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$1.75 AUGUST 1984

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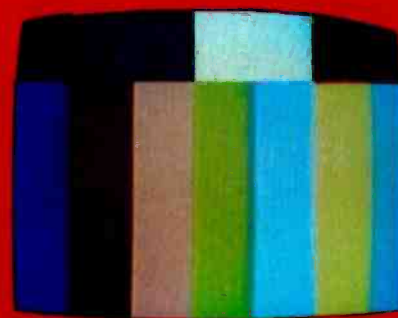

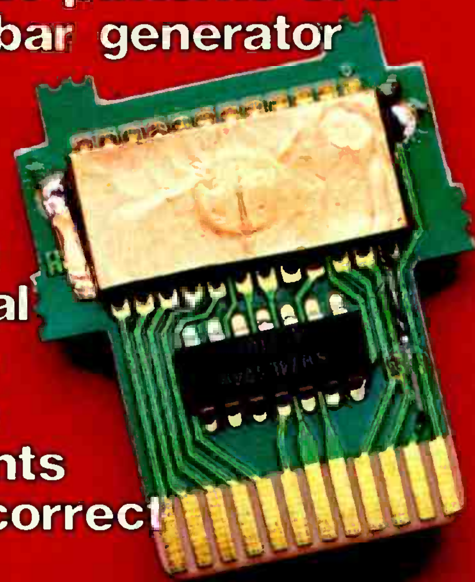

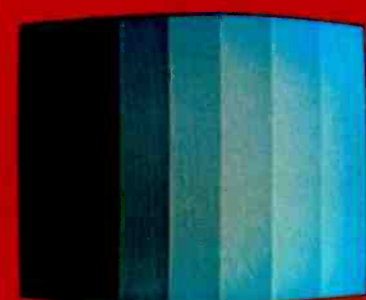

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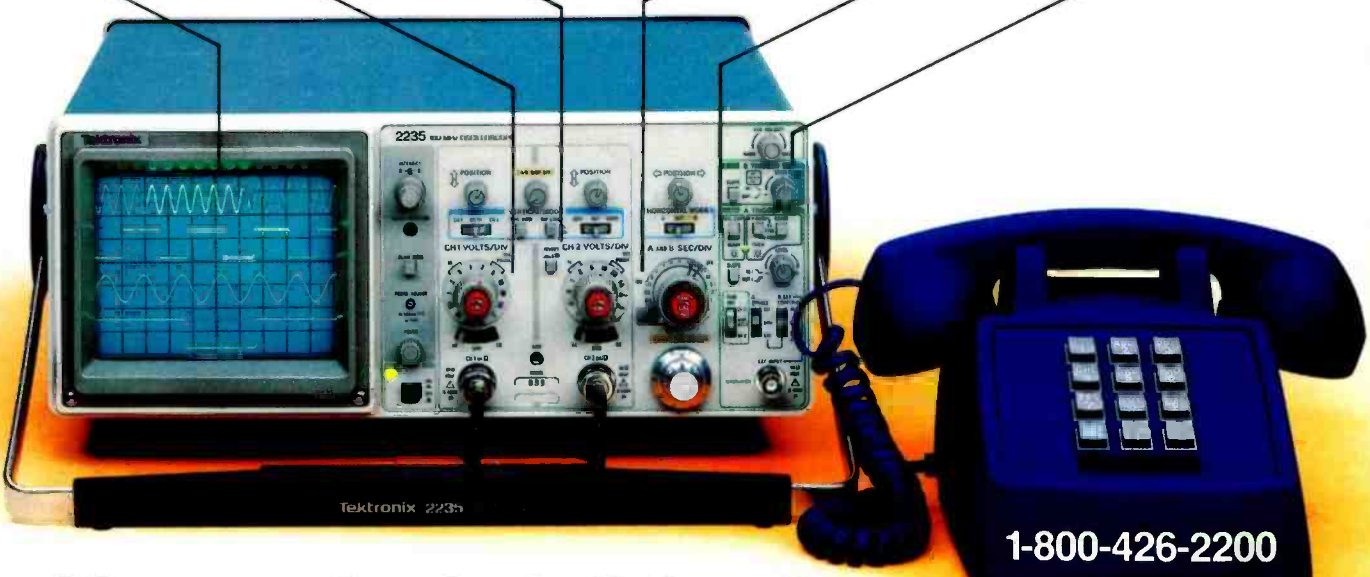

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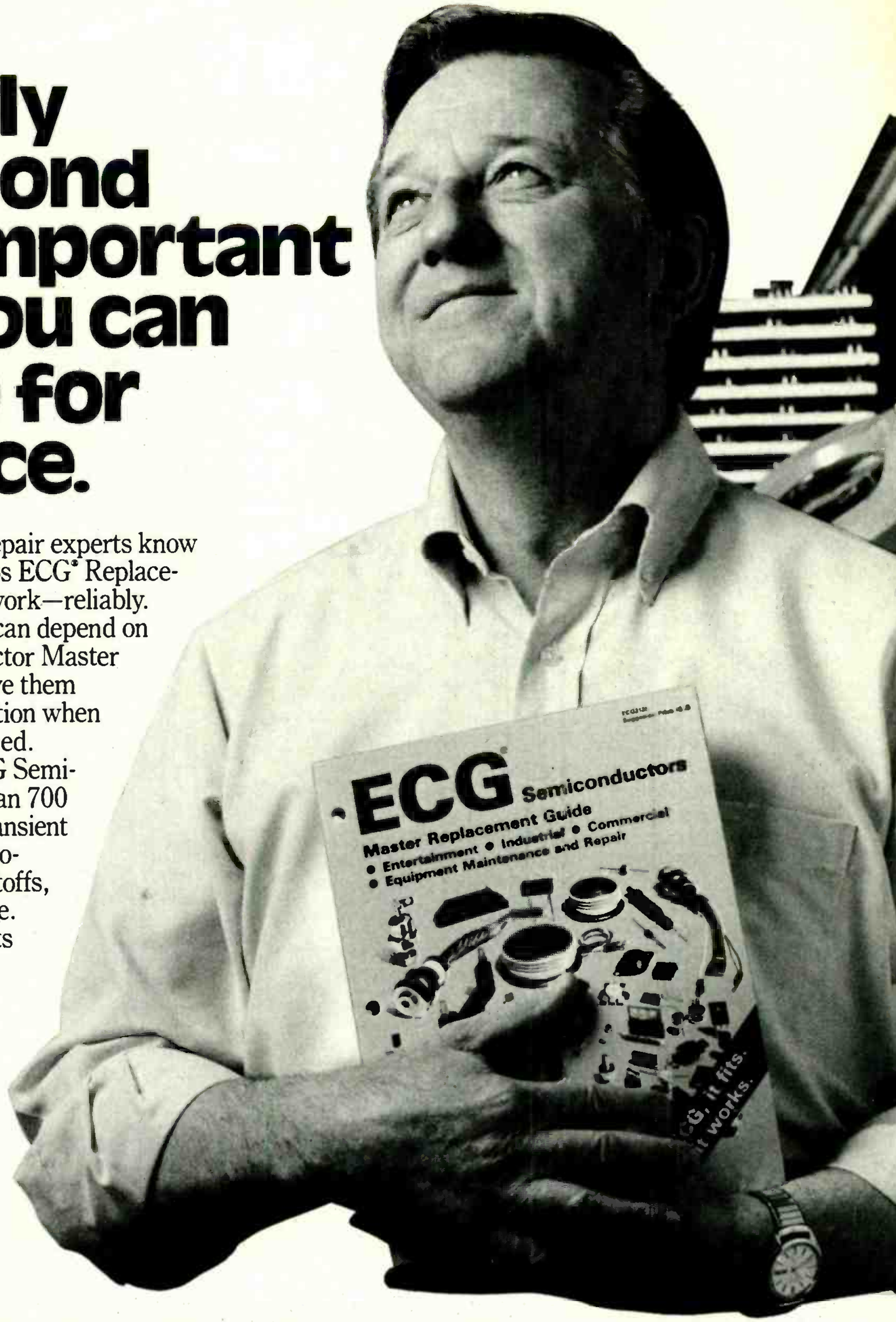

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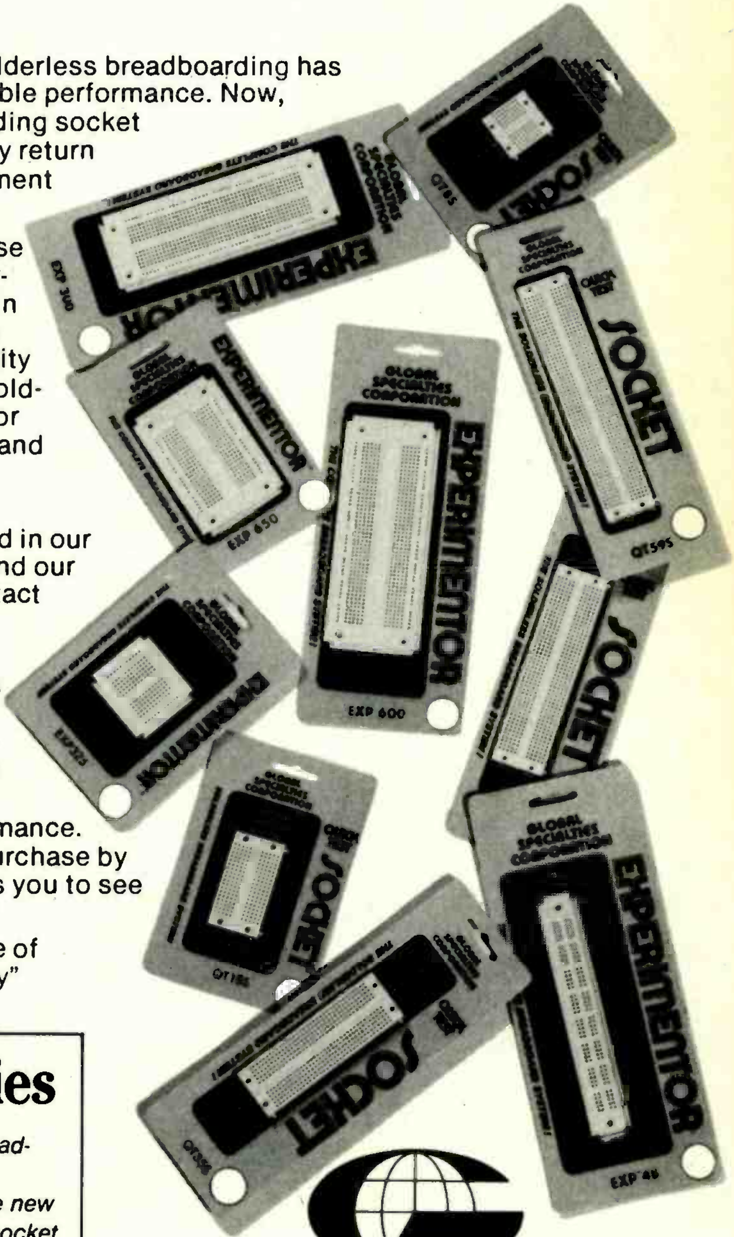

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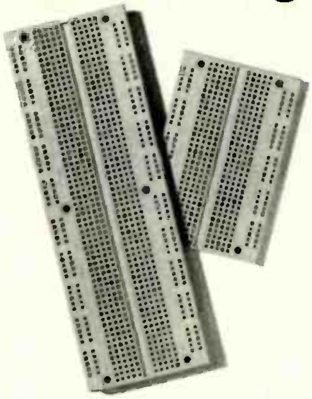

Two new solderless breadboarding sockets have been added to the Global line. The new UBS-100 is now the largest socket in the line, with 840 tie-points and the smaller UBS-500 has 430 tie-points. Each includes two rows of bus strips on each side for power and ground connections and the UBS sockets are made of the highest grade plastic material to insure maximum resistance to warping and breaking.

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CIRCLE 33 ON FREE INFORMATION CARD

Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

AUGUST 1984 Vol. 55 No. 8

ON THE COVER

A color-bar generator is one of those pieces of equipment that is needed only occasionally. But when that device is needed, nothing else will do in its place. That is, until now. This month we present an inexpensive alternative—a plug-in cartridge for your Atari *2600* that generates color bars and other patterns required for proper color-TV alignment. To learn more about it, turn to page 41.

INFRARED COMMUNICATIONS is used these days in a wide variety of a remote-control applications. This month we'll show you how you can add remote control to just about anything by building an infrared transmitter/receiver pair. The story starts on page 57.

COMING NEXT MONTH
On Sale August 21

- **Sonic Motion Detector.** It uses sound to detect motion. Great for use with a burglar alarm.
- **Electronics Measurements in Medicine.** A look at the electronic instruments used to monitor our health.
- **What's New in Batteries.** A look at the current state-of-the-art.
- **And lots more!**

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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

STEREO TV

Sets designed for the new *M*ultichannel *T*elevision *S*ound (MTS) are beginning to arrive, well in advance of any substantial amount of MTS broadcasting. The new audio system, called BTSC (after the EIA's *B*roadcast *T*elevision *S*ystem *C*ommittee, which selected the standards), permits broadcasting in stereophonic sound, as well as on a *S*eparate *A*udio *P*rogram (SAP) channel. The mono SAP channel may be broadcast at the same time that stereo is being transmitted on the main channel. One of the first uses for the SAP channel may be to supply sound in a second language.

Sound was an important feature in the 1985-model TV set introductions. RCA introduced 18 TV sets—fifteen 25-inch models and three projection sets—with stereo-sound systems and built-in multichannel tuning, capable of receiving stereo sound or the separate channel. They are relatively high-priced sets, starting at more than $1000. RCA says multichannel sound tuning adds $50 to $75 to the price of the set. Zenith chose a different approach. Although it introduced only two sets with built-in MTS, 20 of its new models—all of its sets with stereo amplifiers—are consumer adaptible with the addition of a special converter (see photo). The converter contains a 2-watt-per-channel stereo amplifier and can utilize the TV set's speakers, external speakers, or an external audio amplifier. The converter is controlled by the TV set's remote control. When stereo and/or a SAP soundtrack is being transmitted, the audio system in the converter takes over for the set's amplifier. Zenith's converter-amplifier carries a suggested list price of $179.95.

General Electric also has a converter, or adaptor, which is easily attached to the back of eight TV models in both its 1984 and 1985 lines. Those sets have much of the stereo circuitry built in, along with the needed pilot lights to show when a stereo or SAP program is being transmitted. GE's adaptor will sell for less than $100. Panasonic and Quasar both have introduced a few high-priced MTS models, as well as relatively low-priced 19-inch monophonic sets designed to receive the SAP and the main channel, for bilingual listening. Zenith introduced SAP sets in both 13- and 19-inch sizes. In addition to its consumer-convertible sets, Zenith says more than 3,000,000 of its sets produced since late 1981 may be quickly adapted to multichannel sound by a service technician.

MTS broadcasting may be much slower in coming than MTS sets. TV stations must modify their transmitters and add other special equipment. It's doubtful that there'll be much MTS broadcasting before mid-1985.

POLAROID GOES VIDEO

Like its competitor Eastman Kodak, Polaroid has announced it will introduce a combination video camera-recorder that uses the new 8mm videocassete later this year. The 8mm cassette is about the size of a standard audio cassette and can record for up to 90 minutes. Polaroid's camcorder will be made for them by Toshiba, while Kodak's will be built by Matsushita (which also will make a similar unit for GE). The Polaroid unit, unlike Kodak's, uses a CCD solid-state pickup in place of a tube, and has an optical viewfinder in place of an electronic one. As a result, Polaroid's camcorder weighs less than four pounds, making it the lighest such combination announced to date. Kodak's model weighs nearly six pounds. Kodak's camcorder is due late this summer, Polaroid's before year's end. **R-E**

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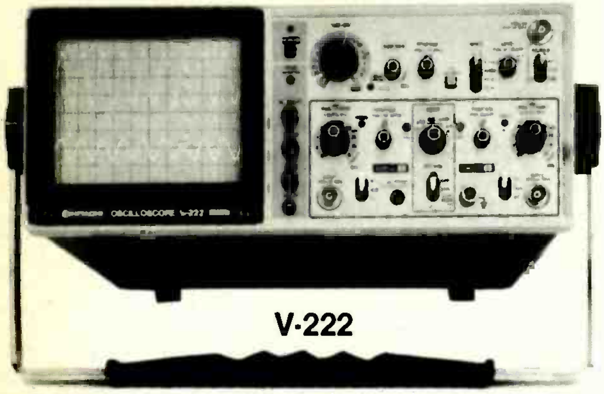
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ADVANCE ELECTRONICS

WHAT'S NEWS

FCC approves system of verifying commercials

The FCC has approved an application by the Audicom Corp. of New York, NY, for transmitting television and radio commercials so encoded that the identity, source, and time of any such transmission can be known. The decoded information is automatically transmitted to a central computer for immediate and continued access by users of the system. The encoding uses inaudible signals placed in the soundtracks of tapes, film, or other recordings.

The system is expected to provide advertisers with indisputable proof that what they paid for actually ran as ordered. It should eliminate guesswork and time-consuming verification procedures—problems that have long hampered advertisers' and broadcasters' accountability efforts.

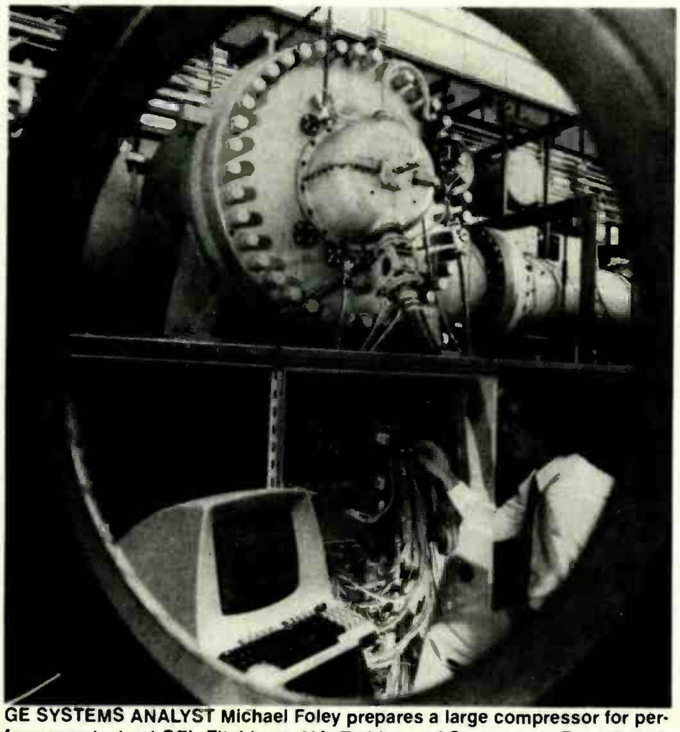
Besides advertising, the new system has applications in monitoring the use of copyright and syndicated materials, and in efforts to combat piracy of tapes or other recordings.

Automatic test system includes analysis

A new GE software package, known as Test Manager, or TMGR, makes it possible to automate almost completely the testing of many types of heavy industrial equipment.

Automatic test equipment is widely used in the field today. But the usual type simply acquires data, which then must be analyzed and acted on by the technician. TMGR handles the routine tests—it issues orders to call up remotely operated sensors and retrieves, stores, and displays data from them.

But unlike older systems, TMGR performs detailed engineering analyses on the data it receives—while the test is still going on. "A test engineer gets performance results immediately—not after days or even weeks of calculation from the raw data."



GE SYSTEMS ANALYST Michael Foley prepares a large compressor for performance tests at GE's Fitchburg, MA, Turbine and Compressor Department. The new software program analyzes the data as it is being collected, thus avoiding the days or even weeks of tedious calculations that might otherwise be required.

Multiple-picture TV proposed at conference

A method of viewing several pictures on the same TV screen at the same time was proposed at the 18th annual Society of Motion Pictures and Television Engineers (SMPTE) winter meeting by Joseph S. Nadan, of Philips Laboratories.

That is made possible by a new integrated-circuit development by N.V. Philips of the Netherlands. Called an integrated circuit frame-store charge-coupled-device, it adds memory to the receiver.

The multiple picture-in-picture (MPIP) would allow a viewer to see nine channels at a time on the TV screen. Or he could pull up one station as the "main" program and monitor three others in a strip on the side of the screen. Likewise, he could fill the screen with one picture, leaving only one small box in an upper corner of the screen to monitor another station. By pressing a button, the small screen could become the larger one, and vice versa.

New AM stereo adapter receives "All-Four"

Kahn Consumer Products, Inc., of Garden City, NY, has made agreements with several AM-stereo broadcasters to purchase and promote a new AM-stereo adapter. The adapter will make any car radio that receives only the Motorola AM-stereo system able to receive AM-stereo broadcasts from all four of the FCC-accepted AM stereo systems.

A Kahn spokesman said that the new product was developed to satisfy consumer demand, as well as to block Motorola's efforts to monopolize the AM-stereo market by capitalizing on Motorola's long-standing relationships in Detroit.

The new adapter is named the "All-Four" to indicate that it will convert single-system Motorola receivers to all-system stereo reception. In quantities of 1,000 it is expected that the "All-Four" can be delivered at a price not exceeding $6.50.

US-Israel grants for joint research

The governing board of the US-Israel Binational Industrial Research and Development (BIRD) Foundation has approved funds for eight research projects to be undertaken jointly by private companies from each country, reports the Department of Commerce.

The eight projects, valued at approximately $8.5 million, include development of improved, high-speed micro-electronic signal processors; an advanced voice-telephone message system; a computerized comprehensive training program for use in electronics laboratories; a comprehensive software application package for industrial organizations; video mapping systems; a polymer heart-valve prosthesis; a diagnostic system for the detection of parasitic diseases, and finally a management software system for the printing industry.

New products from space research program

A long-range basic research program aimed at making products that cannot be produced on Earth was announced jointly by James Beggs, administrator of the National Aeronautics and Space Administration, and Louis W. Lehr, chairman and chief executive officer of 3M. The first efforts will be directed toward advancing the state of the art in processing organic materials in a low-gravity and high-vacuum environment.

The first actual space experiments, which could occur as early as this month, will investigate the prospects for growing crystals from organic materials that cannot be crystallized on Earth because of gravity, and development of thin films with novel properties.

Answers will be sought in three areas of research, says a 3M spokesman: "The effects of gravity and high vacuum on materials processes we know we can do on Earth; processes we know we can't do, and some 3M proprietary technologies." The results could have applications in a wide range of fields.

continued on page 12

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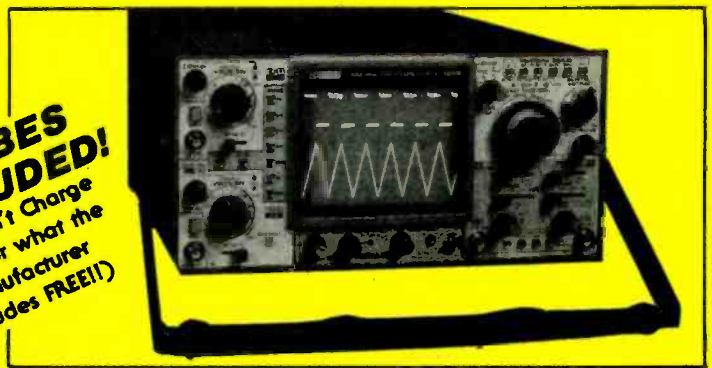

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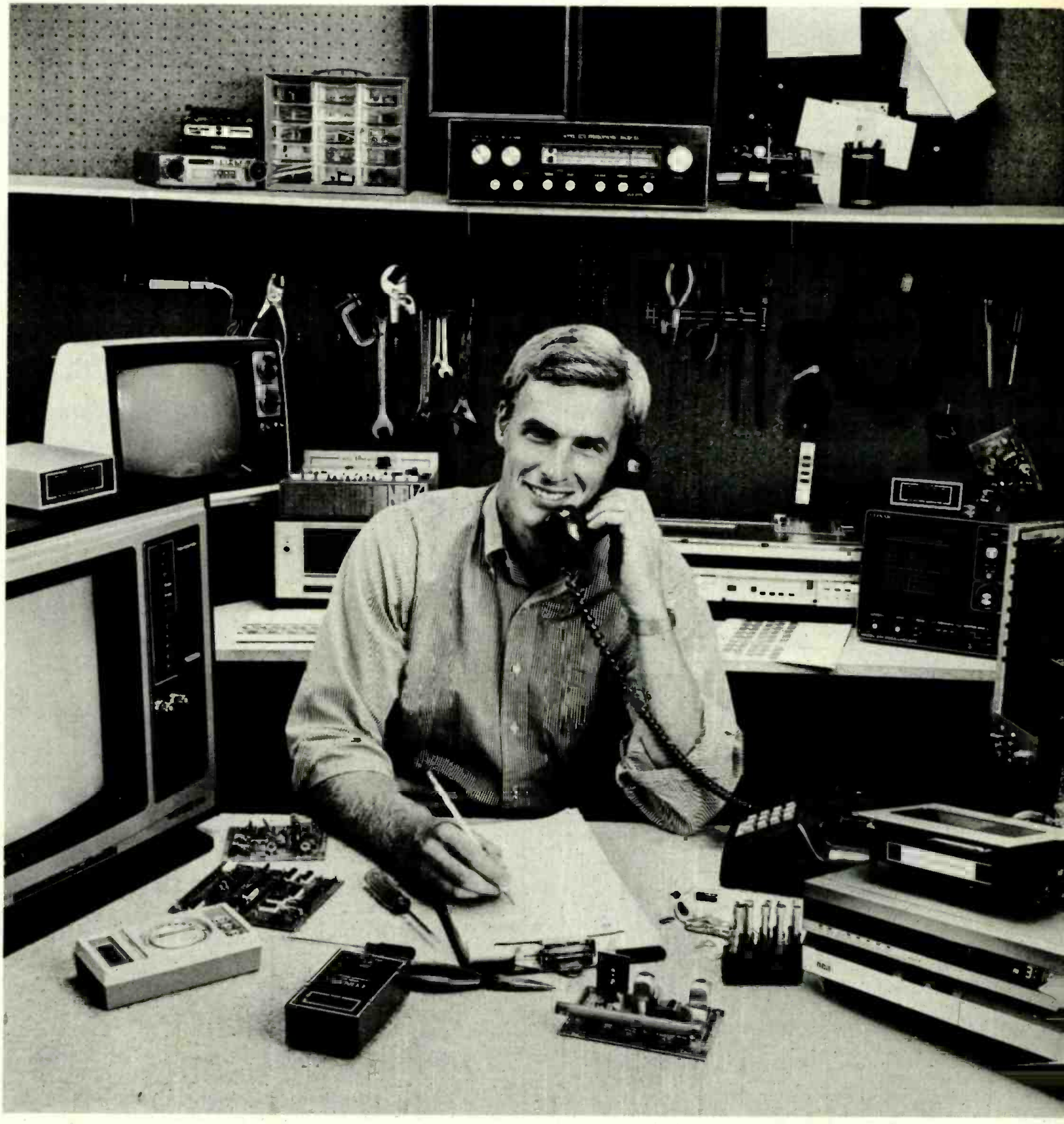

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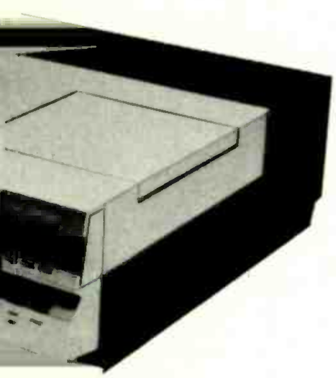

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WHAT'S NEWS

continued from page 6

Remote-controlled VCR programs a year ahead

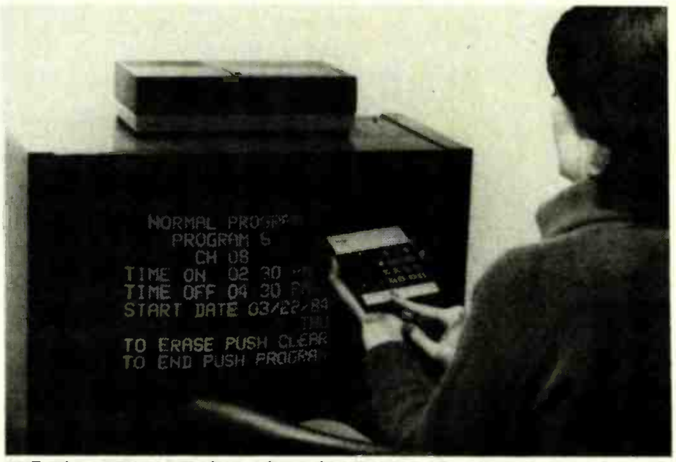
RCA has introduced a video cassette recorder that uses a remote-control unit to pre-program as many as eight programs up to a year in advance. The new *VKP900's* wireless infrared remote control also activates alphanumeric graphic displays on the TV screen to guide the user step-by-step through the programming sequence, with a screened request for each instruction as needed.

To start programming, the user pushes the PROGRAM button on his remote control and a "menu" appears on the TV screen: 1. Clock Set; 2. Normal Program; 3. Daily Program; 4. Weekly Program; 5. Program review.

Button 1 enables the viewer to set the clock and indicate AM or PM, day, month, and year, in response to requests for each piece of information. Button 2 is pressed to record a one-time program. The on-screen graphics ask first for the channel desired, and whether AM or PM, then for the time to start and to stop recording, and finally the date. Buttons 3 and 4 will bring forth the same queries, and the programs listed will then be recorded daily or weekly. The same steps can be repeated for seven more programs.

To review what has been programmed, press button 5, and the screen displays each program in storage, pausing about ten seconds for each. Pressing the CLEAR button erases the program displayed at the moment.

Other features of the *VKP900* include 133-channel capability, a five-head record/playback system with "field still" special effects, express recording (XPR), and stereo recording/playback with high-frequency noise reduction. The unit has a suggested list price of $1,295.



THE RCA *VKP900* REMOTE-CONTROLLED VCR. The viewer is using her unit to review the programs stored in the memory. The alphanumeric display also assists the viewer in setting the equipment to record one-time daily, or weekly programs.

New device dissipates charges on spacecraft

Hughes Research Labs is building for the U.S. Air Force a system designed to overcome the problem of electrical buildup on a space vehicle. Called the Flight Model Control System, it uses a self-contained plasma source to dissipate charges on the spacecraft surface to the surrounding space plasma, eliminating destructive arcing from charged surfaces.

The system includes three types of charging sensors, a plasma source, and a microprocessor-based controller.

The sensors are a proton electrostatic analyzer, two side-by-side surface-potential monitors, and a transient pulse monitor. Those, respectively, detect absolute charging (relative to space), differential charging (relative to the spacecraft ground), and pulses generated as arcing begins.

The plasma source establishes a dilute plasma cloud of low-energy electrons and ions near the spacecraft surface. The ions in the plasma transport electrons through space to neutralize charge imbalance, thus preventing high-potential buildups.

The controller interprets the sensor outputs, determines if and when charging is occurring, and controls the discharge device. It will include software that can be altered from the ground in order to permit in-space refinement of the charge detection and neutralization operation.

World's fastest IC's use gallium arsenide

Two new digital integrated circuits, a universal shift register, and a binary counter, have been introduced by Harris Microwave Semiconductor Co., of Melbourne, FL. Based on gallium arsenide (GaAs) technology, they operate at five times the speed of the fastest silicon-based integrated circuits available today.

The speed and miniaturization characteristics of the two new products are particularly applicable in very-high-speed signal processing, test instrumentation, computing, and telecommunications applications.

1,000 charge cycles in carbon-lithium cell

Matsushita Electric of Osaka, Japan, has developed a new 3-volt carbon-lithium battery which assures at least 1,000 charge-discharge cycles. Mass production is scheduled for late 1984.

The new battery uses activated charcoal for its positive electrode and lithium for the negative one. It uses a non-aqueous organic electrolytic solution. A special metal material, coupled with lithium, forms the negative electrode. The new metal absorbs lithium when charging, to form an alloy, and ionizes lithium when discharging.

The new coin-type battery, R2020, is 20-mm in diameter and 2.0-mm thick. Output voltage is 3, in contrast to lead or nickel-cadmium types, whose output has been limited to 2 volts. **R-E**

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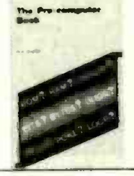

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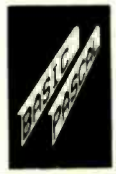

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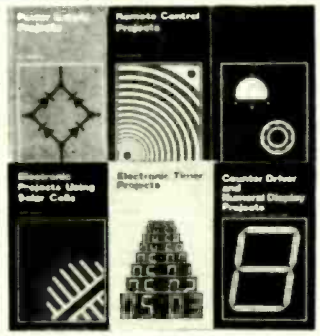

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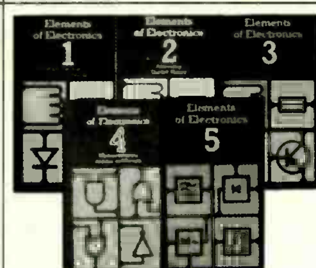

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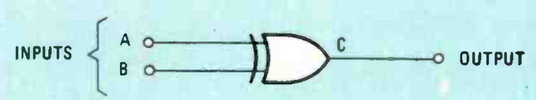
DESIGNER'S NOTEBOOK

Single-gate circuits

ROBERT GROSSBLATT

WHENEVER MOST OF US THINK ABOUT CIRcuit-design shortcuts or tricks to make life easier, it usually involves taking a handful of familiar circuit elements and using them in a way *not* mentioned in the data books. Plenty of brainwork goes into saving time and energy and, of course, component cost. In general, the slicker the trick, the simpler the design and the greater the savings. This month we're going to look at the simplest design you can possibly have—one gate!

For the purpose of this discussion we'll be looking at an exclusive-OR (XOR) gate. You can use the 4070 CMOS version or, if you're into TTL design, you can pick any of the 7486 family. The XOR gate is a really useful device when you're thinking about a one-gate design. But, just how much can you do with a single gate? Well, let's see.



INPUTS		OUTPUT
A	B	C
H	H	L
H	L	H
L	H	H
L	L	L

FIG. 1

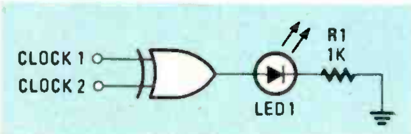


FIG. 2

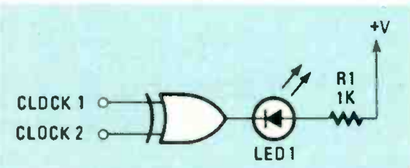


FIG. 3

Exclusive-OR circuits

Figure 1 shows the symbol for the XOR gate along with its truth table. The truth table shows that its output is low whenever both inputs are the same, and high if the inputs are different. (That's an important characteristic, as we shall soon see.) The most immediate use for that truth table is to build the world's cheapest phase detector. All we have to do is route the two signals in question to the inputs of the gate and hang an LED on the output. Two possible layouts are shown in Figs. 2 and 3. The Fig. 2 circuit shows an XOR gate with its out being fed to an LED and resistor in series.

The LED's cathode is tied to ground through the resistor. When the two inputs are equal (both high or both low), the output of the gate is low. On the other hand, when the inputs are out of phase (one high and one low), the gate outputs a high. That forward-biases the LED, thus causing it to light. Now, if we turn LED around and connect its cathode to + V, as shown in Fig. 3, it will light when the inputs are in phase. What could simpler?

Another possibility is shown in Fig. 4. Here we see that if we replace LED 1 with a tri-color LED and tie it to a point halfway up the supply rail, it will be one color when the inputs are in phase and another color when they're not. Let's see why that happens. To understand how the circuit operates, we must first look into the matter of how a tri-color LED works.

The tri-color LED can be thought of as two LED's connected anode to cathode in parallel. (It's not quite that simple, but, for discussion's sake, we'll use that illustration.) Anyway, when the voltage is negative, one LED will be forward-biased and will therefore light (let's say red). But, when the voltage is positive (or reversed) the other LED will light—this time green. The third color (yellow) lights when an AC voltage is applied, but we won't get into that this time. Now, let's get back to our circuit.

Let's say that the two inputs to our gate are in phase (both high). That drives the gate output low; that low is then applied to the tri-color LED, causing one color to light (let's say red). But why not both? Remember, only one LED is forward-biased at a time, therefore only one will light—it's just that simple. Now, we've all built "cheapo" oscillators using a pair of inverters; but, as you will see, the XOR lets us cut the gate count in half!

Figure 5 shows a clock circuit that we can build using just one gate and a resistor. Although its operation is reliable, it is *not* as stable as an oscillator built from two inverters. However, if all you need is a clock, try that circuit.

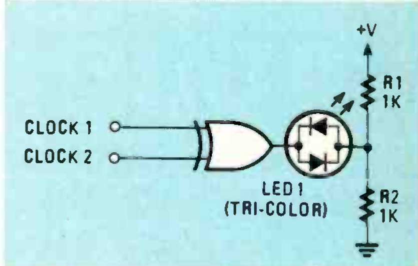


FIG. 4

FIG. 5

So that you can understand why it works, let's see what is actually going on in that circuit. First, let's assume that the output of the circuit in Fig. 5 is high. Since the B input is tracking the output, it will be high as well. If we apply a high to input A (making both inputs high), the output will go low. That makes input B low, thus driving the output high again, and the whole cycle starts all over.

What you can expect to get from that circuit will depend on the level of voltage (+ V) and the resistor value you use. If you're using a CMOS gate you will find that the output swing is less than you would get with a more traditional design. The output will only have an amplitude of about 80% of the supply. The frequency you get will depend on the supply because you have a resistor in line and a certain amount of time has to go by before input B "sees" enough voltage to make the gate change states.

Obviously the value of the resistor is going to come into play as well. Experiment with different values, but make sure you stay above 10,000 ohms or so. If you use a supply of about 7 volts (a 9-volt battery) and the resistor value is around 50,000 ohms, you should be able to get about 5 MHz out of the gate.

The actual frequency is also somewhat dependent on the IC itself. The propagation delay of the gate (the time it takes to

continued on page 83

LETTERS

Address your comments to: Letters, **Radio-Electronics,** 200 Park Avenue South, New York, NY 10003

ROBOT PARTS!

A note for those of you who have purchased the "Build Your Own Robot" reprint and have had trouble finding the various motors required: I have found a new source for all kinds of DC motors (including the all-important gearmotor for wheels and shoulders) at a very reasonable price ($24.75). In addition, the company carries a host of relays, casters, motorized wheel assemblies, and a screw jack that extends from 12½ to 20 inches (for those wanting the extendable type manipulator). For more information, contact: H&R Corporation, 401 East Erie Avenue, Philadelphia, PA 19134. Catalog sales: 215-426-1708.

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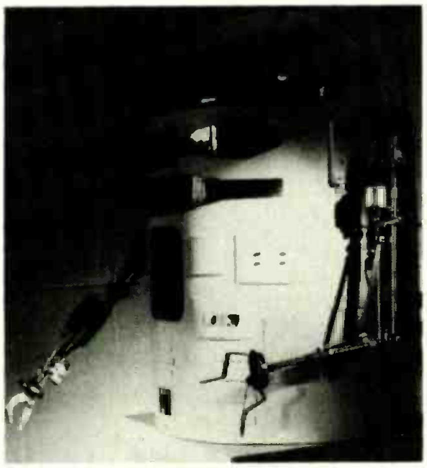

REPAIR MANUAL NEEDED

I am repairing an Accuphase C-200 stereo preamplifier and am in need of a schematic and service manual for it. The preamp was distributed in the United States around 1975–1980 by the Teac Corporation of Montebello, California. Can anyone help me with that? I would be willing to pay a fair sum for a repair manual if necessary. Thank you.

RONALD F. MORRIS
4823 Canehill Ave.
Lakewood, CA 90713

POWER SUPPLIES

I've just finished reading Mr. Horowitz's article, "How to Design Power Supplies", in the March 1984 edition. While I found it to be very

continued on page 18

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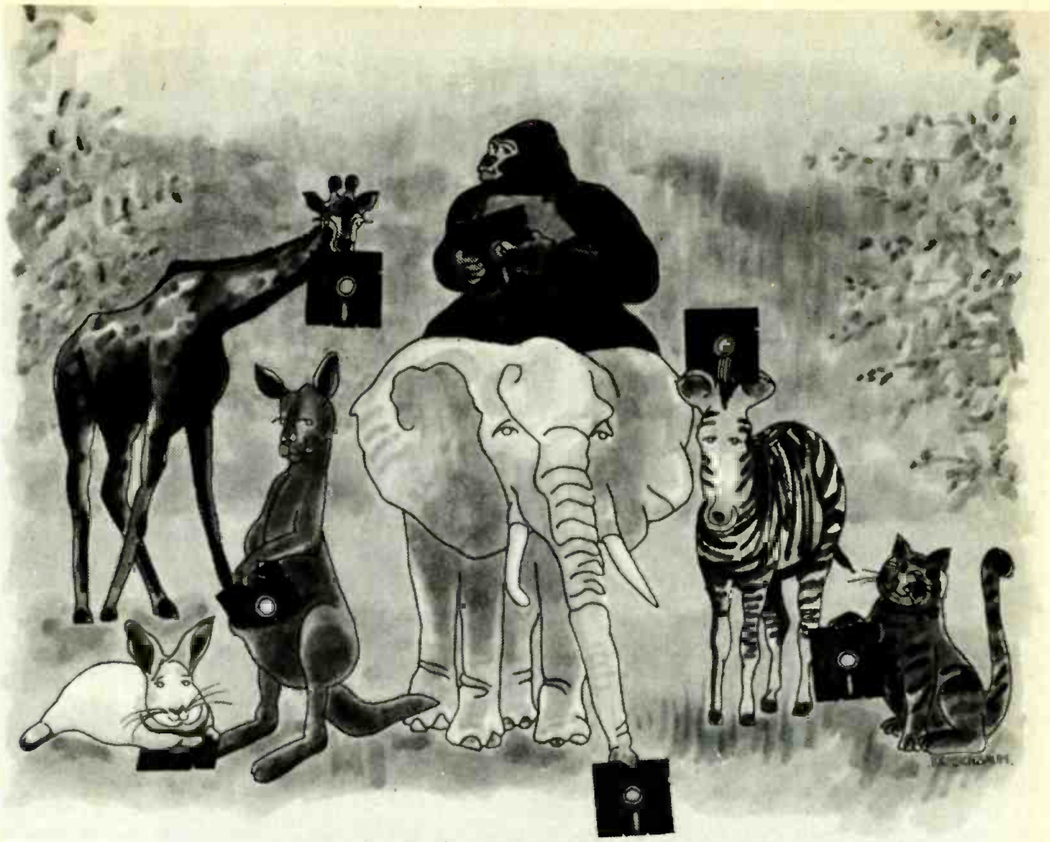

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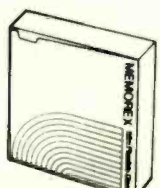

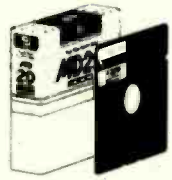

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—	—	3062-J	1.94	81726-J	1.99	F1-S-J	2.69	FD1S-128N-J	2.79	800501-J	2.79
—	—	3015-J	1.94	—	—	—	—	—	—	—	—
—	—	3090-J	2.39	—	—	—	—	—	—	800605-J	3.19
—	—	3102-J	2.89	82701-J	2.94	F2D-S-J	3.29	FD2D-J	3.59	800803-J	3.59
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	3104-J	2.89	82708-J	2.94	F2D-S1024-J	3.29	FD2D-1024-J	3.59	800839-J	3.59
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
28820-J	1.79	3481-J	1.84	51401-J	1.89	M1D-S-J	2.09	MD1D-J	2.14	801187-J	2.49
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	52402-J	2.69	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
28821-J	2.54	3491-J	2.59	52401-J	2.64	M2D-S-J	2.84	MD2D-J	2.89	802060-J	3.49
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
28823-J	3.44	3501-J	3.49	52801-J	3.54	M2DX-S-J	3.89	MD2D-96TPI-J	3.94	802067-J	4.29
—	—	6100-J	3.74	—	—	—	—	—	—	—	—

Verbatim	Memorex	Ultra	TDK	Fuji	Dysan
Lifetime warranty	*5 year warranty*	*Lifetime warranty*	*Lifetime warranty*	*Lifetime warranty*	*1 year warranty*
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LETTERS

continued from page 15

informative, I did notice several errors/omissions. I admit to some nitpicking, but there were enough bonafide errors to warrant the time to write this note. When Mannie talked about selecting a diode, he suggested that fullwave rectifier diodes would "see twice the secondary voltage across it when not conducting. It will actually "see" twice the *center-tap* voltage, or the full secondary across it when turned off. In explaining the choice of a proper transformer, he said, "Add the value you get for ΔT to R_C." I'm not sure how to add °C to ohms.

For Fig. 7-b and the equation for the voltage across Q1:

$$V_2\left(\frac{R_2+R_3}{R_3}\right),$$

V2 is not identified.

"In Fig. 8 we've added," should be Fig. 9.

Under Crowbar circuits: "A crowbar circuit is used to prevent damage to a regulated power supply...". A Crowbar circuit is used to protect the load, not the supply. When a high voltage appears across the load, for whatever reason, the SCR shorts the supply, thereby protecting the load from a possible damaging voltage. The supply could be damaged but, one hopes, not the load. Quite often a fuse is placed in the power supply to protect it from excessive current.

Thank you for your time. I hope my observations are of some help.

ALFRED L. IZATT
Aberdeen, Washington

Yes, your observations are of some help—not only to turn our faces red but to give us the opportunity to correct ourselves. You cannot, of course, add °C to ohms. You should add the temperature at which R_C was measured to ΔT. The voltage V_2 is actually V_Z, the Zener voltage. If a high voltage is applied across the load, both the supply and the load could be damaged. A crowbar circuit can protect both. (Of course, if the supply is the source of the high voltage, all you're concerned about is protecting the load.)—Editor

THANKS

Since you published my "Suggestions Needed" letter in the February 1984 issue of **Radio-Electronics**, I have received a phenomenal number of responses from readers all over. Thanks to them, my dream is a reality—I now have a 70-MHz IF amplifier and detector made from discrete parts. I would like to extend a most heartfelt thanks to all those who made it that way for me.

The response was really great and I have **Radio-Electronics** to thank also. By the way, I renewed my subscription for yet another year of fantastic articles of electronics innovation that has become a standard for your magazine. Keep up the good work.

LeROY SMITH
Wetumpka, AL

PLEASED WITH COMPUTER DIGEST

I was extremely pleased with your feature section **ComputerDigest**, especially because it didn't take any "editorial space" from **Radio-Electronics.**

With the death of *Popular Electronics* (I know they are now *Computers & Electronics*), you are the last decent electronics magazine left on the market.

I enjoy computers as much as the next person, but I also enjoy electronics and as far as I'm concerned I have my choice of computer magazines I can read.

Thank you for preserving my sanity.

BOB BROADWAY
Canoga Park, CA

CORRECTION: C-QUAM STEREO CONVERTER

I've noticed an error in the parts-placement diagram that appeared in the January, 1984 article, "Build This C-Quam AM Stereo Converter." In all three parts-placement diagrams C17 and C18 listed as 2.2 µF and 4.7 µF respectively are interchanged from that of the schematic diagram. I assume the schematic has them listed correctly.

DOUGLAS FINK
Dearfield, MI

You are correct. Also note that, as we've mentioned before, IC2 is incorrectly labeled Q1, although the package outline is correct. We're sorry for any inconvenience we've caused.—Editor

USEFUL ELECTRONICS FOR THE HANDICAPPED

I read with interest your "Communications Corner" column in the July 1983 issue of **Radio-Electronics** concerning electronics aids for the handicapped. However, I think that the article missed one of the most useful and obvious of those aids, namely the closed-caption device used by the hearing-impaired for watching television.

Perhaps you could devote a column and a construction article for such a device. I can't believe it would be that difficult to extract and save these characters from horizontal lines 10 through 13 and display them at the bottom of the screen. I would do this myself if I could find any literature on the format transmitted, exactly which lines carry the information, etc. Is it ASCII data? I have looked through all the reference guides at my library and can find no information. If this is a public service for the deaf, why isn't any information available? I know Sears Roebuck sells a decoder for about $300.00, but couldn't a few dollars worth of chips do the same thing?

Two Teletext standards used in the United States are NAPLPS and Prestel. Is it possible that one of those two standards is being used, or is closed-captioning completely different? I know closed-captioning doesn't seem to work on my NAPLPS decoder (Zenith CV-550).

Please perform a public service and provide the technical details if not a complete construction project.
JOHN BUNTING

INPUT HELP NEEDED

I have a 9-inch Sanyo monitor and a Ball monitor, each with separate horizontal and vertical sync inputs. Can one of your readers help me with the circuit that will allow me to input composite video so I can use them with my home computer. Thank you.
WALTER MOORE
551 Elmwood Drive
Brandon, MS

COMPUTERS & RADIO-ELECTRONICS

I thoroughly agree with the opinion expressed by Richard Taylor in his letter published in the May 1984 issue of **Radio-Electronics**. I had subscribed to *Popular Electronics* almost since its inception, and before that, its parent, *Radio News*, for more years than I can remember. However, when *Popular Electronics* switched to its almost completely computer-oriented format, I allowed my subscription to expire. I don't feel I left them—they left me!

Although I do own a Commodore 64, my first love is still general electronics and ham radio. I am now retired, after about 42 years with the Bell System. I would expect to continue subscribing to **Radio-Electronics** as long as you see fit to continue the present mix of general electronics and computers. I've been through a long career in electronics with Gernsback publications—*Radio-Craft*, *Short-Wave Craft*, and **Radio-Electronics.** There are more than enough computer magazines out there already. Stay as you are—I'll stay with you!
ALLEN L. BARNETT WB2QPM
Jersey City, NJ **R-E**

NEW IDEAS

Energy-use monitor

ENERGY CONSERVATION IS BECOMING INcreasingly more important, particularly when your trying to save a couple of bucks—and who isn't? In fact, it is often with thoughts of energy conservation that we decide to get rid of an appliance and replace it with a new one. But replacing old appliances is not always worth the expense. The circuit described this month will allow you to monitor the time that an appliance—such as an old refrigerator with worn out insulation—runs. Then, with some simple arithmetic you can figure the kilowatthours used.

Multiplying the run-time in hours by the appliance load in watts (as printed on the appliance) will let you know the kilowatthours used. Armed with that information, it is a simple matter to figure your total cost (by multiplying the kilowatthours by the cost of electricity in your area. Now, let's take a look at the circuit.

How it works

Figure 1 shows the schematic of the energy monitor. Besides having a low parts count, most of the components are commonly available. Power for the circuit is provided by T1 (a 33-volt transformer) and diodes D4–D7 (1N4004), which form a full-wave bridge rectifier. The rectified AC voltage is filtered by capacitor C3. The LOAD and CLOCK sockets (SO1 and SO2 respectively) are connected to the primary of the transformer. One side of the line cord to socket SO1 is passed through the center of (handwound) coil L1 so that they are inductively coupled. (More about that coil in a moment.)

When an appliance is plugged into socket SO1 and power is turned on, a current is induced in L1. That creates a potential difference that is then applied to the input of the op-amp, IC1, causing its output to saturate. Because of the high open-loop gain of the op-amp, a few millivolts is all that is needed. Capacitor C1 and diodes D1 and D2 are used to protect the input of IC1.

The output of IC1 is then fed through resistor R1 to the base of NPN transistor Q1, turning Q1 on. Transistor Q1 provides the necessary drive current for relay RY1, while capacitor C2 filters the 60-Hz pulses to prevent erratic relay operation. When Q1 is turned on, a signal path to ground is provided for RY1, causing its contacts to close. With the relay contacts closed, current flows to SO2, causing the clock plugged into that socket to begin operation.

With the components shown, a load current of from 6–8 amps can be monitored. Here the limiting factor is the size of the line cord and hook-up wire to the load socket. None of the components are critical, therefore, junkbox parts may be used. For instance, coil L1 was salvaged from an industrial power supply acquired from a junk dealer. The coil, one-inch in diameter, was rewound using 34 turns of No. 24 stranded hook-up wire.

The supply voltage can be varied to match the requirement of the components used. An ordinary household clock was used along with the circuit to find out how much the old refrigerator cost to keep running. —*Sharon Christy*

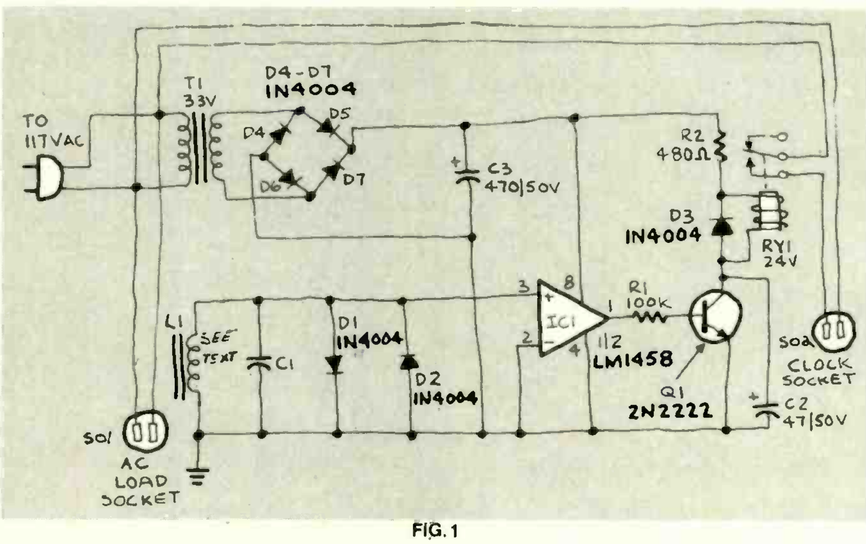

FIG. 1

EQUIPMENT REPORTS

Iwatsu SS-5702 Dual-Trace Oscilloscope

A 20-MHz, dual-trace model at an attractive price

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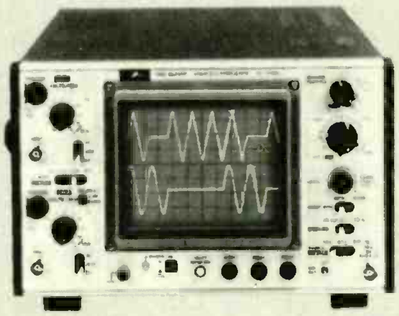


THERE ARE MANY DIFFERENT MODELS OF oscilloscopes available today—literally hundreds. They include low-cost, single-channel, narrow-bandwidth scopes; dual-beam, quad-trace scopes with 100-MHz bandwidths, and flat panel, LCD-screen, storage oscilloscopes. But what type of scope are you looking for?

If you're in the market for an oscilloscope—and a 20-MHz, dual-trace model will fill your needs—then you may want to start your shopping by checking out the *SS-5702* from Iwatsu Electric Co. Inc. (1200 Commerce Road, Carlstadt, NJ 07072). We'll look at its capabilities shortly—after a look at its physical characteristics.

The *SS-5702* weighs about 14 pounds. So although it's not a portable scope (in the sense that you need an AC power outlet), it is easy to move around. Its maximum dimensions are less than 11 × 7 × 18 inches. A comfortable carrying handle is included at the side of the scope, and three sets of feet (side, back, and bottom) let you store the unit in any position.

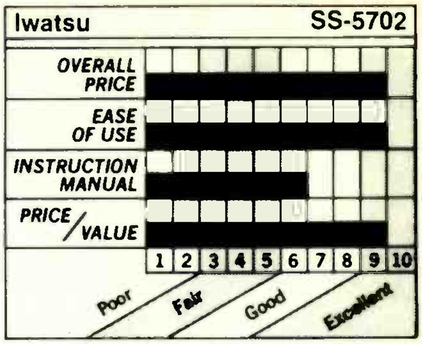
The front panel of the scope is dominated by a 8 × 10 cm display. The graticule, with 1-cm divisions, is internal (to eliminate parallax error) and it is lighted. A front-panel control lets you continuously vary the graticule brightness.

Controls and features

Now that you have an idea of what the *SS-5702* looks like, let's look at some of its capabilities. Perhaps the best way to do that is to go through some of the front-panel controls. To the left of the CRT are the vertical-amplifier controls. Each channel has a BNC INPUT jack and a coupling switch (with AC, DC and GND positions) as well as a VOLTS/DIV control that allows you to vary the vertical-deflection factor from 5 millivolts per division to 10 volts per division in the familiar 1-2-5 sequence.

An inner, concentrally mounted control can be used to continuously vary the deflection factor. When that control is set in its CALibrated position, measurements can be made within ±4%.

A display-position control is also included for each vertical channel. Incorporated in that rotary control is a push-pull switch that can be used to magnify the vertical sensitivity by a factor of five. The vertical-deflection factor can then be varied from 1 millivolt per division to 2 volts



per division by using the VOLTS/DIV control. However, the accuracy of your measurements decreases to ±5% in the ×5 mode.

Channel 1 and Channel 2 share a four-position V-MODE switch that is used to select the vertical operating mode (Channel 1, Channel 2, dual, and add). In the CH 1 (or CH 2) position, only the signal input to Channel 1's (or Channel 2's) BNC jack is displayed. In the DUAL mode, the signals that are input to both channels are displayed. (Chopped or alternate display is selected automatically: Below a sweep rate of 0.5 ms/division, the chopped mode is automatically chosen, while above that rate, the alternate mode is chosen.) The fourth position selects the ADD mode. In that mode, the signals that are input to both channels are algebraically added together. You can also determine the algebraic *difference* of two input signals because Channel 2 has a POLARITY switch that inverts the polarity of the Channel 2 display. Then, when the ADD vertical mode is chosen, the difference of the input signals (A − B) is displayed. Other controls include trace-intensity (INTEN), TRACE ROTATION and FOCUS.

Moving to the horizontal-deflection system, we see a POSITION control, a TIME/DIV, and a continuously variable time-per-division control. The sweep rate can be adjusted from .5 microseconds to .25 seconds-per-division in 18 steps (arranged in a 1-2-5 sequence on the control). Measurements made over the 8 center divisions are accurate within ±5%. A rotary SWEEP LENGTH control doubles as a push-pull switch that increases the displayed sweep rate by a factor of five. However, measurement accuracy in that mode (again over 8 divisions) decreases to ±15%.

Another group of controls are those for the trigger circuit. It includes the LEVEL/SLOPE control that is used to set the trigger level—that is, the level of the input signal that will cause the sweep to begin, and the slope of the input signal that will cause triggering.

The next trigger control is the SOURCE switch that is used to select internal trigger signals (from Channel 1 or Channel 2) or an external signal. (A BNC connector is used as the external-signal input.)

The COUPLING switch selects either TV-V or AC (external DC) coupling. TV-V coupling is used mainly to view composite-video signals. The other position allows AC coupling (if internal triggering is chosen) or DC coupling (if the EXT trigger source is chosen).

The SWEEP MODE toggle switch is used to choose between the unit's AUTO and NORM sweep modes. In the AUTO position, the sweep can be triggered by signals with repetition rates greater than 50 Hz. In the NORM position, the sweep can be triggered by signals that are within the frequency range selected by the COUPLING switch, including DC.

The front panel also contains a CAL OUT terminal that is the source of a 0.3-volt P-P squarewave at 1 kHz. While the voltage is accurate within 3%, the signal cannot be used for frequency measurements—the frequency of the calibration signal is accurate only within 50%. It can, however, be used for probe compensation.

On the rear panel of the *SS-5702* are several connectors. There is a four-position plug that is used to select the line voltage (90 – 110, 104 – 128, 194 – 238, and 207 – 257 volts P-P). A ground connector and an AC line input connector (a cable is supplied with the unit) are also on the rear panel, as is the Z-AXIS INPUT BNC connector. That Z-axis input is used to modulate the intensity of the trace. That is very useful for frequency measurements: You can compare a signal of unknown frequency (applied to the Z-AXIS INPUT jack) to an adjustable signal of a known frequency (applied to the horizontal amplifier). The unknown frequency can be determined by the number of segments (or blanks) on the trace and the frequency of the known signal.

An X-Y mode is also available on the *SS-5702*. Applications of the X-Y mode include comparing the phase of two signals by displaying a *Lissajou* pattern.

Usability

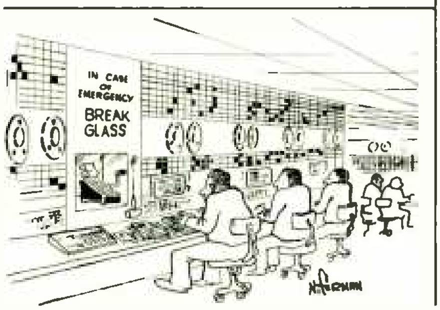
The front panel's neat layout makes finding the right control easy—even if you've never used the scope before. Not only are the controls grouped according to function—for example, the TRACE ROTATION, INTEN, FOCUS, and SCALE-illumination controls are all located under the CRT)—but a two-tone panel helps make the groupings even more evident.

Two probes are included with the *SS-5702*. Each has a slide switch that selects attenuation factors of 1 or 10. A convenient ground lead is located at the tip end of the probe. An "arrow tip" (what we would call a mini-hook clip) is included as a probe accessory. An adjustable capacitor for probe compensation is located in the BNC-connector assembly.

A tilt bail, included at the oscilloscope's base, makes using the unit on a work bench easier.

The instruction manual, although better than some we've come across, is the weak point of the *SS-5702*. It includes the usual specifications and operating instructions. Sections on maintenance (including a troubleshooting guide, performance check, and parts-placement diagrams) are also included, as are calibration instructions, schematics, and a parts list. Our complaint about the manual is that it is obvious that it is translated from the Japanese language. There are numerous misspellings, and "sentences" with bad grammar. (Magazine editors are sensitive to those things.) But the manual is usable and shouldn't cause *too* much

continued on page 30



Heathkit instruments. Some buy

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EQUIPMENT REPORTS

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confusion.

Some people might complain that the scope should have a polarity switch for *both* vertical channels; or that the calibration frequency should be more accurate, or that the scope should have provision for being powered by, say, 12 volts DC. (That is, incidently, an option). But with the *SS-5702*'s list price of $535, we're not complaining. R-E

Regency Scanner Model Z30 Programmable Scanner

Listen in on the excitement of the public-service bands

CIRCLE 102 ON FREE INFORMATION CARD

THERE'S A LOT OF ACTIVITY AND EXCITEMENT to be found on the VHF and UHF bands. Police, fire, government, mobile telephone, amateur radio, and many other services use that portion of the spectrum for communications, and listening in on those communications has become a popular pastime.

Because of the wide range of frequencies we are dealing with, and because some exciting activity can be taking place on any one or more of those frequencies at any time, the most effective way to listen in is with a scanning radio. One such radio that we recently had a chance to examine is the Regency Electronics (7707 Records St., Indianapolis, IN 46226) model *Z30* programmable scanner.

That unit is a programmable 30-channel, three-band, FM scanner receiver. It also incorporates a digital alarm clock. It can be powered from either the 117-volt line or from a 12-volt negative-ground DC supply such as found in a car, truck, or boat. To simplify mobile installation, a DC power cord is included. Also included is a detachable telescopic antenna.

The unit is compact, measuring 10¾ × 2⅞ × 8⅜ inches, and weighs 2¾ pounds. It is housed in a brown plastic case, with a simulated wood-grain finish.

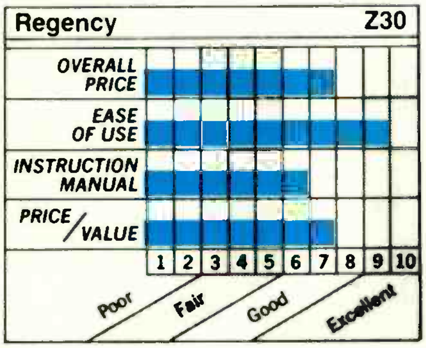
Turning to the receiver itself, it is a double-conversion, superheterodyne circuit. It receives narrow-band FM communications over three bands: 30–50, 144–174, and 440–512 MHz. The unit boasts a sensitivity that varies by frequency from 0.7 to 1.5 μV (12 dB Sinad, maximum), and a selectivity of ± 7.5 kHz at 6 dB and ± 18 kHz at 50 dB.

Use

Aside from an ON/OFF switch and VOLUME and SQUELCH slide controls, all functions and frequencies are entered using a front-panel keypad called the Program Panel. (As you would expect in a unit of this type, except for the one used as a reference, there are no crystals. Instead, a microprocessor-controlled frequency synthesizer is used.)

The keys on the Program Panel are grouped into two types: the mode keys and the program keys. The mode keys are used to place the unit in one of its various modes. They are also used to activate or deactivate the unit's special features and to control the built-in alarm clock. The program keys are used for entering frequencies and for selecting the channel number during programming.

Frequencies, channel numbers, and the time of day during periods that the unit is turned off, are displayed on a blue vacuum-fluorescent readout. In addition, the readout can display a variety of prompting messages to alert the user to a particular condition. For instance, if the frequency entered is not within one of the bands that the unit covers, a FR ERR message is displayed. Also, a variety of annunciators are used to alert the user to which special functions and features are active. Finally, the brightness of the display can be controlled using the DISPLAY DIM key.



The unit has three primary modes of operation: search, scan, and manual. The search mode is used to find new frequencies. To use that mode, the PROGRAM key is pressed and upper and lower search limits are entered. Once that is done, the search is initiated by pressing the SEARCH key. The band of frequencies selected is then searched continuously in 5-kHz (VHF) or 12-kHz (UHF) increments.

Once you have found a frequency of interest, it can be entered into the unit by placing it into the manual mode. Entering frequencies is a very simple operation. It involves merely pressing the MANUAL key, entering the frequency using the program keys, pressing the ENTER key, and finally entering the channel (from 1 to 30) that you want the frequency stored in.

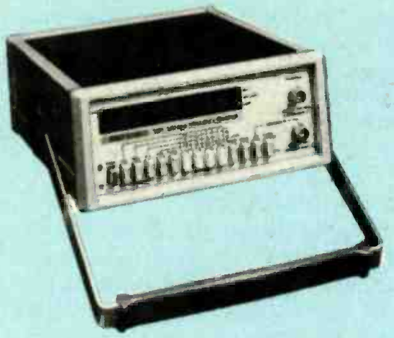
After you have programmed the frequencies of your choice, they can be scanned automatically by using the scan mode. That mode is entered by pressing the SCAN key.

The *Z30* has several special functions that are designed to give the unit maximum flexibility. In the scan mode, you may want to delay the resumption of scanning after activity on a channel has ended so that you might hear a reply that might otherwise be missed. Pressing the DELAY key causes the unit to pause for about 2 seconds before resuming the scan. In the search mode, the DELAY key is used to select between a 4-second delay and a hold function. If the hold function is selected, the unit will remain on a previously active frequency until either the SEARCH or DELAY key is pressed. (Note that pressing the DELAY deactivates the hold function.)

Other special functions include a priority mode that lets you sample a favorite frequency every two seconds during the scanning process. Channel 1 has been set aside for that function. A channel-lockout feature lets you force the scanner to skip over any channel that you select.

The manual that accompanies the unit is, as you would expect, pretty much just an instruction manual. It covers the operation of the unit in step-by-step fashion, but has little in the way of technical details such as theory of operation, schematics, parts lists, or parts-placement diagrams. In fact, the company discourages any user adjustments by stating that such unauthorized adjustments will invalidate the unit's one-year warranty. One bit of useful information that is provided is a list of national frequency allocations. The model *Z30* sells for $269.95. **R-E**

continued on page 32



B+K Model 1851 Frequency Counter

This unit is suitable for even UHF work

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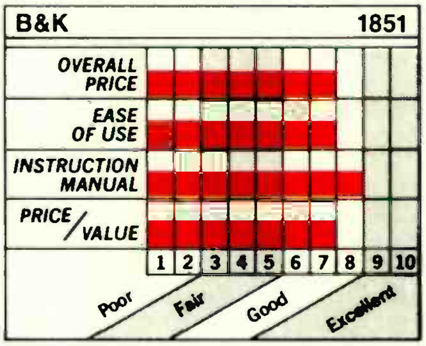
NO MATTER WHAT YOUR INTEREST IN electronics, and no matter whether that interest is as a professional or a hobbyist, you're sure to have run across countless instances where a frequency counter was an absolute necessity. That's not surprising, though, when you consider that no other instrument will do when you need to know the frequency of a signal precisely.

We recently had the opportunity to look over the model *1851* frequency counter from B+K Precision, Dynascan Corporation (6460 West Cortland St., Chicago, IL 60635).

Features

The first thing we should mention is the unit's wide frequency range. It is capable of measuring input frequencies of 5 Hz to 520 MHz. That means the unit is suitable for even UHF work.

In addition to measuring frequencies, the unit can also measure period and total the number of times an event occurs during a time interval. In the period mode, the counter will measure the period of one cycle, in microseconds, of inputs with frequencies of 5 Hz to 2 MHz. The period mode is particularly useful when working with low-frequency signals because it will yield much more accurate results when working with such signals. It is, of course, a simple matter to convert a period reading into a frequency.



The unit's totalize mode is used to count the number of individual events over a period of time. That period of time can be defined manually by the use of a front-panel HOLD switch. In addition, the time period can be defined by applying a gating signal to the counter via a rear-panel connector. Because of the capacitive coupling of the counter's input, events should occur at least 5 times-per-second to assure an accurate count.

Signals are input to the device via one of two front-panel BNC connectors. The one-megohm CHANNEL A input is used for signals from 5 Hz to 80 MHz. For high-frequency signals, from 10 to 520 MHz, the 50-ohm PRESCALE input is used.

The display

Measurements are displayed on an eight-digit LED readout. Annunciators

continued on page 40

THE DRAWING BOARD

Finishing the sinewave generator!

ROBERT GROSSBLATT

THIS MAY SEEM HARD TO BELIEVE, BUT we've just about reached the end of our discussion on digital sinewave generators. This month we're going to put a lid on the whole thing and take a look at the bits and pieces that have to be added to make a working unit. If you have been following along the last couple of months, you know that all that's left to do is to select an oscillator for the front end and a filter for the back end. Let's take care of the rest of the design and then talk a little bit about the advantages that come your way by generating sinewaves with digital, rather than analog circuitry.

If you were to single out the most often designed (or redesigned) circuit in the history of electronics, the oscillator would win hands down. The reason for mentioning that is to point out that it would be a waste of brain power to sit down and design a special one for our application.

Our requirements are sufficiently simple to make use of most existing general-purpose oscillator circuits. All we need is something that is easily tunable over a 1000:1 range, has good stability, is foolproof, and has a garbage-free output. The bells and whistles would include an adjustable pulse-width, minimum parts count, low power consumption, and so on. But first we must select an oscillator!

Oscillator circuit

Obviously, the first thing that should come to mind is the venerable 555 timer. Not only is it easy to use, but the design equations are simple to apply. And if power requirements are really a problem, we can use the CMOS version (7555). Both parts also satisfy another unspoken design criteria. That is, they are common enough to be to be found almost everywhere except in a box of *Cracker Jacks*.

Figure 1 shows the basic circuit layout for an oscillator using a 555 timer. We are looking at one IC and four components—not a whole lot of parts. Now, there is absolutely no doubt (in my mind) that all of you out there know everything there is to know about the 555; but just to make sure, let's go through the circuit, equations, and the math.

The first thing that must be realized is that the output duty-cycle will not be exactly 50%. With the circuit in Fig. 1, we

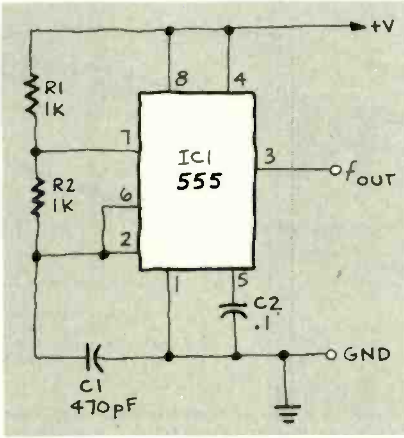


FIG. 1

can get extremely close to 50%, but never quite reach it. The reason for that is capacitor C1 charges up through resistors R1 and R2, but discharges only through R2. If you were to look inside a 555, you would see that there's a transistor handling the discharge half of the cycle and that its collector is connected to pin 7 of the IC. Its emitter is connected to ground and the base sits on the output of an internal flip-flop.

When the output of the 555 is high, capacitor C1 charges up until the voltage across it reaches about ⅔ of the supply. At that point the internal transistor turns on providing a discharge path for capacitor C1 through resistor R2, while the flip-flop changes states and the IC's output goes low. When the capacitor voltage gets down to about ⅓ of the supply, the flip-flop again changes states and the transistor turns off. Capacitor C1 starts to charge up again through both R1 and R2.

Now that we understand what determines the duty cycle of the basic 555 oscillator, a quick look at some of the design equations for the IC will show you what has to be done to square up the duty

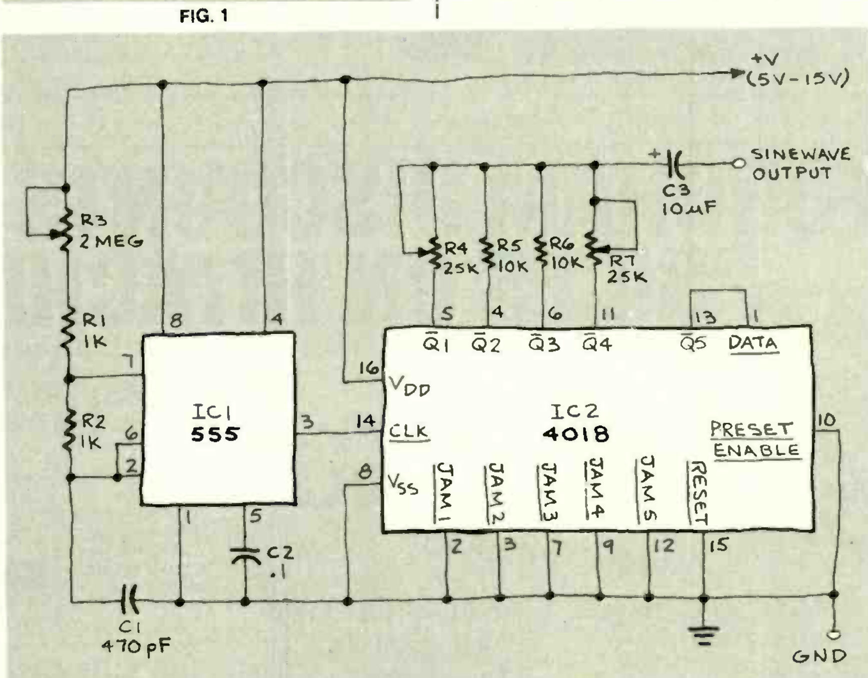


FIG. 2

cycle. Because we're looking at a series R-C timing circuit, the equations related to the duty cycle will be as follows:

$$\text{high time} = K(R1+R2)C1$$
$$\text{low time} = K(R2)C1$$

The "K" in the formula is a constant, which we'll get to in a minute. But for now, we can ignore it because when we calculate the duty cycle, we'll see that

continued on page 36

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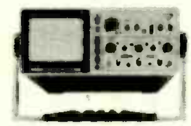

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DRAWING BOARD

continued from page 33

"K" takes care of itself and disappears.

$$\text{duty cycle} = \text{high time/low time} = K(R1+R2)C1/K(R2)C1 = (R1+R2)/R2$$

The duty cycle is controlled by the value of the two resistors (R1 and R2), so we can approximate 50% by making R1 really small when compared to R2. A ratio of up to two or three thousand to one is perfectly workable. The frequency of the oscillator, as we all know, is just the reciprocal of the period (or one divided by the period). Rather than just throw formulas at you, let's briefly reason the whole thing out.

$$\text{period} = \text{high time} + \text{low time} = K(R1+2R2)C1$$

The frequency (f) is therefore:

$$f = 1/K(R1+2R2)C1$$

For the circuit shown in Fig. 1, the value of 'K' is about .695. That value comes about because the 555's internal comparator is set to trigger at ⅔ of the supply voltage. The actual math to derive that value is far from being interesting but, if you want to, you can check it out in any good data book that includes the 555 timer. You can set the trigger level higher by applying a DC voltage to pin 5, but for our application it's not needed. Besides, we can bypass it with C2 to help make the circuit a bit more immune to noise. Now, let's move on to the sinewave generator.

Generator circuit

The original design criteria we set up for the sinewave generator called for an output range of 100 Hz to 100 kHz. Since the 4018 is dividing by ten, the range of the oscillator must be 1 kHz to 1 MHz. Because the upper limit of the 555 is just around 1 MHz, we should be all right.

Figure 2 is the layout for the complete sinewave generator with all the values shown. You can plug your own numbers into the formulas we've just described and change anything you want. Nothing is engraved in stone and, to tell the truth, you'll learn much more if you experiment with different value components.

Potentiometer R3 serves as the frequency selector, making the 555 tunable from about 1 kHz to 1 MHz. I say "about" because it's impossible to find standard value parts that will plug into a formula and give you exactly the results you want.

Resistors R4 through R7 are the famous ones we spent so much time examining. They determine the shape of the wave you're going to get from the 4018. As shown, the fixed resistors are set at 10,000 ohms: and trimmers were used for the $\overline{Q1}$ and $\overline{Q4}$ outputs, because the value we want for each of them is calculated to be 1.617K—not exactly a standard value!

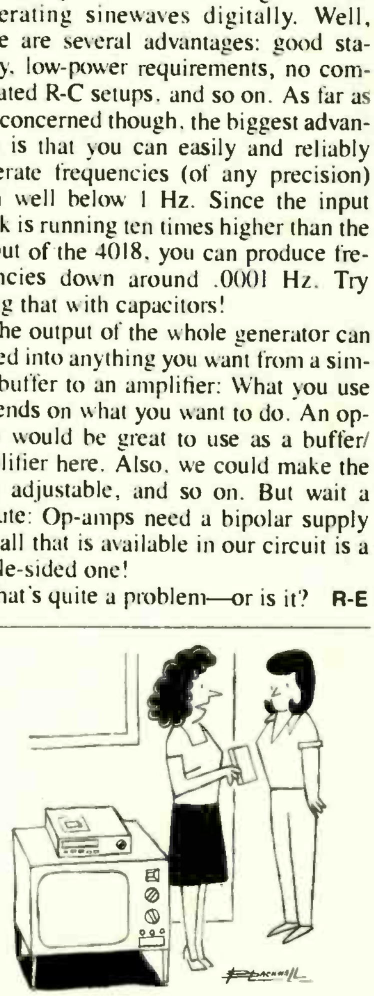
Not only that, but the strange resistor value is correct only if the fixed resistors are exactly 10,000 ohms. Since we all routinely use 5%- or 10%-tolerance resistors, the best thing to do is take two 10,000-ohms units, measure them (out of circuit), and then do the arithmetic necessary to find the value for the two trimmers. After you set the trimmers, it might be a good idea to put a drop of lacquer (or nail polish) on the turnscrews to hold them in place.

The output filter is just a 10-μF capacitor. It should work well enough to smooth the wave out for most applications. However, if you feel that it does not fulfill your needs, by all means substitute some other type filter. Harmonics are not going to be much of a problem because they're quite a bit above the fundamental frequency and they are a good deal smaller in amplitude.

You may wonder what's so great about generating sinewaves digitally. Well, there are several advantages: good stability, low-power requirements, no complicated R-C setups, and so on. As far as I'm concerned though, the biggest advantage is that you can easily and reliably generate frequencies (of any precision) even well below 1 Hz. Since the input clock is running ten times higher than the output of the 4018, you can produce frequencies down around .0001 Hz. Try doing that with capacitors!

The output of the whole generator can be fed into anything you want from a simple buffer to an amplifier: What you use depends on what you want to do. An op-amp would be great to use as a buffer/amplifier here. Also, we could make the gain adjustable, and so on. But wait a minute: Op-amps need a bipolar supply and all that is available in our circuit is a single-sided one!

That's quite a problem—or is it? **R-E**



"John and I had a big row, so all last night he played this videotape of our wedding ceremony in reverse."

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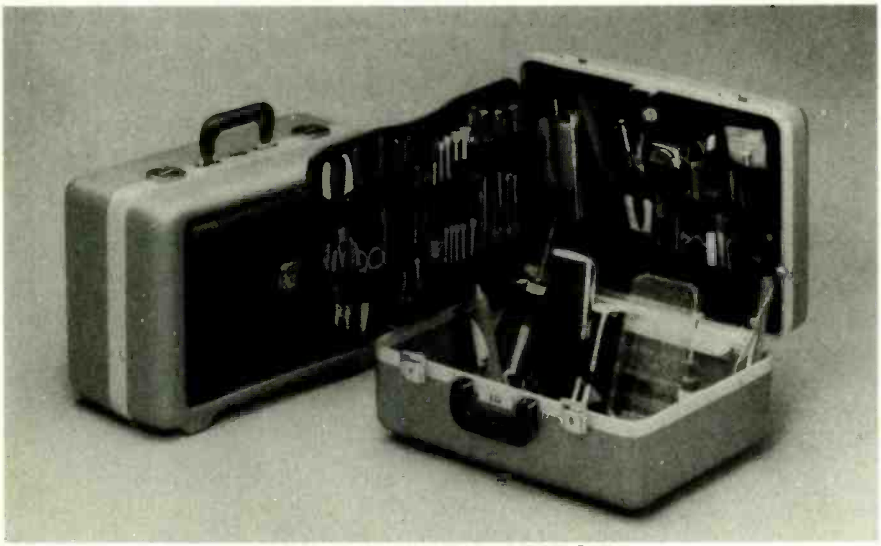

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The case measures 17¾ × 12¾ × 6½ inches and also features two removable gate-swing pallets. That permits easy access to tools, parts, and equipment carried in the case bottom. The model *JTK-87* is available with a selection of over 100 tools, and is priced at $509.00. The portfolio case only is priced at $189.00—**Jensen Tools, Inc.,** 7815 South 46th St., Phoenix, AZ 85040.

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The unit delivers horizontal resolution of 270 lines; a minimum required luminance of 35 Lux; image signal-to-noise ratio of 45 dB; video-output signal of 1.0-volt p-p/75 ohms, and an audio-output level of −20 dB (1000 ohms).

Other features of the model *CV-301* include a unidirectional electret condenser microphone, and f/1.5 manual 3-to-1 zoom lens with 10 – 30mm focal length, a through-the-lens optical viewfinder with in-finder LED to indicate recording low-light and power warnings, and a light balance control to match four separate color temperatures.

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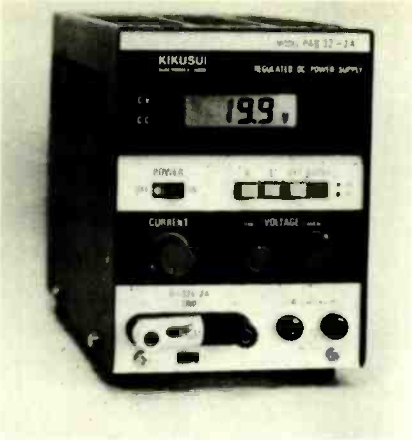

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continued on page 40

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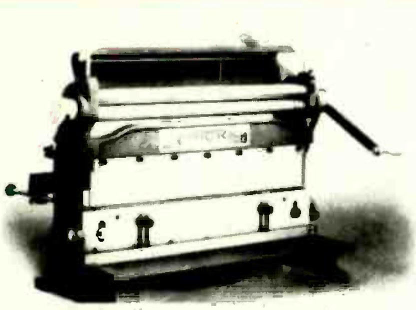

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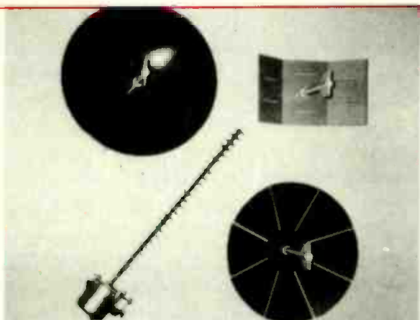

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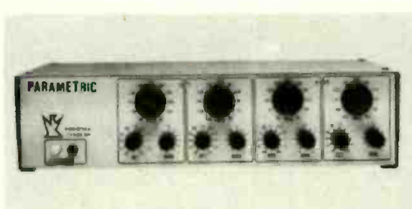

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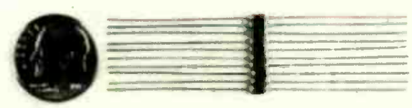

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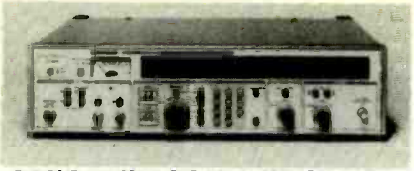


CIRCLE 117 ON FREE INFORMATION CARD

MHz in 1-kHz steps. Output-level range is −10 to 120 dBμvolt in 1-dB steps.

The model *LSG-215A* is designed particularly for use in the communications industry, but is a general-purpose signal generator as well. It is priced at $2,795.00.—**Leader Instruments Corporation,** 386 Oser Avenue, Hauppauge, LI, NY 11788. **R-E**

EQUIPMENT REPORTS

continued from page 32

are used to indicate whether the reading is in kHz or MHz. Annunicators are also used to indicate when a measurement (GATE) is being taken and if an overflow (OVER) condition exists. The OVER annunicator lights whenever the range of the display is exceeded and one or more significant digits are not displayed.

The resolution of the display depends upon the frequency of the input signal. For signals up to 10 MHz, the maximum resolution is 0.1 Hz. For signals from 10 MHz to 80 MHz the maximum resolution is 1 Hz. For signals higher than 80 MHz, the maximum resolution is 10 Hz. Lesser resolutions can be switch-selected in four decades from the front panel. For instance, for signals up to 10 MHz, the four selectable resolutions are 0.1, 1, 10, and 100 Hz. All available resolutions are shown on a handy front-panel chart.

All functions and measurements are selected using front-panel pushbuttons. In addition to the connectors and controls we've already touched upon, a RESET button is provided that can be used to clear the counter back to zero. When the button is released, a new measurement is taken. Also switch-selectable from the front panel are a ×10 attenuator and a 100-kHz lowpass filter. Those features are available whenever a signal is input through the CHANNEL A BNC connector. The attenuator is used to help prevent miscounting that might be caused by noisy or improperly terminated high-amplitude signals. The lowpass filter is used to prevent the miscounting of low-frequency signals due to the presence of high-frequency noise at the input.

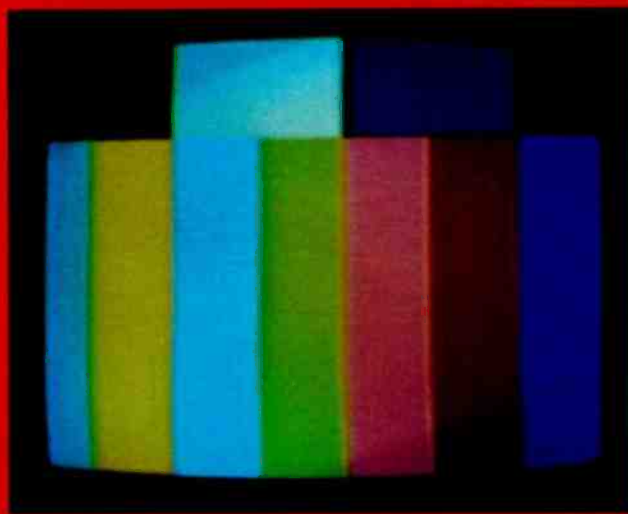
The counter uses a 10-MHz time base. That time base is generated by a temperature-compensated crystal oscillator for excellent temperature and line-voltage stability. The specifications for the unit claim a temperature stability of ±1 part-per-million over a range of 0°C to +50°C. Line voltage stability is about ±0.1 part-per-million for a line-voltage variation of ±10 percent.

The unit is housed in a rugged steel case that measures 3.75 × 9.5 × 12.6 inches; the unit weighs 5.31 pounds. In addition to making the unit more durable, the use of a steel case provides excellent RF shielding.

The manufacturer did a nice job with the instruction manual: It covers almost everything you need to know to use and maintain the unit. Included are sections dealing with specifications, operating instructions, circuit descriptions, maintenance and calibration, parts-placement diagrams, available accessories, and warranty information. You may have noticed that we did not list a parts-list or schematic diagram. That's because those are provided in a separate booklet that comes with the instrument.

Note that although there is a handle that doubles as a tilt stand, since there is no provision for battery power the instrument is not really suitable for most field work. Our only complaint, and it's a minor one, is that no probes were supplied with the unit. Those must be purchased separately and are available from B + K as outlined in the manual. The model *1851* carries a suggested retail price of $575.00. **R-E**

COLOR-BAR GENERATOR



JERRY LAWSON and DAN McELROY

This novel cartridge for the Atari 2600 lets you use that videogame computer as a color-bar generator.

PROBABLY THE LEAST APPRECIATED PIECE of test equipment is the color-bar generator. It is one of those pieces of equipment that there is no substitute for when needed. But since that is so infrequent, the price tags on those units would make most of us squirm.

But there is an alternative. In this article we will show you a color-bar generator that will produce color bars, dots, crosshatch patterns and lines. And it can be built for less than $25.00.

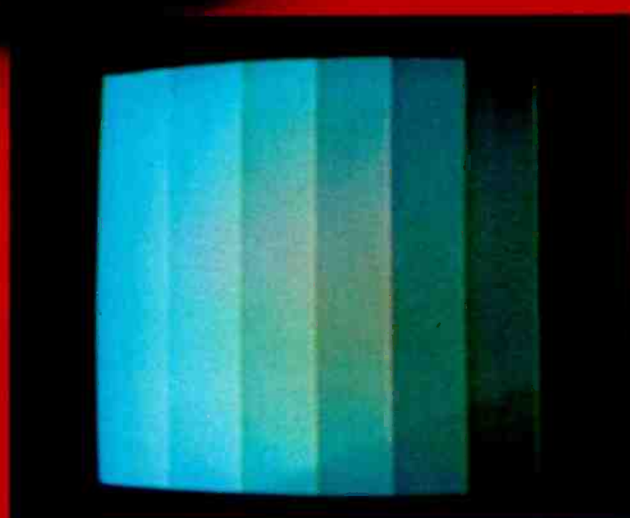
What makes that possible is a device that is found in over 15 million households: the Atari *2600*. That color-graphics generator, which most people call a videogame computer, along with others that are available, can be programmed to produce graphics of almost any shape. For the sake of this project, it can be programmed to produce the same graphics pattern as a conventional color-bar generator, but at only a fraction of the cost.

The *2600*

What makes this device practical is the popularity of the *2600*. Considering the number of those units that have been sold, the odds are excellent that either you or your children own one of those machines. If not, perhaps a friend would be willing to lend you his for a while. If all else fails, those units can often be bought at a substantial discount or even second hand.

Let's look a little more closely at the *2600*. That unit (see Fig. 1) consists of three LSI IC's—A 6507 microprocessor (28-pin version of the popular 6502 CPU), a 6532 RAM-I/O-timer array, and a custom graphics IC known as a VIC. There is some other circuitry, but those three IC's are the heart of the *2600* game console.

The VIC IC and the 6532 act as the peripherals to the 6507 CPU. Since the



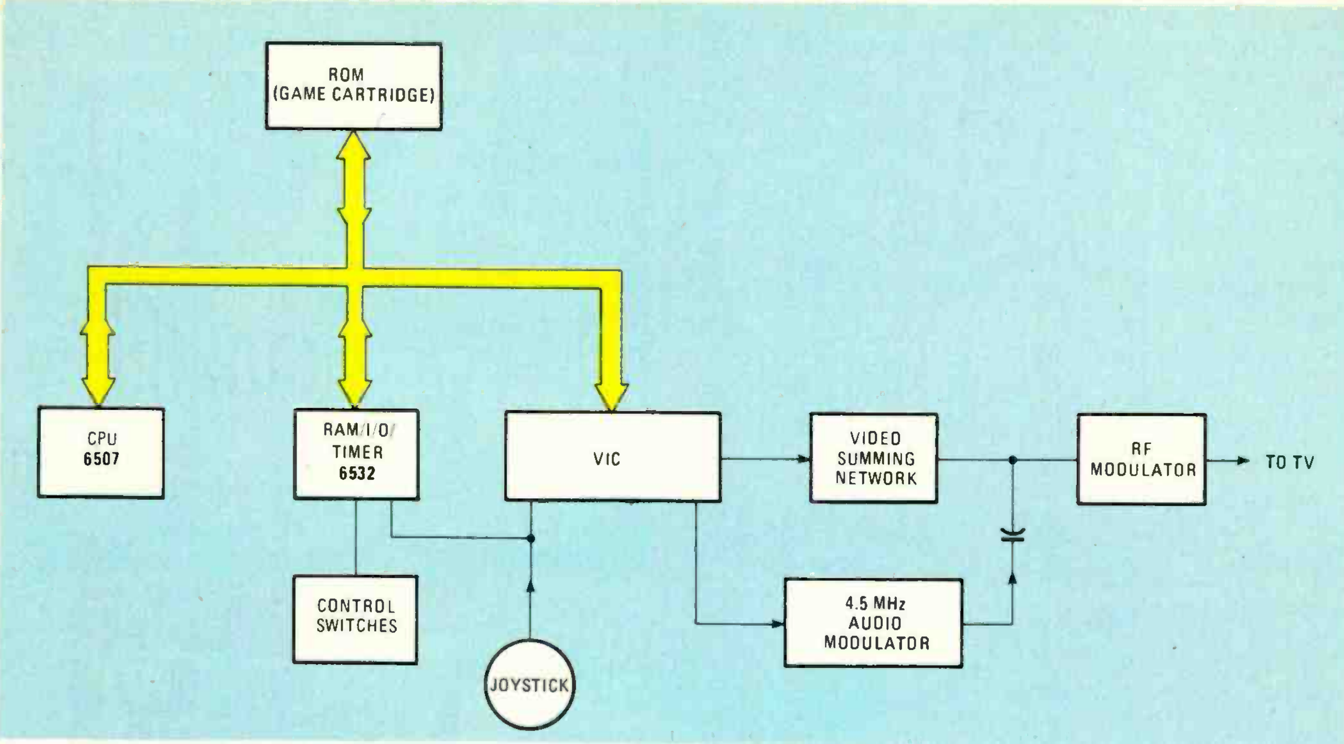


FIG. 1—BLOCK DIAGRAM OF THE *2600*. Three IC's, a 6507 microprocessor, a 6532 RAM-I/O-timer array, and the VIC graphics IC form the heart of the unit.

6507 has only thirteen address lines, designated A0–A12, it can address only 8K bytes of memory.

The *2600* uses address line A12 to select whether the peripherals or the ROM, which is inside the external cartridge (more on that shortly), will be addressed. When address line A12 is high (logic 1), the ROM in the cartridge is selected; when address line A12 is low (logic 0), the peripherals inside the *2600* are selected.

Let's see how the memory of the *2600* is organized. The VIC is memory mapped at addresses 0000H to 002FH (the H at the end indicates that a number is in hexadecimal). Loading in the right data to the right address at the correct instant will produce the desired pattern or sound.

The RAM occupies the addresses from 0080H to 00FFH. The RAM is used by the *2600* for temporary data storage during program execution. The hand controllers and the unit's console switches are memory mapped at locations 0280H to 02FFH. The 6532's internal timer is also memory mapped within that range.

Color-bar cartridge

The plug-in cartridges used by the *2600* consists of a printed-circuit board and a ROM that contains the instructions, or programs, to produce patterns or sounds from the game console. The contents of the ROM is memory mapped at locations 1000 to 1FFF. When a memory location within the ROM is selected by the address bus, the contents of that location is placed on the the data bus and passed on to the 6507 CPU.

The program, which is contained in a 2732 EPROM, causes the *2600* to ack like a test-pattern generator. A TTL inverter (74LS04) is used to transform the $\overline{OE}$ signal from the *2600* to the OE signal required by the EPROM. A schematic diagram of the color-bar cartridge is shown in Fig. 2. The pinout of the device is shown in Fig. 3.

Construction

The task of building the color-bar generator cartridge is very simple and straightforward: after all, there are only two components in the circuit. A double-sided PC board is required, however. The patterns for that board are shown in Figs. 4 and 5. The parts-placement diagram is shown in Fig. 6. Note that there is a metal shield over IC1. That shield is formed from copper foil and simply tack soldered to the board.

Use

Connect The *2600* as you would normally to play a game. Insert the color-bar generator cartridge as you would an ordinary game cartridge, turn the power on, and the screen will display a title page. If you made your own board and do not have a cartridge case, be sure to insert the board with the component side up.

Table 1 is a listing of the display functions of the color-bar generator. By depressing the GAME-SELECT switch you move forward through the functions in the order they are listed in the table. By depressing the RESET switch you move backward through the functions.

PARTS LIST

IC1—2732 EPROM (see text)
IC2—74LS04 inverter
Miscellaneous: PC board, metal shield, plastic case
The following are available from Video Soft, Inc., PO Box 4242, Santa Clara, CA 95050: Color-bar generator cartridge kit, $23.95, plus $1.70 postage and handling; assembled unit, $29.95, plus $1.70 postage and handling; Source-code listing for the EPROM, $10.00, plus $1.70 postage and handling. California residents add 6% sales tax. VISA and MasterCard accepted.

The color-bar display is a close approximation to the NTSC standard color bar. The top colors are grey, yellow, cyan, green, magenta, red, blue, and black. The bottom colors are a very dark green, white, blue, and black.

The gray-scale pattern produces eight shades across the screen, going from white to black. That pattern is used to check that the television can reproduce uniform changes in the luminance amplitude. The brightness and contrast can be adjusted so that all bars are showing across the screen. Note: It is not possible to turn off the color-burst signal on the game console, even with the COLOR/BLACK-WHITE switch.

The cross-hatch, dot, vertical lines, horizontal lines, and center-cross patterns are very useful for checking vertical and horizontal linearity on any television, and are also useful for checking and aligning

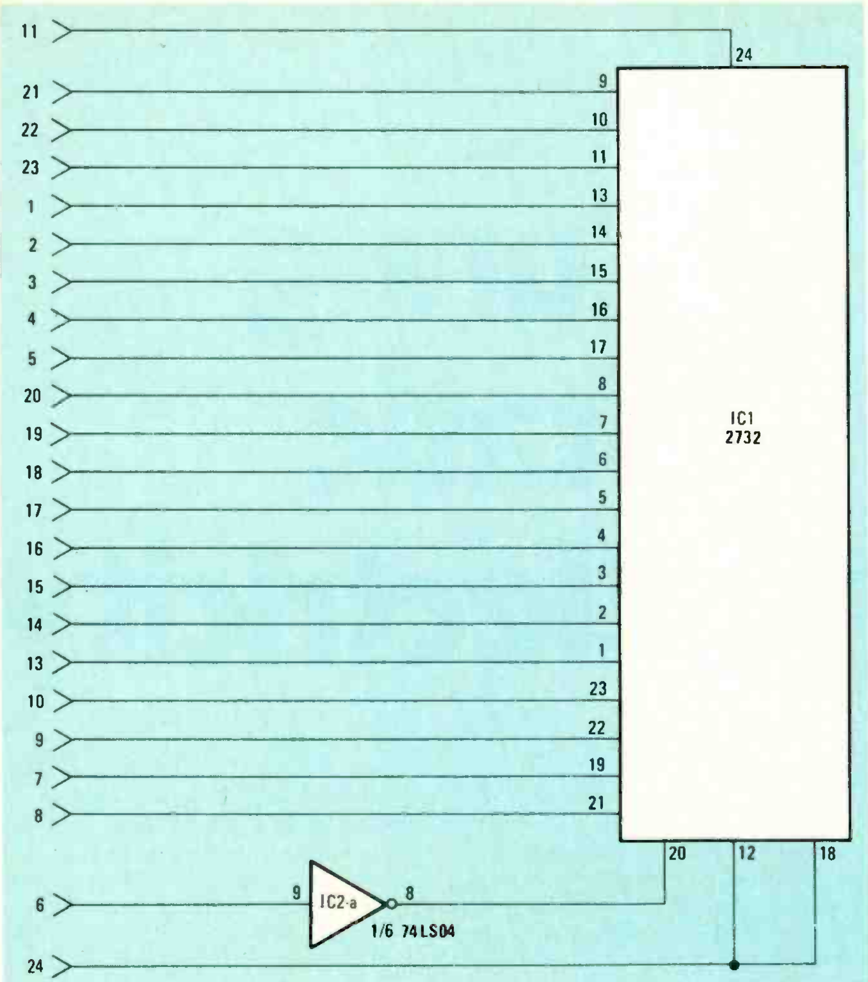


FIG. 2—THE COLOR-BAR CARTRIDGE. This simple circuit allows you to use the *2600* as a color-bar generator.

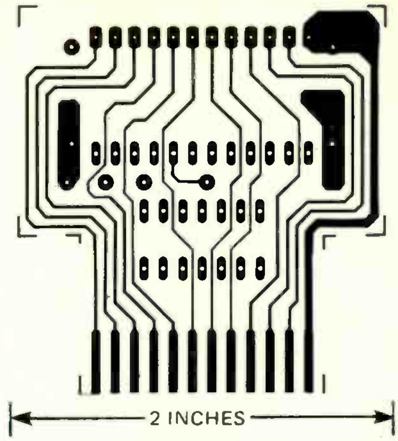


FIG. 4—THE COMPONENT SIDE of the double-sided PC board is shown here.

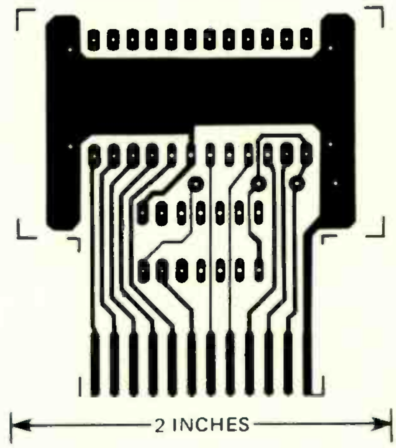


FIG. 5—THE FOIL SIDE of the double-sided board is shown here.

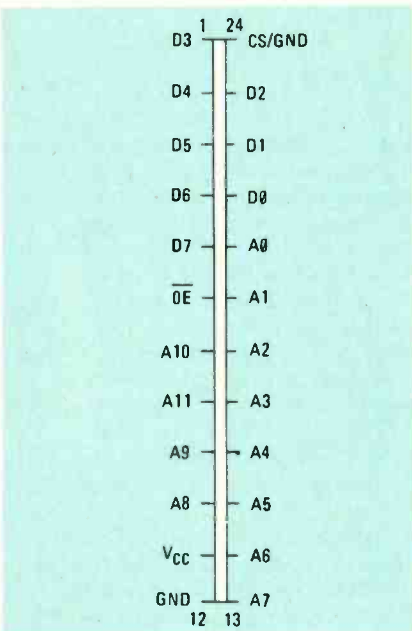


FIG. 3—THE PINOUT of the color-bar generator cartridge's card-edge connector.

TABLE 1—FUNCTIONS

Title Page
Green Screen
Red Screen
Blue Screen
Low-Level White Screen
Window
Wide Vertical Bars
Circle
Cross Hairs
Horizontal Lines
Vertical Lines
Dots
Cross Hatch
Stair Step (Gray Scale)
Color Bars

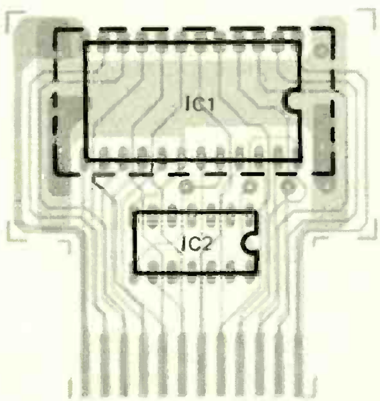


FIG 6—PARTS-PLACEMENT DIAGRAM. The dashed box around IC1 is a shield made of copper foil. That shield is tack soldered to the PC board.

convergence on a color television.

The circle pattern is used to adjust the vertical size and linearity. If the vertical size and/or linearity are out of adjustment, the circle will look like an oval or an egg.

Wide vertical bars are provided to test for smearing or fading of the video signal. If all is in order, the bars should appear as completely white and black bars.

If all is normal, the window pattern will appear as a white window in a completely black background. If the black background changes between black and grey at the top or bottom of the window, the DC coupling or DC restoration between the video amplifier and the picture tube is not functioning correctly.

The white screen is used to adjust the color circuits to produce a white screen on a color television. The red screen is most useful in adjusting color purity. If the screen is not completely red (that is, if it shows other colors around the edges), the television should be degaussed (or the color-purity magnets will need adjustment). **R-E**

ALL ABOUT

Curing Static Electricity

ELLIOTT S. KANTER

Learn the "shocking" facts about static electricity, the damage it can do, and how it can be controlled.

HIDDEN IN YOUR HOUSE, OFFICE, OR GAME room is a sinister and silent enemy. It sits quietly waiting for the proper moment to "zap" either your computer, disks, or videogame into oblivion. It has no smell, taste, leaves no odor, and can strike in the best of homes or offices. That silent killer of things electronic is static electricity. It strikes without warning, and in the blink of an eye can send over 50,000 volts of electricity coursing through the sensitive electronics of your computer, videogame, or data-filled floppy disk.

None of us would knowingly connect sensitive electronics equipment to such a large potential surge, but in fact, that potential is present all over your house, shop, office, or den. The problem, while not exactly the topic of conversation in polite circles, has found its way more than once to the pages of a national financial daily paper. There, a videogame company was quoted as acknowledging the hazard, its potential destruction of equipment, and then, perhaps in a tongue-in-cheek manner, suggested that game owners get themselves a large, hairy dog and touch it before operating their videogame, or handling a game cartridge.

While the suggestion does have some basic merit, it clearly would be inconvenient to use in an office situation, not to mention the obvious requirement to feed, water, and walk such an acquisition. However, there is hope; and in fact, the principles of dealing with this hazard are well known, documented, and even simple to implement in your office or home with little or no extra cost. You need not resort to sophisticated devices, or even hairy animals.

For years, hospitals throughout the country, and the world for that matter, have been forced to deal with static electricity and more important, to develop techniques to keep it in its place.

Static electricity is usually produced by differing potentials, friction, or the flow of gases through tubing at high flow-rates. What makes that static-electric formation dangerous in the hospital is the effect of a discharge of static electricity in the form of a seemingly harmless spark in the presence of either flammable anesthetic-agents or in oxygen-enriched areas. Obviously, if you were to apply a spark in an area rich in fumes or oxygen, a fire or explosion would result.

In order to safeguard the lives of patients and health-care personnel, hospitals embarked on an aggressive program of static-electric control that resulted in a number of simple cures and a better understanding of the problem. Readers desiring more information on that program are referred to *Document 56A*, a complete "course" on static-electricity control available from the National Fire Protection Association, Boston, Mass., for about $3.00.

Static electricity can also cause serious problems in a number of other special situations. In the munitions industry, for instance, electrically ignited devices such as blasting caps and primers can be set off by static electricity.

A little closer to home, a variety of electronics components, such as MOS semiconductor devices (see Fig. 1), are extremely static sensitive. Because of that, special handling is generally required. When working with MOSFET's, for example, both the user and the device case should be grounded at the same potential during any handling. During transit, all device leads should be shorted together. When soldering a device into a circuit, the soldering-iron tips should be grounded. Finally, the chassis and cabinet of any unit using MOSFET devices should be grounded.

In the balance of this article, we shall examine the basic principles and rules for keeping static electricity in its place, not in your sensitive equipment.

Terms

To fully understand static electricity and how to control it, we have to change some of the ways we think about or define terms. Normally, when we refer to a conductor, we would assume that it has a very low resistance. An insulator, on the other hand, could be thought of as something that has a high resistance. Copper wire is a good example of a conductor, and rubber immediately comes to mind as a typical insulator. There are other examples, but for the purpose of this article, let's accept them as is.

In things of a static-electric nature, a good conductor will have a resistance of between 25,000 and 500,000 ohms; insulators a resistance of over 500,000 ohms. Typically, the resistance as measured from chassis ground to the ground pin of the power cord, would be less than 2 ohms, so we can see the disparity in terms and definitions. Another term we might want to examine is "isoelectric." Speaking in terms of static-electricity control, that term is defined as a condition wherein all objects are at the same potential.

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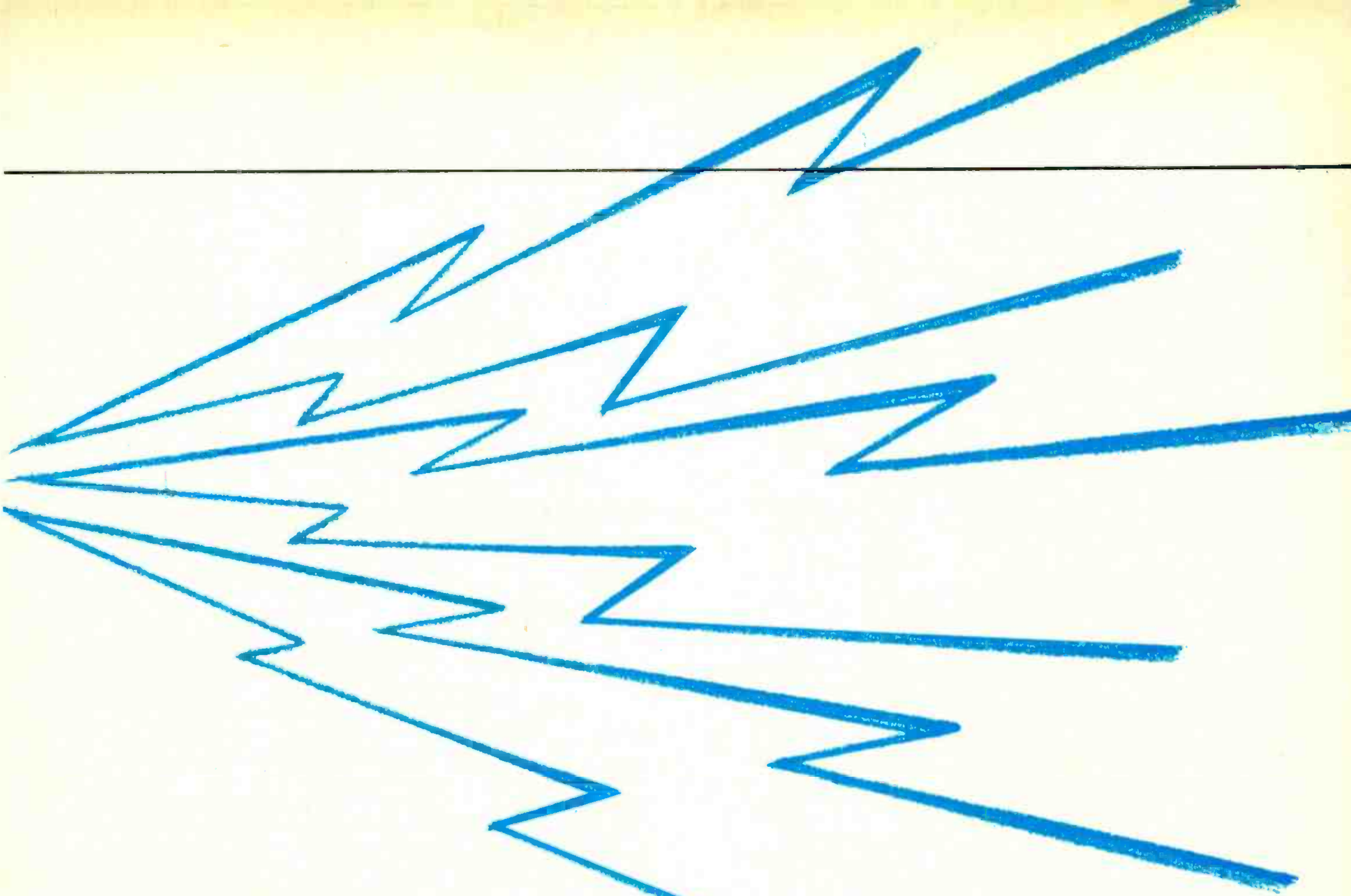


Static electric charges

If you recall from your childhood, rubbing a hard rubber comb with a piece of wool "charged" the comb with static electricity and enabled you to pick up bits of paper in a manner not unlike a magnet attracting small metal filings. Likewise, if you have carpeting and shuffle your feet as you walk, you will have a visual and startling example of static electricity when you touch a metal object such as a door knob.

Those are examples of static electricity being produced by friction, the most common cause of static-electric build-up in the home or office. Static electricity may be generated anytime that two objects rub against each other, especially if the objects are made of dissimilar materials. While the objects are in contact, the electrons move from one to the other. But if either (or both) of the objects are non-conducting, when they separate, the built-up charge remains on the non-conducting object as it has nowhere to go. An object is considered to be strongly charged if it has an excess or deficiency of only one electron in 100,000 atoms.

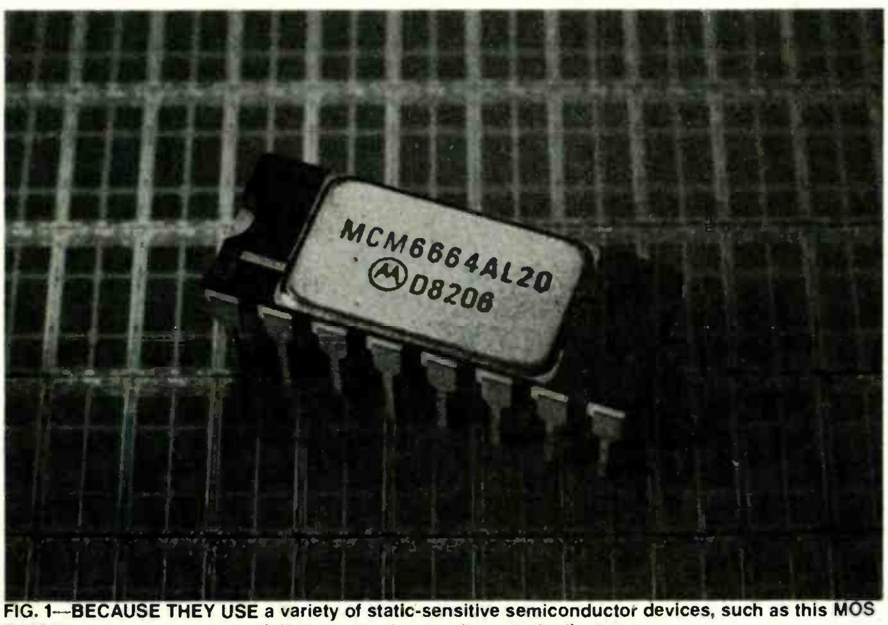


FIG. 1—BECAUSE THEY USE a variety of static-sensitive semiconductor devices, such as this MOS RAM IC, computers are especially prone to damage from static discharges.

The more perfect an insulator, the longer an object will retain its built-up charge. If the charge leaks off rapidly, there is no problem. If it continues to accumulate, the accumulation will become sufficient at some point to jump to some nearby object. That is what causes a spark (see Fig. 2).

A spark may be as long as eight inches, or may be too small to see. The energy in the spark is given by $E = \frac{1}{2}CV^2$, where E is the energy in joules, C is the capacitance in farads, and V is the voltage in volts. The capacitance for a person is considered to be 100 pF. The human body can build up some considerable static voltages under commonplace situations. For instance, sitting on a varnished wooden stool can generate up to 20,000 volts; a walk across the floor can generate up to 50,000 volts (see Fig. 3). Thus, since voltages of 50,000 are possible, a person can

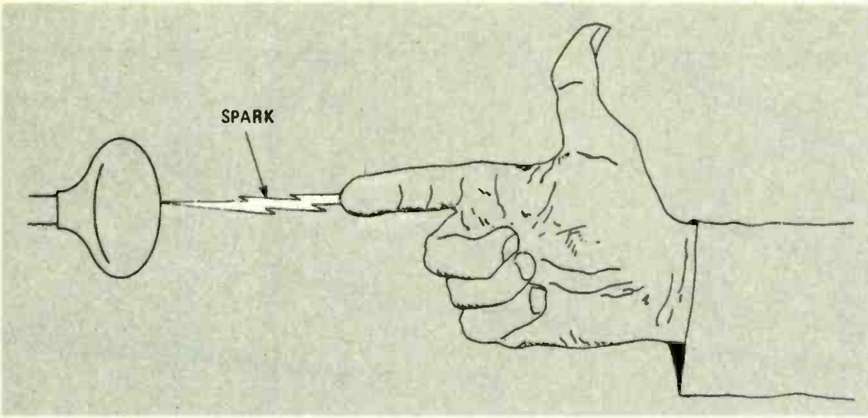


FIG. 2—IF A CHARGE DOES NOT LEAK OFF, the accumulation of charge will at some point be sufficient to jump to a nearby object. That is what causes a spark.

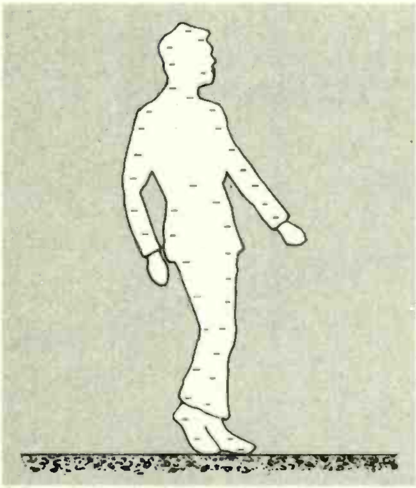


FIG. 3—THE ACT OF WALKING across a wood floor is sufficient to build up a charge of up to 50,000 volts.

cause a spark with an energy of 0.01 joule. A spark with that energy level is quite hazardous in many situations, as it is enough to ignite such chemicals as acetone, benzene, alcohol, and propane gas under certain circumstances. All of those are commonly used in industry, and also might be found in the home or workshop. To further complicate matters, if a drum of acetone, for instance, is left to sit for some time, it too will pick up some charge (see Fig. 4).

The spark caused by a static build-up can also cause some less spectacular, but quite harmful effects when dealing with sensitive electronics or computer equipment. A static discharge can be quite fatal to that data disk you are reaching for to load into the computer, or for that CMOS IC or a videogame cartridge.

Besides friction, we do need an atmosphere conducive to static-electric build-ups. That atmosphere or environment usually consists of a dry, (low-level humidity) room. For various reasons, low levels of humidity tend to amplify the effects of static-electric charge build-ups. Keeping that environment in mind, it would seem that if we had a controlled and humidified atmosphere or environment, then we would have taken one important step in keeping static electricity in its place.

Think humidity

Tests have shown that humidity levels of fifty percent (50%) or more tend to discourage the formation of static-electric build-ups. Hospitals condition their static electric critical areas to ensure that the humidity does not fall below that level. In the home or office, it is essential to first determine what the present humidity level is before taking any action. Humidity indicators are available at most discount stores and hardware dealers. Frequently they are available with thermometers so that you can keep track of temperature as well as humidity.

The NFPA suggests that the temperature be around 72°F, with a minimum humidity level of 50%. The normal change in seasons affects the natural humidity found in a room. During the summer or warm months, the humidity level in a room could conceivably be considerably higher than the suggested 50%. Conversely, warm heated air present during the winter months tends to dry out the room. Knowing exactly where you stand is quite important in combatting static-electric charge build-ups. If your room or work area has a humidity level of 60%, it is not necessary to reduce it to the level suggested by the NFPA. Remember, that level is a minimum one where tests have shown that static-electric charge build-ups are discouraged. Too high a humidity level is uncomfortable for both people and equipment.

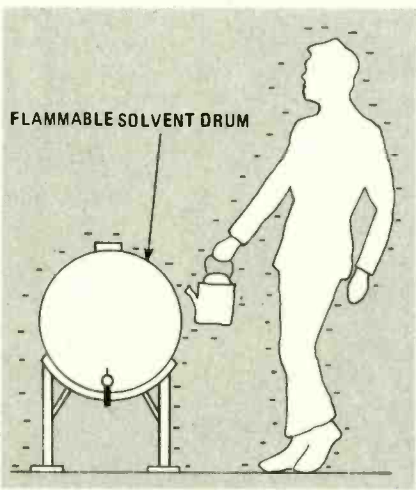


FIG. 4—SINCE BOTH a drum of solvent and a person moving about can accumulate a charge, the potential for disaster in an industrial situation is great.

If the humidity level is too low, we would want to add moisture to the air. That can be done by using a humidifier to add precise amounts of water to the air until an acceptable level is reached. Those devices vary in size and cost; and if more than one area is affected, it might be wise to consider a central humidifier that would work with the centralized heating and cooling system. Conversely, if a room is too wet or overly humid (and we would define that as being at a level perceived as uncomfortable by the occupants of an area), then a dehumidifier, a device designed to remove moisture from the air is indicated. Again, we are looking to establish an environment that contains at least enough humidity (50%) to discourage the formation of static-electric build-ups but low enough to provide comfortable working conditions.

Typically, we will be removing moisture during the warm summer months and adding moisture during the dry winter months. However, if you live in a climate which is excessively dry or wet, you should make the needed adjustments accordingly.

In search of a common potential

Building on our previous definition of isoelectric, we can see that we must attempt to bring all objects to a common potential. In pure electrical terms, that common potential would be ground; but unlike the pure electrical potential, we do not want the degree of conductivity that an electrical ground would produce. That is to say, our definition of conductive must follow the requirements for static-electric control and be somewhere between 25,000 and 500,000 ohms. The reason for those levels, rather than the traditional 2 ohms or less, is that the higher-resistance conductor will permit the static-electric charge to bleed harmlessly to ground. That bleeding off of the charge avoids the obvious differing potentials that would not be of any concern if we were dealing exclusively with conventional electrical energy.

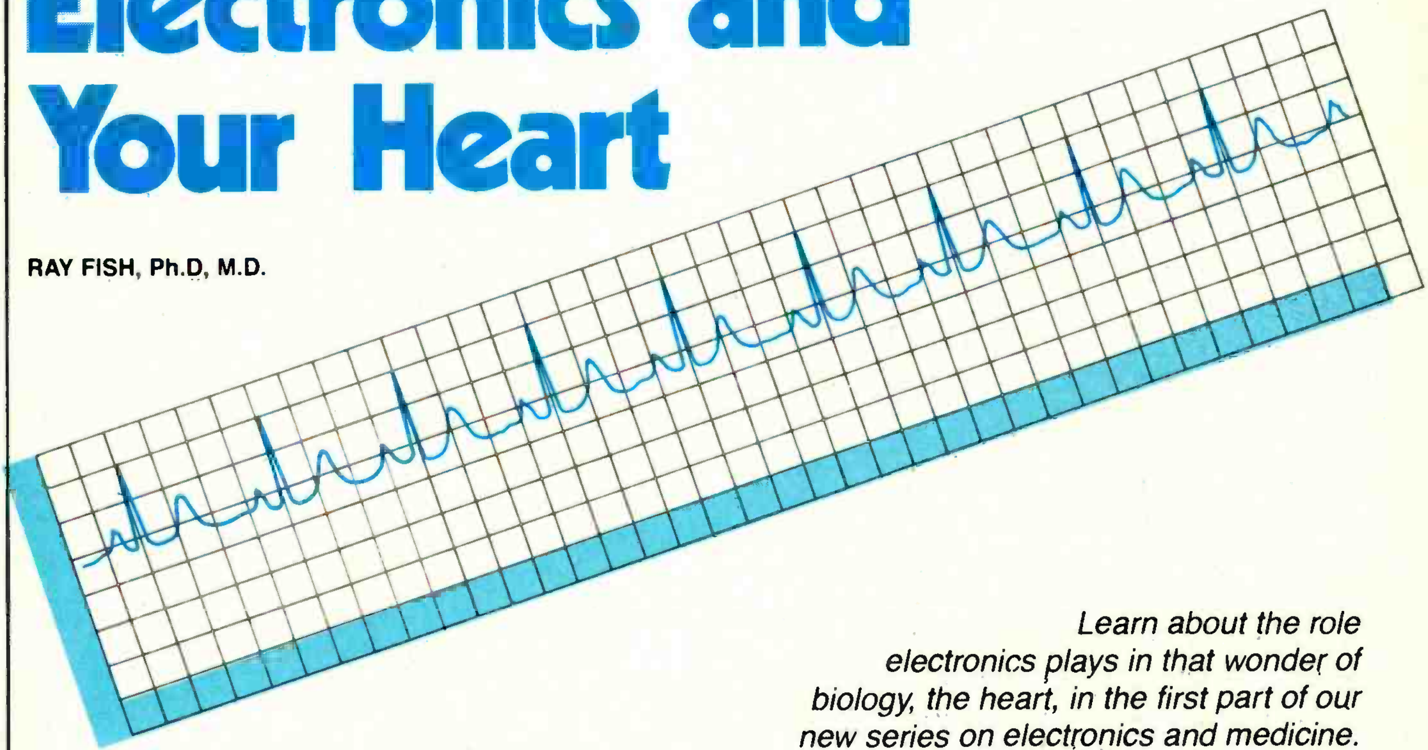
Simplistically, if a stranded wire of perhaps 18-gauge were attached to the case (metallic only) of each item and then routed to a central ground through an individual 27,000-ohm, ½-watt resistor, then all

continued on page 89

ALL ABOUT

Electronics and Your Heart

RAY FISH, Ph.D, M.D.



Learn about the role electronics plays in that wonder of biology, the heart, in the first part of our new series on electronics and medicine.

WE OFTEN HEAR THE WORDS BLOOD PRESSURE, electrocardiogram, cardiac arrest, heart attack, and myocardial infarction. But, what do those terms really mean? This article is the first of a series of articles which will explain those terms. Other topics to be discussed will include electrical rhythms of the heart, the causes of cardiac arrest, means of resuscitation (reversing cardiac arrest), electronic pacemakers, and the electronic monitoring of critically ill patients.

As we will see, there are many different causes and types of cardiac arrest (cessation of heartbeat). The most common cause of sudden, unexpected cardiac arrest is a myocardial infarction, or heart attack. In a myocardial infarction, a part of the heart loses its blood supply and dies. In the USA there are about 1,500,000 myocardial infarctions with 650,000 deaths resulting each year.

Structure and function of the heart

The heart is the muscular pump that moves blood throughout the body. As shown in Fig. 1, the heart receives blood from the veins of the body. The blood first goes into the right atrium. The right atrium is the first of the four compartments, or "chambers" of the heart through which the blood will pass. Blood goes from the right atrium to the right ventricle. The tricuspid valve (see Fig. 2) keeps the blood from flowing backward into the right atrium. After leaving the right ventricle, blood goes to the lungs.

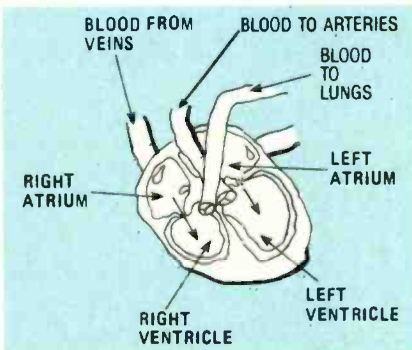


FIG 1—THE FOUR CHAMBERS of the heart. The arrows shown the direction of blood flow.

The lungs add oxygen to the blood and get rid of the waste gas (carbon dioxide) that the blood has accumulated while going through the body. The blood returns to the left side of the heart.

Blood passes from the left atrium to the left ventricle through the mitral valve. The left ventricle can then pump blood to the body through the aortic valve. The aorta is the largest artery in the body.

The aorta branches and divides into smaller arteries, as shown in Fig. 3. Those smaller arteries divide repeatedly into smaller and smaller arteries. Finally the dividing of arteries leads to the very small capillaries. Capillaries join to form small veins. The small veins join together to form larger veins. The larger veins come together to form the great veins that return blood directly to the right atrium. The actual giving of oxygen to the body occurs at the capillary level.

Although the heart is full of blood, the heart's thick muscular walls must receive oxygen and nutrients through a separate system of arteries. The arteries that bring oxygen and nutrients to the heart muscle are called coronary arteries. If a coronary artery is blocked, or "occluded," the heart muscle supplied by the artery will die (infarct). Thus, a coronary artery occlusion is a blockage of an artery that leads to the death (infarction) of a part of the heart muscle. That muscle death is termed a myocardial infarction or heart attack.

The heart is an electrically controlled pump. Electrical signals cause a sequence of events to occur. First, the heart rests between heartbeats. Then the left and right atria, the top half of the heart, contract. Then the left and right ventricles, the bottom half of the heart, contract.

Between heartbeats, the heart rests and blood flows into the right and left atria from the body and lungs, respectively. Blood also flows into the ventricles at that time. Then the atria contract and force even more blood into the ventricles. There

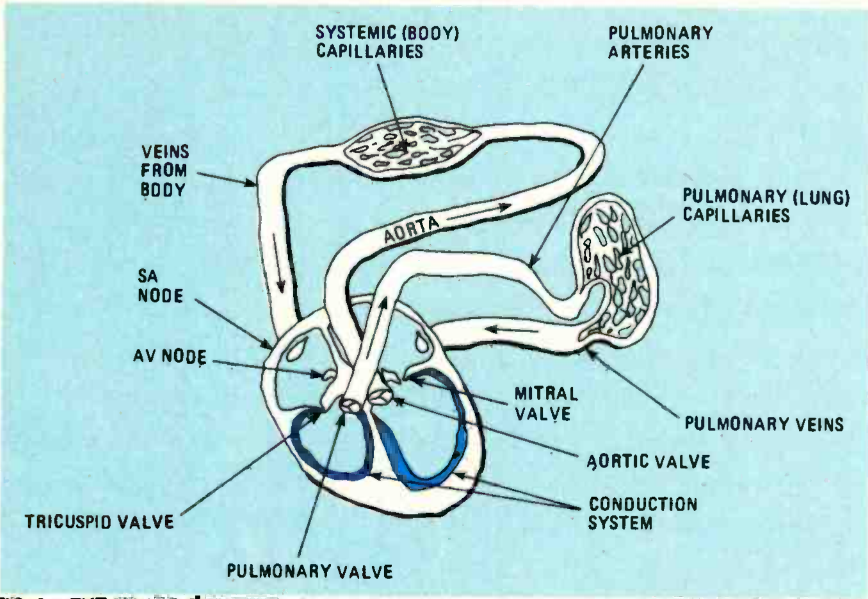


FIG. 2.—THE MAJOR PATHWAYS of blood flow are shown here. Also shown is the heart's electrical conduction system.

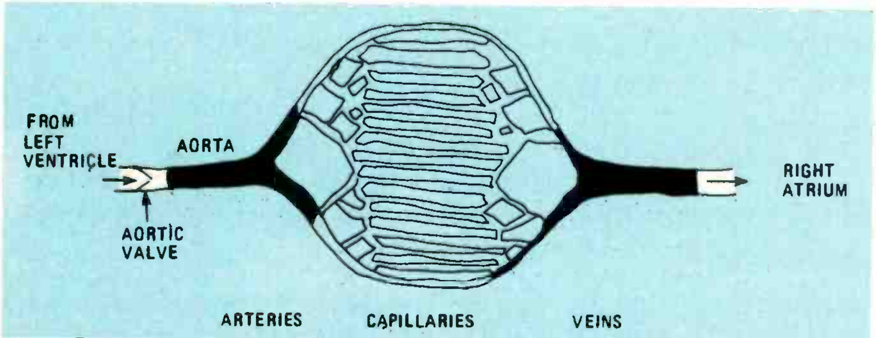


FIG. 3—BRANCHING IN the vascular system. Nutrients and waste are exchanged between the blood and the cells of the body through the walls of the capillaries.

is a pause to allow time for the blood to flow, then the ventricles contract. That ventricular contraction forces blood into the lungs from the right ventricle and into the body (via the aorta) from the left ventricle.

Electrical character of the heart

A heart muscle cell normally has a voltage on the inside of the cell membrane that is about 90 millivolts more negative than the voltage outside of the cell. (See Fig. 4.) That voltage is called the resting potential. If the resting potential is raised to a threshold voltage, the cell will suddenly discharge (or "depolarize"). When discharge occurs, the potential inside the cell becomes about +30 millivolts, and the cell contracts (the muscle cell becomes physically shorter in length). After about 200 milliseconds, the potential inside the cell returns to the resting potential, and the cell relaxes mechanically until the cycle repeats (when the resting potential is again raised).

The cells of the atria are connected to adjacent atrial cells electrically. Therefore when a cell discharges, nearby cells will receive the stimulus to discharge. A wave

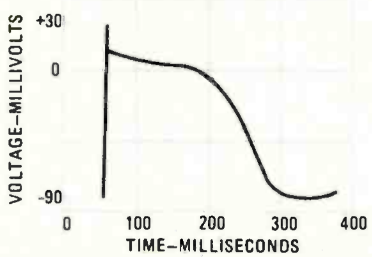


FIG. 4—THE VOLTAGE inside a heart-muscle cell. When caused to depolarize, the voltage becomes briefly positive, drops to 0 for about 200 milliseconds, and then goes negative.

of depolarization spreads through the atria. Eventually all the cells of the atria will have discharged. The atria will have contracted. Waves of depolarization involving large numbers of cells cause a voltage that can be detected by electrodes placed on the body surface. The voltage detected in that manner is the electrocardiogram (ECG or EKG).

Similar to the arrangement in the atria, all cells of both ventricles are connected electrically to adjacent ventricular cells. Therefore, discharge of any ventricular cell will spread and eventually cause discharge (and contraction) of all ventricular cells.

However, the atria and the ventricles are not directly connected together. The atria are connected electrically to the ventricles by a small area called the AV (*Atrio-Ventricular*) node. That conduction path between the atria and the ventricles delays the signal about 0.04 second. That delay gives the atria time to eject blood into the ventricles. That delay also limits the number of beats per minute that can reach the ventricles. In conditions in which the atria are beating much too fast, this limiting of the ventricular rate is often life saving. That is because it is mostly the pumping of the ventricles that causes blood to flow to the brain and other vital organs. If the ventricles are made to beat too rapidly, the flow of blood is decreased because there is insufficient time for the ventricles to fill with blood between contractions.

Refer back to Fig. 2. A "schematic diagram" of the "circuitry" used to control organized sequential depolarization of heart muscle cells is shown there. If not caused to depolarize from some outside stimulus, most cells of the heart slowly depolarize from their resting potential and discharge a characteristic number of times per minute. The cells that discharge most quickly are the "pacemaker cells" in the SA node. The depolarization signal from the pacemaker cells spreads through the atria first. Then the AV node conducts the signal to the rapid conduction fibers that line the inside of the ventricles. The stimulus to depolarize then spreads from the inside to the outside of both ventricular walls simultaneously. Cells in the atria tend to depolarize at the rate of around 60 to 100 times per minute. The cells in the AV node tend to depolarize at a rate of about 60 times a minute. The cells in the ventricle tend to depolarize at a rate of about 30 times a minute.

Thus, the atria contract, first, then, following a delay, the ventricles contract. There will then be a pause before the next heartbeat or "cardiac cycle." All of the heart muscle cells become depolarized and contract in an orderly, timely fashion. Before any heart muscle cells outside of the SA node have time to depolarize and contract at their characteristic rate, another signal from the SA node will come along and cause depolarization again. Thus, the SA node is the normal pacemaker of the heart. If the SA node fails, or if signals are blocked in a diseased AV node, the ventricles will sometimes be able to effectively beat because some ventricular cells spontaneously depolarize and act as a pacemaker for the ventricles. The rate is often slow (around 30 beats-per-minute), but that "escape rhythm" will often be sufficient to sustain life until something can be done to help the patient.

The electrocardiogram

The electrocardiogram is a signal that one can obtain by connecting electrodes to a person's chest, arms, and legs. Figure 5 shows a typical electrocardiogram. The signal is about 1 millivolt in amplitude, so low-noise differential amplifiers are usually used to obtain that signal. The chart recorder paper moves at 25 millimeters-per-second. The signal can also be displayed on an oscilloscope screen.

Several key points in a cardiac cycle are shown in Fig. 5. The P wave occurs due to atrial depolarization. The QRS complexes arise as a result of ventricular depolarization. The T wave comes as a result of ventricular relaxation (repolarization). The wave associated with atrial repolarization is usually hidden by the QRS complex.

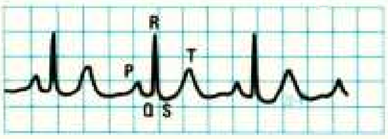


FIG. 5—A NORMAL ELECTROCARDIOGRAM tracing. The P waves cause by the atria are followed by the QRS complexes from the ventricles, which are followed by the T wave.

Electrical problems in the heart

What problems might occur with this system? Just about anything you could imagine, and more! Some of those problems will be discussed in this series of articles.

With myocardial infarction, one of the arteries that supply blood throughout the thickness of the heart muscle becomes blocked. That blockage causes a lack of oxygen and nutrients to a portion of the heart muscle. The injured cells may not conduct electrical signals (may not depolarize) as they should. At other times the injured cells become irritable and depolarize more frequently than they should.

Thus, a signal to depolarize may be blocked by an injured or dead cell. Or, extra depolarizations from an injured cell may cause inappropriate contractions. In that case the result may be further harmful signals that propagate throughout the heart muscle.

Similar problems can occur with any condition that interferes with oxygen or blood supply to the heart. Thus the heart will often develop unusual rhythms (dysrhythmias or arrhythmias) or stop when there is lack of oxygen. Lack of oxygen may occur due to inadequate breathing, drugs, head injury, chest injury, drowning, or lung trouble. Arrhythmias can also occur as a result of blood loss or dehydration (depletion of body water). The heart's electrical function is also predictably affected by inbalance of salts and other substances in the blood such as calcium and potassium and certain drugs.

Electronic monitoring

The electrocardiogram is the first means of electronically monitoring the patient with a myocardial infarction or other heart problem. The electrocardiogram does not tell the whole story, however. Sometimes the electrocardiogram will look normal but the person will be having significant problems. Other measurements of heart (cardiac) function must be made. Electronic instrumentation plays an extremely important role in many of those measurements and will be discussed in future articles in this series.

In order to obtain vital information about cardiac function in an acutely ill patient, the blood pressure is often measured in the arteries, the veins near the heart, and in the pulmonary artery. Electronic pressure transducers are used to measure pressures in those locations. Sometimes the transducer itself is put in the area of interest. More often, however, a plastic tube filled with fluid goes from the transducer to the area of interest. The tubing transmits the pressure to the transducer.

The actual function of the heart can be determined by measuring the cardiac output, the blood flow coming from the heart as measured in liters-per-minute. Future articles in this series will discuss those measurements in detail.

What happens in cardiac arrest

In cardiac arrest, the heart stops pumping blood. In the first type of cardiac arrest, the electrocardiogram may show a flat line representing no electrical activity (see Fig. 6-a). In the second type of cardiac arrest, the electrocardiogram may show ventricular fibrillation (see Fig 6-c) or ventricular tachycardia (see Fig. 6-d). Those tracings show that an electrical signal is present in the ventricles. However, the three dimensional sequence of depolarization and muscle contraction in ventricular fibrillation is irregular, nonrepeating, and chaotic. Because there is no coordinated contraction of the ventricle, blood is not pumped into the lungs or body. Instead, the heart simply quivers or vibrates irregularly.

In ventricular tachycardia (tachycardia means fast heart) the same situation often holds. However, if the patient is lucky, ventricular tachycardia may produce a sequence of contractions that are effective in pumping blood. Such a patient would have ventricular tachycardia, but would not be in cardiac arrest.

In the third type of cardiac arrest, termed "electromechanical dissociation," the electrocardiogram looks normal. Yet, no blood is being pumped. How can that be? There are several ways. A large coronary artery occlusion (heart attack) may cause such a large part of the heart muscle to lack oxygen so that effective pumping does not occur. The electrical signals go through most of the heart normally, but pumping is undetectable. Another type of electromechanical dissociation occurs if blood is prevented from entering the heart. The heart puts out a normal electrocardiogram and goes through the motions of pumping, but no blood flows. That may occur when there is massive bleeding, when major blood vessels are plugged up (as with blood clots), or when the heart is compressed by outside mechnical forces.

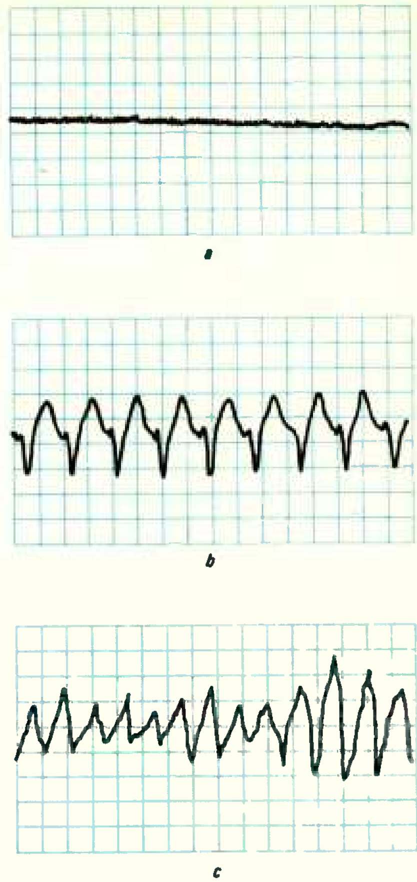


FIG. 6—THREE ELECTROCARDIOGRAM TRACINGS. The one in *a* shows only electrical noise; either a connection is loose or the patient's heart has stopped. The tracing in *b* shows ventricular tachycardia. The tracing in *c* shows ventricular fibrillation.

A fourth general category of cardiac insufficiency may be defined. In that fourth category would be included various ineffective cardiac situations. For example, the heart may beat too slowly or the heart may beat too weakly.

The causes of cardiac arrest

Cardiac arrest in children most often occurs due to obstruction of breathing. A child may have his or her airway obstructed, as by an ingested toy. Without oxygen, the heart muscle cannot function and eventually will die. Adults similarly sometimes choke on food and have a later cardiac arrest because the heart muscle

A GLOSSARY OF TERMS

Aorta—The largest artery in the body. That artery branches off into smaller arteries and finally into small capillaries. It is at the capillary level that nutrients and oxygen are passed on to the individual cells.

Arrhythmias (or dysrhythmias)—An unusual heart rhythm.

Atrium—A chamber of the heart that receives blood from the veins. The right atrium receives blood from the body; the left atrium receives oxygenated blood from the lungs.

AV Node—The conduction path between the artia and the ventricles.

Cardiac Arrest—The stopping of the heart.

Cardiac Cycle—The series of contractions that form the heartbeat.

Coronary Arteries—The arteries that supply blood to the thick walls of the heart.

Conorary Artery Occlusion—The blockage of a conorary artery; that condition usually leads to the death of a part of the heart muscle and a heart attack.

ECG (or EKG)—Electrocardiogram. When large numbers of heart cells discharge, a voltage that can be detected by electrodes place on the body is generated. The record of that voltage is called an electrocardiogram. (An ECG is shown in Fig. 6.)

Electromechanical Dissociation—A condition where the electrocardiogram looks normal but no blood is being pumped.

Myocardial Infarction—The death of part of the heart muscle; otherwise known as a heart attack.

SA Node—*S*ino*A*rterial node; the group of cells responsible for beginning the cardiac cycle. The natural pacemaker of the heart.

Ventricle—One of the chambers of the heart. The ventricles force blood ino the arteries. The right ventricle sends blood to the lungs while the left ventricle sends blood into the body via the aorta. (See Fig. 1 and 2.)

Ventricular Fibrillation—Irregular, nonrepeating, and chaotic contraction of the ventricular muscle. (See electrocardiogram in Fig. 6-c.)

Ventricular Tachycardia—A very rapid heartbeat. (See electrocardiogram in Fig. 6-b.)

dies due to the lack of oxygen. Other causes of cardiac arrest include chest trauma, drugs, salt and fluid balance problems, and bleeding.

The most common cause of cardiac arrest, however, is acute coronary artery occlusion. In that situation, an artery supplying blood to part of the heart muscle is blocked. The blockage may be caused by a blood clot or by a muscular spasm of the wall of a coronary artery. Cardiac arrest may result because a large area of muscle was made incapable of pumping. Alternatively, cardiac arrest may follow coronary artery occlusion because the electrical signals telling the ventricles to pump were blocked (and the ventricles did not have an effective escape rhythm). More often than not cardiac arrest follows coronary artery occlusion because an area of ventricular muscle puts out extra signals and causes ventricular fibrillation.

How cardiac arrest is treated

Quite often, a small area of heart muscle dies and causes ventricular fibrillation because of electrical impulses generated by the dying heart muscle. In those cases, ventricular fibrillation comes early during the myocardial infarction. In fact, over half the people who die of myocardial infarctions do so before they reach a hospital. That is often within the first two hours of the myocardial infarction. If the ventricular fibrillation could be stopped, many of those people could be saved because frequently only a small percentage of the heart muscle has lost its blood supply. Those patients are said to have "hearts that are too good to die." When they die it is because the electrical activity of the heart is disorganized.

Ventricular fibrillation is commonly the rhythm found in a person who has had a cardiac arrest following a coronary artery occlusion (heart attack). In ventricular fibrillation electrical signals are going every which way through both ventricles. Because of that, the heart muscle is quivering, not contracting in an organized manner.

Ventricular fibrillation can be stopped by applying a large electrical shock to the chest. The shock is created by an instrument called a defibrillator, which causes a current to flow through the heart. The voltage applied comes from a capacitor that is charged to several thousand volts. An inductor limits the peak current. The shock lasts 4 to 12 milliseconds.

That shock causes depolarization of all the muscle cells of the heart. The chaotic pattern of depolarizations is stopped because all the cells are depolarized simultaneously. The first cells to recover are those that naturally depolarize the fastest—the SA-node pacemaker cells. Thus, in ventricular fibrillation, a normal heartbeat can often be restored by means of electrical shock.

Drugs can suppress unwanted spontaneous depolarizations occuring in dying or irritable areas of heart muscle. Suppressing those depolarizations with drugs will tend to prevent the reoccurrence of ventricular fibrillation.

In cardiac arrest caused by absence or blockage of the normal pacemaker signal from the SA node, an artificial electronic pacemaker can be connected to the heart muscle by means of wires. Small electrical shocks carried from the pacemaker to the heart muscle will then initiate waves of depolarization. That electrical activity caused by the pacemaker will cause the ventricles to contract.

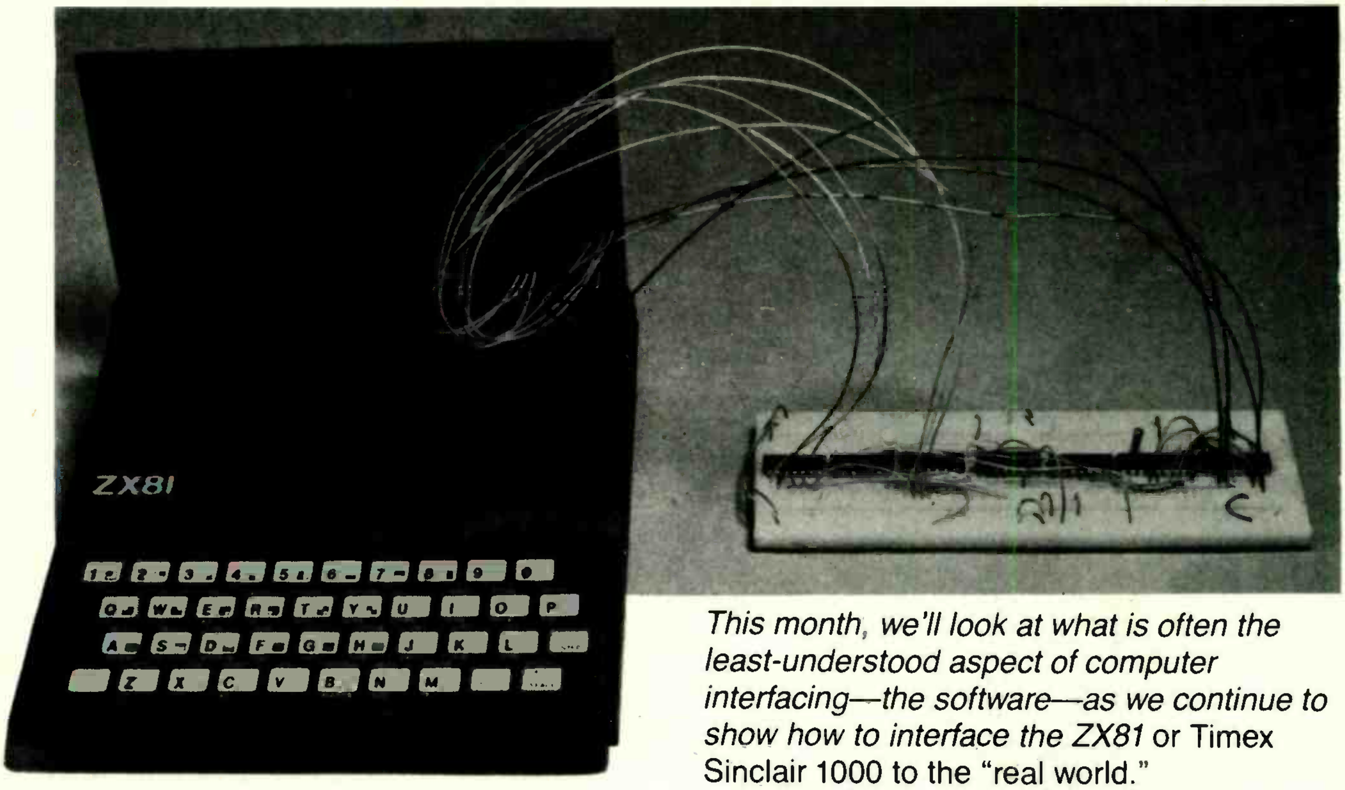
So, in our simplified discussion of the cardiac arrest situation, rhythm problems can be treated with shocks, drugs, and pacemakers. Assuming there are no other major problems such as blood clots or bleeding, will restoration of the normal cardiac rhythm save the patient? Not usually. In addition to the original cause of the cardiac arrest, there are other problems that come up when a person has a cardiac arrest.

When a person's heart stops beating a number of things happen. Actually a person may remain awake and continue to talk for about 10 seconds after his or her heart stops. Relatively ineffective breathing may continue for about 30 seconds. No permanent damage occurs until about 4 minutes after the heart has stopped. At that time permanent braindamage begins (though that time is less if the person was not functioning fairly normally before the cardiac arrest). Future developments in medicine may extend that 4-minute period.

Does that mean that if one cannot restore normal heart function and breathing within 4 minutes, the person will suffer brain damage? Fortunately not. There are ways to replace the functions of the heart and chest muscles with external forces applied to the body. Specifically, one can press on the chest about once a second to replace the heartbeat and breathe into the person's mouth to cause breathing to occur. Millions of Americans have learned the technique that was outlined above, which is called CPR, or *C*ardio*P*ulmonary *R*esuscitation."

While CPR is being done, additional procedures are prepared and performed. Those procedures include giving oxygen, intravenous fluids, drugs, electrical shocks, and pacemakers. Those additional procedures are termed ACLS, or *A*dvanced *C*ardiac *L*ife *S*upport. The procedures used in CPR and ACLS have been widely taught in programs organized by the American Heart Association.

We've already covered a bit of ground, though not in too much detail. That detail will be supplied in future articles in this series. **R-E**



This month, we'll look at what is often the least-understood aspect of computer interfacing—the software—as we continue to show how to interface the ZX81 or Timex Sinclair 1000 to the "real world."

Interfacing the ZX81

NEIL BUNGARD

Part 2 LAST MONTH, IN THE first part of this article, we took a look at hardware that allows us to connect external devices to the Sinclair *ZX81* (or Timex-Sinclair *1000*). We also looked at some basic principles of computer interfacing and described some of the *ZX81*'s interfacing idiosyncrasies.

We used the interface circuit to connect a clock/calendar IC (OKI's MSM5382) to the *ZX81*. But we couldn't do anything with the resulting circuit—we never discussed the software that is required to operate the it. This month, we'll start with a review of some general software principles and take a look at machine-language programming.

Machine language vs. BASIC

Why do we have to discuss machine-language programming? You might wonder why you can't use BASIC—a language that you're so familiar with and that is so easy to use—to control the interface. (If you're not familiar with BASIC and need more information, your *ZX81* user's manual has a good explanation of most instructions, and many examples of how to use them.) Actually, you *will* use BASIC to control the interface. But, because the Sinclair BASIC has no IN or OUT commands, you have to use machine language as well.

When you program in machine language, you are programming in the language that the Z80 microprocessor understands. BASIC simplifies programming by allowing many machine-language instructions to be represented by a single command. (When you program in BASIC, the *ZX81* must break each command into machine-language instructions before can execute it.) In addition, BASIC was written to be more understandable and easier to learn by the inexperienced programmer. Its word structure is similar to the English language, and the command-words more explicitly describe the operation that the command represents.

If you program in BASIC, you do not have to be familiar with the architecture of the microprocessor (CPU). However, when programming in machine-language the architecture of the CPU becomes increasingly more important: You must be more aware of how the microcomputer system is configured. That's because you become responsible for all of the "housekeeping" that BASIC takes care of automatically. If you don't completely understand that, don't worry—it will become clear as we study the machine-language mode of programming.

As mentioned earlier, the reason we must program in machine language is because no provisions were made in Sinclair's BASIC that allow us to output data to (or input data from) any external devices. There's another reason: Machine language executes many times faster than BASIC. That speed advantage, as you'll soon see, is a necessity in many interface applications.

Machine language and the *ZX81*

To begin programming in machine language, we must first consider the *ZX81* memory configuration. The *ZX81* system-control software, and a number of stacks and registers occupy the first 16,512 memory locations of the computer's memory space. (Actually, it only occupies the first 8K, but "repeats itself" in the next 8K.) That means that when you enter a program into the *ZX81* it begins storing your program at memory location 16513. For *ZX81* owners with 1K of memory, your user memory extends to 17408, giving you only 895 memory locations into which you can store program instructions.

When you program in BASIC, the *ZX81* takes care of storing the instructions for you, and only bothers you with memory information (error-message 4) if you run out of space. But when programming in machine language, *you* are responsible for reserving memory locations for your program. Each instruction must be placed into a specific memory location within the reserved space.

Reserving space for machine code

One way to reserve space for the machine-language instructions or machine code is to set up a REM (*REM*ark) statement. The REM statement takes the following form:

1 REM 0123456789

Anything after the REM is not acted on by the computer—it is treated simply as a remark. However, the remark *does* occupy space in memory. For example, for the statement just listed, ten memory locations are occupied by the numbers from 0 to 9. Those ten locations are a good place to put the machine code. (Of course, the numbers 0 to 9 are not the machine code—they simply act as place holders until you enter the code.)

The reason we want to reserve the space in line number 1 is because we know the address where the first line of the program starts: The first character after the REM occupies location 16514. So the 0 in the REM statement is at location 16514, and the number 9 resides in memory location 16523. If your machine-code subroutine is longer than 10 bytes and you need more space, you can simply place more characters in the REM statement. If you want to know the ending address of your reserved space just add the number of characters after the REM statement to 16513. Once you have reserved sufficient space for the machine code you must then place the desired machine code into the reserved space.

We should point out that there are alternate ways to store machine code in the *ZX81*. One of the most convenient we've seen is to store it in RAM that occupies the addresses from 8K–16K. (That area is transparent to the *ZX81*'s operating system and is not affected by NEW or LOAD commands.) A circuit that allows you to do that was described in the July and August 1983 issues of **Radio-Electronics**.

Binary, decimal, and hexadecimal

If you're going to do any machine-language programming, you're going to have to get used to working in different number bases. The *ZX81* understands numbers only if you enter them in decimal (base 10) form. In other words, when you POKE anything into the *ZX81*'s memory, the address and data must be decimal numbers.

If you've never done any machine-language programming, you might think that using decimal numbers is convenient. It isn't. Usually, machine code is listed in hexadecimal (base 16) form. That's because it lets us represent one byte using just two symbols.

However, because everyone does not follow the same conventions, it is necessary to be able to convert from one number base to another. We will want to be able to convert to and from binary, decimal, and hexadecimal.

In this article, binary numbers will be listed with a capital "B" following the number while hexadecimal numbers will be followed by a capital "H." Decimal numbers will be written without any indication.

Before we can explain how to convert from one base to another, lets look at our decimal (base 10) system to see how it works. We all remember learning about the "ones' place," the "tens' place," the "hundreds' place," and so on. Each place is worth ten times the place to its right—as you move to the left, the value of each place increases by a factor of ten.

It's essentially the same when you work in other number bases—just the numbers change. For example, in the binary system, the value of each place increases by a factor of 2 as you move to the left. In the hexadecimal system, the value of each place increases by a factor of 16 as you move to the left. A look at Fig. 5 should clear up any questions you have—except, perhaps, one. Since the value of the "ones place" in hexadecimal doesn't change until after it reaches 15, you might wonder how you represent the numbers from 10–15 in hex while still using only one digit. It's rather simple: The numbers 10–15 are represented by the letters A–F. Here's a problem to see if you're following what we're talking about: What is D3H in decimal form? D3H = (D × 16) + (3 × 1) = (13 × 16) + (3) = 208 + 3 = 211.

If you want to convert a hexadecimal formatted instruction to a decimal form, you have a few choices. First, you can follow Fig. 5 and the example above and multiply each number by its place value. But if you don't like multiplying things by 16, there's another way: Convert the hexadecimal form to binary and then convert the binary to decimal. It's very easy to convert hex to binary—it's a special case where you can simply take each number (or place) in hex and replace it with the corresponding number in binary. (See Table 4). For example, D = 1101B and 3 = 0011B. Therefore, D3H = 11010011B.

TABLE 4

Binary	Hexadecimal
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

You can convert the binary number to decimal by multiplying each digit by its place value. For example, the decimal value for 11010011B is (1 × 1) + (1 × 2) + (1 × 16) + (1 × 64) + (1 × 128) = 211.

Which of the two methods is easier? It all depends on your point of view. However, we're sure that you'll agree that the following is the easiest method of all: Use the table shown in Fig. 6. You can use it to convert from hex to decimal and from decimal to hex. Unfortunately, it works only for numbers between 0 and 255.

Whatever method you choose, we would advise you to become comfortable with base conversions—when you do a lot of machine-code programming, you'll do a lot of base conversions.

Entering machine code

We are now ready to begin storing machine-language instructions into the memory space you have previously reserved with the REM statement. How do you replace the contents of the REM statement with the machine code? You use BASIC! Specifically, the POKE instruction, which takes the form:

POKE *address, data*

where the *address* is the memory location

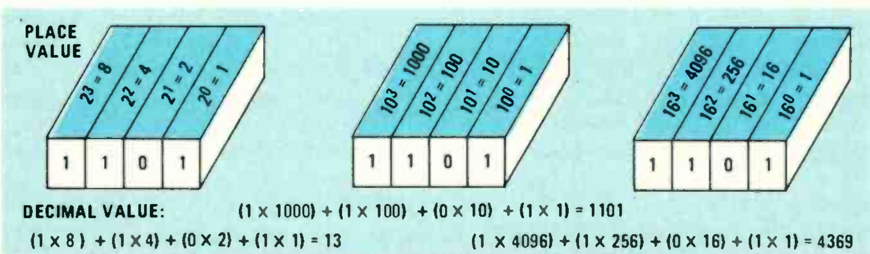


FIG. 5—CONVERTING FROM ONE BASE TO ANOTHER does not have to be difficult or confusing. Just remember that all number bases operate the same as the decimal system you're used to.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
2	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	2
3	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	3
4	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	4
5	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	5
6	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	6
7	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	7
8	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	8
9	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	9
A	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	A
B	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	B
C	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	C
D	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	D
E	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	E
F	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	F
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

FIG. 6—THE EASY WAY TO CONVERT FROM HEX TO DECIMAL. All decimal values from 0–255 can be represented by a two-digit hex number.

where the instruction is to be placed and the *data* is the machine-language instruction. In order for the *ZX81* to understand the POKE command, both the address and the instruction must (unfortunately) be in decimal form. If you want to place an instruction into a single memory location, a POKE instruction is probably the easiest way to do it. But in a situation where you want to store many instructions (the usual case), POKE-ing each value can be a tiresome (and error-prone) process.

One way to get around some of the tedium is to write a small *loader* program that sets the starting address of the machine code, POKEs the first instruction, and advances to the next memory storage location automatically. While we're at it, we'll include a couple of lines in the program to convert hex to decimal so that we can enter instructions in a hexadecimal format.

For the following programs, we'll assume that your *ZX81* has only 1K of memory, which is standard with the *ZX81*. (The Timex-Sinclair *1000* came equipped with 2K.) Unfortunately, all the programs we'll need to operate the clock/calendar interface cannot be stored in 1K of memory at the same time. Therefore, we'll have to write individual programs to perform specific tasks and then erase the programs when we have finished to make room for the next program needed. As you can see, cassette-tape storage is almost essential: Once the programs are written, they can be stored on tape and loaded into the *ZX81* via the tape player as they are needed. (Of course, if you have more memory than the standard 1K, you'll be able to write and save all of the programs in one shot. What? You can't plug in your RAM-pack when you have the interface board connected? We'll show you how to get around that problem next month.

Clear the *ZX81* with the NEW command and enter the program shown in Table 5. If you have a cassette recorder, SAVE the program.

The first line of the program reserves 17 memory addresses for storing a machine-language program. Line 10 sets the variable "X" to the value of the first address of the machine code storage area (16514) which is now occupied by the first number "1" in the REM statement. Line 40 converts your hexadecimal input to decimal and pokes it into memory.

The program takes your first input and POKEs it into location 16514. Your following inputs are POKEd into successive memory addresses until an ""S" is entered. When the machine-language program has been completely entered, input an S, and the program will end. Now you're ready to give the program a try. RUN it, and enter the machine code shown in Table 6.

Loading the registers

The left column is the machine code that is to be entered. The order of entering the code is: Ø6, 4Ø, ØE, 91, ØA, etc. (When prompted, enter one number—two digits—at a time, followed by hitting the ENTER key. Don't, of course, enter the commas.) The right-hand column contains the mnemonics that represents the Z80 machine-language instructions. Unfortunately, we cannot go into a detailed description of the mnemonics at this time. (A full explanation of the Z80 instruction set is contained in the *Z80 Software Manual* from Zilog Corporation, and in a number of Z80-programming books on the market.)

TABLE 5—MACHINE-CODE ENTRY

```
 1 REM 12345678901234567
1Ø LET X=16514
15 PRINT "INPUT DATA"
2Ø INPUT A$
3Ø IF A$="S" THEN STOP
4Ø POKE X,16*CODE A$+CODE
   A$(2)-476
5Ø LET X=X+1
6Ø GOTO 3Ø
```

TABLE 6—REGISTER LOADING

Ø6 4Ø	LD B, 4Ø
ØE 91	LD C, 91
ØA	LD A, (BC)
D3 ØØ	OUT ØØ , A
ØE 92	LD C, 92
ØA	LD A, (BC)
D3 Ø8	OUT Ø8 , A
D3 Ø4	OUT Ø4 , A
C9	RET

After all of the machine code has been entered, enter an "S." Look at a LISTing of the BASIC program. In the REM statement, you'll notice that the first 15 numbers have been replaced with strange looking characters. Those characters represent the machine-language program that has just been entered. The reason that you do not see the machine code as it was entered is because the *ZX81* stores its "character set representation" of the hexadecimal numbers that were entered, and not the numbers themselves. A complete listing of the *ZX81* character set and the associated codes can be found in "Appendix A" of the *ZX81* User's Manual.

Now that you have the machine-language program in memory, you will no longer need the machine-code-entry program. Erase everything but the REM statement that contains the machine code (line 1) and enter the BASIC program in Table 7.

TABLE 7—REGISTER LOADING

```
1Ø FOR I=Ø TO 12
2Ø PRINT I
25 PRINT "INPUT VALUE FOR REGIS-
   TER";I
3Ø INPUT A
4Ø POKE 16529,I
5Ø POKE 1653Ø,A
6Ø LET C=USR 16514
7Ø NEXT I
8Ø PRINT "END OF LOAD"
9Ø STOP
```

That BASIC program, along with the machine-language program previously entered, work together to load the MSM5832 clock/calendar IC with its initial settings. The BASIC program asks for an input of the value to be stored in each of the 12 registers of the MSM5832. (Table 8 defines the registers and their allowable data ranges.) The BASIC program then calls the machine-language routine (line 60) which does the actual loading of the values.

Let us follow the operation of these programs line-by-line as they load a register in the MSM5832: Line 10 sets the first register to be loaded to register 0 (seconds register). Line 20 will print the register number and line prompt you to enter the value you want stored there.

After you enter a value, the *ZX81* stores the register code in memory location 16529 (4091H) and stores the register val-

TABLE 8—MSM5832 REGISTERS

Register	Contents	DATA I/O D3	D2	D1	Ø	Allowable output range (decimal)
Ø	SECONDS	×	×	×	×	Ø–9
1	TENS OF SECONDS	—	×	×	×	Ø–5
2	MINUTES	×	×	×	×	Ø–9
3	TENS OF MINUTES	—	×	×	×	Ø–5
4	HOURS	×	×	×	×	Ø–9
5	TENS OF HOURS	*	**	×	×	Ø–1/Ø–2†
6	DAY OF WEEK	—	×	×	×	Ø–6
7	DAYS	×	×	×	×	Ø–9
8	TENS OF DAYS	—	††	×	×	Ø–3
9	MONTHS	×	×	×	×	Ø–9
1Ø	TENS OF MONTHS	—	—	—	×	Ø–1
11	YEARS	×	×	×	×	Ø–9
12	TENS OF YEARS	×	×	×	×	Ø–9

Notes:
× Indicates that data can be either I or Ø
* D3 = 1 for 24-hour format. D3 = Ø for 12-hour format
** D2 = 1 for PM. D2 = Ø for AM
† Depends on D3
†† D2 = 1 for 29 days in Feb. D2 = Ø for 28 days in Feb.

TABLE 10—REGISTER RETRIEVAL

```
Ø6 4Ø       LD B,4Ø
ØE 99       LD C,99
ØA          LD A,(BC)
D3 ØØ       OUT ØØ,A
3A 9A 4Ø    LD A,(4Ø9A)
47          LD B,A
3A 9B 4Ø    LD A,(409B)
4F          LD C,A
DB ØØ       IN A, ØØ
E6 ØF       AND ØF
Ø2          LD (BC), A
D3 Ø4       OUT Ø4, A
C9          RET
```

TABLE 11—REGISTER RETRIEVAL

```
8ØØ LET C=Ø
81Ø LET D=156
82Ø FOR I=Ø TO 12
83Ø POKE 16537,C
84Ø POKE 16538,64
85Ø POKE 16539,D
86Ø LET A=USR 16514
87Ø LET C=C+1
88Ø LET D=D+1
89Ø NEXT I
9ØØ STOP
```

ue in location 16530 (4092H). Line 60 calls the machine-language subroutine.

The first thing the subroutine does is take the register code out of memory location 16529 (4091H) and send it to the MSM5832 via OUT device-code pulse 00H. (Recall from Part 1 of this series that that device code selects the MSM5832 for inputting and stores the register code in the 74LS75.) The machine-language routine then retrieves the value to be placed into the selected register from memory location 16530 (4092H). The *ZX81* then sends the register value to the MSM5832 via the OUT device-code 08H. An OUT device-code 04H is then generated to deselect the MSM5832 so that it can resume normal timing operation. Program execution returns to the BASIC program and the remaining function registers are filled. When the last register is set, the *ZX81* prints "end of load" and the program execution stops.

Table 9 is an example of the values that must be loaded to initially set the MSM5832 to: Sunday, April 18, 1983, 1:25:00 PM. At completion of the above program, the MSM5832 clock/calendar IC will be loaded with initial values for time (*hours, minutes, seconds), date (year, month, day), and day of the week.

TABLE 9
INITIAL REGISTER VALUES FOR SUNDAY, AUGUST 19, 1984

Register code	Register value
Ø	Ø
1	Ø
2	5
3	2
4	1
5	4
6	6
7	9
8	1
9	8
1Ø	Ø
11	4
12	8

Reading the register contents

Great—the MSM5832 knows the time and date, but we don't. A short program, however, will allow us to retrieve the time and date information from the MSM5832. To make room for the new retrieval program, clear the *ZX81* with the NEW command. That will erase both the machine-language and the BASIC programs used to load the MSM5839 with initial values. Since a new machine-language routine is to be used, the BASIC program which loads hexadecimal machine code must be re-entered. If you SAVEd the machine code entry program on cassette tape the first time you used it, it can be LOADed from tape. If not, you will have to type it again. (You can waste a lot of time that way, can't you?) After the hexadecimal machine-code entry program has been entered, you will need to reserve 39 memory locations for the machine-language program which retrieves the date and time values from the MSM5832. That is done via the REM statement:

1 REM (*40 characters*).

Type in the REM statement and load the machine-language program in Table 10, using the same method as you did earlier.

With the machine-language program in place, erase the entry program (lines 10 through 80) and enter the BASIC program in Table 11.

The BASIC program and machine-language routines work together to retrieve time and date information from the MSM5832. As the values of the 13 registers in the MSM5832 are retrieved, they are placed in memory locations 16540 through 16552. Table 6 lists the addresses and contents. (Those memory locations were reserved earlier by the REM statement with 40 characters.) Let's follow the program through one complete register retrieval.

In lines 800 and 810, the initial register code (0 for seconds) and initial register content storage location are defined. In line 830, the initial register code is stored in location 16537 (409AH). In lines 840 and 850, the address of the initial register-content storage-location is placed into memory locations 16538 and 16539. Note that the address 16540 (409CH) has to be entered in two commands. Line 840 enters 64 (40H) and line 850 enters 156 (9CH). Line 860 calls the machine-language routine.

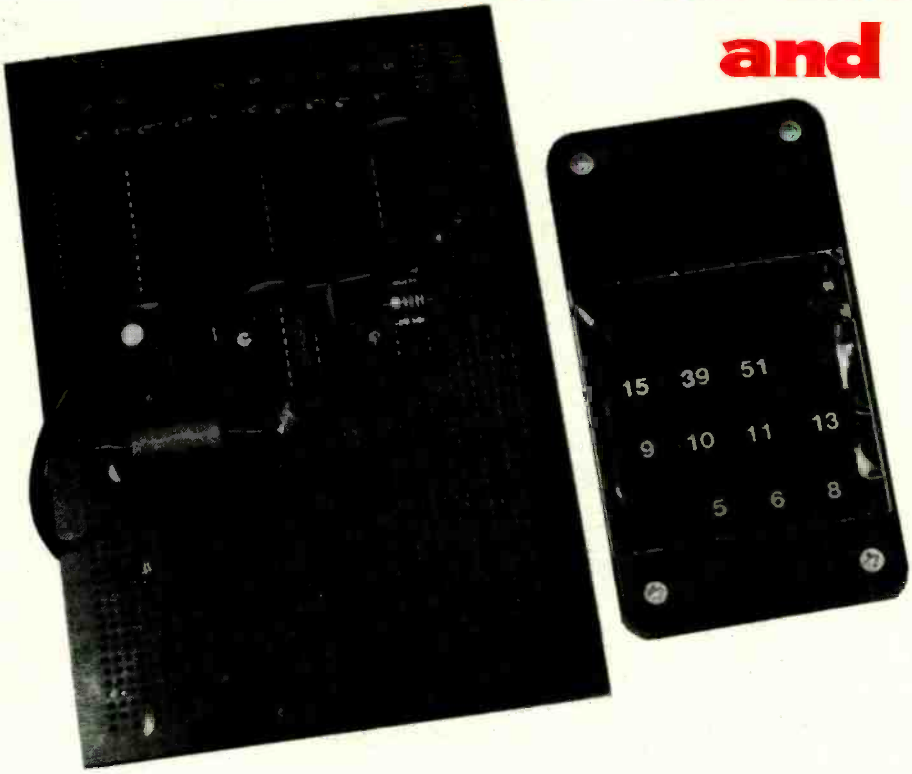
The first three instructions of the machine-language program place the contents of memory location 4099H (16537) into the Z80's accumulator. That value is the code that defines the MSM5832 register that will be accessed. (That location was previously loaded by line 830 before branching to the machine-language routine.) The OUT 00H,A instruction loads the 7475 (IC7 of the interface circuit) with the register code, and selects the MSM5832 for inputting. The next 4 instructions retrieve the address of where the MSM5832 register contents will be stored in the *ZX81*'s memory. (That was also previously defined in the BASIC program, lines 840 and 850, before branching to the machine-language program.)

The instruction IN A, 00H inputs the MSM5832 register contents. AND 0FH masks the four higher-order bits to logic zeros, and LD (BC), A stores the MSM5832 register contents in the *ZX81*'s memory.

The OUT 04H, A instruction deselects

continued on page 98

Infrared Transmitter and Receiver



STEVEN M. MARGOLIN

You can add remote-control features to just about anything with an easy-to-build infrared transmitter/receiver pair.

COMMUNICATION BY INFRARED LIGHT has found numerous applications in remotely controlling the operation of electronic equipment. If you don't beleive that, just walk into any video store today. You'll find that many TV's and VCR's use infrared transmitters and receivers to change channels, set the volume level, or control videotape speed and direction.

That technology can be made practical for the electronics hobbyist. It is easier than you think to control some device, say a computer game, from a distance—*without* running wires around the room. Perhaps the best thing is that you don't have to spend a fortune to get started. We'll show you how to build an infrared (sometimes called IR) receiver/transmitter combination that you can experiment with and put to practical use. We'll show you one particular applications example—a remote TV-channel selector (for TV's in which channels are selected by pushbuttons.) But we're sure that you'll discover practical applications for infrared communication on your own—you probably have a million going through your head right now.

When the infrared receiver and transmitter was designed, every effort was made to use as simple a circuit as possible and to use parts that are relatively easily available and inexpensive. That's because our goal is to bring infrared-communication technology within easy reach of the hobbyist. If the price is kept low, the project becomes practical for many more hobby applications. But the circuits are not limited in potential applications just because they are simple to build. As we will see, the versatility of the receiver/transmitter design is limited only by your imagination.

The receiver/transmitter circuits contain CMOS IC's and few other components. That makes battery operation very feasible. However, we should point out that you can use TTL IC's instead of their CMOS equivalents. That would makes battery operation impractical, however.

Why infrared?

You may wonder why we would want to use infrared light for a remote-control project when any number of radio-frequency (RF) designs would do the job as well. One reason is that infrared light offers distinct advantages that, for the applications to be discussed, far outweigh those of RF circuits. For example, no tunable circuits are required—the circuitry simply pulses an infrared LED on and off. In addition, infrared light does not interfere with RF reception.

The problem with radio-frequency designs is that they require accurate tuning of both receiver and transmitter circuits. Also, RF circuits can be noisy and may interfere with a neighbor's TV or radio reception. But more important, they are prohibited by the FCC's regulations regarding the use of unlicensed transmitters. Finally, RF circuits typically contain more devices not only to transmit carrier and information signals, but also to detect them and separate the transmitted data. Those characteristics not only add to the cost of the project, it means that the power requirement is greater, and battery use, if possible, will be limited.

We will admit, though, that RF does have at least one advantage over infrared light—transmission range: An RF design transmits its signal longer distances (even if the path is obstructed) than an infrared transmitter (whose beam path must be unobstructed) can. But if you think about it for a while, the range restriction is not necessarily a disadvantage: Most in-home remote-control applications are really in-room applications (such as controlling a TV). And the restriction on the unobstructed path for the infrared beam between the transmitter and receiver is not necessarily a disadvantage either: We can use another infrared transmitter/receiver pair in the room next door without any interference between units.

The infrared transmitter

Let's begin our look at the remote control system with the infrared transmitter.

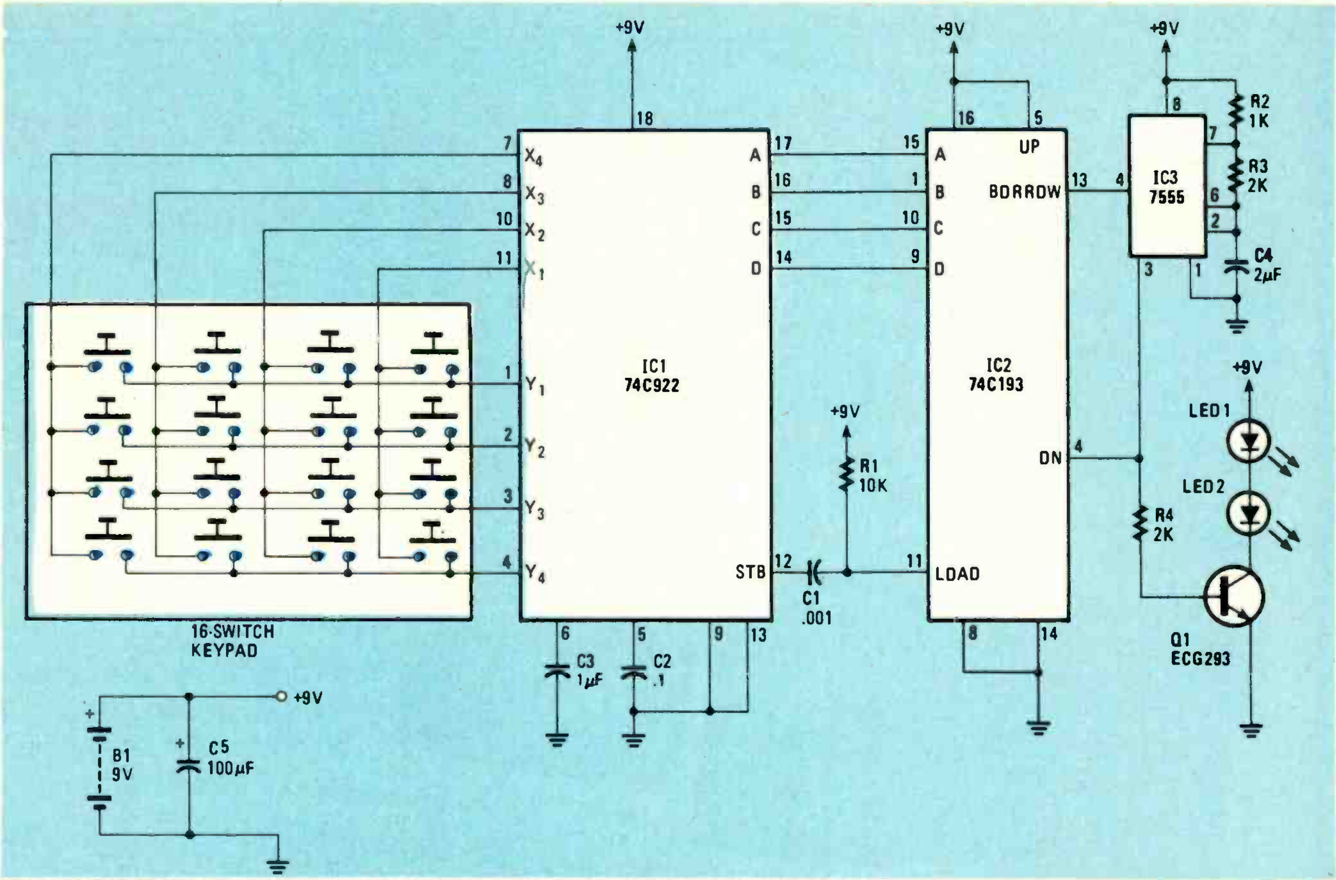


FIG. 1—INFRARED TRANSMITTER. To prolong the life of the battery, you might want to add a power switch.

Figure 1 shows its schematic. A 16-switch keypad, an X-Y matrix type, is connected to IC1, a 74C922 16-key keyboard encoder. That IC passes a 4-bit binary representation of the key number pressed to its outputs, A through D. Those outputs are applied to the DATA inputs of IC2, a 74C193 up/down counter.

Whenever a key is pressed, IC1 generates a data-available strobe signal at pin 12, which is differentiated by C1 and R1 to produce a low-going spike at pin 11, the LOAD input of IC2. When the 4-bit data is loaded into IC2, the BORROW output (pin 13) goes high to enable the clock, IC3, a 7555 timer. The clock signal is sent to the COUNT DOWN input of IC2, causing it to count down from the value that was first loaded into its registers. When the count reaches zero, the BORROW pin returns low, shutting off IC3. The pulses that clock IC2 also turn transistor Q1 on and off, which "fires" the infrared-emitting diodes, LED1 and LED2.

The LED's therefore pulse the exact number of times it takes IC2 to count down to zero—we have a circuit that generates a number of infrared pulses that corresponds to the key that was pressed. Actually, only 15 of the 16 keys, 1 through 15, generate pulses—the "0" key does not produce an output which can be pulsed.

Note that the clock speed could be varied to yield a faster pulse or transmission rate. For the component values shown, IC3 operates at about 150 Hz; however, too fast a rate diminishes the pulse current through the LED's, thus reducing the transmission range. At a rate of 150 Hz, the transmitter range is about 15 feet.

Since the transmitter uses CMOS IC's, the current requirement from a 9-volt battery is minimal—about 7 milliamps when no key is pressed. The current increases to about 60 mA when the maximum number of pulses (15) is sent.

The receiver

The receiver circuit is somewhat more complex than the transmitter because it must not only detect the transmitted pulses, but count and decode them as well. We'll start our description with a look at the basic circuit; we'll then add features to it.

Figure 2 shows the basic receiver circuit. The infrared pulses are detected by phototransistor Q2 and amplified by IC4, which is configured for very high gain. The output of IC4 is fed to a Schmitt trigger, IC5, which conditions ("squares up") the pulses to be counted by IC6, a 74C193 up/down counter. The output of IC6 (at pins 3, 2, 6, and 7) is the binary equivalent of the number of pulses received, 0001 to 1111.

The receiver circuit described thus far yields some interesting applications. For example, the binary outputs of IC6 could be tied to an input port of a computer programmed to respond in some way to the received commands. A videogame remote control could be one application. Note, however, in this circuit configuration IC6 continually adds successive pulses as they are counted. So, if "0001" is present on IC6's outputs, and the next pulse train counted consists of two pulses, IC6's outputs will become "0011," the binary equivalent of three. That can be modified by allowing the computer to clear the 74C193 after the input port data is read. Figure 3 shows a possible application of that kind. Note that a buffer with three-state outputs is used to effectively disconnect the 74C193 from the data bus when not in use.

To expand the receiver's capability even more, we could add timing circuits that would freeze the outputs of IC6 for each pulse stream it counts. The outputs would remain stable until a new value is received. The addition to the circuit, IC7, a 4098 dual one-shot, is shown in Figure 4. The new circuit operates as follows: One half of IC7 triggers on the leading edge of the first pulse sent and immediately triggers its second half, which sends a CLEAR pulse to IC6. So, before IC6 can count the first transmitted pulse, the counter is cleared and allowed to count only the remaining pulses. The result is that the number of pulses detected is one less than what is transmitted. We can use that fea-

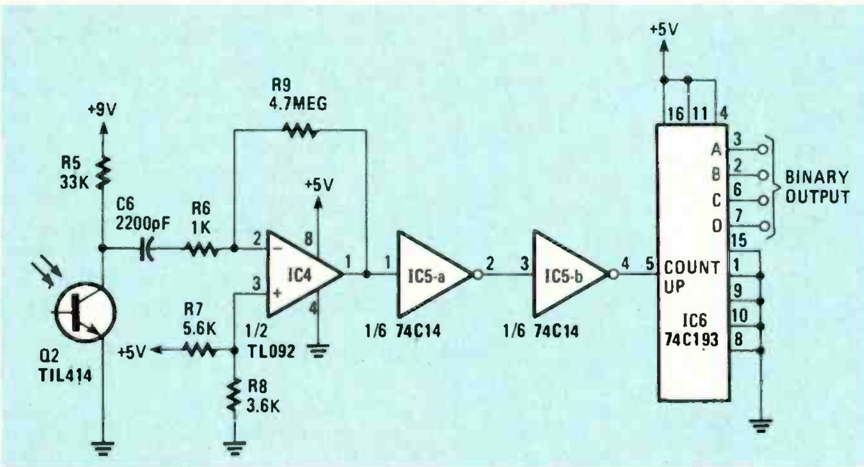


FIG. 2—THE BASIC INFRARED RECEIVER counts the pulses sent from the transmitter. The number it counts is output from IC6.

PARTS LIST

All resistors ¼-watt, 10% unless otherwise noted.

R1,R12,R14,R16—10,000 ohms
R2,R6—1000 ohms
R3,R4—2000 ohms
R5—33,000 ohms
R7,R10—5600 ohms
R8—3600 ohms
R9—4.7 megohms
R11,R13,R15—4700 ohms

Capacitors

C1—.001 µF, ceramic disc
C2—.1 µF, ceramic disc
C3—1 µF, 16 volts, electrolytic
C4—2 µF,
C5—100 µF,
C6—2200 pF, ceramic disc
C7—4.7 µF, 16 volts, electrolytic
C8—0.05 µF
C9—10 µF, 16 volts, electrolytic

Semiconductors

IC1—74C922 16-key keyboard encoder
IC2, IC6—74C193 synchronous up/down dual clock counter
IC3—7555 timer
IC4—TL092 op-amp
IC5—74C14 hex inverter
IC7—4098 dual monostable multivibrator
IC8—4047 monostable/astable multivibrator
IC9—4514 4-to-16 line decoder (or 4545—see text)
IC10—74C74 dual D-type flip-flop
Q1—ECG293
Q2—TIL414
Q3,Q4—2N4401
LED1,LED2—XC880-A infrared LED (Radio Shack 276-143 or similar)

Other components

RY1—SPDT miniature relay (Radio Shack 275-240 or similar)
RY2—DPDT relay (Radio Shack 275-215 or similar)
B1—9-volts, transistor type

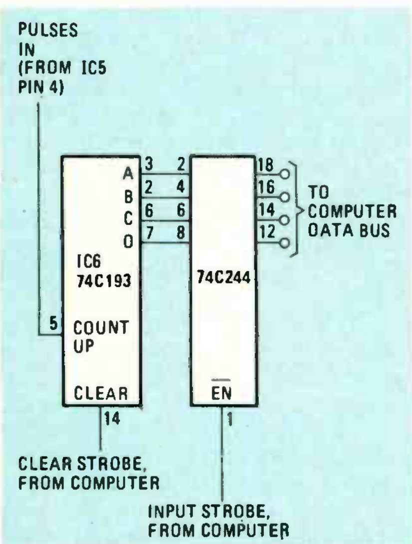


FIG. 3—AS MORE PULSES ARE COUNTED, they are merely added to the output already on IC6. You could use strobes from a computer to clear the output and enable a 3-state buffer.

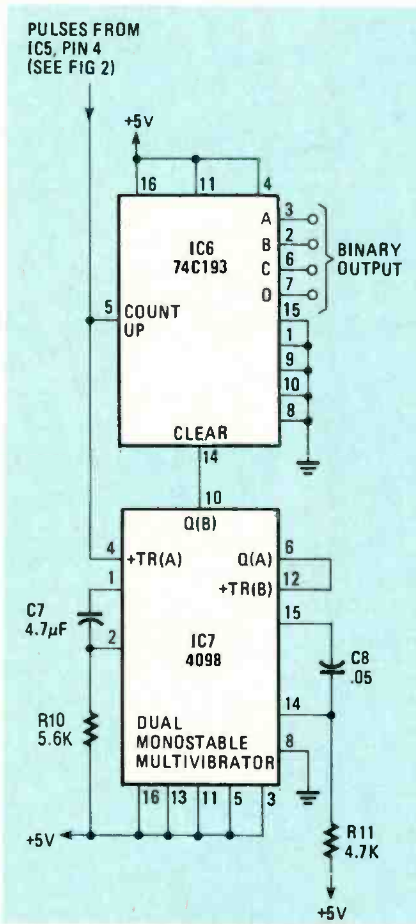


FIG. 4—A DUAL ONE-SHOT, IC7, sends a CLEAR pulse to IC6 upon receipt of an initial pulse.

ture to our advantage: By transmitting one pulse, we can clear all outputs to 0000. The pulse that is sent is effectively ignored by IC6, due to IC7's clear-before-count action. Alternately, the maximum number of pulses this circuit may count is 14, yielding a "1110" output.

Simply by adding another CMOS one-shot, IC8, shown in Fig. 5, we enable IC6 to momentarily hold its 4-bit outputs, then be reset and readied for the next value. Now, when IC7 reacts to the first pulse it received, it triggers IC8 to remove the high state on IC6's CLEAR input. That enables IC6 to count all the pulses and display the number on its outputs. But, IC5 times out after about .5 second, its $\bar{Q}$ output, pin 11, returns high and clears IC6 to zero. IC6 may now count the next pulse stream, output the value briefly, and be reset.

But what if we can't use a binary output and want the receiver's outputs in a different form? This is easily done with the circuit shown in Fig. 6. That circuit uses a one-of-sixteen decoder, IC9, to supply 15 unique output signals for a variety of control applications, such as a channel selector for a TV with push-button channel switches. By using one of the two timing circuit designs just mentioned, we allow each selected output to be held momentarily, or be frozen until a different output is selected.

The new circuit operates in the same way, except that when the first pulse is detected, IC9 is disabled by the high-going trigger pulse from pin 6 of IC7. (That's done to prevent IC9's outputs from cycling as IC6's outputs change states during counting.) After the last pulse is counted, IC7 times out and enables IC9. By that time, the inputs to IC9 are stable and are decoded to select the appropriate output. IC9 may either be a 4514 (as shown) or a 4515 CMOS IC. If an application requires active-high signals, use a 4514. If the application requires active-low signals, use a 4515.

The receiver may be powered by a 9-volt battery and regulated by a voltage regulator to +5 volts. Current drain is between 7 and 15 milliamps, depending on how many of the additional IC's are used. Of course, the receiver could be powered by the circuit in which it is used; in this case, the receiver's voltage regulator might not be necessary.

Although not shown in the schematic, it's a good idea to add bypass capacitors (about .01–.1 µF) between the positive supply pin and ground at each IC. (They

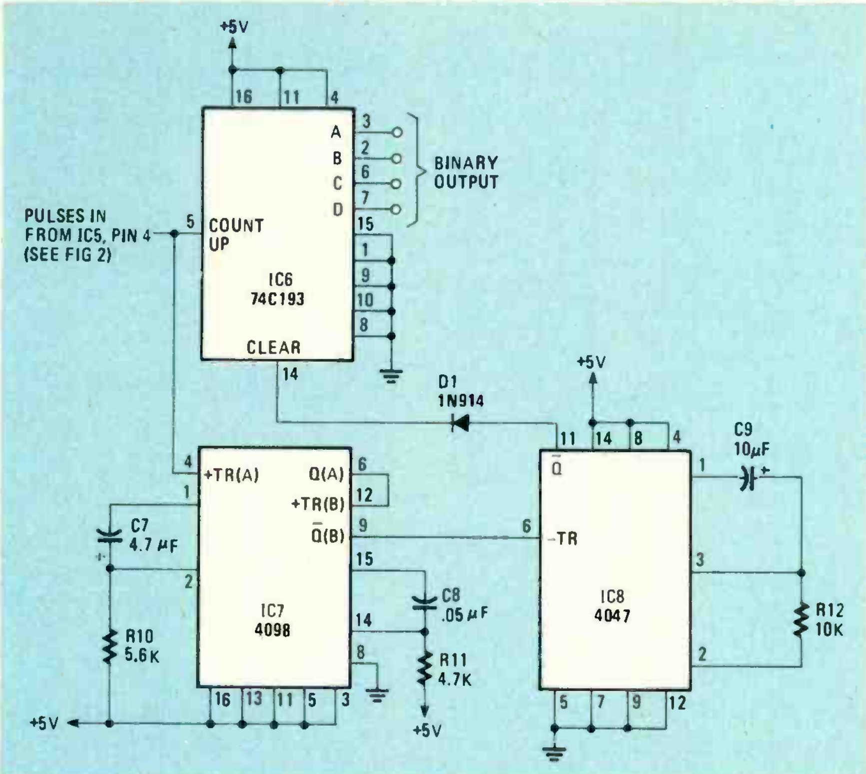


FIG. 5—THE ADDITION OF IC8 causes the output of IC6 to be automatically reset to zero after about ½ second.

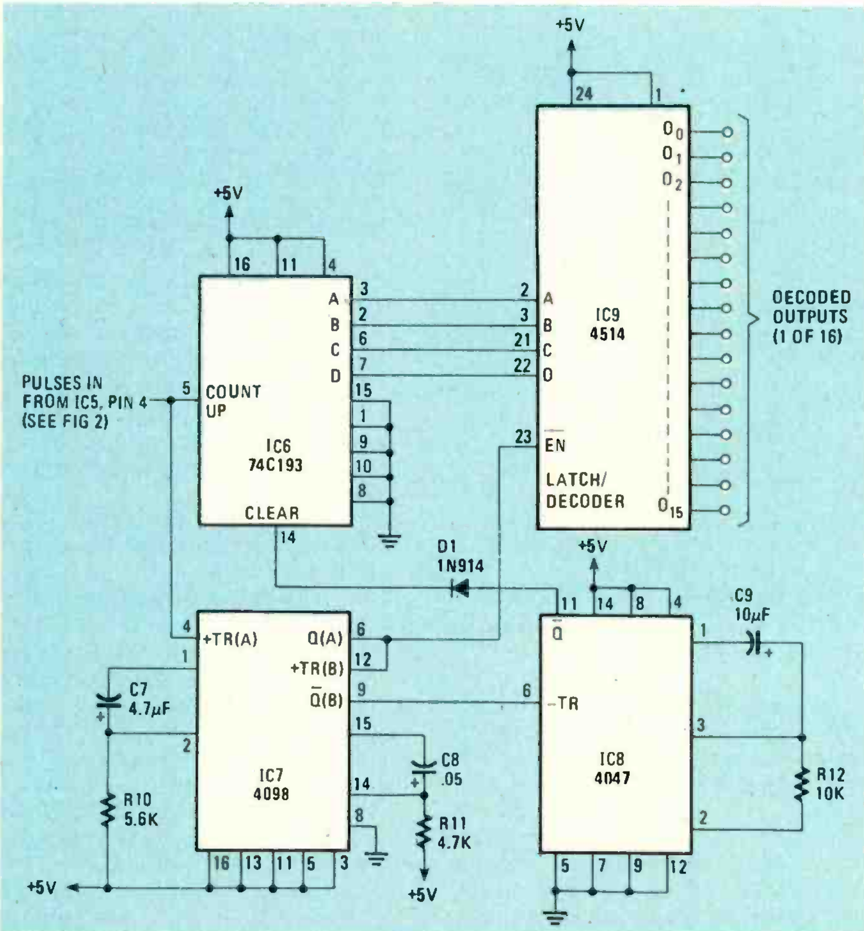


FIG. 6—THE 4-BIT OUTPUT of IC6 can be converted to a one-of-sixteen output with the addition of IC9, a 4514 latch/decoder.

should be mounted close to the IC.) Those bypass capacitors are especially important if the receiver is mounted in a "noisy" environment, such as inside a TV. Another step you should take to decrease on-board noise is to add a 100-µF capacitor between power and ground where the power cable is connected to the board. You might also find it necessary to add a .1µF bypass capacitor across the the phototransistor (where the leads are connected to the board).

Remote control TV

Using the circuitry shown in Fig. 6, we'll take a look at one particular application in more detail—a wireless TV-channel selector for a TV that uses a row of push-button channel switches. First, though, a word of caution: Adding remote control to a TV requires connecting wires to the circuitry inside a TV set. Extreme care must be taken when making connections to the switch board inside the TV. Obtain a copy of the set's schematic and be familiar with it before opening the set. Keep in mind that in making such connections, you may be voiding the manufacturer's warranty on the set. More important, remember **there are potentially dangerous voltages present in the set, even when it is unplugged from the AC line.**

The most critical design consideration in this receiver is to make the unit completely isolated from the TV's circuitry. We can use small relays to act as the channel selector switches (so that there are no electrical connections between the relay's contacts and the infrared-receiver circuitry). Do not attempt to bypass that safety function (unless other electrically isolated devices, such as opto-isolators, are used). The infrared receiver could be battery powered. But because it's likely that you don't need a portable receiver, you can use a small power supply, such as a "battery-eliminator" unit.

Figure 7-a shows one relay circuit that could be activated by one of the outputs of IC9. You may want to reserve one switch for muting the TV's sound, as is shown in Figure 7-b. For that feature, a 74C74 D-type flip-flop is added to hold the relay on for as long as the sound is to be muted. It will release the relay when the mute command is transmitted again. Note that a speaker-substitution resistor is connected to one set of relay contacts. The resistor's value must match the impedance and power rating of your set's speaker.

The original design of the receiver/transmitter was laid out on perforated construction board and hard-wired together as shown in Fig. 8—the wiring of the circuits is not very critical. Of course, you could use a printed-circuit board or another construction method. Enclose the phototransistor in a small black tube, with a diameter of about ½ inch: that reduces

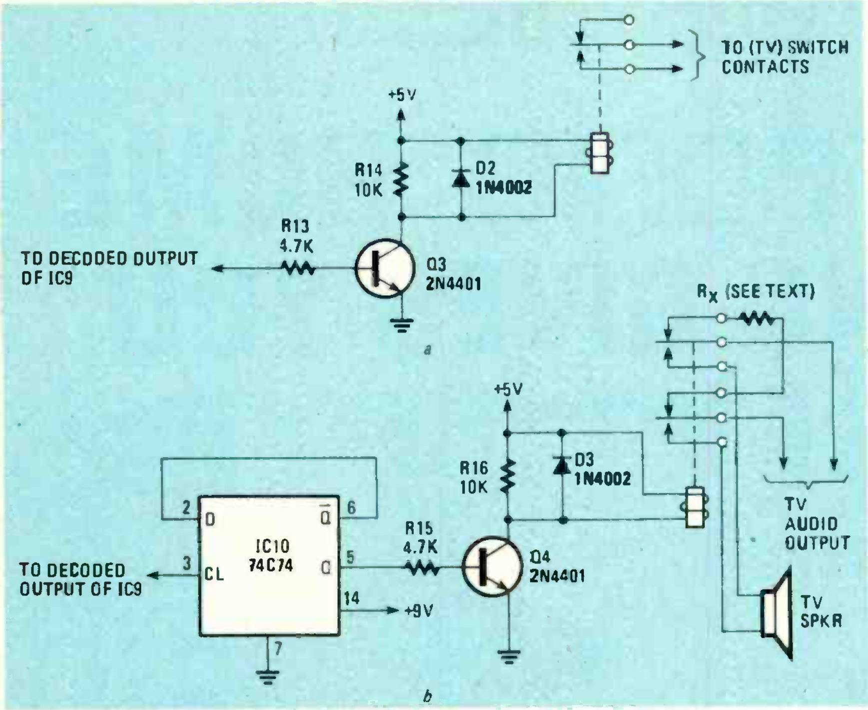


FIG. 7—THE OUTPUTS FROM IC9 can be used to turn on relays. In *a*, relay RY1 is set up to close switch contacts on a TV. In *b*, relay RY2 is set up to act as a remote muting switch.

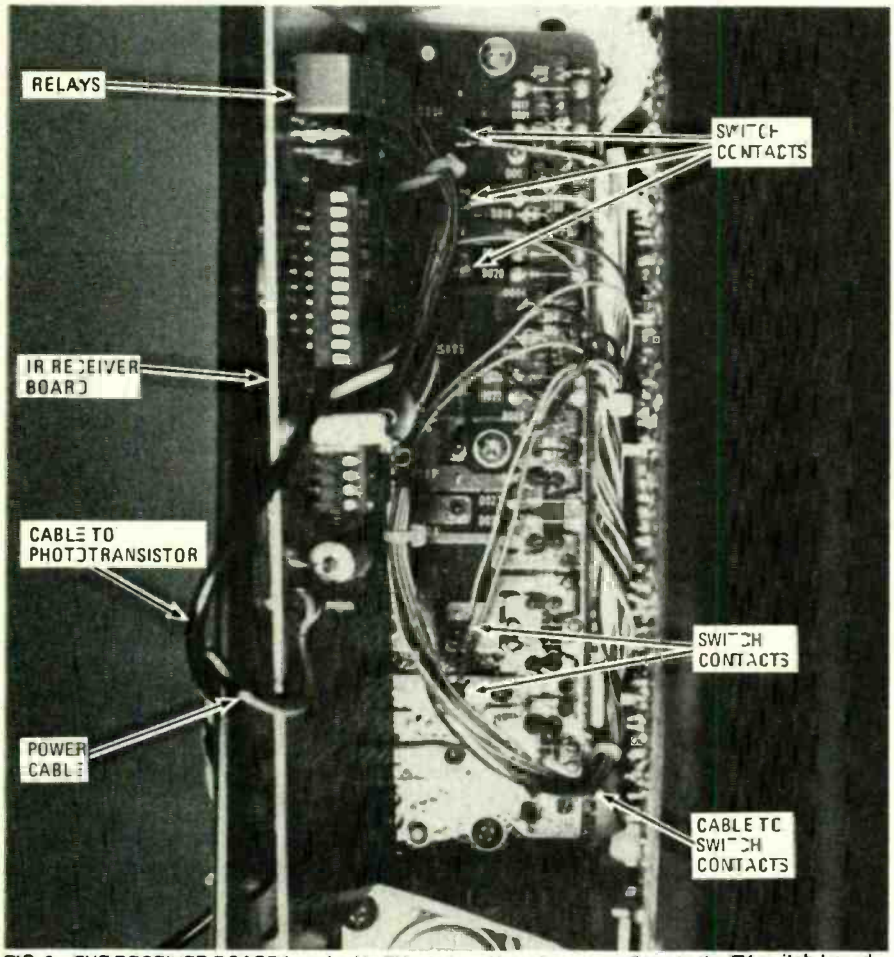


FIG. 9—THE RECEIVER BOARD installed in TV receiver. Note the connections to the TV switch-board.

the amount of ambient light falling on the photo device and improves reception.

The receiver can be built into a plastic box that can be mounted to the rear of the set. If space permits, you can mount the receiver board inside the TV, as shown in Fig. 9. The phototransistor and housing should be attached to a length of shielded cable, and the sensor should be mounted on the top or side of the TV, toward the front of the set.

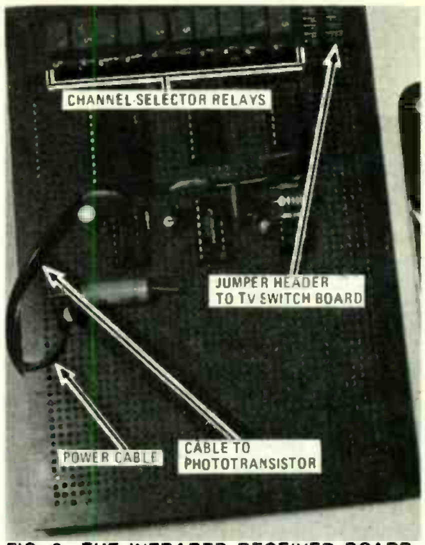


FIG. 8—THE INFRARED RECEIVER BOARD. Note that construction is not critical.

The transmitter can be enclosed in a small plastic box and the keys labeled to correspond to the channel numbers and mute feature. The author's prototype used a membrane keyboard salvaged from a calculator. That, of course, is not a requirement; you can use any matrix arrangement of 16 keys.

Troubleshooting

If you double check the wiring of all circuits before powering up the project, you shouldn't have any trouble. Even if you do, troubleshooting a faulty circuit should not present too many problems because the receiver and transmitter designs are fairly simple. Checking the transmitter can be done quickly by connecting an oscilloscope probe to the collector of Q1. Press one of the keys and watch for the corresponding number of pulses at this point. Look for the pulses at the base of Q1, also. Q1 may be faulty if no pulses appear at the collector, but are present at the base.

The receiver should be checked in stages. Using an oscilloscope, observe the output of phototransistor Q2 for a series of pulses from the transmitter. Trace through the circuit to locate the point where the pulses are no longer present. Check the output of IC4 and both sections of IC5. If the pulses are present, verify the operation of the timing circuits, IC7 and IC8, by looking for the various output pulses at their Q outputs while transmitting a number.

By now, you must certainly have a sense of how versatile this infrared communication project is and how you can enhance other projects by providing this wireless communication link. **R-E**

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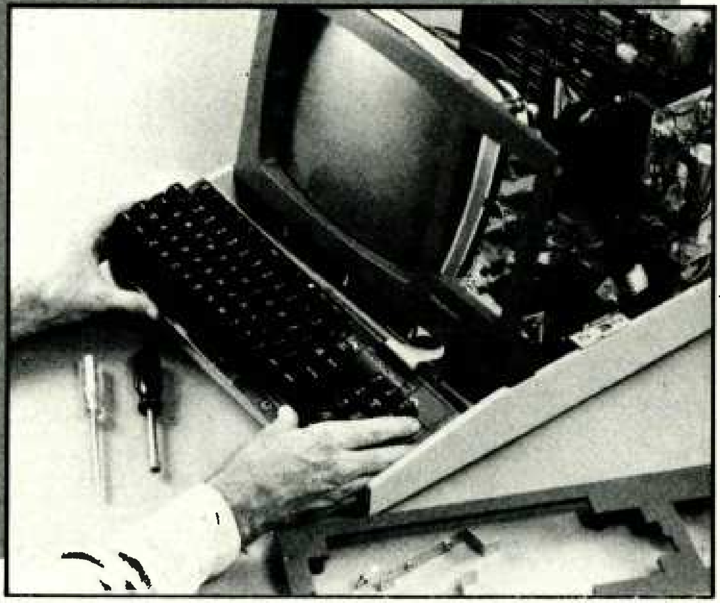

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DESIGNING WITH LINEAR IC'S

A look at differential and instrumentation amplifiers, and how to use them.

JOSEPH J. CARR

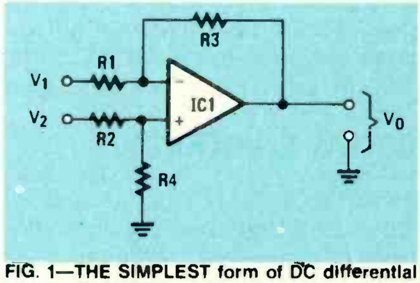


FIG. 1—THE SIMPLEST form of DC differential amplifier using an op-amp.

Part 4

THE AMPLIFIERS DISCUSSED thus far in this series have all been single-ended; that is, they have a single input that is referenced to either ground or the power-supply common. In this part of the series, we are going to discuss the differential-input amplifier. A differential amplifier uses two ground-referenced inputs; one inverting, the other noninverting. Those inputs have an equal but opposite effect on the output voltage. As a result, applying equal voltages to the two inputs will cause cancellation; that is, zero output voltage. That phenomenon is called *C*ommon *M*ode *R*ejection (CMR), and is expressed by the *C*ommon *M*ode *R*ejection *R*atio (CMRR) specification. Devices are available with CMRR ratings of 60 dB to 120 dB; the higher the rating the better.

Differential amplifiers find extensive use in scientific and medical instrumentation. The electrocardiograph (ECG) amplifier is an example. The ECG amplifier must acquire a 1-millivolt signal generated by the heart, and amplify it to the 1 volt or so needed to drive an oscilloscope or strip-chart recorder. Thus, the ECG amplifier needs a gain of 1000 or so. The signals for the ECG amplifier are taken from the patient's limbs, with the right leg (RL) being common. For example, the "lead I" ECG signal uses the right arm (RA), left arm (LA), and RL signals. Since the bioelectrodes used to acquire the signal are high impedance, and the system is used in the presence of 60-Hz electric fields from local power lines, a substantial amount of 60-Hz signal pickup can be expected. If it were not for the CMRR of the differential ECG amplifier, the 60-Hz interference would be several hundred times higher than the desired signal. But, since the 60-Hz fields affect both leads equally, the 60-Hz signal is common mode, so it will be nulled to zero.

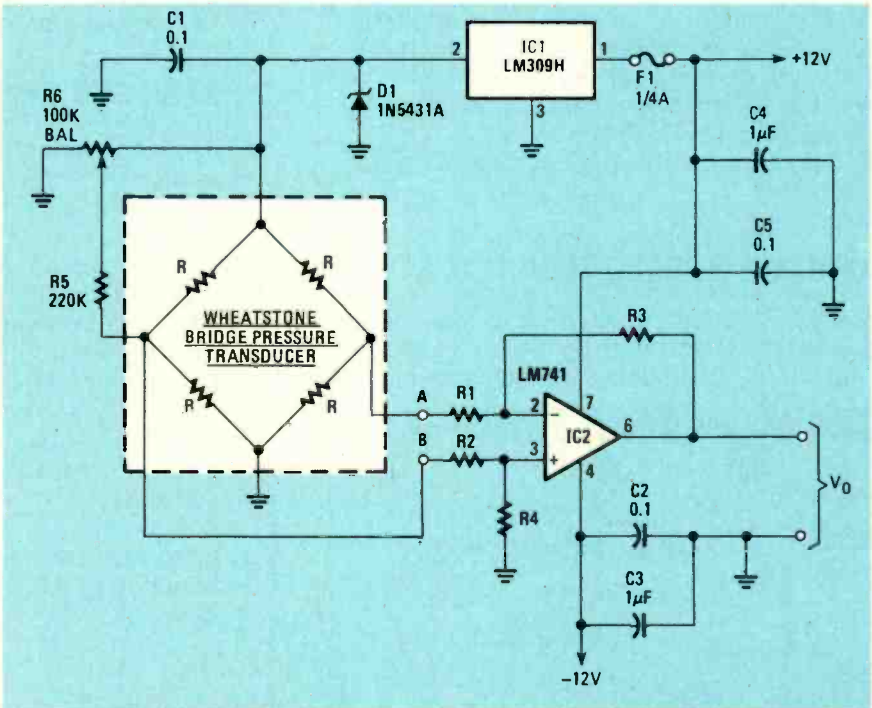


FIG. 2—DIFFERENTIAL AMPLIFIERS are used in a wide variety of medical applications. Here, one is used in a circuit that uses a Wheatstone-bridge transducer to measure arterial blood pressure.

Ordinary operational amplifiers have differential inputs, so they can be used to form differential amplifiers. Figure 1 shows the simplest form of DC differential amplifier using an op-amp. The differential voltage gain is given by:

$$A_{VD} = R3/R1 \qquad (1)$$

provided that R1 = R2, and R3 = R4. The value of R1 and R2 must be high enough to not load the signal source. A Wheatstone-bridge transducer might have a source resistance of, say, 200 ohms. By the "rule-of-ten," then, the minimum value of R1 and R2 should be 2000 ohms.

In order to illustrate the design method, let's consider a practical example. Suppose we have a Wheatstone-bridge transducer that measures arterial blood-pressure. Assume a transducer sensitivity of 40 μV/(V)(P) (where P is pressure, measured in units of torr). Design a simple pressure amplifier that has an output scale-factor of 10 mV-per-torr and a maximum range of 300 torr. Figure 2 shows the required circuit, while Table 1 shows details of the calculations and the specifications for our circuit.

The Wheatstone bridge requires a DC-

TABLE 1
Specifications

Sensitivity of Transducer:

$\phi = \frac{40\mu V}{V\ torr}$

Full scale pressure: 300 torr
Output scale factor (S): 10 mV/torr or 3000 mV/300 torr
Transducer excitation potential: 5 volts

Calculations

1. Output voltage from transducer at full scale:

$V_o = \phi V_e P_{max}$

$V_o = \frac{40\ \mu V}{V\ torr} \times 5V \times 300\ torr$

$V_o = (40\ \mu V)\ (5)\ (300) = 60{,}000\ \mu V$

$V_o = 60\ mV\ @\ 300\ torr$

2. Find the required gain by dividing the output scale factor by the transducer output. (Note: Use values taken at same pressure, e.g. 300 torr.)

$$A_{VD} = \frac{S}{V_O} = \frac{\frac{3V}{300\ torr}}{\frac{60\ mV}{300\ torr}} = \frac{3000}{60} = 50$$

excitation voltage, which is provided from a +5-volt regulator (IC1). The LM-309H selected for that delivers 100 mA at +5 volts DC, so it can handle transducers with equivalent resistances down to 50 ohms.

The Zener diode (D1) in Fig. 2 is not used to regulated voltage, but to protect the transducer from faults in IC1. The diode is a 1N5431A, or any equivalent 6.2-volt, 5-watt Zener. Most resistive transducers have a maximum excitation voltage limit of 7.5- to 10-volts DC. A shorted IC1 would place +12-volts DC across the transducer, causing it to burn out. If IC1 shorts out, however, the excessive voltage will turn on D1, which conducts heavily and thereby blows fuse F1.

Potentiometer R6 is used as a balance control, and in most cases will be panel-mounted for operator use. It works by injecting a current into one arm of the bridge to counter offsets. All transducers have some inherent unbalance. In addition, there is also the possibility of induced unbalance. In the arterial-blood-pressure transducer, for example, hydrostatic pressure-heads (which can be positive or negative) develop from differences in patient position and in the position of the interconnections between the patient and the transducer. Potentiometer R6 eliminates those problems.

Under most circumstances, potentiometer R6 is adjusted with the parameter it detects equal to zero. In our hypothetical blood-pressure amplifier, the potentiometer is adjusted to zero the output of IC2 when the transducer is open to atmosphere. That establishes a baseline; when the system is closed again, the transducer will measure gage pressure—i.e. pressure above and below atmosphere.

To provide the required gain of 50, we must select resistor values that have the ratio R3/R1 = 50. Furthermore, since the transducer has a Thevenin-equivalent resistance of 200 ohms, we must select R1 greater than or equal to 2000 ohms.

The process of finding suitable resistors is a matter of trial and error using standard values. Equation 1 may have to be worked several times to find a combination in which both R3 and R1 are standard values. Here, however, it is simple because 2000 ohms (the minimum value permissible for R1) is a standard value; fifty times 2000 ohms is 100,000 ohms, also a standard value. We accomplish our goal, therefore, by setting R1 = R2 = 2000 ohms, and R3 = R4 = 100 kilohms.

Maintenance of an acceptable CMRR requires that we specify resistors R1 through R4 as 1% tolerance, low-drift types. We might also want to build in a CMRR control. An example of that would be to replace R4 in Fig. 1 with a series combination of a fixed resistor and a potentiometer. The potentiometer should have a value not more than 20 percent of the total value of the series combination, and the total value of the series combination must be capable of swinging above and below the nominal R4 value.

Adjusting the CMRR control is best done with the transducer disconnected. Short together the differential amplifier's inputs and then connect the inputs to an AC sinewave source (100 to 1000 Hz). Adjust the CMRR control for minimum output (zero if attainable).

The principal problems facing the simple circuit presented thus far are similar to those that plague the inverting follower; input-impedance limitations and gain limitations. We can overcome those by using the instrumentation amplifier.

Instrumentation amplifiers

The basic instrumentation-amplifier (IA) circuit is shown in Fig. 3. That particular design requires three operational amplifiers. If possible, IC1 and IC2 should be a dual op-amp so that drift problems are minimized by keeping the two input devices in the same thermal environment.

Amplifiers IC1 and IC2 are operated as noninverting followers, so the overall input impedance of the IA is extremely high. Amplifier IC3 is the IA output stage, and is operated as a simple DC differential amplifier.

The differential voltage-gain is given by the following expression:

$$A_{VD} = \left[\frac{2R2}{R1} + 1\right]\left[\frac{R6}{R4}\right] \quad (2)$$

provided that R1 = R2, R4 = R5, and R6 = R7. The term in the first set of brackets is the gain of IC1-IC2, while the term in the second set of brackets is the gain of IC3.

Having two stages gives us more flexibility when juggling resistance values to get precise gains. The overall gain is the product of the gain of the two stages, so we can increase one or decrease the other in order to force-fit the values into the standard values normally available.

The IA would be selected when either

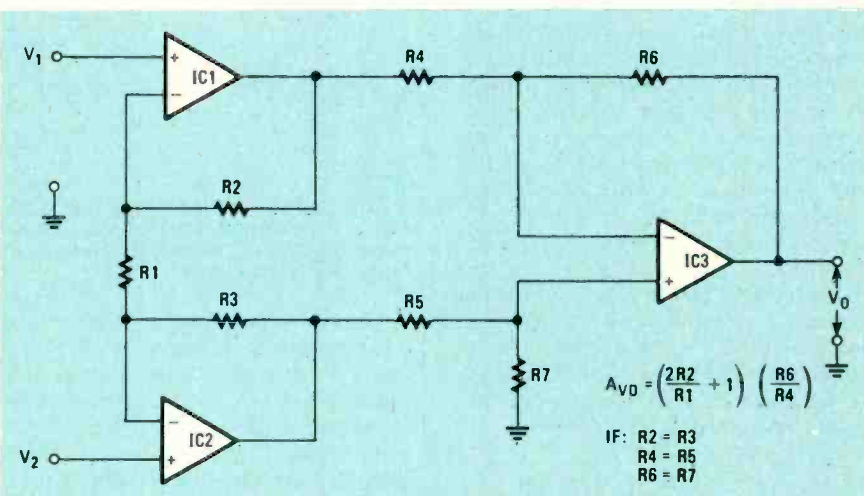


FIG. 3—A BASIC INSTRUMENTATION AMPLIFIER. Three op-amps are used: IC1 and IC2 are configured as non-inverting followers while IC3, the output stage, is a differential amplifier.

high gain or high input-impedance is needed. There are certain applications where those are required, for instance when certain chemical electrodes and most bioelectric amplifiers are used.

The circuit in Fig. 3 is a DC amplifier, so it can be used to amplify signal frequencies from DC to the upper limit of the amplifier bandwidth. Some applications, however, cannot tolerate a DC amplifier. The ECG amplifier, for example, has to contend with a half-cell potential formed when metallic electrodes are connected to skin through an electrolytic gel; in other words, a battery is formed. The half-cell potential is seen as an input offset by the amplifier, so that can produce problems. The solution is use AC- coupling.

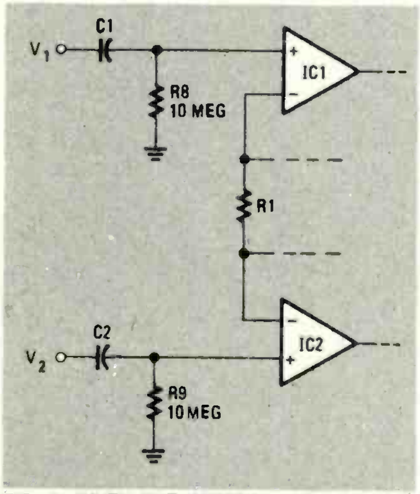


FIG. 4—WHEN THE INPUT to a circuit is AC-coupled, capacitors are used to block any DC.

Figure 4 shows the input circuit of the I A modified for AC-coupling. The capaci or in series with each input blocks the DC component. If the op-amp input is truly an infinite impedance, then the 10-megohm resistors are not needed. But real op-amps do have bias currents in the input circuits, so the capacitors will accumulate charge. The effect of that charge is to place a DC voltage in series with the input. The amplifier would see that voltage as a valid DC offset signal, which would eventually cause the amplifier to latch up. The solution is to ground the resistor so that the charge on the capacitor is drained off. In order to prevent degradation of the input impedance, the value of those resistors needs to be very high; 10 megohms, such as is used here, is usually selected.

Let's next see how to find the values for C1 and C2. Assuming that the input impedance is very much higher than 10 megohms (or whatever value is selected for the input resistor), the low-end frequency response is set by:

$$f_L = \frac{1}{2\pi RC} \qquad (3)$$

Or, if 10 megohms is used, we can rearrange the "standard" formula to find what we really want to know—what value capacitor will yield the specified frequency response. That is found from:

$$C = \frac{1.6 \times 10^{-2}}{f} \qquad (4)$$

where C is capacitance in microfarads and f is the frequency in hertz.

Lets work an example. An ECG amplifier requires a frequency response of 0.05 Hz to 100 Hz. Select a capacitance valve for C1 and C2 in Fig. 4 that will result in 0.05-Hz lower limit. $C = (1.6 \times 10^{-2})/(0.05\ Hz) = 0.32\ \mu F$. Since 0.33 µF is the next lower standard valve, specify 0.33 µF for C1 and C2 in the final design.

IC instrumentation amplifiers

The integrated circuit instrumentation amplifier (ICIA) combines in one package all of the components required to make an IA, with the possible exception of a single gain-setting resistor (R1 in Fig. 3).

The ICIA is not usually cheap, at least when compared with 741-family devices, yet it is often the most economical selection. Also, the IC packaging confers certain assembly advantages, and the ratings of the ICIA are often better than 741-family devices. The proper cost comparison would be between the ICIA and an ordinary discrete IA built from precision resistors and three premium-grade op-amps.

Figure 5 shows the National Semiconductor LM-363 device. Three versions of that device, with the difference between them being the gain, are available. Those are the LM-363-10, LM-363-100 and LM-363-500, which offer gains of 10, 100, and 500, respectively.

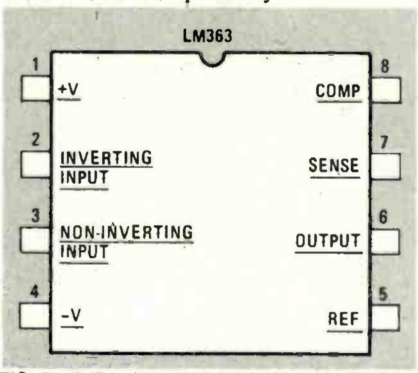


FIG. 5—THE INSTRUMENTATION AMPLIFIER is available in IC form. The pinout for one such IC, the LM-363, is shown here.

Ordinarily, the LM-363 is connected in a circuit such as the one shown in Fig. 6. The COMPENSATION terminal (pin 8) is connected to a series RC network for frequency-response tailoring. The REFERENCE terminal (pin 5) is connected to ground, and SENSE (pin 7) is connected to the output. No external components are needed to set gain as that is fixed. The IC comes in an eight-pin metal case.

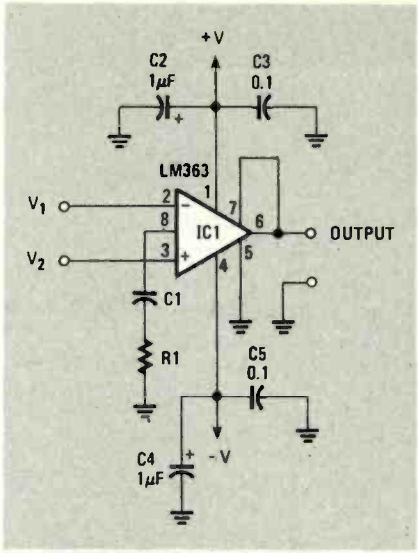


FIG. 6—THE SERIES R-C NETWORK is used to tailor the frequency response of the circuit, thus the values of C1 and R1 will vary according to the application.

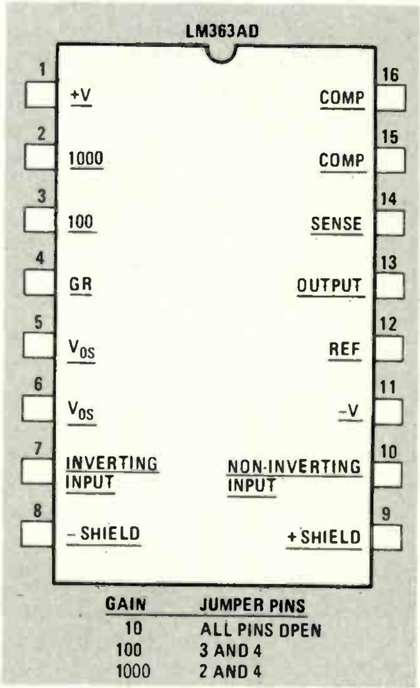


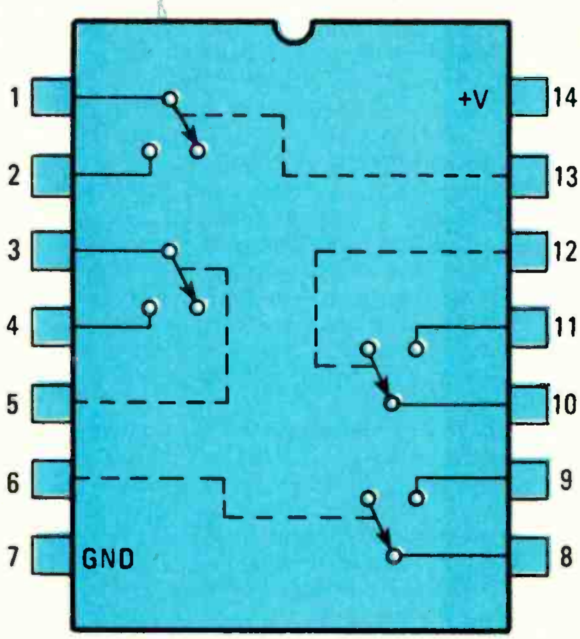
FIG. 7—PINOUT of the LM-363AD. The gain for that device is pin-selectable.

Another version of the LM-363, the LM-363-AD, is shown in Fig. 7. That 14-pin DIP also features fixed gain, but three selectable gain levels—10, 100, and 1000—are available in a single device. The gain is set by shorting the GR terminal (pin 4) and the gain terminals, × 100 (pin 3) and × 1000 (pin 2) as shown in Fig. 7.

The LM-363-AD has two terminals that may look a little strange; + SHIELD and − SHIELD. Those terminals are used to drive the input-wire shield (i.e. when shielded cable is used) with a sample of the signal. A shield treated in that manner is called a guard shield, and tends to im-

continued on page 88

Cmos Analog Switches



ROBERT GROSSBLATT

With CMOS switches, you can use digital techniques to control analog signals.

IN THE "OLD" DAYS—WHEN TTL (*T*ransistor-*T*ransistor *L*ogic) was the only game in town—all sorts of hassles used to crop up when you designed circuitry that had both digital and analog elements. Not only were there different voltage requirements for each section, but transients generated by one section of the circuit were a problem for the other section. All sorts of design tricks had to be dreamed up if you expected the circuit to be reliable and glitch-free.

Designing the interface portion of the circuit also presented its own special problems. Schemes of incredibly complex circuitry had to be dumped in the middle of an otherwise sane and orderly design. The benefits you could enjoy by using digital logic to control analog signals were often outweighed by the problems inherent in the design.

Fortunately those days are gone forever. With the introduction of CMOS (*C*omplementary *M*etal *O*xide *S*emiconductor) technology a few years ago, most of the design problems we've been talking about went out the window. The construction techniques used in the design of the chips in that family opened up whole new worlds of possibilities. Because CMOS uses both P- and N-channel MOS transistors, (remember that the "C" in CMOS means Complementary), we aren't limited to having the current flow in only one direction. Everything depends on how we connect up the transistors on the chip. We can see some of the possibilities that appear if we connect the P- and N-channel transistors back to back as shown in Fig. 1.

The simple CMOS switch

When S1, the control switch, is connected to ground, the gate of the N-channel transistor is grounded and the gate of the P-channel (because of the inverter) is at +V volts. Since both transistors are turned off, points "A" and "B" are isolated from each other. (Well, that's not entirely true—because of the leakage current of the transistors.) When we move the control switch to +V, a much more interesting thing happens. The P-channel gate is now grounded and the N channel gate is at +V. Both transistors are turned on and points "A" and "B" are connected to each other through the transistors. Since we're using two complementary transistors, the circuit of Fig. 1 can handle current flow in either direction. The P-channel transistor will conduct in the one direction and the N-channel transistor will conduct in the other. In other words, we can use the circuit to pass either digital or analog signals.

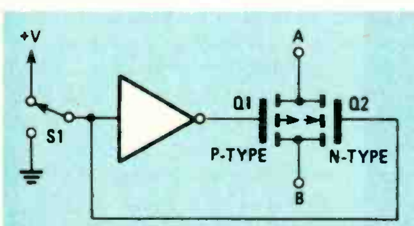


FIG. 1—SIMPLE CMOS ANALOG SWITCH. When S1 is switched to V, a signal path is created between points "A" and "B." When S1 is switched to ground, the path is opened.

The OFF resistance of the circuit will be pretty high since we're essentially looking at a reverse-biased silicon diode. The ON resistance will be low; it's determined by the voltage across and the transistors and their physical characteristics. Although that looks wonderful, let's see what's wrong with it—and what can be done to make it better.

For starters, the ON resistance is going to be on the high side (about 500 ohms) for low-level analog signals. Running audio through that amount of resistance, especially low-voltage audio, can lead to possible termination problems and floating signals. A further problem with the circuit of Fig. 1 is that the resistance is going to change as the voltage changes across points A and B. That's because there's *always* a voltage drop across a transistor and the conductivity of even the world's most perfect transistor will vary somewhat with changes in voltage and frequency.

There's one more problem with the circuit of Fig. 1. Even though the transistors are a matched pair built on the same substrate, they are not *exact* complements of each other. That means that the signal path from point "A" to point "B" won't be exactly the same as the path from "B" to "A." In practical terms, that means that the resistances are going to be slightly different in each direction, and the switch will run the risk of distortion and latch-up if the current flow gets up around the maximum limits of the transistors.

The improved CMOS switch

It's for those and other reasons that the type of switch circuit shown in Fig. 1 was soon referred to as a "simple" switch and the semiconductor manufacturers introduced an "improved" version.

Figure 2 is the schematic of the improved version. At first glance at seems as if there has been quite a bit of change, but a second look will show you that we've simply made a few common-sense additions to the circuit of Fig. 1. Two inverters have been added to the control input of the switch to isolate the control voltage from the voltages being switched. That prevents the possibility of the control voltage being modulated by the voltages across the switch terminals. The high ON resistance of the simple switch has been reduced by adding two new transistors, Q4 and Q5, in parallel with Q1 and Q2. Since they're in parallel, the voltage drop across the two pairs will be less than it was in the simple switch—and a smaller voltage drop means a smaller resistance.

Because the controlling inverter is isolated from the control switch, we can add Q3 to make sure that the switching pairs of transistors stay off when the control switch is connected to ground. Since Q3 is an N-channel transistor, a logic-low at it's gate will turn it on and help make sure that the other transistors are held in cutoff when the switch is opened. Remember that we added the extra switching pair, Q4 and Q5, to lower the voltage drop across the switch. Well, nothing is without a price. The cost of the lower resistance we achieved was the increased possibility of signal leakage through the switch when it's turned off. Even though Q3 goes a long way in helping to lock the other transistors in cutoff, the simple switch of Fig. 1 is still a better choice if your application demands the absolute lowest leakage current when the switch is turned off.

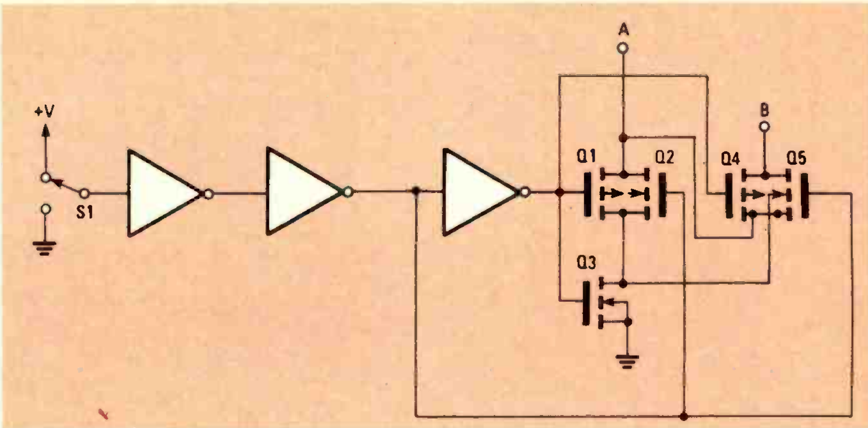


FIG. 2—IMPROVED SWITCH. The ON resistance has been decreased at the expense of a greater signal leakage when the switch is turned off.

By using the basic principles we've just analyzed, chip designers have come up with an incredible variety of CMOS switches. By combining the switches with other digital circuits, MSI (*M*edium *S*cale *I*ntegration) IC's have been designed that can solve almost any circuit switching problem. On-chip binary counters and decoders allow the use of standard binary addressing to control the switching in a circuit. It doesn't take a great deal of imagination to realize the enormous advantage of being able to easily switch analog signals using digital control lines. Before you rush out and pick up some of those IC's, let's take a look at some of the rules you have to follow when you use them.

1. CMOS technology is used to make analog switches. That means that they are subject to the same sort of damage from static electricity that you can expect with any other CMOS IC. The oxide layer between the gate and channel of a CMOS transistor is extremely thin and can be punctured by even a moderate amount of static discharge. Follow the same handling procedures you would with any MOS device and *never* insert or remove one of those IC's from a circuit that's powered up. It will ruin the chip—and your whole day.

2. The amount of current you can route through the switch changes somewhat with the supply voltage, but it should never be more than 25 mA for improved switches and 15 mA for simple ones. Trying to force more current through the switch will do things like degrading the internal transistors (if you're lucky) or blowing them up (if you're not).

3. There are voltage limits to your input signals. Never allow the voltage swing of the input to go above the supply rail or below ground. That isn't as much of a restriction as it would seem because CMOS IC's can operate over an astonishingly wide power-supply range. If you're sure that the voltage swing of the signals going through the switch in your circuit is going to exceed the range of the power supply, you're going to have to do some designing to meet that restriction. Since CMOS can operate safely at up to 15 volts however, you shouldn't have too much of a problem: It's a fairly simple matter to cut an input signal down to size ahead of the switch and boost it back up afterwards.

4. Never let the control pins float. That's especially true if you have signal voltages always present at the switch inputs. Don't forget that a general rule for all CMOS design is that all inputs have to go somewhere. Remember that the control pins are connected to inverters inside the IC. If the control inputs are floating, the state of the switches will be indeterminate at best and haywire at worst. More than likely, the inverters will bias themselves into linear operation and the whole circuit will start oscillating. Since the inverters will have no clear path to either end of the supply rail, they'll draw a lot of power and you'll be running the risk of blowing up the IC and doing severe damage to the other parts of your circuit.

All those usage rules may make things seem a lot worse than they really are. But in practical terms, CMOS switch IC's are extremely easy to use and provide solutions to design problems by using methods that simply didn't exist before the introduction of CMOS technology.

Table 1 is a listing of some of the switch packages that are available. As you can see, some of the IC's are multiplexer/demultiplexers—switch configurations that are controlled by onboard binary decoders. They're a little bit slower than the plain switch packages, but they come in really handy when you're looking for an easy way to distribute analog data.

Before we examine some of the infinite amount of uses for these IC's, let's examine one consequence of usage rule 3—the input voltage can't exceed the IC's power supply. Although the voltages running around in a digital system are usually within those limits, analog signals are something else. It's perfectly normal for an analog signal to swing below system ground. That is especially possible if the analog signals are being generated by circuitry whose power supply is separate from the digital supply. Figure 3 is a graph that illustrates that problem perfectly. The digital voltage is between 0 and V+ and the analog swing is between +(V/2) and −(V/2). Although the voltage ranges are the same (V volts), it's evident that the difference in the values is going to present a special design problem—or at least one that has to be solved before the switches can be used to process analog data.

The solution is the same as it is with op-amps: The IC has to be powered by a bipolar supply. You're going to have to do something about generating a negative voltage for the IC. That means using center-tapped transformers or some other arrangement to produce the negative

TABLE 1—ANALOG SWITCH IC TYPES

IC type	Switch type	Quantity	ON resistance	Frequency response	Operating speed
4016	SPST	4	500 ohms	40 MHz	25 MHz @12 volts
4051	1 of 8	1	80 ohms	40 MHz	2 MHz @12 volts
4052	1 of 4	2	80 ohms	40 MHz	2 MHz @12 volts
4053	1 of 2	3	80 ohms	40 MHz	2 MHz @12 volts
4066	SPST	4	80 ohms	40 MHz	30 MHz @12 volts
4067	of 16	1	200 ohms	40 MHz	5 MHz @12 volts
4097	1 of 8	2	200 ohms	40 MHz	5 MHz @12 volts
4529	1 of 4	2	300 ohms	35 MHz	5 MHz @12 volts
	or				
	10 of 8	1	300 ohms	35 MHz	5 MHz @12 volts

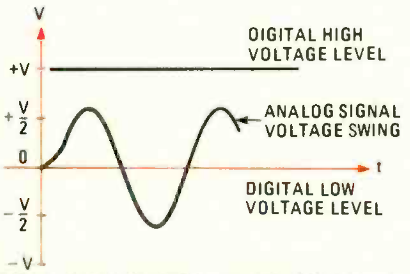


FIG. 3—SITUATIONS WHERE THE ANALOG signal swings below the system ground require that a bipolar supply be used to power the IC.

voltage level. The exact amount of power you'll need from a negative supply will depend on how you're using the switch, the frequency of the input voltage, the output load, and so on, but the current demand will never exceed about 5 to 10 milliamps. Since so little is needed, a center-tapped transformer is really overkill. A more realistic approach is to get below system ground by using some "Mickey-Moused" circuits or even one of the IC's specifically designed for the job, such as Intersil's ICL-7660 voltage converter.

Some real devices

Figures 4 and 5 show you two of the IC's in the family of analog switches. Since they're typical of the basic types of switches available, understanding them will make you familiar with the other IC's in the series.

The 4016 (in Fig. 4) is a package containing four simple switches exactly like the ones we analyzed. The 4066 is a pin-for-pin replacement containing four improved switches. The switches can be ganged together any way you want to satisfy whatever switching needs you have. A high signal on any control pin will close its associated switch and a low signal will open it.

Aside from the rules and limitations we've already discussed, there's nothing special you have to watch out for when you use this IC. The switches are all independent of each other and the crosstalk between them is very low—isolation is on the order of about 50 dB.

The 4051 (in Fig. 5) is one of the MSI rotary type switches we discussed before. It's a single-pole, eight-position switch

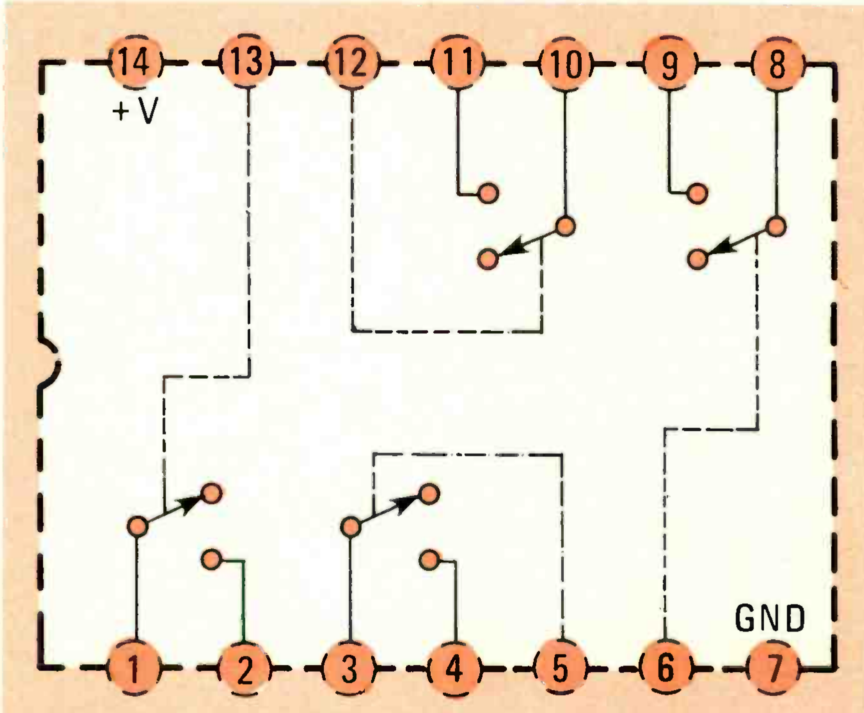


FIG. 4—QUAD ANALOG SWITCH. Functional diagram of the 4016 and 4066 switches.

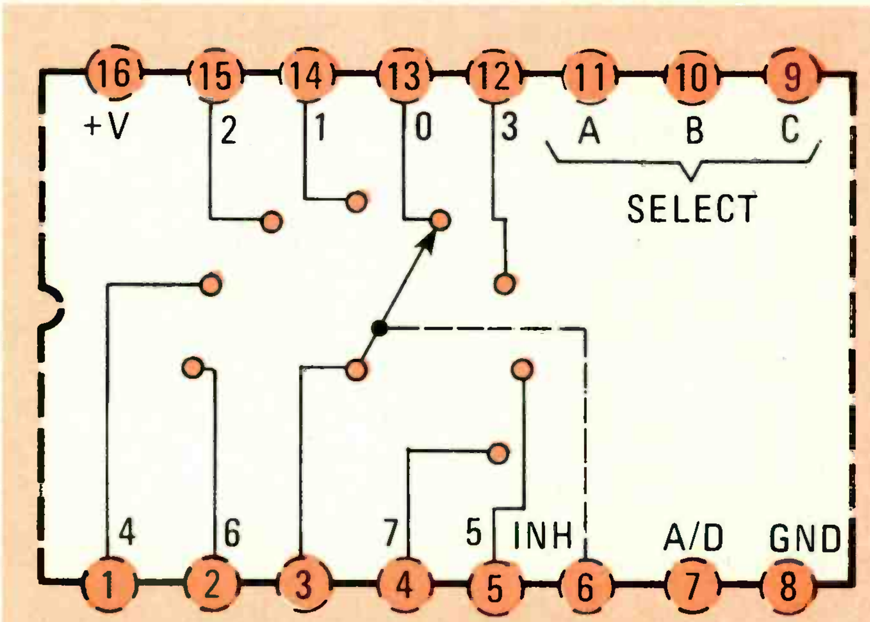


FIG. 5—ROTARY ANALOG SWITCH, the 4051, is essentially the same as its mechanical counterpart.

and can be used, like its mechanical counterpart, to either select or distribute data. Pin 3 is the center pole of the switch and it will be connected to whatever pole is designated by the three-bit word presented to the weighted select pins (9, 10, and 11). Pin 6 is an enable or inhibit control for the IC—if it's made high the inputs will be disconnected from the output. That's a useful feature because there might very well be times when you want no channel to be connected. Pin 7 gives us an easy way to make the IC usable for both digital and analog applications.

If you're going to use the 4051 to handle only digital signals, you should tie pin 7 to ground. That pin is connected to circuitry inside the IC that takes care of the voltage translation needed to handle analog signals. When analog signals are going to be routed through the chip, you should connect it to the lowest voltage level in your system. That would be the lower limit of the analog voltage swing presented to the chip. In practice, that would probably be whatever negative voltage level you're generating in your system.

Remember that you can't ever let the input signals exceed the voltage range spanned by the supply levels on pin 8 and pin 16. If you connect pins 16 and 7 to +6 and −6 volts respectively, and connect pin 7 to ground, you can handle analog voltages of up to 12 volts and still use 6-volt digital-control signals to select the channel you want selected in the IC.

Even the slowest of the analog switches will operate at 2 MHz with a 12-volt supply. The frequency response of the switches is typically 40 MHz. That means that you can easily switch audio signals and even standard NTSC video signals. Since the propagation times are on the order of about 200 nanoseconds, you're probably thinking that these devices can be used for popless audio switching, remote control of analog signals, and so on.

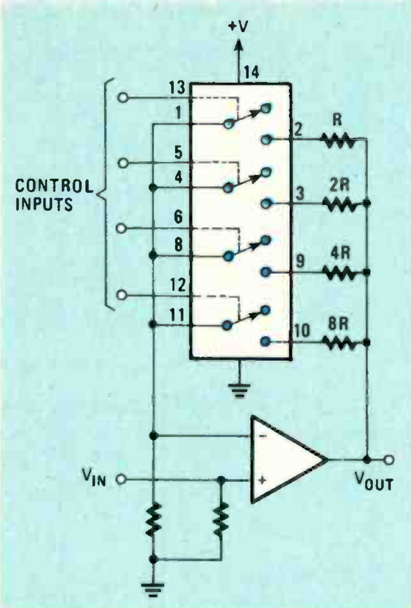


FIG. 6—SIMPLIFIED SCHEMATIC of a digitally controlled variable-gain control.

tially an open circuit, crosstalk is less than 50 dB, and because CMOS is an inherently noise immune logic-family, that sort of circuit is a real possibility.

The question of video switching is interesting. The analog switches have more than enough speed and bandwidth to handle it. Even the slowest devices can pass frequencies up to 40 MHz and premium IC's can go way past that. I've built video switchers using analog switches and, beyond the normal precautions you take when working with high frequencies, no particular problems showed up. Remember: I'm talking about NTSC video—not un-demodulated broadcast television signals. TV signals would be a bit of a problem because you'd be looking at VHF and UHF signals. You might be able to handle the extreme lower end of the VHF band, but that's about it. Since Channel 2 centers around 58 MHz, you're starting out at the upper limit of most analog switches. And since UHF begins somewhere around 440 MHz, it's out of

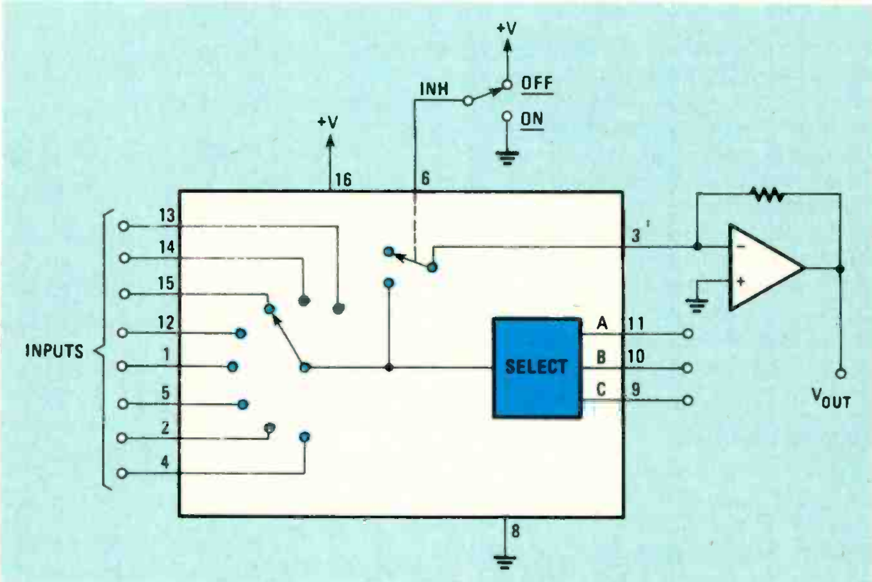


FIG. 7—INPUTS TO AN AMPLIFIER can be switched in any order using the select lines.

Digitally controlled gain

Well you're absolutely right. Let's look at two basic examples. Figure 6 shows how you could use a 4066 to digitally control the gain of an amplifier. The amplifier is an op-amp in a non-inverting configuration, and the gain is determined by the amount of resistance in the feedback path.

By putting a binary word on the control pins, we can have any one of 16 possible gain settings that are both precise and repeatable. Obviously that circuit is not the last word in this sort of thing, and we're not limited to using a 4066. We can gang as many switches as we want, use one of the "rotary" switches, or any combination at all. Microprocessor control of things is a real possibility and the range of control you have will be limited only by the width of your data bus.

The advantages of digital gain-control are obvious. Anyone who has fooled around with audio knows the insidious nature of 60-Hz hum from the power lines. As you run more and more lengths of shielded cable, your chances of maintaining a clean signal get less and less. That's in sharp contrast to digital signals: You can grind the digital control lines into the dirt and not upset anything. (Well, almost anything.)

Figure 7 shows you how you can use a 4051 to select the inputs to an amplifier. If you use that sort of arrangement with audio signals, the transition from one channel to another will be smooth, popless, and absolutely undetectable. Notice also that you don't have to switch channels in any particular order as you do with mechanical switching. You might refer to that sort of circuit as a random-access selector. Since those are analog switches, you can turn the circuit upside down and use it to send a signal to a selected output—in other words, a distribution amplifier.

That isn't as trivial an observation as it may seem. Remember that the 4051 will scan outputs at greater than 2 MHz. That immediately brings to mind a unique sort of distribution amplifier. A little bit of design ingenuity will allow you to use one amplifier to feed eight outputs by scanning the outputs so quickly that there's no noticeable signal loss at any one of them. (That's similar to multiplexing LED displays.) Since the OFF resistance is essen-

the question. The best approach is to demodulate those signals before the analog-switch circuitry, and cut the frequencies down to a level more easily handled by the switches

CMOS switches are the digital windows to the analog world. No logic family has ever been able to directly process the signals those IC's were designed to handle. Although they can be used to deal with digital data, their real advantage comes in being able to deal internally with analog voltages. The next time you design circuitry for audio or video signals, using these specialized IC's can save you time at the bench. They'll also help reduce the number of problems with power supplies and provide you with an elegant solution to what used to be an impossibly complicated problem. **R-E**

This August marks the 100th anniversary of the birth of Hugo Gernsback—author, publisher, and inventor. In this article, we'll look back at the life and achievements of that great man, the founder of ***Radio-Electronics****.*

HUGO GERNSBACK: A MAN WITH VISION +

ROBERT A. W. LOWNDES

"IF HUGO GERNSBACK HAD STAYED HOME, everything would have been different." So begins *The Futurians*, by Damon Knight—a book about a famous science-fiction fan club of the late 30's and early 40's, many of whose members became prominent science-fiction writers and editors. That statement is even more true of the world of electronics and radio, and electronics periodicals.

Where was Gernsback's "home?" He was born in Luxembourg on August 16, 1884. That was the year that Grover Cleveland was first elected President of the United States; Harry S. Truman and August Piccard (Swiss physicist) were born, and the first practical steam turbine engine was invented.

As a boy, young Hugo was fascinated by the electrical workings of a doorbell he'd been given for his 8th birthday, and that concentrated interest in all aspects of electricity proved to be life-long. He studied that subject at the Bingen Technicum, one of the best technical institutes in Europe, from which he graduated. But his education was not a narrowly scientific one; he had a thorough classical education as well, and knew the literature of three languages in which he became fluent: German, French, and English.

His first venture toward a career was invention: He developed a greatly improved dry battery, and emigrated to the United States, at the age of 19, where he hoped to make his fortune as an inventor. His name had actually been Gernsbacher; he changed it to "Gernsback," for the purposes of simplification.

The battery was, indeed, a superior one—but the cost of manufacturing it at the time proved to be too great. He got a job with a storage-battery manufacturer, and developed a cheaper, lighter, and stronger battery case than any other then available. Unfortunately, he neglected to test it fully and it proved all too vulnerable to corrosion. That ended his job and his career as an engineer.

His third venture would be successful and lead directly into his career as a publisher and writer. He formed the Electro Importing Co., to obtain equipment from Europe and sell it to electrical and wireless experimenters. His catalogs not only showed and described the products he was selling, but also contained short articles explaining how electrical equipment actually worked.

Gernsback the publisher

In 1908, he decided to try publishing a magazine devoted to instructive articles on new and unfamiliar equipment, as well as background material on electrical fundamentals. The first issue of *Modern Electrics* was dated April, 1908, and from the start was concentrated on wireless theory and construction projects. The magazine was a success, and in 1911 Gernsback started to write what he would later term "scientifiction"—a charming story rooted in sound scientific principles, speculating upon the future (near or far) when as-yet unheard of devices and inventions would be realities. Because of its combination of sound scientific background and vision, that first story, "Ralph 124C41+," contained a cornucopia of what proved to be accurate predictions: radar, television, tape recording, and night sports games, are just a few of them. The story ran serially for 12 issues in *Modern Electrics*, and it is very likely that Gernsback had no idea, when he started it as a space-filler, that it would wind up as a novel. It was rewriten for hardcover publication in 1925, and reprinted in the winter 1929 issue of *Amazing Stories Quarterly*.

Modern Electrics was sold in 1912; Gernsback had already started another publication with a broader base: *The Electrical Experimenter* was a large-size, roto magazine. (*Modern Electrics* had been something between pulp magazine and digest size.) The title was changed to *Science and Invention* in 1920. By then, he was already publishing *Radio Amateur News*; the word "amateur, was dropped from that title in 1920.

In 1925, Hugo Gernsback established radio station WRNY, the first broadcast station to devote regular time to broadcasting programs of interest to electrical experimenters and technicians. The editors of *Science and Invention* and *Radio News* were frequent speakers, and Gernsback himself talked on scientific subjects every Monday night at 9 PM.

In 1928, station WRNY began daily

television broadcasts, and those who had built themselves TV receivers saw tiny images comparable to halftones in the daily newspapers. There was no sound, however, and those without receivers who tuned into WRNY when TV broadcasts were going on heard only peculiar noises. In the same year, Station WRNY was broadcasting by shortwave all over the world.

He had already achieved considerable influence not only on inventors and researchers, but also on legislators. He founded the Wireless Association of America in 1909; its purpose was to advance the interests of both professionals and amateurs in the field. It went farther than that: it protected them. On two occasions when legislators would have eliminated the amateur and amateur radio itself, Gernsback's editorials (and undoubtedly much mail from his readers) prevented that from happening. The amateur section of the Wireless Act of 1912 reads like a paraphrase of one of his editorials. Gernsback also formed the first organization of radio repairmen, the Official Radio Service Men's Association.

Gernsback's humor came out, however, not only in stories, but in "April-Fool" type articles. For that purpose he adopted the pseudonym of Mohammed Ulysses Socrates Fips, office boy, who was also an immigrant from Mars. Fips' inventions, in the *Modern Electrics* days, included a device to obtain ham sandwiches through matter transmission.

Although his initial experience had convinced him that he wasn't going to make his living as an inventor, Hugo Gernsback didn't stop inventing. That aspect of his life continued and he obtained over 80 patents, few of which he made any attempt to commercialize. Among those that were developed was what he called the "hypnobioscope," described in "Ralph 124C41+"—a device by which one can be instructed or educated while asleep. It was tried and used successfully in 1922 at the Pensacola, Florida, Naval Training School for teaching students Morse Code. Another was a bone-conduction hearing aid; he patented it in 1928 but never made or developed it, nor objected when someone else "reinvented" and manufactured it. His comment then was "I never intended to market it. Why should I bother someone else?"

One exception was the compression type "condenser," which was a prototype of the present-day trimmer capacitor. That was used as the "book condenser" in the Crosley radios. Patents were also obtained to protect devices he had developed for the Electro Importing Company.

However, he did not forsake developing some of his own ideas. In 1906, he brought forth the first radio set ever sold in the United States. It was a spark set that included both a transmitter and receiver, and was portable. The price was $7.50 and it included what would later be called receiving and transmitting antennas. While the range was limited (one mile), it operated in the UHF band and did not need tuning. There was no such thing as a commercial radio station at the time; the Telimco Wireless Outfit, as it was called, was used by experimenters and hobbyists who would later be known as radio hams.

Not all of Gernsback's periodicals were dedicated to radio or electricity. He also published *Your Body*, a magazine dedicated to sound medical instruction for the layman, as opposed to other, "health-fad", types of periodicals at the time. One of the publishers of that type of magazine was Bernarr MacFadden, who would play an important part in Hugo Gernsback's later fortunes.

While *Amazing Stories*, Gernsback's scientifiction magazine introduced in 1926, did not become a money-maker, it was popular; and the response to it was such that, after experimenting with one issue of *Amazing Stories Annual* in 1927, Gernsback started a second scientifiction title in 1928: *Amazing Stories Quarterly*, which featured a book-length novel, a novella, and short stories, all complete in each issue.

It was at this time that MacFadden tried to buy *Amazing Stories* and *Your Body* from Gernsback. MacFadden was a sincere scientifiction enthusiast, and it was more practical to obtain an already-established title than take the risks of starting a new one. (He wanted *Your Body*, however, in order to bury it.) Gernsback declined the offer, and assumed that that had ended the matter.

It hadn't. Early in 1929, Hugo Gernsback suddenly learned that bankruptcy proceedings had been set up against his Experimenter Publications. A sizeable debt to one of his suppliers (who also did much business with MacFadden) had been manipulated so that bankruptcy petitions could be presented to the court. Such a ploy would be prosecuted as criminal conspiracy today, but in 1929, the steps taken by the "conspirators" were entirely within the law. The bankruptcy laws in New York were changed thereafter, to prevent further such incidents, but that could not restore Gernsback's ownership of his publishing company.

A few months later, proof appeared that Hugo Gernsback was not broke and finished. On May 3, 1929 the first issue of *Science Wonder Stories* came out, with the familiar "Hugo Gernsback, Editor" line on its cover. That cover was by Frank R. Paul, who had done all the previous covers for the monthly and quarterly *Amazing Stories*. The term Scientifiction had been dropped and "Science Fiction" substituted. Inside was a full-page announcement of another science-fiction title, *Air Wonder Stories*, which would start the following month. And that same month, June 1929, the first issue of *Radio-Craft* went on sale. Hugo Gernsback had made the fastest comeback in magazine-publishing history!

From its first issue, *Radio-Craft* gave close attention to not only hobbyists and experimenters, but also service technicians. (The editorial in that initial issue was titled: "How to Become a Service Man.") At that time it was extremely difficult to obtain needed technical information, or even parts, from radio set manufacturers; Gernsback's influence would gradually change that situation to the point where any layman could obtain information needed to repair his equipment or use components in his projects.

The year 1933 saw the inauguration of Hugo Gernsback's most important non-technological magazine: *Sexology*, the first periodical devoted to sound, scientific, and absolutely non-sensational articles on the entire range of sex, medical and psychological, including marital counseling.

The same year, one of Gernsback's choicest bits of humor backfired upon

HUGO GERNSBACK at the key of the Telimco wireless transmitter. The receiver is at the left.

him: The May 1933 issue of *Radio-Craft*, on sale in April, contained a description of a "super-hetero-ultradyne" radio so small that it could almost fit into the owner's pocket. It was called the "Westingmouse." Although the words "APRIL FOOL," in capitals, appeared at the end of the article, readers refused to believe it was all a joke. The manufacturer whose name was suggested received innumerable orders for the "Westingmouse," as did *Radio-Craft*. As steady readers know, **Radio-Electronics** now has "April Fool" material each year, but that was not the case for a number of years after 1933.

In 1934, readers saw the first article in *Radio-Craft* to use the term "high fidelity." (As with the word "television," high fidelity was not a Gernsback coinage, but he was prominent in bringing attention to the latter, while he introduced the former into English.) There were construction articles in 1933 issues on how to add high-fidelity to old sets, and the May issue of that year had five articles on the subject of hi-fi.

Also in 1935, the first mention of FM came up in discussion of an invention by Major Edwin H. Armstrong that would eliminate static; at the beginning that was its principal use. Earlier, Hugo Gernsback had championed de Forest in his claims to have developed an entirely new device in the Audion (rather than just an improvement on the Fleming diode valve), and the Supreme Court recognized de Forest as the inventor of the regenerative circuit.

In 1937, there was a serial: "How to Build Your *Radio-Craft* Television Receiver."

Nikola Tesla, now recognized as one of the world's greatest electrical inventors and engineers, died in 1943. Gernsback had been an admirer and personal friend of Tesla from the very beginning. It was through Gernsback's influence that Westinghouse arranged for Tesla to receive the pension as "consulting retainer" that kept him from poverty in his last years. The February 1943 issue of *Radio-Craft* was a special Tesla issue.

Today, the electret, which is a dielectric disc with a permanent positive charge on one face and a negative charge on the other, is widely used in microphones. The public first heard about it, however, in an article, "Electret—Frozen Electricity," appearing in the November 1945 issue of *Radio-Craft*. Few scientists and technicians paid any attention, but Gernsback kept pushing the idea and finally persuaded Edward Padgett to make some. Padgett described his experiments in a series of articles, and another author showed readers how to make their own.

The birth of *Radio-Electronics*

By now, the magazine had a new title. Gernsback repeated a procedure he had used when he started his new company in 1929: he asked readers to choose a title—in this case a more appropriate name for *Radio-Craft*, whose coverage now had expanded far beyond the limits of radio. He specified that he wanted the word "television" in the new title—but the voters didn't. Starting with the September 1948 issue, the magazine became **Radio-Electronics**. (The old title was phased out on the cover after several months.)

Gernsback wrote all the editorials for the magazine, but began to confine his long, highly speculative and predictional material to his annual Christmas card. It was far from a card; each year, it appeared as a take-off on some other well-known national-circulation magazine, following that publication's general format. (*Time* was burlesqued as *Tame*.) The articles on scientific subjects, sound as they were in principle, read like science fiction, and many of them were illustrated by Frank R. Paul. A number of them were reprinted in Gernsback's last attempt to launch a successful science-fiction magazine in 1953. (*Wonder Stories* had folded in 1936.) There was a boom in science-fiction magazines at the time, although by the time the first issue of *Science-Fiction +* appeared, it had started to die down. The magazine was edited by Sara Moskowitz, and printed on coated paper, large size, but it only lasted for eight issues.

Some of the material from Christmas cards and *Science Fiction +* found its way into the original manuscript of Hugo Gernsback's final novel, *The Ultimate World*, which he wrote in 1958 and 1959. No publisher would take it because of the intermingling of narrative fiction and prophetic articles. It was finally published in 1971, as edited by Sara Moskowitz, without any of the non-fiction.

Gernsback had seen a number of his dreams come true, but one of them was proving to be a nightmare by the end of the 50's. FCC Commissioner Minnow had summed it up when he described commercial television (and that was the only variety then available) as a "wasteland." Gernsback noted in the February 1962 **Radio-Electronics** that TV programs had "shrunk to an incredible low." But what could be done about it? Gernsback suggested canned TV recordings, either in tape or disc format; such recordings existed at the time in experimental form. Educational material and entertainment on a high-quality level could thus be produced and sold profitably. Those who owned TV sets could buy such discs and view them whenever they wanted to.

The early 60's saw the first active communications satellite, Telestar, launched; the discovery of voiceprinting, the electret microphone and earphone, microwave ovens, and the first weather satellite. More and more electronics devices and procedures that Hugo Gernsback had either predicted, or championed when no one considered them commercially viable, had come into being.

One of his last predictions was a voice-operated typewriter; he based that prophecy on work in progress. One experimenter, Count Dreyfus-Graf, had reached the point where he could dictate readable Christmas cards. Gernsback's powers were failing by 1965, and many of the editorials in **Radio-Electronics** that year were written by guest writers, such as John R. Pierce of Bell Labs (who had been a winner in a *Science Wonder Stories* cover contest); David Lachenbruch, onetime associate editor, and managing editor, Fred Shunaman. Gernsback had not stopped writing, but he was saving his material for his Christmas card, *Forecast—1966*. That would be the final one he would write.

He lived to see the opening of the computer age, and one of his most serious proposals was that of a computerized National Facts Center. While that has not come about, and may not because of the danger of massive government intrusions into citizen's privacy, privately-owned data files, accessible at reasonable prices, constitute the essence of his idea. Back in 1930, in ads for his science-fiction magazines, he had predicted that we would reach the Moon by 1950; he had predicted in 1929 that the first Moon-shots would be unmanned. His later prediction that the event would occur before 1970 hit the mark. He added that he wouldn't be around to see it happen—but in a sense he was there at the famous moon-landing in 1969: a crater on the Moon had been named after him.

Hugo Gernsback died on August 19, 1967—shortly after his 83rd birthday. His son, M. Harvey Gernsback, who had been working with his father in Gernsback Publications for many years, and had contributed articles to **Radio-Electronics**, continued the magazine.

Although his interest in invention remained throughout his life, the key element of Hugo Gernsback's personal faith was that the world would be greatly improved if the common man had a basic comprehension of science and its meaning in society in all aspects, and at all levels. With a very few exceptions, all his publications were directed to that end.

A collection of tributes to Hugo Gernsback's effectiveness in pursuing his chief goal from those who knew him, from close friends to acquaintances and working scientists and technicians, would fill a good-sized book. Testimonials from those who never met him, but whose lives had been significantly changed by following Gernsback publications, would fill a many-volume set.

Damon Knight, a prominent member of the larger group, was right: Had Hugo Gernsback stayed in Luxembourg, everything would have been different. **R-E**

HOBBY CORNER

Component specifications

EARL "DOC" SAVAGE, HOBBY EDITOR

DESIGNING AN ELECTRONIC CIRCUIT IS A difficult job in itself; nowhere is that better illustrated than in circuits that are to contain IC's. Without knowing something about the components that you intend to use, it's next to impossible.

Several of you out there have written recently about the troubles you've had in designing circuits using IC's. I have probably been of little help because troubleshooting by mail is a difficult, if not impossible, undertaking. However, I can offer this bit of advice to Pat Rube (SD), Walter Bumgarner (NE), William Stamile (NY) and others who may be having similar problems.

For general design information and IC requirements, go first to two books by Don Lancaster (published by Howard W. Sams): The *TTL* and the *CMOS Cookbooks*. They're getting a bit old now, but they still contain valuable information that is clearly presented. The next place to look is in the manufacturer's data sheets or databooks to get information on the specific IC's involved. (Your local library is a good place to look for databooks.)

The databooks will give you necessary information about such things as debouncing input lines, stabilizing power supplies, current requirements, what must be done with unused input pins,

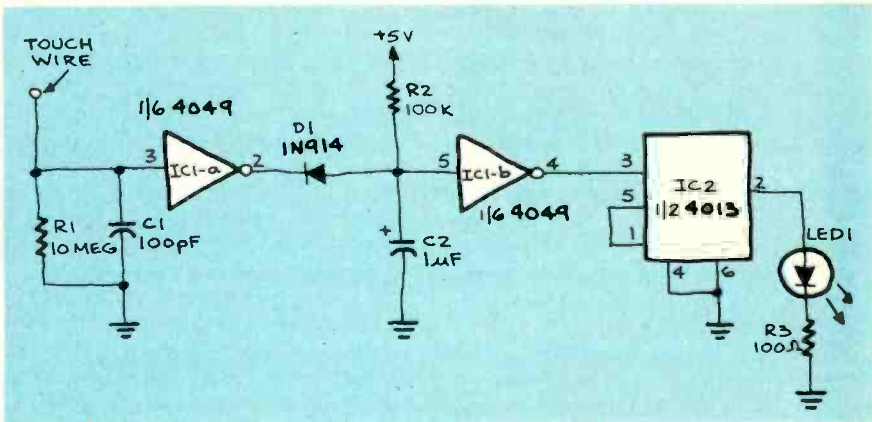


FIG. 1

needed "pull-up" resistors, fan-out limitations, current-sink limits, maximum frequencies, and the like. Those are the kinds of things you should know before you start designing a circuit.

There are many instances where two (or more) IC's have identical pinouts, yet are not interchangeable in most applications. Without both general and specific data, you are likely to go astray.

If you build a device based on an article, or other set of instructions, the author should have done all the ground work. On the other hand, if you are going from "scratch," you will need some references like those mentioned earlier.

Another question related to this subject comes from Roger Secura (OH), who inquired about the use of the phrase "designing for the worst case." You, no doubt, have heard of Murphy's Law—Anything that can go wrong, will. That certainly applies to electronic circuits! For example, someone is sure to put a book over the ventilation holes of a piece of equipment and cause it to run hotter than the designer intended, thus causing it to malfunction. Another instance where it is a good idea to consider the worst case is in dealing with the AC powerline. That is because the voltage on the line does not remain constant, but often varies over a range of ten volts or more and therefore, can affect the power input to a circuit.

In your designs, it's a good idea not to run components at or near their limits. That's because those limits are likely to be exceeded even during the normal operation of the circuit. In other words, *do not*

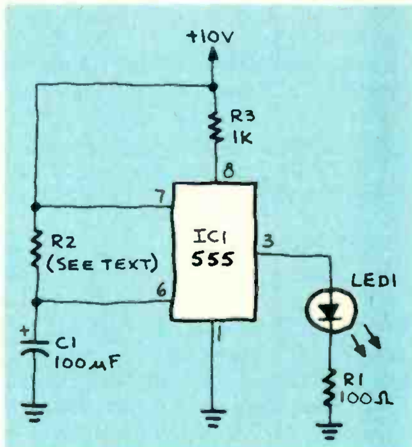


FIG. 2

use capacitors rated at 15 volts in 15-volt circuits. Likewise, don't use a 20 MHz IC in a circuit that you expect to run at 20 MHz. Also, do not use a ¼ watt resistor when you expect it to dissipate 0.25 watts.

Though you may get away with doing such things now and again, your circuits will be more likely to fail or operate erratically. Allow your components and yourself some room to breathe (so to speak). Over-design enough to take care of the worst case the circuit is likely to meet during normal operation. That way your designs are bound to survive a little longer. And now, let's see what else is in the ol' mailbag.

Touch switch

Dave Hipp (IL) sent a neat circuit for a touch (plate) switch using 4049 and 4013

AN INVITATION

To better meet your needs, "Hobby Corner" has undergone a change in direction. It has been changed to a question-and-answer form. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.

If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in "Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:

Hobby Corner
Radio-Electronics
200 Park Ave. South
New York, NY 10003

integrated circuits: That circuit is shown in Fig. 1. He plans to rebuild the circuit and incorporate it into a table lamp, so that the lamp can be operated by simply touching it. His problem is that the circuit works fine when just a touch wire is attached as shown, but it turns on and stays on whenever he attaches a large piece of metal.

Well, Dave, you must first consider the principle on which that type of device operates. Remember, when you touch the end of the wire, the capacitance between your body and ground change the potential on the wire. That, of course, changes the potential on the IC's input pin, which then turns the device on. If you attach a big piece of metal, it forms a significant capacitor with ground, and that keeps the relay on.

You can still use that piece of metal for the touch plate, but you must first decrease the sensitivity of the input. There are two approaches that you can take to reduce circuit sensitivity, depending on the circuit involved. First, you can apply a small voltage to the input; in that way, the applied potential caused by body capacitance must first overcome that voltage to be effective. Second, you can use a voltage divider at the input so that only a portion of potential affects the input. (That's easily done in your circuit by adding a series input resistor).

Another circuit related to your project, one that I am sure will interest you and other readers, was sent in by Dan Napolitan (PA). In his circuit (shown in Fig. 2) he uses only the familiar 555 timer. If you vary the value of resistor R2 you can change the length of ON time. (The value of R2 should be somewhere between 22 kilohms and 1 megohm.) You can combine the two circuits by taking the output of the first and feeding it to the trigger input (pin 2, not shown) of the 555 timer.

Note that both diagrams show LED's in the output. That is done for testing and adjustment purposes. To operate a lamp, or other high voltage/current device, just substitute a relay for the LED.

Wireless doorbell

Pat LoSquadro (NY) has written to ask for help in finding some kind of "wireless" doorbell. It seems that Pat has an apartment with cement-block walls and does not want to have wires strung around in plain view.

Well, Pat, two approaches to your problem occur to me. The first involves a carrier-current transmitter and receiver that sends RF (*R*adio *F*requency) energy through the AC lines. Of course, you could build the equipment yourself, but the cost of the commercially available units is reasonably low. You have probably seen them advertised as wireless intercoms, monitors, or baby sitters.

My thought is to place a small bell or buzzer at or near the door in a small box with the transmitter. Then, you can plug the receiver into any convenient AC receptacle in the house. Obviously, you will not need a two-way intercom, though one could be used. Radio Shack has a wireless FM-monitor for about $30 that could be used in this application.

Another approach would be to use an infrared transmitter and receiver. One circuit that could be easily adapted to your application is described in this issue of **Radio-Electronics**.

Walkie-talkie power modifications

A young man, who shall remain nameless, has written to ask advice on increasing the output power of walkie-talkies. That question raises several concerns. First, you should be aware that fooling around with the circuitry of a transmitter of any kind can change characteristics of the signal it produces. That can result in the radiation of spurious signals that could interfere with other equipment. That is illegal.

Second, there are precise legal limits on the power that can be used by certain types of devices. For those reasons, my young friend, I cannot give you the information you seek. In addition, I strongly advise that you operate the equipment as it was intended. **R-E**

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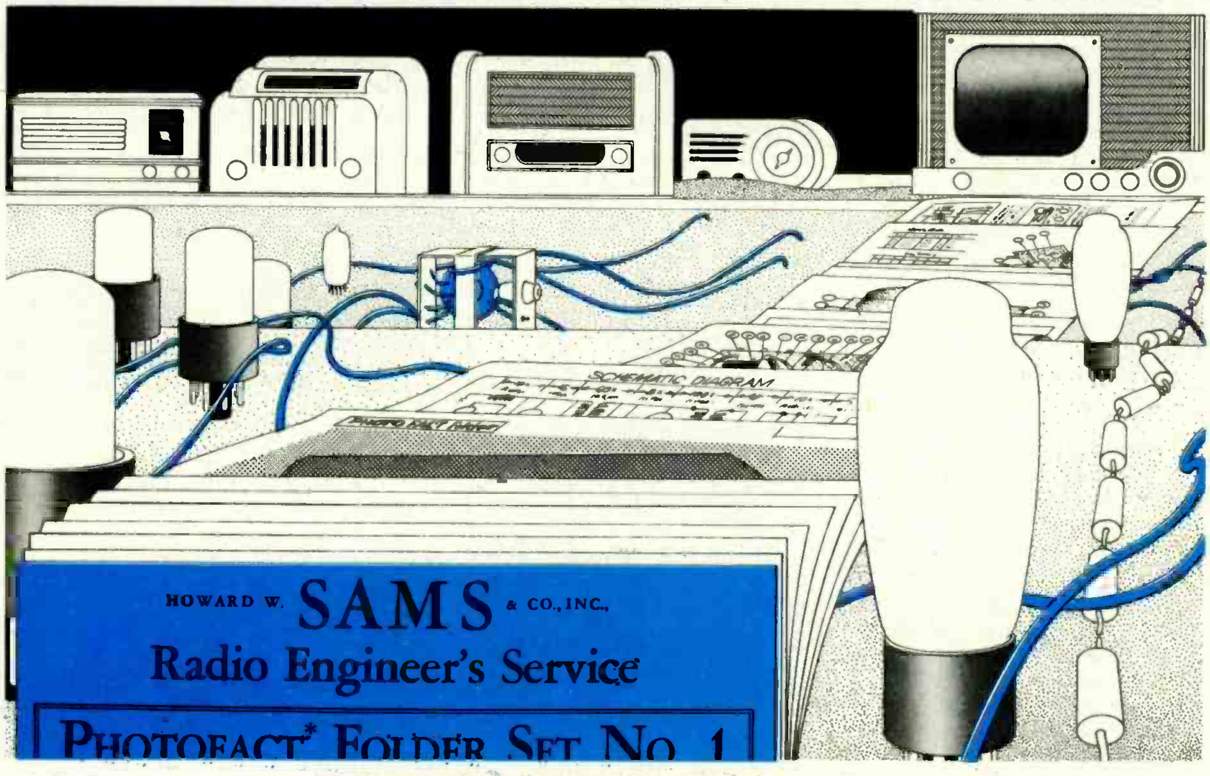

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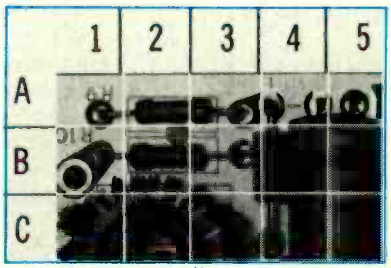

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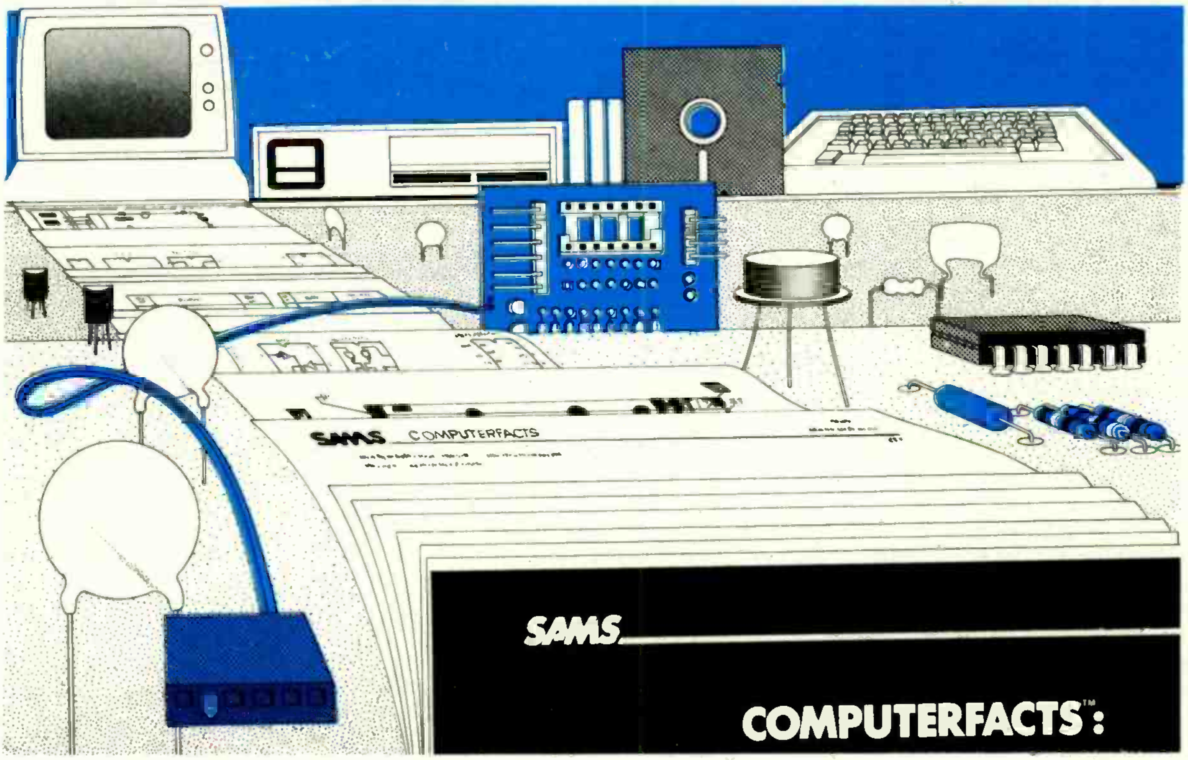

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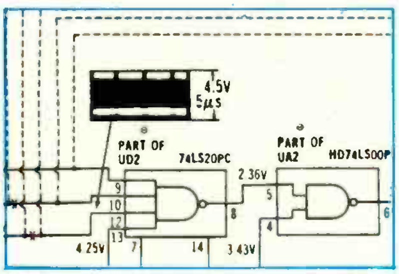

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COMPUTER CORNER

A look at a lesser-known computer

LOU FRENZEL

WHAT MANUFACTURERS COME TO MIND when you think of personal computers? If you're talking about conventional desktop computers, you probably think of Apple, IBM, or Radio Shack without hesitation. If you are talking about low-cost home computers, then Atari, Commodore, Timex/Sinclair, and Texas Instruments probably come to mind. Those are certainly the most popular machines—even though the last two have recently dropped out of the home-computer market. After all, there are more of them than any others in the field. Further, those manufacturers are all large companies that advertise regularly. Therefore, it's difficult not to know about their machines.

On the other hand, there are over 100 other manufacturers of personal computers. Their machines are not as well known and the manufacturers are certainly not as visible. For example, have you heard of Columbia, Corona, Eagle, Franklin, Memotech, Morrow, Seequa, Spectravideo, and TeleVideo? They're just a few of what we might call the second string of personal-computer products. Those manufacturers each sell hundreds of thousands of computers to satisfied customers. Yet most of us tend to forget the off-brand machines, and focus our attention and interest on the more popular mainstream units. Still those lesser-known companies offer excellent products—usually with prices, performance characteristics, or unique features worth considering.

Recently we had the opportunity to take an in-depth look at an offering from one of the smaller and newer manufacturers of personal computers; and what we found was astonishing. No longer will we ignore that second tier of products and neither should you. You could be overlooking the best machine for your needs.

Memotech's *MTX512*

Recently, Memotech decided to take the plunge and offer a "full-blown" microcomputer; The result of their effort was the *MTX512*. While Memotech isn't exactly your basic household word in computers, they are known for their numerous add-on computer products. Their most popular products are memory-expansion modules and plug-in I/O interface adapters for the Sinclair *ZX81* and Timex/Sinclair *1000*. The *MTX512* (known in Europe as the *MTX500*) is manufactured in a small town in England called Whitney and is an excellent example of the powerful new machines being offered today. The U.S. version went on sale in July, 1983.

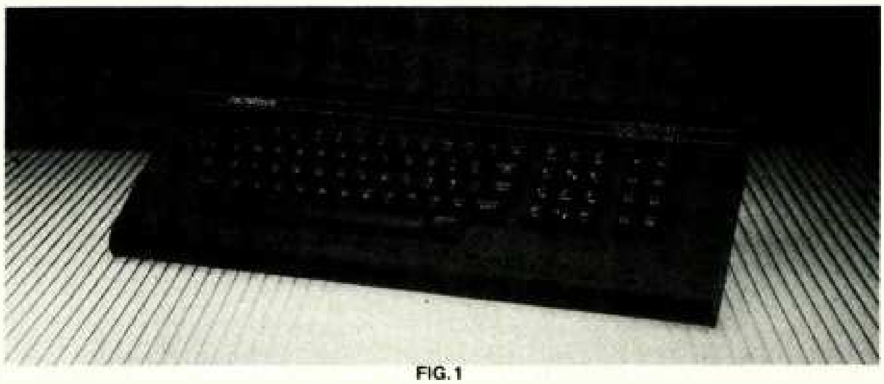

FIG. 1

The *MTX512* is packaged in an unusual but attractive black anodized aluminum cabinet (see Fig. 1). The cabinet itself is really an extrusion especially designed for this application. Very few personal computers have metallic housings; most use inexpensive foam or plastic cabinets. The unit has a 79-key keyboard that includes a numerical keypad and eight special-function keys. The *MTX512* features a Z80 microprocessor running at 4 MHz. It comes with 64K of user RAM, plus an additional 16K of RAM dedicated to video graphics. The user RAM can be extended to 512K using bank switching. In addition, there two disk-drive options available: One is a floppy-disk unit that features a 500K byte double-sided double-density 5¼-inch disk drives, and the other a 10-megabyte hard-disk drive. The unit also comes with 16K of ROM that contains its own version of BASIC (more on that later), the operating system, and other programs.

As for the display, a standard color-TV set or video monitor can be used. The display uses the standard 24×40 format for text and graphics. The machine has excellent color and graphics capabilities. And thanks to a TI9918 graphic IC, the *MTX512* can accommodate up to eight virtual screens. Its graphic resolution is 256 by 192 pixels with a full 16 colors available in the high resolution mode. Up to 32 *sprites* can also be created and used. (A sprite is a special type of user-definable character. By user-definable we mean that the user decides what the character will look like, what color it will be, and where the character will appear on the screen.) An 80-column adapter and an RGB color-output interface are also available.

The unit also comes with several I/O interface ports, which include a standard Centronics-compatible parallel I/O port for a printer, two game-controller ports for joysticks, and a sound output. A built-in 2400-baud audio-cassette interface lets you use an external cassette player/recorder for mass storage. There is also an RS-232 serial-port board (2 ports-per-board) available as an option. Another interesting I/O feature of this unit is the *Oxford Ring*. The Oxford Ring is a built-in communications system using ring nodes that allow up to eight *MTX512*'s to be interconnected for office, school, or lab applications. That is accomplished using the RS-232 ports and the optional disk system. The *MTX512* has a slot on the side for plugging in ROM cartridges, which also accepts Memotech's game programs such as Toado, Blobbo, Kilopede, Super Minefield, Continental Invaders, Chess, and several others. Additional games, and program cartridges such as the Pascal and Forth languages will be available in the future.

Firmware

The special version of BASIC mentioned earlier is known as Oxford BASIC. Oxford BASIC is pretty much the stan-

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COMPUTER DIGEST

NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

IBM COMPATIBILITY...

It's a claim many computer manufacturers make. But just HOW compatible IS your computer?

SOFTWARE DIAGNOSTICS

New software will analyze your disk drives and pinpoint problems before they start.

MAKE YOUR COMPUTER'S MEMORY SAFE

When power fails, you could lose the entire memory. Here's how to keep that from happening.

A GERNSBACK PUBLICATION

EDITORIAL

Let's set the record straight.

■I was having dinner with a friend last night, and he commented that I've probably got—to use his words—a very "cushy" life. "You sit around in a big, walnut-panelled office all day, giving orders, pretty secretaries running in and out, three-hour lunches...You've really got it made!"

'Taint so. Much of my work is done in my bedroom at home, working at my typewriter, wearing only a pair of shorts. When I can spend time at my "office," where I just happen to be right now, I'm in a room perhaps ten feet wide by about fourteen feet long. The computer terminal at which I'm working sits on a Formica-topped table, perhaps four-by-six feet in size, and the room is filled with a bunch of mysterious cartons, an old copying machine, a green metal cabinet or two, and a bank of file cabinets. Glamorous? Hardly.

I'm certain that someplace this side of Hollywood, there may be an editor or two that lives the kind of life my friend's fantasy called up, but I've never seen it, and frankly, I hope I never do.

Editing a magazine is simply hard work. It's exceedingly rewarding work, but it's also hard work. What makes it rewarding is getting mail from people like you, who read the magazine, who tell us that they appreciate what we're trying to do. That makes it all worthwhile. Ask any editor worth his salt what he does for a living, and before long, you're going to hear him talk about his readers. You, the reader, are what it's all about. For example an editor might be personally interested in a subject covered by a manuscript that comes in from an author, but the acid test of whether or not the manuscript is purchased, is "How much reader appeal will it have?" Each and every decision that an editor makes is based on the reader's point of view.

That's why we want to hear from you. We're starting a "letters" column with this issue of **ComputerDigest**, and we'd like some feedback from you. If you like what we're doing, please tell us. If you don't like it, tell us that, too. Got some suggestions on how we can improve things? You'll be amazed at how we listen!

Of course, editors *do* make certain decisions on their own. For example, I just decided—on my own—I'm going to get a cup of coffee.

BYRON G. WELS
EDITOR

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IBM COMPATIBILITY

IBM compatible? Sure! But just how compatible?

MARC STERN

■In the world of personal computers, there's probably no more controversial a topic than compatibility. There are so many stories about it because so many manufacturers want to make their systems just a bit different from others on the market.

Why? Most likely, it's the result of an effort by computer manufacturers to marry users to one company for all their peripheral and software needs. And who can blame them? It seems to make eminently good business sense (at least to the manufacturers—not necessarily to the consumers). But it has led to an abundance of incompatible operating systems, incompatible disk formats and sizes, and incompatible programming languages.

Frankly, it's a confusing, aggravating situation for the average computer user. It's a situation about which many computer users complain, but also about which they have very little control. The various manufacturers have control of the situation—and, for competitive reasons, it's unlikely they will agree on standards in the near future.

Halting steps forward.

By and large, that situation is likely to exist in the personal-computer world for some years to come as droves of computer manufacturers enter, compete and leave the industry and new competitors take their places.

There have been some halting steps toward standardization. It's not due to any cooperation between the manufacturers. It's because of the dominant presence of certain disk-operating and personal-computer systems in the marketplace. For example, the CP/M operating system has brought a measure of standardization to the 8-bit computer world, while the IBM *Personal Computer* and its operating system, PC-DOS, have brought some standardization to the 16-bit world.

Why have these two forces been so dominant? With CP/M, quite simply, it has been a matter of longevity and ubiquity. It was one of the earliest disk operating systems in the microcomputer world and, as such, many programs were naturally written to run under it.

For the IBM *Personal Computer*, the story is much the same. Because IBM is so dominant in the world of computers and because its *PC* has become a major force in the market, it was inevitable that it would become the standard in the 16-bit world. Even the 16-bit version of the venerable CP/M system couldn't compete with it (apparently because of poor marketing decisions).

Limited standards.

Since CP/M has become the *de facto* standard in the 8-bit world and since it has been covered in the pages of **ComputerDigest** (May and June 1984), we will concentrate on what is becoming the standard in the 16-bit world, MS-DOS, or, as it is also called, PC-DOS, the operating system of the IBM Personal Computer and "compatibles."

At the start, let's understand that even though advertising hype may say a computer is "PC-compatible," the range of that compatibility can vary greatly. There are computer systems on the market—

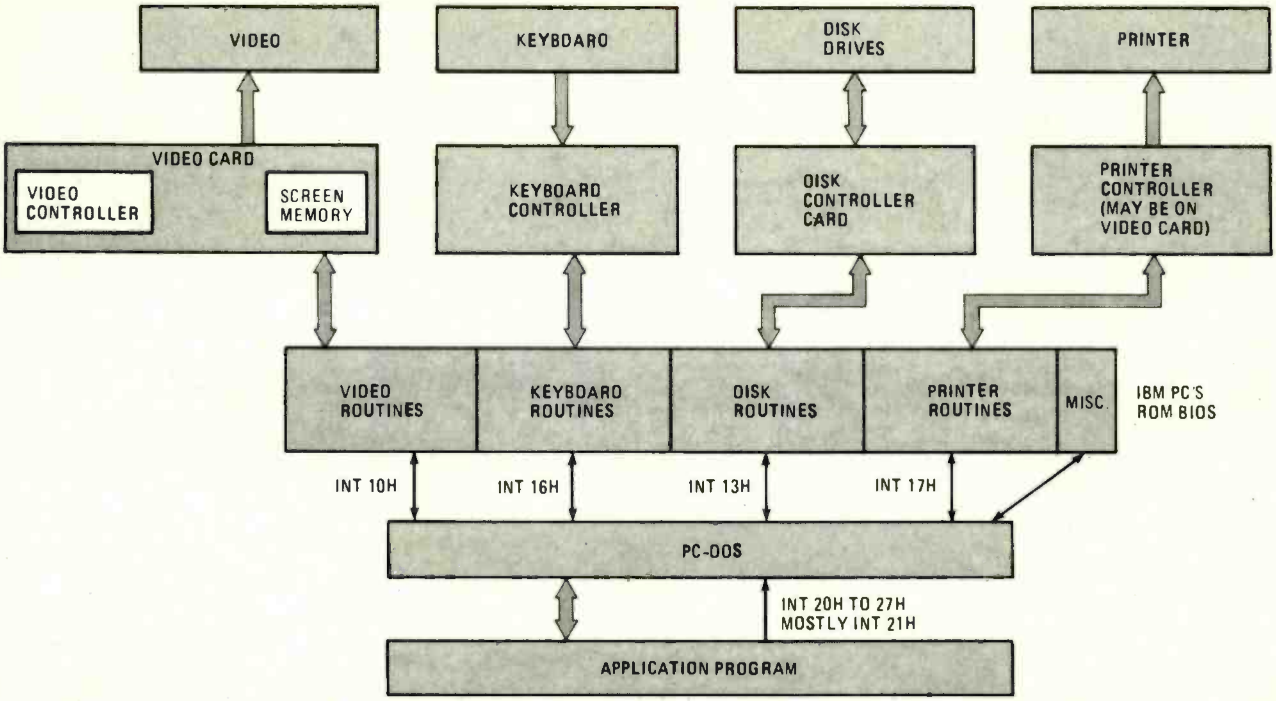


FIG. 1—AN APPLICATIONS PROGRAM can access IBM *PC* hardware through PC-DOS. However, a program can also access the *PC's* ROM directly, causing incompatibility.

such as the Leading Edge PC, Sperry PC, Corona, and Compaq—that can run just about any program available for the IBM *PC*. But there are others on the market, such as the Heath/Zenith *H/Z 100* series that can only read IBM data disks. And there are still others that are only "DOS-compatible," meaning they run MS-DOS but really can't handle program or data disks for the IBM *PC*.

Theoretically, any computer capable of running MS-DOS (MicroSoft-Disk Operating System) is capable of handling any program or data disk created or used by another MS-DOS computer system. In *reality*, it just isn't true. But it's not due to any fault of the operating system. Programmers can develop applications programs that will run under MS-DOS and that won't be difficult to move from machine to machine. But because of the way in which the IBM-*PC*—and those who write programs for the *PC*—handle things, programs that are developed for the PC may or may not run on a machine that is supposed to be compatible. On some "compatible" machines, however, the developers consciously tried to give users access to the wide base of IBM-backed programs. They succeeded in that 95 percent or even more of the programs available for the *PC* will run directly on those machines. But, on others, the developers were only striving for operating-system compatibility—meaning that they wanted a machine that could run MS-DOS. On such machines, few, if any, IBM-*PC* programs will run directly. Of course that doesn't mean that the programs cannot be rewritten so that they will run under MS-DOS. But let's see why they are not written that way for the IBM *PC* which, after all, is an MS-DOS machine.

How IBM does it.

For a better explanation of why all "PC-compatible" machines aren't equal, let's take a look at how IBM does things.

When an applications program interacts with the PC hardware, it does so through PC-DOS. Keyboard I/O, video I/O, disk I/O, printer I/O, etc. are all handled by PC-DOS through software interrupts (which is something like calling a subroutine). But there is another way to access the PC hardware: through the *PC's* extensive ROM.

The advantage of using the PC's ROM instead of PC-DOS is that, in many instances, the ROM software lets you do more. For example, PC-DOS' video control is rather limited—its functions are much like those of a teletypewriter. You can send characters to the screen, but not much more. For example, you cannot directly position the cursor through PC-DOS. So word-processing programs, for example, go to the ROM, which contains extensive text- and screen-handling routines.

The routines in the PC's ROM are also accessed by interrupts. They can be accessed through PC-DOS (as shown in Fig. 1). But an applications program can "go around" PC-DOS and directly access the ROM-based routines. That (not shown in Fig. 1) is the real reason for the incompatibility problem.

The PC uses interrupt 10H (the H indicates a hexadecimal number) for video control, while interrupt 16H handles input from the keyboard. The system uses interrupt 17H to handle output to the printer, while disk input and output is handled via interrupt 13H (See Fig. 1). Those and other interrupts provide for most programmers a chance to control the *PC* more completely than PC-DOS does. They write their applications programs accordingly.

For instance, when a programmer implements interrupt 10H to have direct access to the PC's video capabilities, he is given access to a set of powerful, proprietary, ROM-based routines; with those powerful routines he can make the screen do just about anything he wishes.

Interrupt 16H is used to access keyboard routines. PC-DOS can be used to get information on the keyboard. But programmers prefer to use interrupt 16H directly. You see, the *PC's* keyboard not only has the usual range of keys, but it also has 10 special function keys, and it is capable of generating an alternate set of characters. Some of the key codes are non-ASCII. PC-DOS can pass their values back to the program, but the ROM routine can do it in a more convenient form. So programmers use it.

The fact that so many programmers make use of the *PC's* ROM routines directly makes it hard for users of non-IBM machines. If you try to run a PC-DOS program on your IBM "compatible," you may find that the program makes many calls directly to the *PC's* ROM that may or may not be matched in your MS-DOS machines.

Of course, some developers have purposely opted to build their machines following IBM's blueprint as closely as possible, and some machines are more compatible than others. But on many machines, programs that use the proprietary capabilities of the *PC* will either fail to run or will run erratically, causing strange results or screen messages.

Levels of compatibility.

If all things were equal in the world of microcomputers, then any program written to run under MS-DOS (PC-DOS) would be able to work on any MS-DOS machine. But, as we have seen, that just isn't the case. If you want a machine with 100% compatibility, a machine that will run all programs written for the *PC* without any surprises, then your only choice is to buy an IBM *PC*.

However, there are manufacturers who have chosen to implement IBM-like functionality in their machines and have made them nearly identical in capability with the *PC*. But don't forget that there are others who have only given their machines data-level compatibility, and still others who have chosen only to use MS-DOS without attempting to emulate the IBM *PC*. In a moment we will see the differences between those levels of compatibility.

In all honesty, there are limits to what the manufacturers can do because the routines contained within the *PC's* ROM are proprietary and copyrighted. So those companies that have chosen to implement a nearly IBM-like system have been forced to do massive amounts of engineering in order to achieve IBM-like capability, without violating any copyrights. An almost-fully-compatible machine must provide ROM calls like those in the *PC* (but they don't have to be in ROM). For close compatibility to be achieved, the video memory must also be like the *PC's*.

With that said, you can now see that there are levels of PC-compatibility. The first level is nearly total compatibility, with the machine capable of using IBM programming and data disks and having the ability to create disks which can be read and used by the *PC*. The programming for those machines will also usually run without modification on the *PC*. (Although there will likely be some problems with BASIC unless each machine converts the BASIC instructions into the same single-byte tokens.) Near-total compatible machines can use *PC* programming and data disks, but their BASIC implementation will probably be different.

The next level can be considered system level or data compatibility. An example of such a machine is the Heath/Zenith *H/Z-100*. That microcomputer is capable of using IBM-generated data disks, but will run few, if any, PC-DOS programs. Instead, the user must employ a program ported over to the specific machine, but written under MS-DOS.

In this category of machine, the subtleties of the programmers become apparent. Because PC-DOS programmers make use of calls directly to IBM hardware, those calls usually don't work correctly on the data-compatible machines. The result is that programs that work correctly on the PC either won't run on the data-compatible computers or will run poorly, at best. If you can get them to boot and run, the chances are good that at some point in the program, your computer will head off into never-never land with the disk drive spinning.

The final category of machine is the DOS-compatible machine. That is, a computer that only uses the MS-DOS system and heads its own way as far as implementation and programs are concerned. It usually won't run any *PC* program and it usually can't use a *PC's* data disk. About the only apparent justification for calling it "PC-DOS-compatible" is from a marketing standpoint. It is apparently an effort on the part of the manufacturer to climb on the IBM bandwagon and gain from the popularity of the machine.

Two good tests.

So how can you determine if a machine is a true compatible, a data compatible, or a DOS-compatible? There is an easy test, involving the programs *Microsoft Flight Simulator* and *Lotus 1-2-3*.

Those programs make heavy demands on screen and keyboard interrupts and machine calls. If they will run on a system being considered, then it is a good bet that it is a (nearly) true compatible. But if the computer just sits there with no reaction, then the machine is either only data compatible or DOS-compatible. If you are looking for a true compatible then that system isn't for you.

However, if you all you want is MS-DOS software and the ability to have 16-bit IBM-like power at your fingertips, as well as the broad variety of software available, then a data-compatible or DOS-compatible machine is the ticket because you can take advantage of familiar software names that have been ported to these machines.

DIAGNOSTIC SOFTWARE FOR DISK DRIVES

Diagnose sick disk drives before they give you trouble.

HERB FRIEDMAN

■Of all the various devices that go into a personal computer system, more often than not it's the disk drives that cause the most problems. If a computer fails, it fails: the screen fills with garbage and you know to press the reset key or recycle the power. If the printer fails it also fails: it stops printing, or feeding paper, or a good percentage of the printing is the wrong characters.

But a disk drive...it fails with finesse. It will work fine for 15 minutes, then fail to read data, and when you go to check it out it's back to reading data properly. Or it stores data on Monday, then won't feed it out on Tuesday. Or disk A: won't read data recorded on disk B:, while disk C: won't read data recorded on the computer in the next office.

Disk drives are very fussy, and rightly so. Consider, for a moment, the precision that we expect from something that sells for something like $200 (the cost of a "bare" drive—meaning without power supply or case). We expect it to put down, in the space of 0.8 inch, at least 40 magnetic tracks that are so precisely positioned they can be sensed by any other disk drive (for the same computer) any where, any place, in any environment, anywhere in the world. We expect the polarization of the magnetic fields (the "alignment") to be so precise that data can be recorded on any disk drive and read by any drive. We expect the mechanism itself to be so precise that if we cycle the drive hundreds of thousands of times, the read/write head will always be positioned right where it belongs.

Yes, we ask a lot from disk drives. That they work so well is almost magical. But disk drives work within such narrow tolerances that if wear or aging affects anything concerning the mechanical system the whole system "crashes."

Though a disk drive has many critical areas, for many years the only test commonly available to the average user was the "speed test." The speed of the 5¼-inch floppy disk is standardized at 300-RPM ±2%. Actually, we strive for ±1% because ±2% is really 4% "worse case." (Figure it out: If disk A: is 2% high and disk B: is 2% low, though both are within tolerance, the disparity is 4%—and that's looking for big problems if any other adjustment isn't right "on the money."

The typical speed test is done with software that provides a screen display of the disk speed, either through direct numerical values or through a graphic display. There are speed-test disks available for just about every major computer. Prosoft's (Box 560, North Hollywood, CA 91603) speed-test program called *RPM*, whose screen display is shown in Fig. 1, is representative of the better speed-test software. It continuously updates the data display, while the range of variation is stored by the graphic display—providing a visual indication of the speed range.

Most of the speed-test software available for personal computers is "memory resident," meaning the program loads into memory so the disk itself can be removed. The software disk must be removed because the software records test signals on a "blank" disk. (The speed test(s) will destroy any data on the disk.)

If you have ever examined a disk drive you will wonder why in heck you need test software when the

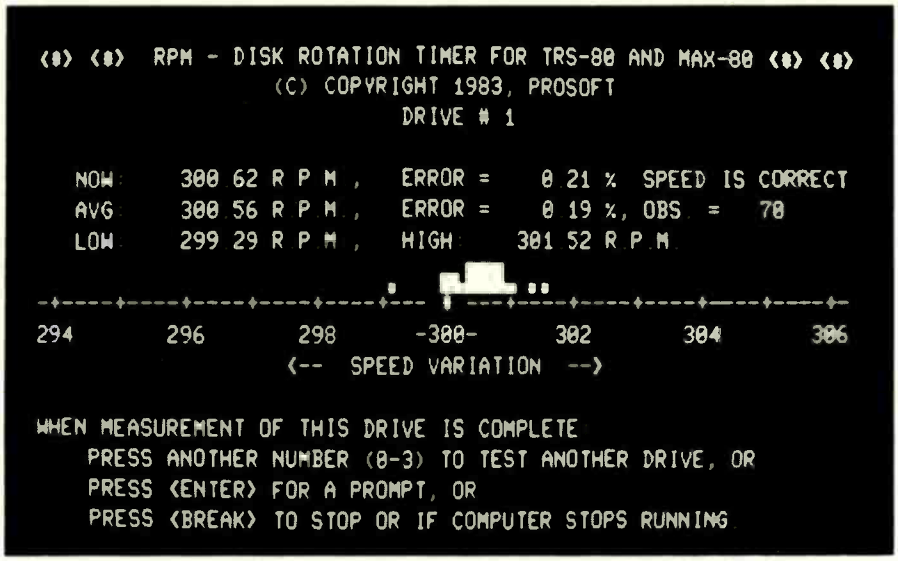


FIG. 1—THE DISK-DRIVE PROGRAM *RPM* displays the speed drift in both direct quantities and on a bar graph. Note the frequent read errors displayed on the graph.

disk drive mechanism has a "strobe" pattern on the flywheel or stabilizer (the metal weight attached to the back of the spindle that rotates the disk). Examined under the "pulsating" light from a fluorescent or neon lamp, the strobe pattern will appear frozen when the drive is running precisely at 300 RPM. So why use software when we can observe a strobe?

There are several reasons why software is preferable to "reading the strobe." First, you don't want to disassemble the drive's cabinet in order to view the strobe every time you feel it necessary to test the disk speed: it's a lot easier just to run software from a disk. Second, unless you're very skilled, it's almost impossible to determine if the speed is within tolerance, if the pattern is "drifting." Third, the strobe pattern doesn't easily disclose "crossover drift." By the time you notice the strobe pattern indicates a "low speed," the drive is running at a "high speed;" a real problem if you're attempting to adjust the disk drive's speed yourself.

Until recently, virtually all 5¼-inch drives in common use had a user-accessible speed adjustment. Generally, it was some form of trimmer potentiometer that could be adjusted using a small screwdriver or a TV-alignment tool. If a test disk disclosed that the disk speed was incorrect, the user could bring it "on the mark" by simply running the software and adjusting the potentiometer until the screen presentation was as close as possible to 300 RPM.

But technology eventually outruns the consumer. Some (and soon all) of the modern disk drives have electronic servo speed control that is often referenced to a crystal-controlled oscillator; hence, there is no user adjustment. The most the speed test disk can do is indicate whether the servo circuit has failed: the actual repair or adjustment must be made by a service shop.

Speed checks aren't enough

Poor speed adjustment is just one of the many things that cause disk read errors. Unfortunately, until recently the only software available to the average user tested only the disk speed, nothing else. The specialized software that tests all the disk drive adjustments, such as clamping (hub eccentricity), head alignment and sensitivity, mechanism hysteresis, and head azimuth was available only to the disk manufacturers.

Actually, all the required tests are on a single special diagnostic test disk manufactured by Dysan (5201 Patrick Henry Drive, Santa Clara, CA 95050), the same people who produce high-performance blank disks. The problem is that the Dysan diagnostic requires a

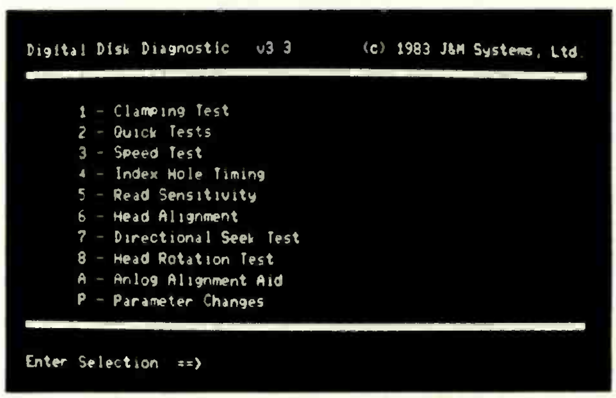


FIG. 2—THE MENU FOR J&M's DDD test disk. Other software well might have a different menu for the same functions.

separate in-memory runtime program written for a specific computer, so until recently the diagnostic disk wasn't available to the average user.

But create a need and someone will write the necessary program. Presently, J&M Systems (137 Utah NE, Albuurqerque, NM 87108) markets a complete diagnostic kit consisting of the Dysan Diagnostic Disk and a separate disk with runtime software written specifically for the Radio Shack Models *III* and *4*. By the time you read this article, Dysan themselves will have introduced a disk-drive diagnostic package for the IBM *PC* (and expects to have diagnostic packages available for other computers in the near future).

The Dysan Diagnostic Disk—which they and everyone else refers to as the DDD—is read-only and contains many different standardized tests and checks recorded in precisely-positioned tracks. When you run

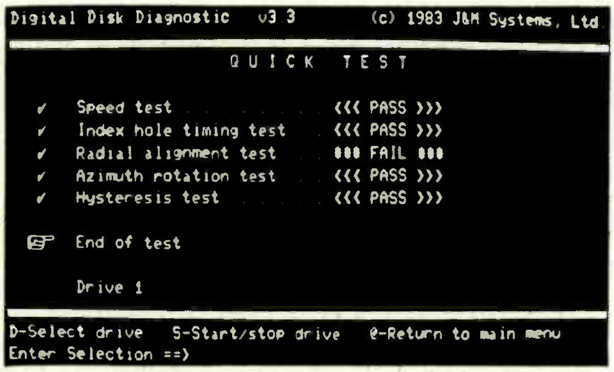


FIG. 3—THE *QUICK TEST* does just what it claims: It tests the drive and compares the results against built-in standards. Note that the drive failed the radial-alignment test.

the DDD you are actually comparing the performance characteristics of your disk drive against recognized standards.

While the visual displays will depend somewhat on the specific diagnostic package you use for your computer, the J&M screen displays are representative of what you can expect. While no one suggests that you muck around inside the drive and try to make adjustments using the screen display, it's really possible for a skilled technician to calibrate a drive using the DDD. In fact, some of the tests are specifically intended for aligning the drive.

All tests are selected from the main menu shown in Figure 2. The DDD provides several individual tests, but if you're in a hurry and want to do quick-and-dirty periodic checks, the DDD contains a "Quick Test" for speed, index-hole timing (you've never heard of that test?), radial alignment (or that one?), Azimuth rotation, and hysteresis. (See Fig. 3.)

The quick test has its own *pass-fail* limits that are compared against the results of the other tests which are run automatically by the resident software. Unlike the individual tests which provide reference values, the quick-test screen display is pass-fail. If you want more specific information, you can run the individual tests.

The first specific test to run is for *clamping*, as shown in Fig. 4. Clamping is a function of the condition of the diskette's hub. The purpose of the clamping test is to insure that the test disk is properly centered around the drive spindle. Also, the clamping test checks the alignment of the read/write head. If the screen doesn't display a perfect set of eight rectangles, as they say, "You got big trouble!" It's probably the reason that disks written in drive A: gives read errors when read in drive B: (and vice-versa).

The clamping test proved to be an accurate guide to the overall performance of disk drives. We had one computer with three drives (Nos. :0, :1, and :2) that was producing sporadic read errors on drive :1. The first time we ran the clamping test we got nowhere near the eight rectangles on drive :1. Further tests indicated just about every conceivable problem with the drive. While no problem was extreme, they combined to produce a worst-case condition—having errors at the limits of the tolerance ranges—that resulted in sporadic read errors.

For example, the speed test, which is indicated on a bar-graph screen display calibrated from 294 to 306 RPM with 300 RPM at the center. (The maximum limits of ±2% are represented by 294 and 306 RPM.) Drives :0 and :2 produced readings which—more or less—remained where they started out. Drive :1 produced a reading that wandered back and forth, always within tolerance but continuously drifting—an obvious harbinger of doom to come.

For soft-sectored disks—the kind with only one

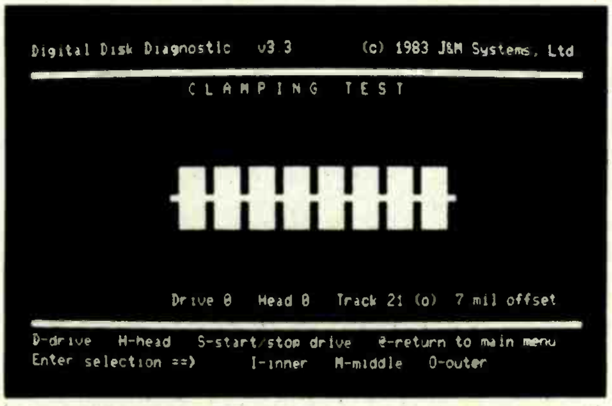


FIG. 4—THE CLAMPING TEST checks the condition of the disk's hub, and also the drive's clamping mechanism. The eight rectangles indicate that the disk is properly centered.

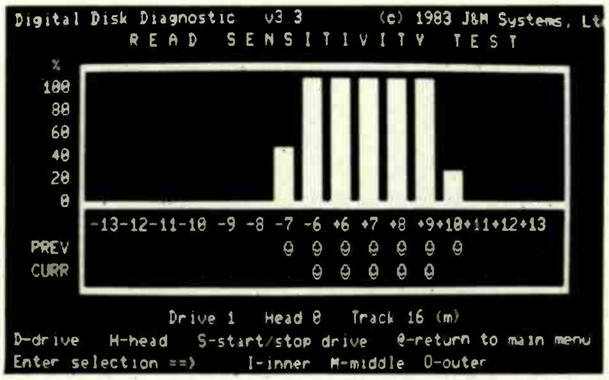


FIG. 5—READ SENSITIVITY is a good indicator of the ability of a drive to read disks recorded on other drives. The display shown indicates that drive 1 passes, but barely.

sector hole—between 100 and 30 microseconds should elapse from the leading edge of the index hole to the beginning of the sector mark. The measured timing is indicated by a bar graph with 200 microseconds—the optimum value—at the center. Actually, unless the drive literally falls apart or the LED that shines through the hole or its photodetector fails, you should never find the screen display in error. If you must align the index hole timing simply move the photodetector while observing the display. (*Don't* do it unless it A) needs it, and B) you know what you're doing.)

Read sensitivity is the ability of the drive to read low-level signals from the DDD. The signals that test for sensitivity are recorded progressively offset from the centerline of the track. The more sensitive the head the greater the offset that can be read.

As shown in Fig. 5, sensitivity is indicated by a special bar graph that indicates how many times out of five tries the offset is read. The results are expressed in percent. (As the drive mechanism ages, the upper and lower limits of the display are reduced.)

The same bar graph is used to indicate head alignment. If the bars are displaced, the head is out of alignment. As we've discovered, if all heads are similarly out of alignment, they cancel the error and disks from drives having the same misalignment can be read (within limits). But read errors can occur when a misaligned head tries to read data recorded on a properly aligned head, or one misaligned on the opposite side of the center mark.

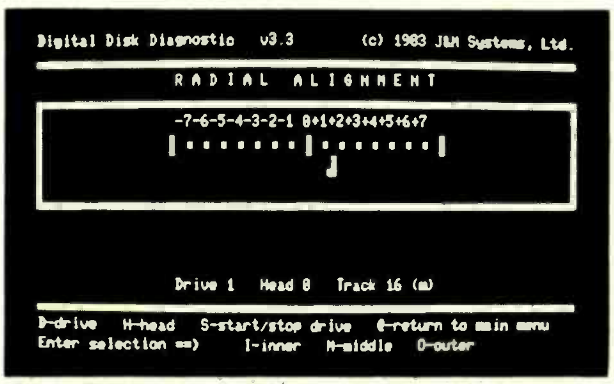


FIG. 6—THE RADIAL-ALIGNMENT TEST must be interpreted in terms of the other tests. Here, drive 1 is shown in alignment, yet all other tests, including the Quick Test, indicated a problem with drive 1. The reason the Quick Test failed is because it combines both read sensitivity and head alignment into the "radial-alignment" quick test.

The radial-alignment test is similar to the read-sensitivity test except only the center of the total good sectors is displayed, thereby making for a much more sensitive display when aligning a drive. As shown in Fig. 6, a special zero-center radial-alignment bar graph is displayed, and the object is to adjust the head alignment so that the display is as close as possible to the center of the scale—the "0" mark.

The directional-seek test is the one that exposes really worn mechanisms because it tests the mechanical parts that move the head back and forth, the parts that get the most wear. This test uses "happy faces" to indicate both proper operation and misalignment. (See Fig. 7.) If the two rows of happy faces aren't in alignment it's likely the head-positioning hysteresis is defective. It works this way: The head is moved *inwards* to the test track and then *outwards* to the test track. If the mechanism isn't worn, it will center on the test tracks regardless of which direction it is moved. If the head positioning mechanism *is* worn, the head takes different positions on the inward and outward positioning. Each direction is represented by its own row of happy faces; if they are stacked one above the other the alignment is perfect. The greater the radial misalignment of the head the greater the misalignment of the happy faces.

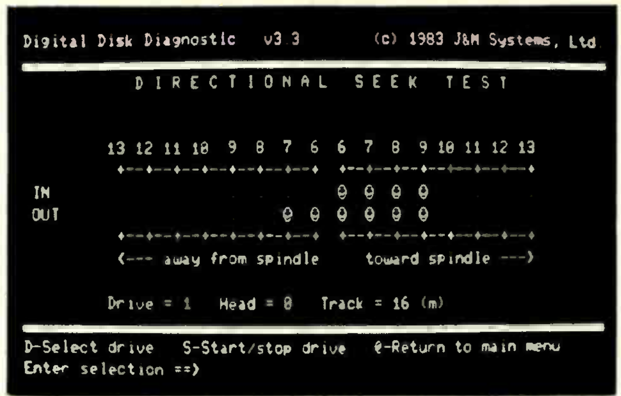


FIG. 7—THE DIRECTIONAL-SEEK TEST indicates either excessive wear or a poorly manufactured drive. Note the results from drive 1, our problem drive.

The head-rotation test or azimuth test is analagous to the alignment test for conventional audio tape recorders. It provides an indication of the angle at which the head intercepts the track's center-line. It uses a special bar-graph display that indicates centering of the pattern. The better the centering, the more precise the head's alignment with the track.

To assist the technician in adjusting the disk drive, the J&M package contains a special *Analog Alignment Aid* program that provides such functions as disk-drive start and stop, select drive, step head in and out, seek track, restore to track 0, etc. All those are procedures for a *qualified* service technician. In no way should the casual user, or even a computer hobbyist, attempt a drive alignment with the program. It requires special knowledge and test equipment, and the service manual for the specific drive.

Summing up

Though diagnostic disks were originally intended for the service technician, they are an invaluable aid to even the applications-oriented user when disk drives start to do peculiar things: when they read properly on even days of the week, but not on the odd days; when they read only when the disks are warm; when disks from drive C: will read in drive B: but not in drive A:. At the very least, they give you an insight into whether the trouble is in the drive or the computer.

HOW TO MAKE YOUR COMPUTER'S MEMORY NON-VOLATILE

TJ BYERS

Don't let power failures wipe out that valuable data forever!

■Ask any computer enthusiast a question about his system—*any question*—and his answer will likely ring with sounds of 64K, 128K, and so forth. Memory has become a buzzword within the computer community. Usually, the larger the memory cache, the more powerful the machine is considered to be.

In large part, most computers use static or dynamic RAM IC's for their memory. Unfortunately, semiconductor memory is volatile. Once power is removed from the device, whether it is accidental or intentional, everything is "forgotten." The sudden loss of power can be most frustrating when you're running a long program or doing word processing. Hours of work can be wiped out in a split second.

Unquestionably, there is a need for a memory that can retain its contents even in the wake of a disaster.

Battery support

The most obvious solution is to place a battery within the memory circuit. Basically, the battery is paralleled with the main power supply and maintained in a standby state until it is needed.

Under normal operating conditions, the computer's main power supply is operating and furnishing power to the RAM. In the event of a power failure, however, the power supply drops out of commission and the battery takes over the task of supplying power for the memory so that the data is not lost.

It is fortunate, indeed, that most memory IC's don't require a full 5 volts in order to retain their stored bits. You'll find that the IC's will maintain their memory with voltages as low as 3 volts. That means that a 5-volt power source is not essential for memory support. Lower voltages can be used, thus relaxing the battery requirements.

Battery isolation

To prevent damage to the battery by the power supply during normal operation, a switching circuit is employed to remove the battery from the circuit unless it is needed. A simple diode switch, like the one shown in Fig. 1, does an excellent job of isolating the battery from the power supply.

The switching circuit uses two diodes to steer currents in the proper direction at the right time. Remember, the battery voltage is normally lower than the 5-volt power supply; it is usually in the neighborhood of 3 to 4 volts. Because the power

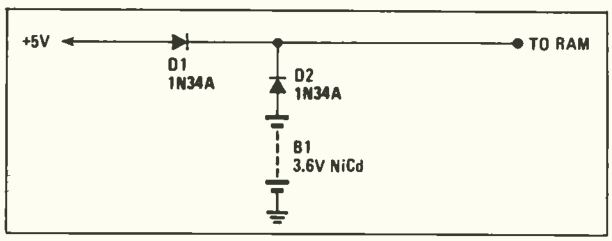


FIG. 1. DIODES WITH LOW forward voltage drops work best in this circuit. Although Schottky diodes usually come to mind first, the trend has been to germanium diodes such as the 1N34A.

supply voltage is higher than the battery voltage, diode D2 becomes reverse biased. Hence no current can flow either to or from the battery, thus isolating it from the rest of the circuit.

When the 5-volt source is removed, though, D2 is no longer reverse biased, and current can flow from the battery and provide power for the RAM IC's. Diode D1 now acts as a blocking diode which prevents the battery current from backing up into the power supply and other computer circuits.

A common choice for the auxiliary battery is the NiCd or nickel-cadmium cell, (commonly known as a "NiCad").

Battery monitor

The voltage across a fully-charged NiCd cell is about 1.2 volts. By stacking three NiCd cells in series, we can make a battery with an output of 3.6 volts—well within the range needed for memory protection.

NiCd batteries have virtually flat discharge curves, which makes them very attractive for computer applications. However, leakage current inside the battery causes the cells to self discharge. The amount of self discharge is dependent upon the type of battery you use and its surrounding temperature. Regardless of the battery though, the entire charge will eventually bleed itself off.

Now this battery death could occur at a most inopportune moment—usually when you least expect it. A quick check of the batteries from time to time will eliminate the problem. But that simple chore often goes undone until it's too late.

Fortunately, Intersil (10710 N. Tantau Ave., Cupertino, CA 95014) makes an inexpensive battery monitor, the ICM7201, that can solve this problem. (That IC is sold through most Radio Shack stores.) Figure 2 shows a simple circuit that lets you monitor the battery voltage.

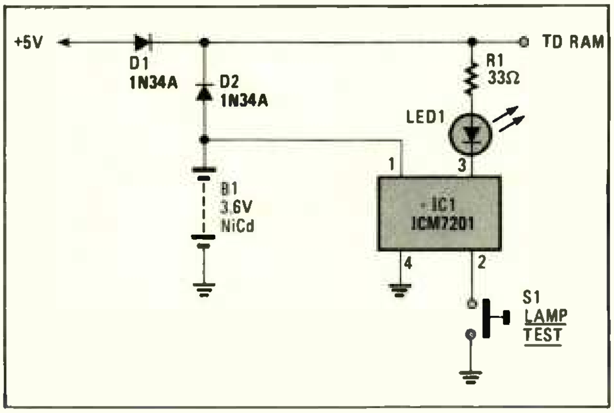


FIG. 2. GROUNDING PIN 2 will light the LED, thus providing a lamp-test feature.

The ICM7201 is a four-lead device that measures the voltage of your battery pack and can be used to give a visual indication of the battery's condition. As long as the battery voltage remains above 3.1 volts, the LED does not light. But if the voltage dips below 2.9 volts, the LED *will* light, indicating that only 5% of the battery's charge is left. That means that it's time you recharged your NiCd cells before they die altogether.

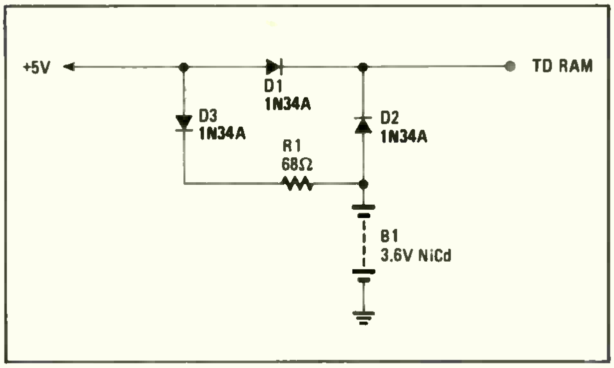


FIG. 3. A 68-OHM RESISTOR limits the charging current to 10 mA.

Battery charging

In most cases the NiCd's can be charged right from the 5-volt line. The charging current, however, must be limited. That's easily accomplished by inserting a resistor between the 5-volt source and the battery, as shown in Fig. 3. The value of the resistor is selected so that the charging current satisfies the charging requirements of the battery, while staying within the limits of the power supply.

Depending upon the cell you use and your particular system, the value of the current-limiting resistor will vary from one application to the next. Calculating the value of that resistor is easier if you realize that the battery is actually placed in a float application. That is, the battery doesn't ordinarily have to supply power and it simply "floats." That means it has plenty of time for recharging between uses. Therefore, the charging rate can be rather small in comparison to other charging schemes.

Normally, a trickle current is all that's needed to keep the battery alive. As a rule of thumb, the trickle current is numerically equal to or less than 10% of the battery's rated capacity. For example, a standard "C" size NiCd cell, which has a capacity of 1200 mAH, should be charged with 120 mA, no more. Otherwise you run the risk of overcharging the cell, and quickly destroying it.

Notice that another blocking diode, D3, has been added to the circuit. Its function is to prevent the discharge of the battery through the power supply via the charging resistor in the event of a power failure.

What battery size?

How long will a fully-charged battery last? That all depends upon the battery itself and the number and type of RAM IC's it has to support. Bipolar RAM's, like the 2101, are pretty power hungry, drawing as much as 5 mA each in the standby mode. CMOS memory IC's, on the other hand, draw very little current, and the battery can be expected to last considerably longer.

Size the battery to your memory power requirements and the time you need it serviced. Let's say, for example, that your memory demands 5 mA. If you select an "AA"cell, which has a capacity of 500 mAH, the battery can maintain the memory for about 100 hours. Remember, you will need three cells in series.

Lithium batteries

One of the problems facing the user of batteries for backup power has always been shelf life. The longer a battery sits, the more charge it loses, even if it's not being used. The NiCd overcomes that problem by constant recharging.

Unfortunately, charging circuits are bulky and expensive. They add to the cost of providing memory protection and require considerable board space.

Recently, a new battery has come into the picture which eliminates the shelf-life problem: the lithium battery. Lithium batteries have a shelf life that exceeds ten years!

Lithium cells also have another characteristic that makes them particularly attractive for computer use. Most batteries, as you know, generate less than 2 volts. The carbon cell produces 1.5 volts and the NiCd stores 1.2 volts. A lithium cell, on the other hand, develops 3 volts. That means one lithium cell can do the work of two flashlight batteries or three NiCds.

That results in a considerable savings of space—a commodity so precious in cramped computer cabinets. And because lithium batteries are primary cells, they require no charging circuits.

When the lithium battery is teamed up with the CMOS memory IC, a natural match up occurs. (See for example, the non-volatile memory add-on for the Sinclair ZX81 in the July and August 1983 **Radio-Electronics.**) The newer static-RAM designs consume almost no power in the standby mode, and the lithium cell will last as long as its shelf life when used in this application *even with constant use!*

Consequently, many lithium cells come with solder tabs rather than button contacts. The battery is simply soldered in place right on the memory board. The chances of the battery going dead before you service the board are very slim.

A more recent development is the introduction of a RAM IC that contains its own battery source. That IC, manufactured by Mostek (1251 W. Crosby Road, Carrollton, TX 75006), plugs right into the same socket as a conventional memory IC and provides its own standby power in the event of a power failure.

Write protection

In most cases, it is not advisable to alter the data within the RAM after the operating voltage has dropped below 4 volts. That precaution is especially critical once the backup battery has taken over control of the IC. First, it requires more power to keep a RAM in its operating mode than it does to keep it in its standby mode. Since the battery already has a limited supply of power, that's important.

Second, and more important, the data bytes don't always write properly when they are entered under low-voltage conditions—the probability of an erroneous entry is quite high.

To protect against accidental data changes therefore, the write function must be disabled while the RAM is in the standby mode. That can't be done with our simple circuit of Fig. 1. We must instead go to a more sophisticated design, which senses the difference between the proper 5-volt input and a low-voltage condition. An example can be seen in Fig. 4.

Monitoring the supply voltage is a low-voltage sensor. That sensor can be built from a comparator. The output of the sensor drives switching transistors Q1 and Q2. When the 5-volt input is present, Q1 is switched on and Q2 is off. Current flows from the power supply, but not from the battery.

When the 5-volt line falls below the preset limit (usually 4.5 volts), the output of the low-voltage sensor toggles: Transistor Q1 drops out, and Q2 is activated. Battery power now supports the RAM. At the same time, the low-voltage sensor inverts the input logic to the NAND gate, which prevents the chip-enable signal from reaching the RAM. Essentially, the write operation is locked out.

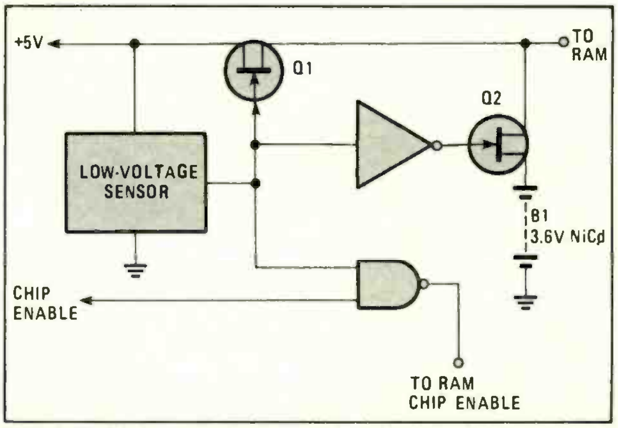


FIG. 4. IT IS NOT ADVISABLE to alter the data within the RAM after the operating voltage has dropped below 4 volts. The low-voltage sensor essentially locks out the write function when the +5-volt line disappears.

Installation

Unfortunately, we cannot instruct you on installing battery protection for your particular computer—computers vary considerably from one model to the next. However, the following guide should help you along. But remember that each conversion is unique. Also remember that this modification might void your computer's warranty.

Your first task is to remove the cover and locate the memory IC's and the power leads.

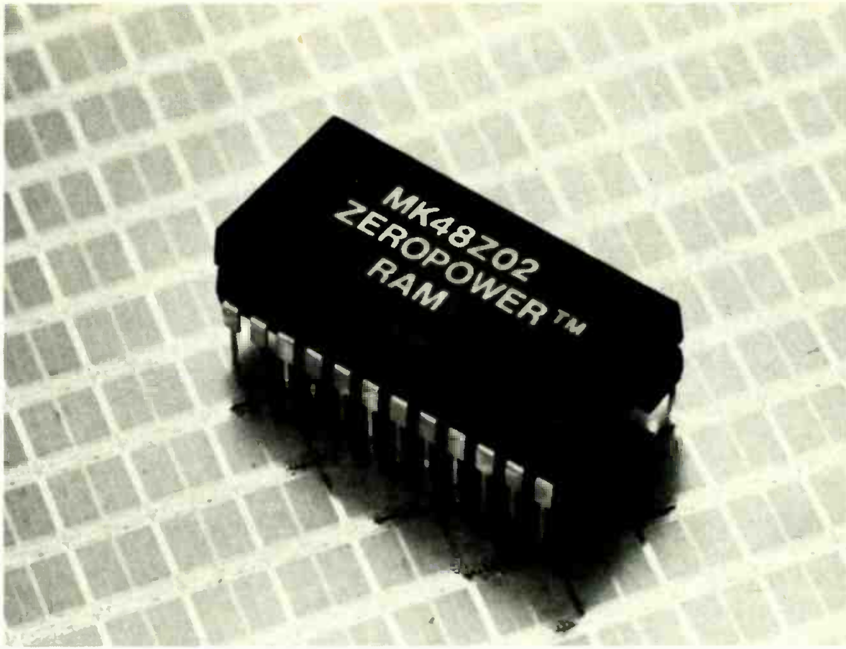
You want to isolate the memory IC's from the main power supply, but not the other circuits. You can do that by cutting the power-supply traces on the board in the proper place using an *Exacto* knife. You may need to make two cuts: One at the input and one in the outgoing line(s). You can then use a jumper to bridge the gap and supply power to the other computer circuits.

Once that is done, all you have to do is to add one of the circuits—such as the ones in Figs. 1, 2, and 3. The hard part is making sure that the components fit on the computer board. If they don't, place them on a separate board and run wires to the memory section.

Standby regulators

Sometimes though, you don't need full-time memory protection. For example, there may be times when you want to temporarily shut down the console without having to dump the memory. Removing the power source to the regulator will, of course, shut everything down and reset the memory. For such applications, a special voltage regulator has been developed. The LT1005 from Linear Technology (1630 McCarthy B'lvd., Milpitas, CA 95035) is a dual-output regulator that contains *two* regulated 5-volt outputs instead of the usual one. (See Fig. 5.) The main power line is controlled by an enable pin on the regulator. A logic

THE MOSTEK MK48Z02 contains its back-up batteries within the IC package.



high to that input enables the main 5-volt output. Pulling the input low kills the output.

The second output is a low-current 5-volt source that supplies power to the memory portion of the computer. It too, is regulated. That output remains on, even if the main output is turned off or shorted.

In other words, the memory will be preserved while the bulk of the system is shut down.

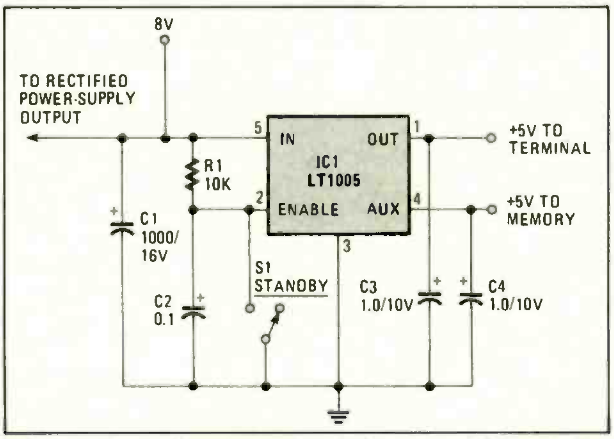


FIG. 5. A DUAL-OUTPUT REGULATOR can provide standby power for the memory while the main systems are shut down.

Mostek's MK48Z02

We metioned earlier an IC that contains a static RAM and lithium battery in one DIP (*D*ual *I*nline *P*ackage). The MK48Z02 combines the low power requirements of CMOS technology with the long lived energy of the lithium battery. But unlike other designs that use external lithium batteries attached to the memory board, the MK48Z02 contains its backup batteries right inside the IC package!

The memory portion of the IC contains a 2K by 8-bit CMOS static RAM. The unique thing about this RAM is its low power requirements. By using advanced CMOS technology, Mostek has been able to reduce the power consumption of the static RAM to an ultra-low 5 nanoamperes. That's about as close to nothing as you can get. In normal operation, the IC functions identically to any other static RAM and has an access time of less than 200 nanoseconds.

Also contained on the chip is an analog voltage sensing circuit that consumes very little power. The precision voltage sensor continuously monitors the +5-volt line. When the voltage falls below 4.5 volts, control logic within the sensor disables the RAM's write circuits and prevents the write-enable signal to the array from becoming active. That ploy locks the memory into the IC and prevents accidental data changes.

After the 5-volt line falls below 3 volts, a switching circuit connects one of the two lithium batteries to the RAM's power distribution bus and disconnects the external power supply. The sensor circuit monitors the voltage of the two batteries contained in the IC. Whichever battery has the highest voltage is the one selected to power the IC. The lithium batteries are removed from service once power is restored.

The batteries are actually welded into the case of the MK48Z02. In other words, they are not replacable. Just how long, you might wonder, will the batteries last? Well, with the combination of low-power consumption and high-battery power, the estimated life of the batteries is ten years.

What happens after the batteries are finally used up? Do they have to be replaced, or will the IC still function? According to Mostek, the IC simply reverts to a standard RAM. It will now use the 5-volt line to power its internal circuits, and completely disregard the internal batteries. Unfortunately, that leaves the memory vulnerable.

It appears that Mostek has succeeded in developing the perfect memory IC. They have avoided the pitfalls of EPROM's while maintaining nonvolatility.

LETTERS

PRO...

Dear Editor:

ComputerDigest is what I've been waiting for. Most computer magazines have no meat in their articles. They seem to be sales pitches for their advertisers.

Radio-Electronics had a good idea in keeping **ComputerDigest** as a separate section instead of scattering it throughout the magazine. Your thoughtfulness is appreciated.
Albert Shugzdis, Arkadelphia, AR

Dear Editor:

Congratulations! I think **ComputerDigest** is heading in the right direction. I cast my vote for its survival and perpetuation!

I pray the "old pros" and electronics purists will be unable to gang up and force you to abandon your new and most promising effort. I think it makes **R-E** all the more valuable.

I also happen to be a fan of Herb Friedman. His piece on CP/M was superb. Wish I had something like that a couple of years ago. Mr. Friedman does a terrific job of boiling the best out of his subject. Please tell him to keep up the good work.
William H. Raden, Toledo, OH

Dear Editor: I welcome the appearance of **ComputerDigest**. As you point out, no one can afford to buy all the computer magazines.

I hope you won't fall into the snare which has captured too many computer magazines. The world does not begin with IBM nor does it end with Apple.

I'll be looking forward to the next insert in **Radio-Electronics.** I've been a Gernsback fan since my youth.
Robert J. McGarvey, Kendall Park, NJ

...AND CON.

Dear Editor:

Regarding **ComputerDigest**: Although it hasn't taken any space away from the regular **Radio-Electronics** editorial features, it must cost a lot of money that could better be spent on developing a series, or several series of articles for the home experimenter. It looks like just another computer magazine, even though it claims otherwise. My subscription is to **Radio-Electronics** and I expect my subscription dollars to be spent keeping it the *best* electronics publication possible. I do not want its precious resources diverted to another computer magazine.
W. M. Tuleja, Boilingbrook, IL

Dear Editor: Regarding your new computer magazine, my advice is "Don't do it!" I want a magazine that covers the entire field of electronics. Sure, an occasional computer article is fine, but don't dwell on them. There is so much more in electronics that is equally, if not more fascinating.
Gary Gordon, Cincinnati, OH

COMPUTER PRODUCTS

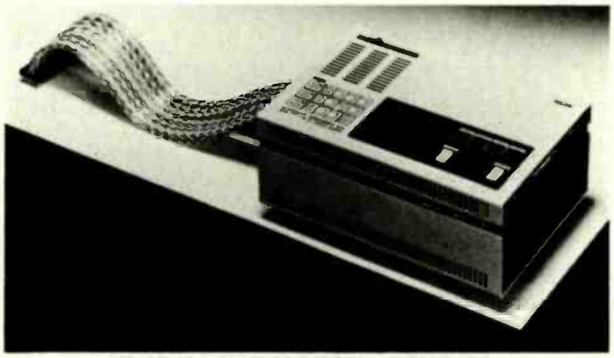
For more details use the free information card inside the back cover

CARTRIDGE WORD PROCESSOR, "*Write Now*", catalog number CØ2 is designed for the Commodore-*64* personal computer. It has a built-in 80-column display, and the user sees exactly what will print. Its features include: easy full-screen editing; compatibility with any printer; special codes

CIRCLE 121 ON FREE INFORMATION CARD

that can be transmitted to printers maintaining justification, and unlimited recall. Finding or replacing any copy is easy, and full-block command enables moving or deleting entire blocks of copy. The "*Write Now*" cartridge word processor is priced at $49.95.—**Cardco, Inc.,** 313 Mathewson, Wichita, KS 67214.

IN-CIRCUIT EMULATOR, the model *ICD-178 68000*, has the following features as standard: It emulates the 68000, 68008, and 68010 in one unit to 10 MHz. There is 128K of emulation memory (expandable to 256K), a 4K × 48 bit realtime trace buffer, and 3 hardware and 8 software breakpoints.



CIRCLE 122 ON FREE INFORMATION CARD

The unit can also be connected to the IBM *PC* with optional software package that turns the *PC* into a complete development system for the 68000. The model *ICD-178 68000* is priced at $7,995.00.—**Zax Corporation, 2572 White Road, Irvine, CA 92714.**

dard BASIC, with statements and commands similar to those used by Microsoft and other popular BASIC language interpreters. However, one uncommon feature of this BASIC is that it contains LOGO-like commands that can be used in creating special graphics effects. Those include: MOVE, ADVANCE, ROTATE LEFT, ROTATE RIGHT, and SPRITE commands.

In addition to BASIC, the on-board ROM includes an assembler/disassembler. Name another machine that gives you an assembler/disassembler as standard equipment. There is also a special program called "*Front Panel*" that provides you with the full capabilities of a standard machine-language monitor. That program is one of the best ones that we've seen; it not only allows you to display and change all register and memory contents, but it also automatically disassembles a portion of the memory content shown on the screen. Three virtual screens show the full-register contents simultaneously along with a 256-byte block of memory in a hex format and a completely disassembled portion of that hex code complete with mnemonics.

You can also single-step the machine and assembler programs one instruction at a time—that feature should prove to be invaluable for such applications as debugging. While the machine/assembly language capability is not often used by the average personal-computer user, it is ideal for learning computer operation and programming, or such things as developing your own special routines.

One exciting bit of firmware included in ROM is a special language called *NODDY*. Its primary application is in developing programs that display sequential blocks or frames of information where the next block shown depends on the response to the previous frame. With that capability, NODDY should be great in creating question-and-answer sequences, exams, and computer-aided instruction (CAI) programs.

The *MTX512* uses the standard CP/M operating system, which puts the entire CP/M applications program library at your disposal. The latest version of CP/M, CP/M Plus (Version 3.0), is included with the disk-drive option.

Overall, the Memotech *MTX512* is an interesting machine; although there is nothing particularly new about a unit with a Z80 microprocessor and the CP/M operating system. What is different here, however, is that few, if any, Z80-CP/M machines feature full-color graphics. Also, most do not contain anything like the *Front Panel* program, assembler/disassembler, or the terminal-emulator program built into this one.

With its color graphics and joystick, the unit would be a good home computer to play games and learn to program on. In addition, the *MTX512* can also be a serious business machine because of its CP/M operating system and software base. Wait 'til you see some of the more popular CP/M programs like WordStar in color: What other Z80-CP/M machine can do that?

In the United Kingdom, the European version (*MTX500*) has little competition. Its main competitor is the popular BBC *Acorn* microcomputer. The U.S. version has already been well received and is obviously on its way to being a best seller, although the competition here is much tougher. Its most direct competition will probably be from the Franklin Ace (an Apple clone), the Commodore *64*, the Apple *IIe*, and the IBM *PCjr.*. Yet the *MTX512* has some uncommon features and benefits that make it worth considering. It's a great machine for the hobbyist or experimenter and dynamite for educational applications.

Billed as a "world class computer," the basic *MTX512* is priced at $595 and is available at many dealers throughout the U.S. For those who want more information, you can write Memotech at 7550 West Yale Avenue, Suite 200, Denver, Colorado 80227. **R-E**

COMMUNICATIONS CORNER

A new era of personal communication

HERB FRIEDMAN, COMMUNICATIONS EDITOR

IN A RECENT ANNOUNCEMENT CONCERNING FM stations, which went unnoticed by most of the general public, the FCC opened up a whole new era in personal communications. In fact, many FM stations are already spending money that they have yet to earn. And the *P*ublic *B*roadcasting *S*ystem (PBS) envisions a national personal-communications network that will bring in millions of dollars for the always financially-strapped public service and educational television systems.

The key to that somewhat grandiose, but not impossible, dream is the recent decision by the FCC to lift virtually all restrictions governing SCA (*S*ubsidiary *C*ommunications *A*uthorization) subcarriers, which are "piggybacked" on the main channel of FM-broadcast stations. To give you some idea of what we're talking about: A "subcarrier" is impressed or multiplexed on an FM-broadcast signal. That signal, transmitted along with normal programming, passes through standard FM receivers undetected—the general listening audience hears only the "main channel." But a special attachment added to the receiver detects the SCA subcarrier, thus providing SCA programming without interference from the main channel.

The SCA service was part and parcel of the restructuring of the FM service in 1945, which moved FM broadcasts to the present 88–108-MHz band. Initially, the SCA service was simply background music (such as Musak) for restaurants and offices, etc. It was originally intended to provide FM stations with a dependable alternate income, while building up a listening audience on a band for which there were few (if any) receivers. Eventually, SCA service grew to accommodate services for specialized audiences, such as talking books for the blind and foreign-language programming. There were even experimental digital-data transmissions of stock-market quotes and news reports. They represented the bulk of SCA-service transmissions with few exceptions.

But the FCC, with its February 1983 decision to deregulate SCA service, has opened up a whole new era in personal communications through common-carrier services. No longer will radio paging be available only through the VHF paging and telephone services. With the new ruling, any group can have their own paging system, if they can find an FM station that will rent them a subcarrier.

As for the national radio-paging service envisioned by PBS, all the user would need to receive radio paging in any major city, and most minor cities, in the U.S. is a pocket pager that can be tuned to the local PBS station. For example, assume that you travel from Boston to Chicago; when you reach your destination, you'd simply tune your pocket-pager to the local PBS station. Now, when your office back in Boston wants you to call them, they call the PBS station in Boston and give them your code and location (Chicago). PBS would then relay the message to its Chicago affiliate, who would then transmit the signal to activate your pager. Then again, perhaps a national directory will be made available, thus allowing your Boston office to directly contact the Chicago service.

Another advantage of the service would be when you're on the road and your office needs to contact you. All they would have to do is simply arrange to have your pocket-pager code broadcast by several stations along the route that you're travelling.

In addition to that, suppose you're travelling cross-country, crossing vast stretches of the nation where it's likely that there would not be an FM station for several hundred miles. Well, that's when satellite paging could come into play. The satellite transmission could close up the void created by the lack of FM broadcasting in any area.

There are also several other possibilities for communications via an SCA service. For example, providing selected stock quotes through digitized SCA-transmissions would likely be a popular one.

Further, how about a receiver with a built-in alpha-numeric keypad for program selection and a display? Imagine the possibilities! A subscriber could then choose the transmission desired (news headlines, stock quotes, etc.) by way of the keypad on his/her receiver. For example, suppose you want to receive the latest stock-market quotes, you could "punch-up" the symbol for that program and receive a plaintext display of the information. At what cost? you may ask. Well, all it will cost you is the price of the pocket receiver/display unit, and a $20 monthly service charge.

Meanwhile, the FM station will incur little additional expense, because the signal is broadcast through the FM transmitter via telephone line or microwave transmission, and is paid for by the service operator. A considerable income can be realized by the FM station, particularly in view of the fact that little is required of it in the way of additional equipment or technical services.

SCA subcarriers

The sidebands of an FM station can extend to 75 kHz as shown in Fig. 1-a. Technically, any number of subcarriers can be placed within that sideband as long as no part of the subcarrier modulation or the main-channel sideband extends beyond 75 kHz. One of the popular subcarrier frequencies is 67 kHz; because with 8 kHz SCA-sidebands, the total main- channel bandwidth would not exceed 75 kHz (67 kHz + 8 kHz = 75 kHz).

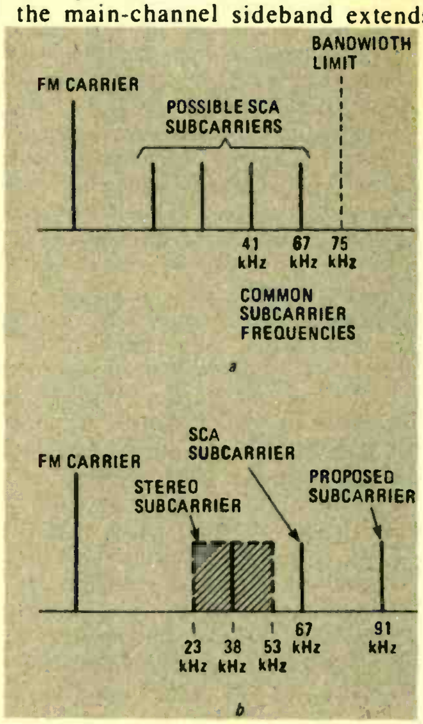


FIG. 1

Back in the days when most FM transmissions were monophonic, the principle limitation on the number of subcarriers was the 30% total-modulation ceiling on the amount of subcarrier modulation applied to the main channel. Since 8% is about the lowest degree of SCA modulation that can be used and still maintain decent reception, the practical limit was therefore three subcarriers, and preferably two. Also, to avoid interaction between the subcarriers due to poor receiver selectivity, the second subcarrier was placed at 41 kHz. But then, along came stereo.

As shown in Fig. 1-b, stereo has its own subcarrier frequency centered around 38 kHz, with its sidebands limited to +/− 15 kHz. That means that the upper frequency-limit for the stereo signal is 53 kHz and the instantaneous frequency of the SCA is now limited to a range of between 53–75 kHz with no more than 10% modulation. That leaves only enough room for one SCA sideband, which must remain for "Talking Books for the Blind," if that's what the station was providing at the time of deregulation.

Since most FM stations transmit stereo signals, there obviously isn't much room available for a national paging service, or any of the other unusual personal communication for that matter. Because of that, it has been proposed that a subcarrier frequency of 91 kHz be permitted for such services as stock-quotes or personal messages, and 67 kHz be reserved for a national paging-service. **R-E**

DESIGNER'S NOTEBOOK

continued from page 14

change state) is about 100 nanoseconds at 7 volts; which translates, theoretically speaking, into a maximum frequency of 10 MHz. The delay caused by the resistor will cut that amount by about half, and individual gates behave differently. Play with the circuit and see what you come up with. You will find, however, that the supply voltage, and not the individual gate, is the most important variable.

There are many other useful things you can do with only one gate. The XOR is a versatile gate and there are lots of other handy-dandy things you can do with it. But don't overlook the rest of the logic gates.

Let us know what unusual uses you've found for one gate and we'll pass them along in a future column. In fact, let's go one step farther and make an official contest out of it. The best and most imaginative circuit will win a one-year subscription to **Radio-Electronics.** What we will be looking for is originality and imagination. You can have as many passive components and diodes as you want, but the only silicon you may use is one gate. That means no transistors and no other IC's. **R-E**

STATE OF SOLID STATE

Power supply over/under voltage monitor

ROBERT F. SCOTT, SEMICONDUCTOR EDITOR

MOST IC'S AND TRANSISTORS HAVE SPECified "absolute maximum voltages" that, when exceeded, can destroy the device. Likewise, electronic circuits that use such devices have maximum supply-voltage limits. In addition, many solid-state devices also have voltage minimums that, when exceeded, can cause the device to malfunction.

Motorola recently announced the MC3425 and MC3525 monolithic power-supply supervisory circuits, which contain dedicated over- and under-voltage sensing channels. Figure 1 shows a block diagram of the MC3425/MC3525. Here we see that the over-voltage and under-voltage detector inputs feed two voltage comparators that are referenced to an internal 2.5-volt bandgap reference.

Separate delay pins (2 and 5) are provided for each channel to independently delay the drive and indicator outputs. That provides greater noise immunity and freedom from false triggering. The two delay pins are really the the outputs of their respective input comparators and provide a constant-current source, $I_{DLY(source)}$. The delay pins are pulled low when their respective input comparator's non-inverting input signal level is brought lower than the inverting input. The delay is based on the time it takes for the 200-μA current source to charge an external delay capacitor (C_{DLY}) to the reference voltage.

The delay pins can sink more than 1.8 mA, so the delay capacitors can discharge much faster than they can charge from the 200-μA source. When V_{CC} is 15 volts, the delay-time ranges linearly from .001 to 100 milliseconds as C_{DLY} is changed in decade values from .0001 to 10 μF.

The delay pins are also directly coupled to the non-inverting inputs of the output comparators, which are also referenced to 2.5 volts. The output time-delay (t_{DLY}), in milliseconds, is determined by the value of the delay capacitor and is equal to $2.5 \times C_{DLY}/200$ or $12,500\ C_{DLY}$.

The over-voltage channel can source 300-mA with a turn-on slew rate of 2.0 A/microsecond; therefore, it is ideal for driving the gate of an SCR used to "crowbar" the power-supply line leading to a voltage-sensitive device. A current-limited emitter follower drives the over-voltage output at pin 1.

In the under-voltage channel, an open-collector NPN transistor can sink up to 30 mA to drive an LED, small relay, or shutdown circuitry. A fault must be sustained for a predetermined time before there is an output. The under-voltage input comparator has a feedback-activated 12.5 μA current sink (I_H) that is used when programming the input hysteresis voltage, V_H. That helps to assure positive shutdown during marginal undervoltage conditions. The source resistance (R_H), feeding that input, determines the hysteresis voltage: $V_H = I_H R_H = 12.5 \times 10^{-6}\ R_H$).

There are several versions of the MC3525 and MC3525-U. The MC3525-U and -AU versions come in ceramic DIP packages and have a −55 to +125°C temperature range. The MC3425-P1 and -AP1 versions are packaged in plastic DIP's, while the MC3425-U and MC3425-AU are housed in ceramic packages. All the last four versions operate in the 0 to 75 °C temperature range. The 2.5-volt band-gap reference regulator is rated at ±4% accuracy in the basic devices. Accuracy for the "A" suffix devices is ±1%. Each of the six versions operate on a supply voltages ranging between 4.5 and 40.

Figure 2 shows how the MC3525 is used for over-voltage protection and under-voltage indication with a programmable delay. The fuse is necessary when the power supply is not current-limited. That is because the crowbar SCR acts as a short circuit directly across the power-supply output. The fuse must be extremely fast acting with an I^2t rating less than that of the SCR, while having a continuous current rating that can handle normal supply

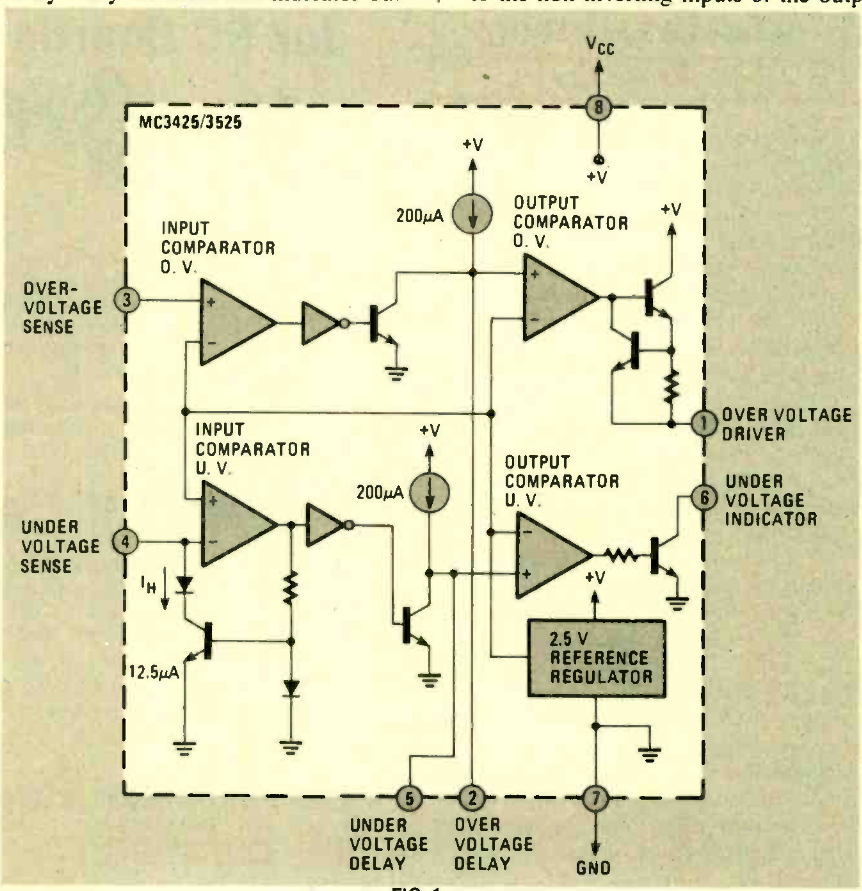


FIG. 1

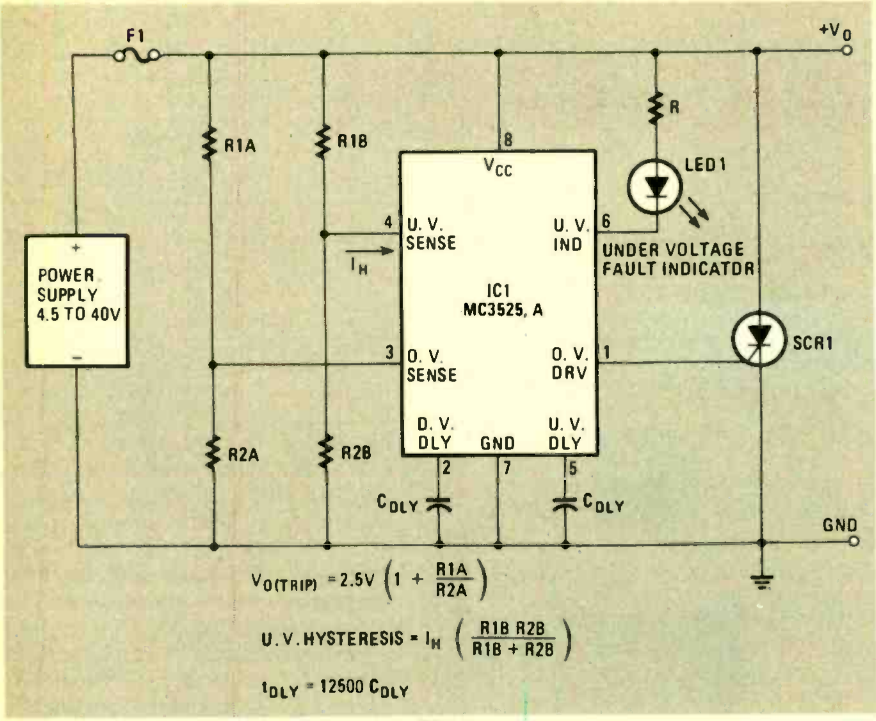


FIG. 2

currents. That type of fuse will be expensive—that is, if one is available. Therefore, we suggest that the protected supply include current limiting in its design. An advance-information data sheet is available from **Motorola Semiconductor Products**, PO Box 20912, Phoenix, AZ 85036

Bi-FET op-amp

Analog Devices has introduced a low-cost Bi-FET op-amp (the AD611KH) that offers premium-grade specifications for as low as $1.00 in 100-piece lots. The AD611KH delivers a maximum offset voltage of 0.5 mV with an offset-voltage drift of 10 μV/°C, and a guaranteed maximum input bias current of 50 pA.

The lower cost AD611JH version guarantees the maximum offset voltage to be 2.0 mV, with an offset-voltage drift of 20 μV/°C, and an input bias current of 100 pA. The exceptionally low bias current makes the AD611 useful in current-to-voltage conversion applications.

Dynamic specifications for the AD611 include a minimum slew rate of 8 volts/microsecond, a unity-gain bandwidth of 2 MHz, and settling to 0.01% in 3 microseconds. Other specifications include a noise voltage of 2 μV peak-to-peak at 0.1 to 10 Hz, and 0.0025% harmonic distortion. The K versions have a minimum open-loop gain of 94 dB and the J grade has a gain of 90 dB. The devices operate on supply voltages ranging from ±5 to ±18 with a maximum of 2.5 mA quiescent current. They are specified over the 0°C to +70°C temperature range, and are housed in 8-pin TO-99 metal packages.—**Analog Devices**, 804 Woburn St., Wilmington, MA 01887. **R-E**

SERVICE CLINIC

Unusual repair problems

JACK DARR, SERVICE EDITOR

INTERMITTENT TV SETS HAVE LONG BEEN the bane of the TV service technicians—they've made many of us totally miserable. Like everyone else, I've come across my share of intermittent sets over the years. And at times, I've felt as though I was getting someone else's share as well! While there are some products that make troubleshooting such sets a little easier, they simply can't handle every situation that comes along. Even that can of freeze spray on your workbench (see Fig. 1) won't *always* help you find the problem. To illustrate, let's look at some real jewels that took up a great deal of my time.

TV repair headaches!

The first case that we'll look at involves a Westinghouse table-model TV, that belonged to a little old lady who lived in a small house all by herself. Her complaint was that it "fell all to pieces" (no joke—that's what she said). Anyway, I hauled it off to the shop, set it up on the old workbench and turned it on. As I more than half expected, the picture came in perfectly. (Many sets will do that.) That's when I decided to let it "cook' for a couple hours; but I still saw no no sign of trouble. Finally, I took the set back to the customer and turned it on. Again it played perfectly; so, I left it there and went away. The next day, a call came in and—wouldn't you know it—the problem was back again.

Well, I returned to the lady's apartment and hauled the set off to the shop once more. (Before I took the set away, I carefully checked her antenna and everything thing else, for that matter. But still nothing.) I checked and rechecked, and rechecked everything again—that went on for quite a while. Eventually, I took the set out of the cabinet and sat it on the bench close to me. (The PC board in this model was upright.) I sat there watching the screen in a mirror on the wall, while I "monkeyed around" in the back of the set. The picture was perfect as usual.

Finally, having run out of ideas, I drew a deep breath and heaved a huge sigh. That's when I noticed that the picture fell out of horizontal sync—very badly, I might add. I sat there, with my jaw hanging open, trying to figure out what was wrong. It was the the first time that I had seen the set act up: But why? Finally it

FIG. 1

dawned on me; I had blown my damp breath on the PC board! By the time I had figured it out, the picture had straightened up. So I blew on it again and, sure enough, out it went.

A little while later, experiments and scope checks revealed that quite a bit of AC was showing up on the horizontal sync when I blew on it. Further examination showed that there was single point in the PC-board wiring that was being used as a tie point; it carried 110 volts AC. It was right smack in the middle of several others points that had the horizontal AFC on them. Needless to say, I soon removed the AC from that point (making a well taped "flying joint"). After that, you could sigh on it all you wanted and have no problem. But what caused it to act up to begin with, and why in her home and not at the shop?

Finally I found the answer: Her apartment was heated by a "wooly-backed" gas heater with asbestos padding behind the flame, but it had no vent. When an open flame burns in a small room, it can liberate an amazing amount of water vapor! That vapor had condensed on the cold PC board throwing the set "out of wack." Removing that AC connection from among all those AFC contacts cleared up the trouble.

Another dandy that that came my way (one that took me most of the summer to figure out) was another table model, made by DuMont this time. It too, would fall out of sync, but would later quit altogether. That is, it would quit at the customers home—not my shop. To make an extremely long story a little shorter, I played the set on the end of my bench, where I could see it, for an estimated total of 200 hours and never saw any sign of trouble.

On several occasions I took the set back to the customer's home, where I'd sit watching it—what fun! (His home, naturally, was 5 miles out of town!) Anyhow, autumn rolled around and I was still trying to catch that thing acting up. The customer had said that it would cut out after about two hours—not so, at least not while I was there. Well, I sat there watching the screen for hours (while being supplied with cold beer by the customer!).

Anyway, one day it did jump a little, so I took the back off it and looked inside. As soon as I did, the customer yelled "Hey, there it goes!" At the time, I was looking at the neck of the picture tube and saw a tiny arc in there! After some tracing around, I finally located the real cause; the CRT screen-grid was intermittently arcing to the cathode. When it did, it shorted out the B+ voltage to the horizontal oscillator. All it took for a permanent repair was an isolation-type brightener, set to isolate, but not brighten. That was the result of all summer's checking of everything (except the picture tube, of course!). I filed that one away for future reference. But to this day, I haven't seen another problem like it.

All that just goes to show you that repair jobs are not always easy, even with all the tools at your disposal; but just hang in there and fortune will smile on you, too. Good luck and happy repairs! **R-E**

SERVICE QUESTIONS

LOST: VERTICAL DEFLECTION

A Panasonic CT-914 has me climbing the walls. The vertical deflection is lost

sometimes after a half hour, sometimes after a half day. I've changed a number of capacitors and resistors without success. Any ideas?—G.S., Red Bank, NJ

Of all the voltage measurements you gave me, the most significant is that of the collector of TR455, the bottom output transistor. It drops to 0 volts when deflection is lost. That tells me that one of the output transistors opens up. Spray them with component cooler.

With intermittents of this nature, the first suspect should be transistors, and unless you can pin it down with the spray technique, you should replace them, one by one, until you hit it. Slow, but certain.

SHRINKING PICTURE

A Sears' hybrid, with tube outputs, has bad shrinking on the sides; the grid voltage on the horizontal output tube is too high, reading −128V where it should read −85V. I found that when I cut out the regulator diode the picture filled out nicely, but the brightness does not look right.—D.A., Babbitt, MN

High-voltage regulation in this set is achieved by tying the output-tube grid into the 6EL4 cathode, which itself is biased in part through the regulator diode, which goes to B−, and D120, the bias diode, which goes to B+. If you have not already tried a new 6EL4, do so at once. Then measure the voltages around that tube and see what turns up. An irregularity in the 6EL4 operating voltages must be upsetting the output tube bias.

HORIZONTAL OUTPUT TRANSISTOR BLOWING

A Sears 528-41950316 blows the 3.25-amp fuse and the horizontal output transistor. Can you give me some assistance with some type of troubleshooting procedure?—S.K., Hamden, CT

Think of it as something loading down the output side of the transistor. If an ohmmeter check from collector to ground shows a low reading, it becomes a simple process to find the source of the low reading. If that is not the case, suspect something that breaks down when power is applied. A variable transformer is very useful for that: While starting at a low voltage and coming up to 70, 80, then 90 volts AC, keep your eyes, ears and nose open for an arc, a smell or *anything* else to catch your attention. If you don't get lucky, you'll have to lift the scan rectifiers from the circuit, or the high-voltage regulator, or anything else that you feel could be responsible. Keep the AC voltage as low as you can, while still getting results, to avoid blowing the transistor.

REGULATOR PROBLEMS?

I have a Sanyo 91C90 that works on 85 volts AC, but will not work above 93 volts AC. I checked several parts around the regulator, but don't know if the trouble is there or in the hold-down circuits. How would you approach this?—D.A., Babbitt, MN

As I interpret the diagram, the twin-transistor hold-down circuit monitors the 120-volt DC B+ voltage through Zener diode D403. If D403 is lifted, the hold-down would then be disabled, no longer killing the horizontal oscillator. Before lifting that, however, I would measure B+ while coming up with the variable transformer. If it goes beyond 120 volts, I would concentrate on the regulator system, whose function is to hold it at 120 volts. If the regulator is OK, check the components in the hold-down that might be causing premature tripping.

TUNER PROBLEMS

The problem in an Admiral 9M50 seems to be in the tuning control. The picture and sound stay on for 3 or 4 seconds and then go out as if the tuner isn't on-station. I need help in repairing the ET200 or ET300 modules as they are very expensive to replace.—C.B., Bernie, MO

Your first job is to determine whether the loss of signal is in the ET boards, the tuner, or the IF section. A tuner subber would eliminate the IF as a possibility. Monitoring the voltages coming out of J306 would tell you whether the tuner is failing or the tuner supply-voltages, coming out of the synthesizer, are going awry. If the elimination process brings you there, you must rely on voltage measurements and perhaps the use of component cooler to pinpoint the transistor or IC at fault.

FINDING THE RASTER

I wrote you about a Magnavox T991 that had no raster, and you suggested that instead of changing modules randomly, I should measure the kine-socket voltages to find out what was missing. I did, and traced my problem back to a bad demodulator IC. It is much easier when you know where to look for trouble rather than just using guesswork.—*R.K.*

BRIGHT VERTICAL LINE

I have a bright vertical line approximately in the center of screen on this RCA CTC39X that, I'm working on. I've changed tubes and the efficiency coil, and tried a new yoke with no luck.—T.C., Lime Ridge, WI

Something is wrong in the control-grid circuit of the output tube causing (what we used to call back in the old days) a drive line. Check C279, the coupling capacitor, for leakage, check all the components in the grid circuit, including the resistor that ties into the 6BK4 regulator. (I hope you tried a new regulator, just for the heck of it.) Also see that the peak-to-peak output of the 6FQ7 is OK. If not, check voltages around that tube. **R-E**

LINEAR IC'S

continued from page 68

prove the CMRR. Because of that feature, the LM-363-AD is useful for applications in difficult environments or unusual signal-acquisition situations.

Figure 8 shows a practical amplifier based on the LM-363-AD. Switch S1 is used to select the gains (10, 100, and 1000) and should be mounted on the front panel, in most cases, so that the operator can select the level desired.

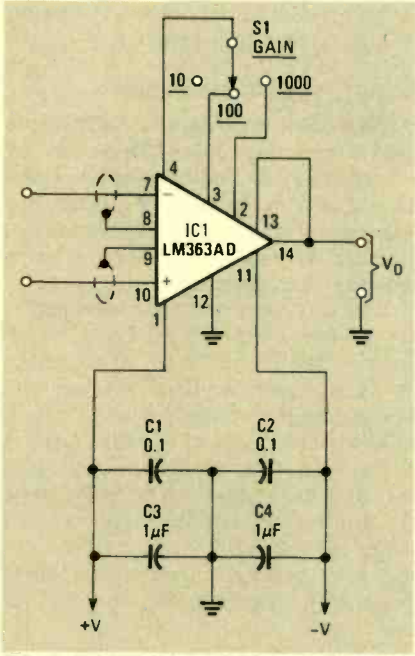


FIG. 8—BY ADDING A SWITCH, a variable-gain instrumentation amplifier can be formed.

If you want to make the circuit shown in Fig. 8 AC-coupled, it can be adapted as per Fig. 4.

It would be wise to configure the circuit such that the leads from gain-selector switch S1 and the IC package are as short as possible. Some lead length is permissible, but do not let it be excessive.

The capacitors used to bypass the −V and +V power-supply lines should also be mounted as close as possible to the body of the IC. The 0.1μF units are the most critical in that respect because they take care of high frequencies. The reason why the 0.1-μF and 1-μF units are connected in parallel is that the 1-μF units are electrolytics and as such are not very effective at high frequencies.

Another IC1A device is shown in Fig. 9. That device is the Burr-Brown INA-101. The voltage gain of that device is set by resistor R_G, which corresponds to R1 in Fig. 3. The gain equation is:

$$A_{VD} = \frac{40{,}000}{R_G} + 1 \qquad (5)$$

If you compare Equation 5 with Equation

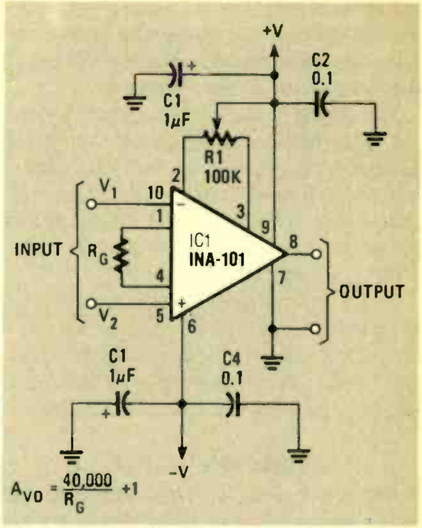


FIG. 9—THE GAIN OF IC1, an INA-101 instrumentation amplifier, is set by R_G.

2, the gain equation for the IA in Fig. 3, you will note that they are similar. In terms of Fig. 3, if R4 = R5 = R6 = R7, and if R2 = R3 = 20 kilohms, then Equations 2 and 5 are identical.

As in most textbook equations, Equation 5 is not in its most useful form. In most practical situations, we know the gain we want to achieve. What we really need, then, is the value of R_G that will produce that gain! Rewriting Equation 5 into a more practical form yields:

$$R_G = \frac{40{,}000}{A_{VD} - 1} \qquad (6)$$

Equation 6 is somewhat more useful than Equation 5—at least outside of classrooms!

As an example, find the value of R_G that will yield a gain of 1000. Substituting into Equation 6 gives us:

R_G = (40K/(1000 − 1) = 40K/999 = 0.04 kilohms = 40 ohms.

It is permissible to make R_G variable in order to provide gain control. You are cautioned, however, to place a series resistor in the circuit with the potentiometer to prevent the gain from going out of sight. As R_G approaches zero, the gain climbs to infinite (not really, of course, but it will not take much at all to make the amplifier saturate). The value of the series resistor is one that satisfies Equation 6 at the highest gain you want to achieve.

Next month

In Part 5 of this series we will discuss non-op-amp linear IC amplifiers, namely the current-difference amplifier (also called CDA or Norton amplifier) and the operational transconductance amplifier.

Looking ahead to the coming months, we will deal with such topics as logarithmic amplifiers, integrator and differentiator design, using isolation amplifiers, and the design of oscillators and multivibrators using op-amps. **R-E**

STATIC ELECTRICITY

continued from page 48

equipment in the area could be considered to have a common potential and we would have achieved an isoelectric environment. However, it would not be practical to connect wires to each and every metal object (including your chair) in, say, a five-foot radius of your workbench or computer or other static-sensitive device. Some more rational approach must be followed.

We have already learned that friction is a chief cause of static-electric build-ups, so it should be apparent that if we eliminate potential sources of friction, especially between dissimilar objects, we would be well on our way to a practical solution to the static-electric problem. Carpets belong in plush homes, dens, cars, private planes, but not in computer rooms or workshops. If finances permit, a tile similar to the type used in hospitals with electrically conductive properties (per our static-electric definition) might be installed. Other approaches include floor covers of a conductive material for the under-desk and chair area. In lieu of those tiles or floor covers, and especially if the room must serve other purposes such as the living room of a home, a commercial "anti-static" carpet treatment may be effective.

Some installations have taken control of static to the level of restricting the type of clothing (material) that one can wear to avoid those fabrics that can produce harmful charges. Such steps are only necessary in ultra-sensitive areas, although personnel in sensitive hospital areas may be required to wear "scrub-clothes" with tiny metal fibers present in the fabric, and also special shoes.

In most situations, an anti-static tabletop or discharge plate (a small square of metal) connected through a resistor of 27,000 ohms to ground, located near, say, a disk-storage area, would provide a convenient pathway to bleed-off potentially harmful charges. Another approach would be to have the equipment operator wear a conductive wrist-strap that would provide that same controlled bleed-off of any charges before any sensitive equipment is damaged. (see Fig. 5)

Ionization

Another method of controlling static build-up is ionization. Although generally impractical for use in the home or office, it is often used in industry. In ionization, the air is ionized so that a conductive path is formed between any charged objects and ground. That allows the charges to dissipate safely.

It is obvious that control of static electricity can be carried to extremes (restrictive apparel, etc.) but it would be safe to assume that if you achieve at least 50% relative humidity, take normal care in removing potential sources of static buildups (carpets, etc.), and further link the major metal surfaces in a reasonable radius to a common ground through appropriate resistors, you will have done much to control and perhaps even eliminate that source of damage to your equipment. **R-E**

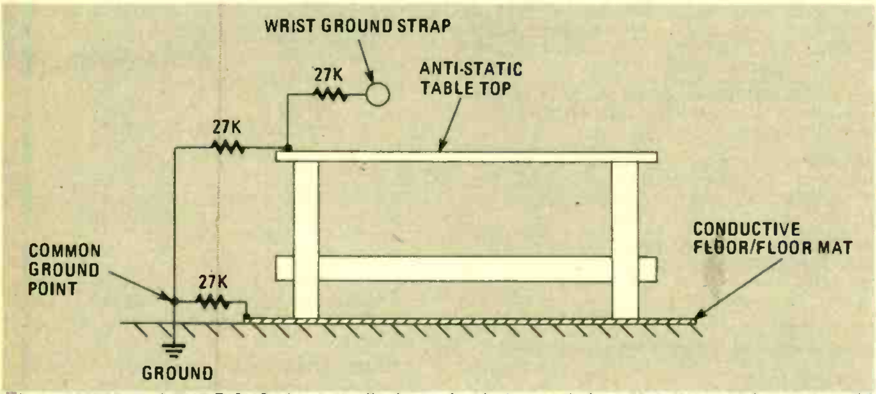


FIG. 5—MINIMIZING THE RISKS of a static discharge in a home workshop. Note the use of an anti-static table-top and a conductive floor or mat.

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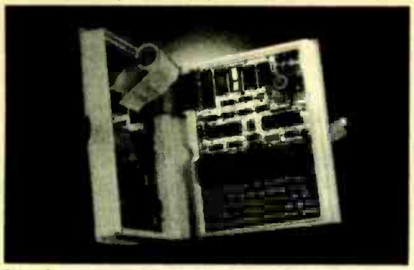

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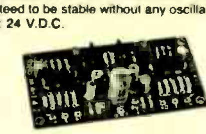

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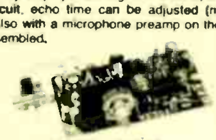

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2112	256 x 4 (450ns)	2.95
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2114L-4	1024 x 4 (450ns) (LP)	8/9.95
2114L-3	1024 x 4 (300ns) (LP)	8/10.95
2114L-2	1024 x 4 (200ns) (LP)	8/11.95
2147	4096 x 1 (55ns)	4.90
TMS4044-4	4096 x 1 (450ns)	3.45
TMS4044-3	4096 x 1 (300ns)	3.95
TMS4044-2	4096 x 1 (200ns)	4.45
MK4118	1024 x 8 (250ns)	9.90
TMM2016-200	2048 x 8 (200ns)	4.10
TMM2016-150	2048 x 8 (150ns)	4.90
TMM2016-100	2048 x 8 (100ns)	6.10
HM6116-4	2048 x 8 (200ns) (cmos)	4.70
HM6116-3	2048 x 8 (150ns) (cmos)	4.90
HM6116-2	2048 x 8 (120ns) (cmos)	8.90
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.90
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.90
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	8.95
Z-6132	4096 x 8 (300ns) (Qstat)	33.95

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UPD411	4096 x 1 (300ns)	2.95
MM5280	4096 x 1 (300ns)	2.95
MK4108	8192 x 1 (200ns)	1.90
MM5298	8192 x 1 (250ns)	1.80
4116-250	16384 x 1 (250ns)	.49
4116-200	16384 x 1 (200ns)	.89
4116-150	16384 x 1 (150ns)	1.20
2118	16384 x 1 (150ns) (5v)	4.90
4164-250	65536 x 1 (250ns)	4.45
4164-200	65536 x 1 (200ns) (5v)	5.45
4164-150	65536 x 1 (150ns) (5v)	6.45

5V = Single 5 Volt Supply

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2708	1024 x 8 (450ns)	2.48
2758	1024 x 8 (450ns)	2.48
2758	1024 x 8 (450ns) (5v)	5.90
2716	2048 x 8 (450ns) (5v)	2.85
2716-1	2048 x 8 (350ns) (5v)	5.90
TMS2516	2048 x 8 (450ns) (5v)	5.45
TMS2716	2048 x 8 (450ns)	7.90
TMS2532	4096 x 8 (450ns) (5v)	5.90
2732	4096 x 8 (450ns) (5v)	3.95
2732-250	4096 x 8 (250ns) (5v)	8.90
2732-200	4096 x 8 (200ns) (5V)	10.95
2764	8192 x 8 (450ns) (5v)	5.95
2764-250	8192 x 8 (250ns) (5v)	13.95
2764-200	8192 x 1 (200ns) (5v)	23.95
TMS2564	8192 x 8 (450ns) (5v)	18.85
MC68764	8192 x 8 (450ns) (5v) (24 pin)	38.95
27128	16384 x 8 Call	19.95

5v = Single 5 Volt Supply

74LS00

74LS00	.23	74LS92	.54
74LS01	.24	74LS93	.54
74LS02	.24	74LS95	.74
74LS03	.24	74LS96	.88
74LS04	.23	74LS107	.38
74LS05	.24	74LS109	.38
74LS08	.27	74LS112	.38
74LS09	.28	74LS113	.38
74LS10	.24	74LS114	.38
74LS11	.34	74LS122	.44
74LS12	.34	74LS123	.78
74LS13	.44	74LS124	2.85
74LS14	.58	74LS125	.48
74LS15	.34	74LS126	.48
74LS20	.24	74LS132	.58
74LS21	.28	74LS133	.58
74LS22	.24	74LS136	.38
74LS26	.28	74LS137	.98
74LS27	.28	74LS138	.54
74LS28	.34	74LS139	.54
74LS30	.24	74LS145	1.15
74LS32	.28	74LS147	2.45
74LS33	.54	74LS148	1.30
74LS37	.34	74LS151	.54
74LS38	.34	74LS153	.54
74LS40	.24	74LS154	1.85
74LS42	.48	74LS155	.68
74LS47	.74	74LS156	.68
74LS48	.74	74LS157	.64
74LS49	.74	74LS158	.58
74LS51	.24	74LS160	.68
74LS54	.28	74LS161	.64
74LS55	.28	74LS162	.68
74LS63	1.20	74LS163	.64
74LS73	.38	74LS164	.68
74LS74	.34	74LS165	.94
74LS75	.38	74LS166	1.90
74LS76	.38	74LS168	1.70
74LS78	.48	74LS169	1.70
74LS83	.59	74LS170	1.45
74LS85	.68	74LS173	.68
74LS86	.38	74LS174	.54
74LS90	.54	74LS175	.54
74LS91	.88	74LS181	2.10

74LS189	8.90	74LS363	1.30
74LS190	.88	74LS364	1.90
74LS191	.88	74LS365	.48
74LS192	.78	74LS366	.48
74LS193	.78	74LS367	.44
74LS194	.68	74LS368	.44
74LS195	.68	74LS373	1.35
74LS196	.78	74LS374	1.35
74LS197	.78	74LS377	1.35
74LS221	.88	74LS378	1.13
74LS240	.94	74LS379	1.30
74LS241	.98	74LS385	1.85
74LS242	.98	74LS386	.44
74LS243	.98	74LS390	1.15
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74LS245	1.45	74LS395	1.15
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74LS253	.58	74LS624	3.95
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74LS258	.58	74LS645	2.15
74LS259	2.70	74LS668	1.65
74LS260	.58	74LS669	1.85
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74LS280	1.95	74LS684	3.15
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74LS293	.88	74LS689	3.15
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74LS299	1.70	81LS96	1.45
74LS323	3.45	81LS97	1.45
74LS324	1.70	81LS98	1.45
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74LS353	1.25	25LS2569	4.20

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4108-3	1.50
4116-15	1.50
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5.000	18.432
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TL062 CP	.96	LM380	1.20	LM1310	1.60
TL064 CN	1.50	LM384	1.60	LM1391	1.00
TL072	1.25	LM386	1.50	1456	.80
TL074	1.50	LM387	1.26	1458	.50
LM201	.75	LF398A	3.50	LM1808	1.75
LM301/748	.50	LM393	.76	LM2901	.95
LM307	.50	LM555	.50	CA3018	1.95
LM308	.65	LM566	.90	CA3078AT	1.50
LM310	1.10	558	1.75	CA3094	1.30
LM311	.80	565	1.25	CA3089E	1.75
LM319	1.30	566	1.25	CA3130	1.00
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200	.40	.50	1.80	200	.50	.80	1.90
400	.60	.70	2.40	400	.70	1.00	2.80
600	.80	1.00	3.60	600	1.00	1.20	3.60

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4002	.50	4029	1.00	4081	.40	74C20	.50
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4007	.50	4034	1.75	4093	.80	74C42	1.00
4008	.70	4035	1.00	4099	1.75	74C76	1.00
4009	.60	4040	1.00	4501	.95	74C83	1.25
4010	.60	4042	.90	4503	1.50	74C86	.70
4011	.50	4043	.90	4506	.75	74C154	2.50
4012	.50	4044	.90	4511	1.00	74C157	1.75
4013	.60	4046	1.20	4514	1.25	74C161	1.15
4014	.70	4047	1.50	4515	1.50	74C174	1.15
4015	.60	4049	.60	4516	1.40	74C175	1.19
4016	.60	4050	.60	4518	1.00	74C192	1.30
4017	1.25	4051	1.00	4520	1.20	74C193	1.75
4018	.70	4052	1.00	4528	1.00	74C901	.60
4019	.70	4053	1.00	4529	1.40	74C902	1.00
4020	.80	4066	.70	4539	1.25	74C903	.75
4021	.80	4068	.50	4583	.90	74C907	.75
4022	1.00	4069	.50	4585	.75	74C914	1.75
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4026	.95	4076	.65	74C10	.50		
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74S15	.50	74S139	1.10	74S257	1.30
74S20	.50	74S151	1.25	74S260	1.50
74S30	.50	74S157	1.25	74S373	2.25
74S32	1.00	74S158	1.25	74S374	1.75
74S42	.85	74S161	1.75		
74S51	.70	74S163	1.40		
74S74	1.10				

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400	1.00	1.65	3.30
600	1.30	1.90	4.40

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200	.06	.17	.50	1.30	7.00	9.00
400	.09	.25	.66	1.50	10.00	12.00
600	.11	.30	.80	2.00	13.00	15.00
800	.13	.35	1.00	2.50	16.00	18.00
1000	.20	.45	1.25	3.00	20.00	26.00

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1UF 20V	5/$1.00	47UF 20V	$ .85
2.2UF 20V	5/$1.00	68UF 16V	$1.00
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7400	.50	7475	.60	74164	.80
7401	.40	7476	.60	74165	.80
7402	.50	7480	.45	74166	.90
7403	.40	7483	.50	74170	1.60
7404	.60	7485	.70	74173	.75
7405	.60	7486	.60	74174	.80
7406	1.50	7489	2.00	74175	.70
7408	.60	7491	.55	74176	.75
7409	.80	7492	.55	74180	1.90
7410	.40	7493	.55	74181	1.90
7411	.40	7494	.60	74182	.90
7412	.40	7495	.55	74190	.80
7413	.45	7496	.60	74191	.80
7414	.75	74107	.50	74192	.80
7420	.40	74116	1.50	74193	.80
7425	.40	74121	.45	74194	.85
7426	.75	74122	.50	74195	.45
7427	.75	74123	.55	74196	.75
7430	.75	74125	.60	74199	1.25
7432	1.00	74126	.45	74221	1.00
7437	.50	74145	.60	74273	.85
7438	1.75	74148	1.10	74279	.60
7440	.30	74150	1.10	74365	.80
7442	.60	74151	.70	74367	.80
7445	1.00	74153	.70	74390	.90
7446	.80	74154	1.60	75325	1.50
7447	1.10	74155	.70	75492	1.05
7448	.80	74157	.70	9601	1.10
7450	.30	74160	.85	8T26	1.40
7472	.50	74161	.65	8T28	1.40
7473	.50	74162	.70	8T98	1.10
7474	.60	74163	.70		

74LS SERIES

74LS00	.70	74LS109	.70	74LS241	1.50
74LS01	.50	74LS112	.60	74LS242	2.00
74LS02	.70	74LS113	.60	74LS243	2.00
74LS03	.50	74LS114	.65	74LS244	2.25
74LS04	1.00	74LS123	1.60	74LS245	2.25
74LS05	1.00	74LS125	1.60	74LS246	.95
74LS08	1.00	74LS126	.90	74LS247	1.50
74LS09	.50	74LS132	.90	74LS248	1.50
74LS10	.50	74LS136	1.00	74LS251	.90
74LS11	.80	74LS137	1.00	74LS253	.90
74LS12	.50	74LS138	1.25	74LS257	.90
74LS13	.55	74LS139	1.30	74LS258	.90
74LS14	.90	74LS147	1.95	74LS259	2.00
74LS15	.50	74LS151	1.00	74LS260	1.75
74LS20	.60	74LS153	1.00	74LS266	1.00
74LS21	.60	74LS155	1.00	74LS273	1.60
74LS22	.60	74LS156	1.00	74LS279	1.00
74LS26	.55	74LS157	1.00	74LS280	1.80
74LS27	.60	74LS158	1.00	74LS283	1.00
74LS28	.80	74LS160	1.20	74LS290	1.20
74LS32	1.50	74LS161	1.20	74LS293	1.20
74LS37	.50	74LS162	1.20	74LS298	1.20
74LS38	.50	74LS163	1.20	74LS320	2.00
74LS40	.50	74LS164	1.20	74LS323	3.50
74LS42	.70	74LS165	1.20	74LS365	1.20
74LS47	1.10	74LS166	1.90	74LS366	1.20
74LS51	.70	74LS170	1.90	74LS367	1.25
74LS54	.40	74LS173	1.20	74LS368	1.20
74LS73	.80	74LS174	1.20	74LS373	3.00
74LS74	1.20	74LS175	1.20	74LS374	4.00
74LS75	1.25	74LS181	1.95	74LS377	2.00
74LS76	.80	74LS190	1.20	74LS386	.60
74LS83	.80	74LS191	1.20	74LS390	1.10
74LS85	1.20	74LS192	1.20	74LS393	1.10
74LS86	.60	74LS193	1.20	74LS446	2.00
74LS90	.90	74LS194	1.30	74LS398	2.50
74LS92	.70	74LS195	1.20	74LS625	1.75
74LS95	.90	74LS196	1.20	74LS668	1.50
74LS96	.80	74LS197	1.20	74LS670	2.00
74LS107	.70	74LS221	1.50	81LS97	1.50
		74LS240	1.50	81LS98	1.50

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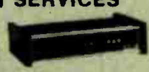

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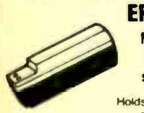

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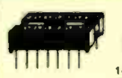

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14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
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28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

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18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
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LM308CN	.98	LM2900N	.99
LM309K	1.49	LM2901N	2.50
LM310CN	1.25	LM2917N	2.95
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LM339N	.95	CA3080T	1.29
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LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
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LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
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74S00	$.39	74S124	$3.69	74S244	$2.99
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74S03	.45	74S134	.66	74S253	1.35
74S04	.89	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.99	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	.46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.99	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

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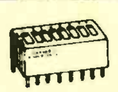

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7400	$.19	7475	$.38	74161	$.69
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7402	.19	7479	4.60	74163	.69
7403	.19	7480	.49	74164	.69
7404	.19	7482	.95	74165	.69
7405	.23	7483	.45	74166	1.20
7406	Call	7485	.55	74167	2.95
7407	Call	7486	.35	74170	1.49
7408	.24	7489	1.75	74172	4.75
7409	.19	7490	.35	74173	.69
7410	.19	7491	.45	74174	.69
7411	.24	7492	.45	74175	.69
7412	.24	7493	.35	74176	.69
7413	.29	7494	.69	74177	.69
7414	.49	7495	.50	74179	1.34
7416	Call	7496	.69	74180	.75
7417	Call	7497	2.90	74181	1.75
7420	.19	74100	2.90	74182	.75
7421	.35	74107	.24	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	1.19	74116	1.25		
7425	.29	74121	.29		
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.45	74191	1.15
7429	.45	74125	.39	74192	.75
7430	.18	74126	.44	74193	.75
7432	.29	74128	.59	74194	.75
7437	.25	74132	.45	74195	.68
7438	.29	74136	.75	74196	.75
7439	1.19			74197	.75
7440	.19	74141	.65	74198	1.29
7441	.79	74142	2.95	74199	1.29
7442	.45	74143	4.50	74221	1.19
7443	.95	74144	2.95	74251	.69
7444	.65	74145	.59	74273	1.05
7445	.79	74147	1.69	74276	1.89
7446	.79	74148	1.19	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.49	74284	3.69
7450	.19	74152	.67	74285	3.69
7451	.19	74153	.49	74290	.89
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.69	74365	.65
7459	.25	74156	.78	74366	.65
7460	.23	74157	.49	74367	.65
7470	.29	74158	1.65	74368	.65
7472	.29	74159	2.49	74390	1.45
7473	.29	74160	.79	74393	1.90
7474	.34			74490	1.90

74LS00

74LS00	$.26	74LS113	$.39	74LS245	$2.99
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74LS02	.25	74LS122	.49	74LS248	1.10
74LS03	.25	74LS123	1.19	74LS249	1.19
74LS04	.69	74LS124	2.75	74LS251	1.40
74LS05	.25	74LS125	.69	74LS253	1.40
74LS08	.25	74LS126	.49	74LS257	.85
74LS09	.25	74LS132	.59	74LS258	.98
74LS10	.25	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.59	74LS260	.65
74LS12	.33	74LS139	.59	74LS261	2.49
74LS13	.39	74LS145	1.25	74LS266	.59
74LS14	.59	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.99	74LS275	4.40
74LS20	.26	74LS153	.99	74LS279	.59
74LS21	.29	74LS154	1.70	74LS283	.99
74LS22	.29	74LS155	1.19	74LS290	.99
74LS26	.29	74LS156	1.49	74LS293	.99
74LS27	.29	74LS157	1.49	74LS295	1.10
74LS28	.29	74LS158	1.49	74LS298	1.19
74LS30	.25	74LS160	1.49	74LS324	1.75
74LS32	.33	74LS161	1.49	74LS347	1.95
74LS33	.55	74LS162	1.49	74LS348	1.95
74LS37	.35	74LS163	1.49	74LS352	1.19
74LS38	.39	74LS164	1.49	74LS353	1.19
74LS40	.25	74LS165	1.49	74LS363	1.49
74LS42	.59	74LS166	2.48	74LS365	.99
74LS47	.79	74LS168	1.15	74LS366	.99
74LS48	.79	74LS169	1.15	74LS367	.99
74LS51	.25	74LS170	1.99	74LS368	.99
74LS54	.29	74LS173	.89	74LS373	2.99
74LS55	.29	74LS174	.89	74LS374	2.99
74LS73	.39	74LS175	.89	74LS375	.69
74LS74	.99	74LS181	2.20	74LS377	1.95
74LS75	.39	74LS190	1.15	74LS385	1.95
74LS76	.39	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83	.59	74LS193	.98	74LS393	1.95
74LS85	.69	74LS194	1.15	74LS395	1.70
74LS86	.39	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.49	74LS197	.89	74LS668	1.75
74LS93	.59	74LS221	1.15	74LS670	2.29
74LS95	.79	74LS240	1.99	81LS95	1.69
74LS96	.89	74LS242	1.99	81LS96	1.69
74LS107	.39	74LS243	1.99	81LS97	1.69
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4002	.24	4041	.75	4094	2.95
4006	.79	4042	.65	4098	2.29
4007	.25	4043	.85	4099	1.85
4008	.95	4044	.69	14408	12.95
4009	.39	4046	.80	14409	12.95
4010	.39	4047	.89	14410	12.95
4011	.24	4048	.99	14412	12.95
4012	.24	4049	.35	14415	8.95
4013	.35	4050	.34	14419	4.95
4014	.75	4051	.75	4501	.39
4015	.39	4052	.75	4502	.95
4016	.35	4053	.75	4503	.62
4017	.65	4055	3.95	4505	8.95
4018	.79	4056	2.95	4506	.75
4019	.39	4059	9.25	4507	.95
4020	.69	4060	.85	4508	1.25
4021	.69	4066	.39	4510	.79
4022	.69	4069	.28	4511	.79
4023	.25	4070	.35	4512	.79
4024	.59	4071	.28	4514	1.18
4025	.25	4072	.28	4515	1.79
4027	.45	4073	.28	4516	1.45
4028	.65	4075	.28	4518	.85
4029	.75	4076	.75	4520	.75
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CIRCLE 80 ON FREE INFORMATION CARD

INTERFACING

continued from page 56

the MSM5832, which resumes normal timing operations. Program execution then returns to the BASIC language routine. Line 870 defines the next MSM5832 register which is to be input. Line 880 defines the next storage location for that register's contents, and if all 13 registers in the MSM5832 have not been accessed, the machine-language program is called again. If all 13 registers of the MSM5832 have been accessed, program execution stops.

After program execution stops, the contents of all 13 registers of the MSM5832 will reside in memory, in the addresses listed in Table 12. Once the date and time information reside in memory, it is a simple matter to retrieve it and display it using the PEEK instruction. For instance, if you wish to retrieve the day of the week, write this simple program, you can enter the direct command:

PRINT PEEK 16546.

The number retrieved represents a day of the week as defined in Table 13. (Of course you could write a simple program to give you back the actual day instead of the number.)

If you want the time to be retrieved and displayed try the program in Table 14. And if you want to retrieve and display the entire date, try the program in Table 15.

Of course, using separate programs is not the most elegant way to use the clock/calendar circuit. You could put all of the simple BASIC routines in a loop and have the time information updated periodically. To demonstrate updating, make the following changes:

TABLE 14—TIME RETRIEVAL

```
10 DIM A(6)
20 LET  X  16540
30 FOR J=1 TO 6
40 LET A(J)=PEEK X
50 LET X = X +1
60 NEXT J
70 LET B$="AM"
75 IF A(6)>2 THEN LET B$="PM"
80 IF A(6)>2 THEN LET
   A(6)=A(6)-4
85 CLS
90 PRINT A(6);A(5);":";A(4);
   A(3);":"; A(2);A(1);" "B$
100 STOP
```

TABLE 15—DATE RETRIEVAL

```
10 DIM A(6)
20 LET X =16547
30 FOR J=1 TO 6
40 LET A(J)=PEEK X
50 LET X =X+1
60 NEXT J
70 LET B=19
80 PRINT
   A(4);A(3);"-";A(2);A(1);"-";
   B;A(6);A(5)
90 STOP
```

- Delete line 90 in the time-display program (Table 14).

TABLE 12—MEMORY LOCATIONS OF MSM5832 REGISTER VALUES

Hexadecimal	Decimal	Register
409C	16540	0—SECONDS
409D	16541	1—TENS OF SECONDS
409E	16542	2—MINUTES
409F	16543	3—TENS OF MINUTES
40A0	16544	4—HOURS
40A1	16545	5—TENS OF HOURS
40A2	16546	6—DAY OF WEEK
40A3	16547	7—DAYS
40A4	16548	8—TENS OF DAYS
40A5	16549	9—MONTHS
40A6	16550	10—TENS OF MONTHS
40A7	16551	11—YEARS
40A8	16552	12—TENS OF YEARS

TABLE 13—DAY-OF-WEEK VALUES

0—Monday
1—Tuesday
2—Wednesday
3—Thursday
4—Friday
5—Saturday
6—Sunday

- Change line 900 in the retrieval routine (Table 8) to: 900 GOTO 20.

Those changes allow the time-display routine to print the time values (lines 10 through 80); go and get updated values from the MSM5832 (lines 800 through 900); and return to the time display routine. The program does that until a BREAK is entered.

We now have a good idea of how to control the clock/calendar IC. Controlling other external circuits and devices is not too much different. Next month, when we continue, we'll look at how to do that. When we're finished, you'll see how we can add an alarm function to the clock/calendar circuit. In addition to an alarm function you can use the MSM5832 in conjunction with the *ZX81* as a nighttime light controller and a date/time home security system. **R-E**

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LP = Low Power   Qstat = Quasi-Static

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5v = Single 5 Volt Supply   21vPGM = Program at 21 Volts

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4050	.35	74C151	2.25
4051	.79	74C154	3.25
4053	.79	74C157	1.75
4060	.89	74C160	1.19
4066	.39	74C161	1.19
4068	.39	74C162	1.19
4069	.29	74C163	1.19
4070	.35	74C164	1.39
4071	.29	74C165	2.00
4072	.29	74C173	.79
4073	.29	74C174	1.19
4075	.29	74C175	1.19
4076	.79	74C192	1.49
4078	.29	74C193	1.49
4081	.29	74C195	1.39
4082	.29	74C200	5.75
4085	.95	74C221	1.75
4086	.95	74C244	2.25
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	14.95	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C910	9.95
4508	1.95	74C911	8.95
4510	.85	74C912	8.95
4511	.85	74C914	1.95
4512	.85	74C915	1.19
4514	1.25	74C918	2.75
4515	1.79	74C920	17.95
4516	1.55	74C921	15.95
4518	.89	74C922	4.49
4519	.39	74C923	4.95
4520	.79	74C925	5.95
4522	1.25	74C926	7.95
4526	1.25	74C928	7.95
4527	1.95	74C929	19.95

6800

68000	49.95
6800	2.95
6802	7.95
6803	19.95
6808	13.90
6809E	14.95
6809	11.95
6810	2.95
6820	4.35
6821	2.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	7.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

6800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B40	19.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

6500

1 MHZ

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	6.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	9.95

DISC CONTROLLERS

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1793	26.95
1795	29.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
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8185-2	39.95
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CRT5037	24.95
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8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95
8292	14.95

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	3.95
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	3.95
Z80-SIO/0	11.95
Z80-SIO/1	11.95
Z80-SIO/2	11.95
Z80-SIO/9	11.95

4.0 Mhz

Z80A-CPU	4.49
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	12.95
Z80A-PIO	4.49
Z80A-SIO/0	12.95
Z80A-SIO/1	12.95
Z80A-SIO/2	12.95
Z80A-SIO/9	12.95

6.0 Mhz

Z80B-CPU	9.95
Z80B-CTC	12.95
Z80B-PIO	12.95
Z80B-DART	19.95
Z80B-SIO/2	39.95

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74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS375	.95
74LS122	.45	74LS377	1.39
74LS123	.79	74LS378	1.18
74LS124	2.90	74LS379	1.35
74LS125	.49	74LS385	3.90
74LS126	.49	74LS386	.45
74LS132	.59	74LS390	1.19
74LS133	.59	74LS393	1.19
74LS136	.39	74LS395	1.19
74LS137	.99	74LS399	1.49
74LS138	.55	74LS424	2.95
74LS139	.55	74LS447	.95
74LS145	1.20	74LS490	1.95
74LS147	2.49	74LS624	3.99
74LS148	1.35	74LS640	2.20
74LS151	.55	74LS645	2.20
74LS153	.55	74LS668	1.69
74LS154	1.90	74LS669	1.89
74LS155	.69	74LS670	1.49
74LS156	.69	74LS674	14.95
74LS157	.65	74LS682	3.20
74LS158	.59	74LS683	3.20
74LS160	.69	74LS684	3.20
74LS161	.65	74LS685	3.20
74LS162	.69	74LS688	2.40
74LS163	.65	74LS689	3.20
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

74S00

74S00	.32	74S124	2.75	74S197	1.49
74S02	.35	74S132	1.24	74S201	6.95
74S03	.35	74S133	.45	74S225	7.95
74S04	.35	74S134	.50	74S240	2.20
74S05	.35	74S135	.89	74S241	2.20
74S08	.35	74S138	.85	74S244	2.20
74S09	.40	74S139	.85	74S251	.95
74S10	.35	74S140	.55	74S253	.95
74S11	.35	74S151	.95	74S257	.95
74S15	.35	74S153	.95	74S258	.95
74S20	.35	74S157	.95	74S260	.79
74S22	.35	74S158	.95	74S273	2.45
74S30	.35	74S161	1.95	74S280	1.95
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74S37	.88	74S163	1.95	74S288	1.90
74S38	.85	74S168	3.95	74S289	6.89
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74S65	.40	74S181	3.95	74S387	1.95
74S74	.50	74S182	2.95	74S412	2.98
74S85	1.99	74S188	1.95	74S471	4.95
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VOLTAGE REGULATORS

7805T	.75	7905T	.85
78M05C	.35	7908T	.85
7808T	.75	7912T	.85
7812T	.75	7915T	.85
7815T	.75	7924T	.85
7824T	.75		
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
		LM323K	4.95
78H05K	9.95	UA78S40	1.95
78H12K	9.95		

C, T = TO-220 K = TO-3 L = TO-92

SOUND CHIPS

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76488	5.95	AY3-8912	12.95
76489	8.95	MC3340	1.49
SSI-263	39.95		

7400

7400	.19	74123	.49
7401	.19	74125	.45
7402	.19	74126	.45
7403	.19	74132	.45
7404	.19	74136	.50
7405	.25	74143	4.95
7406	.29	74145	.60
7407	.29	74147	1.75
7408	.24	74148	1.20
7409	.19	74150	1.35
7410	.19	74151	.55
7411	.25	74153	.55
7413	.35	74154	1.25
7414	.49	74155	.75
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7425	.29	74163	.69
7427	.29	74164	.85
7430	.19	74165	.85
7432	.29	74166	1.00
7437	.29	74167	2.95
7438	.29	74170	1.65
7442	.49	74173	.75
7445	.69	74174	.89
7446	.69	74175	.89
7447	.69	74177	.75
7448	.69	74181	2.25
7451	.23	74184	2.00
7473	.34	74185	2.00
7474	.33	74191	1.15
7475	.45	74192	.79
7476	.35	74193	.79
7482	.95	74194	.85
7483	.50	74195	.85
7485	.59	74197	.75
7486	.35	74198	1.35
7489	2.15	74221	1.35
7490	.35	74246	1.35
7492	.50	74247	1.25
7493	.35	74259	2.25
7495	.55	74273	1.95
7497	2.75	74276	1.25
74100	1.75	74279	.75
74107	.30	74366	.65
74109	.45	74367	.65
74116	1.55	74368	.65
74121	.29	74393	1.35
74122	.45		

BYPASS CAPS

.01 UF DISC 100/6.00

.01 UF MONOL 100/12.00

.1 UF DISC 100/8.00

.1 UF MONOL 100/15.00

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
18 pin ZIF	6.95	call
24 pin ZIF	7.95	call
28 pin ZIF	8.95	call

ZIF = TEXTOOL (Zero Insertion Force)

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PE-14		9	8,000	83.00
PE-14T	X	9	8,000	119.00
PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
PR-320T	X	42	17,000	595.00

DATA ACQUISITION

ADC0800	15.55	DAC0800	4.95
ADC0804	3.49	DAC0808	2.95
DAC0806	1.95	DAC1020	8.25
ADC0809	4.49	DAC1022	5.95
ADC0816	14.95	MC1408L6	1.95
ADC0817	9.95	MC1408L8	2.95

INTERFACE

8T26	1.59
8T28	1.89
8T95	.89
8T96	.89
8T97	.89
8T98	.89
DM8131	2.95
DP8304	2.29
DS8833	2.25
DS8835	1.99
DS8836	.99
DS8837	1.65
DS8838	1.30

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RS232 Male	2.50
RS232 Female	3.25
RS232 Hood	1.25
S-100 ST	3.95

EXAR

XR 2206	3.75
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XR 2208	3.75
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XR 2240	3.25

INTERSIL

ICL7106	9.95
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ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

LINEAR

LM301	.34	LM348	.99	LM567	.89	LM1812	8.25
LM301H	.79	LM350K	4.95	NE570	3.95	LM1830	3.50
LM307	.45	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308	.69	LM358	.69	NE590	2.50	LM1872	5.49
LM308H	1.15	LM359	1.79	NE592	2.75	LM1877	3.25
LM309H	1.95	LM376	3.75	LM709	.59	LM1889	1.95
LM309K	1.25	LM377	1.95	LM710	.75	LM1896	1.75
LM310	1.75	LM378	2.50	LM711	.79	ULN2003	2.49
LM311	.64	LM379	4.50	LM723	.49	LM2877	2.05
LM311H	.89	LM380	.89	LM723H	.55	LM2878	2.25
LM312H	1.75	LM380N-8	1.10	LM733	.98	LM2900	.85
LM317K	3.95	LM381	1.60	LM741	.35	LM2901	1.00
LM317T	1.19	LM382	1.60	LM741N-14	.35	LM2917	2.95
LM318	1.49	LM383	1.95	LM741H	.40	LM3900	.59
LM318H	1.59	LM384	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM386	.89	LM748	.59	LM3909	.98
LM319	1.25	LM387	1.40	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM389	1.35	LM1303	1.95	LM3914	3.95
LM322	1.65	LM390	1.95	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM392	.69	MC1330	1.69	LM3916	3.95
LM324	.59	LM393	1.29	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49
LM340 (see 7800)		LM566	1.49	LM1800	2.37	MPQ2907	1.95

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

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HP 5082-7760	.43"	CC	1.29
MAN 72	.3"	CA	.99
MAN 74	.3"	CC	.99
FND-357 (359)	.375"	CC	1.25
FND-500 (503)	.5"	CC	1.49
FND-507 (510)	.5"	CA	1.49
TIL-311 4x7	.270"	HEX W/LOGIC	9.95

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JUMBO YELLOW	.18	.15
LED MOUNTING HARDWARE	.10	.09

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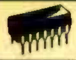

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MC-1350	Video If Amp	1.75	1.19
MC-1352	Video If Amp AGC	2.80	2.09
MC-1358	Audio If Amp	1.75	1.64
MC-1374P	R.F. Modulator	3.19	2.39
MC-1458	Dual Comp. Op Amp	.65	.59
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74LS02	14	.25	74LS95	14	.79	74LS194	16	.69
74LS03	14	.25	74LS96	16	.89	74LS195	16	.69
74LS04	14	.29	74LS107	14	.39	74LS197	14	.79
74LS05	14	.35	74LS109	16	.39	74LS221	16	.89
74LS08	14	.29	74LS112	16	.39	74LS240	20	1.09
74LS09	14	.29	74LS113	14	.39	74LS241	20	1.09
74LS10	14	.29	74LS114	14	.39	74LS242	14	1.09
74LS11	14	.35	74LS122	14	.49	74LS243	14	1.09
74LS12	14	.35	74LS123	16	.89	74LS244	20	1.49
74LS13	14	.39	74LS125	14	.59	74LS245	20	1.49
74LS14	14	.59	74LS126	14	.49	74LS247	16	1.09
74LS15	14	.35	74LS132	14	.59	74LS248	16	1.09
74LS20	14	.29	74LS133	16	.59	74LS249	16	1.09
74LS21	14	.29	74LS136	14	.39	74LS251	16	.59
74LS22	14	.29	74LS138	16	.89	74LS253	16	.59
74LS26	14	.29	74LS139	16	.79	74LS257	16	.59
74LS27	14	.29	74LS151	16	.59	74LS258	16	.59
74LS28	14	.35	74LS153	16	.59	74LS260	14	.59
74LS30	14	.25	74LS154	24	1.29	74LS266	14	.69
74LS32	14	.39	74LS155	16	.69	74LS273	20	1.49
74LS33	14	.55	74LS156	16	.69	74LS279	16	.49
74LS37	14	.35	74LS157	16	.65	74LS283	16	.69
74LS38	14	.35	74LS158	16	.59	74LS290	14	.89
74LS40	14	.29	74LS160	16	.69	74LS293	14	.79
74LS42	16	.55	74LS161	16	.65	74LS298	16	.89
74LS47	16	.75	74LS162	16	.69	74LS352	16	1.29
74LS48	16	.75	74LS163	16	.65	74LS353	16	1.29
74LS49	16	.75	74LS164	14	.69	74LS365	16	.49
74LS51	14	.25	74LS165	16	1.19	74LS366	16	.49
74LS54	14	.29	74LS168	16	1.19	74LS367	16	.49
74LS55	14	.29	74LS169	16	1.19	74LS368	16	.49
74LS73	14	.39	74LS170	16	1.49	74LS373	20	1.49
74LS74	14	.49	74LS173	16	.69	74LS374	20	1.49
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74LS83	16	.65	74LS190	16	.89	74LS399	16	1.49
74LS85	16	.89	74LS191	16	.89	74LS670	16	1.49
74LS86	14	.39				81LS95	20	1.49
74LS90	14	.55				81LS97	20	1.49

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74S02	14	.35	74S133	16	.45	74S244	20	2.49
74S03	14	.35	74S134	16	.50	74S251	16	1.19
74S04	14	.45	74S135	16	.69	74S253	16	1.19
74S05	14	.45	74S136	14	1.39	74S257	16	1.19
74S08	14	.39	74S138	16	.89	74S258	16	1.19
74S09	14	.39	74S139	16	.89	74S260	14	1.19
74S10	14	.35	74S140	14	.55	74S280	14	1.95
74S11	14	.35	74S151	16	.99	74S287*	16	1.95
74S15	14	.35	74S153	16	.99	74S288*	16	1.95
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74S65	14	.39	74S196	14	1.49	74S570*	16	2.95
74S74	14	.55	74S240	20	2.25	74S571*	16	2.95
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CA3046N	14	1.35	CA3083N	16	1.49	CA3160H		1.95
CA3059N	14	2.95	CA3086N	14	.69	CA3161E	16	2.95
CA3060N	16	2.95	CA3089N	16	1.69	CA3162E	16	6.95
CA3065E	14	1.49	CA3096N	16	1.49	CA3189E	16	1.59
CA3080E	8	.89				CA3401N	14	.59

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CD4001	14	.29	CD4041	14	1.19	CD4506	16	1.19
CD4002	14	.29	CD4042	16	.89	CD4507	14	1.19
CD4006	14	1.19	CD4043	16	.79	CD4508	24	3.95
CD4007	14	.29	CD4044	16	.79	CD4510	16	1.29
CD4009	16	.59	CD4046	16	1.19	CD4511	16	1.19
CD4010	16	.59	CD4047	14	1.29	CD4512	16	1.19
CD4011	14	.29	CD4048	16	.59	CD4514	24	2.49
CD4012	14	.29	CD4049	16	.39	CD4515	24	2.49
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CD4014	16	1.19	CD4051	16	.99	CD4518	16	1.19
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CD4017	16	1.19	CD4056	16	2.95	CD4526	16	1.49
CD4018	16	.99	CD4059	24	7.95	CD4528	16	1.49
CD4019	16	.59	CD4060	16	1.49	CD4529	16	1.69
CD4020	16	1.19	CD4066	14	.59	CD4543	16	1.95
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CD4022	16	1.19	CD4069	14	.29	CD4566	16	1.39
CD4023	14	.29	CD4070	14	.39	CD4583	16	2.49
CD4024	14	.69	CD4071	14	.29	CD4584	14	.69
CD4025	14	.23	CD4072	14	.29	CD4723	16	1.19
CD4026	16	2.49	CD4073	14	.29	CD4724	16	1.19
CD4027	16	.45	CD4075	14	.29	MC14409	16	13.95
CD4028	16	.69	CD4076	16	1.19	MC14410	16	13.95
CD4029	16	1.29	CD4078	14	.49	MC14411	24	11.95
CD4030	14	.39	CD4081	14	.29	MC14412	16	13.95
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Part No.	**Pins	Function	Price
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2650	40	MPU (2MHz)	9.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
MCS6502	40	MPU w/Clock	5.95
MCS6502B	40	MPU w/Clock at 3MHz	9.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	11.95
6809E	40	CPU—8-bit (External Clock) 1MHz	14.95
INS8035N	40	MPU—8-bit	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	19.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8748	40	HMOS EPROM MPU	24.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
Z80-CTC	28	Counter Timer Circuit	3.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-P10	40	Parallel I/O Interface Controller	3.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80-S10/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
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)	12.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-S10/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-P10	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

Part No.	**Pins	Function	Price
MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Inf. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8000 SERIES

Part No.	**Pins	Function	Price
INS8080A	40	CPU	2.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	8.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
8284	18	Clock Generator/Driver	9.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

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

SPECIAL FUNCTION

Part No.	**Pins	Function	Price
DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss int.	5.95
COP470N	20	32 seg VAC Fluor. Drvr. (20-pin pkg.)	3.25
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)	2.49
4116N-2	16	16,384x1	(150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1	(200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1	(200ns)	5.95 - 8/44.95
MM5261	18	1024x1	(300ns)	.49 - 8/1.95
MM5262	22	2048x1	(365ns)	.10
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
41256	16	256x1	(150ns)	75.00
MM5290-2	16	16,384x1	(150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

STATIC RAMS

Part No.	**Pins	Function		Price
1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	16	256x4	(450ns) MOS	1.95
2114	18	1024x4	(450ns)	1.49 - 8/9.95
2114L	18	1024x4	(450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4	(200ns)	1.75 - 8/11.95
2114L-2	18	1024x4	(200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1	(70ns)	4.95
2148	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	2.95
5101	22	256x4	(450ns) CMOS	2.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-3	24	2048x8	(150ns) CMOS	5.95
HM6116P-4	24	2048x8	(200ns) CMOS	4.95
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8	(150ns) CMOS	45.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	49.95
27LS00	16	256x1	(80ns) L.P.	6.95
7489	16	16x4	(50ns) 3101	2.25
74C920	22	256x4	(250ns)	3.95
74C921	18	256x4	(250ns) CMOS	3.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	3.95
74S189	16	16x4	(35ns) 93405	1.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.25
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	(1us)	4.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	2.95
TMS2516	24	2048x8	(450ns) 2716	5.95
TMS2532	24	4096x8	(450ns) NMC2532	6.95
TMS2564	28	8192x8	(450ns)	14.95
TMS2716	24	2048x8	(450ns) 3 voltage	9.95
2716	24	2048x8	(450ns)	4.95
2716-1	24	2048x8	(350ns)	5.95
27160-5	24	2048x8	(550ns)	4.49
2732	24	4096x8	(450ns)	6.95
2732A-3	24	4096x8	(300ns)	7.95
2732A-4	24	4096x8	(450ns) 21V	8.95
27320-4	24	4096x8	(550ns)	5.95
27580-A	24	1024x8	(450ns)	2.95
2764-4	28	8192x8	(450ns)	9.95
2764-3	28	8192x8	(300ns)	10.95
MM52040	24	512x8 (1us)		4.95
MCM68764	24	8192x8	(450ns)	24.95
27128	28	16,384x8	(450ns) 128K EPROM	29.95
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
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.	8.95
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
82S190	24	2048x8	(80ns)	14.95
82S191	24	2048x8	(80ns)	14.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
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
DM87S190N	24	2048x4	PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

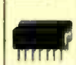
DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
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	16	12-bit D/A Conv. (0.20% Lin.)	8.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	40	30K Baud Uart (TR1602)	3.95

LOW PROFILE (TIN) SOCKETS

	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
36 pin LP	.48	.42	.39
40 pin LP	.49	.46	.43


LP


SG


ST


WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.30	.27	.25
14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.16
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

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INTERSIL

* Evaluation Kits

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	16.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356 p.) **$9.95**

NEW PRODUCT! 74HC High Speed CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74HC00	14	.59	74HC139	16	.99	74HC253	16	.99
74HC02	14	.59	74HC147	16	1.19	74HC257	16	.89
74HC03	14	.75	74HC151	16	.89	74HC259	16	1.49
74HC04	14	.59	74HC153	16	.99	74HC266	14	1.19
74HCU04	14	.65	74HC154	24	2.49	74HC273	20	2.89
74HC08	14	.59	74HC157	16	.89	74HC280	14	3.95
74HC10	14	.59	74HC158	16	.89	74HC299	20	4.95
74HC11	14	.59	74HC160	16	1.29	74HC366	16	2.39
74HC14	14	.85	74HC161	16	1.29	74HC367	16	2.39
74HC20	14	.59	74HC162	16	1.29	74HC373	20	2.39
74HC27	14	.59	74HC163	16	1.29	74HC374	20	2.39
74HC30	14	.89	74HC164	14	1.29	74HC390	16	1.49
74HC32	14	.75	74HC165	16	2.79	74HC393	14	1.49
74HC42	16	.99	74HC166	16	2.95	74HC533	20	2.39
74HC51	14	.75	74HC173	16	1.69	74HC534	20	2.39
74HC58	14	.75	74HC174	16	.99	74HC595	16	3.95
74HC73	14	.79	74HC175	16	.99	74HC688	20	3.19
74HC74	14	.79	74HC192	16	1.39	74HC4002	14	.59
74HC75	16	.89	74HC193	16	1.39	74HC4017	16	2.19
74HC76	16	.79	74HC194	16	1.09	74HC4020	16	1.39
74HC85	16	1.59	74HC195	16	1.09	74HC4024	14	1.59
74HC86	14	.69	74HC237	16	2.95	74HC4040	16	1.39
74HC107	14	.59	74HC240	20	1.95	74HC4060	16	1.39
74HC109	16	.79	74HC241	20	1.95	74HC4075	14	.59
74HC112	16	.79	74HC242	14	1.95	74HC4078	14	.69
74HC113	14	.79	74HC243	14	1.95	74HC4511	16	2.69
74HC125	14	.99	74HC244	20	1.95	74HC4514	24	3.79
74HC132	14	.99	74HC245	20	2.49	74HC4538	16	2.39
74HC137	16	1.95	74HC251	16	.89	74HC4543	16	3.49
74HC138	16	1.09						

74HCU04 is unbuffered. All others are buffered.

74C—C/MOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74C00	14	.35				74C221	16	1.95
74C02	14	.35				74C240	20	1.95
74C04	14	.29	74C95	14	1.39	74C244	20	1.95
74C08	14	.35	74C107	14	.89	74C373	20	2.49
74C10	14	.35	74C151	16	2.49	74C374	20	2.49
74C14	14	.69	74C154	24	3.49	74C901	14	.59
74C20	14	.35	74C157	16	2.25	74C903	14	.59
74C30	14	.35	74C160	16	1.19	74C906	14	.59
74C32	14	.39	74C161	16	1.19	74C911	28	8.95
74C42	16	1.39	74C162	16	1.19	74C912	28	8.95
74C48	16	1.95	74C163	16	1.19	74C915	18	1.19
74C73	14	.79	74C164	14	1.49	74C917	28	8.95
74C74	14	.69	74C173	16	1.19	74C922	18	4.49
74C85	16	1.95	74C174	16	1.19	74C923	20	4.95
74C86	14	.39	74C175	16	1.19	74C925	16	5.95
74C89	16	5.95	74C192	16	1.49	74C926	18	5.95
74C90	14	1.19	74C193	16	1.69	80C95	16	.69
74C93	14	1.19	74C195	16	1.39	80C97	16	.69

LINEAR

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
TL071CP	8	.79				LM741CN	8	.35
TL072CP	8	1.39				LM747N	14	.69
TL074CN	14	1.95				LM748N	8	.59
TL081CP	8	.59	LM342P-5		.69	LM1310N	14	1.49
TL082CP	8	1.19	LM342P-12		.69	MC1330A1	8	1.95
TL084CN	14	1.95	LM342P-15		.69	MC1349	8	1.79
LM301CN	8	.35	LF347N	14	1.49	MC1350	8	1.49
LM302H		1.95	LM348N	14	.99	MC1358	14	1.95
LM304H		1.95	LM350K		4.95	LM1456V	8	1.95
LM305H		.99	LF351N	8	.60	LM1458CN	8	.59
LM307CN	8	.45	LF353N	8	1.00	LM1488N	14	.89
LM308CN	8	.69	LF355N	8	1.10	LM1489N	14	.89
LM309K		1.25	LF356N	8	1.10	LM1496N	14	1.95
LM310CN	8	1.75	LM358N	8	.69	LH1605CK		8.95
LM311CN	8	.69	LM359N	14	1.79	LM1800N	16	2.49
LM312H		2.49	LM370N	14	4.49	LM1871N	18	2.95
LM317T		1.19	LM373N	14	3.95	LM1872N	18	3.25
LM317K		3.95	LM377N	14	1.95	LM1877N-9	14	2.49
LM318CN	8	1.95	LM380CN	8	1.10	LM1889N	18	2.25
LM319N	14	1.95	LM380N	14	.89	LM1896N	14	2.95
LM320K-5		1.35	LM381N	14	1.79	LM2002T		1.95
LM320K-12		1.35	LM382N	14	1.39	ULN2003A	16	.89
LM320K-15		1.35	LM384N	14	1.79	XR2206	16	3.95
LM320K-24		1.35	LM386N-3	8	.89	XR2207	14	2.95
LM320T-5		.89	LM387N	8	.89	XR2208	16	2.49
LM320T-12		.89	LM389N	18	1.19	XR2211	14	3.95
LM320T-15		.89	LM391N-80	16	1.19	LM2877P		1.95
LM320T-24		.89	LM392N	8	.69	LM2878P		2.95
LM322N	14	1.65	LM398N	8	3.95	LM2901N	14	.59
LM323K		5.95	LM399H		5.00	LM2902N	14	.89
LM324N	14	.59	TL494CN	16	3.95	LM2907N	14	2.49
LM329DZ		.65	TL496CP	8	1.19	LM3900N	14	.59
LM331N	8	3.95	NE531V	8	2.95	LM3905CN	8	1.19
LM334Z		1.19	NE544N	14	2.95	LM3909N	8	.99
LM335Z		1.40	NE550A	14	1.95	LM3914N	18	2.95
LM336Z		1.19	NE555V	8	.35	LM3915N	18	2.95
LM337MP		1.15	XR-L555	8	.59	LM3916N	18	2.95
LM337T		1.95	LM556N	14	.69	RC4136N	14	1.25
LM338K		6.95	NE564N	16	2.95	RC4151NB	8	1.95
LM339N	14	.69	LM565N	14	1.19	RC4194TK		4.49
LM340K-5		1.35	LM566CN	8	1.49	RC4195TK		4.49
LM340K-12		1.35	LM567V	8	.99	LM4250CN	8	1.29
LM340K-15		1.35	NE570N	16	3.95	LM4500A	16	1.95
LM340K-24		1.35	NE571N	16	2.95	NE5532	8	2.49
LM340T-5		.79	LM703CN	8	1.19	NE5534	8	1.69
LM340T-12		.79	LM709N	14	.49	79M05		.69
LM340T-15		.79	LM710N	14	.69	ICL8038B	14	3.95
LM340T-24		.79	LM711N	14	.79	LM13080N	8	1.19
LM341P-5		.75	LM723N	14	.55	LM13600N	16	1.19
LM341P-12		.75	LM733N	14	1.00	76477	28	3.95
LM341P-15		.75	LM739N	14	1.95			

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . **$11.95**

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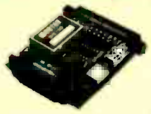
HOME COMPUTER ACCESSORIES

RS232 ADAPTER FOR VIC-20 AND COMMODORE 64



The JE232CM allows connection of standard RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.

· Plugs into User Port · Provides Standard RS232 signal levels · Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready).

JE232CM $39.95

VOICE SYNTHESIZER FOR APPLE AND COMMODORE

NEW!

JE520AP

JE520CM

• Over 250 word vocabulary - affixes allow the formation of more than 500 words • Built-in amplifier, speaker, volume control, and audio jack • Recreates a clear, natural male voice • Plug-in user ready with documentation and sample software • Case size: 7¼"L x 3¼"W x 1-3/8"H

APPLICATIONS: • Security Warning • Teaching • Instrumentation • Telecommunication • Handicap Aid • Games

The JE520 VOICE SYNTHESIZER will plug right into your computer and allow you to enhance almost any application. Utilizing National Semiconductor's DIGITALKER™ Speech Processor IC (with four custom memory chips), the JE520 compresses natural speech into digital memory, including the original inflections and emphases. The result is an extremely clear, natural vocalization.

Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	$114.95
JE520AP	For Apple II, II+, and //e	$149.95

JE664 EPROM PROGRAMMER

8K to 64K EPROMS — 24 & 28 Pin Packages

Completely Self Contained — Requires No Additional Systems for Operation

· Programs and validates EPROMs · Checks for properly erased EPROMs · Emulates PROMs or EPROMs · RS232C Computer interface for editing and program loading · Loads data into RAM by keyboard · Changes data in RAM by keyboard · Loads RAM from an EPROM · Compares EPROMs for content differences · Copies EPROMs · Power Input: 115VAC, 60Hz, less than 10W power consumption · Enclosure: Color-coordinated light tan panels with molded end pieces in mocha brown · Size: 15⅝"L x 8¾"D x 3½"H · Weight: 5¾ lbs

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM, (2) from an external computer via the optional JE665 RS232C BUS, (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value) allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity and 2 stop bits.

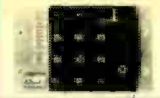
FOR A LIMITED TIME A SAMPLE OF SOFTWARE WRITTEN IN BASIC FOR THE TRS-80* MODEL I, LEVEL II COMPUTER WILL ALSO BE PROVIDED

JE664-ARS EPROM Prog. w/JE665 Option. $1195.00
Assembled & Tested (includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, Natl, Intel, TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, Natl, NEC, TI, AMD, Hitachi, Mostek	$14.95
JM16B	TMS2716 (3-V's)	-5V, +5V, +12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95

KEYBOARDS



HI-TEK 14-KEY NUMERIC KEYPAD

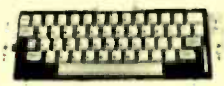
· Great keypad for many home and business computer applications · SPST switching · Mounted on P.C. board · Size 5" L x 3" W x 1½" H · Color: Grey · Weight: 1 lb. · Spec available

K-14 . . . . $9.95

MICRO SWITCH ASCII Encoded Keyboards

· Large selection of keyboards · Hall effect switching · Some have parallel interfaces · Some have serial interfaces · All have status LEDs and a minimum of 68 keys · Some with numeric keypad capabilities, cursor controls, or both · Styles may vary · Weight: 2 lbs. · No specs available

KB-MISC $9.95



13⅛"L x 4¼"W x ⅜"H

Mitsumi 54-Key Unencoded Matrix All-Purpose Keyboard

· SPST keyswitches · 20 pin ribbon cable connection · Low profile keys · Features: cursor controls, control, caps (lock), function, enter and shift keys · Color (keycaps): grey · Wt.: 1 lb. · Pinout included

KB54. . . . . $14.95

New!

16-9/16"L x 6⅝"W x 1⅝"H

76-Key Serial ASCII Keyboard

· Simple serial interface · SPST mechanical switching · Operates in upper and lower case · Five user function keys: F1-F5 · Six finger edge card connection · Color (keys): tan · Weight: 2 lbs. · Data Incl.

KB76. . . . . $29.95

Nationally Known Manufacturer!

21⅛" L x 9.8" W x 3⅛" H

106-KEY 8-BIT SERIAL ASCII KEYBOARD

· The terminals were designed to be daisy chained around a central host computer and used as individual work stations · Hall effect switching · numeric and cursor keypad · 10 user definable keys · 50" interface cable with 9-pin sub-miniature connector · 7 LED function displays · Security lock · N-key roll-over · Automatic key repeat function · Color: (case): white, w/black panel—(key caps): grey and blue · Weight: 6½ lbs. · Data included.

KB139 . . . . $59.95

New!

14½"L x 5½"W x 1½"H

68-Key Keyboard with Numeric Keypad for Apple II and II+

· Plugs directly into Apple II or II+ motherboard with 16-pin ribbon cable connector · 26 special functions · Color (keys): white/grey · Weight: 2 lbs.

KB-A68. . . . . $99.95

POWER SUPPLIES

TRANSACTION TECHNOLOGY, INC. 5VDC @ 1 AMP Regulated Power Supply

· Output: +5VDC @ 1.0 amp (also +30VDC regulated) · Input: 115VAC, 60 Hz · Two-tone (black/beige) self-enclosed case · 6 foot, 3-conductor black power cord · Size: 6½" L x 7" W x 2⅝" H · Weight: 3 lbs.

PS51194 . . . . $14.95

Power/Mate Corp. REGULATED POWER SUPPLY

· Input: 105-125/210-250 VAC at 47-63 Hz · Line regulation: ±0.05% · Three mounting surfaces · Overvoltage protection · UL recognized · CSA certified

Part No.	Output	Size	Weight	Price
EMA5/6B	5V@3A/6V@2.5A	4⅝"L x 4"W x 2⅝"H	2 lbs.	$29.95
EMA5/6C	5V@6A/6V@5A	5⅝"L x 4⅝"W x 2⅝"H	4 lbs.	$39.95

New!

ASTEC SWITCHING REGULATED POWER SUPPLY

· Apple III Power Supply · Multiple outputs for bench top uses and other applications · Input: 115VAC, 50-60 Hz @ 3.0 amps · Output: +5VDC @ 1.0 amp, +12VDC @ 1.0 amp, -12VDC @ 1.0 amp, +24VDC @ 2.5 amp, -24VDC @ 2.5 amp · Size: 15" L x 3¾" W x 2⅝" H · Weight: 2½ lbs.

AS1155 . . . . $39.95

POWER SUPPLY +5VDC @ 7.6 AMP, 12VDC @ 1.5 AMP SWITCHING

· Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp · Fan volt./power supply select switches (115/230VAC) · Output: 5VDC @ 7.6 amp, 12VDC @ 1.5 amp · 8 foot black power cord · Size: 11½"L x 13¼"W x 3¾"H · Weight: 6 lbs.

PS94VOS. $39.95

KEPCO/TDK 4-OUTPUT SWITCHING POWER SUPPLY

· Ideal for disk drive needs of CRT terminals, microcomputers and video games · Input: 115/230VAC, 50/60Hz · Output: +5V @ 5 Amp, +12V @ 1.8 Amp, +12V @ 2 Amp, -12V @ 0.5 Amp · UL recognized · CSA certified · Size: 7¾"L x 6-3/16"W x 1⅝"H · Weight: 2 lbs.

MRM 174KF. $59.95

4-CHANNEL SWITCHING POWER SUPPLY

· Microprocessor, mini-computer, terminal, medical equipment and process control applications · Input: 90-130VAC, 47-440Hz · Output: +5VDC @ 5A, -5VDC @ 1A, +12VDC @ 1A, -12VDC @ 1A · Line regulations: ±0.2% · Ripple: 30mV p-p · Load regulation: ±1% · Overcurrent protection · Adj.: 5V main output ±10% · Size: 6⅜"L x 1⅝"W x 4-15/16"H · Weight: 1½ lbs.

FCS-604A. . . . . $69.95 each

Switching Power Supply for APPLE II, II+ & //e™

· Can drive four floppy disk drives and up to eight expansion cards
· Short circuit and overload protection · Fits inside Apple computer
· Fully regulated +5V @ 5A, +12V @ 1.5A, -5V @ .5A, -12V @ .5A
· Direct plug-in power cord included · Size: 9⅞"L x 3½"W x 2⅛"H
· Weight: 2 lbs.

KHP4007. . . . . $79.95

4-Digit Fluorescent Alarm Clock Kit

The JE750 Clock Kit is a versatile 12-hour digital clock with 24-hour alarm. The clock has a bright 0.5" high blue-green fluorescent display. The display will automatically dim with changing light conditions. The 24-hour alarm allows the user to disable the alarm and immediately re-enable the alarm to activate 24 hours later. The kit includes all documentation, components, case and wall transformer. Size: 6⅝"L x 3¼"W x 1¾"D.

JE750 Alarm Clock Kit. $29.95

DISK DRIVES AND SUPPLIES

5¼" APPLE™ Direct Plug-In Compatible Disk Drive

• Uses Shugart SA390 mechanics • 143K formatted storage • 35 tracks — compatible with Apple controller • Complete with connector and cable — just plug into your disk controller card • Size: 5"L x 3¼"W x 8-9/16"D • Weight: 4⅝ lbs.

ADD-514...$195.95

+5VDC @ 6 Amps
+12VDC @ 4 Amps
-12VDC @ 0.5 Amps

Microcomputer Power Inc. Regulated Power Supply

13¼"L x 6¼"W x 5"H

· Perfect for computer or disk drive systems · Supply has AMP connectors for direct connection to two 5¼" disk drives · Cooling fan · Input: 100/115/200/230VAC, 47-63Hz · Output (above) · Weight: 9 lbs.

CP167. . . . . $59.95

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DATASHIELD® Surge Protector

· Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss · 6 month warranty · Power dissipation (100 microseconds): 1,000,000 watts · 6 sockets · 6 foot power cord · Normal line voltage indicator light · Brown out/black out reset switch · Weight: 2 lbs.

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Provides up to 30 minutes of continuous 120 VAC 60Hz power to your computer system (load dependent) when you have a black out or voltage sag · Output rating: 200 watts · Six month warranty · Weight: 24 lbs.

Model 200 (PC200). $349.95

IBM MEMORY EXPANSION KIT COMPAQ COMPATIBILITY

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $49.95

TRS-80 MEMORY EXPANSION KIT

TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III $12.95
TRS-16K4 *250ns for Model I $10.95

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kits comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 color computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K2. . . . . $44.95

UV-EPROM Eraser

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser . . . $79.95
UVS-11EL Replacement Bulb . . $16.95

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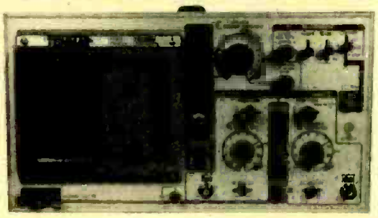

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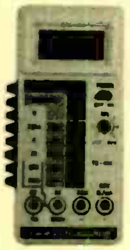

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BAR-GRAPH TACHOMETER
Add this sleek 40 segment tach to your dashboard instrument set. Measurement range is user adjustable (1K to 6K, 0 to 8K, etc.). Only 1.5 inches thick, can be mounted on the steering column without blocking view of the speedometer. Advanced circuitry provides fast, stable, and accurate readout. **Complete kit $59.95.**

AUTOMOTIVE VOLTMETER
Don't get stranded in the middle of no-where because of a dead battery. Build this expanded scale bar-graph voltmeter and keep an eye on the condition of your car or boats electrical system. Ten L.E.D.'s indicate battery voltage in .5 volt steps between 10.5 and 15 volts. Easy to build and very accurate. **Complete kit $24.95.**

OSCILLOSCOPE DELAYED SWEEP KIT
Upgrade your scope to lab quality. Contains a high quality video sync separator and trigger delay. Lock onto and expand any portion of a video waveform. Examine in detail the VITS waveforms. A must for all TV repair shops and scrambled video experimenters. Works with any triggered sweep scope that has external trigger input. **Complete kit $54.95.**

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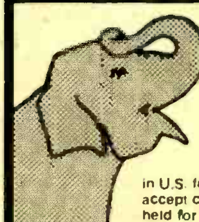
Save your voltage sensitive appliances (refrigerators, air-conditioners, etc.) from deadly brownouts. Sounds an alarm when the power line voltage drops to low or rises to high. Alarm trip points are adjustable. **Kit $29.95.** With 10 amp power outlet for auto shut-off and four minute timeout delay *(pictured)* **$39.95.**



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PHOENIX, AZ 85080

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Mini	6.3	300 mA	273-1384	2.59
Mini	12.6	300 mA	273-1385	2.79
Mini	25.2	300 mA	273-1386	3.49
Mini	12.6 CT	450 mA	273-1365	3.59
Mini	25.2 CT	450 mA	273-1366	3.99
Std.	6.3	1.2 A	273-050	3.79
Std.	12.6 CT	1.2 A	273-1505	3.99
Std.	25.2	1.2 A	273-1480	4.39
H-D	12.6 CT	3.0 A	273-1511	5.99
H-D	25.2 CT	2.0 A	273-1512	6.29
H-D	18.0 CT	2.0 A	273-1515	6.99

Tantalum Capacitors

- 20% Tolerance
- Standard IC Pin Spacing

µF	WVDC	Cat. No.	Each
0.1	35	272-1432	.49
0.47	35	272-1433	.49
1.0	35	272-1434	.49
2.2	35	272-1435	.59
10	16	272-1436	.69
22	16	272-1437	.79

Ceramic Disc Capacitors

Low As **39¢** Pkg. of 2

For RF, bypass and coupling. Hi-Q. Moistureproof coating. 50 WVDC.

pF	Cat. No.	Pkg. of 2
4.7	272-120	.39
47	272-121	.39
100	272-123	.39
220	272-124	.39
470	272-125	.39

µF	Cat. No.	Pkg. of 2
.001	272-126	.39
.005	272-130	.39
.01	272-131	.39
.05	272-134	.49
.1	272-135	.49

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5 VDC Coil. 275-232 .... 1.49

12 VDC Coil. 275-233 .... 1.49

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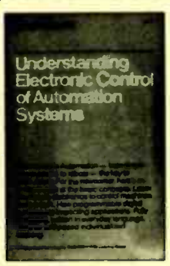

Understanding Electronic Control of Automation Systems. This illustrated, 256-page book explains how electronics is being applied to industrial automation to increase productivity. 62-1387 .... 2.95

Low-Profile DIP Sockets

Quality non-wicking sockets for PC use. Low-resistance contacts.

Type	Cat. No.	Price
8-Pin	276-1995	2/.59
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16-Pin	276-1998	2/.89

Type	Cat. No.	Each
18-Pin	276-1992	.49
20-Pin	276-1991	.59
24-Pin	276-1989	.79
28-Pin	276-1997	.89
40-Pin	276-1996	.99

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Card Edge Socket	44	276-1551	2.99
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No-Solder Sub-D Fem.	25	276-1565	4.99
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

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Type	Cat. No.	Each
XR 2206 AFSK Generator	276-2336	5.95
XR 2211 Decoder/PLL	276-2337	5.95
MC1330 Video Detector	276-1757	1.99
MC1350 IF Amp With AGC	276-1758	1.99
MC1358/CA3065 FM Detector	276-1759	1.79

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39¢ Pkg. of 5

Ohms	Cat. No.
10	271-1301
100	271-1311
150	271-1312
220	271-1313
270	271-1314
330	271-1315
470	271-1317
1k	271-1321
1.8k	271-1324
2.2k	271-1325
3.3k	271-1328
4.7k	271-1330
6.8k	271-1333

Ohms	Cat. No.
10k	271-1335
15k	271-1337
22k	271-1339
27k	271-1340
33k	271-1341
47k	271-1342
68k	271-1345
100k	271-1347
220k	271-1350
470k	271-1354
1 meg	271-1356
10 meg	271-1365

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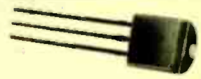
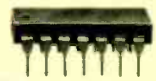
Teaches the basics of modern electronics with an emphasis on integrated circuits. Easy-to-read text and diagrams. 128 pages. Already a "classic". 276-5003 .... 2.49

Replacement Transistors



Type		Cat. No.	Each
2N1305	PNP	276-2007	1.19
MPS222A	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
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
2SC1308	NPN	276-2055	7.95
2N3819	N-FET	276-2035	.99
MPF102	N-FET	276-2062	.99

4000-Series CMOS ICs



With Pin-Out and Specs

Type	Cat. No.	Each
4001	276-2401	.99
4011	276-2411	.99
4013	276-2413	1.19
4017	276-2417	1.49
4049	276-2449	1.19
4066	276-2466	1.19

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7408	276-1822	1.29
7447	276-1805	1.59
7490	276-1808	1.09

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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

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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

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HB-0100 Buss Strip
Each buss strip contains four groups of labeled contact points (25 per group) providing multipoint distribution for Vcc, ground and signal paths. When interconnected, HB-0100's can simulate Micro-Processor's data or address busses simplifying ROM, RAM, UART, etc. to processor interconnects.
Competition Price: $3.00!
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With HANDY sockets, breadboarding is easy because you always know where you're at. Each group of 5 contacts is labeled from 1-64 and each position within a group is labeled from a-j. With 64 groups of 5 contacts each you have more then enough room for infield and lab mock-ups that always come up when you least expect them.
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HB-1000 $9.95
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One socket and one buss strip with self-adhesive backing and metal ground plate.
Big nine 14-pin DIP capacity.
Competition Price: $18.50!
HB-1210 $13.95
HB-1110
One socket and two buss strips with self-adhesive backing and metal ground plate.
Big nine 14-pin DIP capacity.
Competition Price: $15.49!
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Handy HB-2112
Va
Vb
HB-2112
A compact breadboard ideal for beginners, students, professionals and hobbyists. It's quick and easy to use and immediately becomes the most useful tool on your workbench. Includes: • 2 sockets • 1 buss strip • 2 binding posts and is mounted on an 8.7"x5.4" aluminum ground plate. 18 14-Pin DIP capacity.
HB-2112 $24.95
ORDER NOW!
HB-2313
Holds enough IC's to meet any quick-fix situation. Includes: • 2 sockets • 3 buss strips • 3 binding posts and is mounted on an 8.7"x5.9" aluminum ground plate. 18 14-Pin DIP capacity.
Competition Price: $51.50!
HB-2313 $31.00
HB-3514
Ideal for light industrial as well as secondary level educational and hobbyist experimentation.
Includes: • 3 sockets • 5 buss strips • 4 binding posts and is mounted on a 9.4"x7.7" aluminum ground plate. 27 14-Pin DIP capacity.
Competition Price: $66.00!
HB-3514 $47.95
HB-4714
Largest HANDY breadboard available today. Complete PCB or even system mock-ups can easily fit on this breadboard. This high capacity, heavy duty board is a must for industrial users where time is money ...Great for advanced educational and hobbyist applications.
Includes: • 4 sockets • 7 buss strips • 4 binding posts and is mounted on a 10.3"x9.5" aluminum ground plate.
Giant 36 14-Pin DIP capacity.
Competition Price: $89.00!
HB-4714 $63.95
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Giant .7 Inch 4-Digit LED Display

- F° and/or C° and virtually any number of sensors
- 50/60Hz line frequency operation
- 12 or 24 Hour Display

Typical applications: Clock Radio Timers, Alarm Clock, Desk Clock, TV and Stereo Timer, Instrument Panel Clock, Digital Thermometer and much more.

Part No.	Description	Price
MA1026M	MA1026 clock module only	$30.90
MA1026P	Digi-Key switch panel kit (P.C. Board, 12 switches, two LM3342 temp. sensors, two KOA32 potentiometers, instructions).	11.95
MA1026T	110 VAC transformer for MA1026M	3.95
MA1026B	Alarm buzzer for MA1026M	3.10
MA1026K	MA1026M, P, T, B	46.75

For additional sensor units, you will need:

LM3342	Temperature Sensor	1.51
K4A32	300 ohm Potentiometer	.32
502PB	Normally open SPST Switch	.84

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0.7" or 0.84" Red 4-Digit LED Display

User Programmable For:

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- Fixed or flashing dot (colon indicator)
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- Battery back-up in case of power failure
- Typical applications include: clock radio timer, alarm clock, desk clock, instrument panel clock, and many more

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Cat. No.	Description	Price
MA1020M	MA1020 Clock Module only	$16.65
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MA1020T	110 VAC Transformer for MA1020M	3.95
MA1020B	Buzzer for MA1020M alarm output	3.10
MA1020K	MA1020M, P, B and T	31.65

MA1023 — 0.7 INCH HIGH DIGITS

Cat. No.	Description	Price
MA1023M	MA1023 Clock Module only	$12.85
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MA1023T	110 VAC Transformer for MA1023M	3.95
MA1023B	Buzzer for MA1023 alarm output	3.10
MA1023K	MA1023M, P, B and T	25.10

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12 VDC — for Car, Van or Boat!

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3AG SLO-BLO FUSES

Silicon Transistors

DIGI-KEY Part No.	1	10	100	1,000
2N3055	1.44	12.00	108.00	980.00
2N3904	.23	2.20	18.90	173.25
2N3906	.23	2.20	18.90	173.25
2N4124	.24	2.27	19.50	178.75
2N4126	.24	2.27	19.50	178.75
2N4401	.23	2.20	18.90	173.25
2N4403	.23	2.20	18.90	173.25
2N4410	.33	3.15	27.00	247.50
2N5087	.24	2.20	20.00	180.00
2N5088	.28	2.60	24.00	220.00
2N5210	.23	2.20	18.90	173.25
2N5457	.67	6.30	54.00	495.00
92PU01A	.46	4.20	36.00	330.00
92PU10	.46	4.20	36.00	330.00
92PU45A	.48	4.56	39.00	357.50
92PU51A	.46	4.20	36.00	330.00
MJ2955	2.76	25.72	220.50	2021.25
MJE172	.67	6.30	54.00	495.00
MJE182	.71	6.65	57.00	522.50
MJE340	.71	6.65	57.00	522.50
MJE344	.67	6.30	54.00	495.00
MJE370	.78	7.35	63.00	577.50
MJE371	.87	8.10	78.00	715.00
MJE520	.75	7.00	60.00	560.00
MJE521	.86	8.05	69.00	632.50
MJE703	.78	7.35	63.00	577.50
MJE712	.78	7.35	63.00	577.50
MJE722	.86	8.05	69.00	632.50
MJE803	.87	8.10	78.00	715.00
MPF102	.56	5.25	45.00	412.50
MPS2222A	.23	2.20	18.90	173.25
MPS2369A	.23	2.20	18.90	173.25
MPS2907A	.23	2.20	18.90	173.25
MPS3392	.23	2.20	18.90	173.25
MPS3393	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.28	2.62	22.50	206.25
MPS3565	.23	2.20	18.90	173.25
MPS3638A	.23	2.20	18.90	173.25
MPS3641	.23	2.20	18.90	173.25
MPS3643	.23	2.20	18.90	173.25
MPS6510	.28	2.62	22.50	206.25
MPSA13	.33	3.15	27.00	247.50
TIP112	1.08	10.15	87.00	797.50
TIP117	1.12	10.50	90.00	825.00
TIP120	1.01	9.45	81.00	742.50
TIP122	1.01	9.45	81.00	742.50
TIP127	1.05	9.80	84.00	770.00
TIP132	1.05	9.80	84.00	770.00
TIP135	1.35	9.80	84.00	770.00
TIP29C	.78	7.35	63.00	577.50
TIP30C	.78	7.35	63.00	577.50
TIP31C	.78	7.35	63.00	577.50
TIP32C	.75	7.00	60.00	560.00
TIP61C	.75	7.00	60.00	560.00
TIP62C	.75	7.00	60.00	560.00

1% Metal Film Resistors

Max. RC WV: 250V Max. Voltage: 500V
Dielectric Withstanding Voltage: 500V

Standard Resistor Values from 10 to 1.00M ohms

STANDARD RESISTOR VALUE TABLE

How To Order: Take any standard resistor value and add "X" (e.g. 3.32KX), that is the Digi-Key part number. Order by quantity and price listed below.

For large quantities and prices at low as ... contact DIGI-KEY

5% Carbon Film Resistors

5% Carbon Film Resistor Values in Ohms

¼ WATT 5% CARBON FILM RESISTOR ASSORTMENT

½ WATT 5% CARBON FILM RESISTOR ASSORTMENT

In order to receive the pricing below, the resistor part number must be followed by a "-ND" (i.e., 10KQ-ND) and ordered in multiples of 1,000 only.

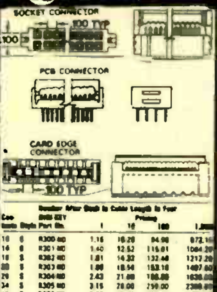
Price /1000	1M	10M	50M	100M	500M	1000M
¼W	9.00/M	8.00/M	6.50/M	6.00/M	5.80/M	5.60/M
½W	13.60/M	11.40/M	10.80/M	9.80/M	8.35/M	7.40/M

ROBINSON NUGENT INC

SOCKET CONNECTOR

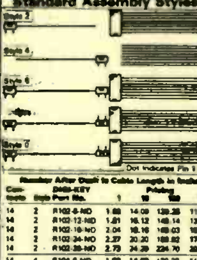
PCB CONNECTOR

CARD EDGE CONNECTOR



DIP Jumper Cable Assembly

Standard Assembly Styles



Dot indicates Pin 1

alpha wire cable tubing

Hookup Wire, Stranded PVC Insulated

D Subminiature Connectors

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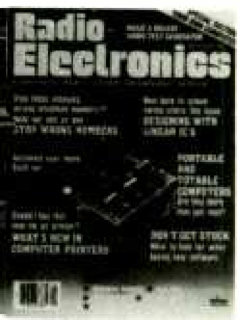

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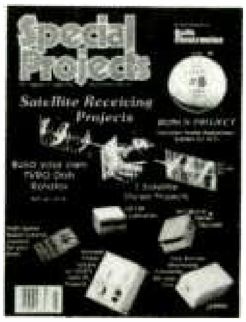

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