 1 bit. It then checks the name tag, which is output to the LAST GAME FOUND display. If the name tag matches the name of the game you selected, it keeps on reading bytes and storing them in the RAM. If the tag doesn't match, the game recorder keeps looking for another start-of-game header. (We'll give more details on that—and other operation aspects of the computer—a little later on in this article.)

You may recall that a parity bit is added to each instruction so that the game recorder will recognize when something

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TABLE 1—GAME-RECORDER SOFTWARE

```
CURRENT_GAME_OUT             EQU  8000H
GAME_SEL_OUT                 EQU  0A000H
INPUT                        EQU  0C000H
RAM_FIRST_BYTE_ADD           EQU  4000H
ROM_FIRST_BYTE_ADD           EQU  2000H
LAST_PLUS_1_BYTE_RAM_HIGH    EQU  50H
LAST_BYTE_ADD_RAM            EQU  4FFFH
;START OF INITIALIZATION
         .Z80
         LD    A,00H                 ;CLEAR LEDS
         EXX
         LD    B,A
         LD    (CURRENT_GAME_OUT),A
         LD    A,3FH
         LD    C,A
         LD    (GAME_SEL_OUT),A
         EXX
;START OF MAIN PROGRAM
LOOP1:   LD    A,(INPUT)             ;SEE IF INC GAME
                                     ; PUSHED
         AND   01H
         JP    NZ, LAB1
         LD    A,0FFH                ;WAIT AND CHECK
                                     ; INPUT AGAIN
LOOPA:   DEC   A
         JP    NZ,LOOPA
         LD    A,(INPUT)
         JP    NZ,LAB1
         EXX                         ;START OF INC GAME
                                     ; PROGRAM
         LD    A,B
         INC   A
         AND   0FH
         LD    B,A
         EXX
         LD    IY,XX1
         JP    CONVERT
XX1:     EXX
         LD    C,A
         EXX
         LD    (GAME_SEL_OUT)A,
         LD    DE,7FFFH              ;WAIT HALF A SECOND
LOOPB:   DEC   A
         LD    A,E
         ADD   A,D
         JP    NZ,LOOPB
         JP    C,LOOPB

;CONTINUATION OF MAIN PROGRAM
LAB1:    LD    A,(INPUT)             ;SEE IF COPY PUSHED
         AND   02H
         JP    NZ,LAB2
         LD    A,0FFH                ;WAIT AND CHECK
                                     ; INPUT AGAIN
LOOPC:   DEC   A
         JP    NZ,LOOPC
         LD    A,(INPUT)
         AND   02H
         JP    NZ,LAB2
         LD    DE,RAM_FIRST_BYTE_ADD
                                     ;START OF COPY
                                     ; PROGRAM
         LD    HL,ROM_FIRST_BYTE_ADD
         LD    BC.1000H
         LDIR

;CONTINUATION OF MAIN PROGRAM
LAB2:    LD    A,(INPUT)             ;SEE IF DOWNLOAD
                                     ; PUSHED
         AND   04H
         JP    NZ,LAB3
         LD    A,0FFH                ;WAIT AND CHECK
                                     ; INPUT AGAIN
```

```
LOOPD:   DEC   A
         JP    NZ,LOOPD
         LD    A,(INPUT)
         AND   04H
         JP    NZ,LAB3
         EXX                         ;START OF DOWNLOAD
                                     ; PROGRAM
         LD    A,C                   ;TURN ON DECIMAL
                                     ; POINT
         EXX
         OR    80H
         LD    (GAME_SEL_OUT),A
BLOCIN:  LD    DE,01F4H
LOOPE:   LD    HL,XX2                ;FIND 500 ZEROS
         JP    BITIN
XX2:     JP    C,BLOCIN
         DEC   DE
         LD    A,E
         ADD   A,D
         JP    NZ,LOOPE
         JP    C,LOOPE
LOOPF:   LD    LH,XX3                ;FIND 1ST BIT OF 1ST
                                     ; BYTE
         JP    BITIN
XX3;     HP    NC,LOOPF
         LD    A,01H                 ;GET 1ST BYTE
         LD    B,07H
         LD    IX,XX4
         JP    BYTEIN
XX4;     AND   0FH                   ;CONVERT TO 7 SEG
                                     ; AND DISPLAY
         LD    IY,XX5
         JP    CONVERT
XX5:     LD    (CURRENT_GAME_OUT),A
         LD    D,A                   ;SEE IF CORRECT
                                     ; GAME
         EXX
         LD    A,C
         EXX
         CP    D
         JP    NZ,BLOCIN
         JD    DE,RAM_FIRST_BYTE_ADD
                                     ;GET REST OF BLOCK
LOOPG:   LD    A,00H
         LD    B,08H
         LD    IX,XX6
         JP    BYTEIN
XX6:     LD    (DE),A
         INC   DE
         LD    A,D
         CP    LAST_PLUS_1_BYTE_RAM_HIGH
         JP    NZ,LOOPG
         LD    DE,0FFFFH             ;WAIT ONE SECOND
LOOPH:   DEC   DE
         LD    A,E
         ADD   A,D
         JP    NZ,LOOPH
         JP    C,LOOPH
         EXX                         ;TURN OFF DECIMAL
                                     ; POINT
         LD    A,C
         EXX
         LD    (GAME_SEL_OUT),A

;CONTINUATION OF MAIN PROGRAM
LAB3:    LD    A,(INPUT)             ;SEE IF RECORD
                                     ; PUSHED
         AND   08H
         JP    NZ,LAB4
         LD    A,0FFH                ;WAIT AND CHECK
                                     ; AGAIN
LOOPI;   DEC   A
```

TABLE 1 (continued)

```
          JP    NZ,LOOPI
          LD    A,(INPUT)
          AND   08H
          JP    NZ,LAB4
          EXX                          ;START OF RECORD
                                       ; PROGRAM
          LD    A,C                    ;TURN ON DECIMAL
                                       ; POINT
          EXX
          OR    80H
          LD    (GAME_SEL_OUT),A
          LD    DE,07D0H
LOOPJ:    AND   0FFH                   ;OUTPUT 2000 ZEROS
          LD    HL,XX7
          JP    BITOUT
XX7:      DEC   DE
          LD    A,E
          ADD   A,D
          JP    NZ,LOOPJ
          JP    C,LOOPJ
          EXX                          ;OUTPUT BLOCK
                                       ; ADDRESS
          LD    A,B
          EXX
          OR    0F0H
          LD    IX,XX8
          JP    BYTEOUT
XX8:      LD    DE,RAM_FIRST_BYTE_ADD
                                       ;OUTPUT BLOCK
LOOPK:    LD    A,(DE)
          LD    IX,XX9
          JP    BYTEOUT
XX9:      INC   DE
          CP    LAST_PLUS_1_BYTE_RAM_HIGH
          JP    NZ,LOOPK
          LD    DE,0FFFFH              ;WAIT ONE SECOND
LOOPL:    DEC   DE
          LD    A,E
          ADD   A,D
          JP    NZ,LOOPL
          JP    C,LOOPL
          EXX                          ;TURN OFF DECIMAL
                                       ; POINT
          LD    A,C
          EXX
          LD    (GAME_SEL_OUT),A
LAB4:     JP    LOOP1

;START OF SUBROUTINES
;BYTEIN SUBROUTINE - GETS ONE BYTE FROM TAPE
;IX = RETURN ADDRESS
;GIVEN: A IS (EMPTY) BYTE
;         B IS # BITS LEFT
;RESULT: A IS BYTE
;USES: B
;CALLS: BITIN
;CANNOT AFFECT: DE
BYTEIN:   LD    HL,XX10                ;START OF BYTEIN
                                       ; PROGRAM
          JP    BITIN                  ;GET ENTIRE BYTE
XX10:     RLA
          DEC   B
          JP    NZ,BYTEIN
          AND   0FFH                   ;COMPUTE PARITY
          EX    AF,AF'
          LD    HL,XX11                ;GET PARITY BIT
          JP    BITIN
XX11:     JP    C,LAB5                 ;SEE IF ERROR BY
                                       ; CHECKING 'CARRY'
                                       ; THEN
          EX    AF,AF'
          JP    PE,PERROR
          JP    (IX)
LAB5:     EX    AF,AF'                 ;RECALL BYTE &
                                       ; FLAGS AND CHECK
                                       ; PARITY
          JP    PO,PERROR
          JP    (IX)
PERROR:   LD    A,94H                  ;ERROR, DISPLAY
                                       ; MESSAGE
          LD    (CURRENT_GAME_OUT),A
          LD    DE,LAST_BYTE_ADD_RAM
          JP    (IX)

;BITIN SUBROUTINE - GETS ONE BIT FROM TAPE
;HL = RETURN ADDRESS
;RESULT: BIT IS CARRY
;USES: D',E',H'
;CANNOT AFFECT: DE,B,A

BITIN:    EXX                          ;START OF BITIN
                                       ; PROGRAM
          LD    D,A                    ;EXCHANGE
                                       ; REGISTERS AND
                                       ; STORE A
LOOPM:    LD    A,(INPUT)              ;FIND HIGH
          AND   10H
          JP    Z,LOOPM
          LD    E,8FH                  ;WAIT 1MSEC
LOOPN:    DEC   E
          JP    NZ,LOOPN
          LD    E,0CH                  ;SEE IF 1 OR 0 FOR
                                       ; 0.25MSEC
LOOPO:    LD    A,(INPUT)
          AND   10H
          CCF
          JP    NZ,LAB6
          DEC   E
          JP    NZ,LOOPO
          CCF
LAB6:     LD    E,5DH                  ;WAIT 0.65MSEC
LOOPP:    DEC   E
          JP    NZ,LOOPP
          LD    A,D                    ;RECALL A,
                                       ; EXCHANGE REGS &
                                       ; RETURN
          EXX
          JP    (HL)

;BYTEOUT SUBROUTINE - WRITES A BYTE ONTO TAPE
;IX = RETURN ADDRESS
;GIVEN: A IS BYTE
;USES: B
;CALLS: BITOUT
;CANNOT AFFECT:DE
BYTEOUT:  LD    B,08H                  ;START OF BYTEOUT
                                       ; PROGRAM
LOOPQ:    RLCA                         ;OUTPUT BYTE
          LD    HL,XX12
          JP    BITOUT
XX12:     DEC   B
          JP    NZ,LOOPQ
          AND   0FFH                   ;COMPUTE AND
                                       ; OUTPUT PARITY
          JP    PO,LAB7
          CCF
LAB7:     LD    HL,XX13
          JP    BITOUT
XX13:     JP    (IX)

;BITOUT SUBROUTINE - WRITES A BIT ONTO TAPE
;HL = RETURN ADDRESS
;GIVEN: CARRY IS BIT
;USES: C
;CALLS: PULSE
;CANNOT AFFECT:DE,B,A
```

TABLE 1 (continued)

```
BITOUT:   EX    AF,AF'          ;START OF BITOUT
                                ; PROGRAM
          SCF                   ;STORE ORIGINAL
                                ; BYTE AND FLAGS
          LD    IY,XX14         ;OUTPUT 1ST PULSE
          JP    PULSE
XX14:     LD    C,6BH           ;WAIT
LOOPR:    DEC   C
          JP    NZ,LOOPR
          EX    AF,AF'          ;GET ORIGINAL FLAGS
                                ; AND BYTE
          LD    C,A             ;STORE ORIGINAL
                                ; BYTE ONLY
          EX    AF,AF'
          LD    A,C
          EX    AF,AF'
          LD    IY,XX15         ;OUTPUT 2ND PULSE
          JP    PULSE
XX15:     LD    C,6BH           ;WAIT
LOOPS:    DEC   C
          JP    NZ,LOOPS
          EX    AF,AF'          ;RECALL ORIGINAL
                                ; BYTE AND RETURN
          JP    (HL)

;SUBROUTINE PULSE - WRITE A PULSE ONTO TAPE
;IY = RETURN ADDRESS
;GIVEN: PULSE IF CARRY
;USES: C
;CANNOT AFFECT:DE,B

PULSE:    LD    A,00H           ;START OF PULSE
                                ; PROGRAM
          JP    NC,LAB8         ;SET OUT IF
                                ; REQUIRED
          OR    80H
LAB8:     LD    (CURRENT_GAME_OUT),A
                                ;OUT AND WAIT
          LD    C,24H
LOOPT:    DEC   C
          JP    NZ,LOOPT
          LD    A,00H           ;TURN OFF
          LD    (CURRENT_GAME_OUT),A
          JP    (IY)

;SUBROUTINE CONVERT - CONVERTS DATA TO 7 SEGMENT
;IY = RETURN ADDRESS
;GIVEN: A IS TO BE CONVERTED
;RESULT: A IS CONVERTED DATA

CONVERT:  CP    00H             ;START OF CONVERT
                                PROGRAM
          JP    NZ,LABA
          LD    A,3FH
          JP    (IY)
LABA:     CP    01H
          JP    NZ,LABB
          LD    A,06H
          JP    (IY)
LABB:     CP    02H
          JP    NZ,LABC
          LD    A,5BH
          JP    (IY)
LABC:     CP    03H
          JP    NZ,LABD
          LD    A,4FH
          JP    (IY)
LABD:     CP    04H
          JP    NZ,LABE
          LD    A,66H
          JP    (IY)
LABE:     CP    05H
          JP    NZ,LABF
          LD    A,6DH
          JP    (IY)
LABF:     CP    06H
          JP    NZ,LABG
          LD    A,7DH
          JP    (IY)
LABG:     CP    07H
          JP    NZ,LABH
          LD    A,07H
          JP    (IY)
LABH:     CP    08H
          JP    NZ,LABI
          LD    A,7FH
          JP    (IY)
LABI:     CP    09H
          JP    NZ,LABJ
          LD    A,6FH
          JP    (IY)
LABJ:     CP    0AH
          JP    NZ,LABK
          LD    A,77H
          JP    (IY)
LABK:     CP    0BH
          JP    NZ,LABL
          LD    A,7CH
          JP    (IY)
LABL:     CP    0CH
          JP    NZ,LABM
          LD    A,39H
          JP    (IY)
LABM:     CP    0DH
          JP    NZ,LABN
          LD    A,5EH
          JP    (IY)
LABN:     CP    0EH
          JP    NZ,LABO
          LD    A,79H
          JP    (IY)
LABO:     LD    A,71H
          JP    (IY)
          END
```

has been misrecorded. If incorrect parity is detected when the computer is reading from the tape, it will stop reading, and the LAST GAME FOUND display will show a message of three horizontal bars to indicate an error.

Before we go any further, we should talk a little about the memory mapping used in the game recorder. The system ROM resides from 0000H to 1FFFH. (Note that a capital "H" indicates that a number is written in hexadecimal.) The game cartridge occupies the second 8K block—2000H to 3FFFH. The game recorder's RAM is located from 4000 to 5FFFH. Cassette I/O and the displays are also memory mapped: The block from 8000H to 9FFFH is used for the LAST GAME FOUND display and the cassette data output, while the block from A000H to BFFFH is used for the GAME SELECTED display and for the remote cassette control. The cassette data input and the switches are memory mapped from C000H to DFFFH. Note that two 8K blocks (6000H–7FFFH and E000H–FFFFH) are not used.

The easiest job that our computer has to do is to read the program ROM. As it operates now, the computer can copy all 2K × 8 ROM's and 4K × 8 ROM's. As you might expect, it is possible to modify the recorder to copy 8K × 8 ROM's. Note, for example, that although an 8K block was left available for program-storage RAM, the hardware as presented has provision for only 4K.

We'll talk more about how to expand the unit to record larger programs, and show you how to build and use it, when we continue our look at the Atari game recorder next time. **R-E**

High-Power FET Audio Amplifier

Get high performance and high fidelity from this FET stereo amplifier. It feels equally at home in your living room or in a disco!

REINHARD METZ

Part 2 NOW THAT WE KNOW how our FET power amplifier works, let's now turn our attention to building the unit.

Building the amplifier

It is essential that a printed-circuit board be used for the amplifier. Figures 6 and 7 show foil patterns for the component and solder side respectively. Note that one board is required for each channel. If you don't want to etch your own boards, etched, pre-drilled, and plated-through boards are available: see the Parts List for information. If you *do* want to etch your own boards from the patterns shown, keep in mind that the board uses plated-through holes. You can, of course, get around that by soldering some of the components, including the output transistors, on both sides of the board. Note that the wiring to the output transistors is incorporated in the PC-board layout. That keeps the wire lengths to the output devices to a minimum. (It also simplifies construction by eliminating 48 wires, reducing the chance of error in that particularly critical area!)

Before we begin with the construction details, we should point out that the values shown in the schematic are for 1%-tolerance resistors. For most applications, it is not essential that you use such parts. Thus, the parts list also shows acceptable values for 5%-tolerance resistors. (One source for 1% resistors is Digi-Key Corporation, Highway 32 South, P.O. Box 667, Theif River Falls, MN 56701.)

Once you have your boards and components, you can begin construction by referring to the parts-placement diagram in Fig. 8 and by installing the fixed resistors. Check the values with an ohmmeter as you go, and be sure that the leads are sufficiently far from the ground plane!

Next, install capacitors, carefully checking values and ensuring that the polarized electrolytic types are properly oriented. Follow by installing the diodes, except for D3–D5. (Those three diodes mount on the output-transistor heat sink, and should not be installed yet.) Again, be careful of the polarity—the diode band indicates the cathode. Next, install the transistors (except for the output transistors Q21–Q28). Transistors Q19 and Q20 should be mounted with insulators and heatsink compound. (If you look closely at Fig. 9, you'll see some heatsink compound around those transistors.) Transistors Q12, Q13, Q15, and Q18 use TO-5-type heat sinks.

Adjust potentiometers R8 and R19 to their middle positions and install. (For R19, which is a multiturn potentiometer, you will need to use an ohmmeter.) You will have to make L1: Wind 15 turns of 16-gauge magnet wire on R42. Solder to the leads of R42, and install the assembly. The PC boards are now complete.

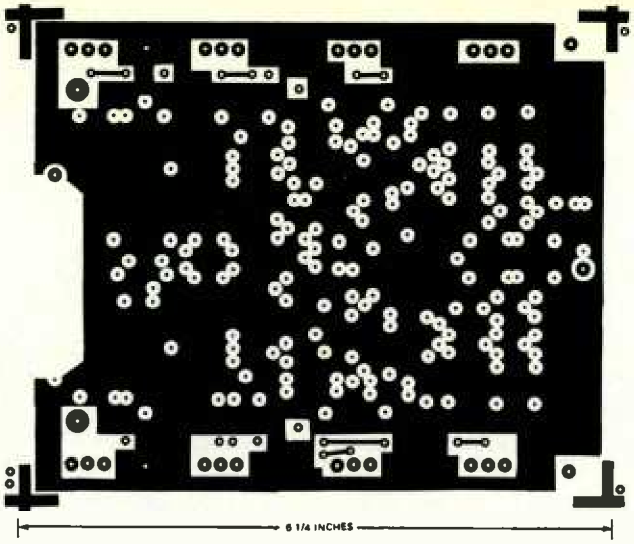


FIG. 6—THE COMPONENT SIDE of the amplifier board is mainly used as a ground plane.

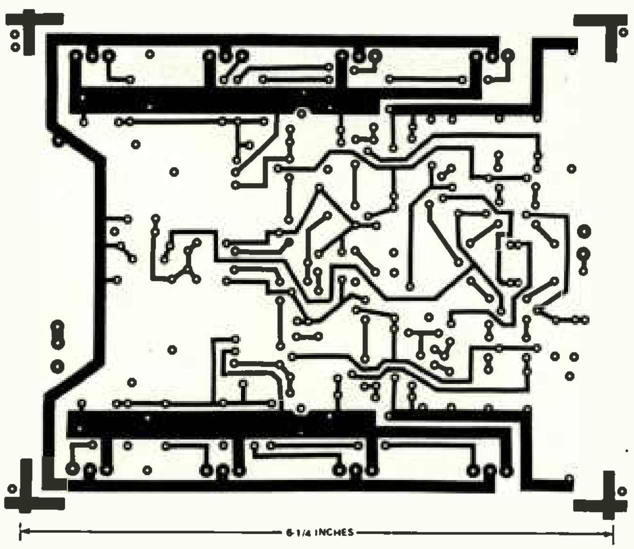


FIG. 7—THE SOLDER SIDE of the amplifier board. Remember that you need one board for each channel.

Preparing the heat sink

The Wakefield heat sinks that are used for the output transistors (see Fig. 10) were not chosen arbitrarily. Their design is almost 100% more efficient for natural convection applications than conventional designs of equivalent volume.

You can use other heat sinks but a minimum surface area of 800 square inches per channel is required. A flat-backed heat sink is desirable for the TO-220 package, but is not essential.

The Wakefield type 512 is available in a 14-inch long extrusion, which needs to be cut in half to yield the two 7-inch pieces called for. After you cut it, drill holes for the output transistors according to the layout shown in Fig. 11. To keep the transistor-mounting hardware to a minimum, you might want to drill and tap the heat sink. However, screws with nuts may also be used. The optional over-temperature sensor and thermal-compensating diodes D3–D5 should also be glued to the heat sink as shown in Fig. 11.

If you have a confined-space application, you can mount the two heat sinks back to back; they will then readily accept a muffin fan for forced convection. For home applications, however, we recommend natural convection—to eliminate the noise, filter, and/or temperature-sensing aspects typically associated with fans. We should make a final note that wiring length should be kept to a minimum, with less than 2 inches from transistor to PC board. Even with that length, a ferrite bead is necessary on each gate lead, and using coaxial cable is recommended.

Preparing the chassis

The design and construction of a chassis for the amplifier is not critical. The author's prototype was built with rack mounting in mind. It consists of an 8 × 17 inch bottom plate with 1 inch turned up at the front and back. The front plate is 19 × 17 inches. As shown in Fig. 10, the two heat sinks mount on the back of the unit, leaving a 2½ × 7-inch strip for a small plate where the input and output jacks and fuses are mounted. Finally, an 8¼ × 31-inch U-shaped piece of perforated metal makes up the cover.

Begin mounting the components with the transformer, bridge rectifier, filter capacitors, and fuse-holders. Then, mount the power switch, pilot lights, and level controls on the front panel.

Next you'll have to make up a suitable mounting plate and install output jacks that are insulated from their mountings. Install the input-fuse holder and the power cord with a strain relief. Then wire the transformer primary and secondary as shown in the schematic. If you plan to use the optional thermal cutouts, leave a pair of wires to go to the heat-sink area. Use 18-gauge (minimum!) wire in the power supply. We recommend that you use some simple color code for the DC wiring—it will help reduce the possibility of errors during subsequent tests.

Locate a suitable single-point ground, such as a screw through the bottom of the chassis near the power supply, and attach the filter capacitors' common power-supply ground to it. If you use a 3-wire power cord, do not ground or terminate the cord's ground lead.

Checkout procedures

The amplifier checkout is by far the most important part of building this amplifier, so, shift into low gear and **proceed with great care through the following steps!**

First we strongly advise you to make a final visual check of all parts placements on the circuit boards and the power-supply wiring. Then, before applying any power, measure each supply terminal with an ohmmeter to ground. An initial low reading should slowly move up to high resistance as the capacitors charge. Install the main power fuse and, with the DC fuses F2–F5 not installed, apply power. Check the two supplies for ± 75 volts. Remove power, and discharge the filter capacitors through a 1K resistor.

Next, install a pair of ¼-amp fuses for F2 and F3. Measure the resistance from each power-supply input to ground on both driver boards. The reading should be greater than 100K. If it is, temporarily connect one board to F2, F3 and ground. Connect a clip-lead from the collector of Q1 to the collector of Q3. Connect another clip-lead from the collector of Q7 to the collector of Q8. Temporarily clip-lead D3, D4, and D5 into the circuit. Apply power, and measure the voltage between the bases of Q16 and Q17. It should be near 7 volts. Adjust R19, and observe this voltage changing. Leave it at 6.8 volts. Measure the voltage from the emitter of

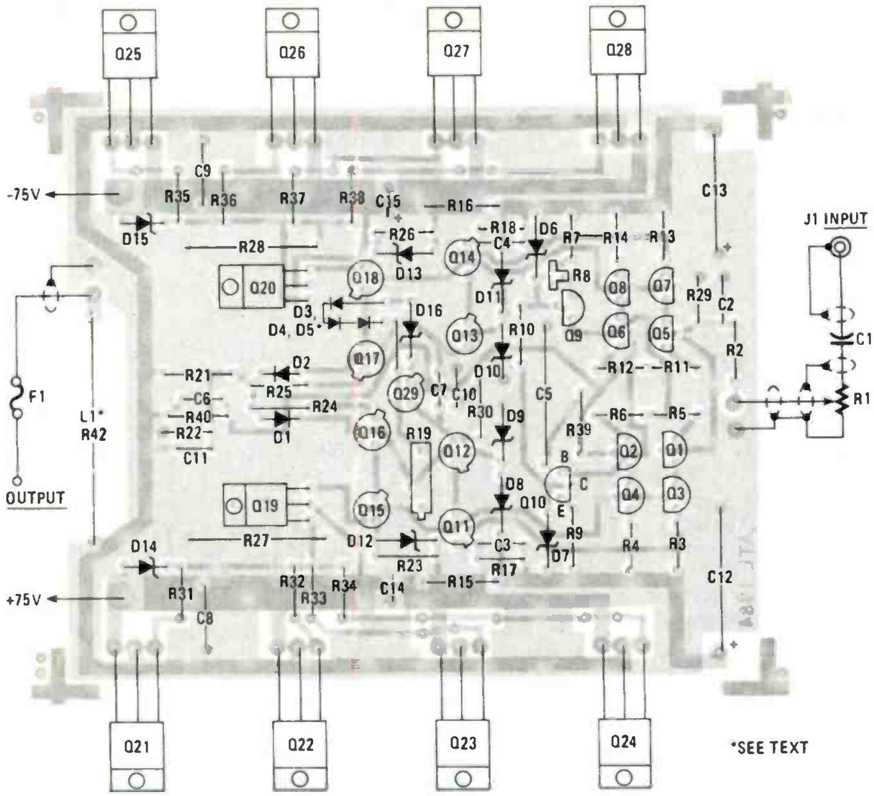


FIG. 8—PARTS-PLACEMENT DIAGRAM for the amplifier board. Refer to the text for information on mounting the output transistors (Q21–Q28) on a heat sink.

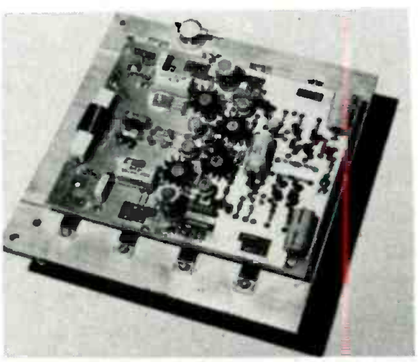


FIG. 9—AMPLIFIER BOARD is shown here mounted on heat sink. Note that Q12, Q13, Q15, and Q18 use TO-5 type heat sinks.

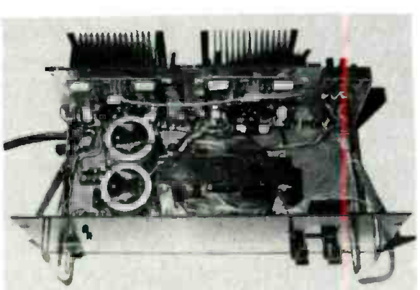


FIG. 10—COMPLETE STEREO AMPLIFIER with cover removed. The chassis configuration is not at all critical.

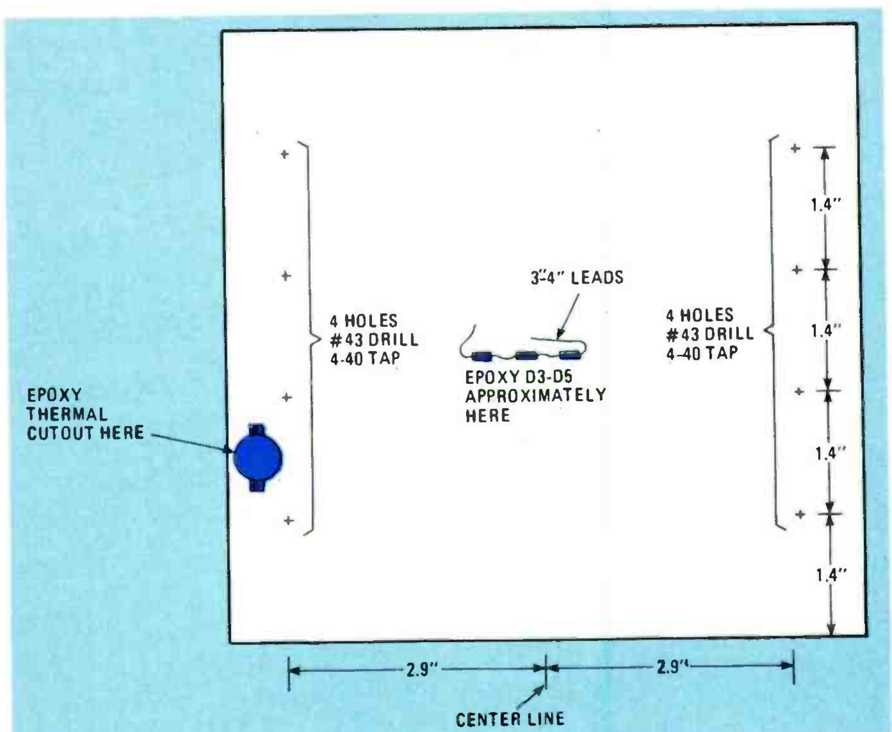


FIG. 11—HEAT-SINK DRILLING GUIDE. Note that some parts are fastened with epoxy to the heat sink.

Q19 to the +75-volt supply, and the voltage from the emitter of Q20 to the −75-volt supply. One should be around 7 volts and the other about .6 volt. Remove power, discharge the filter capacitors, remove clip leads, and repeat with the other driver board.

Next, solder the output transistors to the driver board. Note that it is important that the transistors be matched (within each particular type) so that they will share the output current equally. A simple circuit for checking the matching is shown in Fig. 12. They should be matched to be within 100 millivolts of gate voltage at 50 mA of drain current and 200 millivolts of gate voltage at 2 amps of drain current. Make the 2-amp measurement quickly, or with the transistor heat-sinked.

To mount the transistors, first bend the leads up at a 90-degree angle right at the point where their width changes. Spread the leads a bit and insert in board. Solder carefully while aligning the transistors as much as possible in a common plane. (They may temporarily be screwed to the heat sink as a holding fixture for this operation.) Solder short leads from D3–D5 to the bottom of the driver board, carefully observing polarity. Apply heat-sink compound and insulators to the transistors, and screw the driver and output-transistor assembly to the heat sink, using insulating shoulder washers. Tighten carefully.

Measure each transistor's tab (or case, if you are using TO-3's) to the heatsink. The readings should all be infinite, indicating no insulator shorts. (If you are using TO-3 output parts, it will be necessary to run individual leads to each transistor. When doing that, be extremely cautious: Double-check all your connections and keep your leads as short as possible. Don't forget to install a ferrite bead on each gate lead if you are using TO-3's. In no case should the wiring to the transistors be more than 2 inches in length.) Install the heatsink and driver assemblies.

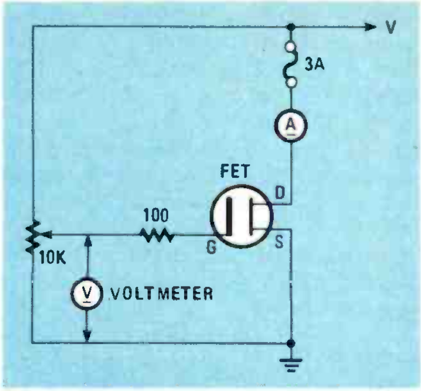


FIG. 12—TO CHECK THE MATCHING OF TRANSISTORS, you might want to use this simple circuit. Start by setting the potentiometer's wiper voltage to zero. Then turn it up to the desired drain current and measure the voltage as shown. For N-channel devices (IRF630), V should be +5 volts. For P-channel devices (IRF9630), V should be −5 volts.

Wire one channel to F2 and F3 with 18-gauge (minimum) wire. Connect a wire from the circuit board ground, near the output, to the chassis single-point ground. Install a ½-amp fuse for F3, and a 1-mA fuse for F2. Apply power, and check for a current through F3 of less than 500 mA. Also check that the output voltage at L1 is between ± 1 volt. If either of those tests fail, immediately turn off power, and look for the source of the problem before proceeding. Adjust R19 to set the current through F3 to about 250 mA, corresponding to an output idle current of about 150mA. Next, adjust R8 carefully to bring the output voltage at L1 as close as possible to zero. Turn off the power, and repeat for the second channel, using fuse positions F4 and F5.

PARTS LIST—BARGRAPH DISPLAY and CLIPPING INDICATORS

All resistors are ¼ watt, 5%, unless otherwise specified.

R43—24,000 ohms
R44, R46, R53—12,000 ohms
R45, R52, R70—22,000 ohms
R47, R54—1000 ohms
R48, R55—470,000 ohms
R49, R51, R58, R59, R61, R62—10,000 ohms
R50, R56—150 ohms
R57, R60—53,000 ohms
R63, R65—1200 ohms
R64, R66—7500 ohms
R67—350 ohms, 20 watts
R68—15,000 ohms
R69—2200 ohms, 5 watts

Capacitors

C18, C19—1 µF, 10 volts, electrolytic
C20—2.2 µF, 10 volts, electrolytic

Semiconductors

IC1—LM139 Quad op-amp
Q30—ECG291
D17, D18—1N4001
D19, D20—1N4741A 11 volts, 1-watt, Zener
D21—1N4735A 6.2 volts, 1 watt, Zener
D22—1N4744A 15 volts, 1 watt Zener
D23—1N4750A 27 volts, 1 watt, Zener
LED1, LED2—Standard red LED
DISP1, DISP2—NSM39158 logarithmic bargraph display with driver (National)

Other components

S2, S3—SPDT

The following items are available from A&T Labs, Box 552, Warrenville, Illinois, 60555: Etched, drilled, plated-through PC boards, $22 each; Power transformer, $69 each; Set of 8 matched power FET's, $66; Drilled heatsink (type 512), $27. Add 5% shipping and handling, 12% for transformer. Illinois residents include 5-1/4% sales tax.

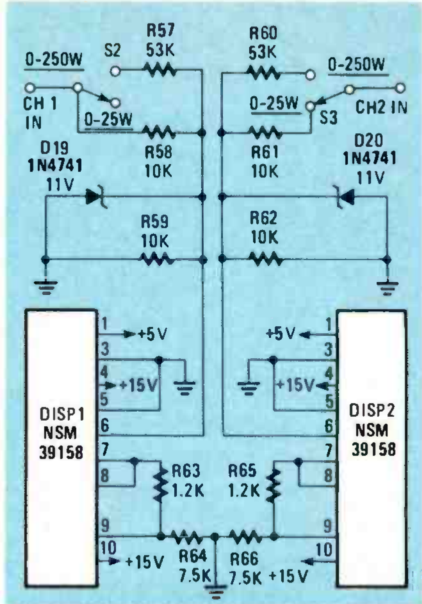


FIG. 14—BAR-GRAPH POWER METERS will certainly make a nice addition to any stereo amplifier.

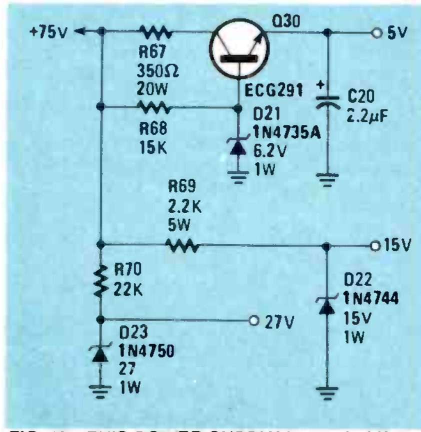


FIG. 15—THIS POWER SUPPLY is needed if the clipping indicators and bar-graph power meters are added. Note that Q30 requires a 10-watt heat sink.

Upon completion of those initial tests, finish wiring the remainder of the chassis. Run at least 18-gauge wire from each driver-board output, along with a ground from the board to the output binding posts. Shielded cable should be used from the level controls to the input jacks. The input-coupling capacitors mount at the level controls.

For continuous full-power applications, it will be necessary to use 5-amp fuses for F2–F5, and 8-amp output fuses for F1. However, for normal, or even loud general listening situations, it is advisable to use much smaller fuses to protect the speakers. It is usually sufficient to use 2-amp supply and 1- or 2-amp output fuses, and work up from there if necessary.

You may want to add clipping indicators and/or bar-graph power meters to your amplifier. The clipping indicator is shown in Fig. 13, the power meter, in Fig. 14, and the power supply needed for the two additions is shown in Fig. 15. **R-E**

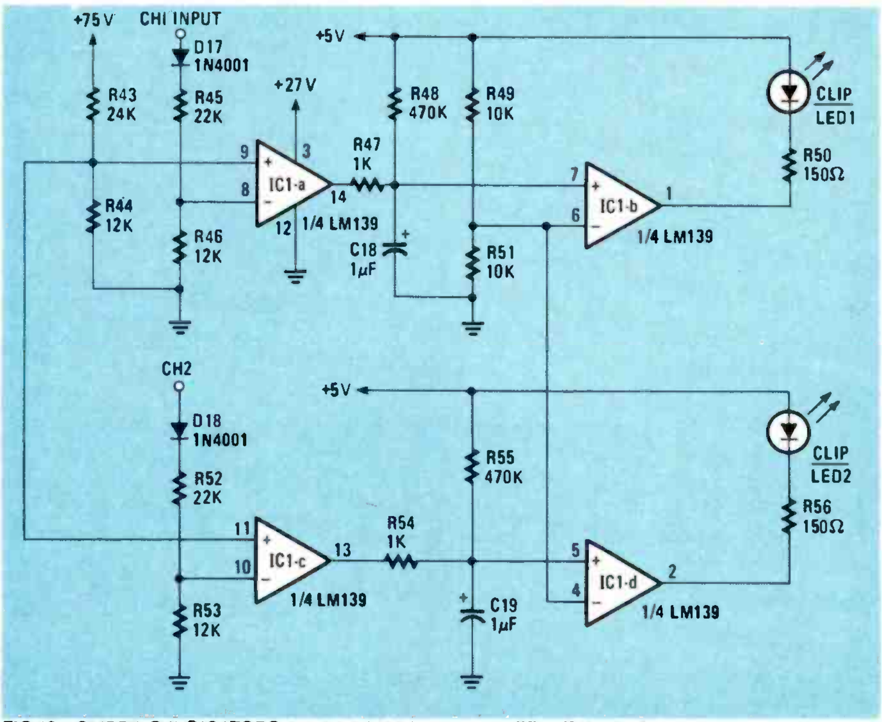
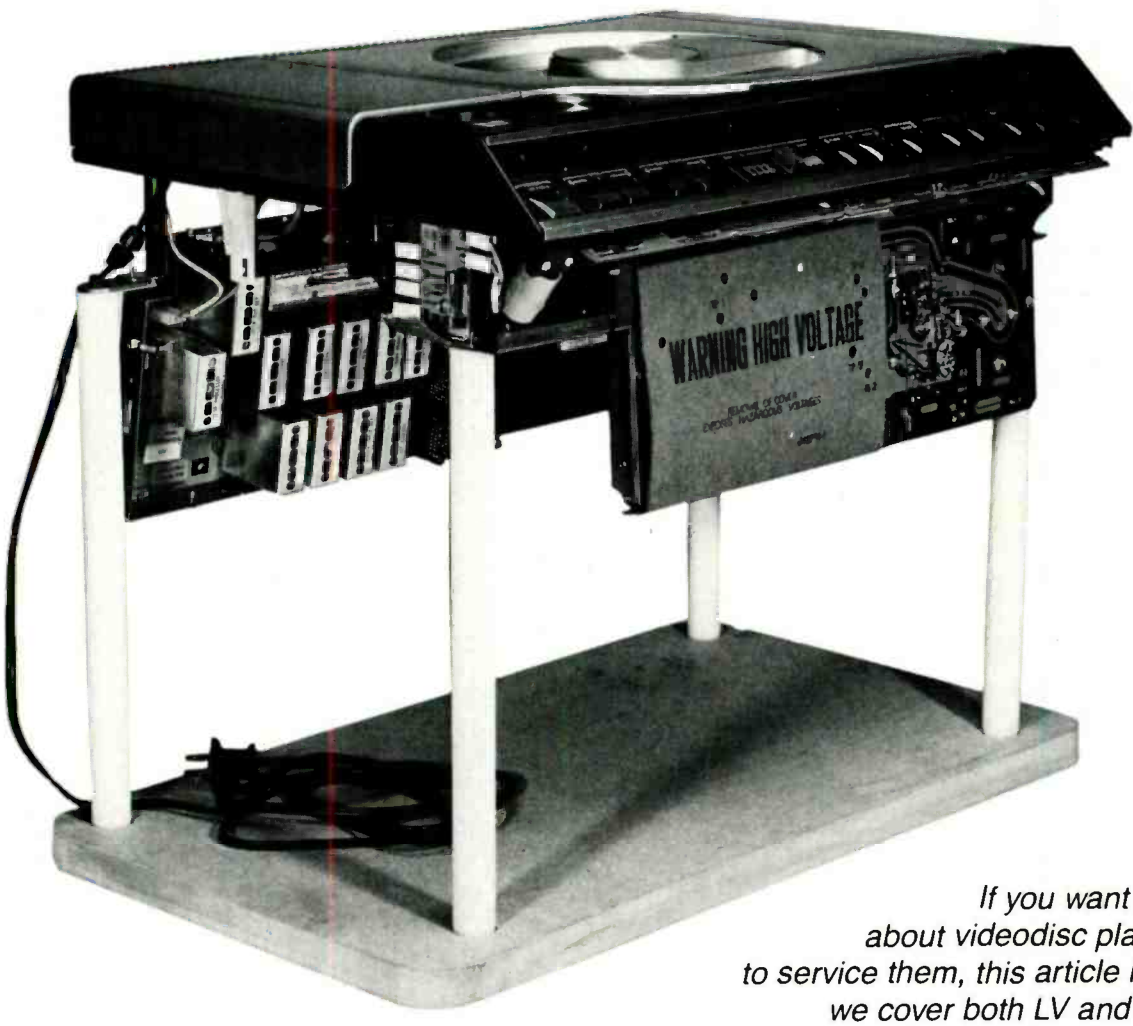


FIG 13—CLIPPING INDICATORS can be added to your amplifier, if desired.

Servicing Videodisc Players



JOHN LENK

If you want to learn more about videodisc players and how to service them, this article is for you. In it we cover both LV and CED players.

Part 2 LAST TIME, WE BEGAN our look at servicing videodisc players with a discussion of how LV players worked. Let's finish that discussion now and then move on to an overview of the CED system.

Referring to Fig. 6 (see P. 68, December 1984 **Radio-Electronics**), the prism is designed to deviate the path of the reflected beam so that the beam passes through the cylindrical lens to the photodiodes, which generate (or control) three voltages in response to the three light beams returning from the disc. The center beam generates the FM signal and the focus error-voltage. As shown in Fig. 7, if the disc is too close or too far from the objective lens, the reflected beam becomes elliptical in shape. If the disc moves too close to the objective lens, diodes A and B receive more light, and conduct more than C and D. The opposite is true if the disc moves too far from the lens. If the light bundle is not perfectly focused on A,B,C, and D, a focus error-voltage is generated to move the objective lens up or down as required to maintain correct focus. (The objective lens is attached to a coil of wire and is surrounded by a permanent magnet, similar to a loudspeaker. Current through the coil, as determined by the photodiodes, moves the lens up or down as necessary.)

The light beams striking diodes E and F serve to maintain correct radial tracking. If the beams shift to the left or right, E receives a different amount of light than F, and a radial error-voltage is generated to move the radial-tracking mirror as necessary to deflect the beam back onto the center of the track. The movable tangential-mirror operates in an identical manner, but receives the error correction-voltage from the video circuits.

We will not go further into the LV op-

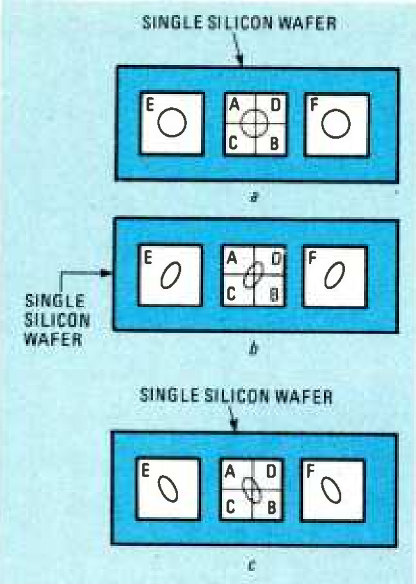


FIG. 7—PHOTODIODES are used to keep the videodisc perfectly in focus. The ones in *a* show a disc in focus, the ones in *b* show a disc that is too far away, and the ones in *c* show a disc that is too close.

tical system here, except to say one thing: The optical system of an LV player (or more properly the optical/mechanical system) is the critical part of the player from a servicing standpoint. You must follow the manufacturer's instructions regarding adjustment and/or replacement. Even a minor misadjustment can result in poor player performance (and possibly no performance).

The basic CED videodisc system

Let's begin our look at CED with a review of user controls. Again, remember that the controls described here are "typical" for most CED players.

With CED, the disc is stored in a protective plastic sleeve or caddy, which is inserted into the player as shown in Fig. 8. The CED disc is mounted on a rigid spine (Fig. 9) that holds the disc in place, both in the caddy and in the player.

In some players, a FUNCTION lever (or some similar control) must be in the load position to insert and remove the disc. Many of the more recent CED players have some form of automatic load function, and do not include such a lever.

The caddy ensures that the CED disc is always correctly loaded, as well as protected when not being played. Once the disc is loaded, the FUNCTION lever is set to play (or the automatic mechanism places the player in play). At that time, a system control microprocessor takes control of the player. At the end of the program, the user sets the FUNCTION lever to unload (or the player puts itself into unload) and the user reinserts the caddy into the player to remove the disc. The caddy now serves as a safe, convenient storage container for the CED videodisc mounted on the spine.

In players equipped with a function lever, throwing the FUNCTION lever to load applies power and opens the caddy door, allowing the caddy to be inserted into the player. After the caddy has been removed, leaving the disc and spine inside the player, the FUNCTION lever is placed in the play position. That causes a stylus to be lowered onto the disc, allowing the player to begin detecting signals on the disc and generating a display on the TV screen. Note that the CED stylus is somewhat similar to that of an ordinary phonograph pickup, in that the stylus must be driven across the grooves by means of an arm and drive motor (although not a true tracking servo as in the case of LV).

To operate a player equipped with autoload, you apply power by pressing the ON/OFF button, which places the player in load (caddy door open). A loaded caddy is then inserted into the player (gently) until the player's automatic loading mechanism takes hold and pulls the caddy into the player. (In any type of CED player, *do not force the caddy into the player*.) When the caddy spine is latched, the loading mechanism reverses and returns the empty caddy out beyond the door. You then remove the empty caddy and the player places itself in play. In about 10 seconds, a picture appears on the TV screen. In most players, a digital readout displays the elapsed playing time in minutes.

About 10 seconds after play is completed, the player places itself in UNLOAD. The caddy door then opens, and you insert the empty caddy to retrieve the disc and spine.

In a typical CED player, the user controls also include RAPID-ACCESS (to rapidly move in both forward and reverse directions for quick location of a particular program segment) and VISUAL-SEARCH controls (which do the same thing). The difference is that with former, the stylus is lifted and you get no display on the TV (you use the elapsed time indicator to find a program segment), and with the latter, you get a video display in fast motion (but no audio). Most CED players also have a PAUSE feature that raises the stylus (no video display) and cuts the audio at any point during the program.

A special code is recorded at the end of the program on each side of the disc. That code causes the player to go into and "end" mode. When the code is detected, the stylus is lifted and the elapsed-time readout will display a flashing E. The player remains in the end mode until the disc is removed, or until RAPID ACCESS or VISUAL SEARCH are selected.

Capacitance pickup theory

The CED disc is somewhat like a typical phonograph record in that the signal information is placed in grooves. However, there are many differences. One such difference is the density of the

FIG. 8—THE CED DISC is protected by a plastic caddy. The disc is inserted into the player by inserting the caddy as shown.

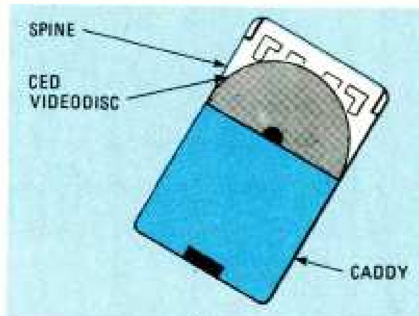


FIG. 9—THE CED DISC rests on a rigid spine. Both the disc and the spine are enclosed by the caddy.

grooves. There are about 10,000 grooves in a 1-inch radius of the CED disc (that density is about 40 times that of a phonograph record).

In CED, the audio and video signals are placed on the disc via FM carriers by varying the groove depth. As the stylus travels over the grooves, the vertical position of the stylus remains constant (unlike that of a phonograph record). A thin metalized electrode is placed on the trailing surface of the stylus. That electrode acts as one plate of a "capacitor." The CED disc, which is made of a conductive plastic with a thin lubricating coating, acts as the other plate. As the disc rotates, the distance between the bottom edge of the stylus electrode and the modulation in the groove varies as a function of the modulation, even though the stylus does not move vertically. That action varies the distance between the plates of the "capacitor" at the modulation frequency, and thus modulates the capacitance of the stylus capacitor.

The changing of stylus-to-disc capacity, in turn, modulates a UHF signal in the pickup-arm resonator assembly. The resultant AM UHF signal is peak-detected, generating an output signal that is a voltage replica of the FM audio and video carrier signals recorded on the disc. Those FM carriers are then demodulated to recover the video and audio signals.

Note that the stylus is part of a *cartridge*. Many CED player cartridges are provided with handles, and are easily removable. That makes it possible to replace the stylus/cartridge simply, often from the outside of the player through an access door. (But do not count on such easy access to the stylus/cartridge on all CED players. Also, do not assume that all CED cartridges are interchangeable with all other CED cartridges.)

CED signals

The CED system uses a vertical field rate of 60 Hz, and is phase-locked to the AC power line. The CED system also uses the conventional black-and-white TV horizontal rate of 15,750 Hz. The color signals from a CED player are at the NTSC standard of 3.579545 MHz. The video signal recorded on the CED disc is an FM 5-MHz video carrier. As shown in Fig. 10, the black level of the video signal causes zero deviation of the carrier, or a frequency of 5 MHz. Sync tips cause the video-carrier frequency to deviate to 4.3 MHz. Peak white in the video signal causes the video-carrier signal to deviate to 6.3 MHz. The sidebands from that frequency modulation extend from 2 to 9.3 MHz.

On monaural CED videodiscs, one channel of audio is placed on a FM carrier at 716 kHz. On stereo or two-channel independent CED discs, the two channels of audio are at 716 and 905 kHz. Audio signals generate a frequency deviation of ±50 kHz.

Prior to modulating the 5-MHz video carrier, the 3.58-MHz chroma subcarrier, and resultant sidebands are down converted to 1.535626 MHz (usually called 1.53 MHz), as shown in Fig. 11. Down-converted chroma is developed by heterodyning the 3.58-MHz chroma with a 5.115170-MHz oscillator signal. The resultant 1.53-MHz chroma subcarrier is then sideband-limited to ±500 kHz. Luminance information is then added to the down-converted chroma to generate a composite video signal.

CED player operation

As shown in Fig. 12, The operation of a CED player is controlled entirely by a microprocessor. User functions such as PLAY, RAPID ACCESS, VISUAL SEARCH, etc., are input to the microprocessor through the corresponding user function switches. In turn, the microprocessor decodes the commands and controls the player's electronics to carry out the functions. Note that when the *squelch* line from the microprocessor is low, all electronic circuits are disabled (to provide an automatic shutoff feature).

The microprocessor also controls the pickup arm electronics, including the *stylus lifter* operation (which raises and

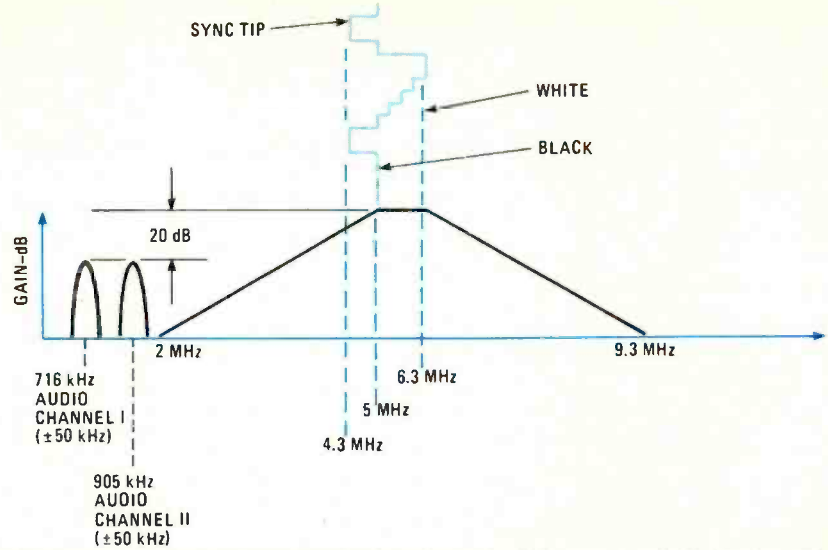


FIG. 10—CED SIGNALS. As shown here, the black level is at 5 MHz, which is the carrier frequency, the peak white is at 6.3 MHz, and the sync tips are at 4.3 MHz.

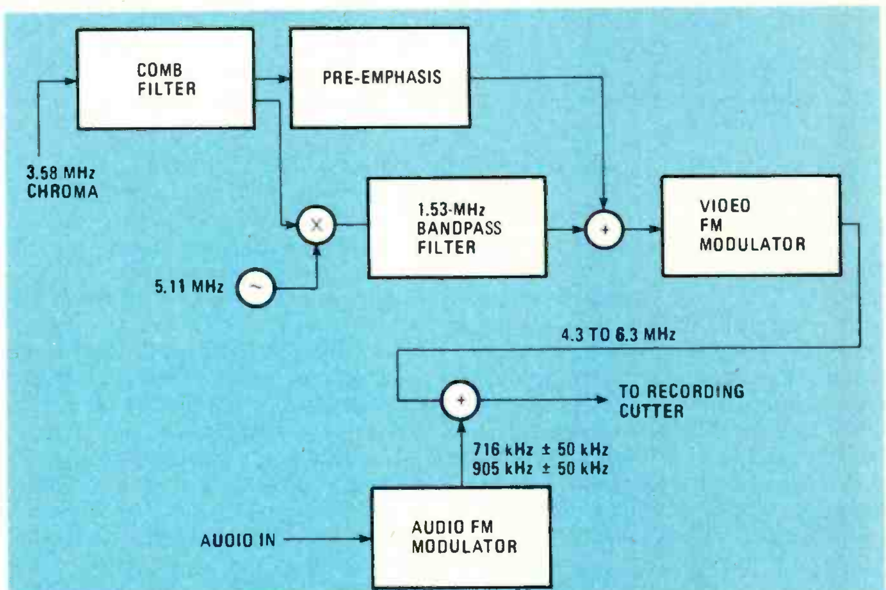


FIG. 11—THIS SIMPLIFIED BLOCK DIAGRAM shows the method used to record CED discs

lowers the stylus as various functions are initiated) and the *kicker* operation (which enables the system to provide VISUAL SEARCH, and to prevent the stylus from being stuck in a groove). The microprocessor also decodes the digital auxiliary information (DAXI) code recorded on the disc. The DAXI code contains a *field identification* number that is decoded to display the elapsed play time of the program (in minutes). Since DAXI is not available during RAPID ACCESS (the stylus is lifted from the disc) a *photo interrupter* circuit provides the approximate elapsed time by tracking the relative position of the pickup arm with respect to the disc.

The pickup arm assembly contains components that are responsible for detecting video information on the disc. The arm also contains stylus-kicker coils that cause the stylus to skip grooves in the disc (to prevent a locked groove condition and to provide for VISUAL SEARCH). Also located in the pickup arm is the *armstretcher transducer*, which corrects for timebase variation in the recovered chroma and luminance signals (the variation may be due to warpage, eccentricity, and/or changes in turntable speed).

The main function of the pickup electronics is to detect the video signals on the disc. That is done by modulating a 910-MHz *resonator circuit* (a UHF tuned line) with capacitance changes on the disc surface. The variations in capacitance cause the 910-MHz resonator center frequency to be modulated. The video and audio carrier signals from the arm are applied to two FM demodulator stages. The sound demodulator decodes one of the audio carriers and generates an audio signal that then FM-modulates a 4.5-MHz carrier in the RF modulator. The sound demodulator also contains a *defect corrector* or

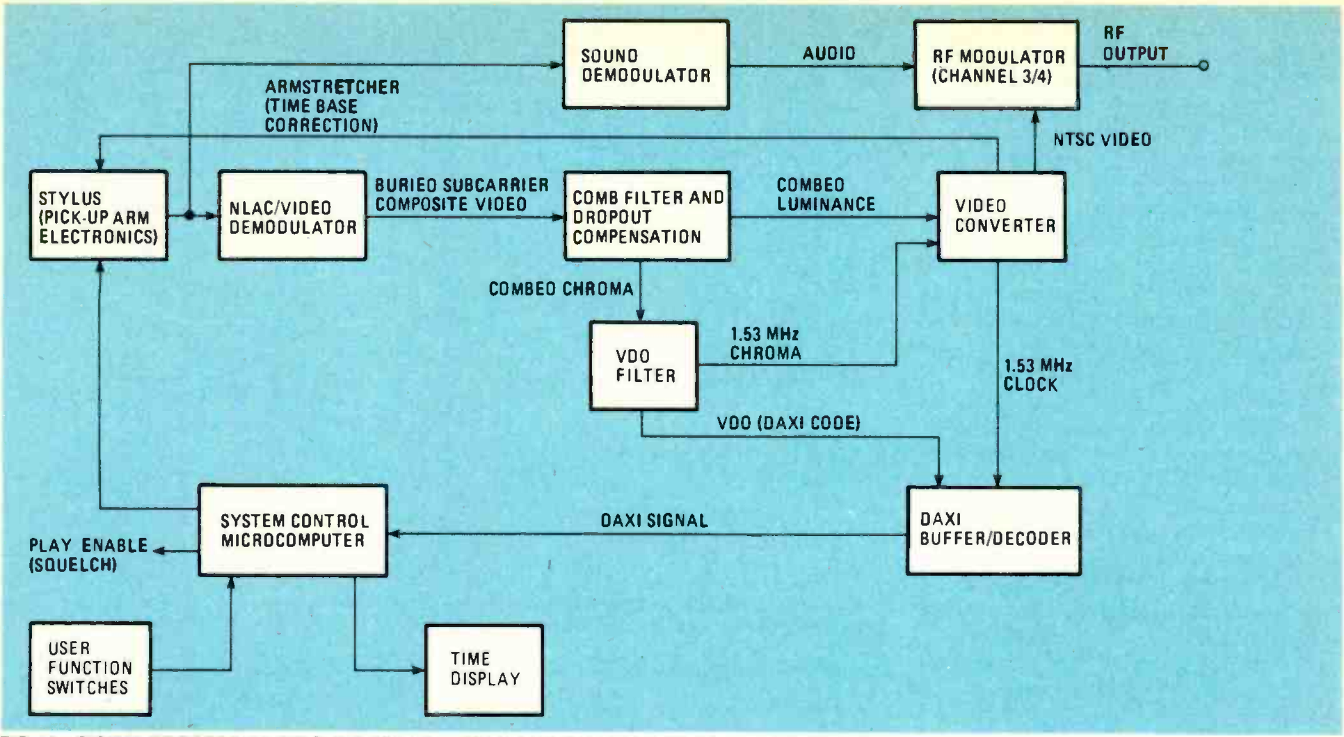


FIG. 12—SIGNAL PROCESSING CIRCUITS. This simplified block diagram shows the circuitry used to playback a CED videodisc.

dropout corrector (DOC) similar to that in a VCR.

Before demodulation, the FM video-carrier is passed through a nonlinear aperture correction (NLAC) circuit that eliminates the 716- and/or 905-kHz sound beats in the video due to sound-carrier phase modulation of the recovered video-carrier information. The video demodulator also contains a DOC circuit that allows a portion of the previous horizontal line to be inserted when a dropout occurs.

The output of the video demodulator is applied to a comb-filter circuit that separates chroma, luminance, and DAXI information from the composite video. The DAXI signal is supplied through a DAXI buffer/decoder to the microprocessor. The chroma/luminance information is applied to the video converter, which up converts the 1.53-MHz data to 3.58 MHz, and combines the chroma/luminance signals. The composite-video signal is then supplied to the RF modulator (along with the audio).

The video converter also develops a drive signal for the armstretcher time-base correction circuits. Any phase or frequency difference produces an error signal, which is applied to the armstretcher solenoid and moves the stylus as necessary to maintain a constant disc-to-stylus velocity. The armstretcher output is also coupled to the video-converter oscillator in order to maintain phase lock between the up-converted 3.58-MHz color signal and the 3.58-MHz reference.

Test equipment

The test equipment used in videodisc player service is basically the same as that used in TV service. In addition, a test, or reference disc, and a video monitor can prove to be most valuable.

Most player manufacturers provide test discs as part of their recommended test equipment and/or tools. A test disc is essentially a standard videodisc with several very useful signals recorded at the factory using very precise test equipment and signal sources. You play the test disc on a player being serviced, and note the response, and/or use the signals to perform alignment and adjustment. With the proper test disc, you can generally eliminate the need for your own signal sources (signal generators, audio generator, color generator, etc.) There is no standardization in test discs. Also, the alignment procedures found in most service literature calls for signals and displays not available on all test discs. The only way around that problem is to use the recommended test disc.

A video monitor has no tuner; it is designed to accept video and audio inputs from some source such as a separate tuner, VCR, or videodisc player. There are also some TV receivers on the market that can accept video and audio inputs. A monitor or receiver with video/audio inputs is very useful in videodisc-player service as they make it possible to examine the audio and video signals from the player before they are applied to the RF modulator so you can check the baseband signals independently from RF. Without such connections, it is difficult to tell if faults are present in the audio/video circuits or in the RF unit. If you use a TV receiver as a monitor, it is helpful to adjust the vertical-height control to underscan the picture (so you can see the video switching point in relation to the start of vertical blanking).

Maintenance

Videodisc player manufacturers disagree considerably about routine maintenance. For example, one manufacturer recommends that the laser be replaced at 5000 hours, the motors at 3000 hours, and the turntable components after 9000 plays. Another manufacturer recommends "fix it if it breaks down." Nevertheless, remember the following points.

The picture quality of an LV player can be degraded if too much dust or dirt accumulates on the objective lens. Dust can be removed with an air blower (as used on a camera lens). Never touch the lens surface. Keep the lid closed, except when inserting or removing a disc. If an LV disc becomes very dirty, hold the disc by the edges, and wipe both sides with a clean, soft, dry cloth. Check for warped LV discs since a warped disc can cause skipping, loss of picture, and even hit the lens or lid. Some manufacturers recommend removing scratches on an LV disc with polishing compound (but never use rubbing compound). If LV discs are very cold (frozen), allow about 45 minutes for the disc to return to room temperature before playing. Store LV discs in their jackets on the edge in a standard phonograph record rack. Do not stack LV videodiscs, and avoid storage in hot areas.

Keep CED discs in their caddy. Never remove a CED disc from the caddy (except in the player). Never try to clean a CED disc.

Next time, we'll show you how to service LV and CED players. **R-E**

DESIGNING WITH LINEAR IC'S

A look at op-amp based sinewave, squarewave, and triangular wave generators.

JOSEPH J. CARR

Part 8 THIS MONTH, WE'LL turn our attention to squarewave, triangular wave, and sinewave generator circuits based on operational amplifiers. The heart of each circuit is a comparator. While there are several different types of IC comparators available, for the purposes of our discussion we will consider only op-amp-based comparators.

Op-amp comparators

One author once called the comparator "an amplifier with too much gain." The purpose of the comparator is to provide unique outputs to indicate the relative values of two voltages, V1 and V2. The three possible conditions are: V1 = V2, V1 less than V2 and V1 greater than V2.

Figure 1 shows a simple comparator circuit. Note that the operational amplifier has no negative feedback circuit. That fact means the gain is essentially the open-loop gain (A_{VOL}) of the op-amp. Depending upon type, A_{VOL} might be anything from 20,000 to over 1,000,000. An implication of that is that very small input voltages will saturate the output of the op-amp. Let's assume, for example, an op-amp with 12-volt power supplies that permits ±10-volt output signals. With a gain of 100,000 (moderate for an op-amp), the input voltage that will saturate the output is (10-volts)/100,000, or 0.0001 volt (i.e. 100µV)!

If V1 equals V2, then output V_{OO} will be zero. If V1 is greater than V2, we get the same result as applying a positive voltage to an inverting amplifier: the output saturates at a negative voltage. The last situation, V1 less than V2, is the same as applying a negative voltage to an inverting amplifier: the output saturates at a positive voltage.

Diodes D1 and D2 are sometimes used to limit the output voltage V_{OO} to some value. That limitation might be to protect a following circuit, or to sharpen the output waveform (saturated amplifiers don't always recover quickly). Diode D1 limits the output on positive excursions to V_{D1} + 0.7 volts, while diode D2 limits negative excursions to $-(V_{D1}$ + 0.7 volts). In both cases, one diode is in the reverse-bias Zener region, while the other is forward biased (which accounts for the 0.7-volt term).

If we ground the noninverting input of a comparator, then V2 = 0. By applying a sinewave to the inverting input we will generate a squarewave (V_{OO} in Fig. 3) at the comparator output. Because of their ability to convert a sinewave into a squarewave, comparators are used sometimes as the input stage of frequency counters, Modem's and other devices.

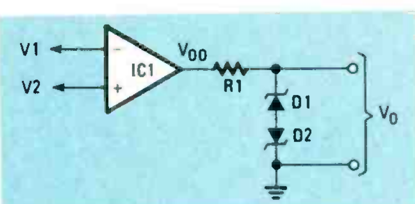


FIG. 1—A SIMPLE COMPARATOR built around an op-amp. Note that the op-amp has no feedback circuit.

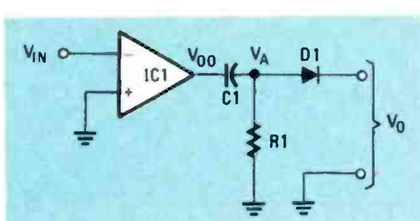


FIG. 2—THIS COMPARATOR CIRCUIT can be used to convert sinewaves to squarewaves and to detect positive to negative (zero crossing) transistions.

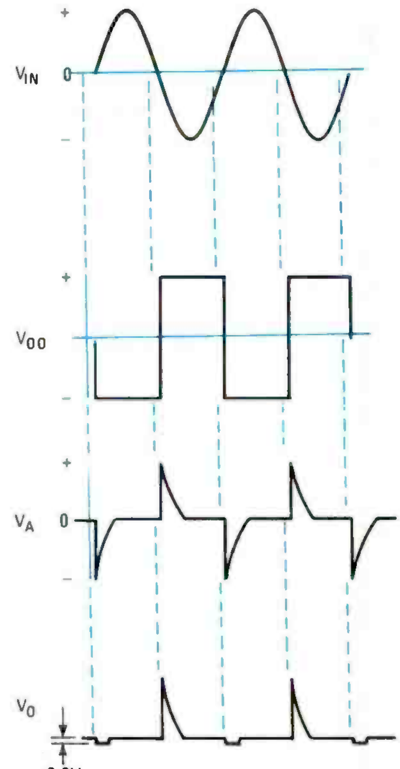


FIG. 3—WAVEFORMS for the circuit shown in Fig. 2.

A comparator can also be used as a zero-crossing detector by differentiating the comparator output; that is the function of R1 and C1 in Fig. 2. The waveform at V_A is the differentiator output. The time-constant formed by R1 and C1 should be very, very short (e.g. 0.01) compared with the duration of waveform V_{OO}. We can select either positive-going (as shown) or negative-going transitions by placing diode D1 in series with the signal line. That diode will clip the spikes of one polarity or the other. (As shown in Fig. 2, it clips the negative spikes (see Fig. 3); reverse it to clip positive spikes).

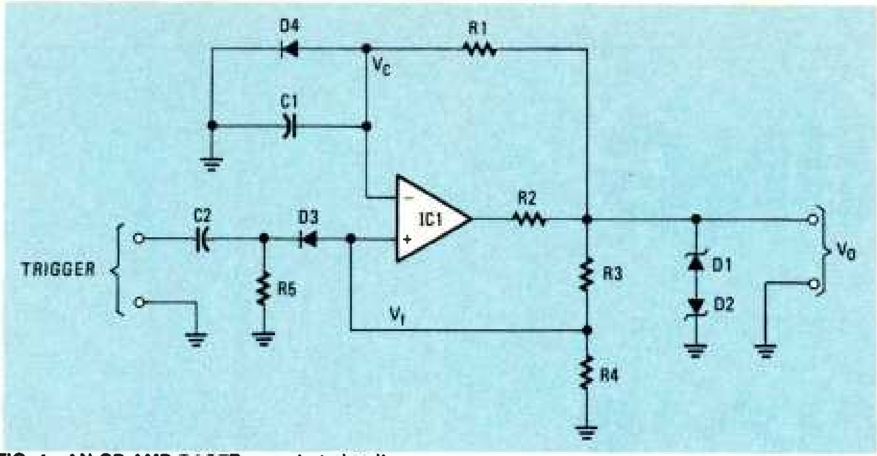


FIG. 4—AN OP-AMP BASED one-shot circuit.

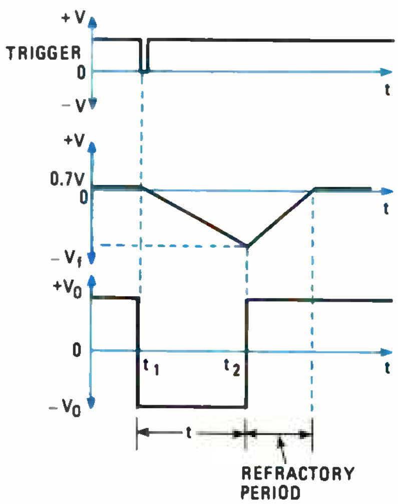


FIG. 5—TIMING WAVEFORMS for the circuit shown in Fig. 4. Note that the one-shot can not be retriggered until both the period t and the refractory period have expired.

Monostable multivibrators

A monostable multivibrator, or one-shot, is a circuit that has but one stable state. When triggered by an input pulse, the one-shot switches to the unstable state for a predetermined period of time before reverting to the stable state.

Figure 4 shows a one-shot circuit based on the op-amp, while Fig. 5 shows the timing waveforms for that circuit. There are two feedback paths in the circuit of Fig. 4. The negative feedback path consists of R1 and C1, in which C1 charged by the current in R1 generated by potential V_O. The positive feedback loop consists of R3 and R4; V_f is the positive feedback voltage.

When a negative-going trigger pulse is applied to differentiator C2-R5, the op-amp output will snap to $-V_O$, and remain there. The voltage will be negative, so capacitor C1 will begin to charge to a negative voltage. When $-V_C = -V_O$, the op-amp output snaps high again, ending the output pulse period. Capacitor C1 is then discharged because V_O is positive. Diode D1 clamps V_O to +0.7 volts.

The period T of the output pulse is:

$$T = R1C1\ln\left[\frac{1 + (0.7V/V_o)}{1 - R4/(R3+R4)}\right] \quad (1)$$

If we put some constraints on values, then Equation 1 can be simplified. If V_O is much larger than 0.7 volts (it almost always is!), and R3 = R4, then Equation 1 reduces to:

$$T = .69R1C1 \quad (2)$$

Normally, we know the required period T, and will select C1 from tables of standard values. We will thus want to rearrange Equation 2 to find R1:

$$R1 = \frac{T}{.69C1} \quad (3)$$

When designing the circuit, try several values of C1 in order to find a value for R1 that is close to a standard value.

The circuit of Fig. 4 cannot be retriggered until both period t_m and the refractory period (i.e. time to discharge C1) expire. Figure 6-a shows the operation of such a circuit. When the first trigger pulse is received at time t_1, the output V_O drops to $-V_O$ for period t_m. The second trigger pulse (at t_2) has no effect. The third trigger pulse (at t_3) effects the output because the period has expired, as has the refractory period. That type of one-shot is sometimes called a nonretriggerable monostable multivibrator.

Figure 6-b shows the timing diagram for a retriggerable monostable multivibrator. The output drops low (i.e. to $-V_O$) at time t_1 when the first trigger pulse is received. If no other pulses are received, the output will snap high (i.e. to $+V_O$) after time period t_{m1} expires. But before t_{m1} expires, a second trigger pulse is received. That pulse resets the timing for another period t_{m2}. The total period the output remains low is t_m plus the previously expired portion of the other pulse. In other words, $t_m(\text{total}) = t_m + (t_2 - t_1)$.

Figure 7 shows a method for making the one-shot circuit of Fig. 4 into a retriggerable one-shot. Transistor Q1 is connected across timing capacitor C1. In the dormant state, the positive voltage on the trigger input keeps Q1 reverse biased, thereby turned off. But when a negative triggering pulse is received, however, Q1 is momentarily forward biased, discharging C1; that restarts the timing period. A subsequent trigger pulse will discharge C1 again, provided the pulse is received prior to the end of t_m (or after the refractory period).

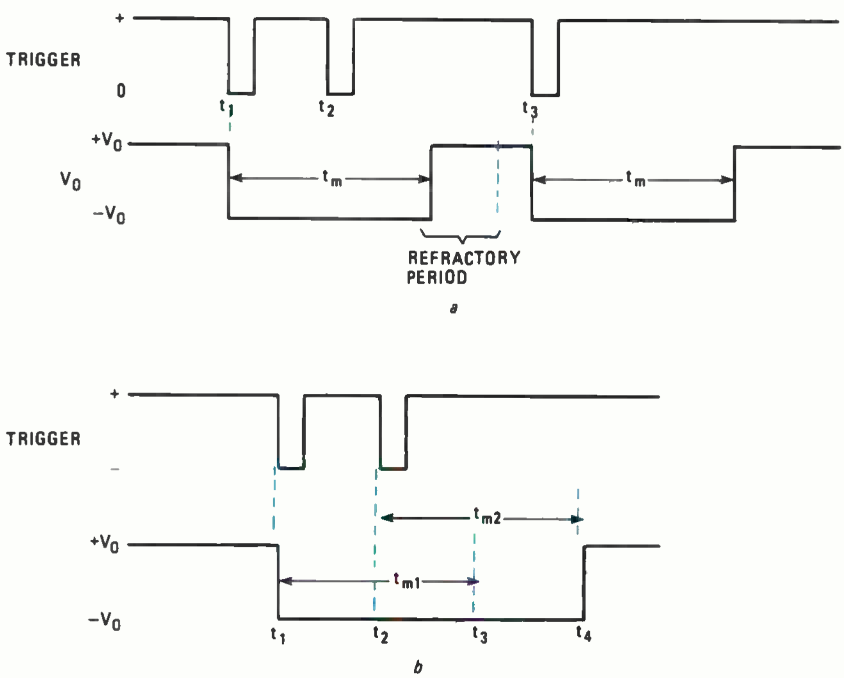


FIG. 6—A NONRETRIGGERABLE ONE-SHOT can not be retriggered until both t_m and the refractory period have expired; the timing diagram for such a circuit is shown in *a*. In a retriggerable one-shot, each trigger pulse restarts the timing period, t_m; the timing diagram for that circuit is shown in *b*.

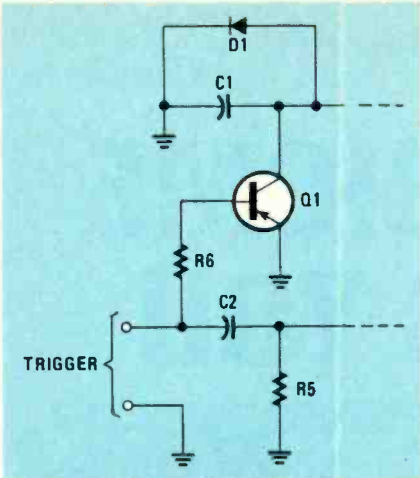


FIG. 7—THE NONRETRIGGERABLE ONE-SHOT of Fig. 4 can be turned into a retriggerable one-shot with the modification shown here.

Squarewave generator

A squarewave generator produces a train of equal duration pulses that alternately snap between positive and negative extremes. A perfect squarewave is symmetrical in two ways: amplitude and period. In other words, the positive and negative excursions have equal durations and equal amplitudes. A perfect squarewave will also have extremely fast rise and fall times (which requires high-frequency op-amps). An implication of that latter characteristic is that the squarewave is rich in upper harmonics (which is why squarewave oscillators are used in frequency multipliers and crystal frequency-markers).

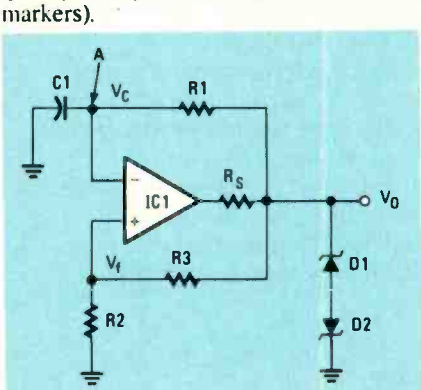


FIG. 8—A SIMPLE op-amp based squarewave generator.

Figure 8 shows a typical squarewave generator based on an IC operational amplifier; Fig. 9 shows the timing diagram for the circuit.

The squarewave-generator circuit bears a certain resemblance to the one-shot circuit shown previously. There are two feedback paths. The negative feedback path consists of timing components R1 and C1. That circuit causes capacitor C1 to be charged by a current in R1, which is generated by output voltage V_O.

The positive feedback path consists of resistor voltage-divider network R2/R3. Voltage V_f (see Fig. 8) is the feedback voltage, and is a equal to $V_O \times R2/(R2+R3)$.

Looking at Fig. 9, output waveform V_O is superimposed on capacitor charging voltage V_C. Let's assume the output V_O snaps high (i.e. to $+V_O$) at turn-on. Capacitor C1 will start charging in a positive direction at a rate determined by the values of R1, C1, and V_O. When capacitor voltage V_C rises to $+V_f$, the op-amp essentially sees a zero-voltage differential input, so the output snaps low again. At this point, V_O is negative so capacitor C1 begins to charge in the negative direction. When $-V_O = -V_f$, the output will snap high again.

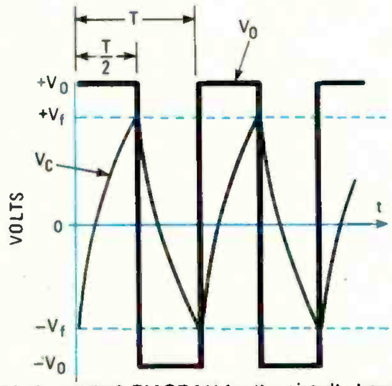


FIG. 9—TIMING DIAGRAM for the circuit shown in Fig. 8.

A generator whose output alternates back and forth, as is the case for the circuit in Fig 8, is called an astable multivibrator; in other words, it has no stable states.

The period of the waveform in Fig. 9 is the sum of high and low times, and can be expressed by:

$$T = 2R1\,C1\,\ln\left(1 + \frac{2R3}{R2}\right) \qquad (4)$$

where T is in seconds. If R2 = R3, we can simplify Equation 4 to the form:

$$T = 3.2\,R1C1 \qquad (5)$$

As with many textbook equations, Equations 4 and 5 are not in the most practical format. In most cases, we will know T and will select C1 from a table of standard values. Thus, we need to rearrange Equation 6 to solve for R1. The value of R1 can be calculated from:

$$R1 = \frac{T}{3.2C1} \qquad (6)$$

For example, let's find the value of R1 if T is 0.2ms (2×10^{-4} seconds) and C1 is 0.01µF.

R1 = T/3.2C

R1 = 0.0002 sec/3.2(1×10^{-8} farads)

R1 = 2×10^{-4} sec/3.2×10^{-8}

R1 = 6250 ohms

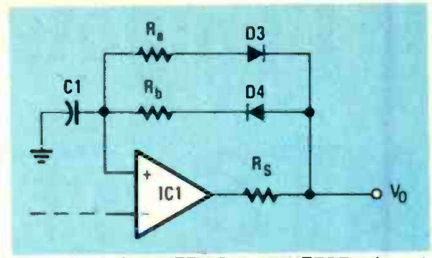


FIG. 10—A SYMMETRICAL WAVEFORM is not always desired. This modification to Fig. 8 produces an asymmetrical waveform.

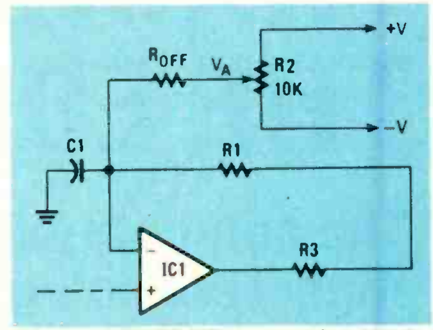


FIG. 11—ANOTHER WAY to generate a squarewave with an asymmetrical waveform is to use a potentiometer. The circuit shown here is another modification of the one shown in Fig. 8.

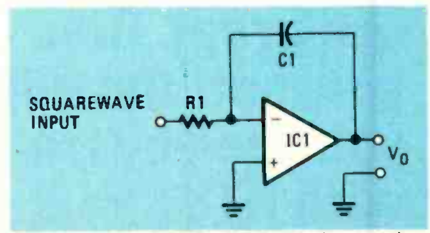


FIG. 12—ONE COMMON METHOD of generating a triangular wave is to input a squarewave into a Miller integrator.

The circuit of Fig. 8 produces the symmetrical waveform of Fig. 9. Both positive and negative excursions occupy equal time durations. That situation occurs because $|+V_O| = |-V_O|$, and C1 is charged through R1 on both sides of the waveforms. Unfortunately, however, symmetry is not always desired. The modifications to Fig. 8 shown in Figs. 10 and 11 provide asymmetry in a controlled manner.

The method shown in Fig. 10 uses two feedback resistors and a pair of switching diodes to accomplish the job. The polarities of the diodes are such that D3 is forward biased by negative V_O, while D4 is forward biased by positive V_O. As a result, the capacitor is charged by $-V_O$ via R_a, and by $+V_O$ through R_b. If R_a and R_b are not equal, then the durations of positive and negative excursions of waveform V_O are not equal.

An alternate to varying the symmetry is shown in Fig. 11. An offset voltage (either positive or negative) is provided by setting potentiometer R2. Since varying R2 will vary the voltage across C1, it can be used to modify the charging time required for V_C to reach either $-V_f$ or $+V_f$ (depend-

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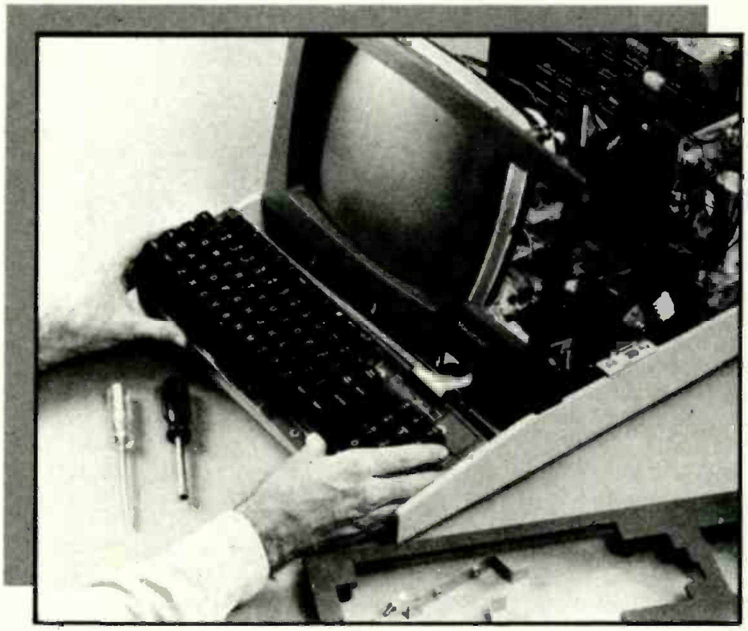

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ing upon the polarity of V_A. An advantage of the circuit shown in Fig. 11 is that it includes a potentiometer that allows you to continuously vary the relative duration of the positive and negative excursions of the waveform.

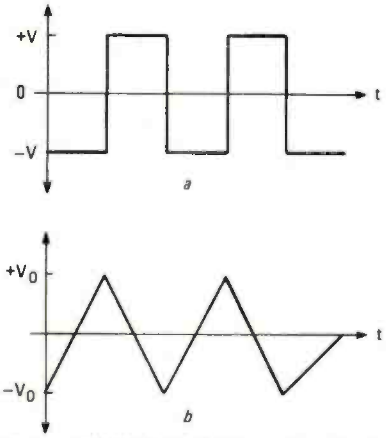


FIG. 13—TIMING DIAGRAM for Fig. 12. The squarewave, shown in *a*, is input to the Miller integrator; the resulting triangular waveform is shown in *b*.

Triangular waveform generator

There are several ways to generate a triangular waveform. Figure 12 shows one very common method—drive a Miller integrator with a squarewave generator. The timing waveform is shown in Fig. 13.

The triangle, wave circuit is modified in Fig. 14 to include a self-generating squarewave source. The frequency of the output of that circuit is given by:

$$f = \frac{R2}{4R3\ R1\ C1} \qquad (7)$$

Sinewave oscillators

Sinewaves can be generated either by filtering a square or triangular waveform, or by using a feedback oscillator circuit.

The filtering method uses a very sharp cut-off low-pass filter, or a notch filter, to remove the harmonics from a complex waveform such as a triangular wave or squarewave. Of course, the amplitude is greatly reduced, but that problem is easily overcome through the use of fixed-gain amplifiers.

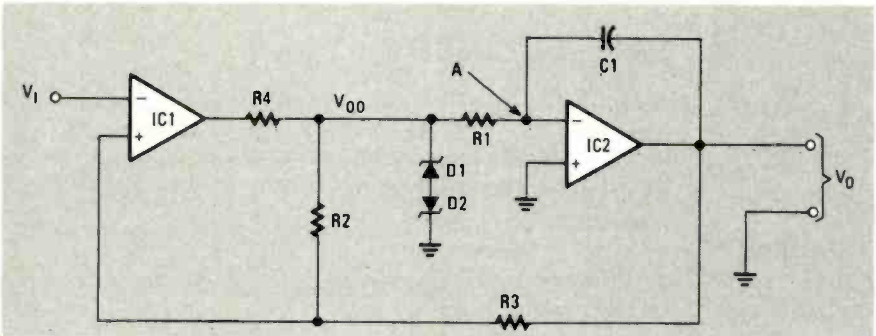


FIG. 14—THIS TRIANGULAR-waveform generator includes an integral squarewave generator.

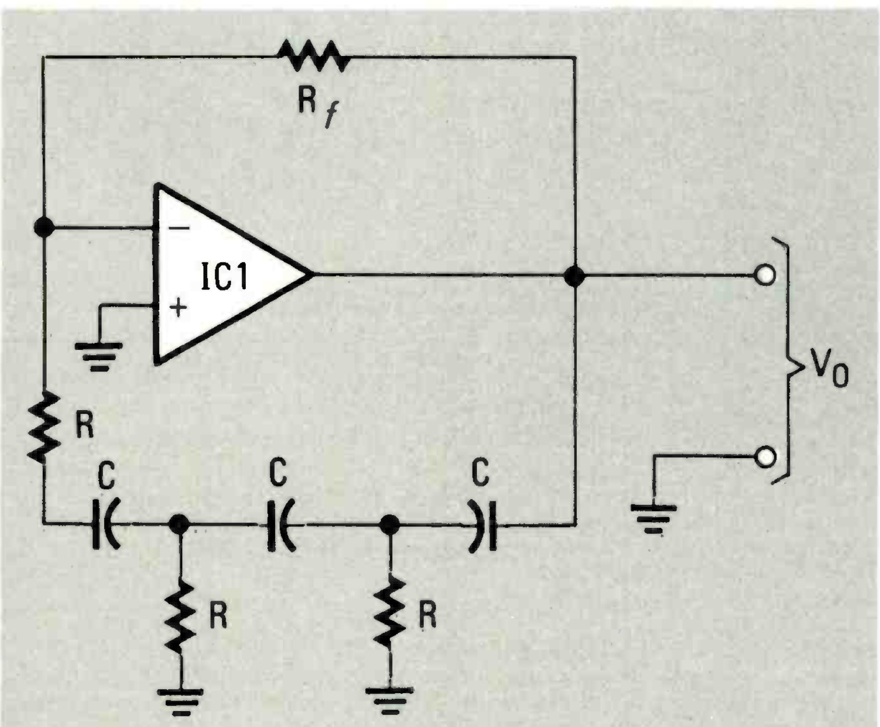


FIG. 15—AN RC phase-shift oscillator, such as the one shown here, can be used to generate a sinewave.

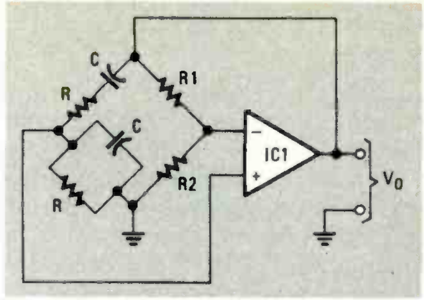


FIG. 16—THIS WIEN-BRIDGE OSCILLATOR can also be used to generate a sinewave output.

An advantage of the filtering method is that it is easy to maintain amplitude stability over a wide range of frequencies. Where fixed frequency operation is used, however, one might want to use a feedback oscillator.

There are two criteria that must be met by a feedback oscillator: The loop gain must be one or greater, and the feedback must be in-phase with the input signal only at the desired frequency of oscillation. Two different sinewave oscillator circuits are presented here—the RC phase-shift oscillator and the Wien-bridge oscillator.

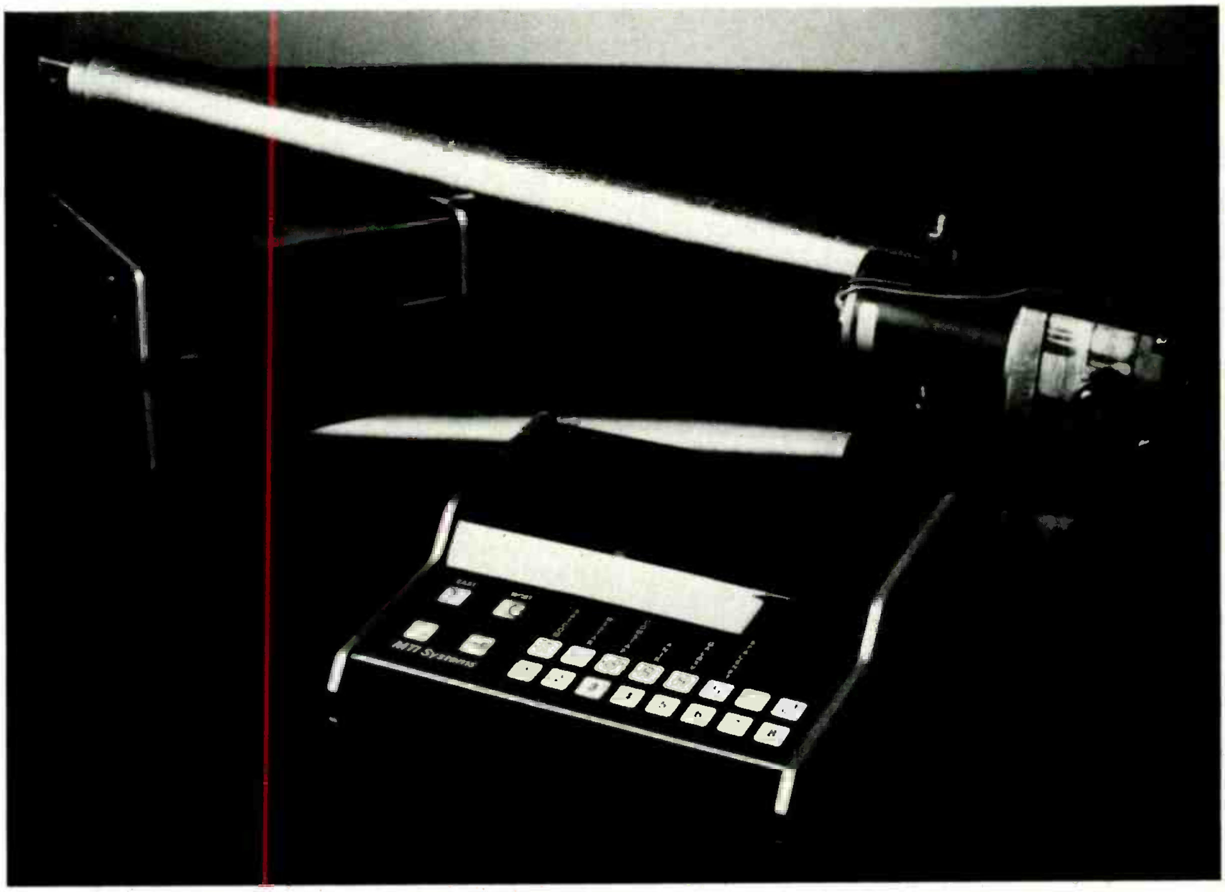
The RC phase-shift oscillator is shown in Fig. 15. The inverting amplifier IC1 provides 180 degrees of the required 360 degrees of phase shift. The remaining 180 degrees of phase shift is provided by a three-stage RC network (each stage provides 60 degrees). The frequency of oscillation is given by:

$$f = \frac{1}{2\sqrt{6}RC} \qquad (8)$$

The circuit will oscillate provided that the gain, which is set by $-R_f/R$, is sufficient too overcome the losses of the RC phase-shift network. Analysis shows that the attenuation factor of the network (V_f/V_O) is 1/29, so the gain must be 29 or more.

The Wien-bridge oscillator is shown in Fig. 16. The "bridge" is a frequency-selective AC version of the old-fashioned Wheatstone bridge. If R1 = 2R2, the circuit will oscillate at a frequency of $f = 1/2\pi RC$. **R-E**

"Radio is just like TV—only the picture tube blew."



Satellite-TV Accessories

Once you have your basic TVRO system set up, it's time to look for add-on devices to make your viewing more enjoyable, or simply more convenient. Here we'll take a look at some of those accessories.

MARC STERN

WHILE A BASIC TVRO SYSTEM—MADE UP of a receiving antenna, LNA, downconverter, and receiver—will certainly bring you much enjoyment, there are many accessories that can make your setup even more pleasant. For example, you can add a stereo synthesizer or stereo processor, a remote antenna actuator, and a host of other devices.

In this article, we'll tell you about some of the many of the satellite add-ons that are available and how to choose them. We'll also describe what they can do for your system. Let's begin our look at these items with the stereo synthesizer and the stereo processor, both of which will add to your listening pleasure.

Stereo synthesizers and processors

A stereo synthesizer, as its name implies, creates synthetic stereo sound from the mono signal that may be transmitted by a satellite's transponder. It is pseudo stereo, not true stereo sound. However, when you use such a synthesizer with a good stereo amplifier, you can achieve rather good results.

A stereo processor, on the other hand, is used to decode stereo signals from satellites. The result is true stereo, not pseudo stereo. We recommend stereo processors over stereo synthesizers, especially since the price of decoders has dropped rather dramatically. In fact, stereo synthesizers are becoming increasingly difficult to find, because their price advantage has slipped away.

A stereo processor should have a tuning range from 5.5 to 8 MHz—that will permit you to tune in the whole range of possible audio subcarrier frequencies. If you're a regular **Radio-Electronics** reader, then there's a good chance that you'll want to build a stereo processor yourself. If so, check our October 1984 issue for construction details for a stereo decoder.

Many stereo processors feature selectable bandwidths (150 and 500 kHz, for example). Selectable audio bandwidth can be a useful feature to help increase the signal-to-noise ratio of many signals. But remember that as you decrease the bandwidth, you lose some of the high-frequency music information. However, in noisy conditions, that is often a worthwhile tradeoff.

IF filter

Another useful add-on component for your TVRO setup is an IF filter. There are several kinds. One type is a passband filter—it filters out those frequencies above and below the satellite-TV IF. It also narrows the IF bandwidth. Thus, it can be useful to pull some weak signals out of the snow (but you don't want to use it with stronger signals).

Another type of filter is the notch filter. Its main purpose is to eliminate annoying black and white spots (sparklies), which are usually caused by terrestrial interference. (Transcontinental telephone microwave transmissions have carriers at ±10 MHz from the transponder's center frequency.) When connected between the downconverter and receiver, the filters can eliminate the interference at 60 and/or 80 MHz.

Do you really need a filter? We think that you should put off buying one until you set up your TVRO system. You may find that your reception is adequate without a filter. Anyway, they are easy enough to install (they just connect in-line between the downconverter and receiver) so that you can add them at any time.

Antenna positioners

Because of their popularity, it is becoming hard to think of antenna positioners as TVRO add-ons. Since few people are willing to run outside to crank their dishes to a new position, antenna positioners are becoming more like standard equipment! In general, an antenna positioner consists of two parts: a control unit and an antenna actuator. The control unit is mounted indoors at the satellite receiver. It controls the actuator, which is mounted at the dish.

The two units are connected by a cable, and the control voltage is low, usually around 24 volts DC. Many control units feature digital displays that let you return the antenna to a particular satellite. Those displays, typically from 2 to 4 digits, are not true indicators of position. They are guide numbers so that you can return to a particular satellite. In other words, when you locate a satellite (such as SATCOM F3), you make note of the display (say, "247"). Then, whenever you want to return to SATCOM F3, you simply press the direction controls until the display shows "247." Some positioners allow you to store satellite positions in memory so that you can return to them, with a single command. And some units let you store the satellite name in memory as well.

When shopping for an antenna positioner, make sure that the actuator is protected against damage from overtravel. If it isn't, someone who is not familiar with the system could easily damage the actuator. Most systems do have limit indicators and automatic braking so that the possibility of damage from misoperation is small.

Some positioners offer "extra" features that you might find to be very convenient. Read through our look at the marketplace for more details. The other considerations in buying an antenna positioner are mostly mechanical. Of course, you should look for sturdy construction, and systems with little backlash. Weatherproofing is also desirable. Most important of all, perhaps, is to make sure that your actuator has at least a one-year warranty.

Video switching

It is quickly becoming true that the average television set isn't just receiving an input from a VHF or UHF antenna anymore. Instead, it may have inputs from a video cassette recorder, a cable-television system, a home computer, as well as a home satellite-signal receiving system. A video switcher is almost a necessity to eliminate the familiar "rat's nest" of wire and cable, and the confusion that grows as the TV is called upon to handle so many items.

There are two things you want to look for when buying a switcher: High isolation between inputs, and a lot of inputs. (You should get more inputs than you think you have need for—you're sure to need them eventually.) As an added convenience, you might want to buy one with two or more outputs as well.

There are other accessories that you can get for your TVRO. Signal splitters, distribution amplifiers, remote controllers, outboard signal-strength meters and tunable audio (if your receiver is not so equipped), etc. can all be found along with a host of other goods. Let's now take a look at just some of those add-ons you will find in the marketplace:

Arunta

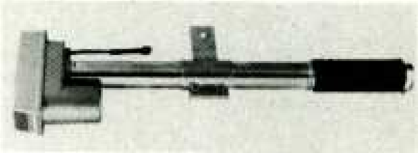
Arunta has three IF filters available for $165. The *47022* threshold extension filter passes 59 to 81 MHz with fairly sharp skirts. It helps to reduce interference on weak transponders. The *47019* notch filter features dual notches at 60 and 80 MHz. It is most useful for eliminating terrestrial (telecommunications) interference. The narrow-bandwidth *47015* enhances reception of INTELSAT feeds. (While most TVRO systems have bandwidths of about 27–30 MHz, INTELSAT signals have bandwidths of about 18 MHz.) Each filter can be simply turned on or off with the touch of a button (especially important with the *47015*).

Arunta also offers their *SSP-318* satellite-stereo processor, which can be used to listen to mono signals as well as those broadcast in multiplex, adaptive deviation multiplex, matrix, and discrete formats. It features dual tuners, a 5–8 MHz range, automatic deviation, dual tuning meters, noise reduction, dynamic-range expansion, and AFC. Dual IF bandwidths (300 kHz and 130 kHz) are also offered.

Burr Equipment

Burr's *Sat-Trol 1* satellite actuator and positioner control box, is available for $479.95. The *Mini-Trol* is available for $399.95.

The *Sat-Trol 1* uses membrane-type EAST-WEST control keys; it has dual scan rates and a position indicator. The actuator uses zinc-plated tubes, a die-cast aluminum powerhead, and a special weatherproof boot.



BURR EQUIPMENT *Sat-Trol 1* actuator.

The *Mini-Trol* is designed to eliminate electronic problems. Built without potentiometers or Hall-effect sensors, only the motor and screw are left at the dish. Although that system is very reliable, there is no display of position at the control unit. So returning to a specific satellite is more difficult than it would be with the *Sat-Trol 1*, which does feature a digital display of position. The *Mini-Trol* features pushbutton operation and an automatic brake circuit. It is rated at 1,000 pounds thrust and 5,000 pounds static loads.

R.L. Drake

Drake offers several add-on TVRO accessories; among them are *APS24* antenna positioner ($499), their *VS35* video selector ($165), and their *NF60/80* notch filters.

The *APS24* makes it easy to relocate a polar-mount antenna. The console features a two-digit LED display and EAST-WEST actuator buttons. The control motor operates on 36-volts DC, and can be used with most antennas that require a maximum linear travel between 18 and 36 inches.

R.L. DRAKE *VS-35* video switch.

The *VS35* video selector takes inputs from 5 program sources. It offers pushbutton source-selection and isolation is better than 60 dB. Its frequency response (0 dB to 3.5 dB) is 50–400 MHz. Three outputs are offered: TV, REMOTE, and

VCR. All active inputs and outputs are indicated by front-panel LED's.

The *NF60/80* notch filters, available for $79.95, cut out terrestrial microwave interference. The *NF60* is for removing interference at 60 MHz, while the *NF80* is for 80 MHz. For each filter, the notch depth is 45 dB, and the 3-dB bandwidth is ± 1.5 MHz of the center frequency.

Dynasat

The *DT-200 Power Tracker*, available for $289, combines a weather-sealed, maintenance-free actuator and an electronic control unit that features two-speed east and west controls. An LED readout and *Polarotor I* control are also included. The 24-volt DC system uses Hall-effect sensors. It features an 18-inch stroke, hardened steel gears, stainless steel extension tube, and a rated thrust of 2,000 pounds.

Earth Station Accessories

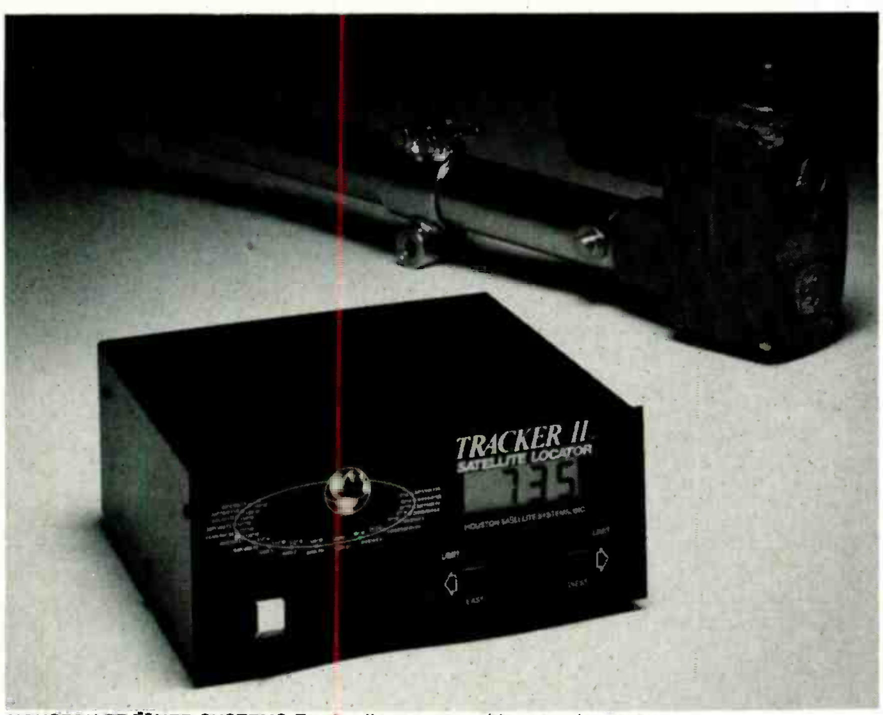
A weatherproofing boot for satellite actuators/positioners is available for $21.50. It can be used to protect many positioning jacks. A two-piece boot protects motor and gear works.

Houston Tracker Systems

The *Tracker IVplus* is a top-of-the-line antenna positioner with remote control ($610 with remote, $439 without). The computer-programmable drive system features UHF wireless remote control (up to 200-feet away). Other features include a 16-character, blue fluorescent display that gives instructions while programming, and parental lockout capability.

The *Tracker IVplus* offers control of the Chaparral *Polarotor I*, and can interface directly to many receivers for automatic polarity selection. (Some receivers require an interface board.) The east-west over-travel limits are user programmable. The unit is supplied with an 18-inch, ball-screw actuator and 100 feet of wire.

The *Tracker II* ($305) is a manual-drive antenna and positioner that features an LCD readout of satellite "location" and user-adjustable over-travel limits. It features a self-contained 6-amp power supply. The suggested system load is 800 pounds or a 10-foot lightweight dish. The *Tracker II* is supplied with an 18-inch actuator and 100 feet of wire.



HOUSTON TRACKER SYSTEMS ***Tracker II*** **antenna positioner and actuator.**

ICM/Video

The *VP-300C* ($349) is a completely automatic video processor. It regenerates synchronizing signals, and a clamp circuit removes hum and flicker. It features a copyguard stabilizer, four video and audio outputs, NTSC and PAL compatibility, AGC, and a 6-MHz bandwidth. Its S/N is specified at 50 dB.

ICM VIDEO ***Signal Purifier***

The *VE-200C* ($495) is also automatic. It regenerates all sync signals and features a copyguard stabilizer, four audio and video outputs, image enhancement and noise reduction, fade to black, a 5-MHz bandwidth, and its S/N is specified as 60 dB. It has controls for video level, color level, burst phase, and noise level.

The *SA-50 Signal Purifier* ($150) is a filter/amplifier containing a five-pole bandpass filter to reduce out-of-band interference. The *SD40* ($325) stereo matrix decoder is used to decode matrix-stereo transmissions. The *TA-30* ($115) is a tunable-audio device—it allows you to tune all subcarrier frequencies from 5.5 to 8.5 MHz (but not in stereo).

Kent Research

The *SurveyorSeven*, available for about $320, is a programmable (12-memory) antenna positioner that offers an optional remote control. It features an LCD antenna "position" indicator; east-west travel and limit indicators. Up to 12 positions can be set in its non-volatile memory and recalled by turning a 12-position rotary control.

The *Surveyor-167*, which sells for about $700, is perhaps the most sophisticated controller on the market. It is interfaced directly with your receiver. (That is done by your dealer—or by yourself, if Kent is convinced that you are capable of doing it yourself. One disadvantage is that interfacing the *Surveyor-167* will void your receiver warranty.) Once the *167* is installed, your complete station can be controlled by a handheld unit. That includes channel, scanning, polarity, audio-frequency (and stereo) selection; video inversion, power and volume control, antenna position, fine tuning, bass and treble, AFC, etc. The *167* also features a parental lock-out system.

KENT RESEARCH ***Surveyor-7*** **antenna positioner and actuator.**

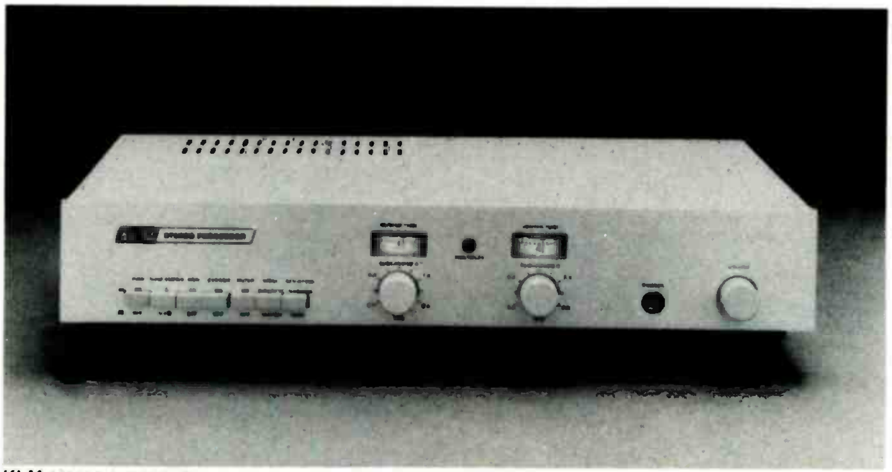
There are no knobs, dials, or readouts on the unit—all controls are on the handheld remote. Another impressive feature is that you can display in color, on your TV screen, the satellite that you are watching, the channel you are watching, the date and time, the channel lock-out status and total system status.

The *Surveyor-167* features a 36-satellite memory, two-speed drive, up and down scanning, a timer, parental lock-out, a key lock to prevent unauthorized programming, polarity control, non-volatile memory, LED indicators, skew compensation, and a scan function. The actuator has an

18-inch stroke and its thrust is rated at 1,500 pounds. Skew, tilt, and format correction are chosen automatically, and audio frequencies are automatically selected. It also features stereo decoding, volume mute, bass-treble adjustment, AFC, and dynamic noise reduction.

KLM

KLM station-accessory offerings include their *Memory Trak* ($550) and a stereo processor ($360). *Memory Trak* is an antenna positioner featuring a 50-satellite-position memory, digital readout of relative position and satellite name, polarity control, full east-west manual dish control, and 80-hour memory retention.



KLM stereo processor

KLM's stereo processor works with standard receiver video outputs or unfiltered, unclamped video outputs. It features discrete and matrix modes, A and A + B subcarriers, narrow and wide deviation, individual A and B tuning controls, a 5.3–8.3 MHz range, center tuning edgemeters, noise reduction, an interference filter, expansion switch, LED multiplex indicator, video output jack, and mono-audio output jack. The decoder includes an amplifier section (5 watts per channel) with volume control, left and right speaker terminals, headphone jack, and bass boost.

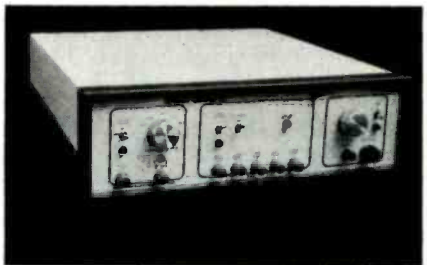
Luxor

The model *9534* remote-controlled antenna actuator is available for $699. It features wireless remote operation, microprocessor control, 30-satellite memory; battery backed-up memory, 175-feet of cable, and automatic polarity switching. The unit can be manually controlled for programming setup and override. An LED satellite readout and position readout is included. The *9536* infrared remote control sensor is available for $99.

Newton Electronics

Newton offers satellite-TV test equipment, including the $995 *GBS 2600*, which features a 3.7–4.2 GHz output. It is calibrated in transponder numbers and the output can be modulated with audio and video to test LNA's, LNC's or downconverters. It features an RF-transmitting horn antenna, and selectable signal level at 70 MHz and 3.7–4.2 GHz. Audio (mono, discrete or matrix stereo) and composite video outputs, as well as a color-bar output are available. The unit contains a built-in battery charger.

The *GBS 2000* ($2,995) features a microwave output that is tunable from 3.7–4.2 GHz. Its power level is equivalent to 11 dB CNR. Its LNA feed has a nominal level of −30 dBm. The 70-MHz output, which can be used to align IF and detector



NEWTON ELECTRONICS *GBS 2000* satellite-TV test set.

systems, has a power level of −10 dBm. It contains an internal audio generator, and the four most commonly used subcarrier frequencies (5.8, 6.2, 6.8, and 7.4 MHz) are front-panel selectable.

Quantum Associates

The $395 *Quanta Q-7* programmable satellite scanner can be programmed for 12 satellites and has a 2-digit LED position readout as well as a liquid-crystal clock display. It features manual and automatic scanning capability. Two drive units are available: The short unit extends 18 inches, the long drive one 52 inches.

Regency

The *VDS-5000* electronic video switcher, available for $119.95, features auto-

REGENCY electronic video switcher

matic pushbutton switching of four inputs (labeled ANT, SAT, VCR, and GAME) to two outputs (TV and VCR). The inputs are indicated by LED's.

Sat-Tec

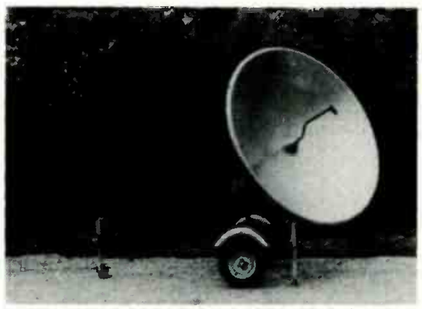
The $159 *S-5000* stereo demodulator decodes matrix or discrete stereo. It features 5–8 MHz subcarrier tunability. The bandwidth is selectable (150 or 500 kHz)

SAT-TEC *S5000* stereo demodulator.

and its frequency response is 15 Hz to 15 kHz. Its harmonic distortion is specified as less than 1 percent. Standard line outputs, for connection to stereo amplifiers, are included.

Satellite Reception Systems

A variety of devices are available, including the *Speedster* trailer ($1885),



SATELLITE RECEPTION SYSTEMS *Speedster* trailer and dish.

which includes an 8-foot dish and feed. The trailer, which weighs 875 pounds, can be taken with you when traveling! It uses a 3-inch pole polar mount.

Superwinch

Superwinch offers their $470 *Skywalker II* programmable antenna controller and actuator. It features an LED readout, a 16-position satellite memory, illuminated satellite-position display, a limit indicator (which shows antenna is at end of travel), one-week memory protection, overvoltage protection, and full automatic and manual operation. **R-E**

HOBBY CORNER

EARL "DOC" SAVAGE, K4SDS,
HOBBY EDITOR

A versatile module

ONE OF THE MORE INTERESTING THINGS in the fast-paced world of electronics is to discover a small company starting up on the basis of a new idea or product. The fascinating part is to watch what happens to the company after it has started up. Many such fledglings last only a short time and then fade away. You can't always predict whether they'll be able to make a go of it, because there are so many factors involved.

Many emerging companies with good products or ideas have gone down the tubes because their service, dependability, and responsiveness to customers has been somewhat less than desirable. Don't get us wrong: We're not saying that an occasional new product or idea doesn't make a difference in the success or failure of the company. What we are saying is that there's more to the creation of a successful business than the product itself.

Ben Johnson's Kaltek is one of those enterprises that seems to be doing the right things and turning out useful new products. You may recall a discussion back in March 1982 in which I told you about their small module—the RC-111—which, along with a calculator and a handful of common components, can be used to build a capacitance meter, ohmmeter, and so on. That original module is still available ($14.62, postage paid). But now, there is an advanced version of the original device.

The RC-103 (which sells for $18.00 postage paid) is an RC-111 with Schmitt-trigger inputs for increased precision. Using the RC-103 along with a half-dozen common components and a simple calculator, you can build an instrument to measure resistance, capacitance, temperature, RPM, length, or angles. A stopwatch or a light meter may be constructed just as easily. So that you will know just how simple the whole thing can be, the basic circuit is shown in Fig. 1.

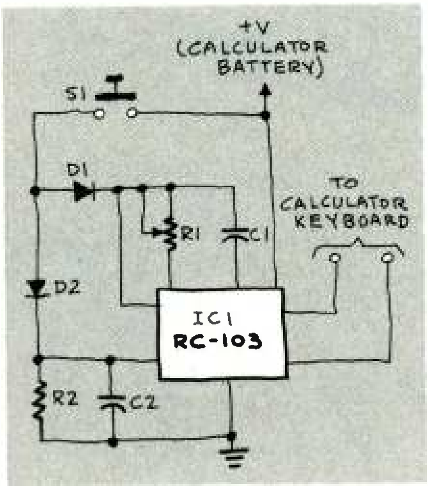


FIG. 1

That circuit may be used, too, in a variety of applications depending on the component used at R2. For instance, by replacing R2 with a photodiode, you can build a light-intensity meter. The circuit may also be used to construct a capacitance meter, ohmmeter, and so on. (For more information and/or applications contact Kaltek at the address below).

Another item that should be of special interest to many of you are several circuits, developed by Kaltek, which use the RC-103 along with an inexpensive Timex Sinclair computer. One circuit forms a signal conditioner for reading "difficult" tapes. Others provide on-screen readouts of resistance, capacitance, and frequency. (Though I haven't tried it yet, I see no reason why the same circuits shouldn't work equally well with other computers—Commodore, Radio Shack, etc.—provided appropriate changes are made in the short machine-language and BASIC programs.)

As you would expect, using a computer for the calculations and display opens up all sorts of possibilities. For example, the measurements can be displayed just in numbers, but why not graphs or words, or both for convenience (which would be especially useful to the young student)? And how about a "lie detector" measuring skin resistance and showing a thermometer-like readout rising from "True" through "Are you sure?" to "Why not tell the truth?"

If you have been looking for low-cost test instruments, give some thought to the RC-111 and RC-103 with a calculator or computer. James Pennington (FL) could make a device for tuning his musical instrument. Kaltek will send you the application notes for $1.00 and an SASE, then give you a buck credit on your subsequent order.

The saga of Kaltek is not yet up to date. They've developed another module, the SL-6. With a couple of components (included with the SL-6 for $17.46, postage paid), it makes a touch-sensitive switch that holds "on" for about one second. Of course, the hold time can be changed by substituting another capacitor for the one that is supplied.

So what good is a short delay circuit? The SL-6 was developed as an addition to the keyboard of the Timex Sinclair *1000* computer (also known as the Sinclair *ZX81*). In small inexpensive computers, like the Timex *1000*, many keys serve several functions, depending on which mode the computer is in.

For example, a single key might be use to enter a letter, a graphics character, and the cosine function. To enter the function you first press the SHIFT key and then the alphanumeric/function-control key. In the function mode, the alphnumeric keys become function keys.

The short delay allows you to press the SHIFT key and then use the same hand or finger to hit the control key. That greatly increases the convenience and speed of keyboard operation. It can be especially valuable for certain handicapped individuals.

While the SL-6 application notes refer to the Timex *1000* and its shift key, it should function equally well on other keys and other machines. I am just beginning to experiment with the SL-6 on other computers, and I'll let you know the results of my efforts.

Certainly, use of the SL-6 is not limited to computer keys. Instead of completing a circuit around a computer key, it could complete a circuit to energize a small relay. That could make a dandy compact and portable alarm to sound off when someone touches a doorknob or a car, for example.

Perhaps now you can understand why I find Kaltek an interesting company. I suspect that more and more applications will be found for the RC-111, RC-103, and SL-6 modules. (If you discover one, be sure to let me know about it.) There is also a rumor that Kaltek is on the development trail that will soon lead to another useful module.

Oh yes, please note that I own no stock in Kaltek (wish I did!). And if you wish to contact them, be aware that they are planning to move. The current address is Box 7462, Rochester, NY 14615. After January 1, it will be Box 971, Adjuntas, PR 00601.

Help!

A request has come in from Jack Agueros (NY) for information that I have been completely unable to find. He is looking for a means of getting in touch with others interested in old radio receivers. There must be clubs and newsletter publishers for collectors and hobbyists. If you know of one (or more), let me know and I'll pass the word to Jack and others who are interested that subject. (*Editor's note*: You might try these: *The Horn Speaker*, PO Box 53012, Dallas, TX 75253, Bruce Kelley, Secretary, Antique Wireless Association, Holcomb, NY 14469, and Niagara Frontier Wireless Association, Box 68, Central Park Station, Buffalo, NY 14215.) R-E

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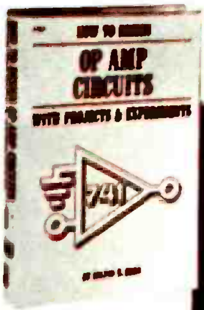

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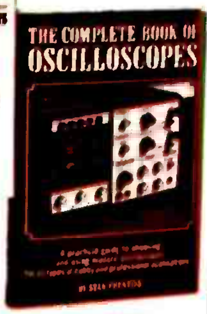

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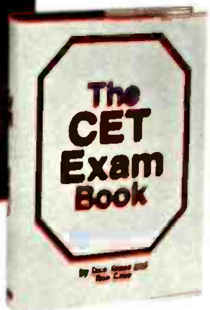

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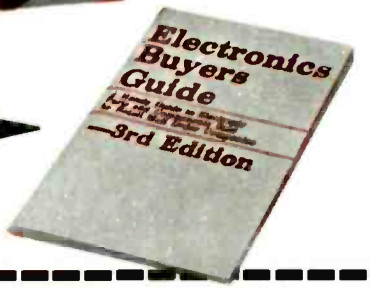

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VOL. 2 No. 1 January 1985

COMPUTER DIGEST

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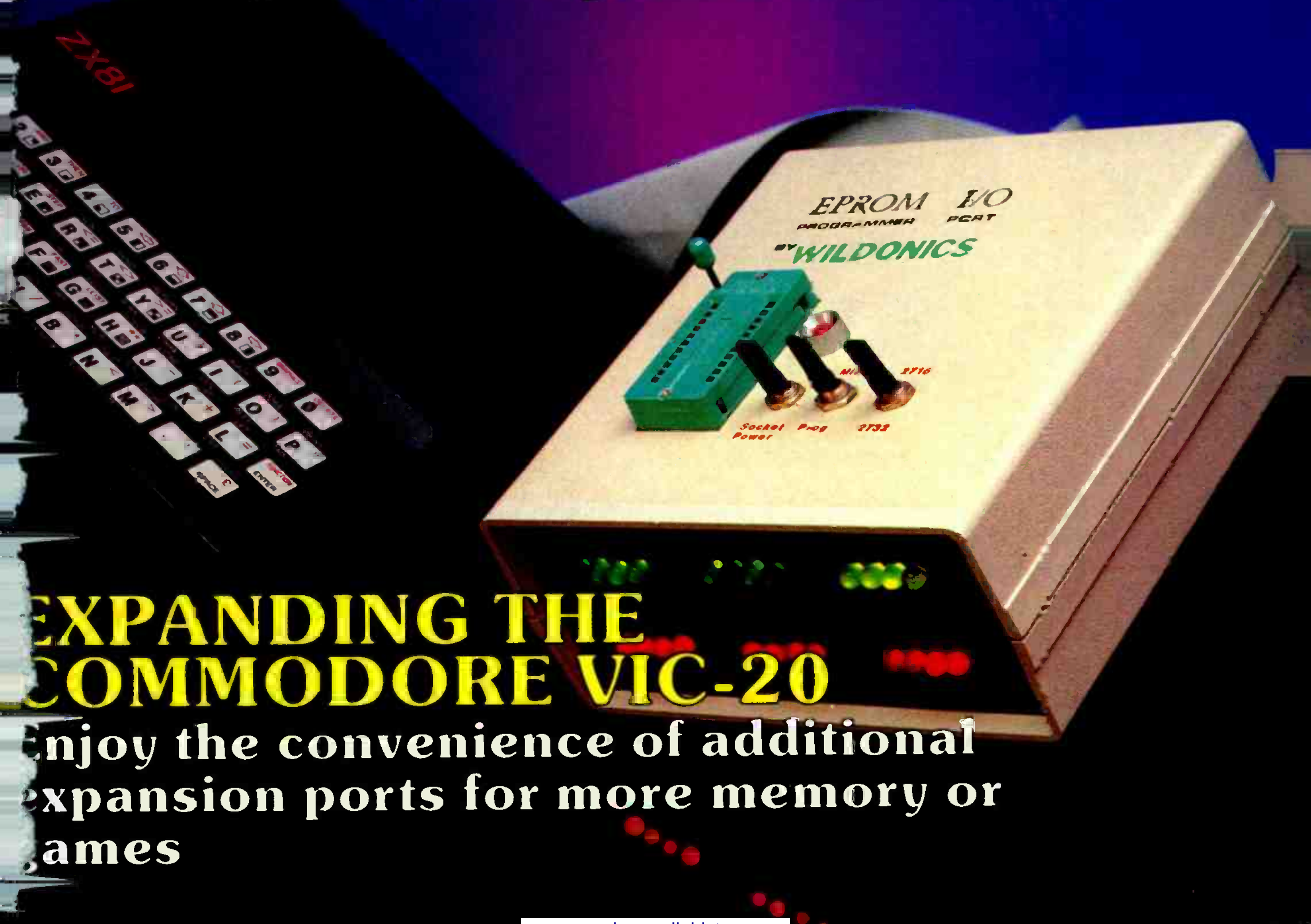

EXPANDING THE COMMODORE VIC-20

Enjoy the convenience of additional expansion ports for more memory or games

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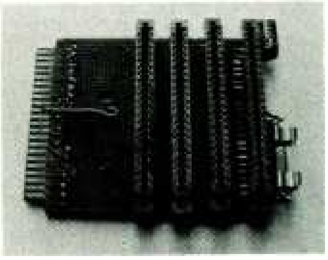
Vol. 2 No. 1 January 1985



Our VIC-20 Expander is shown here ready to go. To find out more about it, **see page 15.**

ON THE COVER

If you own a Sinclair ZX81 or a Timex Sinclair 1000, you already know that programs written in BASIC execute very slowly on those machines. What's more, programming those computers in machine-code can be somewhat less than convenient. This month, we'll show you a project that can make writing and storing machine-code programs a lot easier. What's more, it can double as an EPROM programmer for the ZX81/1000, or an EPROM emulator for another computer system. **See page 7.**

EDITORIAL

Here we go again!

■It's 1985. You know what that means... For the next few weeks, you're still going to be writing "1984" on your checks and letters. A new year takes a little getting used to. But the number of the year isn't the *only* thing that changes.

We're going to be seeing some changes—drastic changes—in our business, too. It seems that there will be drastic new developments announced this year. That computer that you bought because it was the latest, the best, the most up-to-the-minute model, is suddenly going to pale by comparison, and you're going to wonder if you shouldn't trade it in on one of those newer units. Suddenly, the features announced on the new machines will seem essential to you, and you'll wonder how you manage to get along without them.

Don't misunderstand—This is called "built-in obsolesence," and we're in favor of it. It helps keep the economy moving, keeps the money circulating (your money) and the challenge to produce the new and unique in order to compete, keeps the manufacturers on their toes. This results in technological advancement that benefits us all.

Timing is usually a critical factor, too. Remember when the Christmas Season began on December 25th? Now it seems to start on Thanksgiving Day. And the people in Detroit introduce their next year's models during the previous Summer. Happily, computers haven't fallen prey to that gambit as yet. The 1985 models will be coming out now—in 1985. That has both its good and bad aspects: On the positive side of the ledger, those who plan to buy new computers will now be ready to spend their bucks, now that they can shop for the new lines. And others who have been looking for a traded-in "bargain" will therefore find the shelves loaded with choices. And many of us, our Christmas-present money burning a hole in our pockets, will be ready to spend.

People who had been planning to change their jobs waited until after the holidays so they could collect their time off and those Christmas bonuses, but since that's behind us, they *will* be changing jobs now. That's probably going to mean more money for them, a chance to advance for others, and still more openings for those looking for jobs.

Yes, 1985 bodes well for the economy.

And for all of us too.

We, the staff of **ComputerDigest** wish all of our friends a healthy, happy and prosperous 1985

Byron G. Wels

Byron G. Wels
Editor

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COMPUTER DIGEST

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LETTERS

DESIGN THOSE AUDIO NETWORKS CORRECTLY!

It was a pleasure to see my article "Computer-Designed Audio Networks" in the November issue of **ComputerDigest**. It was not as pleasant to see that some errors crept into the program listing. The corrected lines follow:

```
5 CLS: PRINT
115 ON N GOTO 120.150: PRINT
    "ERROR - DO OVER": GOTO 110
125 RA = INT(Z*((K-1) (K - 1))):
    RC = INT(Z*((2*K)
    (K[2 - 1))):A = Z:B = Z
145 GOSUB 2000: GOSUB 2025:
    GOSUB 2055: GOTO 3000
160 RA = INT((((A - B)*KA) -
    (A - B)) 2)
220 GOSUB 1000: GOSUB 1030:
    GOSUB 1050
310 RA = INT((A SQU(A B))*
    (((K*SQR(A/B)) - 1) K))
530 DB = CINT(ABS(20*(LOG(SQR
    (1 (A B)) (1 - SQR(1 - (1 (A B)))))
    LOG(10))) + 1)
2055 X = 60: FOR Y = 16 TO 19:
     SET(X,Y): NEXT Y
2060 X = 60: FOR Y = 24 TO 28:
     SET(X,Y): NEXT Y
```

In line 135, the quotation marks were omitted after the last word, but the program will run without them.—Frank Galdes, Murrysville, PA

Sorry, Frank. Program listings are inherently subject to typesetting/transcription errors—even more so than schematics! If anyone has plans to submit a listing with an article, sending it on an 8-inch SSSD (IBM 3740 format) disk is the best way to avoid any problems.

FLYING ENTHUSIAST

I've become enchanted with the flight simulator on my computer and want to know how valuable this can be toward getting a pilot's license?—Frank Stembo, Dallas, TX.

Frank, as a pilot myself, I can tell you it's very valuable! Student pilots spend a lot of time in the air (and dual instruction costs plenty!) learning the rudiments of instrument flight and navigation. Your flight simulator is saving you a fortune in that way alone. But as one of the old, great aviators once said, "If you want to learn about flying, watch the birds. If you want to learn to fly, get into an airplane!"

COMPUTER VERSATILITY

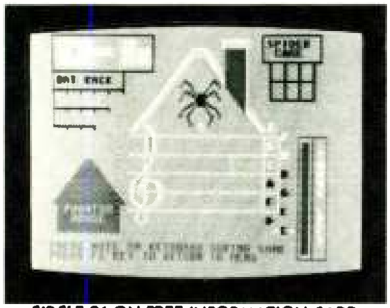
Most people buy computers to solve one particular problem in their lives and only rarely do they look for other applications outside their immediate sphere of interest. Your magazine has made me aware of some of the other things computers can do, and you've broadened my own computer usage. Thanks!—Mort Sabin, Yonkers, NY.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

EDUCATIONAL SOFTWARE, *The Notable Phantom,* teaches children ages 5–10 basic keyboard (musical) and note-reading skills as they compete against a slew of specters, spiders, and the famous phantom himself.

Haunted-house ghouls lead players through exercises to identify note names and positions on a music staff and keyboard, and to train the ear to identify different tones, depending on which lesson plan the user selects.



CIRCLE 21 ON FREE INFORMATION CARD

Children learn to read music using a songbook of favorite tunes that is included in every game. Budding composers can save their own song creations and play them back later.

The software comes with a realistic keyboard overlay of black and white notes, more than an octave and a half. The suggested price of *The Notable Phantom* is $49.95.—**Designware,** 185 Berry Street, San Francisco, CA 94107.

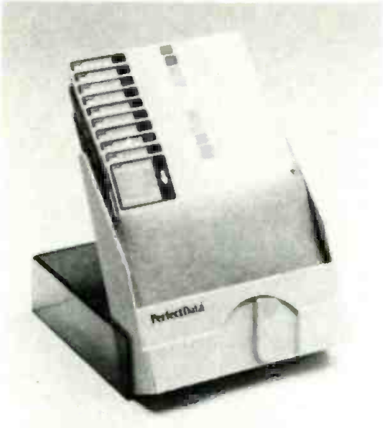
PRINTER, the *ThinPrint 80,* is designed for use with portable computers. It is battery-powered, weighs only four pounds, and supports either serial or parallel interfacing to most computers (including Tandy *100* & *PC-2,* Epson *HX-20,* IXO *Telecomputer,* IBM *PC XT, Jr,* and many others).

The *ThinPrint 80* has 80 or 136

CIRCLE 22 ON FREE INFORMATION CARD

columns per line, 40 character-per-second bidirectional printing, 2K buffer memory, and 120 dot-per-inch graphics. It holds 80 pages of 8½" wide paper, produces silent thermal printing, and fits into less than half a briefcase. Its suggested retail price is $279.00, complete with rechargeable batteries, AC adapter, and one roll of paper.—**Axonix Corporation,** 417 Wakara Way, Salt Lake City, UT 84108.

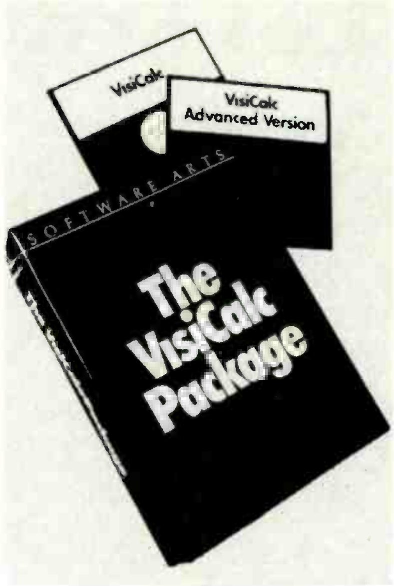
FILING SYSTEM, *Dial 'N File,* is designed for 5¼ diskettes. It is made of high-density, molded plastic and holds up to ten 5¼-inch diskettes and one PerfectData drive-head cleaning disk. When opened, the plastic cover swings into an easel position and becomes a display stand. A clockwise turn of the dial operating the fanning action, places individual diskettes at the user's fingertips, with all diskette labels clearly visible. The *Dial 'N File* case closes with a counterclockwise turn of the dial, and locks securely to protect diskettes from damage and contaminants. Its suggested retail price is $6.95— **PerfectData Corporation,** 9174 Deering Ave., Chatsworth, CA.



CIRCLE 23 ON FREE INFORMATION CARD

SPREADSHEETS, the *VisiCalc Package,* is a two-in-one product containing both a single and a double disk-drive spreadsheet program—*VisiCalc* and *VisiCalc Advanced Version*— for users of the Apple *II* family of personal computers.

The *VisiCalc* disk includes models in home management and finance that can be expanded by the user. They are: checkbook balancing, household budget, individual retirement account analysis, future value of an investment,



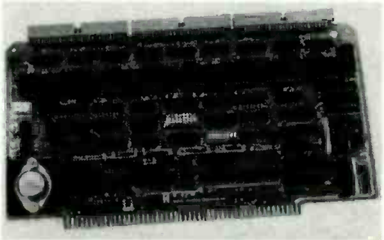
CIRCLE 24 ON FREE INFORMATION CARD

income averaging, and car-loan payment analysis.

The *VisiCalc Advanced Version* features full word prompts and variable column-width capabilities, as well as date functions, print commands that produce presentation-quality reports, and both 40- and 80-column displays.

The *VisiCalc Package* is priced at $179.00.—**Software Arts Inc,** 27 Mica Lane, Wellesley, MA 02181

COMMUNICATIONS INTERFACE is IEEE-696 (S-100) compatible. It provides a means to connect up to 8 RS232-C devices, regardless of their baud rate, stop bit, and parity configuration. Up to eight of these cards can be used in one system, for a total of 64 channels, with data rates up to 38.4 baud. Also featured are a



CIRCLE 25 ON FREE INFORMATION CARD

calendar/clock, switch register, and an encryption device. The calendar/clock is battery backed-up and the device may be disabled in systems requiring several cards. The encryption device is an MMI PAL, and its use is generally for software protection. The interface is priced at $695.00.—**Inner Access Corporation,** PO Box 888, Belmont, CA 94002.

MACHINE CODE DEVELOPMENT SYSTEM
FOR YOUR TIMEX SINCLAIR 1000

Turn your Timex Sinclair 1000 or Sinclair ZX81 into a high-speed, machine-code development system.

MARK W. LATHAM

By now you may have seen dozens of Timex Sinclair *1000*/Sinclair *ZX81* add-on projects in various electronic magazines. It's not surprising considering that at one time, Timex was shipping 100,000 units a month. While some people are content to fool around with whatever they can hook up to the back of the unit, others have bought real keyboards and extra RAM, hoping to turn their computers into real business or entertainment machines.

If you've ever used a Timex Sinclair *1000* (which we'll simply call a TS *1000* from here on), you know that speed keeps that computer from serving any useful purpose. You could take a short nap while the computer is loading even a 16K program from cassette. Once it's loaded, you run into the other speed problem—execution time. That's because the Z80A CPU spends most of its time updating the video, and, let's face it, the BASIC is too slow, even in the FAST mode. The simplicity of the TS *1000*, which is one of its virtues, is also its downfall.

If you own a TS *1000* and want to turn it into a useful device, why not consider the following: 1) run high-speed machine-language level programs and, 2) store those programs in EPROM.

This project, a machine-code-development-system/EPROM-programmer, will let you do just that. With it, you can use your TS *1000* to load programs from EPROM's, and program EPROM's with data anywhere in the RAM. You will be able to store and recall 4K bytes of battery-backed-up external CMOS RAM. Also, the unit can be disconnected from the TS *1000* and used to emulate an EPROM for a different microprocessor.

You will be able to use the EPROM programmer as a general I/O port, each line of which is monitored by LED's. The LED's are great if you are just learning machine language commands. Of those lines, 20 are available for input/output, while four others are configured as output-only lines capable of sinking 500 mA each. All those lines are available through a socket in the back of the unit and, if you hook them up with a test clip, you will have a five-volt, multi-channel logic monitor with both LED and on-screen viewing. Best of all, the whole EPROM I/O system operates under machine-language level software control, which is, of course, stored in EPROM.

System architecture

The unit is interfaced to the TS *1000* with an 8255 PPI (parallel peripheral interface) I/O port. We could have treated the program socket as a memory space accessed directly by the Z80A, but then we would have had to insert many wait states during the program pulse. Unfortunately, there is no way the CPU can refresh dynamic RAM during waits so that option is out. What we must do then is create a second bus system as shown in Fig. 1, the schematic diagram.

Gates IC1-c and IC2-c allow the Z80A to access the 8255 when A7 and $\overline{\text{IORQ}}$ are low. (A7 is included to ensure that there will be no erroneous writes to the 8255.) If we leave the 8255's AØ and A1 lines set for all I/O operations, the computer's monitor system won't crash during I/O operations regardless of whether the computer is in the fast or slow mode. The A4 and A5 lines of the Z80A are used to control the 8255's AØ and A1 inputs, so, in hexcidecimal, the I/O addresses will be Ø3H, 23H, and 33H.

The 8255 has three eight-bit ports, one of which is bit-addressable. Port C (PB4–PB7) will function as the secondary bus control outputs. Port B (PBØ–PB7) will function as the data I/O port, and ports C (PC3–PCØ) and A (PAØ–7) will function as address outputs Ø–11, respectively. (The reason PC3–PCØ are used in reverse as AØ–A3 is twofold; that both simplifies circuit board layout and arranges the bus and LED's for use as a logic monitor, as you will see later.)

When the 8255 is reset (either by the computer or on power up) all the ports are configured as inputs. Any time those ports are changed from inputs to outputs, or vice-versa, all the port registers are reset. That presents a problem for the control lines in our secondary bus system because those lines must remain high (set) until a memory access is desired. Transistors Q1–Q4 are used to alleviate that problem. If a port's input or output is low, the corresponding transistor output is high, holding the control line secure. If the data in the CMOS RAM is of no importance, then those transistors may be used as high current outputs, capable of sinking up to 500 mA each.

The CMOS RAM, IC9 and IC10, and the CMOS one-of-eight decoder, IC7, provide 4K of data storage for program saving and ROM emulation. The decoder

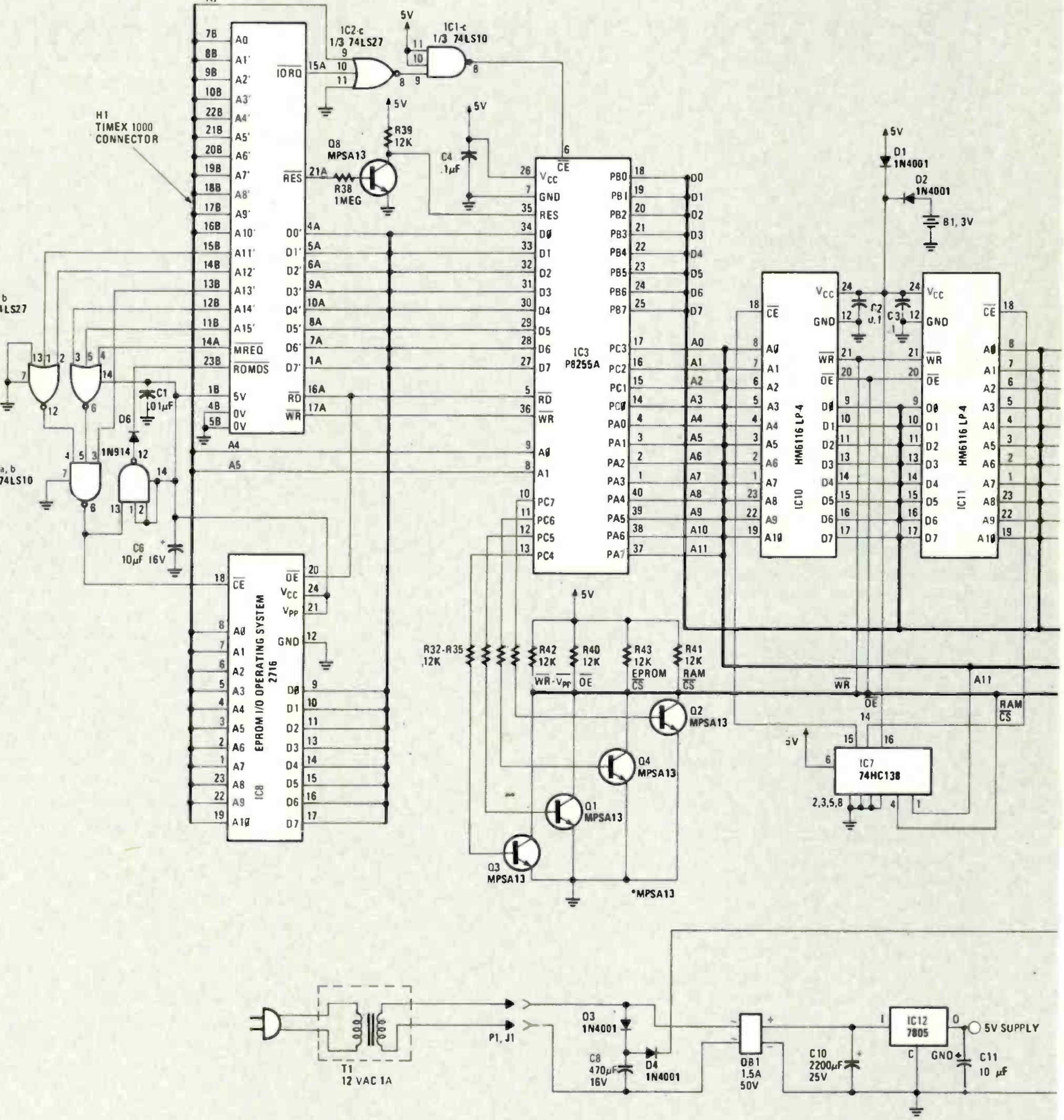


FIG. 1—COMPLETE SCHEMATIC DIAGRAM. Reference the diagram carefully while reading the text, as it helps clarify some of the more-complicated points.

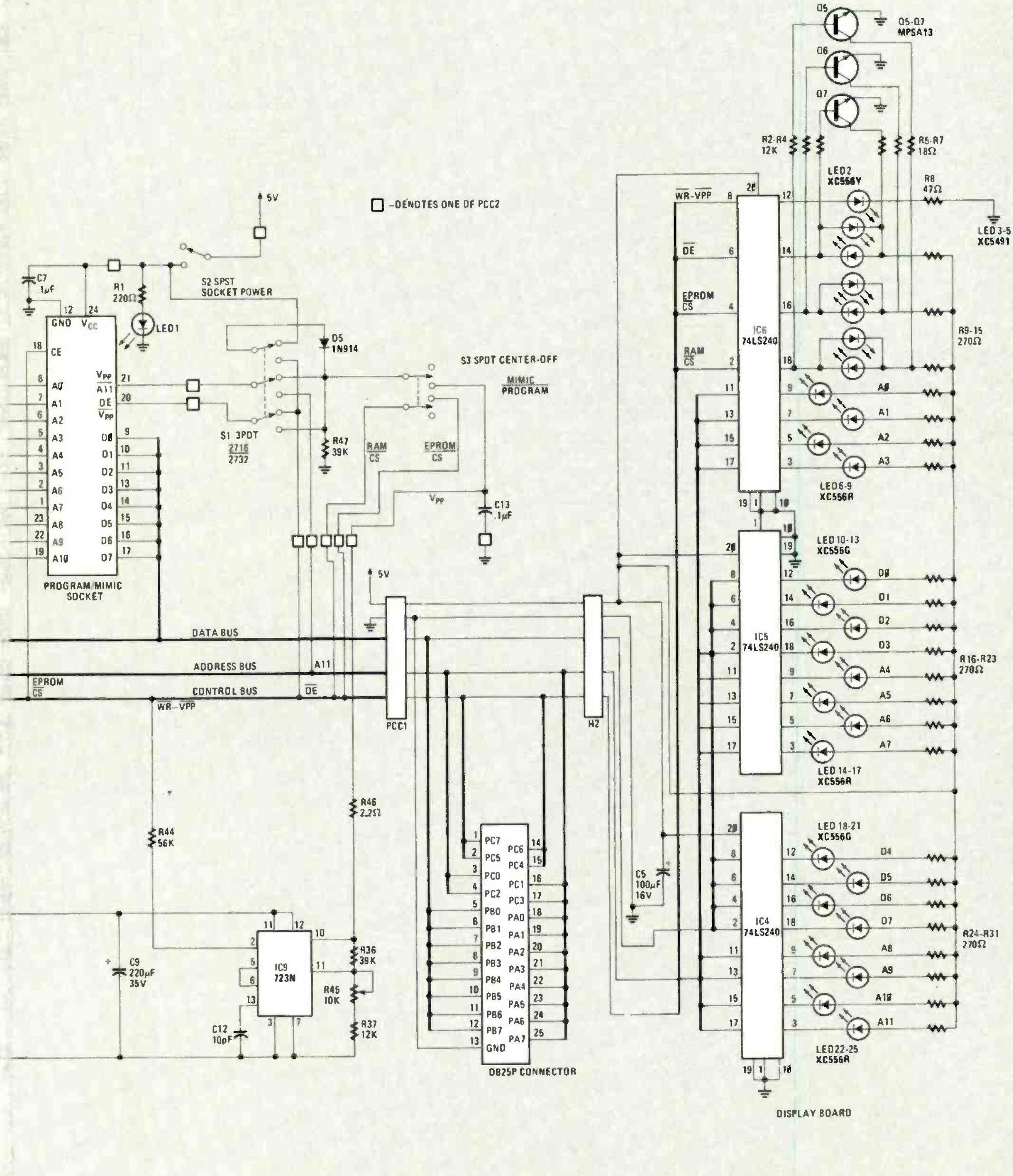
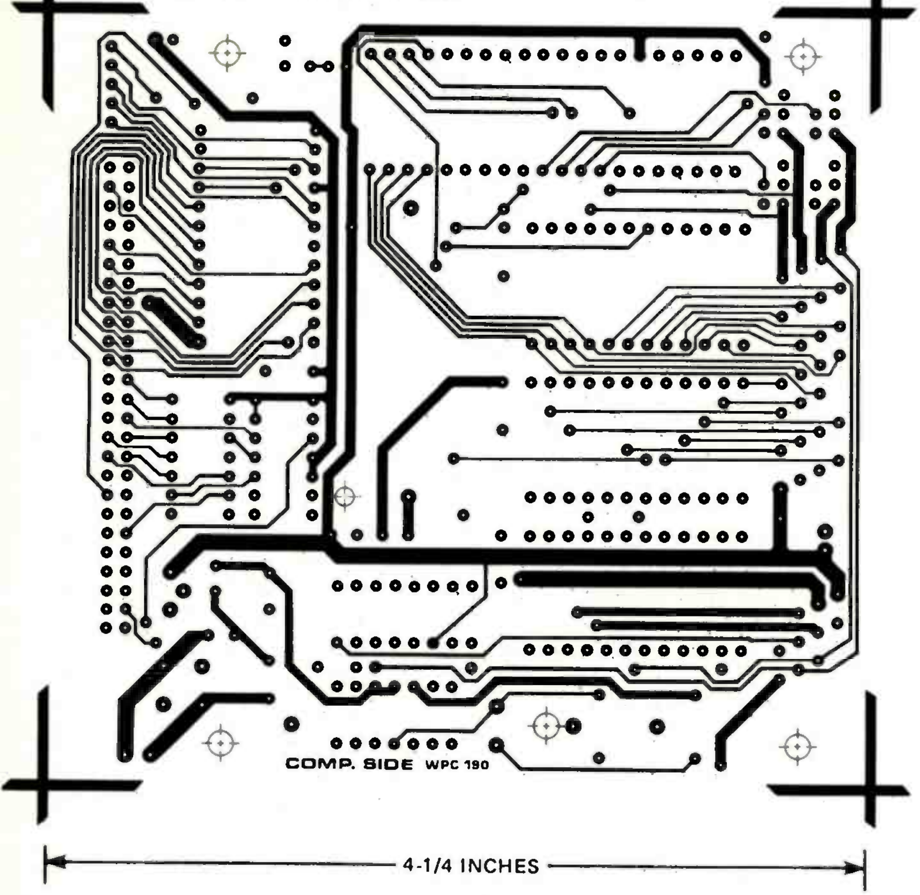
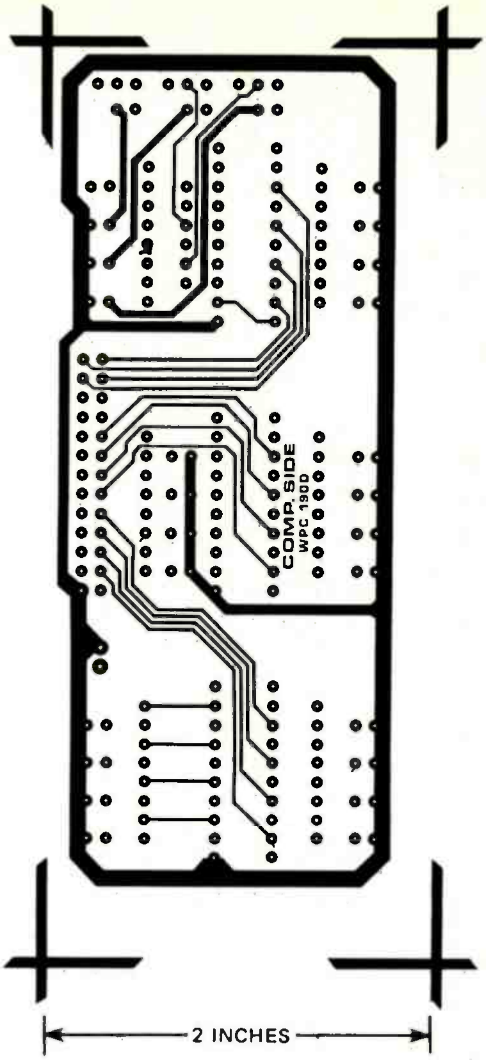

☐ –DENOTES ONE OF PCC2
5V
S2 SPST
SOCKET POWER
C7
.1µF
R1
220Ω
LED1
GND
VCC
CE
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
VPP
A11
DE
VPP
D0
D1
D2
D3
D4
D5
D6
D7
PROGRAM/MIMIC
SOCKET
D5
1N914
S1 3PDT
2716
2732
R47
39K
S3 SPDT CENTER-OFF
MIMIC
PROGRAM
RAM
CS
EPROM
CS
VPP
C13
.1µF
DATA BUS
ADDRESS BUS
A11
EPROM
CS
CONTROL BUS
OE
WR–VPP
PCC1
H2
R46
2.2Ω
R44
56K
C9
220µF
35V
IC9
723N
C12
10pF
R36
39K
R45
10K
R37
12K
PC7
PC5
PC0
PC2
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
GND
PC6
PC4
PC1
PC3
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
DB25P CONNECTOR
C5
100µF
16V
Q5
Q6
Q7
Q5-Q7
MPSA13
R2-R4
12K
R5-R7
18Ω
LED2
XC556Y
R8
47Ω
LED3-5
XC5491
WR–VPP
OE
EPROM
CS
RAM
CS
IC6
74LS240
R9-15
270Ω
A0
A1
A2
A3
LED6-9
XC556R
LED 10-13
XC556G
IC5
74LS240
D0
D1
D2
D3
A4
A5
A6
A7
R16-R23
270Ω
LED 14-17
XC556R
LED 18-21
XC556G
IC4
74LS240
D4
D5
D6
D7
A8
A9
A10
A11
R24-R31
270Ω
LED22-25
XC556R
DISPLAY BOARD

FIG. 2—FULL-SIZE CIRCUIT BOARDS are provided here for those readers who desire to duplicate the boards from scratch. Note that the main board is shown in *a* and the display board in *b*. The boards are double-sided; the side shown here is the component side.



a



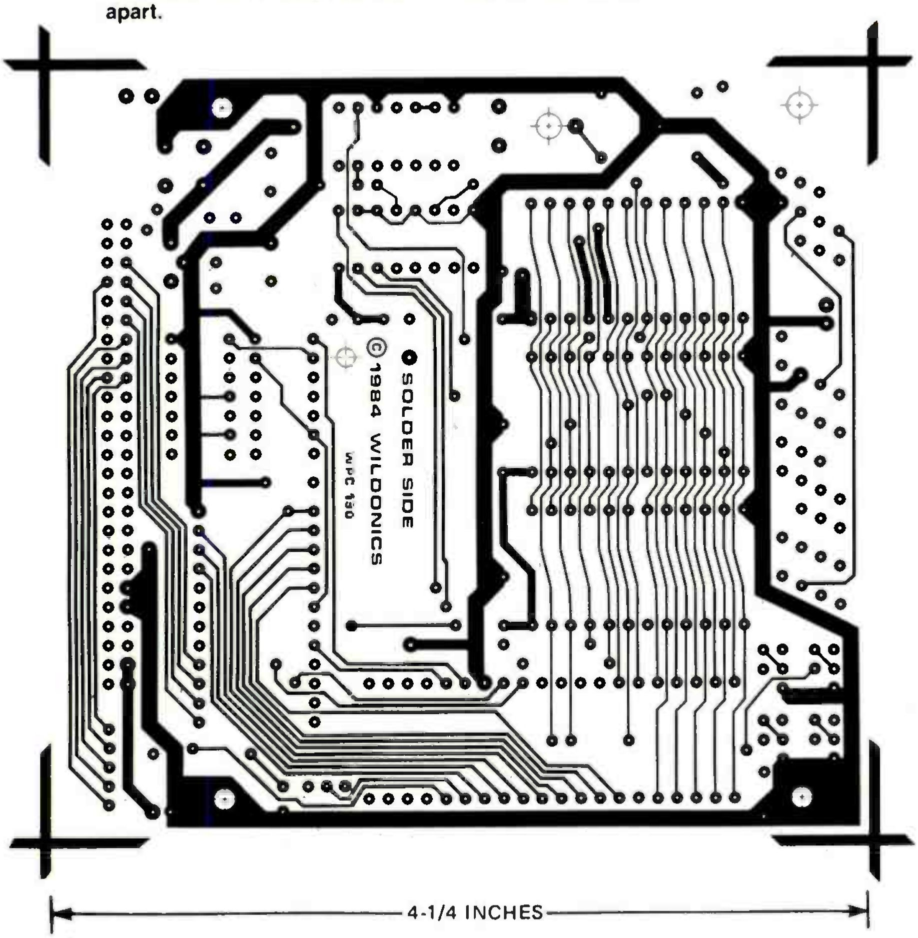
b

PARTS LIST

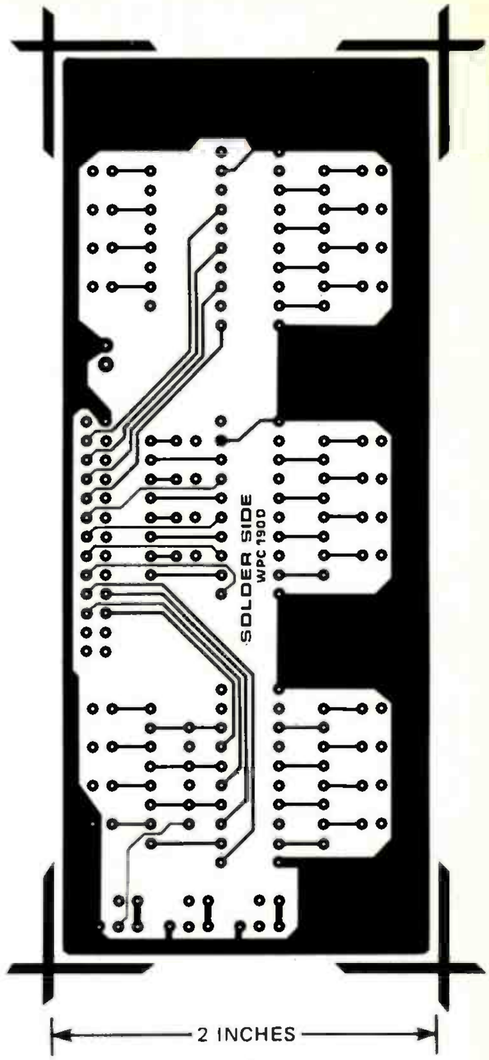
Resistors
All resistors are 1/4 watt, 5%
R1—220 ohms
R2–R4, R32–R35, R37, R39–R43—12,000 ohms
R5–R7—18 ohms
R8—47 ohms
R9–R31—270 ohms
R36, R47—39,000
R38—1 megohm
R44—56,000 ohms
R45—10,000 ohms, potentiometer, PC mount
R46—2.2 ohms
Capacitors
C1–C4, C7, C13—0.1µF, ceramic disc
C5—100µF, 16 volts, miniature radial electrolytic
C6, C11—10µF, 16 volts, miniature radial electrolytic
C8—470µF, 16 volts, miniature radial electrolytic
C9—220µF, 35 volts, miniature radial electrolytic
C10—2200µF, 25 volts, miniature axial electrolytic
C12—10pF, ceramic disc
Semiconductors
D1–D4—1N4001
D5, D6—1N914
DB1—RB151 1.5-amp, 50 volt, diode bridge
Q1–Q18—MPSA13
LED1, LED6–LED9, LED14–LED17, LED22–LED25—red LED, XC556R or equivalent
LED 2—yellow LED, XC556Y or equivalent
LED3–LED5—tricolor LED, XC5491 or equivalent
LED10–13, 18-21—XC556G
IC1—74LS10 triple 3-input NAND gate
IC2—74LS27 triple 3-input NOR gate
IC3—P8255 programmable peripherial interface
IC4—IC6—74LS240 octal buffer
IC7—74HC138 3 to 8 decoder/multiplexer
IC8—2716 EPROM
IC9—723N positive adjustable regulator
IC10, IC11—HM6116LP-4 CMOS static RAM
IC12—7805 5-volt regulator
Miscellaneous
T1—12VAC, 1-amp, wall-plug transformer
P1—coaxial power plug
J1—coaxial power jack
S1—3PDT switch

reads $\overline{\text{RAMCS}}$ (PC7) and A11 to select the appropriate memory IC. Those three IC's are powered by either the five-volt supply through D1 or the lithium three-volt battery through D2. Pin 6 of the decoder monitors the five-volt supply and disables the RAM when the power is off.

FIG. 3—THE SOLDER SIDE OF BOTH BOARDS (the main board is shown in *a*; the display board in *b*) is given here, also full size. Both boards can be etched at once and then cut apart.



a



b

S2—SPST switch
S3—DPDT switch, center-off
H1—50-contact, right-angle header
H2—26-contact header
PROGRAM SOCKET—24-pin ZIF socket with extender pins (or wire wrap socket)
PC boards, IC sockets, enclosure, hardware, ribbon cable, card-edge connector, DB-25 connector, etc.

The following are available from Wildonics Computer Technologies, P.O. Box 1763, Boise, ID, 83701: Complete kit of all parts including power supply, all connectors, lithium battery, PC boards, and case (does NOT include 2716 EPROM with Operating System), $149.95; 2716 EPFOM with Operating System, $19.95; set of drilled and etched PC boards only $19.95; Assembled anc tested unit with Operating System Software, $219 95. Shipping, handling and insurance, $3.00 for EPROM with software or PC boards only. $6.00 for complete kit or assembled unit.

With S3 set for MIMIC and the 8255's ports all configured as inputs, a secondary CPU can directly access the CMOS RAM through the PROGRAM socket. Setting S3 for MIMIC simply OR-ties the $\overline{\text{RAMCS}}$ and the $\overline{\text{EPROMCS}}$ lines and bypasses V_{pp}-blocking diode D5. Resistors R38 and R39, and transistor Q8, which normally act as an inverter for the $\overline{\text{RESET}}$ signal, hold the 8255 reset if the EPROM-I/O unit is used apart from the ZX81 during a mimic operation.

When S3 is set to PROGRAM, the output of the V_{pp} switching regulator, IC9, is connected to the appropriate EPROM I/O pin. $\overline{\text{WR}}$ (PC7) controls the regulator's output by sourcing the base of the regulator's current limiting transistor. For that application, that transistor's emmitter is connected to ground. Capacitor C12 is connected to the frequency-response pin to slow the V_{pp} rise and fall times. Diodes D3 and D4 and capacitors C8 and C9 act as a voltage doubler to provide 30 volts at 60 mA to the regulator's input.

All the bus lines can be monitored with the display board. Three 74LS240's, IC4–IC6, power the LED's. Red LED's (LED6–LED9, LED14–LED17, and LED22–LED25) are used for the the address lines and the LED's for the data lines (LED10–LED13 and LED18–LED17) are green. Those LED's will light when the corresponding bus lines are high or high-impedance. The yellow LED (LED2) will light if the $\overline{\text{WR-V}_{pp}}$ line is low.

While we are out of space, we're not our of things to say. We'll finish up next month.

BUILD THE BIO-BOX

You can build this biofeedback monitor for your TRS Model I or Model III.

JIM BARBARELLO

Part 2 Last month, we described the BioBox and told you how to build it. However, while we gave you a brief idea of what software was involved, we still have a lot to say about it. We'll start there. Then we'll tell you how to put the BioBox in action.

The BASIC program

The BioBox BASIC program is shown in Program Listing 2. This version is for the *Model I*, cassette or disk based, 16K to 48K memory.

On the *Model I*, addresses 16561 (least significant byte or LSB) and 16562 (Most Significant Byte or MSB) point to the top of BASIC memory. Addresses 16527 (LSB) and 16528 (MSB) point to the single USR entry point in a cassette-based system. Also, address 16561 is always 255, but 16562's contents vary according to the available memory (127 for 16K, 191 for 32K and 255 for 48K). With this understood, we must protect memory for the machine-language subroutine that will be placed there by POKE-ing the individual data values. So our first command is to POKE the number 215 into location 16561. This reserves an ample 40 bytes for our subroutine. Next, we clear 1000 to reserve string storage space and reset BASIC pointers. Line 10 also defines an error handling routine starting at line 550.

Line 20 is valid for a disk system. J is set to two bytes past the protected memory start. The second statement adjusts J if it is greater than 32767, so it can be used in the POKE statements. Finally, we jump over line 30 (which is used only for cassette-based systems) and continue execution at line 40. If we run this program on a cassette-based system, the DEFUSR statement in line 20 will cause an error, branching execution to line 550.

Line 560 checks to see if the error has occurred in line 20 (indicating that this is not a disk system). If so, we resume execution at line 30. In this manner, we can have the program decide which line to use, based on the system configuration.

The first statement in line 30 is for older *Model I's*. Those units had a software error in the ROM which affected the DATA pointer, making DATA reads impossible. POKE-ing 255 into location 16553 corrects this. Line 30 then sets the USR entry point and calculates the starting location to begin POKE-ing the machine language code. Line 40 prints a heading, while line 50 POKES the subroutine code into memory. Line 50 also performs a checksum and aborts the program if the sum of all placed bytes is incorrect.

Line 60 clears the working area of the screen (GOSUB 900) and prints the vertical graph axis. Lines 90 through 140 complete the screen presentation. Line 150 tests a flag (FLG) to see if this is the initial run of the program (as opposed to a restart). If FLG is not equal to 0, the option to view the instructions is skipped. Otherwise, the user is given the option to view the instructions contained in a subroutine starting at line 600. Line 170 sets the flag and asks for your initial mood. Line 180 allows only numbers between 2 and 9 as a valid input. Line 190 equates the number you enter to CC, which is then used to create string AB. Line 200 uses AB to reprint the graph presentation minus all boxes to the right of the row you specified. It also clears the message line (above the graph).

Initialization takes place in lines 210 through 240. Based on the user's individual skin resistance, the BioBox will produce a count between 1 and 65535. The initialization procedure obtains an average start reading, equating this to the initial mood you selected. It then sets upper (maximum calm) and lower (maximum tenseness) count limits and a change increment (INC). INC is the maximum change in count that will cause one box to be removed or added. The USR call in line 210 is not included in the average count, but simply insures that the BioBox is reset before sampling begins. Line 240 erases the INITIALIZING message before proceeding to the actual biofeedback monitoring of lines 250 through 410.

First we print a box at the present position, and a period (dot) directly above it. Then line 260 samples the BioBox and, if 0 is returned, creates an error to pass execution to the error-trap routine at line 550. Line 270 increments the time (XT) and line 280 polls the keyboard to see if a Restart or End was requested (GOSUB 740). If not, the current square is blanked out (this creates the blinking effect). Line 300 checks to see if the count change is less than one increment. If so, execution branches to line 410 where a delay proportional to the current count is created before returning to line 250 for the next sample.

If the change is greater than one increment, line 310 checks to see if the count is increasing (less tense) or decreasing. For an increasing count, line 330 increases XO by one increment. Then R and C are checked and adjusted if necessary to point to the top of the preceding column (if the last square in the current

PROGRAM LISTING 2

```
10 POKE 16561,215:CLEAR 1ØØØ:DEFSTR A: DEFINT
   C,I,R:DIM T(5Ø,3) ON ERROR GOTO 55Ø
20 J=217+PEEK(16562)*256:J=J+(J>32737)
   *65535:DEFUSR=J+1:GOTO 4Ø
30 POKE 16553,255:POKE 16526,217:POKE 16527,PEEK
   (16562): J=216+PEEK(16527)*256:J=J+(J>32737)
   *65535
40 CLS:PRINTTAB(14);"B I O F E E D B A C K
   M O N I T O R" :PRINTSTRING$(63,131):
   PRINTTAB(18);"(c) 1983 by J. J. BARBARELLO"
50 FORI=1TO32:READ N:POKE J+I,N:K=K+N:NEXT:IF
   K<>3647 THEN PRINT @536, "CHECKSUM
   ERROR.":END
60 GOSUB 9ØØ;FORI=1TO1Ø:PRINT" ";CHR$(157)
   :NEXT:PRINT" ";CHR$(141)
70 DATA 243,62,1,211,255,6,64,16,254,62,Ø,211,255,17,1,
   Ø,33
80 DATA Ø,Ø,219,255,254,255,4Ø,3,25,48,247,251,
   195,154,1Ø
90 PRINT@839,CHR$(14Ø);:FORI=1TO1Ø:PRINTSTRING
   $(2,14Ø):CHR$(142);STRING$(2,14Ø);:NEXT
100 AL=" ":A=STRING$(3, 143)+" ":FORI=1TO1Ø:
    AL=AL+A:NEXT
110 FORI=1TO1Ø:PRINT@2Ø1+(I-1)*64,AL;:NEXT
120 PRINT@9Ø5, ;:FORI=1TO1Ø:PRINTUSING"##
    ";I;:NEXT
130 PRINT@968, "CALM";TAB(52);"TENSE";
140 T$="/\TENSE":FORI=1TO6:PRINT@259+I*64,
    MID$(T$,I,1);:NEXT
150 IF FLG>Ø THEN 17Ø
160 PRINT@98Ø, "INSTRUCTIONS? (Y/N)...";:GOSUB 8Ø
    Ø:IF AI="N" THEN PRINT @98Ø,STRING$(25,32);
    ELSE GOSUB 6ØØ
170 FLG=2:PRINT@145, "SELECT INITIAL MOOD
    (2-9)...";
180 AR=INKEY$:IF AR=""THEN18Ø ELSE GOSUB 76Ø:IF
    VAL(AR) <2 OR VAL (AR)>9 THEN 18Ø
190 PRINTAR;:CC=VAL (AR) :R=2ØØ:C=CC*5:
    AB=STRING$((1Ø-CC)*5,32)
200 FORI=Ø TO9:PRINT@R+C+64*I,AB;:NEXT:
    PRINT@145,STRING$(5Ø,32); :C=C-5)
210 PRINT@985, "INITIALIZING...";:Y=Ø:FLG=2:XT=Ø:
    X=USR(Ø)
220 FORI=1TO5:PRINT@R-62+C, ".";:X=USR(Ø):
    PRINT@R-62+C," ";:IFX<Ø THEN X=65534+X
230 Y=Y+X:NEXT:XO=Y/5:INC=XO/(1Ø*(CC+5))
    :XL=XO-CC*INC*1Ø
240 PRINT@985,STRING$(15,32);
250 PRINT@R+C+1,A;:PRINT@R-62+C, ".";
260 X=USR(Ø):IF X<Ø THEN X=X+65536 ELSE IF X=Ø
    THEN ERROR 1
270 XT=XT+X/3ØØØØ
280 GOSUB 74Ø
290 PRINT@R-62+C, " ";
300 IF ABS (XO-X) <INC THEN 41Ø
310 IF X<XO THEN 37Ø
320 IF X<XO THEN 4ØØ
330 PRINT@R+C+1,STRING$(5Ø-C,32);:XO=XO+
    INC:R=R+64:IF R=84Ø THEN R=2ØØ:C=C-5
340 IF C>-1 THEN GOSUB 5ØØ:GOTO 32Ø
350 PRINT@468, "MAXIMUM CALM ATTAINED.";:
    PRINT@525, "PRESS <R> TO RESTART, OR <E>
    TO END...";
360 GOSUB 74Ø:GOTO36Ø
370 R=R-64:IF R=<136 THEN R=776:C=C+5
380 IF C>45 THEN C=45:R=2ØØ:GOTO 4ØØ
390 XO=XO-INC:PRINT@R+C+1,A;:GOSUB
    5ØØ:GOTO 31Ø
400 X=XO
410 FORI=1TO(X-XL)*25Ø/XL:NEXT:XT=XT+I/5ØØ:GOTO
    25Ø
510 FOR Z=1 TO 5Ø:NEXT:XT=XT+.25:RETURN
530 PRINT@98Ø, "PRESS ANY KEY TO CONTINUE";
540 AI=INKEY$:IF AI="" THEN 54Ø ELSE RETURN
560 IF ERR=56 THEN PRINT@985, "PRINTER
    ERROR";:STOP ELSE IF ERL=2Ø THEN RESUME 3Ø
570 PRINT@966, "ERROR OCCURRED. PRESS <R> TO
    RESTART, <E> TO END ..";
580 AR=INKEY$:IF AR=""THEN58Ø ELSE
    NU=ASC(AR):IF NU>91 THEN AR=CHR$(NU-32)
590 IF AR<> "R" AND AR<>"E" THEN 58Ø ELSE
    PRINT@966,STRING$(55,32);:RESUME 76Ø
610 GOSUB 89Ø:PRINT@26Ø, "The Biofeedback System I
    measures and displays your changes in mood. Before
    beginning, check that the hardware interface is attached,
    and power is applied."
620 PRINT" Next, attach one BioProbe to your index finger
    above the first joint. Then place the remaining BioProbe
    on your middle finger above its first joint."
630 PRINT" When you have finished reading these
    instructions, you'll be asked the question ";CHR$(34);"
    SELECT INITIAL MOOD (2-9)...";CHR$(34);". Select a
    number between 2 (CALM) and 9 (TENSE). ";
640 PRINT"If you're in an average mood, select 5. If you're
    calmer, try a lower number (like 3). Otherwise, select a
    higher number (like 8).";
650 GOSUB 53Ø:GOSUB 89Ø
660 PRINT@26Ø, "Your mood is represented by the 1ØØ
    blocks. When you select your initial mood, the higher
    tension-indicating blocks will disappear.";
670 PRINT"The object is to relax and in the process make
    all the blocks disappear. If you increase tension the
    blocks will begin reappearing. A blinking dot will remind
    you where you currently are.";
680 PRINT"The more tense you get, the faster it blinks. The
    calmer you get, the slower it blinks."
690 PRINT"If a fault occurs in the BioBox (EX: BioProbes
    come loose, power not applied), a message will appear
    and allow you to re-start by pressing <R>. If you wish
    to restart at any other time, press <R>.";
700 PRINT"When you wish to end the session, press <E>."
710 GOSUB 53Ø:FLG=2:GOTO 6Ø
750 AR=INKEY$:IF AR=""THEN RETURN
760 IF AR="R" OR AR="r" THEN PRINT@128, TAB(24);
    "R E S T A R T";TAB(6Ø);:GOSUB 84Ø:GOTO 6Ø
770 IF AR="E" OR AR="e" THEN GOSUB 84Ø:GOTO 99Ø
    ELSE RETURN
800 AI=INKEY$:IFAI=""THEN8ØØ ELSE NU=ASC(AI)
810 IFNU>91THEN NU=NU-32
820 AI=CHR$(NU):IFAI<> "Y"ANDAI <> "N"THEN8Ø
    ØELSERETURN
840 REM** STORE RESULTS
850 PRINT@98Ø, "STORE RESULTS? (Y/N)...";:GOSUB
    8ØØ:PRINTAI;
860 IF AI="Y" THEN
    S=S+1:T(S,1)=CC:T(S,2)=XO-(Y/5))/
    INC:T(S,3)=XT
870 RETURN
900 PRINT@128," ":FORI=1TO11:PRINT" ":NEXT:
    PRINT@96Ø STRING$(63,32);:PRINT@192,;:
    RETURN
1000 ST=1:TN=Ø:GOSUB 9ØØØ:IFS=Ø THEN 1Ø5Ø ELSE
     ON ERROR GOTO 1Ø5Ø
1010 PRINT@64, TAB(27);"R E S U L T S"TAB(63):
     PRINT@129, "TRIAL #" TAB(2Ø)
     "START"TAB(32) "END"TAB(44) "TIME"TAB(56)
     "FACTOR":PRINTSTRING$(62,"-")
1020 FORI=ST TO S:PRINTUSING" ##";I;:PRINTTAB(21);
     :PRINTUSING"###";T(I,1)*1Ø;:PRINTTAB(32);
     :PRINTUSING";T(I,1)*1Ø-TI,2);:PRINTTAB(43);
     :PRINTUSING"####";T(I,3);
1030 PRINTTAB (55);:PRINTUSING"####.##";T(I,3)/
     T(I,2)
1040 TN=TN+1:IF TN=1Ø THEN GOSUB 53Ø:
     TN=Ø:ST=ST+1Ø:GOSUB 9ØØ:GOTO 1Ø1Ø
     ELSE NEXT
1050 PRINT:PRINT"RESTART? (Y/N)...";:GOSUB 8ØØ:IF
     AI="Y" THEN PRINT@64,STRING$(63,131);
     STRING$(65,32):ON ERROR GOTO 55Ø:GOTO 6Ø
1060 END
```

column is being removed). If C has not been decremented past 0, we jump to the subroutine at line 500, where a fixed delay is created and the time is updated. Then we return to line 320. This procedure continues until the difference between X and XO is less than one increment. The same procedure is followed in lines 370 through 390 for a decreasing count.

If at any time, all squares are removed, execution passes to line 350 where the MAXIMUM CALM ATTAINED message is displayed, and we are allowed to (R)estart or (E)nd. Lines 500 through 710 contain various subroutines, including that to display the instructions. The Restart/End subroutine begins at line 740. This subroutine is used throughout the program and allows one to restart or end at almost any time. It also calls another subroutine that gives you the option to save the results of any trial for later presentation. (STORE RESULTS, beginning at line 840).

The END routine begins at line 990. Line 1000 passes execution to Line 1050 (Restart?) if no data are present, or branches to the error trap if any error occurs. Otherwise, line 1010 proceeds to display the results previously stored in the T array. Notice that the "Factor" is a relative measure of results, since it reflects number of squares removed per unit time. Since up to 50 trials can be stored, the FOR/NEXT loop starting at line 1020 prints results in groups of 10 maximum, waits for you to press any key, and then continues. Line 1050 allows you to restart or truly end. In this manner, you can select the END function at any time, review your results and then RESTART to continue monitoring.

Using the biobox

Select a quiet, comfortable area (around 70 degrees F). Relax by loosening tight clothing, removing your shoes, etc. Sit in a comfortable position that provides arm and elbow support. Make sure your hands are clean and dry.

Type in, save and then RUN the BIO program. After the initial screen has been displayed, place the black cassette cable plug in J2 (out) and the large grey cassette cable plug in J1 (in). The small grey plug is not used. Place S1 (power) in the ON position.

The display consists of a title at the top, an underline, an "option/status" line, the biofeedback graph and a command line. At this point, the status line contains a copyright notice and the command line is asking "Instructions? (Y/N)..." Press "Y." The screen will clear below the title and the first page of instructions will be displayed. When done reading, press any key to continue (as instructed at the bottom of the screen) to read the second page of instructions. When you press any key again, you are returned to the opening screen. But note that the copyright notice is replaced by the question "SELECT INITIAL MOOD (2-9)..." You would have been brought to this point immediately if you responded N (no) to the "INSTRUCTIONS" question.

Now place one bioprobe on your index finger, and the other bioprobe on the middle finger of the same hand. The bioprobe foil should contact the fingerprint. Set the BioBox's ON/OFF switch to the ON position, and press "5." Columns 6 through 10 will disappear. The message "INITIALIZING" will appear at the bottom, and a dot (period) will appear over the top box on the last row (5th row in this example). If the BioBox is not working properly, (power not on, bioprobe not attached, skin resistance too high, etc.) the message "ERROR OCCURRED. PRESS (R) TO RESTART, (E) TO END..." will appear at the bottom. Correct the problem (power up the BioBox, attach probes, clean fingers, etc.) and press (R) to try again. You will be asked if you want to "STORE RESULTS? Y/N..." If you have completed a valid session, you would select "Y." If you encountered an error (or simply do not want to store results) press "N." The message "R E S T A R T" will appear at the top of the screen and the original display will be provided.

Select an initial mood between 2 and 9. The dot will blink five times, and the "INITIALIZING" message will then disappear. You are now in the biofeedback monitoring mode. Make a fist; boxes will begin to be added. Release the fist; boxes will disappear (in an actual session, you should keep your hand stationary). The object is to remove all boxes. If you do, the message "MAXIMUM CALM ATTAINED. PRESS (R) TO RESTART, OR (E) TO END..." will appear in the middle of the screen. Whichever you choose, the message "STORE RESULTS? (Y/N)..." will appear at the screen bottom. Note that during monitoring you may press (R) to restart or (E) to end at any time, but you may have to hold the key down for a second or so before it is recognized. When you select (E) you will see the RESULTS screen. The RESULTS display contains five columns, labelled TRIAL #, START, END, TIME and FACTOR. For each trial, the START and END columns show the number of squares you started and ended with. For instance, if you selected "6" as your initial mood and acheived maximum calm, the START indication would be 60 (6 columns × 10 squares/column = 60) and the END indication would be 0. The next column indicates the elapsed time of the session (not seconds, but relative units of time). The final column gives an indication of how well you did. It is a ratio of the number of squares removed per one unit of time. The object is to get this number as close to zero without going negative (which indicates squares were added, not removed.)

If there are more than 10 results stored, they will be shown in pages of 10. When all results have been displayed, you will be given the option to "RESTART? (Y/N)..." By pressing "Y" you can continue monitoring. (This allows you to periodically check your progress and then return to monitoring.) If you select "N," the program will end. As currently written, the data is not permanently saved. Depending on your individual system and requirements, a short subroutine may be added to save the data to a tape or disk file.

Summing it up

The BioBox can turn your Model I or III into a computerized biofeedback monitoring system, and may even help you to reduce everyday stress and tensions. But don't limit it strictly to biofeedback monitoring. Try it as a lie detector at your next party. Just make sure you don't become the subject!

VIC-20 EXPANDER

Build this expansion port for your VIC-20.

JIM STEELE

■If you own a Commodore *VIC-20*, you're probably tired of switching memory-expansion modules and game cartriges in and out of the user port. You might have considered buying one of those port expanders you've seen advertised. They are certainly a possible solution—you can switch between several cartridges at the flip of a switch—but they're expensive. We'll show you a less-expensive alternative—building your own port expander.

Additional ports

While the expander module shown here will provide three additional ports with another available for future expansion, there is no reason why this selfsame system could not be further expanded upon almost to an infinite number of ports, limited only by your own requirements and your own pocketbook. There are actually two ways to go.

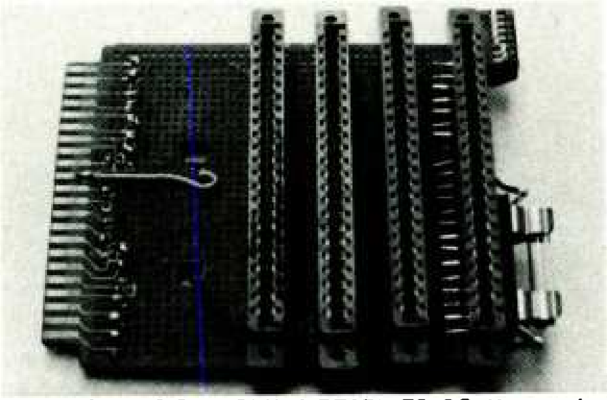


FIG. 1—EXPANSION MODULE READY TO GO. Here, we're looking down at the top of the board.

One way is to make additional expanders, as shown here, and simply plug the second expander unit into the open port on the first one. However, if you anticipate the need for several more ports than would be furnished by this unit, you can readily "expand the expander" by adding additional ports wired in the same configuration as these are.

The result will be even more versatility.

The justification for this expander is simply in its added conveniece to the user. Before the expander, it was necessary (within limiations) to pull a cartridge and replace it with another when cartridges needed changing. If you rarely if ever change cartridges, the expander will seem a mere nicety that you could probably do as well without. However, if you're constantly changing cartridges, as would be the case when you're using your computer predominatly for game-playing, the expander becomes a vital and important tool, as you leave *all* the cartridges plugged in, and flip switches to change from one to another. It makes life a great deal simpler.

You can put the expander together for about $20.00—perhaps less if you have some of the parts around. But it will work just as well as the commercial models that cost up to five times as much. The expander we'll show you was built to accept three cartridges, with a fourth available for future additions. It is fully switchable and it's fused to protect both the VIC and cartridges.

Easy to build

Even if you don't have much experience building electronics projects, you shouldn't have too much trouble with the expander. The hardest task is the point-to-point wiring, but you can get around that by designing a printed-circuit board. Whatever method you use, you should be able to finish everything up in a weekend.

To begin with, you will need a general-purpose plug board with a 22/44 edge connector. Such boards are available from many sources, including Radio Shack. Next, you will need three or four wire-wrap 44-pin card-edge connectors. Those, too, are easily available. You'll also need some 30-gauge (or larger) insulated wire. Stranded wire works best, and you should try to use a color-coded arangement. Finally, you will need a 2- or 3-amp line fuse and three or four switches. I used an eight-position PC-board-mounted switch.

With one exception, the card edge and card-edge-connector sockets are wired in parallel. Example: Contact "A" on the contact board is wired to contact "A" on each card-edge socket. Contact "B" is wired to contact "B" on each socket, etc. (See the diagram, Figure 2.) The only exception to that is contact No. 21, which is the +5 volt supply from the computer to the expander board. This contact is wired through a switch for each socket, and then to contact No. 21 of the socket. Thus, what is plugged into the socket will be powered up only when the switch is closed. Contacts "Z" and No. 22 are common ground.

Another alternative for those who are of an experimental turn of mind, would be the use of a rotary switch mounted to a small panel. You'd want to use a switch with the same number of contacts as there are switches on the boards, or ports on the boards, and wire to the rotary switch instead of having individual switches at each port. While this might appear to complicate the circuit a bit, it would result in up-front control of the ports. Make sure you use a non-shorting rotary switch for this application, and the rotary switch can then be mounted in a small separate plastic box of its own and placed either atop or alongside the computer. The added convenience that this affords would make it worth looking into.

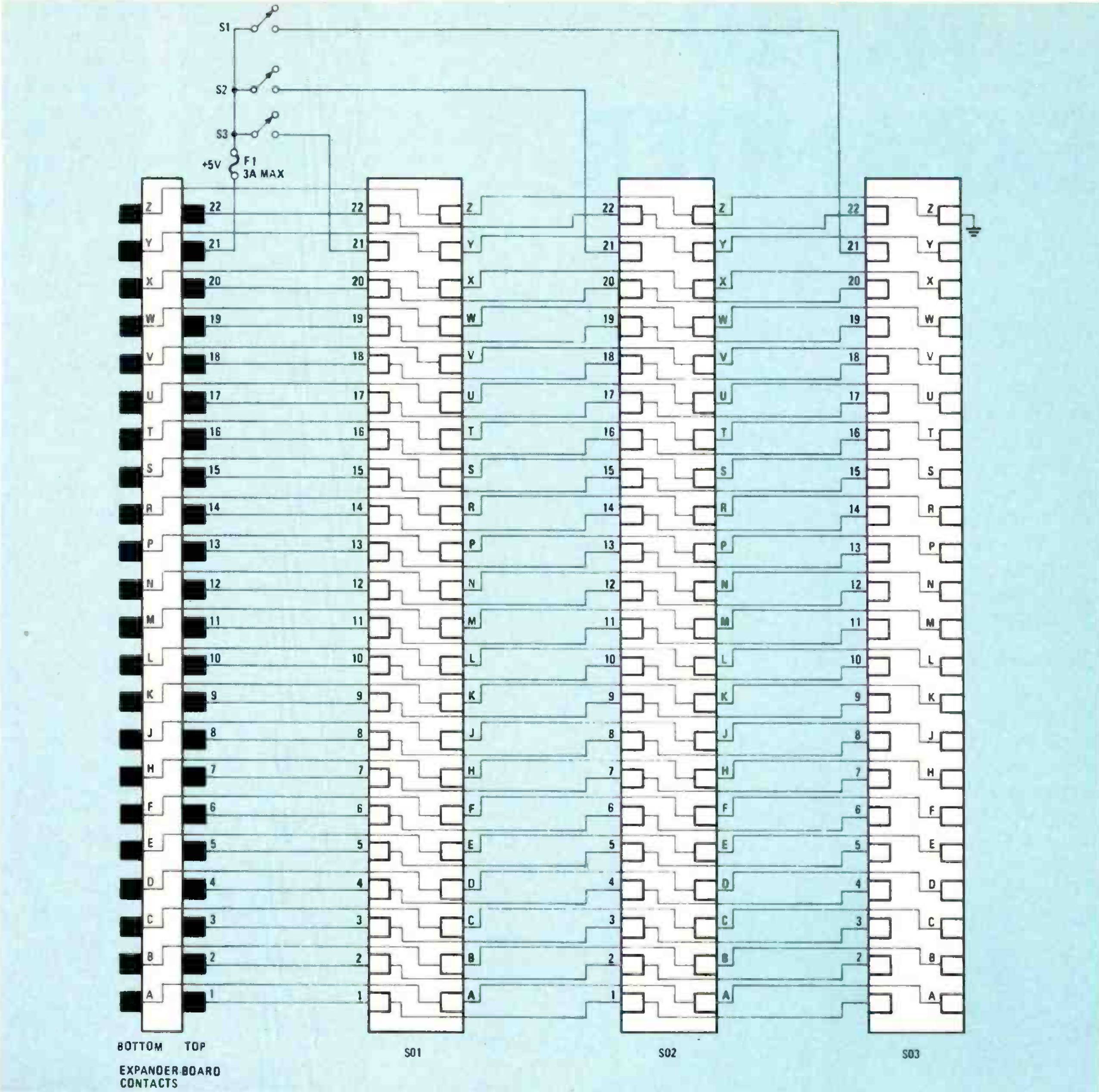


FIG. 2—SCHEMATIC DIAGRAM shows simple point-to-point wiring. Circuit is straightforward and direct with no hidden traps.

FIG. 3—UNDERSIDE VIEW REVEALS WIRING. The VIC-20 expander makes a good one-weekend project that will reward you with years of added convenience.

Check the wiring!

Once the wiring is completed, check the continuity of each circuit. This procedure is a *must* because any bad connection could cause your VIC to behave radically or crash memory at a most inopportune time. When you are sure that each connection is right, plug your unit into the VIC-20 expansion port, wire-side down, making sure the contacts line up. Plug in your game and/or your memory expansions. Check the operation of each of the expansion ports with a game you are familiar with or a memory expansion. If you turn on your VIC and it does not work properly, turn it off and recheck your wiring and make sure that the contacts from the plug line up with the expansion port contacts.

That's all there is to it! Unless you have more than three expansion modules and games you don't have to worry about plugging in a module every time you need one—just switch it on when you need it!

COMMUNICATIONS CORNER

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

Phantom power

ONE OF THESE DAYS, SOMEONE IS going to write a definitive book called *Reinventing the Wheel*. It will be a book containing all the ideas rediscovered by succeeding generations. If asked for suggestions about what wheels to include, I think *phantom power* should head the list. Each new generation of students and hobbyists with whom I've been involved has "discovered" phantom power. For those of you who haven't rediscovered it yet, phantom power is a means whereby the supply voltage for a device is carried along on the same line with the signal.

The first time I ever heard of phantom power was as an assistant radio-technician on my first remote broadcast. I was the guy who lugged around heavy cases containing boat anchors (better known as portable mixers). Maybe it was the free lunch that we were served, but my supervisor took ill and I was left hanging on by my fingernails with equipment that I knew next to nothing about. Under such circumstances, everything will go wrong. (And everything did!)

First, the private phone line dropped out; then the headphones wouldn't work. Finally, after locating a public telephone, I called the head honcho at the studio who mumbled something about us being on a solid-wire circuit. He then told me to bypass the resistive pad on my mixer's output, and connect a spare dial lamp from the center tap of the mixer's output transformer to an earth ground. I was told that when the light went on I was "on the air."

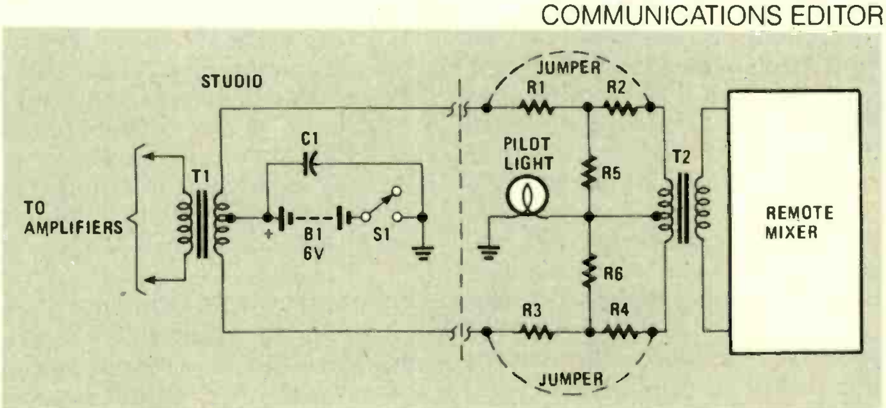


FIG. 1

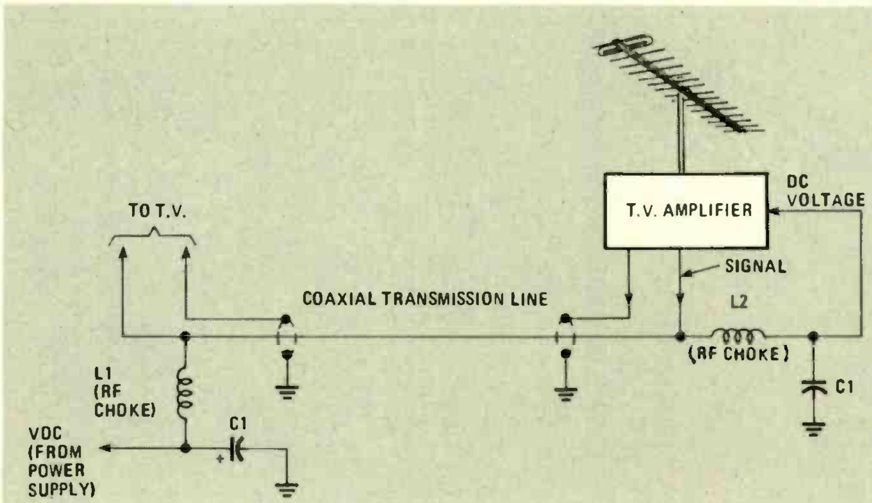


FIG. 2

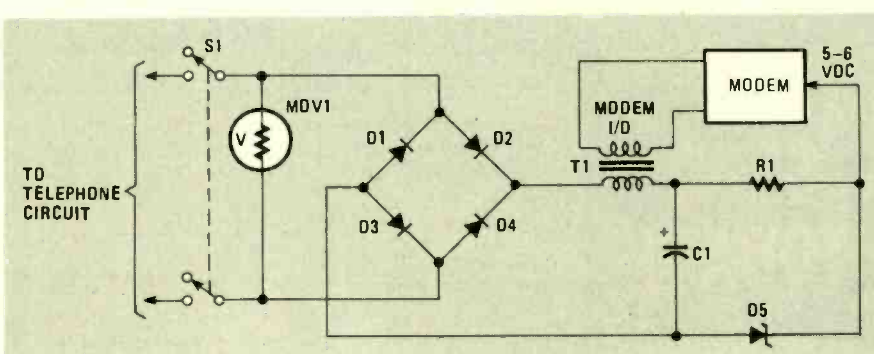


FIG. 3

Phantom-powered circuits

The phantom-power circuit used to light the signal lamp is shown in Fig. 1. It's almost a textbook circuit. Back then, though, it was "the cutting edge of technology." (Textbooks, however, forget to mention that between the transformer and the output lines, we usually place a resistive pad—the one I had to jumper.) Needless to say, the darn thing worked. And even though we had plenty of induced hum in the common-ground circuit, someone back at the studio was able to get rid of it with a notch filter.

In the years that followed, I've seen phantom power rediscovered to feed such devices as condenser microphones. If we were to look back and trace the history of phantom power, we would find that it originated with the telephone system (for their line amplifiers). Most of you are probably more familiar with phantom power for TV amplifiers and microwave converters.

Figure 2 shows the most common phantom-powered circuit that technicians are likely to run across: a mast-mounted TV "antenna amplifier." Of course, in such an application, you do not want to run both a power line and antenna feed to the amplifier. Phantom power lets the amplifier gets its supply voltage from the transmission line. At the receiver end, a DC voltage from the power supply is coupled to the coaxial cable through an RF choke, L1. The choke isolates the RF circuit from the power supply.

At the amplifier/converter end (on the antenna mast), the DC voltage is stripped off the coaxial cable by another RF choke, L2, to power the solid-state devices. As far as the RF signal is concerned, the choke impedance is so high that no RF appears on the DC side.

Phantom powered modems

One of the inconveniences of a modem is the power supply. It can be internal (which requires a fairly large cabinet) or external (which requires a wall-mounted AC adapter—always an inconvenience.) The modem may have to be plugged into the terminal or computer so it can tap the equipment's power supply; or the supply could be a battery, which is sure to fail when most needed.

The more modern (not really modern) way to get the power is the way it's done in the Universal Data Systems *1003LP* answer/originate modem, directly from the telephone system. The no-load voltage on a dial-up telephone line is 48-volts DC, which falls to nominally 6 volts when the handset is taken off hook, or any normal load is connected across the line.

Fortunately, micropowered solid-state devices—like modems—work very well on 5–6 volts, so we can phantom-power a complex active device directly from the telephone circuit. Figure 3 shows a simplified phantom-power source for a manual communications modem, therefore, no ring detector/automatic power circuits are shown.

Switch S1 connects the modem to the telephone line. The full-wave rectifier (consisting of diodes D1–D4) ensures against polarity problems with the telephone lines; regardless of the line connections, the rectifier's output polarity is unchanged. A metal-oxide varistor, MOV1, is inserted on the line side of the bridge rectifier to prevent transients that may be on the line from entering the modem.

The modem's I/O transformer, T1, is in series with the DC output of the rectifier. Capacitor C1 provides DC filtering and the AC return path for T1. (The signal current in T1 induces an input voltage to the modem, while the modem's output varies the DC current, hence the current in the telephone circuit.) Zener diode D5 is used to clamp the DC at 5 or 6 volts; however, it can be replaced by a voltage regulator.

While the circuit in Fig. 3 looks simple enough, it is not seen in general use because it takes a lot of hardware when a high supply-current is required. In such a case, it simply isn't cost effective. But if micropower devices are used, it's possible to sell a modem—such as Universal Data System's *103LP*—for a list price of $150. **R-E**

STATE OF SOLID STATE

Electronic locks

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

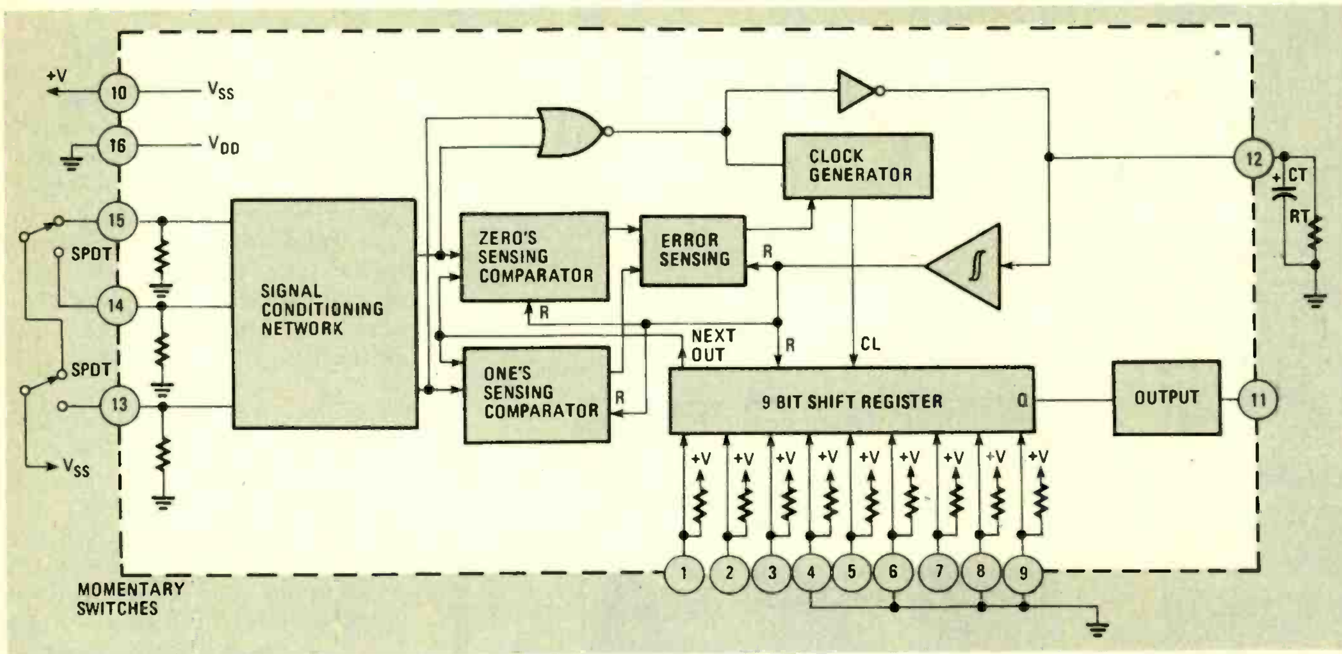


FIG. 1

THE RAPIDLY RISING CRIME RATE HAS forced us to go to the extremes to protect our valuables. For instance, it is not uncommon to see two and three locks on a single door.

If you use conventional locks to secure your home or valuables, you could find yourself carrying large numbers of keys. That means everytime you want to open a door or gain access to your property, you'll be saddled with the task of sorting through several keys to find the one you need at that particular moment. However, there is another way to get the needed security—replace some of those conventional locks with coded electronic types.

Two electronic locks worth your consideration are the LS7228 and LS7229 from LSI. Figure 1 is a block diagram of the innards of the LS7229 (the LS7228 is similar). Both units are ion-implanted, PMOS encoder circuits that include all the necessary logic to interpret the entry code and develop a momentary lock-control output. The LS7228 address decoder is keyed by two pulse trains of logic one's and zero's applied to the correct terminals. The LS7229 is keyed by two double-throw momentary pushbutton switches (which are used to enter one's and zero's).

Both units (housed in 16-pin DIP's) feature stand-alone lock logic, out-of-sequence disabling circuits, current-source lock-control outputs, externally controlled delay to set maximum time between pulses, and a 9-bit entry code determined by 9 parallel inputs. Each IC is powered from a single-ended 2.5- to 15-volt supply. Maximum standby current is 15 μA.

The locks are controlled by a 9-bit binary code that has 512 possible combinations. The leading or most significant bit is set by pin 1 and the end (least significant) bit is set using pin 9. Code terminals 1 through 9 control a 9-bit shift register. The entry code is programmed into the lock by either jumpering or floating (leaving open) certain pins. Refer to Fig. 2, a practical circuit for the LS7229.

To program any given input to accept a logic 1, the pin corresponding to that input is left open. Jumpering a pin to ground programs a zero into the device at the corresponding position in the entry code. For example, if pins 3, 4, 5, 6, and 9 are grounded and the others left open, the binary access-code would be 110000110.

The device is unlocked by entering the code (one's and zero's) in the correct sequence through switches S1 and S2. The zeros' and ones' entry ports are initially at logic zero (ground). As each key is pressed, its entry port goes to logic one and then returns to zero. When the first correct bit of the code is keyed in via S1 and S2, the external capacitor is discharged and an internal inhibit is removed so the circuit will be receptive to the second bit, and so on.

If all nine bits are in the correct sequence, a logic one passes through the shift register to the lock output at pin 11. An out-of-sequence entry or incorrect bit at any point in the entry code inhibits any further entry. After a delay period (determined by the time constant of an external R/C network) a new sequence of key pulses may be applied.

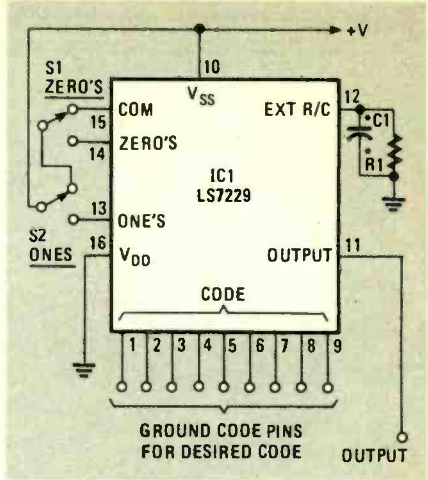


FIG. 2

The lock-output (pin 11) switches from zero to logic one as the voltage on pin 9 returns to zero following the last pulse of the entry code. It remains at logic one for a period about 30% longer than the R/C time constant. To hold the output at logic one, apply a tenth entry bit to either pin 13 or pin 14 and hold it high for as long as is necessary.

The output control is a current source so a load must be connected between pin 11 and ground. The source-current range depends on the supply voltage and the voltage across the load. For example, the source current averages 9 mA with a 9-volt supply and 8.5 volts across the load. It sources 26 mA with 7.5 volts across the load.

The time constant of the external R-C network at pin 12 determines the duration of the output pulse and the maximum permissible interval between valid entry-code bits. The time constant in seconds is the product of the resistance of R1 in megohms and the capacitance of C1 in microfarads. When using a 9-volt supply, the minimum suggested value for R1 is 2200 ohms and the maximum value is 3.3 megohms.

The LS7228 and LS7229 binary-lock circuits are available from **LSI Computer Systems, Inc.**, 1235 Walt Whitman Road, Melville, NY 11747 at $2.70 each for 1 to 24 pieces. Include $5.00 for shipping and handling. New York State residents add sales tax. Data sheets are available on request. **R-E**

DRAWING BOARD

More on the 4089

ROBERT GROSSBLATT

LAST MONTH WE LEARNED A THING OR two about the 4089, but were not quite finished with that device. This time, let's start off by seeing how it can be used to do division.

Division with rate multipliers

Since we treated multiplication as successive addition, let's think of division as successive subtraction. In simpler terms, how many times can we subtract one number from another before we reach zero? To be practical about it, let's take a look at the circuit from our last discussion.

What we want to do with the circuit this time around is to keep track of the multiplied-rate pulses and count the base-rate pulses (the opposite of what we did previously). In hardware terms, that means we have to switch two wires in the circuit!

Figure 1 can be considered an addendum to the circuit we did last month; it shows the extra hardware needed to switch between the multiplication and division modes. With the display added, all we need do is put a DPDT switch to change the operation of the circuit from multiplication to division.

Doing more complex forms of arithmetic, such as squares and roots, is possible as well. Virtually any arithmetic operation can be written as a series of operations that involve only multiplication and division. A good mathmatics textbook will show you what has to be done.

Once you have that taken care of, arrange your circuit to do the necessary arithmetic and that should be that. Start out with square roots and continue from there. If any of you do breadboard such a circuit, send me the details and I'll put them in the column for everybody else to see. Remember that the whole point of this column is to share information (you've got to give a little to get a little).

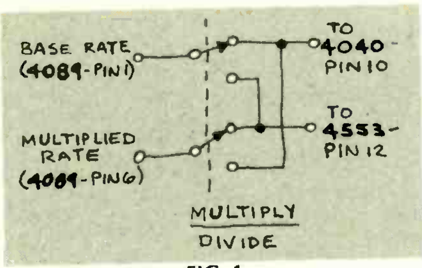


FIG. 1

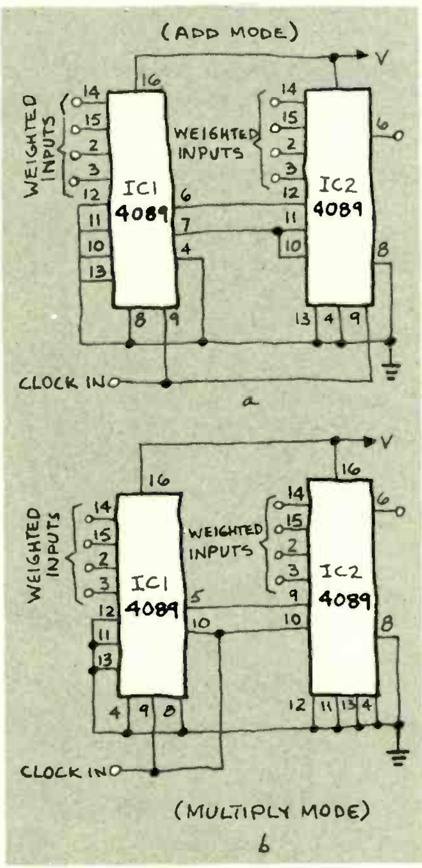


FIG. 2

There are two problems left for us to talk about. The first is figuring out a way to make the circuit easier to use and the second is making the circuit more useful. Let's tackle the second one first.

Cascading the 4089

The 4089, and all the other rate multipliers, are easy to cascade and there are two different ways of doing it. Which way you choose depends on the kind of arithmetic you want to do.

In Fig. 2-a, the IC's are cascaded in what National Semiconductor calls the "add" mode. IC1 works just the way it did in our demonstrator circuit and if you were to check the output of IC1, you would see the same results we saw earlier. Things aren't terribly straightforward when you're in the "add" mode, however. Since IC2 has its cascade input connected to the output of IC1, its multiplied rate will be 16 times greater than that of IC1.

On the other hand, if you wanted to do division by—let's say, 72—you would have to remember that IC1 is working with a base of 16 and IC2 is working with a base of 256 (16 times 16). In order to figure out what numbers to present to the inputs of the 4089, you have to do some additional work to reduce everything to a base of 256. If A is the most significant digit (at IC1) and B is the least significant digit (at IC2), then:

$$(A \times 16) + B = 72$$

The trick is to find how large you can make A without exceeding 73.

Minor brain burning gives us an answer of four for A; therefore, B has to be eight. To sum it up, we put a binary four (0100) and a binary eight (1000) at the weighted inputs of rate multipliers IC1 and IC2, respectively.

A much easier way to take care of that is to use the second method of cascading the 4089, which National Semiconductor refers to as the "multiply" mode. That configuration, shown in Fig. 2-b, is a standard cascading arrangement. It is more common than the "add" mode, but as we'll soon see, it is not as versatile.

The procedure is little different and a lot simpler than the previous method. Here the outputs of the IC's are multiplied together in a normal cascade arrangement, making the arithmetic a lot easier, as can be seen from the equation:

$$A \times B = 72$$

Our only restriction in choosing values for A and B is the four-bit width of the IC's; 12 and 6 are the only choices.

You've probably noticed that not all numbers can be obtained using that method, which is why the add mode is more versatile. However, if we were doing multiplication, the restriction wouldn't apply and this method would be better, since it would mean fewer traces on the board.

Like almost everything else in digital circuitry, our description makes it sound much more complicated than it really is. If you try working with the rate multiplier, you'll find that it can provide easy solutions to what would otherwise be seemingly impossible circuit problems.

The second problem is designing some sort of circuit that would make it easy for us to select the numbers we want to use. Because the 4089 has binary inputs, the keyboard encoder covered in the February, March, and April 1983 installments of "Drawing Board" would be perfect.

If you're interested in the topic of keyboard data entry, check out those issues of **Radio-Electronics** (if you don't have them, try your local library). If there is enough interest in the subject, let us know; we'll spend some more time talking about it. **R-E**

DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT

Audio overload protection

IN ANY CONTEST TO RATE THE MOST popular areas of electronics, audio circuits and projects would undoubtedly be among the top ten. There is probably more home "tinkering" done in the areas of equalization, noise reduction, amplification, and so on than in any other field. And, as we all know, hardly a day goes by without an announcement from one semiconductor manufacturer or another about a new audio IC.

Each successive generation of audio IC has more features packed into it than its predecessor and can handle really mind boggling amounts of power. For instance, it wasn't long ago that an LM386 driver-amp blew everybody away because, with just a handful of external parts, it could output a ½ watt of continuous power into an 8-ohm load. These days, however, IC power-amps need virtually no external components, and one with more than 10 watts of power-handling capability can be held on the end of your little finger!

Every amplifier (regardless of type) has maximum power ratings. If those limits are exceeded, the amplifier and any associated components may be destroyed, so you must be careful. (Remember overloading can cause lots of trouble.) Overloading is hard to guard against because a typical audio signal can have a really wide dynamic range—sometimes more than 30dB.

Overload protection scheme

Protecting audio circuitry against overload (accidental or otherwise) is an important consid-

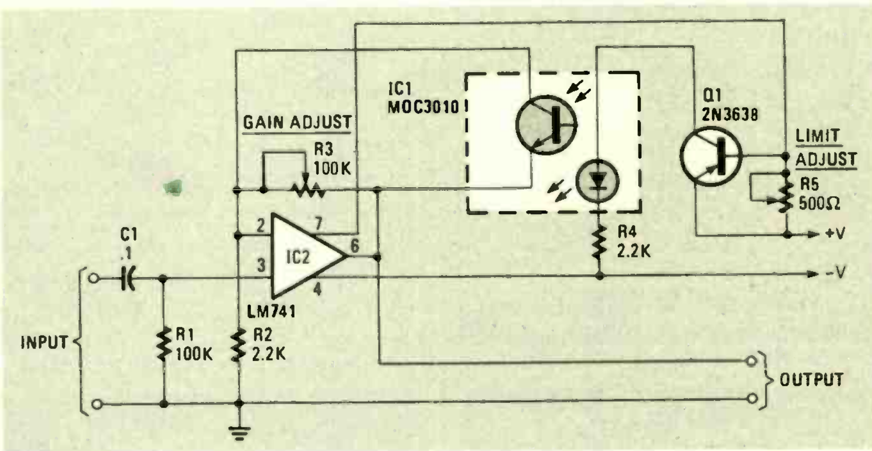


FIG. 2

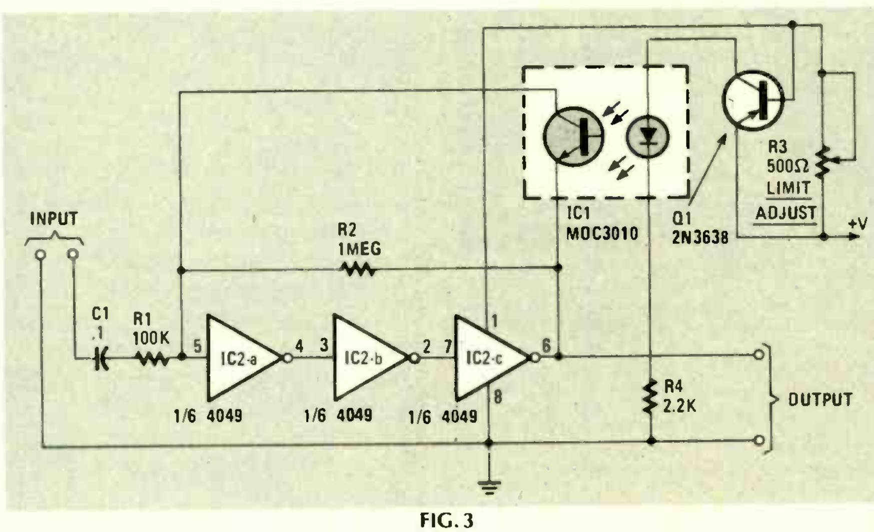


FIG. 3

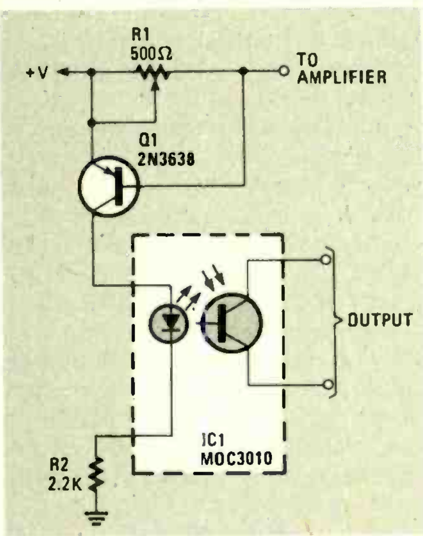


FIG. 1

eration, and should be on the mind of any serious audio-circuit designer. The best place to guard against overload is in the early stages where signal levels are low. The further along you are in the audio chain, the "beefier" the signal becomes, and the harder it is to add some type protection scheme. To complicate matters, overloads in the final power stages stand a much greater chance of "smoking" some expensive parts.

The circuit shown in Fig. 1 is the beginning of a protection scheme that can be made from a few common components. It's capable of monitoring circuit gain, and will also make sure that signal levels stay within the pre-set range. (The original circuit used a nonstandard optocoupler or optoisolator constructed from readily available parts, which we'll tell you how to make a little later.)

The best place to put the circuit is either in the feedback loop or shunted across the preamp input. Although the circuit tends to limit the gain of a preamp, keep in mind that it's meant to show you one way to approach the problem, and is by no means the only way to get the job done. Once you try it and become familiar with how it works, there are several "offshoots" of that design, which you can make following the same basic idea.

Figure 1 shows a 500-ohm potentiometer (R1) sitting right on the line feeding power to the preamp. When the audio signal is increased, the preamp draws more power to handle the larger signal. That results in a greater amount of current through R1, which causes a proportionate voltage to develop across the potentiometer.

Transistor Q1 monitors the voltage supplied to the amp through resistor R1. Whenever that voltage reaches the V_{CE} threshold, the transistor turns on, causing the LED in the optocoupler to light. That, in turn, causes the phototransistor to conduct. What you do with output of the optocoupler depends on how you design your audio circuit but (as already stated) the best place for it is either in the feedback loop or across the preamp input.

continued on page 112

SERVICE CLINIC

JACK DARR

Kit building made easy

HANDS-ON ELECTRONICS IS A GOOD phrase. Everyone should have some experience in making things. Once you've actually built something, you'll know much more about how it works.

One thing every electronics hobbyist should have is some test equipment. But, as you probably know, the most desirable equipment can be expensive. There is, however, a way to get the test gear you need, and save a good deal of money in the process. Of course, I'm referring to test equipment in kit form.

Saving money isn't the only advantage—you can also gain much knowledge about how the device is made and what it can do. Kits range from the simplest (an analog VOM, for example) to things more complex than a digital frequency counter. I speak from much experience: at least ten instruments among my collection were made from kits, and they're darn good instruments, too!

One of the niceties of kit building is that the most complex instrument can be just as easy to build as the simplest one! Instruction and construction manuals (see Fig. 1) supplied with the kit tell you exactly how the instrument works and how to use it. Be warned, however, you must *follow the construction manual to the letter*. Don't take short cuts!.

The manuals were written by people who have made and sold thousands of those devices. Therefore, what they tell you to do is always the best way to do that particular job. Follow them closely and you'll find that the job goes much faster, and you'll wind up with an instrument that stands a far greater chance of working the first time it's turned on.

FIG. 1

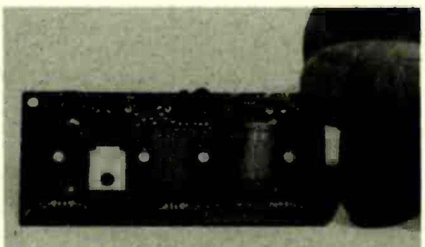


FIG. 2

Believe it or not, I've almost never had one work the first time—always because of some stupid mistake I'd made! And that's what this article is about: how to find and correct those mistakes. Not only will the information found here aid you in kit building, but it can help make any construction project or repair job go a bit smoother.

Correcting construction errors

In building any electronic device, you should check your work both during and after each phase of construction. For instance, when placing a part in a circuit board, make sure it's in the right place, correctly oriented, and is the value called for in the instructions before soldering. In that way, any mistakes—parts put in backwards, etc.—can easily be corrected.

After soldering, check for solder bridges—splashes of solder caused by sloppy workmanship—especially between closely-spaced, adjacent PC-board conductors (see Fig. 2). Solder bridges can be a real headache to locate, because they are the same color as the conductors of the PC board! A magnifying glass is a handy thing to have around when checking for solder bridges. It can help you locate those hair-line bridges, which often are undetectable to the naked eye.

I once wired up a fairly complex kit, taking extreme care (or so I thought) to avoid solder bridges. But when I powered it up, it did nothing! Checking over my work carefully with a big magnifying glass, I found no less than five bridges. After correcting the problem, my kit worked like a charm. So don't ever be too confident that you haven't made any bridges. Look your work over very closely, and if you find any bridges, take them out.

While you're checking for bridges, look for any unsoldered terminals or cold solder joints. Unsoldered terminals are a common occurrence in kit building. That is, after you've finished putting the kit together, a joint or two is still not soldered. That's usually caused by not reading the instructions carefully.

A good construction manual (from Heathkit, for example) will tell you to put in a part and then "S," for solder or "NS," for not solder—which should tell that there are more parts to be connected to that joint—so that terminal should not be soldered yet. After completing a section, make sure that each terminal is soldered or not soldered as instructed.

Cold solder joints are another common source of trouble. They can be identified by their frosty appearance. If you find one or more, simply reheat the joint and, *if necessary*, apply a bit more solder. A good solder joint usually shines like silver. Assuming that all appears well, you can power up the device.

If nothing happens, follow the same routine you would with any other piece of "dead" equipment. Go back and check the wiring, parts placement, and so on. Then if you find no errors, power it up again and check the DC voltage source and the places where DC voltages should be.

Chances are you'll find that the voltage is missing in one or two places. When you find a place that should have voltage but does not, simply trace back through the circuit until you find the place where the trouble is. Fix that point and make sure that there are no more missing voltages. Once you get the DC voltages all straightened out, the device should work. If it doesn't, you'll have to recheck *everything*. Never be lulled into a false sense of security because you believe you've followed every step. Remember, overconfidence can be disastrous!

Suspect everything until you have double checked it. Go back, recheck the manual, and be sure the part in each position is the type and value called for. If you do that carefully, there's a far greater chance of your project working the first time.

Kits are really very easy to assemble (as you will find out) if you follow the instructions. Take it very slow and easy, and be sure to check off each step as you go (using a red pencil, so the check marks will stand out). **R-E**

Radio-Electronics mini-ADS

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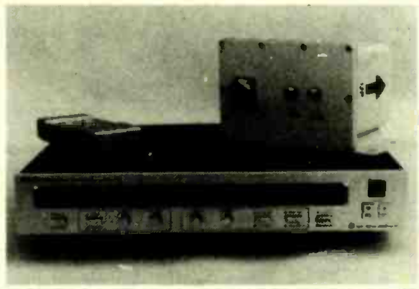

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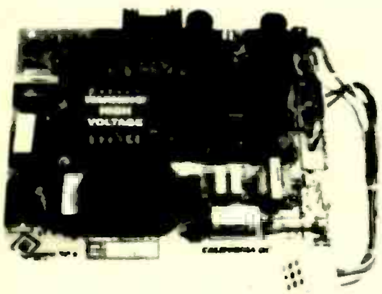

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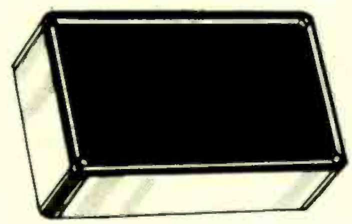

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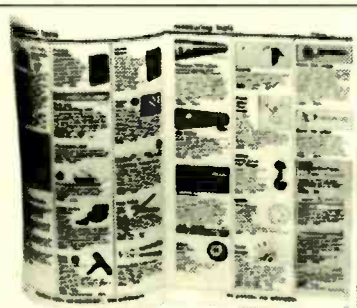

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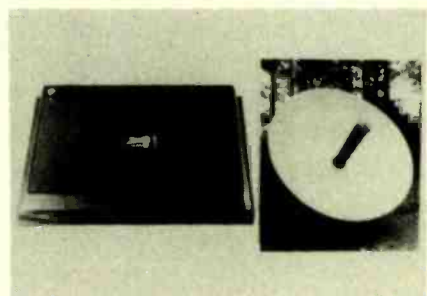

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MARKET CENTER

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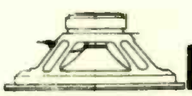

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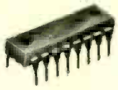
Communications ICs

With Pin-Out And Data



Type		Cat. No.	Each
XR 2206	AFSK Generator	276-2336	5.95
XR 2211	AFSK Decoder	276-2337	5.95
ICL8038	Function Generator	276-2334	5.95
LM565	Phase Locked Loop	276-1720	1.99
MC1488	Quad Line Driver	276-2520	1.79
MC1489	Quad Line Receiver	276-2521	1.79

TTL Digital ICs

With Pin-Out and Specs

Type	Cat. No.	Each
7400	276-1801	.89
7404	276-1802	.99
7408	276-1822	1.29
7447	276-1805	1.59
7490	276-1808	1.09

Replacement Transistors

With Pin-Out and Data

Type		Cat. No.	Each
2N1305	PNP	276-2007	1.19
MPS2222A	NPN	276-2009	.79
PN2484	NPN	276-2010	.89
MPS3904	NPN	276-2016	.69
TIP31	NPN	276-2017	.99
TIP3055	NPN	276-2020	1.59
MPS2907	PNP	276-2023	.79
MJE34	PNP	276-2027	1.49
2N3053	NPN	276-2030	.99
MPS3638	PNP	276-2032	.79
TIP120	NPN	276-2068	1.29
2N3055	NPN	276-2041	1.99
MJ2955	PNP	276-2043	2.19
2N4401	NPN	276-2058	.59
MPSA06	NPN	276-2059	.59
MPSA13	NPN	276-2060	.59
MPSA42	NPN	276-2061	.69
2SC945	NPN	276-2051	.79
2N3819	N-FET	276-2035	.99
MPF102	N-FET	276-2062	.99
IRF511	V-FET	276-2072	2.59
IRFD1Z3	V-FET	276-2073	1.49
2SC1308	NPN	276-2055	7.95

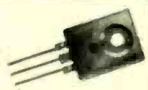
Operational Amplifiers

Type		Cat. No.	Each
741	(Single)	276-007	.89
MC1458	(Dual)	276-038	.99
LM324	(Quad)	276-1711	1.29
TL082	(Dual)	276-1715	1.89
TL084	(Quad)	276-1714	2.99
LM3900	(Quad)	276-1713	1.39
LM339	(Quad)	276-1712	1.49
TLC271	(Single)	276-1748	1.59
TLC272	(Dual)	276-1749	2.19
TLC274	(Quad)	276-1750	2.99

Computer / Game Connectors

Type	Positions	Cat. No.	Each
Solder Sub-D Male	9	276-1537	1.99
Solder Sub-D Female	9	276-1538	2.49
Hood for Above	9	276-1539	1.99
Solder Sub-D Male	15	276-1527	2.49
Solder Sub-D Female	15	276-1528	3.49
Hood for Above	15	276-1529	1.99
Solder Sub-D Male	25	276-1547	2.99
Solder Sub-D Female	25	276-1548	3.99
Hood for Above	25	276-1549	1.99
Solderless Sub-D Male	25	276-1559	4.99
Solderless Sub-D Fem.	25	276-1565	4.99
Printer Connector	36	276-1534	6.99
Cable Socket	34	276-1525	3.19
Disk Drive Connector	34	276-1564	4.95

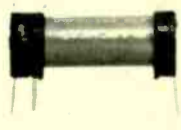
Voltage Regulators



Type	Adjustable	Cat. No.	Each
LM723	0 to 40 VDC	276-1740	.99
LM317T	1.2 to 37 VDC	276-1778	2.79

Type	Fixed Output	Cat. No.	Each
7805	+5 VDC	276-1770	1.59
7812	+12 VDC	276-1771	1.59
7815	+15 VDC	276-1772	1.59
7905	−5 VDC	276-1773	1.59
7912	−12 VDC	276-1774	1.59

Compact SPST Reed Relays



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MC-1330	Video Detector	2.29	1.69
MC-1349	Video If Amp	2.08	1.55
MC-1350	Video If Amp	1.75	1.19
MC-1352	Video If Amp AGC	2.69	2.09
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SN7402N	14	.29	SN7476N	16	.39	SN74161N	16	.59
SN7403N	14	.29	SN7479N	14	4.95	SN74162N	16	.59
SN7404N	14	.35	SN7480N	14	.89	SN74163N	16	.59
SN7405N	14	.49	SN7482N	14	1.49	SN74164N	14	.69
SN7406N	14	.59	SN7483N	16	.55	SN74165N	16	.69
SN7407N	14	.59	SN7485N	16	.59	SN74166N	16	.69
SN7408N	14	.29	SN7486N	14	.39	SN74167N	16	2.95
SN7409N	14	.35	SN7489N	16	2.25	SN74170N	16	1.59
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SN7412N	14	.49	SN7492N	14	.45	SN74174N	16	.59
SN7413N	14	.39	SN7493N	14	.45	SN74175N	16	.59
SN7414N	14	.49	SN7494N	14	.89	SN74176N	14	.79
SN7416N	14	.49	SN7495N	14	.49	SN74177N	14	.79
SN7417N	14	.59	SN7496N	16	.49	SN74179N	16	1.49
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SN7421N	14	.59	SN74100N	24	1.95	SN74181N	24	1.95
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SN7426N	14	.39	SN74109N	16	.39	SN74190N	16	.69
SN7427N	14	.25	SN74116N	24	1.49	SN74191N	16	.69
SN7428N	14	.59	SN74121N	14	.45	SN74192N	16	.69
SN7430N	14	.35	SN74122N	14	.69	SN74193N	16	.69
SN7432N	14	.39	SN74123N	16	.55	SN74194N	16	.69
SN7433N	14	.49	SN74125N	14	.49	SN74195N	16	.49
SN7437N	14	.25	SN74126N	14	.49	SN74196N	14	.75
SN7438N	14	.49	SN74132N	14	.59	SN74197N	14	.75
SN7439N	14	.79	SN74136N	14	.69	SN74198N	24	1.19
SN7440N	14	.19	SN74141N	16	.89	SN74199N	24	1.19
SN7441N	16	.89	SN74142N	16	3.95	SN74221N	16	1.19
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SN7443N	16	1.25	SN74144N	24	3.95	SN74273N	20	1.95
SN7444N	16	1.25	SN74145N	16	.65	SN74276N	20	2.49
SN7445N	16	.69	SN74147N	16	1.29	SN74279N	16	.79
SN7446N	16	.75	SN74148N	16	.89	SN74283N	16	1.39
SN7447N	16	.75	SN74150N	24	1.49	SN74284N	16	2.95
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SN7454N	14	.19	SN74152N	14	.49	SN74365N	16	.55
SN7459N	14	.35	SN74153N	16	.99	SN74366N	16	.55
SN7460N	14	.39	SN74154N	24	1.49	SN74367N	16	.55
SN7470N	14	.39	SN74155N	16	.49	SN74368N	16	.55
SN7472N	14	.39	SN74156N	16	.59	SN74390N	16	1.49
SN7473N	14	.39	SN74157N	16	.49	SN74393N	14	1.49

74LS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74LS00	14	.29	74LS132	14	.65	74LS244	20	1.29
74LS01	14	.29	74LS133	16	.59	74LS245	20	1.49
74LS02	14	.35	74LS136	14	.39	74LS251	16	.59
74LS03	14	.29	74LS138	16	.59	74LS253	16	.59
74LS04	14	.39	74LS139	16	.59	74LS257	16	.59
74LS05	14	.35	74LS145	16	1.19	74LS258	16	.59
74LS08	14	.35	74LS147	16	1.95	74LS260	14	.59
74LS09	14	.35	74LS148	16	1.79	74LS266	14	.49
74LS10	14	.35	74LS151	16	.59	74LS273	20	1.49
74LS11	14	.35	74LS153	16	.59	74LS279	14	.49
74LS14	14	.59	74LS154	24	1.49	74LS280	14	1.95
74LS15	14	.35	74LS155	16	.69	74LS283	16	.69
74LS20	14	.29	74LS156	16	.69	74LS290	14	.89
74LS21	14	.35	74LS157	16	.69	74LS293	14	.89
74LS26	14	.29	74LS158	16	.59	74LS299	20	2.95
74LS27	14	.35	74LS160	16	.69	74LS322	20	3.95
74LS28	14	.39	74LS161	16	.69	74LS323	20	3.95
74LS30	14	.35	74LS162	16	.69	74LS347	16	.79
74LS32	14	.39	74LS163	16	.69	74LS352	16	1.09
74LS37	14	.35	74LS164	14	.89	74LS353	16	1.09
74LS38	14	.35	74LS165	16	.89	74LS363	20	1.49
74LS42	16	.49	74LS166	16	1.19	74LS365	16	.49
74LS47	16	.89	74LS168	16	1.49	74LS366	16	.49
74LS51	14	.29	74LS169	16	1.49	74LS367	16	.49
74LS73	14	.39	74LS170	16	1.49	74LS368	16	.49
74LS74	14	.49	74LS173	16	.69	74LS373	20	1.49
74LS75	16	.45	74LS174	16	.69	74LS374	20	1.49
74LS76	16	.39	74LS175	16	.69	74LS375	16	.69
74LS85	16	.89	74LS181	24	2.49	74LS386	14	.49
74LS86	14	.39	74LS190	16	.79	74LS393	14	1.19
74LS90	14	.55	74LS191	16	.89	74LS399	16	1.49
74LS92	14	.55	74LS192	16	.79	74LS490	16	1.95
74LS93	14	.55	74LS193	16	.79	74LS533	20	1.95
74LS96	16	.89	74LS194	16	.69	74LS534	20	1.95
74LS107	14	.39	74LS195	16	.69	74LS540	20	1.95
74LS109	16	.39	74LS196	14	.89	74LS541	20	1.95
74LS112	16	.45	74LS197	14	.89	74LS640	20	2.19
74LS114	14	.39	74LS221	16	1.09	74LS641	20	2.19
74LS122	14	.49	74LS240	20	1.09	74LS645	20	2.19
74LS123	16	.79	74LS241	20	.99	74LS670	16	1.49
74LS125	14	.59	74LS243	14	1.09	74LS688	20	2.95
74LS126	14	.59				81LS95	20	1.49
						81LS96	20	1.49
						81LS97	20	1.49
						81LS98	20	1.49

74S/PROMS*

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74S00	14	.35	74S114	14	.55	74S241	20	1.95
74S02	14	.35	74S124	16	2.75	74S242	14	2.19
74S03	14	.35	74S132	14	1.89	74S243	14	2.19
74S04	14	.45	74S133	16	.45	74S244	20	2.19
74S05	14	.45	74S135	16	.89	74S251	16	.99
74S08	14	.45	74S136	14	1.39	74S253	16	.99
74S09	14	.39	74S138	16	.89	74S257	16	.99
74S10	14	.35	74S139	16	.89	74S258	16	.99
74S11	14	.35	74S140	14	.69	74S260	14	.79
74S15	14	.35	74S151	16	.99	74S273	20	2.39
74S20	14	.35	74S153	16	.99	74S280	14	1.99
74S22	14	.35	74S157	16	.99	74S287*	16	1.79
74S30	14	.35	74S158	16	.99	74S288*	16	1.79
74S32	14	.45	74S160	16	2.29	74S299	20	5.95
74S37	14	.99	74S169	16	4.29	74S373	20	2.49
74S38	14	.85	74S174	16	1.09	74S374	20	2.49
74S51	14	.35	74S175	16	1.09	74S387*	16	1.95
74S64	14	.39	74S188*	16	1.75	74S471*	20	4.95
74S65	14	.39	74S194	16	1.49	74S472*	20	4.95
74S74	14	.55	74S195	16	1.49	74S473*	20	4.95
74S85	16	1.99	74S196	14	1.49	74S570*	16	2.95
74S86	14	.55	74S240	20	1.95	74S571*	16	2.95
74S112	16	.55				74S572*	18	4.95
74S113	14	.55				74S573*	18	4.95

CA—LINEAR

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
CA3010H		1.09	CA3081N	16	1.15	CA3130E	8	1.19
CA3039H		1.25	CA3082N	16	1.15	CA3140E	8	1.15
CA3046N	14	.99	CA3083N	16	1.15	CA3160H		1.79
CA3059N	14	2.95	CA3086N	14	.85	CA3160E	8	1.49
CA3060N	16	2.95	CA3089N	16	1.95	CA3161E	16	1.79
CA3065E	14	1.49	CA3096N	16	1.75	CA3162E	16	6.95
CA3080E	8	.99				CA3189E	16	2.79
						CA3401N	14	.59

CD—CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
CD4001	14	.29	CD4041	14	.69	CD4503	16	.69
CD4002	14	.29	CD4042	16	.69	CD4506	16	1.29
CD4006	14	.89	CD4043	16	.79	CD4507	14	1.19
CD4007	14	.29	CD4044	16	.79	CD4508	24	1.95
CD4008	16	.89	CD4046	16	.89	CD4510	16	.85
CD4009	16	.59	CD4047	14	.89	CD4511	16	.85
CD4010	16	.49	CD4048	16	.59	CD4512	16	.85
CD4011	14	.29	CD4049	16	.39	CD4514	24	1.49
CD4012	14	.29	CD4050	16	.39	CD4515	24	1.49
CD4013	14	.39	CD4051	16	.79	CD4516	16	.89
CD4014	16	.89	CD4052	16	.89	CD4518	16	.89
CD4015	16	.39	CD4053	16	.79	CD4519	16	.89
CD4016	14	.49	CD4056	16	2.95	CD4520	16	.89
CD4017	16	.79	CD4059	24	3.95	CD4526	16	1.19
CD4018	16	.79	CD4060	16	.89	CD4528	16	1.19
CD4019	16	.49	CD4066	14	.45	CD4529	16	1.69
CD4020	16	.75	CD4068	14	.39	CD4531	16	.89
CD4021	16	.75	CD4069	14	.35	CD4538	16	1.49
CD4022	16	.75	CD4070	14	.29	CD4541	14	1.49
CD4023	14	.29	CD4071	14	.29	CD4543	16	1.19
CD4024	14	.69	CD4072	14	.29	CD4562	14	6.95
CD4025	14	.29	CD4073	14	.29	CD4566	16	2.95
CD4026	16	1.59	CD4077	14	.35	CD4583	16	2.49
CD4027	16	.45	CD4078	14	.29	CD4584	14	.59
CD4028	16	.69	CD4081	14	.29	CD4585	16	1.19
CD4029	16	.79	CD4093	14	.49	CD4724	16	1.19
CD4030	14	.39	CD4094	16	1.95	MC14410	16	7.95
CD4034	24	1.79	CD4098	16	1.95	MC14411	24	11.95
CD4035	16	.79	CD4099	16	1.89	MC14412	16	8.95
CD4040	16	.75				MC14433	24	17.95
						MC14572	16	1.19

(More in Catalog)

74F00 — NEW

Part No.	Pins	Function	Price
74F00	14	Quad 2-Input NAND Gate	.69
74F02	14	Quad 2-Input NOR Gate	.75
74F04	14	Hex Inverter	.89
74F08	14	Quad 2-Input AND Gate	.75
74F10	14	Triple 3-Input NAND Gate	.75
74F32	14	Quad 2-Input OR Gate	.79
74F74	14	Dual D Flip-Flop	.85
74F86	14	Quad Exclusive OR Gate	1.15
74F109	16	Dual JK Positive Edge Flip-Flop	.95
74F138	16	Expandable 3/8 Decoder	1.69
74F157	16	Quad 2-Input Multiplexer	1.69
74F158	16	Quad 2-Input Multiplexer (inv)	1.69
74F193	16	4-Bit Up/Down Binary Counter	5.29
74F240	20	Tri-State Octal Line Driver (Inverting)	3.75
74F244	20	Tri-State Octal Line Driver	3.49
74F257	16	Tri-State Quad 2-Input Multiplexer	1.79
74F373	20	Tri-State Octal Latch	4.89
74F374	20	Tri-State Octal D Flip-Flop	4.59

74ALS00

Part No.	Pins	Function	Price
74ALS00	14	Quad 2-Input NAND Gate	.59
74ALS02	14	Quad 2-Input NOR Gate	.59
74ALS04	14	Hex Inverter	.59
74ALS08	14	Quad 2-Input AND Gate	.59
74ALS10	14	Triple 3-Input NAND Gate	.59
74ALS30	14	8-Input NAND Gate	.59
74ALS32	14	Quad 2-Input OR Gate	.65
74ALS74	14	Dual D Flip-Flop	.79
74ALS109	16	Dual JK Pos. Edge Flip-Flop	.79
74ALS138	16	Expandable 3/8 Decoder	1.25
74ALS240	20	Tri-State Octal Line Driver (Inverting)	2.25
74ALS244	20	Tri-State Octal Line Driver	2.25
74ALS245	20	Octal Bus Transceiver (Non-Inv.)	2.59
74ALS373	20	Tri-State Octal Latch	2.59
74ALS374	20	Tri-State Octal D Flip-Flop	2.59

MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	19.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	Pins	Function	Price
Z80	40	CPU (MK3880N) (780C) 2MHz	2.95
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	3.49
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4) (780C-1) 4MHz	3.49
Z80A-CTC	28	Counter Timer Circuit	4.49
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
Z8001B	48	CPU Segmented (10MHz)	79.95
Z8002B	40	CPU Non-Segmented (10MHz)	59.95

6500/6800/68000 SERIES

Part No.	Pins	Function	Price
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	6.49
6502B	40	MPU with Clock (3MHz)	8.95
6520	40	Peripheral Inter. Adapter	3.95
6522	40	Peripheral Inter. Adapter	5.49
6551	28	Async. Comm. Interface Adapter	10.95
6800	40	MPU	2.95
6802CP	40	MPU with Clock and RAM	7.95
6809	40	CPU — 8-Bit (On-Chip Oscillator)	8.95
6809E	40	CPU — 8-Bit (External Clocking)	9.95
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	14.95
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.95
68B21	40	Peripheral Interface Adapter (2MHz)	5.95
6845	40	CRT Controller (CRTC)	14.95
68B45	40	CRT Controller (CRTC) 2MHz	19.95
6850	24	Asynchronous Comm. Adapter	3.95
6860	24	0-600bps Digital MODEM	7.95
68000L8	64	MPU 16-Bit (8MHz)	39.95
68488P	40	General Purpose Int. Adapter	9.95

8000/80000 SERIES

Part No.	Pins	Function	Price
8031	40	Control Oriented CPU w/RAM & I/O	14.95
8035	40	MPU — 8-Bit	5.95
8039	40	CPU — Sgl. Chip 8-Bit (128bts. RAM)	5.95
8040N-6	40	CPU (256 bytes RAM)	8.95
8080	40	CPU — 8-Bit NMOS	14.95
8070N	40	CPU (64 bytes RAM)	19.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	4.95
8086-2	40	CPU 16-bit 8MHz	24.95
8087	40	Arithmetic Processor	189.95
8088	40	CPU 8/16-Bit	19.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8156	40	RAM with I/O Port and Timer	8.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.95
8224	16	Clock Generator/Driver	2.95
8228	28	System Cont./Bus Driver (74S428)	4.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	19.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	4.95
8250N	40	Async. Comm. Element	10.95
8251	28	Prog. Comm. I/O (USART)	4.95
8251A	28	Prog. Comm. Interface (USART)	7.95
8253	24	Prog. Interval Timer	6.95
8255	40	Prog. Peripheral I/O (PPI)	4.95
8256A-5	40	Prog. Peripheral I/O (PPI) 5MHz	7.95
8259	28	Prog. Interrupt Control	5.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	19.95
8274	40	Multi-Protocol Serial Cont. (7201)	29.95
8279	40	Prog. Keyboard/Display Interface	6.95
8282	20	Octal Latch	8.95
8284	18	Clock Generator/Driver	6.95
8286	20	Octal Bus Transceiver	7.95
8287	20	Octal Bus Transceiver (Inverted)	7.95
8288	20	Bus Controller	19.95
8303	20	8-Bit Tri-State Bi-Directional Trans.	3.49
8304	20	8-Bit Bi-Directional Receiver	3.49
8310	20	Octal Latched Peripheral Driver	3.95
8741	40	8-Bit Univ. Peripheral Interface	29.95
8748	40	HMOS EPROM MPU	39.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	39.95
8755	40	16K EPROM with I/O	39.95
80186-6	68	High Integration 16-Bit MPU	99.95

DISK CONTROLLERS

Part No.	Pins	Function	Price
INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	24.95
FD1793	40	Single/Double Density (True)	26.95
FD1795	40	Dual Density/Side Select (Inv.)	26.95
FD1797	40	Dual Density/Side Select (True)	29.95

SPECIAL FUNCTION

Part No.	Pins	Function	Price
DS0026CN	8	Dual MOS Clock Driver (5MHz)	1.95
INS2651	28	Communication Chip	7.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM54240N	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	1.49
4116N-2	16	16,384x1	(150ns)	1.39 — 8/10.95
4116N-3	16	16,384x1	(200ns)	1.15 — 8/8.95
4116N-4	16	16,384x1	(250ns)	.89 — 8/6.95
4164N-150	16	65,536x1	(150ns)	5.19 — 8/40.95
4164N-200	16	65,536x1	(200ns)	4.95 — 8/38.95
MM5261	16	1024x1	(300ns)	.35 — 8/1.95
MM5262	22	2048x1	(300ns)	.10
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5298-3	16	8192x1	(200ns)	.59
41256	16	262,144x1	(200ns)	31.95

STATIC RAMS

Part No.	Pins	Function		Price
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
2102-2L	16	1024x1	(250ns) LP (91L02)	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114N	18	1024x4	(450ns)	1.29 — 8/9.95
2114N-L	18	1024x4	(450ns) LP	1.95 — 8/13.95
2114N-2	18	1024x4	(200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4	(200ns) LP	1.69 — 8/13.49
2147HN	18	4096x1	(70ns)	4.49
2148HN	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	3.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-2	24	2048x8	(120ns) CMOS	7.95
HM6116LP-2	24	2048x8	(120ns) LP CMOS	8.95
HM6116P-3	24	2048x8	(150ns) CMOS	4.95
HM6116LP-3	24	2048x8	(150ns) LP CMOS	6.49
HM6116P-4	24	2048x8	(200ns) CMOS	4.75
HM6116LP-4	24	2048x8	(200ns) LP CMOS	5.49
HM6264P-12	28	8192x8	(120ns) CMOS	37.95
HM6264LP-12	28	8192x8	(120ns) LP CMOS	39.95
HM6264P-15	28	8192x8	(150ns) CMOS	34.95
HM6264LP-15	28	8192x8	(150ns) LP CMOS	37.95
27LS00	16	256x1	(80ns) LP	3.95
7489	16	16x4	(50ns) 3101	2.25
74C921	18	256x4	(250ns) CMOS	5.95
74C930	16	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

Part No.	Pins	Function		Price
1702A	24	256x8	(1µs)	3.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	3.49
TMS2516	24	2048x8	(450ns) 2716	4.95
TMS2532	24	4096x8	(450ns) MMC2532	5.49
TMS2564	28	8192x8	(450ns)	10.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	14.95
2716-1	24	2048x8	(350ns)	5.49
27160-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.95
2732-20	24	4096x8	(200ns)	10.95
2732A-20	24	4096x8	(200ns) 21V	11.49
2732A-25	24	4096x8	(250ns) 21V	7.19
2732A-45	24	4096x8	(450ns) 21V	6.49
27C32A-30	24	4096x8	(300ns) 21V (CMOS)	22.95
2764-20	28	8192x8	(200ns) 21V	14.95
2764-25	28	8192x8	(250ns) 21V	7.19
2764-45	28	8192x8	(450ns) 21V	6.49
27C64	28	8192x8	CMOS 21V	22.95
MCM68764	24	8192x8	(450ns) 21V	24.95
27128-25	28	16,384x8	(250ns) 128K Eprom 21V	21.95
27256-25	28	32,768x8	(250ns) 256K Eprom (14V)	99.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

Part No.	Pins	Function	Price
DC10		Mostek DC/DC Converter +5V to -9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	3.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)	4.49
DAC1000	24	10-Bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-Bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-Bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-5-1013A	40	30K Baud UART (TR1602)	3.95

Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.55	.49	.45
16 pin SG	.59	.55	.49
18 pin SG	.69	.65	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.39	1.25	1.19
40 pin SG	1.29	1.15	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.56	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.99	.90	.85
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.99	1.89	1.79
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
14 pin HC	.15	.13	.12
16 pin HC	.19	.17	.15
24 pin HC	.27	.25	.22

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Part No.	Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
FE0203D		3½ Digit LCD Display for 7106 & 7116	14.95
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit)	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
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74HC High Speed CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74HC00	14	.59	74HC139	16	1.05	74HC245	20	2.59
74HC02	14	.59	74HC147	16	1.29	74HC251	16	.99
74HC03	14	.89	74HC151	16	.99	74HC253	16	1.09
74HC04	14	.59	74HC153	16	1.09	74HC257	16	.99
74HCU04	14	.69	74HC154	24	2.65	74HC259	16	1.69
74HC08	14	.59	74HC157	16	.99	74HC266	14	.89
74HC10	14	.59	74HC158	16	.99	74HC273	20	2.79
74HC11	14	.69	74HC160	16	1.39	74HC280	14	4.59
74HC14	14	.89	74HC161	16	1.39	74HC299	20	5.59
74HC20	14	.59	74HC162	16	1.39	74HC366	16	2.59
74HC27	14	.59	74HC163	16	1.39	74HC367	16	2.59
74HC30	14	.69	74HC164	14	1.35	74HC373	20	2.69
74HC32	14	.79	74HC165	16	2.15	74HC374	20	2.69
74HC42	16	1.09	74HC166	16	2.49	74HC390	16	1.59
74HC51	14	.89	74HC173	16	1.29	74HC393	14	1.59
74HC58	14	.89	74HC174	16	1.09	74HC533	20	2.69
74HC73	14	.79	74HC175	16	1.09	74HC534	20	2.69
74HC74	14	.79	74HC190	16	1.59	74HC595	16	3.19
74HC75	16	.99	74HC191	16	1.59	74HC688	20	3.59
74HC76	16	.79	74HC192	16	1.49	74HC4024	14	1.75
74HC85	16	1.69	74HC193	16	1.49	74HC4040	16	1.49
74HC86	14	.75	74HC194	16	1.19	74HC4060	16	1.49
74HC107	14	.79	74HC195	16	1.19	74HC4075	14	.59
74HC109	16	.79	74HC221	16	2.95	74HC4078	14	.59
74HC112	16	.79	74HC237	16	1.49	74HC4511	16	1.95
74HC123	16	2.29	74HC240	20	2.29	74HC4514	24	4.19
74HC125	14	1.75	74HC241	20	2.29	74HC4538	16	2.59
74HC132	14	1.29	74HC242	14	2.15	74HC4543	16	3.75
74HC137	16	1.59	74HC243	14	2.15			
74HC138	16	1.19	74HC244	20	2.29			

74HCU04 is unbuffered
All others are buffered.

74C—C/MOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74C00	14	.29	74C107	14	.79	74C240	20	1.95
74C02	14	.35	74C151	16	2.19	74C244	20	1.95
74C04	14	.35	74C154	24	3.25	74C373	20	2.29
74C08	14	.35	74C157	16	1.75	74C374	20	2.29
74C10	14	.35	74C160	16	1.19	74C901	14	.59
74C14	14	.59	74C161	16	1.19	74C902	14	.79
74C20	14	.35	74C162	16	1.19	74C903	14	.59
74C30	14	.35	74C163	16	1.19	74C906	14	.59
74C32	14	.39	74C164	14	1.29	74C907	14	.99
74C42	16	1.19	74C165	16	1.29	74C911	28	8.95
74C48	16	1.79	74C173	16	.89	74C912	28	8.95
74C73	14	.69	74C174	16	1.19	74C915	18	1.19
74C74	14	.59	74C175	16	1.19	74C917	28	8.95
74C85	16	1.39	74C192	16	1.39	74C922	18	4.49
74C86	14	.29	74C193	16	1.39	74C923	20	4.95
74C89	16	5.95	74C195	16	1.29	74C925	16	5.95
74C90	14	1.09	74C221	16	1.75	74C926	18	5.95
74C93	14	1.09				80C95	16	.69
74C95	14	1.19				80C97	16	.69

LINEAR

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
TL071CP	8	.79	LF355N	8	1.09	LM747N	14	.69
TL072CP	8	1.09	LF356N	8	1.09	LM748N	8	.59
TL074CN	14	1.95	LM358N	8	.59	UA760HC		9.95
TL081CP	8	.59	LM359N	14	1.79	LM1456V	8	1.95
TL082CP	8	1.19	LM370N	14	4.95	LM1458CN	8	.59
TL084CN	14	1.95	LM373N	14	4.95	LM1488N	14	.69
LM109K		5.95	LM377N	14	1.95	LM1489N	14	.69
LM301CN	8	.39	LM380CN	8	1.09	LM1496N	14	.99
LM302H		2.49	LM380N	14	.89	LM1605CK		9.95
LM304H		1.95	LM381N	14	1.79	LM1800N	16	2.49
LM305H		.99	LM382N	14	1.49	LM1871N	18	2.95
LM307CN	8	.49	LM384N	14	1.95	LM1872N	18	3.25
LM308CN	8	.69	LM386N-3	8	.89	LM1877N-9	14	2.95
LM309K		1.25	LM387N	8	1.39	LM1889N	18	1.95
LM310CN	8	1.95	LM389N	18	1.19	LM1896N	14	1.59
LM311CN	8	.59	LM391N-80	16	1.19	LM2002T		1.95
LM312H		2.79	LM392N	8	.59	ULN2003A	16	1.49
LM317T		1.19	LM393N	8	.45	XR2206	16	3.95
LM317K		3.49	LF398N	8	3.95	XR2207	14	2.49
LM318CN	8	1.59	LM399H		5.95	XR2208	16	1.79
LM319N	14	1.49	LF412CN	8	1.95	XR2211	14	2.95
LM320K-5		1.35	TL494CN	16	2.79	LM2877P		1.95
LM320K-12		1.35	TL496CP	8	1.59	LM2878P		2.95
LM320K-15		1.35	NE531V	8	1.79	LM2901N	14	.79
LM320K-24		1.35	NE544N	14	1.95	LM2902N	14	.89
LM320T-5		.85	NE550A	14	1.95	LM2907N	14	2.49
LM320T-12		.85	NE555V	8	.35	LM2917N	8	1.95
LM320T-15		.85	XR-L555	8	.69	LM3900N	14	.59
LM320T-24		.85	LM556N	14	.79	LM3905CN	8	1.19
LM322N	14	1.49	NE558N	16	1.59	LM3909N	8	.89
LM323K		4.95	NE564N	16	1.95	LM3914N	18	2.39
LM324N	14	.59	LM565N	14	.99	LM3915N	18	2.39
LM329DZ		.65	LM566CN	8	1.49	LM3916N	18	2.39
LM331N	8	3.95	LM567V	8	.99	RC4136N	14	1.25
LM334Z		1.19	NE570N	16	2.95	RC4151NB	8	1.95
LM335Z		1.29	NE571N	16	2.49	RC4195TK		5.95
LM336Z		1.09	NE592N	14	1.19	LM4250CN	8	1.49
LM337MP		1.15	LM703CN	8	1.49	LM4500A	16	2.95
LM337T		1.89	LM710N	14	.69	NE5532	8	1.69
LM338K		6.95	LM711N	14	.79	NE5534	8	1.39
LM339N	14	.69	LM723N	14	.49	79M05AH		1.29
LM340K-5		1.35	LM733N	14	.89	ICL8038B	14	3.95
LM340K-12		1.35	LM739N	14	1.95	LM13080N	8	1.19
LM340K-15		1.35	LM741CN	8	.39	LM13600N	16	1.19
LM340K-24		1.35				76477	28	3.95
LM340T-5		.75						
LM340T-12		.75						
LM340T-15		.75						
LM340T-24		.75						
LF347N	14	1.49						
LM348N	14	.89						
LM350K		4.79						
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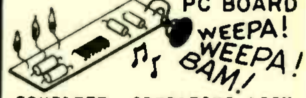

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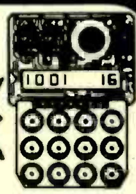

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14 pin ST.	.14	14 pin WW	.68
16 pin ST.	.16	16 pin WW	.68
18 pin ST.	.19	18 pin WW	.98
20 pin ST.	.28	20 pin WW	1.04
22 pin ST.	.29	22 pin WW	1.34
24 pin ST.	.29	24 pin WW	1.44
28 pin ST.	.39	28 pin WW	1.64
40 pin ST.	.48	40 pin WW	1.94

ST = Soldertail   WW = Wirewrap

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16 pin ZIF 5.90
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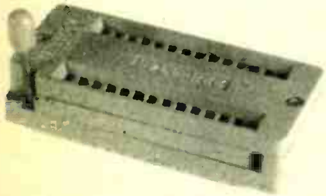

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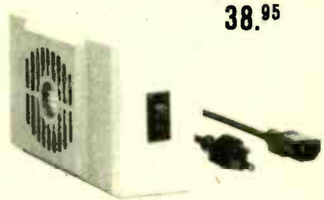

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2114L-3	1024x4	(300ns)(LP)	8/13.45
2114L-2	1024x4	(200ns)(LP)	8/13.95
TMM2016-200	2048x8	(200ns)	4.15
TMM2016-150	2048x8	(150ns)	4.95
TMM2016-100	2048x8	(100ns)	6.15
HM6116-4	2048x8	(200ns)(cmos)	4.75
HM6116-3	2048x8	(150ns)(cmos)	4.95
HM6116LP-4	2048x8	(200ns)(cmos)(LP)	5.95
HM6116LP-3	2048x8	(150ns)(cmos)(LP)	6.95
HM6264P-15	8192x8	(150ns)(cmos)(LP)	34.95

LP = Low Power

DYNAMIC RAMS

4116-250	16384x1	(250ns)	8/7.95
4116-200	16384x1	(200ns)	8/12.95
4116-150	16384x1	(150ns)	8/14.95
4164-200	65536x1	(200ns)(5v)	9/44.95
4164-150	65536x1	(150ns)(5v)	9/49.00
TMS4164	65536x1	(150ns)(5v)	8.95

5v = Single 5 Volt Supply

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2716-1	2048x8	(350ns)(5v)	5.95
TMS2532	4096x8	(450ns)(5v)	5.95
2732	4096x8	(450ns)(5v)	4.95
2732-250	4096x8	(250ns)(5v)	8.95
2732-200	4096x8	(200ns)(5v)	11.95
2732A	4096x8	(250ns)(5v)(21vPGM)	9.95
2732A-2	4096x8	(200ns)(5v)(21vPGM)	13.95
2764	8192x8	(450ns)(5v)	6.95
2764-250	8192x8	(250ns)(5v)	7.95
2764-200	8192x8	(200ns)(5v)	19.95
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5v = Single 5 Volt Supply
21vPGM = Program at 21 Volts

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PE-14T	X	9	8,000	119.00
PE-24T	X	9	9,600	175.00

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8039	5.95
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8087	175.00
8088	29.95
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8155-2	7.95
8156	6.95
8748	24.95
8755	24.95

8200

8203	39.95
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8212	1.80
8216	1.75
8228	3.49
8237-5	21.95
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8259	6.90
8259-5	7.50
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8282	6.50
8284	5.50
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Z80A-SIO/0	12.95

6.0 Mhz

Z80B-CPU	9.95

6500

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6551	11.85
6502A	6.95
6522A	9.95
6551A	11.95

6800

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6800	2.95
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74LS00

74LS00	.24	74LS157	.65
74LS01	.25	74LS158	.59
74LS02	.25	74LS160	.69
74LS03	.25	74LS161	.65
74LS04	.24	74LS163	.65
74LS05	.25	74LS164	.69
74LS08	.28	74LS165	.95
74LS09	.29	74LS166	1.95
74LS10	.25	74LS169	1.75
74LS11	.35	74LS173	.69
74LS12	.35	74LS174	.55
74LS13	.45	74LS191	.89
74LS14	.59	74LS192	.79
74LS20	.25	74LS193	.79
74LS21	.29	74LS194	.69
74LS26	.29	74LS195	.69
74LS27	.29	74LS197	.79
74LS32	.29	74LS221	.89
74LS33	.55	74LS240	.95
74LS37	.35	74LS241	.99
74LS38	.35	74LS242	.99
74LS40	.25	74LS243	.99
74LS42	.49	74LS244	1.29
74LS47	.75	74LS245	1.49
74LS51	.25	74LS251	.59
74LS73	.39	74LS253	.59
74LS74	.35	74LS257	.59
74LS75	.39	74LS258	.59
74LS76	.39	74LS259	2.75
74LS85	.69	74LS260	.59
74LS86	.39	74LS266	.55
74LS90	.55	74LS279	.49
74LS92	.55	74LS280	1.98
74LS93	.55	74LS283	.69
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74LS125	.49	74LS368	.45
74LS126	.49	74LS373	1.39
74LS132	.59	74LS374	1.39
74LS136	.39	74LS377	1.39
74LS138	.55	74LS390	1.19
74LS139	.55	74LS393	1.19
74LS145	1.20	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS670	1.49
74LS153	.55	74LS682	3.20
74LS154	1.90	74LS688	2.40
74LS155	.69	81LS95	1.49
74LS156	.69	25LS2521	2.80

7400

7400	.19	7492	.50
7401	.19	7493	.35
7402	.19	74100	1.75
7403	.19	74107	.30
7404	.19	74116	1.55
7405	.25	74121	.29
7406	.29	74122	.45
7407	.29	74123	.49
7408	.24	74125	.45
7409	.19	74126	.45
7410	.19	74132	.45
7411	.25	74145	.60
7413	.35	74148	1.20
7414	.49	74150	1.35
7416	.25	74151	.55
7417	.25	74153	.55
7420	.19	74154	1.25
7421	.35	74155	.75
7425	.29	74157	.55
7427	.29	74159	1.65
7430	.19	74161	.69
7432	.29	74163	.69
7437	.29	74164	.85
7438	.29	74165	.85
7442	.49	74166	1.00
7445	.69	74173	.75
7447	.69	74174	.89
7448	.69	74175	.89
7473	.34	74185	2.00
7474	.33	74192	.79
7475	.45	74193	.79
7476	.35	74194	.85
7483	.50	74259	2.25
7485	.59	74367	.65
7489	2.15	74368	.65
7490	.35	74393	1.35

74S00

74S00	.32
74S02	.35
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S32	.40
74S37	.88
74S74	.50
74S86	.50
74S112	.50
74S124	2.75
74S132	1.24
74S133	.45
74S138	.85
74S139	.85
74S140	.55
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10	50v	.15	22	16v	.14
47	35v	.18	47	50v	.20
100	16v	.18	100	15v	.20
220	35v	.20	150	25v	.25

50v MONOLITHIC

.01uf	.14	.1	.05
.047	.15	.47	.25

50v DISC

10pf	.05	470	.05
22	.05	560	.05
25	.05	680	.05
27	.05	820	.05
33	.05	.001uf	.05
47	.05	.0015	.05
56	.05	.0022	.05
68	.05	.005	.05
82	.05	.01	.07
100	.05	.02	.07
220	.05	.05	.07
330	.05	.1	.12

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THESE SOCKETS HAVE .5" LEADS, JUST A LITTLE SHORTER THAN THAN THE STANDARD 3 LEVEL WIRE WRAP SOCKETS WITH .67" LEADS.

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14 PIN WW-2	.45	.39
16 PIN WW-2	.45	[illegible]
20 PIN WW-2	.75	[illegible]
22 PIN WW-2	.50	.39
24 PIN WW-2	.89	.75
28 PIN WW-2	.89	.75
40 PIN WW-2	[illegible]	.89

SPECIALS END 1/31/85

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SHUGART SA400L	SS/DD	199.95
MPI B52	DS/DD	139.95
TEAC FD55B ½ Ht.	DS/DD	159.00
TEAC FD55F ½ Ht.	DS/Quad	200.00

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8	.13	.11	.59	.49	---	.65	---
14	.15	.12	.69	.52	5.95	.75	1.45
16	.17	.13	.69	.58	5.95	.85	1.65
18	.20	.18	.99	.90	---	1.00	---
20	.29	.27	1.09	.98	---	1.25	---
22	.30	.27	1.39	1.28	---	1.25	---
24	.30	.27	1.49	1.35	7.95	1.35	2.50
28	.40	.32	1.69	1.49	8.95	1.50	---
40	.49	.39	1.99	1.80	10.95	2.10	4.15
64	4.25	---	---	---	---	---	---

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DESCRIPTION	ORDER BY	CONTACTS 20	26	34	40	50
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RIBBON EDGE CARD	IDExx	2.36	2.65	3.25	3.80	4.74

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+12V @ 2.8A	-5V @ .25A
-12V @ .5A	-12V @ .30A
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GREEN	.18	.15
YELLOW	.18	.15

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MAN-74	CC	.3"	.99
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4016	.39	4047	.95	4093	.49	74C14	.59
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DESIGNERS NOTEBOOK

continued from page 90

You can build an optocoupler using a *L*ight *D*ependant *R*esistor (LDR), a jumbo red LED, and some heatshrink tubing. To make the optocoupler, simply place the LED and LDR inside the tubing so that the light from the LED can strike the lens of the LDR. Don't forget to allow the leads to extend beyond the tubing.

You can then use your optocoupler as you would any other pre-packaged type. Using that arrangement helps keep the active-component count to a minimum. The slow rise and fall times of the LDR actually work out for the best because it gives the action of the limiter a much more natural sound.

As I said, the general approach is more important to understand than the particular example. Figure 2 is an actual preamp using the familiar 741 as a non-inverting amplifier. As you see, the phototransistor (contained in the optocoupler) is connected in parallel with the feedback resistor. When an excessively high signal is pumped into the circuit, the amplifier draws more power to handle the increased input.

When the threshold voltage of the transistor is reached, it turns on and the LED inside the optocoupler lights causing the phototransistor to turn on and lower the gain of the amplifier.

You could just as easily have connected the phototransistor or LDR from the input leg of the preamp to ground. However connecting it in such a manner requires a bit of recalculation of the resistor values in the circuit. Since I don't know what the change in voltage would be across your choice of optoisolator, you'll have to work the values out yourself.

Remember, because our approach to the problem of audio limiting is a general one, you'll have to tailor it to fit the specific needs of your circuit.

In Figure 3, I've put the limiter to work in an amplifier made from a 4049 CMOS hex inverter. Since the gain of the circuit is only a function of R2/R1, connecting the phototransistor in parallel with R2 will reduce amplifier gain whenever signal levels get excessive. The trigger for the circuit comes from the amp's current draw, rather than from the audio itself. That means that the gain is decreased before the amp overloads.

Our approach to limiting has several advantages over more conventional ones. It's has a built-in failsafe because if anything happens to the LED, the phototransistor will not conduct (or the LDR will assume it's in-dark resistance—usually well over 1 megohm).

Since what we've been talking about here is an idea rather than any one particular circuit, drop me a line and let me know how you were able to use this method of signal limiting. More than likely you'll find a use for it that never even occurred to me. **R-E**

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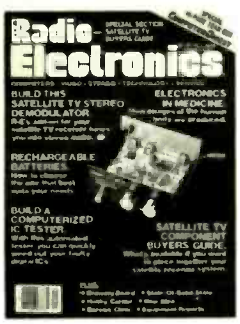

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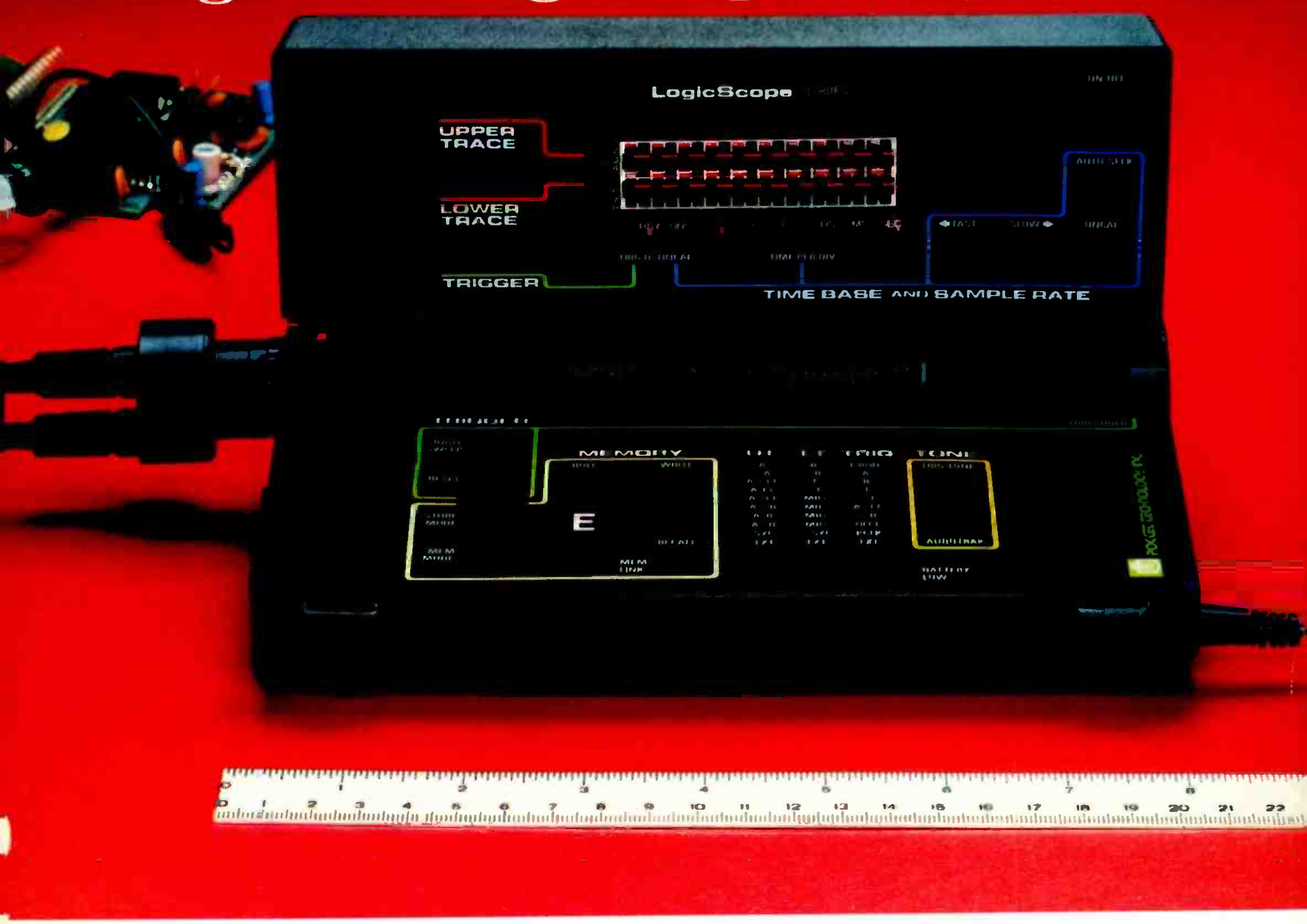

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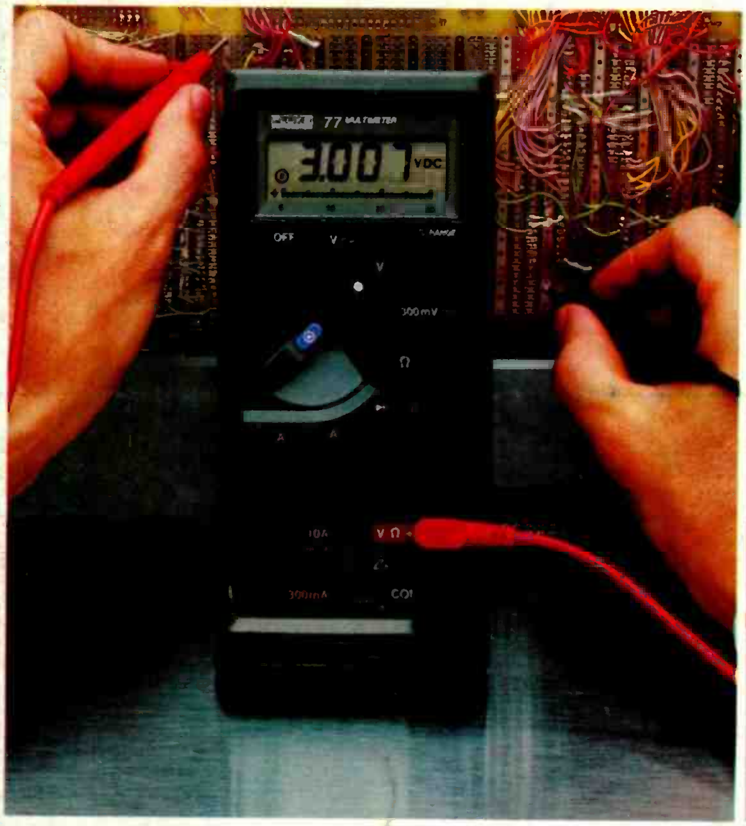

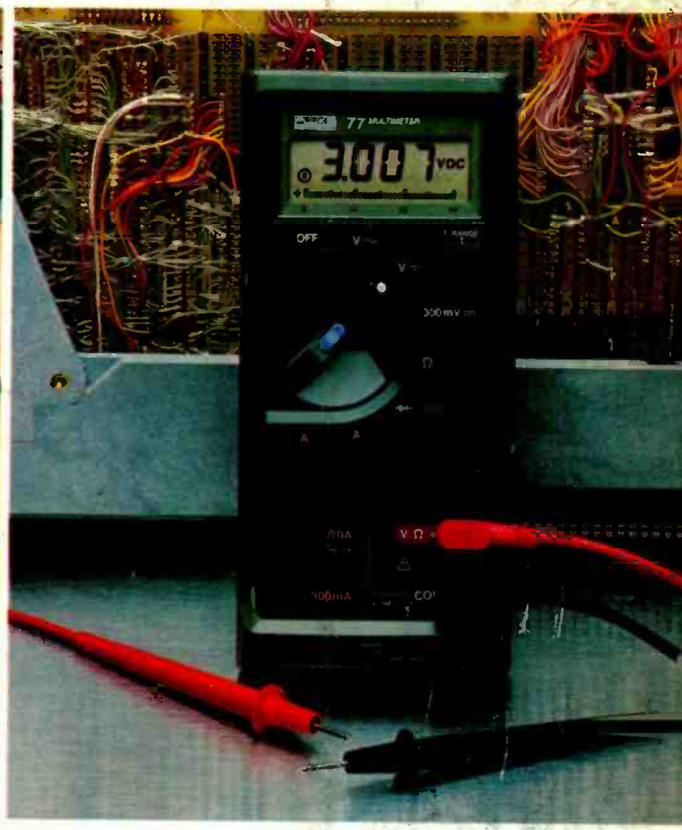

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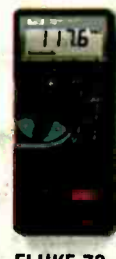
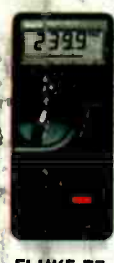


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