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JANUARY 1990

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Build this 8-bit word-recognition logic analyzer for only six dollars!
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COMPUTER DIGEST



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ON THE COVER



Chances are you've already joined the hoards of people who have abandoned the long lines and high prices of local movie houses for the convenience and comfort of their favorite armchairs? Now, if only the films you watch on your VCR sounded as good as they look. . .

Enter our Acoustic Field Generator, which goes a couple of steps past the standard surround-sound decoder project. The apparent separation of the stereo image from the front speakers is greatly increased, while a center dialogue channel keeps the actors' voices realistically near the screen. The AFG is simple to connect into the pre-amp/power-amp loop of your home-entertainment system, and the built-in 75-Hz active low-pass filter provides a sub-woofer output. Turn to page 35.

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COMPUTER DIGEST

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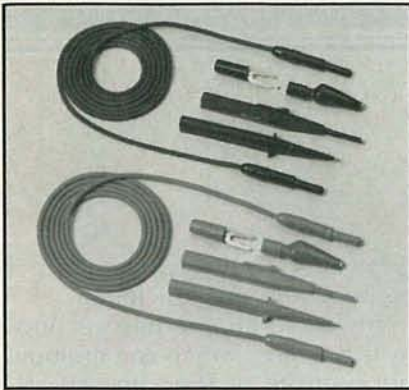
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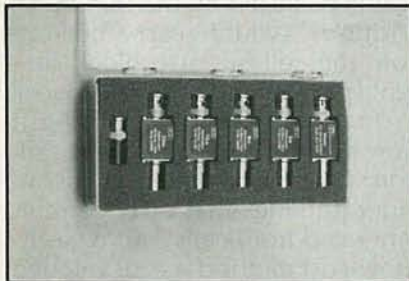




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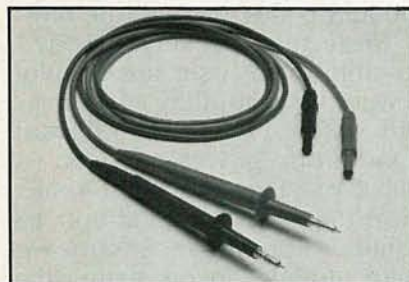


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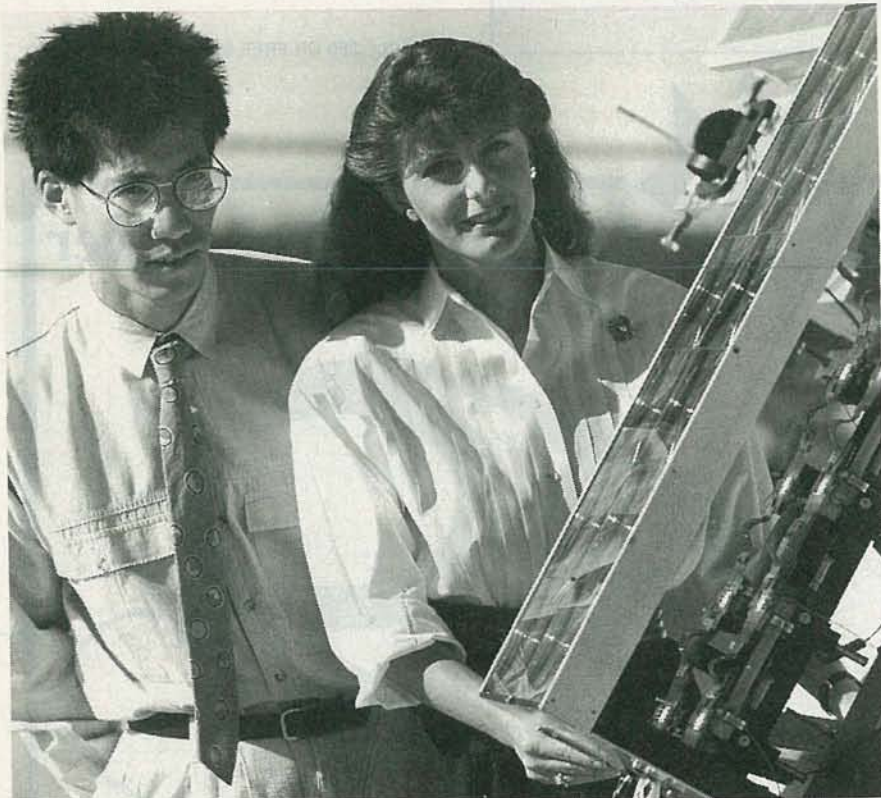
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WHAT'S NEWS

20%-efficient solar module



SANDIA RESEARCHERS CLEMENT CHIANG AND ELIZABETH RICHARDS show the experimental photovoltaic concentrator used to achieve a record-breaking 20.3 peak solar-to-electric conversion efficiency.

Twenty-percent efficiency might not be considered impressive in most instances, but when it means that 20% of the solar energy falling on a solar concentrator module is being converted directly into electric energy, that figure takes on new dimensions. The photovoltaic concentrator module developed by researchers at Sandia National Laboratories—an arrangement of 12 plastic lenses that concentrate sunlight to 100 times its normal

level onto 12 silicon solar cells—has achieved a peak solar-to-electric conversion of 20.3%.

The module incorporates a new silicon concentrator cell with up to 25% efficiency and a transparent cell cover molded directly to the cells to reduce gridline reflection losses. A new technique of soldering cells directly to copper heat spreaders reduces costs and improves performance and reliability, and an anti-reflective coat-

ing improves lens efficiency.

The key to the module's economy is the lens, which can multiply the intensity of the sun several-hundred times and focus it on a cell. The module uses an essentially module-ready, about half-inch square, low-resistivity cell that was developed by Martin Green at the University of New South Wales in Australia. A prismatic cell cover deals with the problem caused by the thin metal gridlines—which carry current from the cell but also block sunlight from falling on the silicon cell surface—by bending sunlight away from the gridlines to the silicon surface. That allows the use of wider gridlines that carry current, generated from cells, more easily. A low-cost method was developed for cleaning the surfaces and soldering them together, allowing the cells to be soldered directly to the heat spreader beneath them, eliminating a ceramic insulator that separates them in conventional modules. Finally, an anti-reflective layer of magnesium fluoride solution was applied to both surfaces.

According to Eldon C. Boes, supervisor of Sandia's Photovoltaic Technology Division, "Industry should be able to duplicate most of these features very quickly." Possible initial uses are in pilot power plants at utility companies and small, 10- to 1000-kilowatt stand-alone power systems. (A 1000-kW system will meet the electrical requirements of about 300 homes.) Boes expects concentrator modules incorporating the innovations to be on the market within about three years.

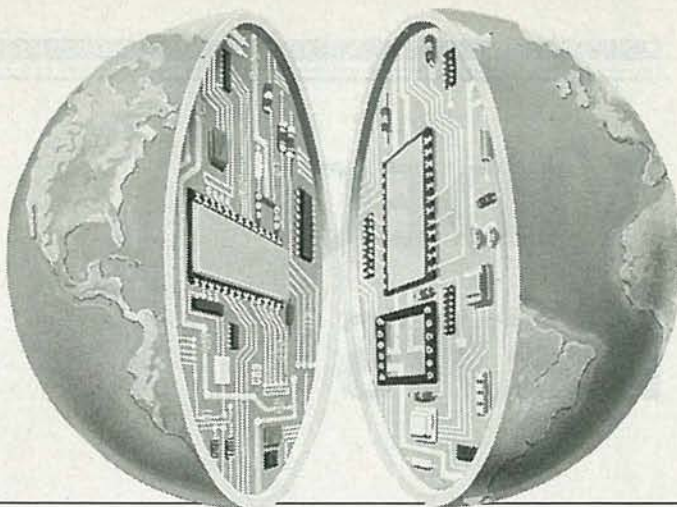
High quality AM sound

The National Association of Broadcasters and the Consumer Electronics Group of the Electronic Industries Association have agreed to enter a joint program to promote high-quality AM sound

using the standards of the National Radio Standards Committee or NRSC. The NRSC standards improve AM radio transmission and reception quality and reduce interference between stations, thus improving the quality of sound.

The first task for the groups is to establish a certification mark or logo that will be used on the faceplate of high-quality AM receivers that are equipped to comply with NRSC deemphasis and bandwidth specifications. **R-E**

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VIDEO NEWS



DAVID LACHENBRUCH,
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● **Zenith sticks with TV.** After a long and fruitless effort to sell its consumer-electronics business, Zenith, in a sudden move, agreed to sell its computer business to Groupe Bull of France. The company said that the move will enable it to strengthen its "original core business" of making and selling TV sets and its work on high-definition TV. The pioneering company now says that it is renewing its commitment to TV and video. Zenith plans to build on its longtime strengths in "consumer electronics and display technologies," according to President Jerry Pearlman. Since the sale of the RCA and GE television business to Thomson of France, Zenith has been the only major American-owned TV manufacturer.

● **LCD developments.** Japanese manufacturers and government agencies appear convinced that the liquid-crystal device will be the ultimate successor to the cathode ray tube as the direct-view and projection-display system for television. Two major Japanese-government-backed projects are aimed at that goal. JTV, a consortium consisting of 17 private companies with the backing of the Ministry of International Trade and Industry (MITI), has a goal of developing a 40-inch flat-screen color display with a resolution of 6,000,000 pixels. The other group, HDTEC, consists of five private firms and the Post Ministry, and is charged with developing a 50-inch rear-projection system with a resolution of 2,000,000 pixels and a light source four times the brightness of a CRT. HDTEC is capitalized at \$24,500,000; JTV, at \$20,000,000.

● **Pay to view as you fly.** The airlines have figured out a new way to keep you spending while you fly. Lockheed is demonstrating to its aviation customers an in-flight entertainment system consisting of a seat-back LCD color display—with a slot for credit cards. The system can provide eight channels of movies or video games that can be paid for by sliding a card through the slot. In addition, the system includes special films advertising products that can be ordered by touching the screen at the proper time and using the credit card. Before you can change your

mind—while the aircraft is still in flight—an on-board computer sends your order by satellite to an on-the-ground sales center, which tallies your bill for watching the movie and for any purchases and dispatches it to your home by mail—perhaps even before you land.

● **EDTV broadcasting starts.** "Clearvision," Japan's Extended-Definition TeleVision (EDTV) system is now being broadcast for five hours each day by many of that country's stations. The compatible system results in an improved picture on Clearvision television receivers without affecting the image on standard sets. The current "Phase I" Clearvision system, employing the standard 4:3 aspect ratio, involves the following improvements at the TV station: (1) better camera performance through the use of high-definition or progressive-scan cameras, with the improved signal downconverted to a standard interlaced NTSC-compatible signal; (2) gamma correction to improve color, particularly at high saturation levels; (3) picture sharpness and signal-to-noise ratio improved by "adaptive emphasis;" and (4) ghost-canceling reference signal.

Clearvision receivers improve the signal by using 3-D comb filters for Y/C separation, and use digital memory to convert the interlace picture to progressive scan. They might also have an optional ghost-reduction circuit, which eliminates ghosts by comparing the received waveform with the transmitted waveform carried on the reference signal (sent on line 18 of the vertical interval). Ghost reducers, which work with standard as well as Clearvision sets, are also available as add-on "black-box" attachments. The Japanese ghost-canceling system is one of several being explored for use in the United States (**Radio-Electronics**, *Video News*, November 1989).

Phase II of Clearvision is expected to use a widescreen 16:9 aspect ratio, extension of chrominance- and luminance-signal bandwidth, and PCM digital audio—without sacrificing compatibility. There's no timetable yet for that second phase.

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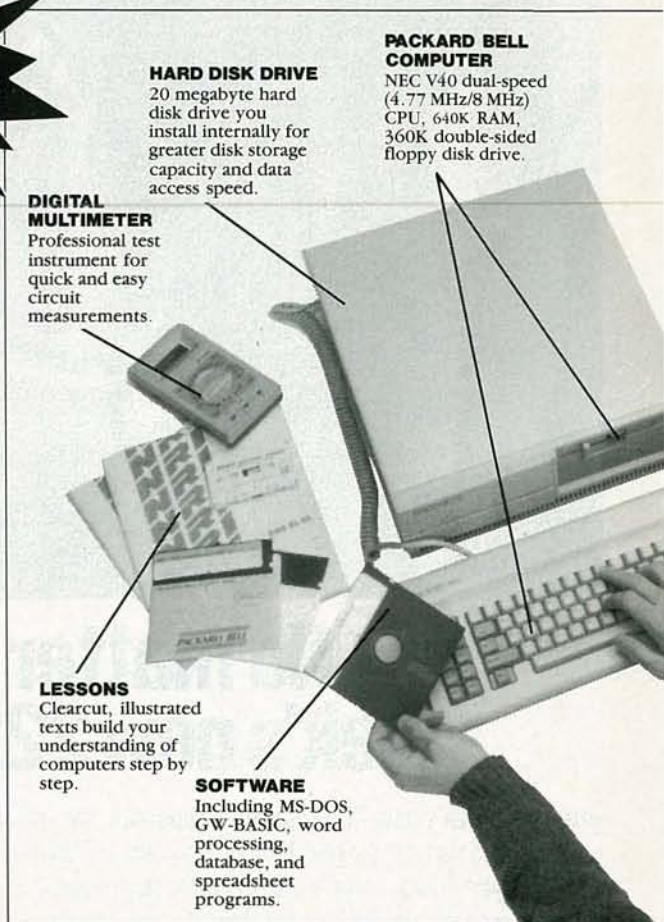
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Farmingdale, NY 11735

BINARY CODING

I've seen lots of information on how numbers are encoded in binary and I've come across IC's that convert one system to the other. What is not clear to me is how binary is used to represent the characters of the alphabet. How is it done and are there any IC's around that can do that?—N. Cohen, Hagerstown, Maryland

You're asking a really basic question, so it seems that you're a bit confused about basic issues. There are quite a few books that do a good job of introducing readers to the standards that have been adopted for number systems and how they're used to encode data. Since you already understand how numbers are represented in binary, you won't have any trouble understanding how the same thing is done with alphabetic characters.

There's a direct relationship between the decimal representation of numbers and their binary counterparts. You can see that in Table 1.

In binary, only two symbols (1 and 0) are used while ten (0 to 9) are used in decimal. The binary symbols are referred to as "bits," and the decimal symbols are referred to as "numbers."

Somewhere back in pre-history, it was decided that eight bits would be referred to as a "byte," and that a different byte would be used to encode each of the characters of the alphabet, the numbers, and the standard punctuation symbols. Each symbol was assigned to a unique two-byte value—an upper-case "A" would be represented by the two bytes 0100 0001 (or 65 decimal), the number "3" would be given the two bytes 0011 0011 (or 51 decimal), and so on. The standard codes became known as "ASCII" (pronounced "as-key," for American Standard Code for Information Interchange), and they are still used as the basis of all data transmission and digital technology.

Since the major use for the ASCII standard was initially in sending information over teletypes, several places in the two-byte table were reserved for additional codes to control the teletype machines as well as make sure that information was transmitted without errors. A "Line Feed" became a 0000 1010 (or 10 decimal), and a "Carriage Return" was a 0000 1101 (or 13 decimal).

You can find a complete ASCII table in most computer manuals or any good book on data transmission. What you'll notice is that only half of the table is used. Even though the two-byte table has room for 256 entries, only the first 128 are used for the standard symbols and the control codes—the upper half of the standard table is empty. The reason for that is that while only seven bits (128 places) were needed to accommodate all the required characters, most digital

technology was built around the idea of eight-bit data.

When computers started becoming popular in the late seventies, the eighth bit in the two-byte table was used by hardware manufacturers to convey extra information. The Apple computer, for example, used the eighth bit to indicate how the character would appear on the screen—normal, inverse, or flashing. Other manufacturers, such as IBM, used the top half of the table to house an "extended ASCII" character set. Those include some foreign-language characters, graphics symbols, and other non-standard things that are unique to the IBM character set.

One of the things that's probably confusing you is the difference between a character's symbol and its value. The number 7, for example, has a particular arithmetic value (one more than 6), but the ASCII character set doesn't deal with arithmetic—it's only used to convey character symbols, not values. The numerical value of 7 can be represented by using "7," "0111," or even "VII." The symbols may be different but they're all being used to represent the same number.

Binary-to-decimal number conversion is such a common job that there are several standard IC's designed specifically for that purpose; a 4514, 74154, and other chips will take a binary input and give you a decimal output.

Converting binary representations of ASCII characters to alphabetic symbols means using "Character Generators." They

TABLE 1

BINARY	DECIMAL
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
and so on	

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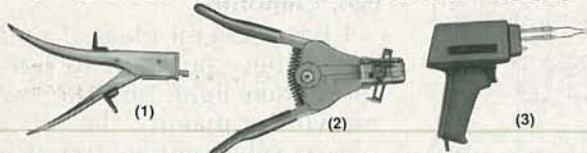
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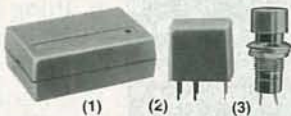
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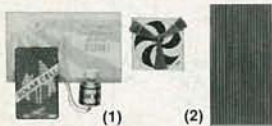
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are just memory IC's that have been programmed with the ASCII character set. They take binary values at their input and present the ASCII equivalent code at their output. Chips like a 4511, or others designed to drive seven-segment LED displays, convert binary data to information you can use to directly display ASCII characters.

Remember that there's a difference between the value of a number and the character used

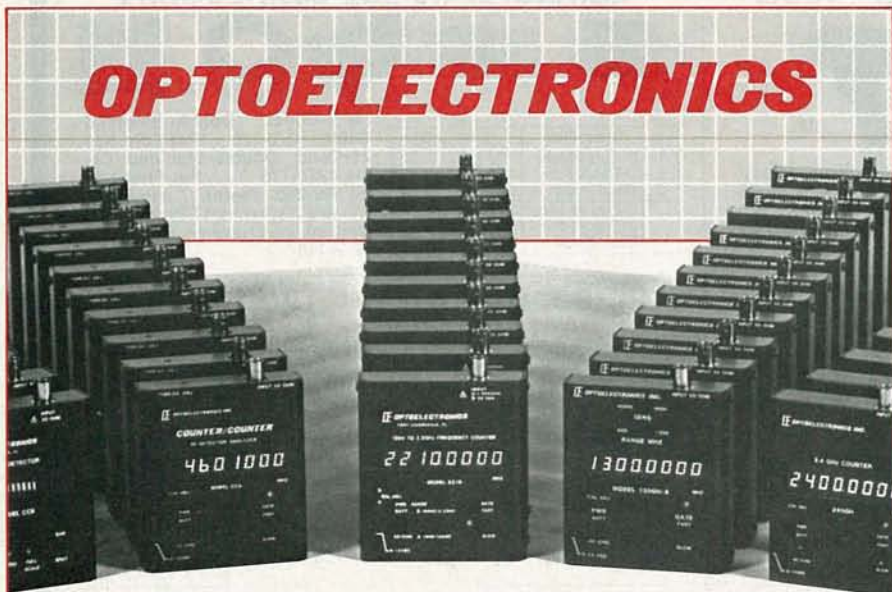
to represent it—one has nothing to do with another. As a matter of fact, that kind of confusion can only come about when you talk about numbers since they're the only members of the ASCII character set that have an absolute arithmetic value. The letters, punctuation marks, and control codes that make up the rest of the standard ASCII set may be able to convey lots of meaning, but you can't use them to balance your checkbook.

2N2222 AND GATE

I learned the basics of digital electronics in the navy, and have even made basic gates from discrete components. At the moment, I'm trying to hook up a third brake light that will light up when the other two light. I need an AND gate to do the job but I'm not sure how to build one with individual components. I haven't experimented yet, but I don't think I can do the job with a pair of 2N2222's and some resistors. Do you have any ideas?—V. Sandoval, San Diego, California

I have several ideas. I understand that you want to light a third brake light, but it seems to me you're making the job unnecessarily complicated. While there's no electronic reason why you can't build an AND gate out of discrete hardware, it seems like a lot of extra work. Of course, there's no rule about that sort of thing and one nice thing about re-inventing the wheel is that you really learn how the wheel works.

One way to do it is shown in Fig. 1. The transistors are operating as simple switches, and when both of your existing tail lights are on, you'll wind up with voltage across the third tail light. I seriously doubt that you can get by with a



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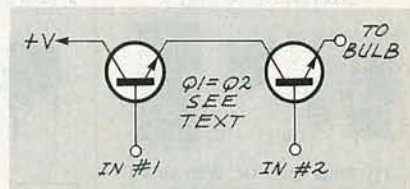


FIG. 1

pair of 2N2222's, because most automotive bulbs draw much more current than can be handled by a small-signal NPN. You can either use beefier transistors or, if you want to complicate your life even further, you can have the transistors drive a relay with contacts rated for a high enough current.

The relay isn't such a bad idea since driving the bulb directly with the transistors will leave you with a working voltage of some 1.2 volts less than battery voltage. Remember that you're going to lose about 0.6 volts through each of the transistors. If you use a relay, you'll be able to power the third bulb directly off the battery.

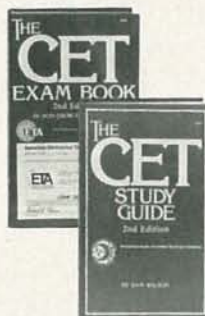
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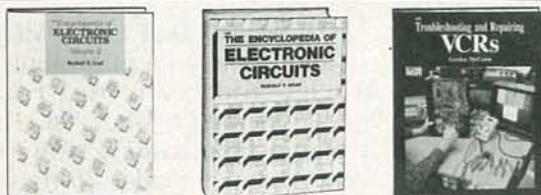
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LETTERS

HELPFUL HINTS

I would like to offer some comments and suggestions concerning some recent items in **Radio-Electronics**.

First, a better way to control a pump than that presented in *Ask R-E* (November 1989) is to use the LM 1830 fluid-detector IC. Its advantages over a simple transistor circuit are fully described in the National Semiconductor *Linear Databook*, along with typical circuits, etc. The most important of those advantages is that the LM 1830 uses a very low-level AC signal (typically 7 kHz) for the sensing function, which eliminates the "plating" that can and does occur over a long period with DC signals. It can control a low-current relay directly, a larger relay via an intermediate transistor, and a triac or quadac via simple intermediate circuitry. I have used that IC and associated components to control a pump that removes water from an area subject to flooding during heavy rains, and as a much more reliable alternative to the high-priced (but poor quality) switches sold to control 12-volt bilge pumps in boats.

Concerning the infrared-controlled A/B switch (**Radio-Electronics**, October 1988), relay switching is enhanced by using a double-pole-double-throw RF relay that connects the input that is not being used to a 75-ohm load resistor. That both improves isolation and avoids any problems that a mismatch could cause.

The Radio Shack 276-137 detector module (\$3.49) is convenient to use for IR controllers. It includes an IR phototransistor, amplifier, filter, and detector in a small PC-mountable package. The IR source should be turned on and off at a

40-kHz rate. That 40-kHz signal should then be pulsed at an audio rate. The output of the Radio Shack detector is the audio rate. It is detected by one or more 567 tone-detector chips. The transmitter is, conveniently, a 556 dual timer. One half of it operates at 40 kHz to drive the IR emitter diode (or, preferably, two diodes in series). The other half operates at the audio rate and pulses the 40-kHz oscillator via its reset pin.

I built a circuit that allows me to select one of three sources (A, B, or C) using two RF relays and small SCR's for latching. Instead of simply toggling back and forth between signals, the receiver has three 567 tone decoders and the logic to select the desired source corresponding to the tone sent by the IR transmitter. The modulation frequency in the hand-held transmitter is selected by pressing one of three buttons. All three buttons turn on both halves of the 567; two of them also control diode switches to change the audio-modulation frequency. Simple diode logic allows the use of single-pole push-buttons. The audio-modulating frequencies are about 700, 1000, and 1300 Hz. When a button is pressed, the one desired is selected by means of diode switches that change the capacitor value in the half of the 556 used in the transmitter to generate the audio tone. The frequencies are not accurately adjusted; the 567 tone decoders are tuned to whatever the modulating frequencies happen to be with the capacitors used in the transmitter. L.D. THOMAS
Georgetown, DE

NTSC/PAL VCR CONVERSIONS

I read a letter in a recent issue of **Radio-Electronics** that discussed



the possibility of converting PAL VCR tapes to NTSC. That is a major dilemma for servicemen stationed in Europe. Here we sit with American TV's and VCR's, unable to watch EURO-TV or rent PAL VCR tapes. To do so we must purchase another TV and VCR in PAL format.

I have searched here in England for a converter device, as the EURO-TV presents American TV shows. There is such a "black box" that has extras required for professional broadcasting (color and sound mixing, enhancers, etc.)—but it costs about \$2500. I would like to find one that just converts either the RF signal or the video and audio signals between PAL and NTSC.

I have also found a Motorola chip, the MC1377P, that converts a video RGB signal to a switchable NTSC/PAL composite signal. I have tried to find a way, but I can't find the solution to make it work.

Could you possibly run an article on the merits or disadvantages of doing that, and maybe a design for a do-it-yourself kit?

CHARLES MAY, TSgt USAF
RAF Alconbury, UK

AUTOMATIC TEST EQUIPMENT

I appreciate your publishing my article, "Automatic Test Equipment," in the October 1989 issue of **Radio-Electronics**. However, some changes made during editing might give readers some erroneous impressions.

A computer and a controller are mentioned, on page 61, as being separate parts of an ATE. Actually, they are one and the same, as stated in my manuscript. The computer controls things in the ATE.

Figure 1 in the article is mislabeled, giving the impression that the ATE is to the bottom of the

dashed lines. The ATE is actually the portion that is shown above the dashed lines. The portion below the dashed lines and the two interface rectangles is the outside world.

Finally, the next-to-last paragraph on page 62 states that functional testers test signals at UUT inputs. In reality, they apply test signals at UUT inputs, and then check the response at the UUT output.

Although the differences are minimal, I felt you and your readers would want to know about them.

ALLAN C. STOVER

CHEMICAL CONFUSION

I appreciate Robert Grossblatt's series of articles on printed circuit-board construction (*Designer's Notebook*, October–December 1989), and I'd like to pass on some information that might benefit other readers. The Kodak chemicals described in the November 1989 column are no longer carried by Kodak. Apparently Kodak sold the division that produces those chemicals to Union Carbide, who placed them in their own KTI division. KTI sells only through distributors and only one of those distributors sells the chemicals in small quantities.

The bottom line is that a company in Pennsylvania called PCE (why do chemical companies always use initials?) will sell to individuals. Their phone number is 215-296-8585. They accept American Express or ship UPS-COD. The prices are roughly \$61.00 for one quart of photo resist, \$30.00 for the developer, and \$7.00 for the booklet. The catalog numbers in the article haven't changed. PCE carries a wide variety of chemicals, so it is important to have the catalog numbers in hand when placing an order.

Thanks for your efforts to keep the hobbyist informed. I look forward to finally making quality printed-circuit boards. Keep up the good work.

DR. BARRY C. MEARS
Florissant, MO

FAX-MATE FACTS

It has come to our attention that there are a few errors concerning

the Fax-Mate article (*Radio-Electronics*, October, 1989). In the schematic of Fig. 2, R3 should be moved into the feedback loop of IC1, and the primary (right side) and secondary (left side) of T1 were not labelled. In the parts-placement diagram of Fig. 3, the labels of the primary and secondary sides of T1 should be transposed. That's because T1 is actually being used in reverse; a voltage input to the *secondary* is stepped up and output at the *primary*.—*Editor*

IR REMOTE EXTENDER

If you built the IR remote-control extender (*Radio-Electronics*, May 1989), and noticed noise or snow on your TV screen when using the device, a 0.1- μ F ceramic-disc capacitor connected between the intersection of D1 and R6 and ground will cure the problem. Other problems with the unit's operation may be caused by a poorly regulated +9-volt DC supply (which is often true with many of the inexpensive plug-in power adapters). The addition of a 9-volt Zener diode across the +9-volts (cathode to positive, anode to negative) will eliminate the possibility of any power-supply related problems.—*Editor*

DIGI-COMPASS

Certain errors made their way into the Digi-Compass story (*Radio-Electronics*, November, 1989). In the schematic of Fig. 3, the labels V_{CC} and V_{DD} should be transposed, and V_{DD} should be 6.8 volts instead of 6.5. Also, the two voltages are outputs, and should therefore have open circles instead of arrows. The labels for pins 2 and 3 of IC3 should also be transposed; pin 2 is INP and should be connected to IC2 pin 7, and pin 3 is REF- and should be connected to IC2 pin 8. On page 51, in the right-hand column toward the bottom of the page, the text states that "the number of data acquisition averages can be changed by pushing the '.,' keys." It should have read "by pushing the ">" and "<" keys." And, last, on page 82, "TEXTCOMPLPTn10" should contain spaces between arguments; it should be written as "TEXTCOMP LPTn 10."—*Editor*

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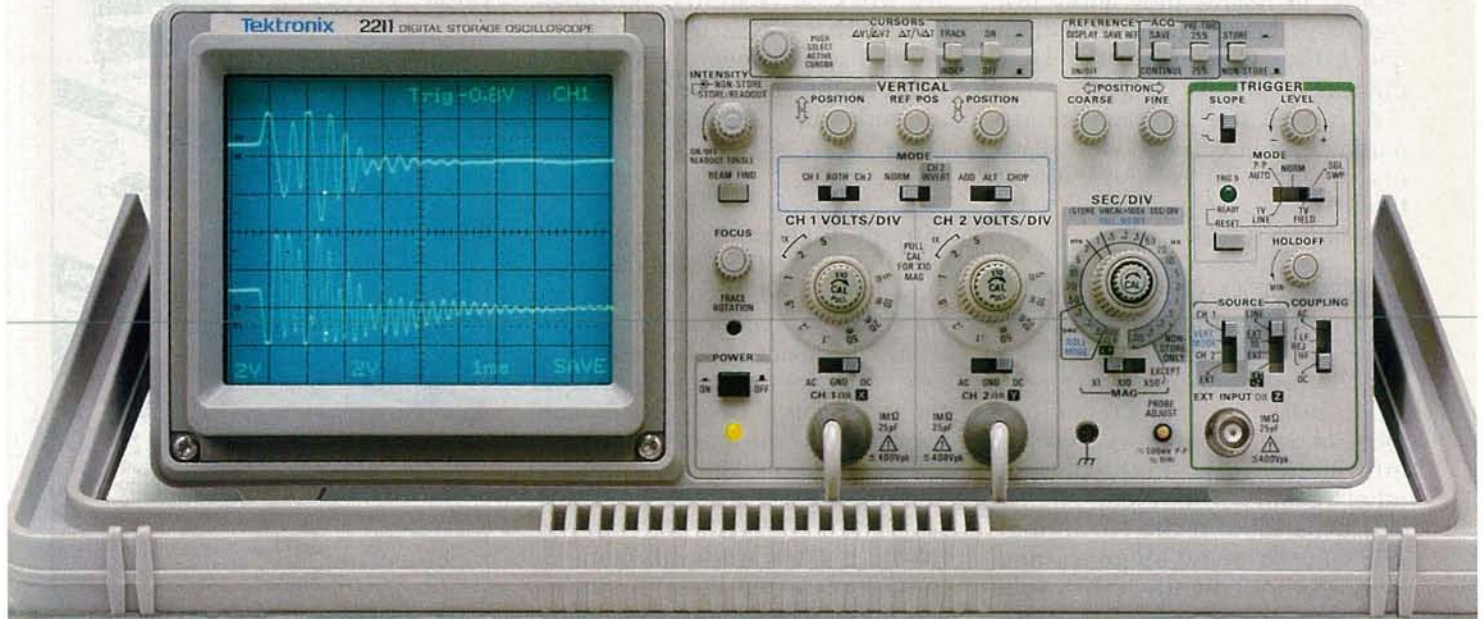
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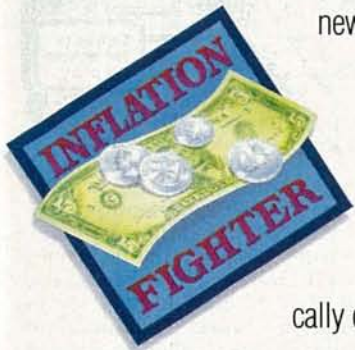


Tek's new 50 MHz 2211 gives you more measurement power for the money than any scope in its class. If you want the performance of an expensive digital scope, but not the cost, our new 2211 is the perfect solution. It represents Tek know-how and quality at its affordable best.

It combines powerful 20 MS/s digital sampling with the familiar operation of an analog scope. In digital storage mode you can capture and display single-shot events, see what happened before a trigger event, or compare newly-acquired signals to a stored waveform.

And if you need to analyze fast or complex signals in real time, simply switch to analog mode with the push of a button.

Productivity-enhancing features are in abundant supply. For instance, all measurements and front-panel scale factors appear on the CRT. Waveform cursors automatically calculate time and voltage. A 4K record length and X50 magnification give you excellent timing resolution, plus analog-quality displays. And trigger levels can be read directly on the screen.



Copyright © Tektronix, Inc. 1989 *Prices subject to change and valid in U.S. only. Educational discounts available on request.

LOW-COST TEST

There's even a standard hardcopy interface that lets you connect the 2211 to Epson printers or HPGL-compatible plotters, such as the Tek HC100, for convenient automatic 4-color documentation.

Of course, the true indication of why the 2211 is "best for low-cost test" is price: it's only **\$2495**. A sum that includes Tek's remarkable 3-year warranty on all parts and labor—even the CRT.

**Three
value-packed
companions
starting at
\$695.**

Model Number	2211	2201	2225	2205
Bandwidth	50 MHz	20 MHz	50 MHz	20 MHz
Storage Bandwidth	1 MHz	1 MHz	N/A	N/A
Sample Rate	20 MS/s/ch	10 MS/s/ch	N/A	N/A
Vert. Sensitivity	500 μ V/div	5 mV/div	500 μ V/div	5 mV/div
Cursors/Readout	Yes	No	No	No
Hardcopy Interface	Yes	Option	No	No
Record Length	4K/ch	2K/ch	N/A	N/A
Vertical Resolution	8 bit	8 bit	N/A	N/A
Price*	\$2495	\$1495	\$1095	\$695



For low-cost testing from 20 to 50 MHz, Tek has the best line-up in the business.

There's the 50 MHz 2225, which offers superb vertical sensitivity, delay, and horizontal magnification up to X50 for only **\$1095**. The 20 MHz, 10 MS/s 2201 is an economical introduction to digital storage at **\$1495**. And for reliable, ultra low-cost analog measurement, get the 20 MHz 2205 for an incredible **\$695**.

It's easy to get the best. To order your low-cost Tek oscilloscope or get more information, contact your local Tek representative. Or call Tek direct at:



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Elenco Micro-Master 8000 Computer System Course

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construction, and
programming with hands-
on experience.

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THERE IS, PERHAPS, NO BETTER WAY TO learn the fundamental concepts of computer operation than by building and programming a computer. The best way to accomplish that is through some sort of structured course, such as the *Micro-Master 8000* microprocessor training system from Elenco Electronics, Inc. (150 West Carpenter Avenue, Wheeling, IL 60090).

The *MM-8000* offers a 14-lesson course that covers the fundamentals of number systems through the writing of practical machine-language programs. The heart of the system is the Intel 8085 8-bit microprocessor. While the 8085 is not the latest and greatest microprocessor, it is a good choice to demonstrate important concepts.

While we examined an assembled version of the trainer, the course is most instructive in its kit form, wherein the *MM-8000* PC board is built step by step as each lesson progresses, and experiments demonstrate the operation of the various subsystems.

Step by step

The first lesson in the course describes the basics of number

systems. Specific attention is paid to the decimal number system with which we are all familiar, and the hexadecimal and binary systems used by computers. The second lesson introduces the concepts of computer data, and data buses, and guides the student through the installation of data-bus indicators and switches.

Intel's 8156 static RAM IC with I/O ports and timer is the subject of lessons 3 through 5. Various on-board switches are used to manually write to and read from the RAM. Once that concept is demonstrated, 7-segment LED displays are added, and the I/O ports of the 8156 are used to control the display. The timer portion of the 8156 is also programmed and run. In lesson 6, a 2816 monitor ROM is added to the setup, and the differences between ROM and RAM are demonstrated.

The 8085 microprocessor is the topic of lessons 7 and 8. Items discussed include the chip's internal registers, flags, and interrupts. The microprocessor's memory-read and -write cycles are described with the help of timing diagrams, and the function of each

pin is explained. Finally the complete instruction set of the 8085 is detailed.

Lessons 9 through 13 describe what the monitor program is, and how it fits in the memory-allocation scheme of the *MM-8000*. The monitor is loaded into a 2816 E²PROM one program at a time. The main components include the initialization, display, keyboard-scan, and function-key sections.

In the final lesson, the complete system is used to execute an external program, adding two numbers and displaying the result. That certainly doesn't sound like any great feat to anyone who has ever operated a pocket calculator—but then again, most people have no concept of how a calculator performs its magic.

The student who completes the *MM-8000* course, however, will understand the basic operation of the 8085 microprocessors, and of microprocessors in general. He will also have an understanding of the basic subsystems of microcomputers, and how they are programmed.

While a dedicated student might find the *MM-8000* ideal as a self-training course, we feel it would be more useful in a school laboratory course, where a teacher and auxiliary texts could augment the course manual. We feel that the manual needs some supplementation because it leaves out what we think is important information. For example, the 2816 is never referenced as an E²PROM, and the functions of some of the other IC's are not well detailed. Granted, those points may not be considered important in a microprocessor course, but they are important nonetheless.

The *Micro-Master 8000* kit costs \$129. We recommend it as an excellent introduction to microprocessors. **R-E**

Hameg HM8028 Spectrum Analyzer Module

Convert any oscilloscope to
a 500-MHz spectrum
analyzer



CIRCLE 46 ON FREE INFORMATION CARD

IF YOU'RE IN THE MARKET FOR A SPECTRUM analyzer but need to keep costs to a minimum, you might find that you can make substantial savings by converting your oscilloscope to do the job. One device that makes it easy to do just that is the *HM8028* spectrum analyzer module from Hameg (88-90 Harbor Road, Port Washington, NY 11050).

The *HM8028* is designed as part of Hameg's *HM8000* modular system series. It can be used, however, with any oscilloscope that offers an X-Y operating mode. The heart of the *HM8000* modular sys-

tem is the *HM8001* mainframe. The mainframe accommodates up to two plug-in modules, and supplies them with power and a signal bus.

The *HM8028* spectrum-analyzer module offers a frequency range of 500 kHz–500 MHz. Its front panel features a clean layout, which is dominated by a 3-digit LED display of the center frequency. A ten-turn potentiometer is used to adjust the frequency. The SCAN WIDTH control, which is used to adjust how much of the spectrum you want to observe around the center frequency, is an 11-position rotary switch. It is adjustable from 50

kHz/div to 50 MHz/div, and a zero-scan position is also available.

Other front-panel controls include an RF gain potentiometer, a 4-pushbutton input attenuator, and bandwidth and video-filter switches.

Input to the analyzer is provided by a 50-ohm BNC connector. A twin BNC connector, along with a special cable, provides output to the X and Y amplifiers of an oscilloscope.

Setting up the spectrum analyzer is quite easy. The analyzer's output is connected to the X and Y inputs of the scope, and the scope is set to its X-Y mode. Both scope channels are set to a sensitivity of 5 volts/div, the input-coupling switches are set to ground, and the beam is adjusted so that it is centered on the graticule. When the scope's input coupling is set to DC, a trace will appear across the bottom of the screen. Adjustment of two trimmers on the analyzer module is required to match the output voltages of the analyzer to the scope being used. When that's

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The SC61 Waveform Analyzer is a triple patented high performance scope that provides you with a digital LCD read-out of all key waveform parameters (DC volts, peak-to-peak volts, and frequency) at the push of a button, and all with one probe connection.

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complete, the setup is ready to make meaningful measurements.

The *HM8028* spectrum-analyzer module comes complete with a connecting cables and a reasonably well written manual. As we mentioned previously, the *HM8028* is part of a series of modular instruments that are designed to use the *HM8000* mainframe. By adding a companion tracking generator, the spectrum analyzer becomes a complete RF test setup.

The tracking generator provides a signal source that tracks the tuning frequency of the analyzer. The combination of analyzer and tracking generator makes it possible to measure the frequency response and insertion loss of any two-port network. Other available accessories include sniffer probes to assist in tracking sources of electromagnetic interference.

While the *HM8028* won't deliver some of the features of full-blown spectrum analyzers, it deserves credit for doing a good job at the reasonable price of \$768. The *HM8001* mainframe costs \$236. R-E

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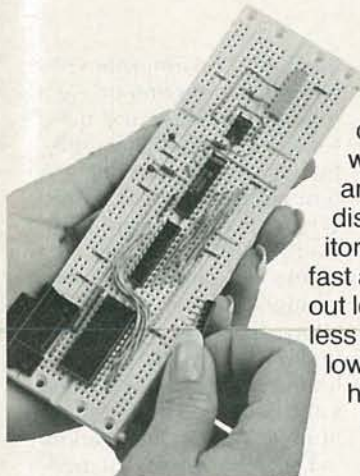
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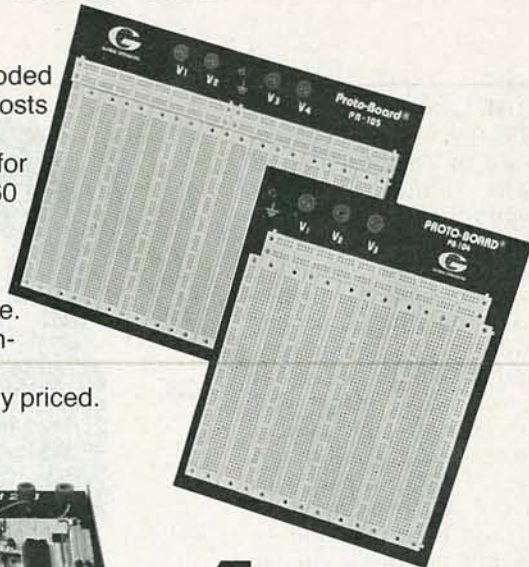
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5 WAYS TO STOP WASTING TIME IN ELECTRONICS.



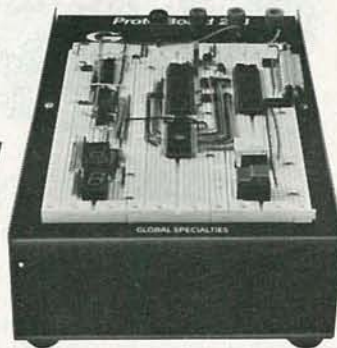
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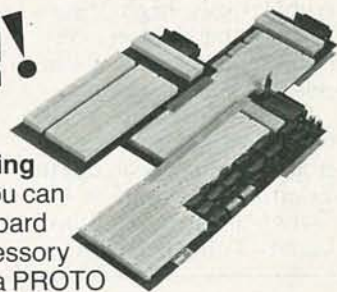
3. Stop wasting your time jury-rigging

large numbers of circuits. Here are two oversized PROTO BOARDS Brand, with expanded area, tie points, and more to keep your ideas together. PB-104 features 3,060 tie points, which can handle to 32 16-pin ICs with ease. Four color coded binding posts, and roomy 9.2" x 8" metal panel make it big...but simple. The humungous PB-105 lets you load up to 48 16-pin ICs, and much more onto its



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JANUARY 1990

25

NEW PRODUCTS

NOISE-CANCELING HEADSETS.

The aviation headsets tested by Dick Rutan and Jeana Yeager on their around-the-world *Voyager* flight, are now directly available from Bose. Stemming from Dr. Amar G. Bose's frustration with passenger headsets on a commercial flight in 1978 (the incessant engine noise interfered with listening pleasure), and the direct result of ten years of R&D, in part with the U.S. Air Force, the *Bose Aviation Headset* features patented electronic circuitry that cancels unwanted noise while allowing desired communications to be heard.

The headset is an integrated system that combines patented physical and electronic noise-attenuation systems and offers two major improvements over conventional headsets. First, the "Clear Comfort" cushions on the earcup, which conform precisely to the contours of the head, seal out noise without uncomfortably high force. Second, the headset's electronic circuitry actively cancels much of the noise.

A sound-pressure servo (feedback) system uses microphones in the earcups to monitor the sound at the user's ear; that measured sound is compared with the



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Boom and Cable can be attached to either left or right earcup

On/Off Switch provides fail-safe operation

Power Input (cigarette lighter adapter supplied)

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sound the user wants to hear—for example, radio communications or, if no signal is provided, silence. The difference between the existing and the desired sound is then "processed" to create a correction signal that is opposite to the unwanted noise and, when reproduced by the speaker in the earcup, cancels the noise. The process of measuring, creating a correction signal, and using it to cancel noise is rapid and continuous, allowing the *Aviation Headsets* to react to any dynamically changing noise source.

The *Aviation Headsets* offer pilots, particularly in propeller-driven aircraft and helicopters, improved communications, reduction in fatigue, and the prevention of permanent hearing loss from ambient noise. Similar headsets would be effective in police, fire, and emergency vehicles, where radio communications must be heard over the sirens.

The *Aviation Headsets* cost \$965.00 each, and are being marketed directly through a toll-free number: 800-242-9008.—**Bose Corporation**, The Mountain, Framingham, MA 01701.

flexibility. An internal voltmeter and ammeter on each model eliminates the need for an external digital multimeter, reduces overall system component costs, and can feed back information via the GPIB. Each unit also offers an automatic programmable timer mode that allows the user to program up to 200 voltage/current-limit settings and 200 time intervals (one-second minimum/ten-hour maximum).

The *PPS Series* of programmable power supplies start at \$995.00.—**Beckman Industrial Corporation**, Instrumentation Products Division, 550 South Harbor Boulevard, La Habra, CA 90631.

HIGH-SPEED COMPARATOR.

Combining a variety of features that simplify analog circuit design, the *AD790* from *Analog Devices* consumes less than one-third the power of other units in its class. It has a maximum 50-ns propagation delay when operated from a single +5-volt or dual ± 15 -volt supplies. With single-supply operation, power dissipation is a maximum 60 mW. It can handle ground-referenced signals, and offers a wide input-signal range, on-board latch, TTL and CMOS logic output, and 500- μ V input-hysteresis voltage.

The *AD790* is the first comparator that is manufactured with Analog Device's high-speed Complementary Bipolar (CB) process. By incorporating CB transistors in the IC design, the comparator can accommodate rail-to-rail input signals and deliver symmetrical output swings. In single-supply operation, the input signal can range from +5

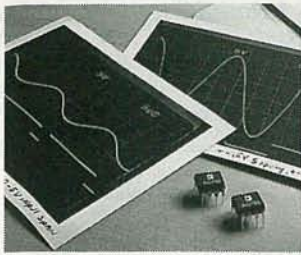
PROGRAMMABLE POWER SUPPLIES.

GPIB capability is built into every model in *Beckman's PPS Series* of system DC-power supplies, eliminating the time-consuming process of choosing GPIB as an option, installing it, and getting it running. The series includes a 30-volt DC/3.5-A, 40-volts DC/7.5-A, 60-volts DC/10.0-A, and



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60-volts DC/17.0-A models. Each offers full-rated power from 100 to 1000 watts, remote sensing to compensate for system wiring loss to the load, and a back-lit LCD with adjustable contrast and illumination. The power supplies feature multiple operating modes, such as delta V, delta T, and manual for increased system



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volts to ground, permitting wide dynamic range data-acquisition in +5-volt logic systems. Built-in 500- μ V hysteresis eliminates undesirable oscillations when handling fast pulses or slow low-level signals. The comparator's output also minimizes current spikes, another source of oscillation in many voltage comparators.

The TTL- and CMOS-compatible output simplifies connection to digital logic. An on-chip latch can be strobed to retain output data, making the AD790 useful in building high-speed discrete analog-to-digital converters. The out-

put voltage is highly symmetrical between V_{LOGIC} and ground, ensuring high accuracy when positive- and negative-slewing input signals cross the threshold level.

The AD790 is available in an 8-pin plastic or ceramic DIP and is specified for operation over the 0° to +70°, -40° to +85°, and -55° to +125° operating temperature ranges. Two performance grades are available, with maximum offset voltage of either 1 mV or 250 μ V. Maximum common-mode voltage is from $+V_S$ to -2 volts; the allowable input signal range is $\pm V_S$.

The AD790 comparator ranges in price from \$2.50 for the JN grade to \$7.95 for the SQ version, in lots of 100.—Analog Devices, Literature Center, 70 Shawmut Road, Canton, MA 02021.

100-MHz OSCILLOSCOPE. Three different signals can be observed at two time-base settings on B&K-PRECISION's model 2190 os-

cilloscope with triple input, six-trace operation. The high-performance scope provides excellent high-frequency triggering, even on signals well beyond its rated bandwidth. The 2190 also features 1-mV-per-division vertical sensitivity, V-mode for viewing two signals that are unrelated in frequency, dual time base, alternate sweep function, a 20-MHz bandwidth limiter, and video-sync separators.



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The 100-MHz scope offers users a choice of 23 calibrated sweep-time ranges from 2 ns to 50 ns per division on the main time base and 20 calibrated ranges on the delayed-sweep time base. Each sweep time

range is fully adjustable between calibrated ranges. A $\times 10$ magnifier, which allows closer examination of waveforms while maintaining display calibration, is also provided. In delayed-sweep operation, the delayed signal can be viewed as a second trace or superimposed on the non-delayed signal.

The 2190 offers front-panel x-y operation, TTL-compatible z-axis input, signal-delay line, single-sweep operation, and channel-1 output on the rear panel for driving a frequency counter or other instruments. It comes with two 10:1 probes, a user manual, and schematic diagram.

The model 2190 100-MHz oscilloscope has a suggested retail price of \$1645.00.—B&K-PRECISION, Maxtec International Corp., 6470 West Cortland Street, Chicago, IL 60635.

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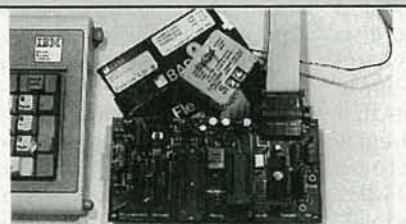
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6805 MICROCOMPUTER DEVELOPMENT SYSTEM

The MCPM-1 system allows the IBM PC and compatibles to be used as a complete development system for the Motorola MC68705P3, P5, U3, U5, R3 and R5 single chip microcomputers. The system includes a cross assembler program, a simulator/debugger program and a programming board that connects to a serial port. Price—\$449.00 VISA and MASTERCARD accepted.

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FCC LICENSE PREPARATION

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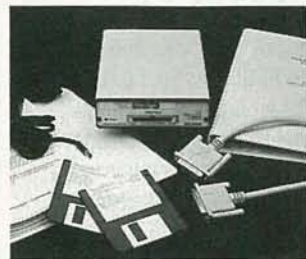
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MIDI PROJECTS



BP182—MIDI interfacing enables any so equipped instruments, regardless of the manufacturer, to be easily connected together and used as a system with easy computer control of these music systems. Combine a computer and some MIDI instruments and you can have what is virtually a programmable orchestra. To get your copy **send \$6.95 plus \$1.25 for shipping** in the U.S. to **Electronic Technology Today Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.**

MetraByte's SCSI-8AIN performs real-time, high-speed, high-resolution, analog input tasks. The eight-channel, 12-bit analog converter is accurate to within 0.02%, with a conversion time of 14µs. With 12-bit resolution, the least-significant-bit value is 4.88 mV in the ±10-volt range. An instrumentation amplifier provides gains of 1, 10, 100, 200, or 500 corresponding to signal spans of ±10 volt, ±1 volt, ±0.1 volt, ±0.05 volt, and ±0.02 volt, respectively. The gain of the instrumentation amplifier is selected by a front-panel DIP switch.



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Data is transferred to or from the *SCSI-8AIN* one byte at a time at a maximum rate of 57.6 kilobytes per second and support sample rates of up to 28,800 samples per second. One waveform can be digitized at 28,000

samples per second, and eight waveforms can be digitized at 3,600 samples per second. Those rates support up to 8 analog input channels simultaneously, making it capable of providing oscilloscope, chart-recorder, and spectrum-analyzer emulations. A master clock synchronizes all *SCSI-8AIN* analog-converter activity, so that state information can be obtained at fixed intervals from multiple channels.

The included software drivers allow the module to be controlled by a variety of software packages that run on Macintosh computers, including seven high-level programming languages and five menu-driven application programs. The *SCSI-8AIN* communicates via the SCIA (Small Computer System Interface) port located on the back of the Macintosh computer. That bus accepts as many as six peripherals to be placed in daisy-chain network. Custom configurations are very easy to develop for such applications as digital signal processing, signal averaging, chromatography, spectroscopy, and more.

The module comes with a peripheral unit; calibration,

test, and I/O software; one SCSI cable; a 117-volt AC desk-top power transformer; and also comes with hardware and software manuals.

The *SCSI-8AIN* 8-channel, 12-bit analog input module is available for \$790.00 and the *SCSI-TERM* termination device costs \$50.00.—**MetraByte Corp.**, 440 Myles Standish Blvd., Taunton, MA 02780.

FUNCTION GENERATOR. Its unique front-panel design coupled with eight different waveforms, seven modulation modes, and optional arbitrary-waveform-generation capability make *Fluke's PM5138* 10-MHz function generator versatile and easy to use. Instead of the array of rotary switches, knobs, and dials usually found on function generators, the *PM 5138* has a large, backlit multifunction LCD and five pairs of keys for selecting the required parameter. The frequency, AC voltage, DC offset, and other numerically programmable parameters are set by pressing the appropriate key and adjusting the unit's one rotary knob until the correct reading appears on the screen. The required waveform and modulation



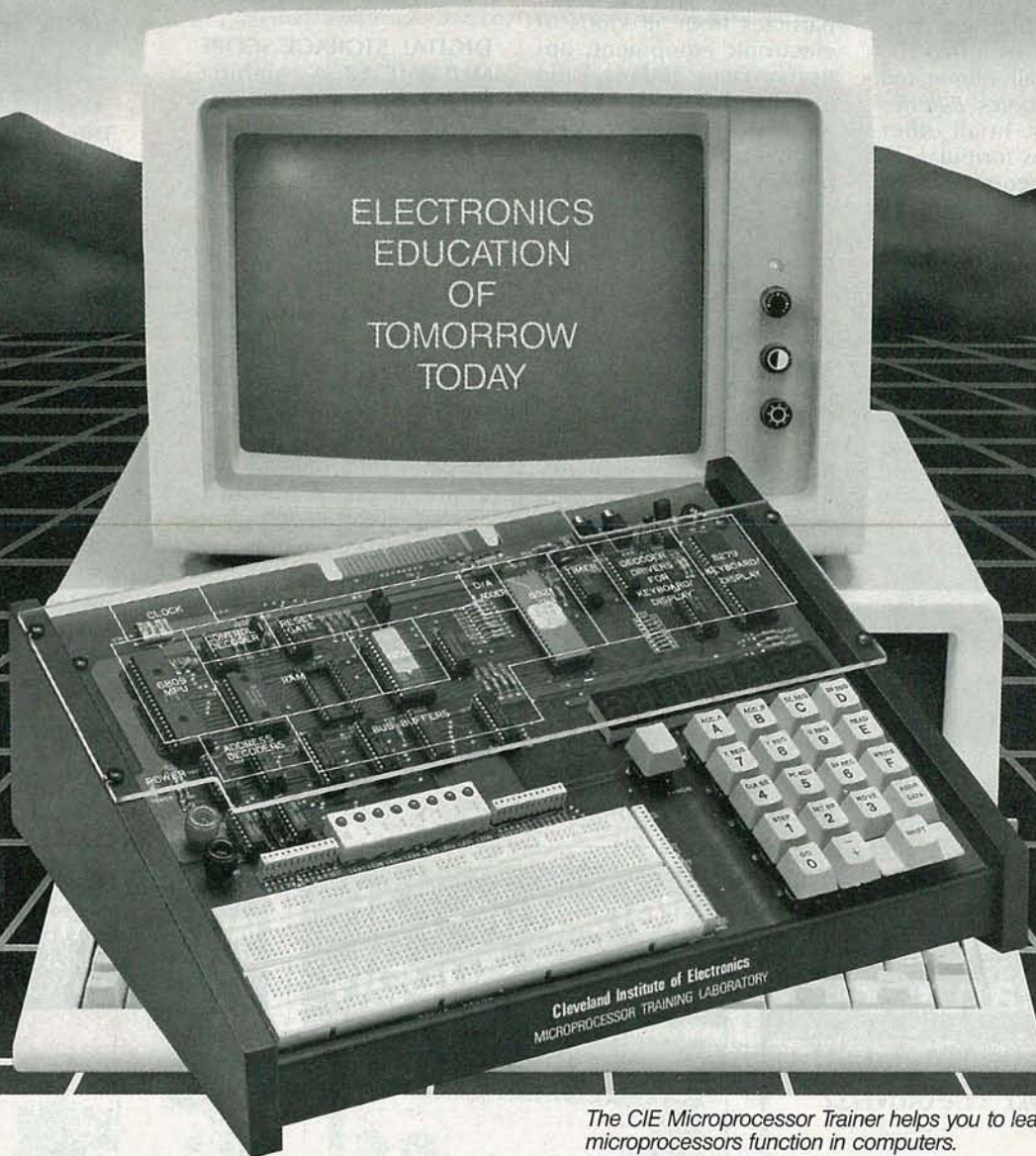
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modes are selected from a menu.

The function generator also offers Arbitrary Waveform Generation (AWG), which is usually found only on specialized arbitrary generators with few waveform and modulation modes. Included with the GPIB/IEEE-488 interface option, AWG features a 20 Mega-points/second sampling rate, 1024-point horizontal resolution, and 1024-point vertical resolution. Waveforms can be programmed over the GPIB either from a computer or directly from a digital storage oscilloscope.

The *PM 5138* function generator has a suggested list price of \$3590.00, or \$3990.00 for the model with the factory-installed arbitrary waveform generation option.—**John Fluke Mfg. Co., Inc.**, P.O. Box C-9090, Everett, WA 98206; 800-443-5853, ext. 77.

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DIGITAL STORAGE SCOPE/MULTIMETER. A combination 2-channel digital storage oscilloscope and digital multimeter from *Leader Instruments*, the model 200, allows two-channel comparisons, addition or subtraction of two signals, and X-Y capability. The portable 2½-pound instrument runs on batteries or AC power.

The model 200's oscilloscope section has a 3-MS/s maximum sampling rate and is completely auto-ranging. The optimal waveform is displayed by touching the auto-timebase and vertical-sensitivity buttons, and the standard printer interface allows waveforms and setting conditions to be output to an optional dedicated printer (model 710) for hard-copy documentation. Sensitivity, timebase, trigger source, slope, and display mode are displayed on screen. The memory banks



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can store three waveforms per channel; in addition, the model 200 is battery-backed for long-term storage of all six waveforms.

The autoranging DMM has a manual override feature as well as audible continuity and overload indicators. It offers AC/DC voltage and current measurement functions, resistance, and a low-power ohm mode to provide a lower test voltage for in-circuit resistance measurements.

The model 200 combination digital storage oscilloscope/multimeter has a suggested price of \$1,645.00; the model 710 printer costs \$480.00.—**Leader Instruments Corporation**, 380 Oser Avenue, Hauppauge, NY 11788. **R-E**

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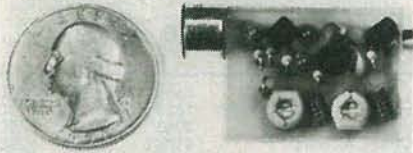
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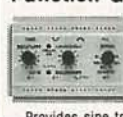
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IF YOU'VE SEEN A RECENTLY PRODUCED motion picture presented in a modern theater, then you are undoubtedly aware of the stunning realism and dramatic impact created by the use of the Dolby-stereo surround-sound audio process. The system was developed by Dolby Laboratories for the motion-picture industry to literally surround viewers with sound and place them in the very midst of the action.

For anyone unfamiliar with the concept, the Dolby-stereo surround-sound process works to increase the sensation of "being there" by reproducing distinct sounds toward the front, sides, and rear of the viewer. In practice, it is accomplished by feeding the primary stereo soundtrack to speakers located behind the screen on the left, the center, and the right side of the theater.

Simultaneously, an additional audio channel, decoded from within the primary channels, is sent to a system of smaller speakers located to the sides and to the rear of the audience. That additional surround channel is used to re-create ambient sounds like wind noise or "on location" street sounds as well as special sound effects intended to travel past the audience from front to rear, or even to seem to circle overhead.

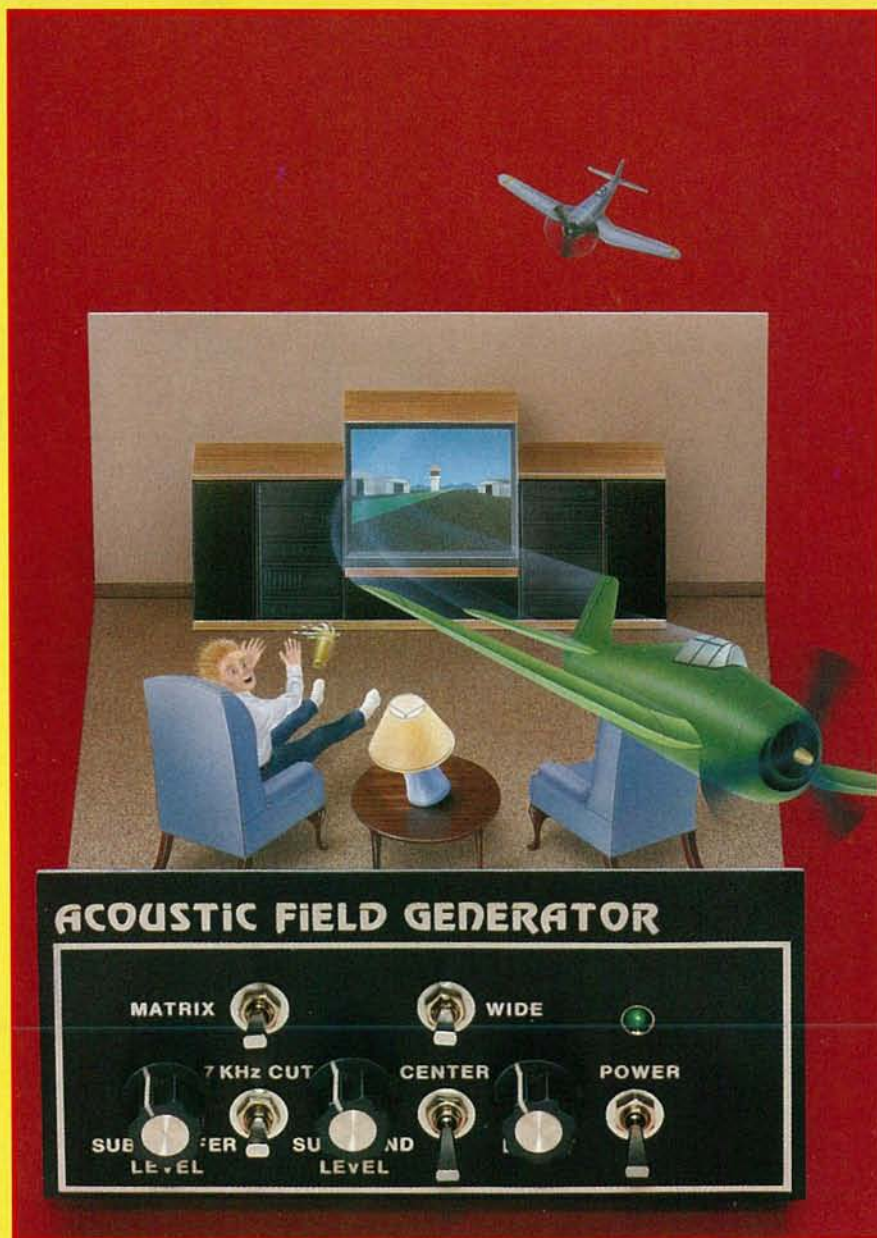
Since the mid 1970's, over 1100 motion pictures have been produced with surround-sound tracks. Because the process encodes the surround information into a 2-channel stereo signal, when the movies are transferred to video tapes and laser discs, the encoded information remains intact. However, in order to enjoy surround sound at home, at the very minimum, a stereo VCR; some type of decoder, and additional surround speakers are required.

The basic principle of all surround-sound decoders, from the simplest to the most expensive, is the same. They all reproduce the surround information by recovering the (L-R) difference signal which is encoded into the left and right channels of the movie soundtrack. The decoder presented here goes beyond the capabilities of a simple surround-sound decoder. Besides the surround decoder circuit, additional circuitry is

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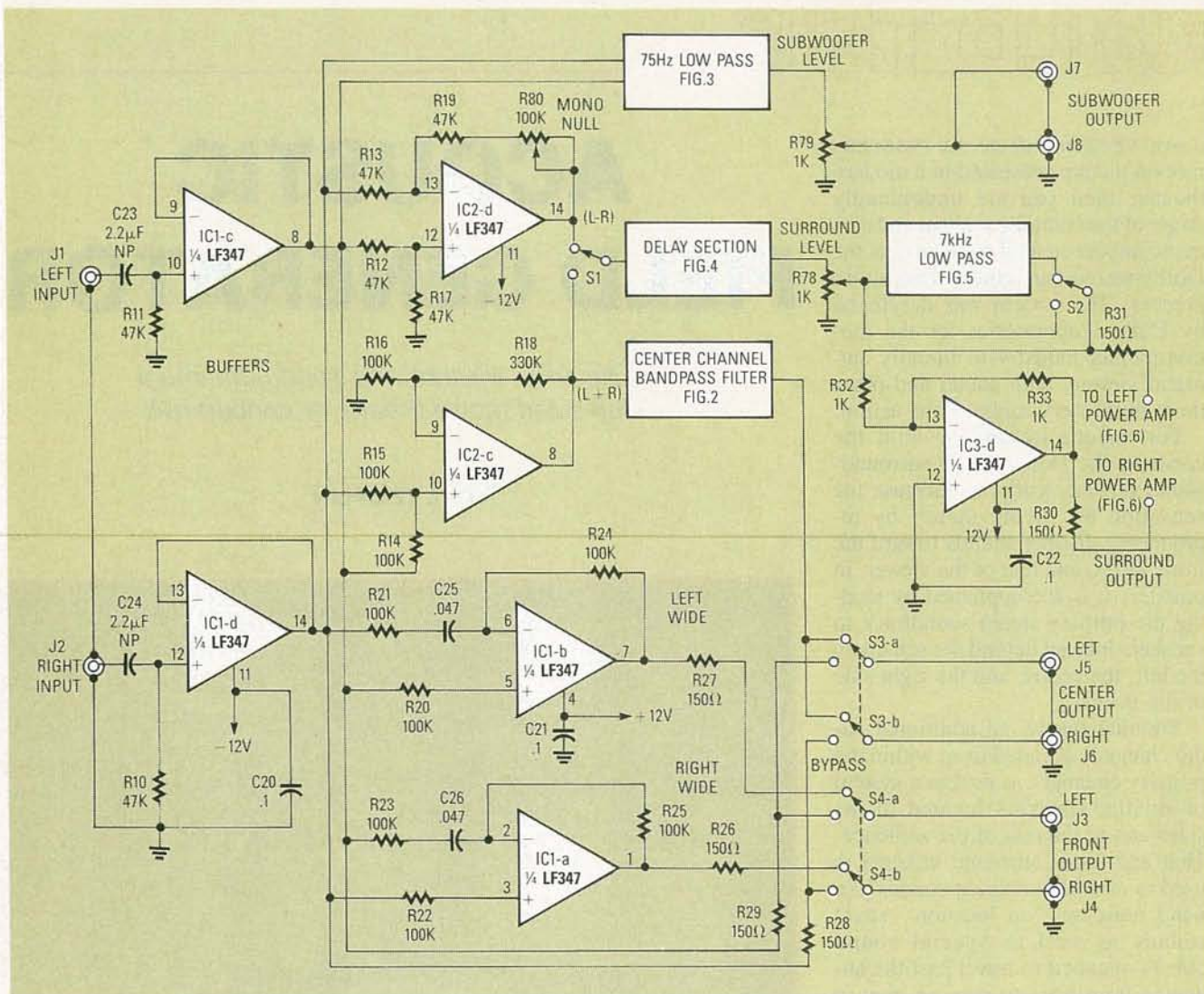


FIG. 1—THE AFG IS MADE UP OF 10 relatively simple circuit elements.

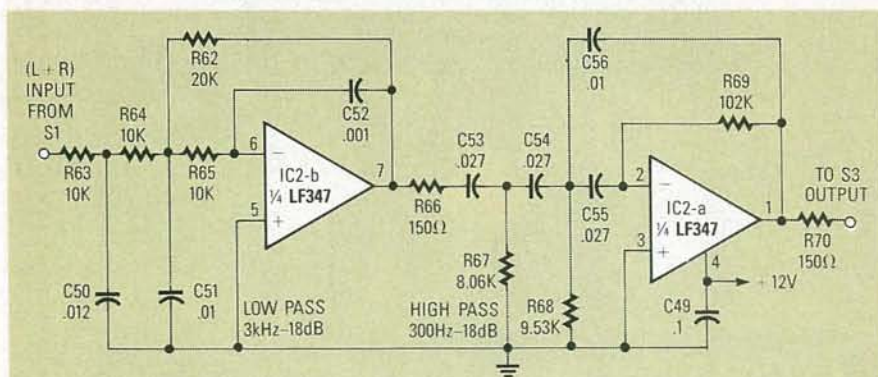


FIG. 2—THE CENTER-CHANNEL SPEECH FILTER is built by cascading a 3-kHz low-pass filter with a 300-Hz high-pass filter to form a band-pass filter.

used to create wide-left, center-dialogue, wide-right, and subwoofer signals. Presenting those signals through six properly arranged speakers results in the acoustical illusion of a large, almost boundless, three-dimensional listening environment, even in a small room; hence the name,

“Acoustic Field Generator,” but we’ll call it the AFG for short. This article is not intended to provide an in-depth tutorial or technical description of the surround-sound system. Rather, it is intended to show you how to construct and install a high-quality, multichannel sound decoder for use in

your home.

The AFG offers two different modes of operation; “matrix” and “concert.” In the matrix mode, the (L-R) difference signal is recovered from surround-encoded source material and is then passed through a 2048-stage bucket-brigade delay line. The delay is continuously adjustable from about 5 to 35 milliseconds, and has a bandpass of 50 Hz to 15 kHz. That enables the accurate decoding and presentation of the surround-channel information present within the source material. The (L+R) sum signal is also recovered to be sent through the delay section of the AFG when the concert mode is selected. That imparts the ambience and realism of a live concert-hall performance to musical material played through the AFG. In either mode, the output of the decoder/delay section is sent to a pair of 10-watt-per-channel power

amplifiers, included on the main circuit board, for driving a pair of surround-channel speakers.

The AFG also provides a means of greatly increasing the apparent separation or "width" of the stereo image presented by the front speakers. In an ordinary decoder, the left- and right-channel signals are sent to the front speakers unaltered, and the center channel, if present at all, is fed a simple sum of the left and right signals. Although that technique provides a very solid front soundstage, it severely limits the system's ability to convincingly present extreme-left or -right sound effects. And, because the screen in most home-video systems is relatively small, especially when compared to the screen in a movie theater, dialogue which should be confined to the screen, tends to appear off screen in the left and right speakers—particularly for viewers seated off center.

The AFG uses frequency-selective circuitry to cancel some of the dialogue from the left and right channels, but that creates a phantom "hole" in the center of the soundstage. So, the AFG also creates a center dialogue channel to fill that hole by summing the left and right channels and passing them through a band-pass filter with a response curve which favors the range of frequencies covered by the human voice. Feeding the voice-only "dialogue" signal directly to the speakers in the video monitor locates the dialogue firmly on the screen without destroying the spatial effects of the front soundstage.

Finally, the AFG includes a 75-Hz active low-pass filter for driving a subwoofer setup. If you are not currently using a subwoofer as part of your system, you are missing out on the dynamic impact and heightened level of excitement which is imparted by the extreme low-frequency sounds used in motion pictures, primarily as a special audio effect. The subwoofer output of the AFG has that sonic information isolated and ready to feed to a power amplifier and speaker of your choice. You may wish to consult with a local audio dealer for advice on selecting a proper subwoofer and power amplifier. Suffice it to say, that a relatively high-power amplifier and large subwoofer will be required if you intend to fill your room with earth-shaking bass that goes far beyond the capabilities of most "full-

range" speakers. It is preferable to place the subwoofer toward the front of the soundstage, although the exact position is not critical, due to the ear's inability to accurately locate very low-frequency sound. Thus, many subwoofers are designed to physically resemble an end table or other piece of furniture, so that they can aesthetically blend into the other room decor.

The AFG was designed to be connected into the pre-amp/power-amp loop of your regular home entertain-

ment system. Consequently, all the functions of the AFG may be switched to bypass and unity gain to effectively remove it from the system, if required. We believe, however, that once you experience the added sonic dimension that the AFG adds to music as well as movies, you'll never want to switch it off.

About the circuit

When viewed as a whole, the AFG circuitry is quite complex. However,

PARTS LIST

All resistors ¼-watt, 5%, except as noted.

R1—1500 ohms
R2, R3, R54—22,000 ohms
R4, R5, R32, R33—1000 ohms
R6, R7, R61, R62, R74—20,000 ohms
R8, R9—1 ohm, ½-watt, 5%
R10—R13, R19, R34, R35—47,000 ohms
R14—R17, R20—R25, R47—R49, R55, R56—100,000 ohms
R18, R57—330,000 ohms
R26—R31, R66, R70—150 ohms
R36—R43, R67—8060 ohms, 1%
R44—R46—16,000 ohms
R50, R51—5600 ohms
R52—2400 ohms
R53—8200 ohms
R58—R60, R63—R65, R71—R73—10,000 ohms
R68—9530 ohms, ¼-watt, 1%
R69—102,000 ohms, ¼-watt, 1%
R75, R80—100,000 ohms, potentiometer
R76—10,000 ohms, potentiometer
R77—50,000 ohms, PC-mount potentiometer
R78, R79—1000 ohms, PC-mount potentiometer

Capacitors

C1—C4—2200 µF, 25 volts, electrolytic
C5, C6—10 µF, 35 volts, radial electrolytic
C7—C12, C19—C22, C27, C28, C30, C31, C45, C49, C58—0.1 µF, 50 volts, metal film
C13, C14, C23, C24, C43—2.2 µF, 50 volts, bi-polar radial electrolytic
C15, C16—22 µF, 16 volts, bi-polar radial electrolytic
C17, C18—0.22 µF, metal film
C25, C26—0.047 µF, metal film
C32—C34—3300 pF, polyester
C36, C37—2700 pF, polyester
C38—C41—270 pF, 5% ceramic disc
C42, C47—0.47 µF, metal film
C44—120 pF, 5% ceramic disc
C46—0.56 µF, metal film

C48—0.039 µF, metal film
C50—0.012 µF, metal film
C51, C56—0.01 µF, metal film
C52—1000 pF, 5% polyester
C53—C55—0.027 µF, metal film
C57—5600 pF, 5% polyester
C58—4700 pF, 5% polyester
C59—470 pF, 5% ceramic disc

Semiconductors

D1, D2—1N5400 50 PIV 3-amp diode
IC1—IC4—LF347 quad JFET
IC5—MN3008 2048-stage bucket brigade device
IC6—MN3101 2-phase clock
IC7—7812T +12-volt regulator
IC8—7912T -12-volt regulator
IC9, IC10—LM1875T audio amp
LED1—light emitting diode pilot lamp

Other components

T1—Power Transformer 25.2 Volt Center Tapped 2 Amp.
F1—F3—1-amp fuse
J1—J8—8-pin RCA-style jack panel
J9—J12—4-position pushbutton speaker-terminal panel
S1, S2, S5—SPDT switch
S3, S4—DPDT switch

Miscellaneous: speakers of your choice, 5 14-pin IC sockets, 1 8-pin IC socket, 1 heat sink (2 × 2 × 5/4-inch aluminum angle stock), 2 T0-220 mica insulators with mounting hardware, silicone grease, 3 in-line fuse holders, 3 knobs, chassis, linecord, solder, etc.

Note: The following items are available from T3 Research, Inc., 5329 N. Navajo Ave., Glendale, Wisconsin 53217-5036: An etched, drilled, and plated PC board, \$15.00; a basic parts kit consisting of all semiconductors, resistors, and capacitors, \$55.00; a piece of aluminum stock for the heat sink, \$3.00. Please include \$2.50 for postage and handling with your order. Wisconsin residents please include appropriate sales tax.

referring to the simplified schematic in Fig. 1, you can see that the AFG is really made up of 10 relatively simple circuit elements. IC1-c and IC1-d are configured as unity-gain non-inverting buffer amplifiers. They transform the 47-kilohm input impedance, which is set by R10 and R11, to a low-impedance source which drives all of the AFG amplifiers, filters, and bypass outputs.

The summing (L + R) amplifier, IC2-c, combines equal amounts of the left and right signals, via R14 and R15, to develop a total composite signal. Left- and right-channel signals are applied equally through R13 and R12 to IC2-d, the difference (L - R) decoder. Any signal that's common to both channels is canceled by IC2-d, thus forming one signal which contains none of the common "mono" information present in the original stereo signal. Potentiometer R80 provides a means of exactly balancing the inverting and non-inverting gains of the amplifier for a perfect null.

The stereo width-enhancement circuit is made up from IC1-a and IC1-b. It works similarly to the (L - R) decoder, except that C25 and C26 have been added in the inverting inputs of each op-amp. Consider, for the moment, just the "right wide" circuit of IC1-a; C26 and R23 form a gently sloping high-pass filter for the left-channel signal only. Thus, the amount of signal cancellation is dependent on frequency and the relative amplitude between the two channels. In other words, the more a signal is the *same* in both channels, the more it is removed from the output of the circuit; the effect increases as the signal's frequency rises. If, however, the input signal appears only in the right channel, no matter what its frequency or amplitude, it does not cancel in the difference amplifier and appears at the output unaffected.

IC1-b functions in the same way to develop the "left wide" signal because its inverting and non-inverting inputs are connected to the left and right channels in a manner opposite that of IC1-a. The net effect of all that is to increase the apparent separation between the left and right channels by eliminating some of the material common between them. The output of the width-enhancement circuit is routed to S4, which selects either the "wide" or the bypass signal for feeding the front-channel amplifier.

The center-channel dialogue filter, or speech filter if you prefer (see Fig. 2), is built by cascading a 3-kHz low-pass filter with a 300-Hz high-pass filter to form a band-pass filter. The frequency characteristics of the human voice fall predominantly within that range. As with all of the other filters used in the AFG, those are of the 3rd order Butterworth design. That design was chosen because it offers minimum peaking within the passband. It has a sharp -18 dB/octave cutoff, a flat voltage and power frequency response, and minimum phase change within the passband. The output of the bandpass filter is routed to the high side of S3. That switch allows the center-channel output of the AFG to be switched between the dialogue filter and the bypass mode.

As shown in Fig. 3, IC3-a and IC3-b form an active crossover network for driving a subwoofer. IC3-a sums signals from the left- and right-channel buffer amps, it inverts the summed signal 180 degrees, and it provides a low driving impedance for the following filter stage. IC3-b and its associated RC network form a 75-Hz, 3rd-order low-pass filter. Because the filter inverts the signal another 180 degrees, the signal that appears across R79 (which is the output-level control) is back in phase with the original input signal.

The delay section of the AFG, shown in Fig. 4, is built around the MN3008 *Bucket Brigade Device* (BBD), made by Matsushita (Panasonic), and the MN3101 two-phase variable-frequency clock generator. The BBD is a P-channel silicon-gate MOS LSI circuit comprised of 2048 bucket-brigade stages fabricated on a single chip. Each stage consists of a small capacitor that stores an electric charge and a tetrode transistor for

switching purposes. Electrical charges corresponding to analog signals are transferred from one stage to the next by a two-phase clock drive, in the same manner that a fireman's bucket brigade transfers a pail of water from one man to the next. A signal presented at the input is transferred down the line of buckets toward the output at a speed controlled by the clock frequency. The more slowly the clock runs, the longer it takes for the signal to travel through the circuit. (See discussion of BBD theory in the October 1986 **Radio-Electronics**.)

The amount of delay required in our system varies between approximately 5 and 35 milliseconds, so our first consideration must be to select the proper range of clock frequency. The delay time of a BBD is equal to the number of stages divided by twice the clock frequency. So, based on manufacturer's data for the MN3101 clock-generator IC, values were chosen for R53, R54, R77, and C44, to produce a clock frequency, adjustable via R77, which varies from about 30 kHz to 130 kHz.

Our next consideration deals with the property of delay lines known as aliasing. If the frequency of the signal applied to the input of a delay line becomes higher than one half of the clock frequency, the time available to store the sample of that signal in the capacitor becomes too short. The amplitude of that signal's frequency has a value which changes during the time of the sample, so the charge stored in the capacitor is not an accurate representation of that instant of time. To avoid the problem and the resulting distortion, a filter is placed ahead of the BBD which limits the input frequency to one half of the lowest clock frequency used. Given that we'd like to run the clock at speeds as slow as 30 kHz, we must limit the maximum fre-

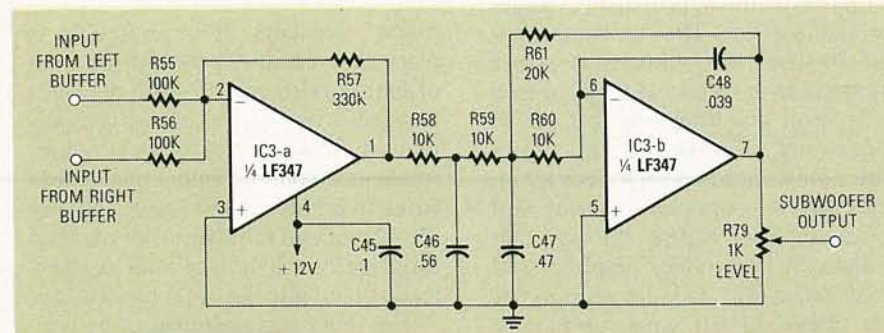


FIG. 3—AN ACTIVE CROSSOVER NETWORK for driving a high-power subwoofer system is made from IC3-a and IC3-b.

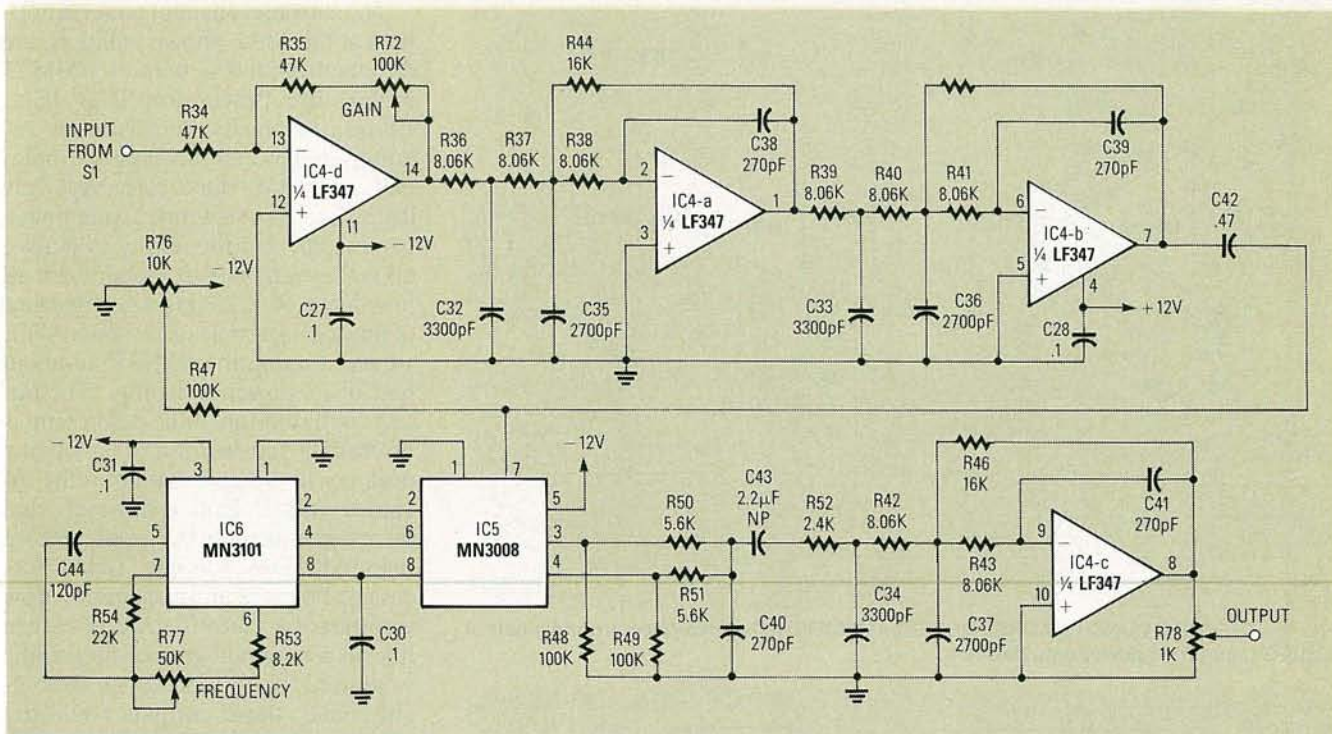


FIG. 4—THE DELAY SECTION OF THE AFG IS BUILT AROUND THE MN3008 bucket-brigade device and the MN3101 two-phase variable-frequency clock generator.

quency that we apply to the BBD to 15 kHz.

If you refer back to Fig. 1, S1 selects the signal to be delayed; either the difference signal ($L - R$) from IC2-d in the matrix mode or the sum signal ($L + R$) from IC2-c in the concert mode. The selected signal is fed from S1 to the delay section (Fig. 4) where IC4-d is configured as an inverting amplifier; R75 adjusts the gain between unity and $\times 3$. Integrated circuits IC4-a and IC4-b, along with their associated RC networks, are identical 3rd-order 15-kHz low-pass filters. Cascading two filters produces a very sharp cut off (-36 dB per octave), which is convenient, as it eliminates any problems that may arise with aliasing, while maintaining a respectable 15-kHz bandwidth for the section. Potentiometer R76 is used to adjust the bias voltage required by the BBD to exactly one half the supply voltage; a requirement of the device. Notice that both the BBD and the clock IC run off of the negative power-supply rail.

Another property of a BBD is that clock phase 1 drives all the odd-number stages of the device and clock phase 2 drives all the even stages. When the signal reaches the end of the line, the output of the last odd stage must be combined with the output of

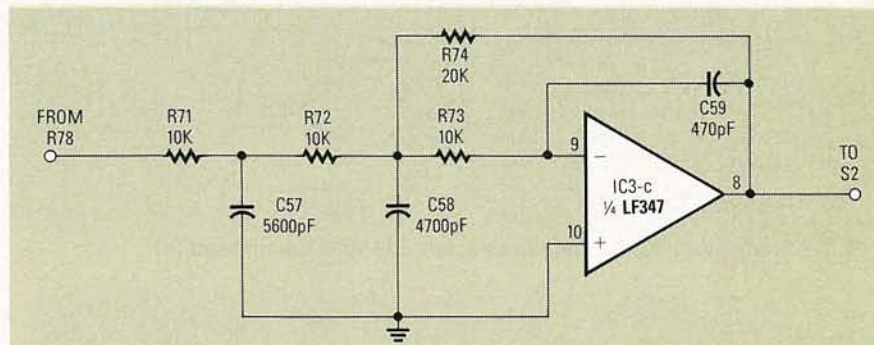


FIG. 5—A 3rd-ORDER 7-kHz LOW-PASS FILTER IS MADE FROM IC3-c AND ITS ASSOCIATED RC NETWORK.

the last even stage to reconstruct an exact replica of the input signal. The purpose for doing that is to self-cancel any of the clock signal from the output of the device; R48 and R49 are the source-load resistors for the last two BBD stages and R50 and R51 sum the two outputs. The delayed signal is next applied to another 3rd-order 15-kHz low-pass filter comprising IC4-c and its associated RC network. That last filter is required to stop any remaining clock signal from reaching the output of the circuit. Potentiometer R78 is there to serve as the volume control for the surround channels by controlling the amount of delayed signal that is applied to the power amplifiers.

To provide for increased high-fre-

quency noise reduction in the surround channel and to more closely comply with the Dolby Laboratories standards for surround sound, a 3rd-order 7-kHz low-pass filter is included in the AFG design. As shown in Fig. 5, IC3-c and its associated RC network forms the filter; S2 then selects between the output of that filter and the bypass mode. If you refer back to Fig. 1, notice that the wiper of S2 is connected to two circuits; it goes directly to the left surround power amplifier via R31, and to IC3-d, a unity-gain inverting amplifier, via R32. The output of IC3-d drives the right surround power amplifier via R30. The reason for driving the power amplifiers out of phase will be explained shortly.

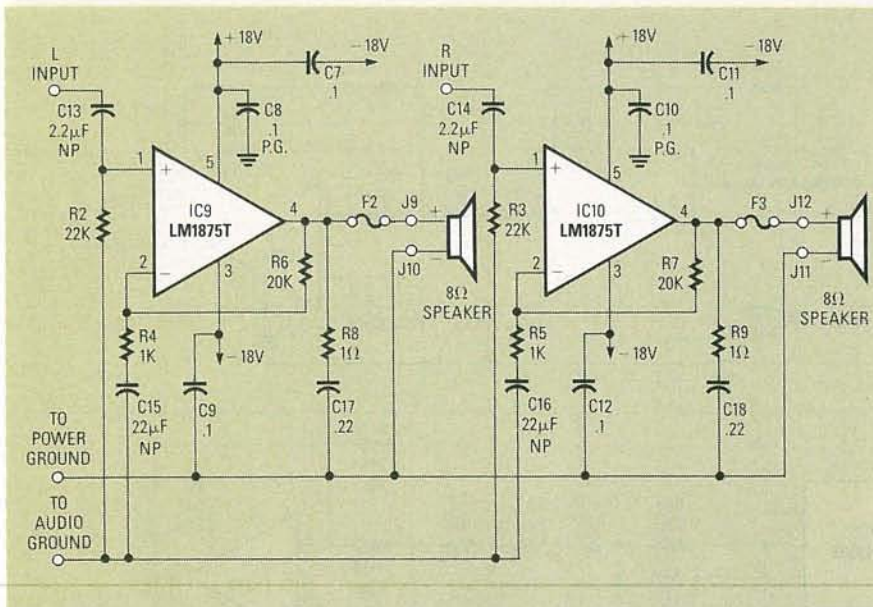


FIG. 6—THE SURROUND CHANNEL POWER AMPLIFIERS are designed around a pair of LM1875 monolithic power-amplifier IC's.

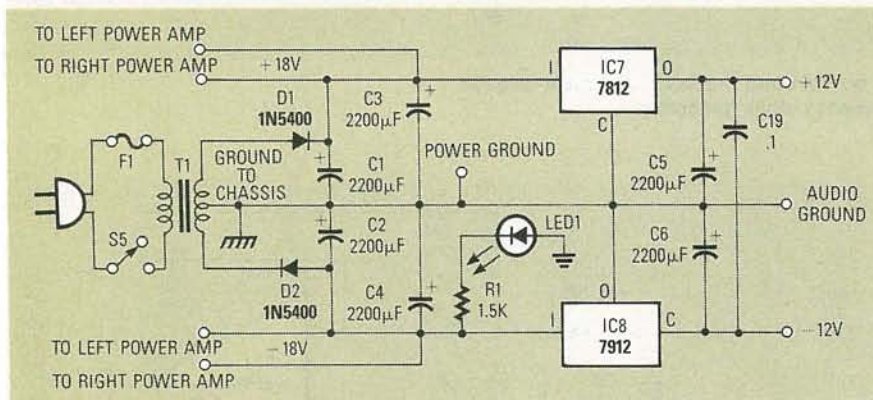


FIG. 7—THE POWER SUPPLY produces about ± 18 -volts unregulated DC.

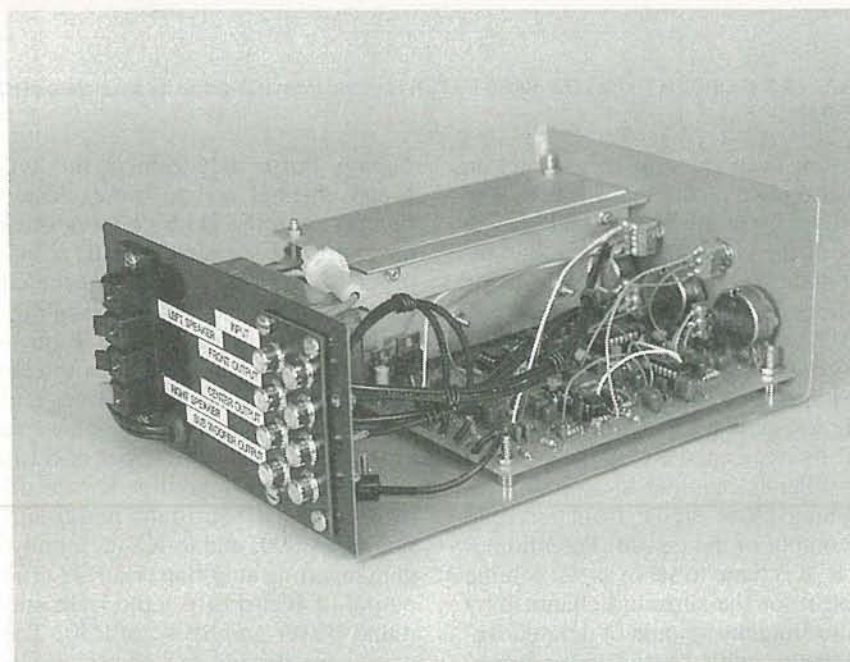


FIG. 8—THE PROTOTYPE ACOUSTIC FIELD GENERATOR. It's a tight fit in this cabinet, but it makes for a neater finished unit.

The surround channel power amplifiers of the AFG, shown in Fig. 6, are designed around a pair of LM1875 monolithic power-amplifier IC's. Chosen primarily because they require very few external parts to implement, and they also offer very low distortion, fast slew rate, wide power bandwidth, and the ability to deliver up to 20 watts into an 8-ohm load; all in a 5-pin TO-220 package. Because of limited heat-sink space in the AFG, we are running the LM1875 at about half of its power capability. The circuit configuration of the power amp is essentially the same as that of any ordinary op-amp operating in the inverting mode. Notice however, that there are two separate ground-return lines to the power supply. That is necessary because high currents flow through the output ground-return line. If a common ground-return line were used for both the input and output signal, those currents could develop enough voltage across the resistance of the return line itself to effectively act as an input signal to the amplifier, thus causing problems such as high-frequency oscillations or distortion.

The power supply of the AFG, shown in Fig. 7, is of conventional design. A 25-volt center-tapped transformer, along with diodes D1 and D2, produces about ± 18 -volts unregulated DC. Two 2200- μ F filter capacitors are used in each leg of the supply to provide ample energy storage to meet the high-current demands of the audio output amplifier IC's during high-output peaks. Integrated circuits IC7 and IC8 regulate the positive and negative supply rails to plus and minus 12 volts for use in the low signal level circuits. The plus and minus 12- and 18-volt rails are bypassed to ground by 0.1- μ F capacitors distributed throughout the entire AFG circuitry. That keeps the impedance of the supply rails at audio frequencies as low as possible, thus reducing the interaction between the various circuits.

That's all we have room for this time. We've given you the list of parts, so that you can at least gather all of them together. Next month we'll give you the foil pattern and parts-placement diagram so you'll be able to build your own AFG. You'll find that more fun than just looking at ours which, by the way, is shown in Fig. 8.

R-E

BUILD THIS

3-CHIP LOGIC ANALYZER

MICROPROCESSOR SYSTEMS OFTEN monitor several signals at once, like address or data bus contents. That's often difficult to duplicate with most logic probes, and logic analyzers are too expensive for most hobbyists. One solution is to build an eight-bit, 3-chip, word-recognition logic analyzer for about \$6. The low parts count keeps size and power demands low, so it can run directly off the Circuit-Under-Test (CUT).

Principles of operation

The schematic is shown in Fig. 1. It uses two cascaded four-bit 74LS85 digital magnitude comparators, IC1 and IC2, to monitor an eight-bit signal in any TTL-compatible environment. The digital word being sent is entered on a group of DIP switch inputs (S1-a-S1-h). If it's matched by signals from the test device inputs (TP0-TP7), the upper 74LS85 sets pin 6 high.

The 74LS00 is a quad 2-input NAND gate; IC3-a and IC3-b make up an R-S flip-flop, IC3-c is unused, and IC3-d is used as an inverter to drive one flip-flop input. The two flip-flop inputs are pin 1 on IC3-a, and pin 4 on IC3-b. Pin 1 on IC3-a is kept high by being tied back to +5V through R3-i. Pressing the RESET switch, S2, momentarily grounds pin 1 of IC1 and pin 6 of IC2, turning off Q1 and LED1.

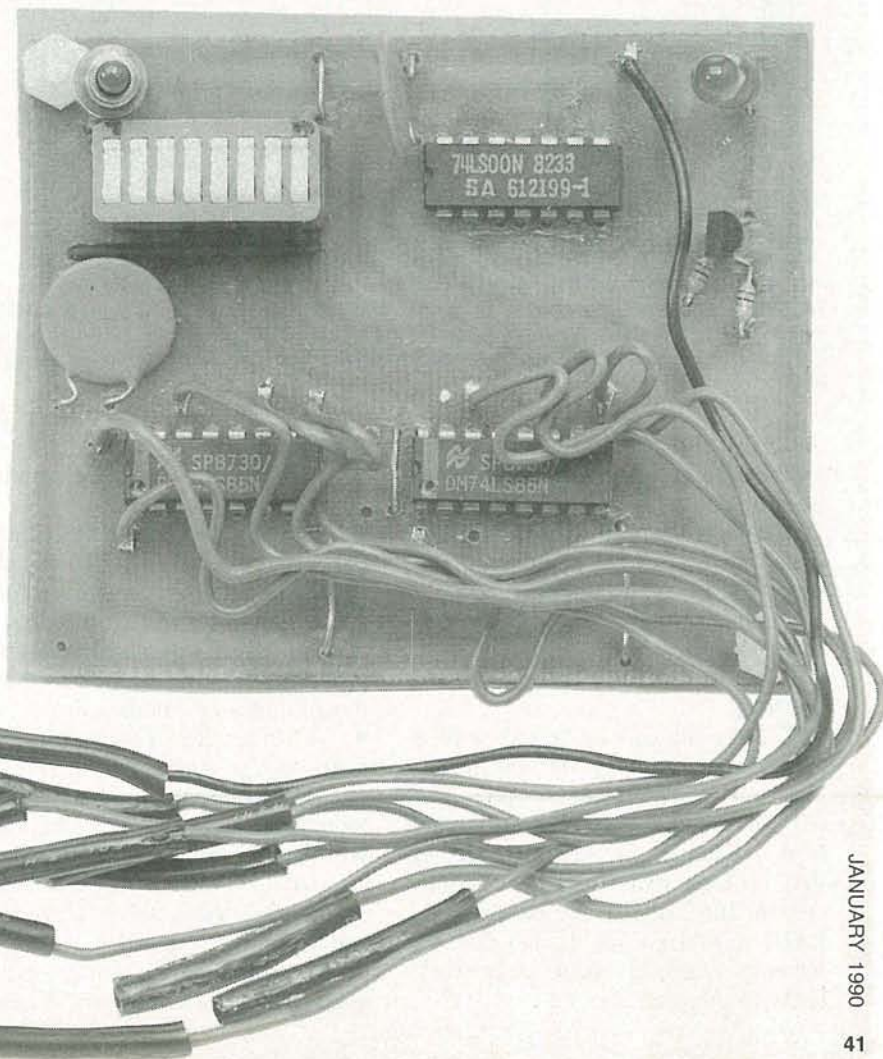
The high from pin 6 of IC2 sets the flip-flop, driving pin 6 of the 74LS00 high, turning on Q1 and LED1 until the user presses S2. However, test points TP0-TP7 shouldn't have latched yet. A comparison ripples through a 74LS85 in about 32 microseconds (worst case), so each eight-bit word has to last about 64 nanoseconds for valid comparison. That shouldn't cause problems with 4-8 MHz microprocessor signals.

Construction

The prototype, shown in use in Fig. 2, was built on a PC board using wire-wrap IC sockets and a nine-element SIP-resistor array. The test leads should be about six inches long. The push-on connectors are single, break-apart, Molex IC sockets, covered with heat-shrink tubing; you could also use

If you have ever needed a simple logic analyzer, or wanted to know more about how they work or how to use them, then try our \$6 circuit.

J.J. ROBINSON II



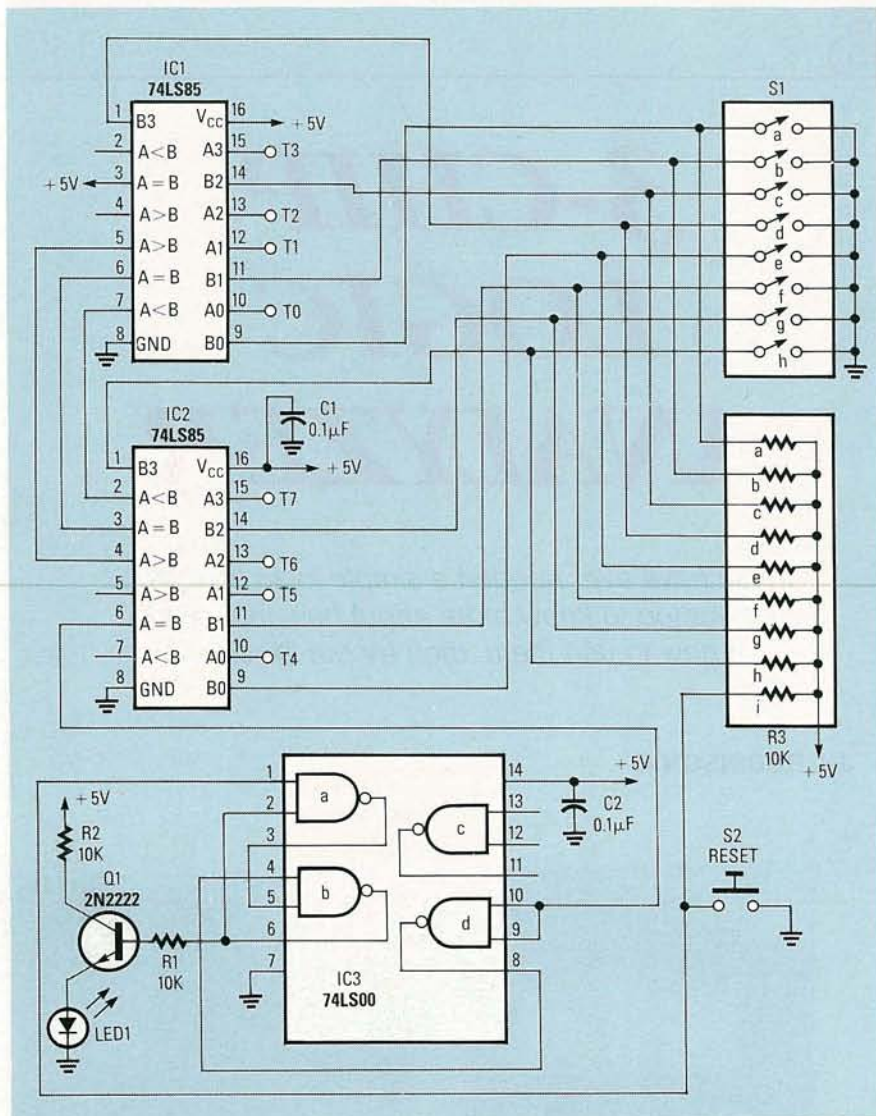


FIG. 1—SCHEMATIC OF THE 3-CHIP LOGIC ANALYZER. It's made from two cascaded 74LS85 4-bit magnitude comparators (IC1 and IC2), and uses an 8-switch SPST DIP switch S1 and 8-resistor SIP array R3 to set the bit states compared against. The output of IC2 is fed into inverter IC3-d, which feeds into RS flip-flop IC4-a and b, which drives Q1 and LED1.

an IC test clip. The space between the PC board and the tested circuit has to be insulated with a sheet of plastic or small block of wood. At high frequencies, use a shielded enclosure. The prototype PC board operated reliably when unshielded near a 16-MHz video PC board.

Testing

The circuit can be tested with a static input word on the test leads. When the analyzer's switches (S1-S8) match it, LED1 should light. If the switches are then changed so they no longer match, LED1 should stay lit. If S2 (RESET) is now pressed, LED1 should go out. If that doesn't happen, carefully check your work for wiring errors.

Applications

There are three tests for which the analyzer is quite useful:

- Data bus: Connect the test leads in the correct order to the microprocessor data bus, and check for the desired eight-bit test word. They can be elements of the machine language program, data transmitted to the microcomputer by another device, etc.
- Address bus: Connect the test leads to the address bus; since it's often 16 bits long, only half can be monitored at once. The upper half will usually be the most significant, and will show what parts of the address space the system is accessing under program control.
- Control signals: Connect the test leads to monitor a selection of control

PARTS LIST

All resistors are ¼-watt, 5%.

R1, R2—10,000 ohms

R3-a-R3-i—10,000 ohms × 9 SIP network

Capacitors

C1, C2—0.1 µF, ceramic disc

Semiconductors

IC1, IC2—74LS85 magnitude comparator

IC3—74LS00 quad NAND gate

Q1—2N2222 NPN transistor

LED1—light-emitting diode

Other components

S1-a-S1-h—8-switch DIP

S2—subminiature, momentary, push-button SPST switch

TP1-TP8—Molex break-apart IC pins

Miscellaneous: PC board, wire, solder, and heat-shrink tubing.

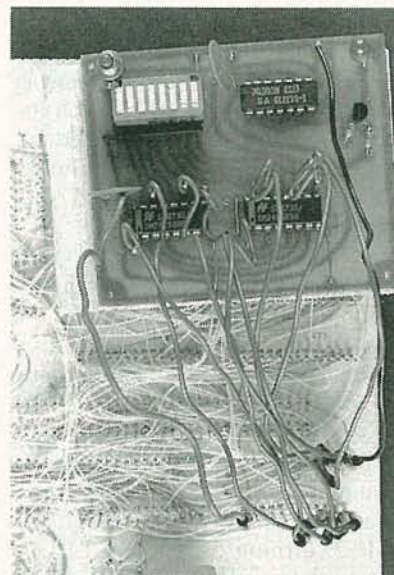


FIG. 2—PROTOTYPE OF THE 3-CHIP logic analyzer; note SPST DIP switch S1 and the SIP resistor array R3 at upper left. The eight pins covered with heatshrink tubing are made from Molex break-apart IC pins.

signals, like chip-, write-, and read-enable (CE, WE, and RE) pins of memory devices, I/O selects, etc. That can show whether the CE, WE, and/or RE are simultaneously active, whether multiple memories are simultaneously selected, and happens to be very useful in debugging address decoding algorithms.

To use the analyzer, connect the power and ground to the test circuit points, and the eight test leads to the appropriate signals. When a positive match is found, the LED glows. For the next test, enter a new search word and press S2.

R-E

between the audio.

The input stage, composed of R1, 10-volt Zener D1, and the base-emitter junction of Q1, places a high-impedance loop across the green (tip) and red (ring) phone-line wires. The current through the phone line should be:

$$I_{\text{phone}} = (V_{\text{tip}} - V_{\text{D1}} - V_{\text{BE1}}) / R1 \\ = (48 \text{ V} - 10 \text{ V} - 0.7 \text{ V}) / 100\text{K} \\ = 373 \mu\text{A}.$$

That causes about a 1-volt drop from the 48-volt level, that drives Q1 into saturation at about 200 millivolts. If the phone rings or is picked up, Q1 cuts off and the inverting input of IC2-a goes to 12 volts. Next, voltage divider R3-R5 biases the noninverting input of IC2-a and the inverting input of IC2-b at:

$$V_{\text{BIAS}} = V_{\text{CC}} \times [R3 / (R3 + R5)], \\ = 12 \text{ V} \times [20\text{K} / (20\text{K} + 10\text{K})], \\ = 8 \text{ V}.$$

At that point, the output of IC2-a goes low, discharging C3. The output of IC2-b goes high, turning Q2 on and driving it into saturation via R6, and activating relay RY1, breaking the audio path between J1 and J2, and J3 and J4. After the phone stops ringing, or is hung up, the output of IC2-a goes high, charging C3 through R4, with a time constant of:

$$\tau = R4 \times C3 \\ = 100\text{K} \times 47 \mu\text{F} \\ = 4.7 \text{ seconds}.$$

If the phone rings before C3 reaches 8 volts as set by R3 and R5, C3 discharges and the timing cycle restarts. After a certain exponential charging interval, the potential across C3 reaches 8 volts, and the output of IC2-b goes low, turning off Q2 and RY1 and reconnecting the audio. The final charging voltage in that case is $V_f = V_{\text{CC}} = 12 \text{ V}$, and the target voltage is $V_t = 8 \text{ V}$. Since τ is known, the charging interval is:

$$T = -2.303 \times \tau \times \text{Log}_{10}[1 - (V_f / V_t)], \\ = -2.303 \times 4.7 \text{ seconds} \\ \times \text{Log}_{10}[1 - (8 \text{ V} / 12 \text{ V})], \\ = 5.164 \text{ seconds}.$$

When RY1 energizes and the audio is cut off, audio output terminals J3 and J4 are shorted through C4 to prevent any hum introduced when the audio-muting circuit switches line-level audio. Here, D2 prevents reverse-bias spikes, generated by switching RY1, from destroying Q2.

PARTS LIST

All resistors are 1/4-watt, 5%, unless otherwise indicated.

R1, R2, R4—100,000 ohms
R3—20,000 ohms
R5, R6—10,000 ohms

Capacitors

C1—47 μF , 16 volts, electrolytic
C2, C4—0.1 μF , 50 volts, non-polarized (NP) ceramic disc
C3—47 μF , 10 volts, electrolytic

Semiconductors

BR1—NTE-5332 1-amp, 600-volt PIV 4-pin DIP bridge rectifier
D1—NTE-140A 10-volt Zener diode
D2—IN4004 rectifier
Q1, Q2—2N2222 NPN transistor
IC1—7812 5-volt regulator
IC2—LM393N 14-pin DIP dual voltage comparator

Other components

T1—120-volt/12.6-volt, 300-mA transformer
RY1—5-volt, DPDT, 8-pin DIP Relay
PL1—AC line cord with plug
PL2—four-conductor modular tele-

phone cord with plug
J1—J4—RCA phono jack

Miscellaneous: Case, AC line cord grommet, two straight-line TO-3 transistor sockets, an 8-pin DIP IC socket, wire, solder, and drill with bits.

NOTE: A kit of parts is available for \$29.95 from Applitron Services, 2721 Creswell Road, Bel-Air, MD 21014. It includes an etched and drilled PC board, but excludes the AC line plug and cord PL1 with grommet, modular telephone plug and cord PL2, and the case. The PC board alone is \$15.00, should you wish to obtain the parts locally. Please enclose \$1.95 postage and handling; allow 4–6 weeks for delivery. Relay RY1 can be obtained separately from All-Electronics Corp., P.O. Box 567, Van Nuys, CA 91408, (800) 826-5432, for \$2.50.

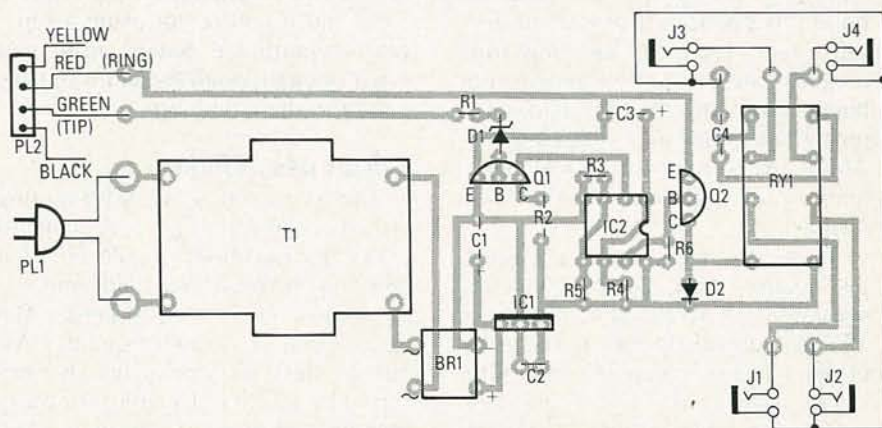


FIG. 2—PARTS-PLACEMENT DIAGRAM for the audio-muting circuit. Note the spacing of the pins of RY1, for orientation purposes.

Finally, the grounds for J1–J4 in Fig. 1 are separate from those of the rest of the circuit. The ground symbol for the main part of the audio-muting circuit is the normal downward-pointing, three-line, triangular arrow, whereas the ground symbol for J1–J4 is a downward-pointing open triangle. The reason is that the radio, stereo, or TV, shouldn't share a common ground with the rest of the audio-muting circuit.

Also, the ground terminals aren't connected J1-to-J3 and J2-to-J4, to attempt to separate the channels and avoid crosstalk. The radio, stereo, or TV will have one common ground for all four terminals within its own cabinet, so joining all four ground termi-

nals of J1–J4 shouldn't make any difference. Similarly, you wouldn't connect J1-to-J2 and J3-to-J4, since that would isolate input and output, preventing the speakers from being properly grounded, and might damage whatever audio source is connected to J1 and J2.

You can also use the audio-muting circuit with two mono sources, like two TV's, instead of one stereo source, but you have to isolate the grounds for the two channels. In that case, *don't connect all four grounds for J1–J4 together*, or you might get one really nasty shock, and/or some pretty spectacular fireworks. You can connect the grounds of J1 and J3 and

continued on page 101

TECHNOLOGY

WHAT'S NEW IN CD PLAYERS

If you're in the market for a new CD player, you should familiarize yourself with all of the new features available

JOSEF BERNARD

WHETHER YOU'RE BUYING A CD PLAYER for the first time, or upgrading your audio system with a new one, 1990 has plenty in store for you. For one thing, you'll find that, as befits today's political era, many of the new players are "kinder and gentler."

CD players have changed a lot since they were introduced jointly by Philips and Sony in 1983. For one thing, they cost a lot less than the \$900 first units, although you can still easily pay that much and more if you put your mind to it. For another, the new players are loaded with features and technology that were barely a gleam in designers' eyes just a few years ago. Here's what's new in the current crop of CD players.

Changers

It seems that the more we have, the more we want. It isn't enough to have as much as 74 minutes of superior sound recorded on an almost indestructible medium—now we don't even want to have to get up to change discs! Enter the CD changer. Changers come in two varieties—carousel and magazine. With a carousel changer (Fig. 1) you load in as many discs as it will hold, usually five, and off you go. When one disc is finished, the next swings into place. Assuming that you always play a given set of discs in the same order, you can pro-

gram carousel changers to play selections in a certain order, or even to skip some selections.

Magazine-type changers accept cartridges that can hold five, six, or as many as ten compact discs (Fig. 2). Again, the order in which discs and selections are played is programmable. Magazines, which cost between \$15 and \$30 each, from different manufacturers are *not* interchangeable, although those used by Sony can be swapped between their home and car units. Most carousel, and some magazine players include a "single-play" drawer for individual CD's. And at least one magazine model has twin drawers (Fig. 3) so you can reload one while playing the other.

Multi-disc players

There are now a number of different disc formats on the market offering a number of different types of programming. There are conventional five-inch (actually closer to 4¾-inches) CD's, the small three-inch discs that offer a shorter "pop-size" playing time, CD-V's for music videos, and 8- and 12-inch laser discs for movies and other visual material. What those formats have in common is that they all involve spinning discs that are read

by bouncing a laser beam off their surfaces. It seemed only natural that someone would eventually come up with a single player that handled all those formats, which are similar in principle, and a quite a few companies have done just that (see Fig. 4).

The devices are sometimes referred to as "multi-disc players," (also as "combi players") but the term "multi-disc" refers not to their ability to accept several discs at once, but to their ability to accommodate several different disc formats—one at a time, of course. Even some portable units can play both 5- and 3-inch CD's without the adapters that have sometimes been necessary in the past.

Programmability

One of a CD player's big selling points, after the quality of its sound, is its programmability. You can instruct



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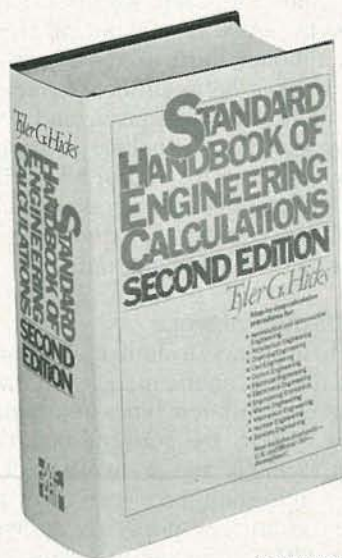
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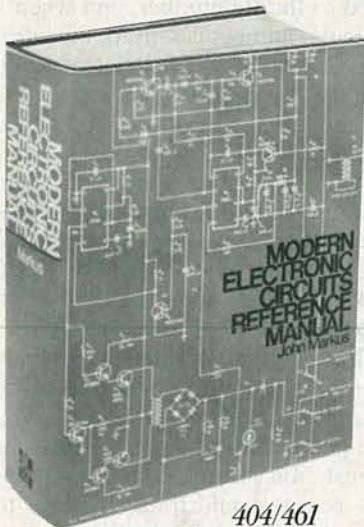
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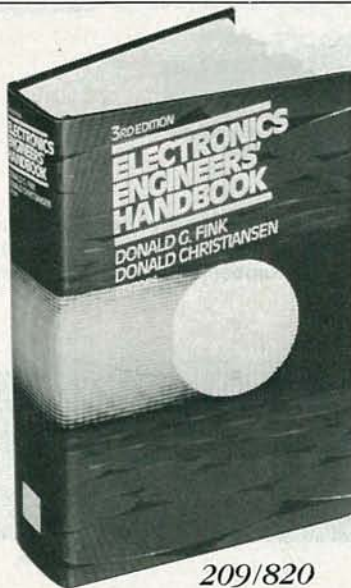
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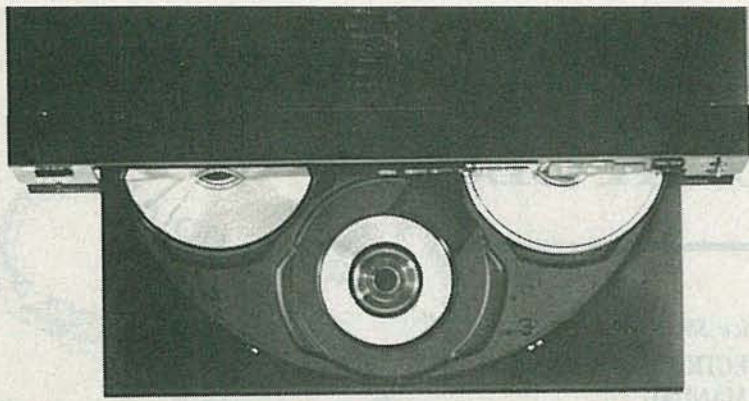


FIG. 1—A CAROUSEL CHANGER, such as Sony's *CDP-C8ESD*, can accept up to five CD's and play them in succession. It can be programmed to skip the tracks that you don't customarily listen to.



FIG. 2—WITH MAGAZINE CHANGERS you can store your CD's in sets of five, six, or ten, ready to play in pre-programmed order. The programming information is stored in the changer and called from memory in response to the ID number of the first disc in the magazine. This is JVC's *XL-M401BK* changer.



FIG. 3—IF ONE MAGAZINE ISN'T ENOUGH, changers such as the Pioneer *PD-T503* have twin drawers so you can have two on line. You can also reload one magazine while the other is playing.

a player to play some selections and skip others (and even to replay the same selections), or decide for itself in what order to play the tracks (random- or shuffle-play), and take it on its own from there. Some players can play tracks at random while remembering to ignore the ones you don't care for.

All players have a time display of some sort, which is useful in making up programs to transfer to tape. Some

models can be programmed to automatically insert a four-second pause between selections, so that you can then use the tapes on players with automatic search functions. There is at least one player on the market that can scan a disc and find the loudest passage, allowing you to set the recording levels on your tape deck to prevent distortion.

CD changers can be programmed in the same way. The programming

information is stored in nonvolatile RAM in the changer. When a magazine or, in the case of carousel players, an assortment of discs is inserted into the changer, the first disc is scanned and a manufacturer's ID number unique to it is retrieved from a sub-code (non-music) area. Programming information for a given cartridge is keyed to the ID number, and when a particular number is sensed, the information pertaining to it is retrieved from the changer's memory. If the first disc in a cartridge is exchanged for another, the program for that cartridge has to be reentered. The same also applies to disc assortments for carousels. There's one player that can keep track of 226 discs at 20 tracks per disc, for a total of 4520 tracks.

The recording format of compact discs allows for index marks to be included by the manufacturer to denote points on the disc of particular interest. You can enter the index numbers as you would track numbers to get to those points immediately, or to select certain portions of the disc during programming. Unfortunately, not many manufacturers take the trouble to include indexing, and the feature is largely unused.

A *Custom Index* feature on some Sony players, though, permits you to enter your own index point (as many as six of them) into the player's memory. When you think you've marked the proper place on the disc, you tell the player; it then replays the three-second passage preceding the marked point to allow you to review and, if necessary, edit the index point. Another touch of the button locks the index point in memory. If you want to adjust the position of the index point you can do so in increments of $\frac{1}{100}$ of a second using the player's FORWARD and BACK buttons.

Sampling, filters, and extra bits

The first stage in converting an analog signal to a digital one, such as what's used on CD's, is a process called *sampling*. The analog-to-digital converter "peeks" at the analog signal many times each second, and the result of each peek is a number in binary form, or a "sample," that represents the instantaneous amplitude of that signal—its level at the instant of the "peek." The process is illustrated in Fig. 5.

To sample a waveform accurately,

the sampling frequency must be at least twice that of the highest frequency that is sampled. If it is lower than that, the digitized signal will not be a proper representation of the analog one, and will be filled with distortion products. In the case of compact discs, the sampling frequency has been standardized at 44.1 kHz, which ensures reproduction of signals having frequencies up to (and a bit beyond) 20 kHz, the theoretical limit of human hearing.

However, while that technique may record the digitized signal with considerable accuracy, the process of playing it back (converting the stream of binary numbers back into an analog waveform that can be amplified and fed to a set of loudspeakers or headphones) introduces its own set of difficulties that must be overcome if accuracy is to be maintained.

In the sampling process used during playback to recover the data stored on a CD, there is an interaction between the frequency of the signal on the disc and that of the sampling clock (which sets the sampling frequency). The interaction, which is known as *aliasing*, gives rise to sum and difference frequencies that represent artificial (and erroneous) information that never was on the disc. That information gives rise to distortion and can also waste amplifier power.

To get rid of those unwanted harmonics, a technique known as *oversampling* is used. Oversampling takes place in a section of the player called the digital filter. In fact, as you shall see, quite a lot happens in a CD player's digital filter, and while the required IC's used to be an expensive high-end luxury, they are now found on virtually every player on the mar-

ket. As shown in Fig. 6, the filter processes the digital signal almost immediately after it has been retrieved from a disc. Oversampling simply means reading the digital information recorded on the disc at a multiple of the basic sampling rate of 44.1 kHz. That results in the frequencies of the harmonics being so high that most aliasing products disappear (they are filtered out, in effect) and those that remain are far out of the way, where they can cause little problem and

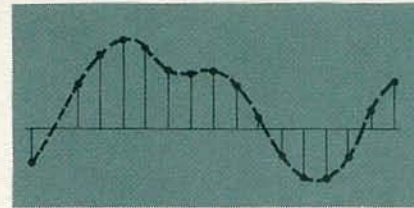


FIG. 5—SAMPLING IS THE PROCESS of recording the instantaneous values of a waveform at specified intervals. The Nyquist theorem states that, for accurate reproduction, the sampling frequency must be twice that of the highest frequency of the signal sampled.

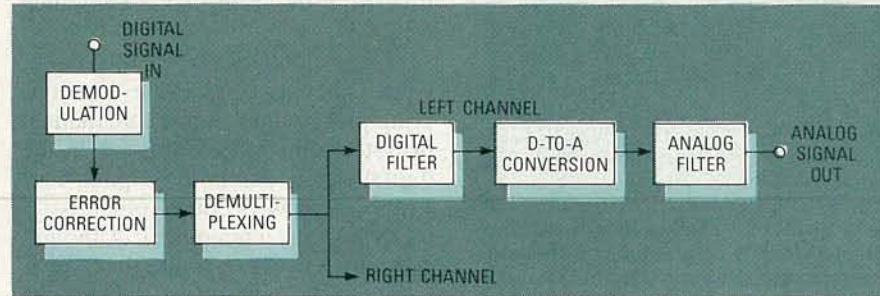


FIG. 6—SIGNAL FLOW in a typical CD player. Much of the signal processing that takes place in today's players occurs in the digital filter section.

where they can easily be removed by an analog low-pass filter.

Oversampling can also increase the accuracy of the information read from a disc to some degree. It is not uncommon to find CD players boasting $4\times$ and $8\times$ oversampling rates, representing frequencies of 176.4 and 352.8 kHz. Generally speaking, the higher the oversampling rate, the better the player.

Digital filters perform another function. An analog signal that will eventually wind up on a CD is first recorded on magnetic tape in 16-bit digital form, eventually winding up on the disc as a stream of 8-bit digital words that, in turn, represent 14-bit words. (See "Compact Discs Bit-by-

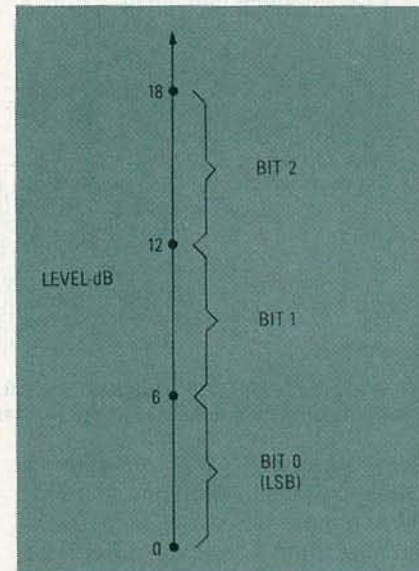


FIG. 7—THERE IS A SIX-DB DIFFERENCE in signal strength represented from bit to bit in the binary words used in digital recording for CD's. At the level of bit-0, the least-significant bit, ambiguities in recording or decoding can result in an artificial raising of a recording's noise floor. Oversampling and other digital-filter processing do much to reduce error at that level and expand a player's effective dynamic range.

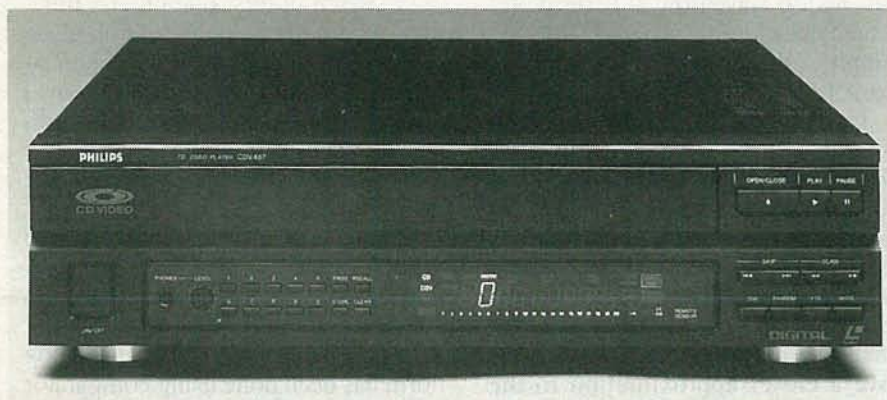


FIG. 4—MULTI-PLAY UNITS can play a variety of laser-read discs containing audio or video material. They include 3- and 5-inch CD's, CD-V's, and 8- and 12-inch laser discs. This is the Philips CDV-487.

Bit" *Radio-Electronics*, August, 1986 for details of the process and information on what else is on a CD besides music.)

In the early CD players, it was considered enough merely to decode the bit stream, convert it back to 16-bit

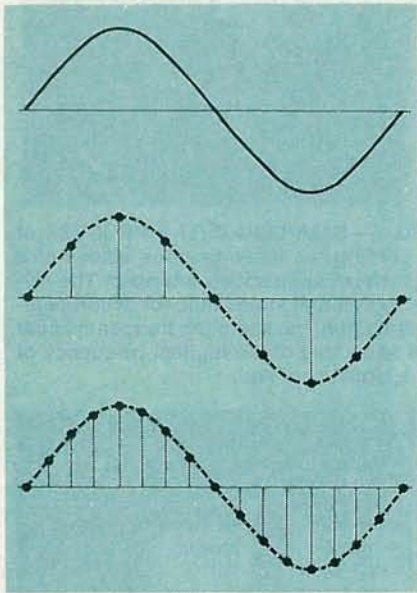


FIG. 8—OVERSAMPLING ADDS EXTRA data points to the waveform reconstructed from a CD's digital information. The process yields a waveform that more closely resembles the original one, and also requires less processing.

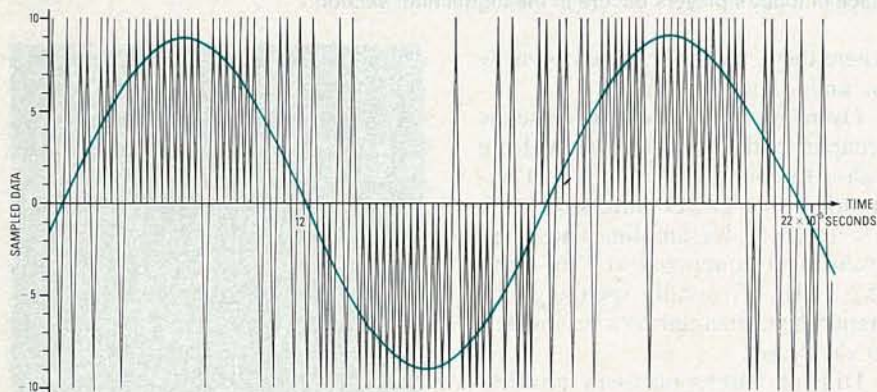


FIG. 9—THE OUTPUT OF PHILIPS' one-bit, 256x oversampling system is a string of pulses of constant amplitude. The pulse density determines the signal's amplitude.

analog form, and pass it through an analog low-pass filter to smooth it a bit and to remove the aliased signals before outputting it to an amplifier. The resulting signal, though, was far from ideal. It was not a very accurate representation of the original. Figure 7 shows how each step of the digitized waveform represents a change in level of six decibels (for a total dynamic range of 96 dB—sixteen steps multiplied by six decibels). For mid- and high-level signals that does not present much of a problem. At very low levels, though, way down at the level of the least-significant bit, the six-dB-per-bit assignment becomes *very* significant.

That first step is a lulu—there's quite a difference between the total silence of zero dB and the sound level, low as it is, at the level repre-

sented by the first bit six dB above it. What's needed is some extra bits to smooth things out and eliminate any ambiguity that may try to creep in (that is part of what manufacturers claim as "improved linearity"). Again, in early players, it was considered sufficient to restore the digital signal to its original 16-bit form. As the speed of D-to-A converter devices increased, though, it became possible for them to generate digital words of even greater length than 16 bits in real time from the information contained on a CD.

Where do those extra bits come from? They arise from the oversampling process and from mathematical operations that are performed on the digital signal within the digital filter which, as now becomes obvious, is more than just a plain filter. Although it is impractical to get into the mathematics of the matter here, the Nyquist theorem, which states that the mini-

imum sampling rate must be twice the highest frequency to be sampled, also implies that if that rule is followed, *all* the information contained in the original analog waveform will be represented in the digital samples. It's then simply a matter of knowing how to extract it.

Today's digital filters have begun to do just that, and from the 8-bit (actually 14-bit) signal stored on a CD it is now easily possible to extract a considerably more accurate 18-bit one. A few players go so far as to generate a 45-bit digital signal! The extra bits represent additional points on the reconstructed waveform (Fig. 8), and give a closer approximation to the original analog signal as well as requiring less analog filtering. The result is, as President Bush might put it, a "kinder, gentler" waveform—one

that does not require as brutal an analog filter. The additional data points also make it possible to perform (within the digital filter, again) a process called *noise shaping*, which reduces greatly the effects of a phenomenon known as quantization error, which is heard as noise.

Just prior to the analog output filter is the circuitry that performs the digital-to-analog, or D-to-A conversion. A manufacturer can choose to operate on any number of the bits generated by the digital filter, but generally restricts the number to 18. An 18-bit Digital-to-Analog Converter (DAC) is about as good as current manufacturing processes can produce at a reasonable cost. Some players advertise "dual D-to-A converters." Using two DAC's means that each has to work less and is not being pushed to the limit of its performance; according to some it also adds extra separation between channels.

One-bit, 256x oversampling

This year you will begin to see CD players that offer 256x oversampling. That's a frequency of 11.2896 MHz, for those readers without their calculators handy, with one-bit accuracy! "All right," you say, "what happened to all the other bits?" And how can just a single bit tell you anything at all about how a piece of music sounds?

The answer depends on how you understand the technique. In the MASH (multi-stage noise-shaping) system patented by Japan's NTT, and in another similar one developed by Philips, all the bits recorded on the disc are used but, rather than being reorganized as they come off the disc into 16-bit words, they are considered as a stream of bits, one bit at a time. (There is a good analogy to be made with parallel and serial communications in personal-computer systems.) The very high sampling rate ensures accuracy and smoothness, and is the equivalent of sampling each bit of the 16-bit word 16 times.

Further accuracy is claimed to be due to the use of a different D-to-A conversion system than is found on conventional players. Traditionally, conversion of digital signals to analog form has been done using comparator networks weighted with resistors to give a stepped-waveform output of the sort described earlier. As the bits come off the line (as it were) in the

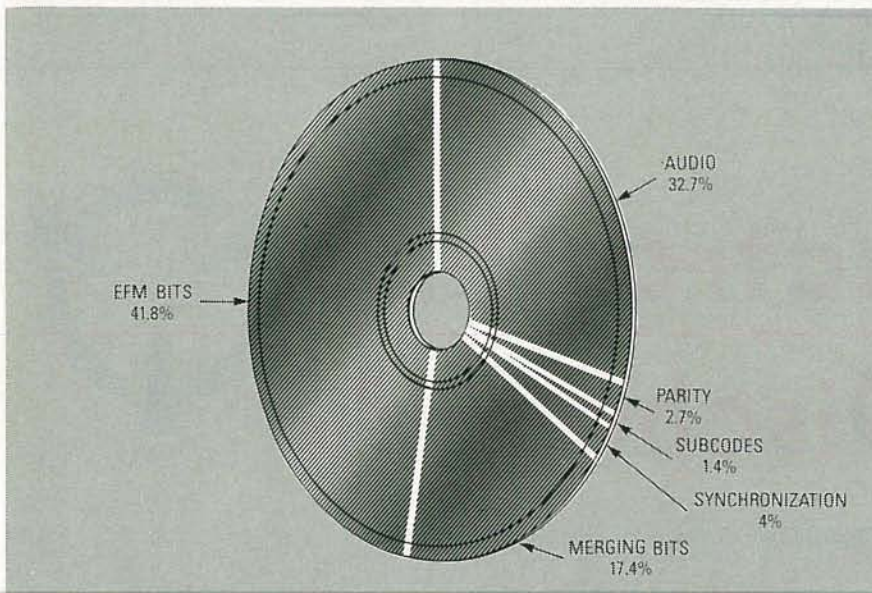


FIG. 10—ONLY ONE-THIRD of a CD's capacity is used to store digitized sound. Much of the rest contains error-correction information, and a substantial portion is devoted to the subcodes that make up a CD + G disc's visual content.



FIG. 11—THE FIRST CD+G/M PLAYER on the market is JVC's XL-G512. It decodes information contained in a CD + G disc's subcodes to output a video signal, and can also output MIDI control information for MIDI-equipped instruments and computers if that information is included on the disc.

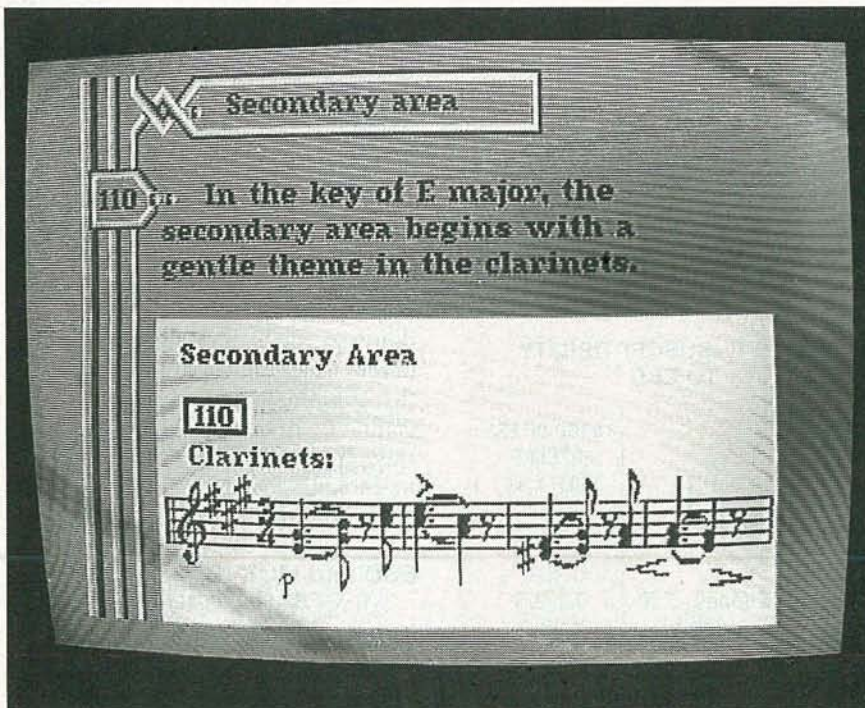


FIG. 12—A CLASSICAL CD + G DISC might contain not only the performance and a copy of the score, but a commentary on the composition as well.

Philips system, they are used to charge small capacitors. It is those charges that form the player's output waveform. An example of that PDM (Pulse Density Modulation) output is shown in Fig. 9. Philips claims greater accuracy for its system compared to the resistor-comparator method. It, too, is "kinder and gentler."

CD + G/M

There's lots more stored on the surface of a compact disc than just music. In fact, only about a third of the information there represents sound; the rest is used for error correction, indexing, and other purposes (see Fig. 10). A sizable chunk of space is reserved for the information known as subcodes. Until now, the subcode area has been pretty much ignored. Aside from a few CD players that had subcode outputs (the output of the digital subcode information, whatever it might be), there were no subcode standards to follow and, consequently, nobody did anything. However, an industry document known as the *Sony-Philips Red Book* has now set forth such standards for the industry, and the result is a new type of CD, known as the CD + G, or sometimes CD + G/M. Players for that new format are just becoming available, the first being JVC's XL-G512BK shown in Fig. 11.

The term "CD + G" stands for "Compact Disc Plus Graphics." The graphics are stored, in digital form, in the subcode area of a disc. They are decoded by a CD + G player and converted into a video signal that can be fed to a monitor or TV receiver. The video, while it cannot present anything like real-time-TV detail or animation, does have the appearance of a high-quality teletext signal.

One application of CD + G is to have the subcoded graphics information accompany popular music as a form of music video. One of the first releases in that form is Donna Summer's *Another Place and Time*. For classical music, the system can be used to display scores and librettos, and can even provide an on-screen commentary on the composition (Fig. 12). As the system becomes popularized, new uses will no doubt be found for it. In the meantime, CD + G discs can be played on ordinary CD players—you just won't see the "G" part.

continued on page 56



Electrostatic Discharge



Fight ESD and keep your components healthy.

DAVE HOLLANDER

CONSIDER THIS SCENARIO: YOU'VE RECEIVED a MOS IC, removed it from its black foam or pink foam packing, and soldered it in place. Your project might work initially, but its performance falls far below expectations. Your IC is probably a victim of electrostatic discharge (ESD), and was likely damaged by improper handling. ESD is one of the most common causes of component failure, and as the actual transistor-device geometries on board a silicon chip shrink, an IC becomes more sensitive to it.

ESD can cause component failure or performance degradation that's difficult or impossible to detect, and is a major concern in modern electronics. The problems of ESD can occur as erroneous data, incorrect instructions, or system shutdown on operating hardware. This article will attempt to explain the mechanisms behind IC failure due to ESD, how to handle sensitive IC's properly, and how to set up a safe work area.

How ESD is generated

ESD is also called triboelectric charging. When two insulators are rubbed together, charge is transferred by friction, like what occurs if you run your feet across a carpet. The charge is a function of separation, extent of contact, rate of separation, humidity, and, of course, the triboelectric material itself (see Fig. 1).

ESD current is pretty low, while potential can exceed 300 kV. When charge is built up in a human body and discharges as a perceptible arc

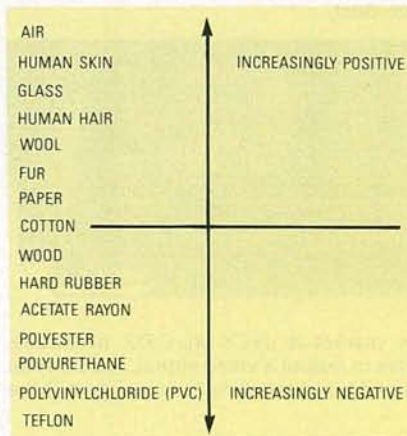


FIG. 1—THIS DEPICTION SHOWS the relative propensity of different common materials to either lose ("INCREASINGLY POSITIVE") or accumulate ("INCREASINGLY NEGATIVE") charge.

(felt as a slight tingle), no damage is done if the potential is under 2.5 kV (the "discomfort threshold"). Levels below that are barely noticeable, but

can disrupt equipment. Table 1 shows the relative susceptibility of various semiconductor devices to ESD.

You might notice that you get electrostatic shocks more often in the winter than in the summer. That's because, in the summer, the relative humidity levels are much higher, and the buildup of moisture on a surface provides a discharge path. By comparison, materials that reject moisture exhibit the highest propensity toward ESD. Above 65% relative humidity, there's no real ESD problem, while below 20%, over 300 times more static charge is generated.

How much charge a human body will accumulate is dependent upon on the individual's size and skin conductivity. Another example of reduced humidity giving rise to electrostatic charging and ESD occurs when you put nylon and polyester clothing together in a dryer. You've no doubt seen how you can often generate as much as 650 volts by doing so, since the primary object in a dryer is the removal of moisture, and the combination of nylon and polyester are prime triboelectric materials. Typical ESD voltages are given in Table 2, for a number of common configurations.

TABLE 1—SUSCEPTIBILITY TO ESD

DEVICE TYPE	RANGE OF ESD SUSCEPTIBILITY, kV
Power MOSFET	0.1-0.2
JFET	0.14-10
CMOS	0.25-2
Schottky Diodes, TTL	0.3-2.5
Bipolar Transistors	0.38-7
ECL	0.5
SCR	0.68-1

ESD and MOS IC's

All MOS devices have an insulated gate that's subject to voltage breakdown. The gates on Motorola's devices are about 800 angstroms thick, and they break down at a gate-source potential (V_{GS}) of about 100 volts.

The high-impedance gates are protected by onboard resistor-diode networks, but they don't make an IC immune to ESD. Laboratory tests indicate that devices can fail after one very high voltage discharge, or after the cumulative effect of several lower potential discharges.

ESD-damaged devices behave in various ways. The most severely damaged devices are easiest to detect because their inputs or outputs have been completely destroyed; they're either shorted to V_{DD} or V_{SS} , or are open, and the device no longer functions. In other cases, detection can be more difficult because the device is intermittent or degraded. From the data in Fig. 1 and Table 2, you can easily see why MOS IC's can be damaged by improper handling.

ESD and Power MOSFET's

Being MOS devices, TMOS™ transistors (Motorola's trade name for its power MOSFET's) can also be damaged by ESD. However, they're not as susceptible as CMOS, due to large input capacitances that let them absorb more energy before breaking down. However, at breakdown potential, there's enough energy in the C_{GS} to totally perforate the gate-oxide. With a typical V_{GS} maximum rating of ± 20 volts DC, and ESD potentials typically reaching 100 volts–25 kV,

you can see why special handling is needed.

Curve-tracer plots of a MOS device before and after ESD degradation are shown in Figs. 2-a and b. Where most power MOSFET's have the ± 20 -volt DC rating, Motorola power MOSFET's use the Bullet-Proof4™ process, resulting in more reliable devices with higher V_{GS} breakdown levels. They're guaranteed to withstand ± 40 volts DC for a single, non-repetitive pulse of 50- μ s duration or less, achieved by control of gate-oxide thickness. With improved dielectric strength comes better resistance to ESD damage.

Classification of devices

Military specifications are used to classify ESD sensitivity of semiconductor devices. Through measurements, the model of Fig. 3 closely approximates the human body. Discharge of that network directly into a device indicates that the model assumes a "hard ground" is in contact with the part. Although all pin combinations should be evaluated (six different versions for a power MOSFET), preliminary tests usually show that gate-oxide breakdown is most likely, and that reverse-bias makes a junction about an order of magnitude more sensitive than forward-bias. The damage mechanism is usually gate-oxide punch-through or junction melt-through. In other words, when a semiconductor device is subjected to unusually high voltages, the charges (holes and electrons) move apart in directions that they were never intended to go.

Static protection

The basic method for ESD protection combines prevention of static build-up and removal of existing charge. Charge-dissipation procedures differ for insulators and conductors. Since charge can't flow through an insulator, it has to be removed by contact with a conductor. If the item is an insulator (plastic box, clothing, etc.), ionized air is required. If it's a conductor (metal tray, conductive bag, person's body, etc.), complete discharge can be accomplished by grounding.

Many methods are used to inhibit

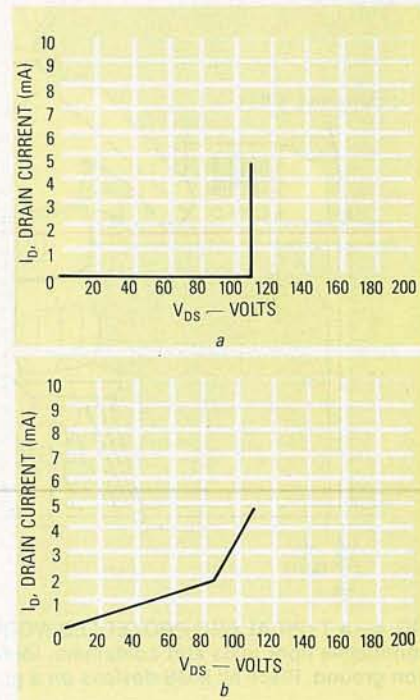


FIG.2—CURVE TRACER PLOTS OF A MOS device before (a) and after (b) being subjected to ESD degradation.

ESD; carpets are made with antistatic materials and coatings. Equipment can be sprayed with antistatic solutions, materials with low triboelectric propensity can be used, and clothing can be made of triboelectrically insensitive fabric. Static-safe work stations are also used. Components are packaged in conductive or antistatic packaging. In addition, relative humidity within the environment is maintained above 65%.

How to prevent ESD?

You might find industrial-grade precautions impractical, but if you're educated in ESD and its effects, you'll have better control of your

TABLE 2—TYPICAL ELECTROSTATIC VOLTAGES

MEANS OF STATIC GENERATION	ELECTROSTATIC VOLTAGES, kV	
	RELATIVE HUMIDITY	
	10-20%	65-90%
Walking across carpet	35	1.5
Walking across vinyl floor	12	0.25
Worker at bench	6	0.1
Vinyl envelope	7	0.6
Common polyethylene bag picked up from bench	20	1.2
Work chair padded with polyurethane foam	18	1.5

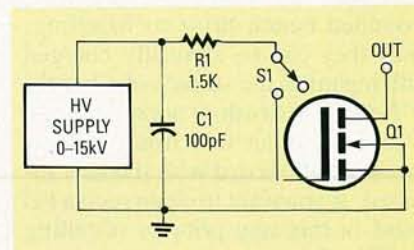


FIG. 3—THIS MODEL CLOSELY approximates the human body. Discharge of this network directly into a device indicates that the model assumes a "hard ground" is in contact with the part.

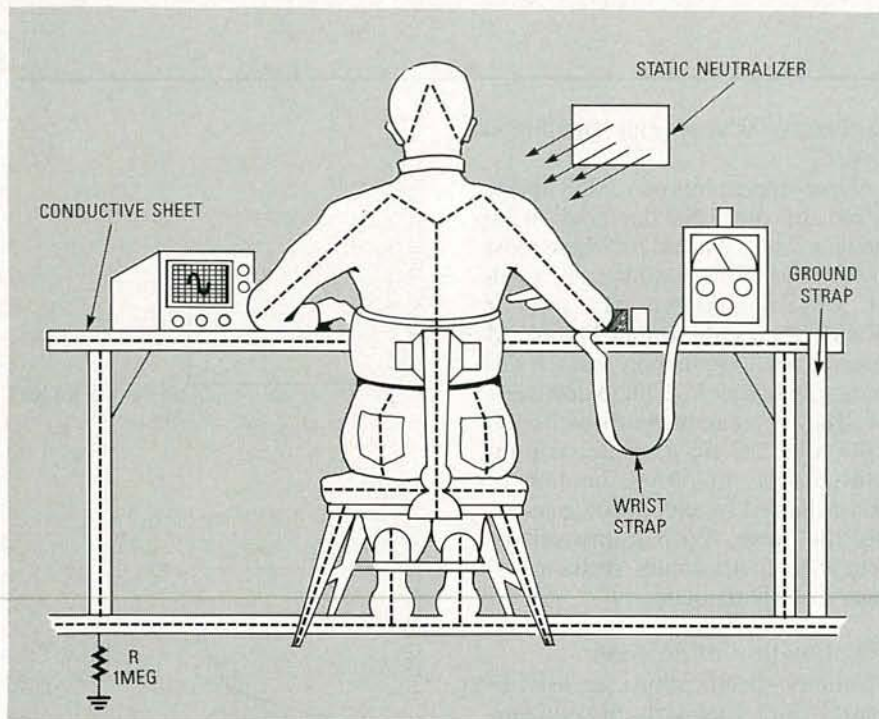


FIG. 4—A TYPICAL ESD-PROTECTED WORK STATION, with a 1/16-inch metallic bench top, conductive floor mats and containers, ionized air blowers, wrist straps, and soldering-iron ground. Place all MOS devices on a grounded bench prior to handling.

working environment. A typical work station is shown in Fig. 4. The steps to



FIG. 5—ALWAYS USE PACKAGING labels like this one to indicate ESD-sensitive parts, and that proper handling of the parts is required.

be taken are listed below:

- Never exceed maximum specified data-sheet ratings.
- Work benches should have grounded metallic tops, conductive floor mats and containers, and ionized air blowers.
- Use wrist straps in contact with the skin.
- Use a ground strap on the tip of all soldering irons.
- Place all MOS devices on a grounded bench prior to handling, since they can be statically charged with regard to the surface of a bench.
- Never use brush or spray cleaning to remove solder flux from a MOS-populated PC board with the IC's installed. If you want to clean such a PC board in this way prior to installing the IC's, fine.
- Place completed PC-board assemblies in antistatic bags if they're transported to another location.
- Keep work benches free of coffee

cups and stirrers, paper, styrofoam, tobacco ash, cellophane wrappers, and plastic.

- Never insert or remove an IC from its socket with power applied.
- Check all power supplies for voltage transients like ripple or spikes.
- All low-impedance equipment like pulse generators should be connected to MOS devices *only* after power up, and disconnected before being shut off.

MOS-device packaging is critical; components purchased for home projects should come with antistatic or conductive packaging. Static-sensitive IC's are normally packaged in either black conductive foam, specially treated pink plastic bags, or an oily antistatic styrofoam. There should also be packaging labels indicating ESD-sensitive parts, and that proper handling is required, as in Fig. 5. Never insert a MOS device into a conventional plastic tray or piece of styrofoam. Keep it in its original packaging until ready to use.

All equipment should have a good earth ground, but particularly if it's ESD-sensitive. In a dry climate, attach a small metal plate with a good ground to your desk/workbench. By touching it to discharge any static potential built up while walking across carpeting, your equipment might live longer.

R-E

CD PLAYERS

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The "M" in "CD + G/M" stands for "MIDI," which itself is an acronym for "Musical Instrument Digital Interface." A MIDI signal is used to store or transmit performance information, such as the output of a music synthesizer's keyboard, which might consist of duration, pressure, and (of course) which-keys-are-pressed data as well as that for other performance parameters. You could use the MIDI signal to have your MIDI-equipped instrument play along.

Gizmos, gadgets and gimmicks

As you browse (or plow, depending on the intensity of your interest) through the literature on the new CD players, you'll come across mention of lots of special features that may tickle your fancy. Many of those features are intended to appeal to the high-end audiophile, and their effect on the quality of the final product (the sound that comes out of your speakers) may be so slight as to be unnoticeable to ordinary people.

Some players use a single-beam tracking system while others boast of a three-beam one. Both use the intensity of the laser light reflected from a disc to provide control information that keeps the beam on track. Don't let the terminology confuse you. A three-beam system does not use three lasers; it just splits the output of a single laser into three beams. Indeed, all CD players contain just one laser whose beam is used both for reading the digital information from a disc and for tracking. A three-beam system can react more quickly to a "drift" situation, but you probably won't notice the difference.

One or two makes of CD players boast a speed stabilizer that supposedly makes a disc rotate at a more even speed than it otherwise would. That feature is similar in purpose to the stick-on stabilizer rings that are sold separately to be attached to the outer perimeter of CD's to add to their mass (and presumably speed stability). In either manifestation, that may not be such a great idea.

First of all, the speed of a CD is constantly changing anyway, from 500 rpm down, as the laser beam tracks farther from the center of the

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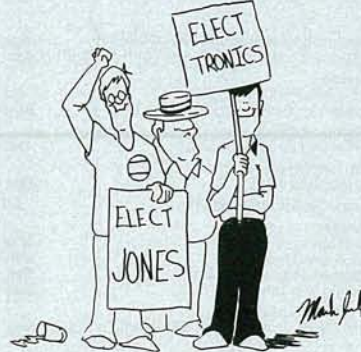
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"They use them in vacuum cleaners."



"No. There's no such thing as a tall circuit."

HARDWARE HACKER

PostScript fractal fern
Unusual cooling ideas
Thermoelectric modules
Chaos science resources
Superintelligent machines

Chaos science resources

DON LANCASTER

LET'S START OFF WITH SOME NEW UPDATE info for our previous columns. The 38.4-kilohertz crystal needed for the stereo broadcaster is available for around \$3 from *Statek*, who stocks quite a wide variety of small and cheap low-frequency crystals.

Since 38.4 kHz is a standard modem value, it seems a better choice than your usual 38.0-kHz stereo-multiplex frequency, and should work just about as well. Probably your best way to throw the project together, though, is to go to one of the kits that are offered in the **Radio-Electronics** classified section.

One interesting use for that chip is to measure the torque on a rotating shaft. A \$1.50 part can easily replace a \$1100 telemetry system here, at a lower power and smaller size.

Two additional sources for heavy water (deuterium) are the *Canadian Atomic Energy Commission* and their *Isotech* reps here in the US. Price is in the forty-cents-per-gram range.

A key cold-fusion paper appears on pages 301-308 of Volume 261 of the *Journal of Electroanalytical Chemistry*. The *EPRI Journal* (Electric Power Research Institute), August 1989, also has some interesting stuff in it.

A few of you callers on our hacker helpline have suggested faking those high-priced linear actuators we looked at two columns back. To do that, take an ordinary stepper and couple it to a piece of threaded rod by using shrink tubing. Then add two nuts and some

sort of platform to create a traveling slider. Various tricks could eliminate backlash, and you should be able to replace a \$57 list price actuator with a surplus \$2 stepper.

As per usual, all of our names and numbers have been gathered together for you into one common sidebar.

Thermoelectric coolers

There sure appears to be a lot of hacker interest in the thermoelectric cooling devices. We'll start off with the bottom line—besides their very high costs, those devices are pretty much useless, since they are so incredibly and horribly inefficient. They are only workable for very specialized and arcane applications where nothing else will do. Thermoelectric coolers will work only when you go to ridiculous extremes on insulation and heatsink efficiency, and then are capable of pumping only tiny amounts of heat. And, to further shatter some hacker dreams, no way will they make ice in the real world.

At any rate, a *thermoelectric module* is a solid-state cooling device. All you do is input a current,

and heat moves through the device, cooling one side and heating the other.

Figure 1 shows you a typical device. That one's the *Cambion* model 801-2007. A similar component is also available through *Melcor*. That dude measures some two inches square and can move up to 22 watts of heat when powered by a 12-volt car battery at 7 amps. Cost is in the \$20-\$30 range.

Solid-state cooling modules use the *Peltier effect*. Figure 2 shows you details. What you do is start off with bismuth telluride or some other semiconductor. Then you cut it up into blocks, while heavily *p* doping some of them and *n* doping others.

When a current is applied in the proper direction, the electron carriers in the *n* material and the hole carriers in the *p* material will "drag" thermal energy along with their motions. In both cases, the heat moves downward, creating a hot side and a cold side.

The amount of heat you do move depends highly upon the temperature differential you have to maintain. As Fig. 3 shows, that particular device can provide a 60°C difference between the hot and cold side, *provided that you pump no heat through it*. On the other hand, if you do maintain both sides at the same temperature, you can pump up to 22 watts of heat through the device.

In most uses, of course, you will want both to cool something and move heat, so you must use the middle of the curve. For instance,

NEED HELP?

Phone or write your **Hardware Hacker** questions to:
Don Lancaster
Synergetics
Box 809-RE
Thatcher, AZ, 85552
(602) 428-4073

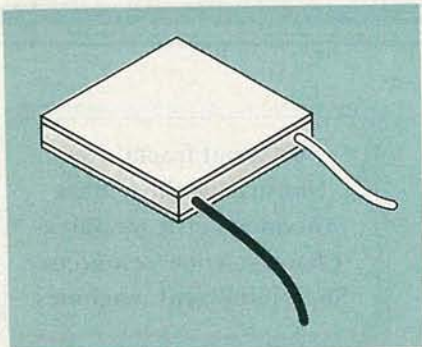


FIG. 1—THERMOELECTRIC COOLING modules are fairly cheap and easy to apply, but they are so inefficient that they are pretty much useless for any higher-power heat pumping.

you could pump eight watts with a 40°C drop. To put that in perspective, the module could, in theory, make a very small ice cube in around one hour...under ideal conditions.

The trouble is that conditions are *never* ideal for thermoelectric modules. There are a number of nasty "gotchas" that will gang up on you when you try to use them in the real world.

**NEW FROM
DON LANCASTER**

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CIRCLE 83 ON FREE INFORMATION CARD

NAMES AND NUMBERS

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1601 N. Powerline Road
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Canadian AEC
34 Slater Street
Ottawa, Ont, CANADA K1A 0S4
(613) 237-3270
Computer Shopper
One Park Avenue, 11th Fl.
New York, NY 10016
(212) 503-3500
DATArx
111 E. Drake Road, Ste. 7041
Fort Collins, CO 80525
(303) 223-2120
Edmund Scientific
101 E. Gloucester Pike
Barrington, NJ 08007
(609) 573-6250

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Haygean Machine
2225 South 170th Street
New Berlin, WI 53151
(414) 797-7520
Lightwave
Box 2139
Tulsa, OK 74101
(918) 835-3161
Melcor
990 Spruce Street
Trenton, NJ 08648
(609) 393-4178

Thermoelectric modules are rather expensive, mostly because they have not been improved one iota in the last two decades. Worse

yet, all of them are horribly inefficient. In a typical use, you'd have to input five watts of input power to provide just one watt of cooling.

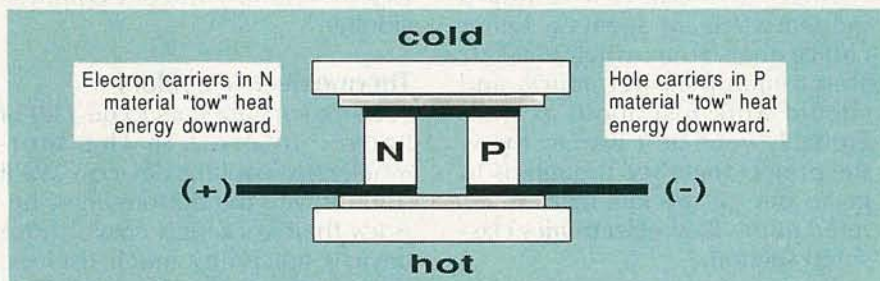


FIG. 2—A THERMOELECTRIC MODULE consists of blocks of bismuth telluride that have been alternately n- and p-doped. The blocks are placed electrically in series and thermally in parallel. When a DC current is applied, electrons in the n material and holes in the p material will tow heat along with themselves.

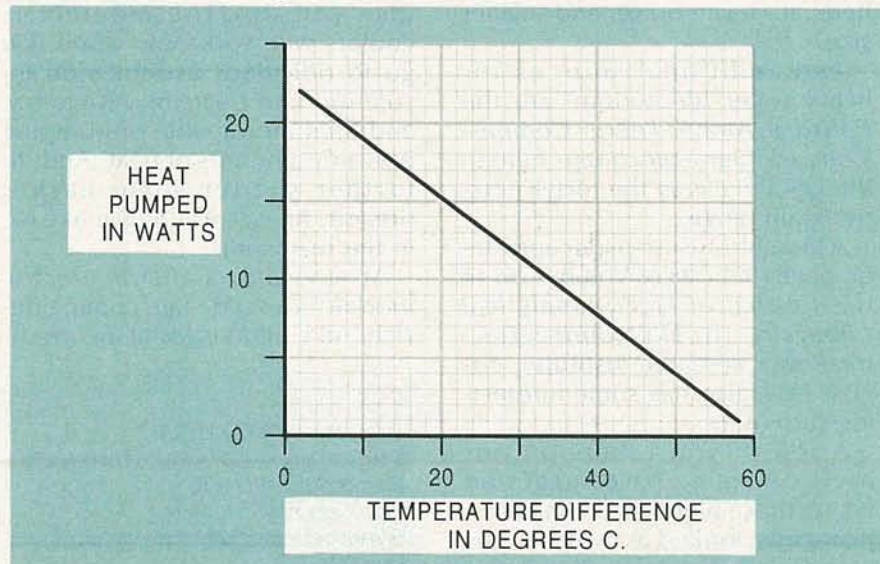


FIG. 3—THE AMOUNT OF HEAT PUMPED by a thermoelectric module depends on the temperature drop you require. Note that the heat transferred at the maximum temperature differential is zero. Note also that the heat differential is with respect to the hot end of your heat sink, and not to ambient.

NAMES AND NUMBERS

Philips/Signetics

45 George Washington Hwy.
Smithfield, RI 02917
(401) 232-0500

Sanyo

7 Pearl Court
Allendale, NJ 07401
(201) 825-8080

SGS

1000 East Bell Road
Phoenix, AZ 85022
(602) 867-6259

Sprague

70 Pembroke Road
Concord, NH 03301
(603) 224-1961

Statek

512 North Main Street
Orange, CA 92668
(714) 639-7810

Stock Drive Products

2101 Jericho Turnpike
New Hyde Park, NY 11040
(516) 328-3300

Synergetics

Box 809
Thatcher, AZ 85552
(602) 428-4073

Tektronix

Box 4600 M/S 94-860
Beaverton, OR 97076
(800) 426-2200

Texas Instruments

Box 809066
Dallas, TX 75380
(800) 232-3200

Vortec

10125 Carver Road
Cincinnati, OH 45242
(800) 441-7475

Mechanical air conditioners are almost *fifty* times more efficient than that! Worse yet, you have to apply that extra heat to exactly where you do not want it.

The heatsink you connect the hot side of the module to must be absolutely flat, and be machined to within 0.001 inch over its entire area. It must then get carefully covered with a thin layer of thermal grease. Obviously, those portions of a module not contacting the heatsink can not deliver any useful cooling.

The real killer of most thermoelectric-module applications lies in the thermal drop between the heatsink and the ambient temperature. For higher power uses, a fan or water cooling is essential.

For instance, a very large plain old heatsink will have at best a 1°C-per-watt temperature rise above the ambient. Say you want to pump the 8 watts at a 40°C drop. The heatsink will have to sink those 8 watts, plus an additional 32 watts or so of input power for a total of 40 watts. At 1°C-per-watt heatsink rise, the heatsink will warm to 40°C *above* the ambient room temperature. *And you've done nothing but break even!* The cooling module has a 40-degree *drop* across it. The heatsink has a 40-degree *rise* across it. And the net cooling is *zero*. You have nothing at all to show for all your effort.

One more time: In the previous

example, your final cooling is zero, because the hot side of the heatsink rises just as much above ambient as the amount of temperature drop you are trying to achieve! And a one-degree-per-watt heatsink is a darn good one...and large, too.

So, an extremely low thermal drop from heatsink to ambient is absolutely essential. Also essential is an incredible quantity of insulation around whatever you are cooling, for any net heat flux into your area being cooled will only make matters much worse than they already are.

The modules can get reversed by reversing the current. Because of the inefficiency, the heating mode is five times more effective than the cooling mode.

One side effect of that inefficiency is that you must run the modules off nearly pure direct current. The least amount of power-supply ripple will dramatically cut the cooling ability, since the ripple troughs will heat your load five times better than the ripple peaks will cool your load.

A car battery is often the best choice to power your thermoelectric modules. You might temporarily demonstrate a module by holding your module between your thumb and finger and then connecting the module to a single alkaline "D" cell. Do not use the "D" cell for more than a few seconds at a time.

What good are thermoelectric modules? You definitely can't buy a 4×8 foot panel of them and use them to air condition your house. But they are lots of fun to play with. They're a sure-fire topic for a winning science-fair project or student paper. Besides that, though, thermoelectric modules are limited to those specialized and low-load uses where nothing else can do the job. Important uses include coolers for infrared detectors, dew-point humidity sensors, chillers for microscope stages, and for thermal-management uses in satellites.

I have often wondered why they are not used in satellite-receiver front ends. I guess the answer is that the gain of the input amplifier drops faster with temperature than the noise figure improves.

Both *Cambion* and *Melcor* have lots of interesting tech literature on thermoelectrics, so you might want to contact both for more info.

Other coolers

There are three other approaches to unusual cooling techniques that are hacker hackable. You just might want to pick up on those instead.

First, Japanese air conditioners are ridiculously better than the American ones, and have been for the past few years. It seems that all the American manufacturers refuse to pick up the new technology, blaming the building codes, and claiming that a customer demand does not exist.

The new air conditioners have EER's (Energy Efficiency Ratings) approaching a value of 15, meaning that they use 33 percent less electrical energy than ours do. That's \$60 per month or so. They are also much quieter and far more comfortable. Four of the secrets include a new beastie called a *scroll compressor*, a motor with an infinitely variable speed blower on the air handler, and a total programmed microprocessor control.

I guess you would call the second device a solid-state cooler, although you do need a large air compressor across the room for a power source. At least the extra heat is not generated at precisely the wrong place, as is the case with thermoelectric modules.

FRactal and Chaos Science Resources

It turns out that rapidly moving air accepts heat from slowly moving air. Thermodynamics and all. So, if you build a suitable *vortex nozzle device* having one inlet for shop air and two outlets, you can arrange things so that cold air comes out one end and hot air out the other—with zero moving parts. Believe it or not, you can get as cold as the $-40^{\circ}\text{Fahrenheit}$ dry-ice temperatures, or else you can optimize the flow rates to get maximum heat pumping at lower temperature differentials.

One obvious use for those is as needle coolers for industrial sewing machines. Any heat-caused needle breakage can be almost completely eliminated by using a vortex nozzle.

The leading manufacturer of vortex cooling nozzles seems to be *Vortec*. Besides offering bunches of free data and free audio-cassette tapes on vortex cooling, they also have a number of other unusual nozzles that can do such things as air amplification.

As a third approach to effective cooling, dry-ice machines are amazingly low cost and simple. *Edmund Scientific* is one source. All you do is to connect the machine to a carbon dioxide tank (also cheap) from your local gas supplier and turn it on. Slightly over half the gas expands and boils off, while the rest of it will cool and solidify into one solid block. Presto—instant cold.

Naturally, you do that only in a well-vented area while you are wearing safety glasses. You also will want to avoid the instant frostbite caused by roughly handling the finished product, or otherwise letting it come into skin or eye contact.

Another contest

In case you have not noticed, the bottom has once again fallen out of the memory-chip market, eliminating that insane two-year pricing blip that was directly caused by some incredibly stupid and monumentally misdirected government meddling in the free-trade process. Your jellybean 1-megabyte dynamic RAM chips can now be had in quantity for as little as \$8 each. That translates to around 800 *microcents* per bit.

Beauty of Fractals, by Peitgen and Richter

Earlier text that is both a coffee table book and a source of useful algorithms. From the same publisher that did the *Science of Fractal Images*. (Springer-Verlag, 1986)
175 Fifth Avenue, New York, NY 10010 (212) 460-1500

BYTE Magazine

Occasional fractal articles and reviews. See *A Better Way to Compress Images*, January 1988, pp. 215-223 in particular.

1 Phoenix Mill Lane, Peterborough, NH 03458 (603) 924-9281

Chaos—Making of a new Science, by James Gleick

Interesting and easily read survey of the entire field of fractals and chaos science. Frustratingly shallow at times. (Viking, 1987)

40 West 23rd Street, New York, NY 10010 (212) 337-5200

Fractal Geometry of Nature, by B.B. Mandelbrot

The original "horse's whatever" book that started it all. Mind-blowing artwork in an otherwise unreadable and excessively egocentric text. (W.H. Freeman Press, 1982)

4419 West 1980 South, Salt Lake City, UT 84104 (801)973-4660

Science of Fractal Images, by M.F. Barnsley et. al.

Outstanding collection of useful hands-on fractal information. Good starting place to extend your own research. Includes algorithms and a good bibliography (Springer-Verlag, 1988)

175 Fifth Avenue, New York, NY 10010 (212)460-1500

SCIENCE Magazine

Occasional fractal and chaos science articles and reviews.
1333 H Street NW, Washington, DC 20005 (202)326-6400

SCIENTIFIC AMERICAN magazine

Occasional fractal articles and reviews. See their *Computer Recreations* column for ongoing info and comments.

415 Madison Avenue, New York, NY 10017 (212)754-0550

SIGGRAPH Proceedings

Far and away the best annual computer graphics show. Includes the latest and best of fractal and chaos science developments, on all three levels—theoretical, tutorial, and artsy-craftsy. (Siggraph-ACM Press, annually)

11 West 42nd Street, New York, NY 10036 (212)869-7440

And hackers can once again rejoice. Yea team.

Now, depending on who is doing the counting, the human brain will contain the equivalent of four billion memory bits or so. That's equal to a dozen CD-ROM platters or a small shoebox full of 1 Meg \times 8 SIMM strips. It's also equal to a mere *eight* of the 64 Meg \times 8 SIMM's just beginning to emerge from their preliminary lab research stage.

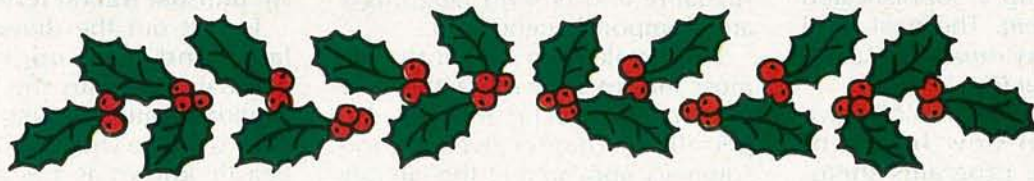
Projecting these ongoing memory trends, in around ten years or so, *machines will definitely be smarter than people*. So, for this month's contest, just write me a short essay on exactly what happens when machines will inevitably become the most intelligent life form on earth.

We'll have all the usual *Incredible Secret Money Machine* book prizes for the dozen or so best entries, with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going to the top entry of all. As usual, all entries have

to be on paper, and should get sent to me here at *Synergetics*, rather than to the editorial department of **Radio-Electronics**.

Now, there's a memory effect that nobody talks about very much, and its implications for machine intelligence are genuinely scary. I like to call it the *threshold effect*. Your threshold effect goes like this: *If you double the size of a memory, the performance capabilities of that memory usually will expand by much more than a factor of two*. That happens because the arrangement and the use of your memory can now be better organized, and can more effectively perform higher-level functions.

For instance, some of your smallest microcontrollers only have room for a single hand-coded program. Add a little memory, and you can step up to a *system monitor* that gives you more power and control. More memory and you step up to some *interpreted language*. More still,



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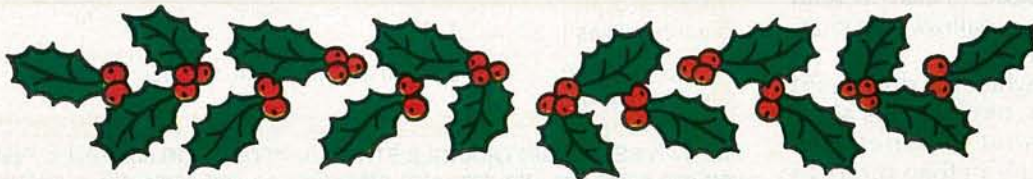
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and you pick up a sophisticated *operating system*. The next level gives you fancy *toolboxes*, and *integrated programs*.

The level beyond that can give you powerful new levels of organizing the programs themselves. *HyperCard* and its mutants are an obvious example here. Beyond that lies all the *expert systems*, *massively parallel architectures*, and *artificial intelligence*.

Because of the threshold effects, going from a 4-megabit memory to a 4-gigabit one will gain you far more than a mere 1000:1 in performance abilities. I feel that something like a million to one is more like it.

It would seem to me that there are probably three or four brand new and previously unthought of thresholds that lie between where we are today and where we will be when we get up to routinely being human-brain sized a decade from now. What are the thresholds and when will they get crossed? Knowing the correct answers to that one could make you filthy rich in a real hurry.

Chaos and fractal resources

There is a new endeavor out there that is known as *Chaos Science*. Actually, it's really a loosely knit collection of all sorts of unusual old and new stuff, much of it only weakly related, if at all. As a general rule, if something can keep a math freak off the street at night and if it looks pretty in an alien sort of way, then it probably can be called chaos science. Since chaos science is futuristic, utterly and totally bizarre, and more than eminently hackable, it should be of foremost interest to most of you **Radio-Electronics** hackers.

Our *Chaos Science Resources* sidebar will give you a quick summary of a few of the main places to go for further info on this exciting new field. You'll probably want to start off with James Gleick's book *Chaos—Making a New Science*. It offers a thorough and easy-to-read but sometimes shallow introduction to the field.

The horse's whatever document on the subject, of course, is Mandelbrot's *Fractal Geometry of Nature*. While more than pretty to look at, the text is pretty nigh un-

readable and is both laughingly and pompously egocentric.

The book I am currently the most impressed with is the new *Science of Fractal Images*, especially in chapter five. A good summary appeared in the January 1988 *Byte* magazine and it was under the title *A Better Way to Compress Images*.

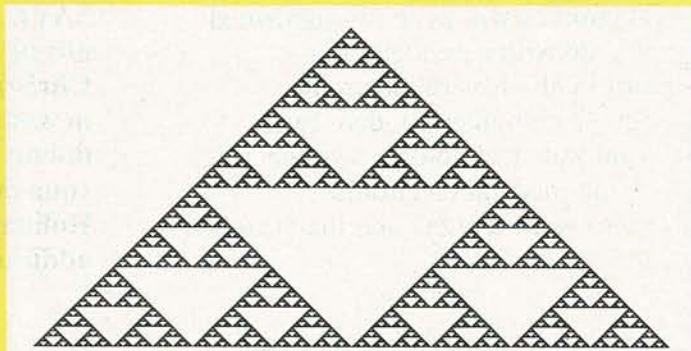
One of the things that struck me about that great book and the *Byte* summary article was that the sample BASIC and C programs were forever making those complicated translate-rotate-scale transformations. That's the kind of stuff that *PostScript* does free, invisibly, and automatically all of the time. Contrary to all the dire negative comments early in the red book, *PostScript* should end up *nearly ideal* for fractal-geometry uses, along with most anything else involving chaos science.

An unusual fractal fern

To test out the theory, I translated and then upgraded the original code into the *PostScript* routines found in Figs. 4 and 5. They will give you a typical chaotic beastie known as a *Serpenski* triangle, plus *the fern*, the second most popular fractal image of all time. Of course, the *Mandelbrot Set* is numero uno, and I am saving it for sometime later.

While you can run the code through any old word processor, you do need a *PostScript* speaking laser printer or a *PostScript* emulator to get your final copies. You could reverse-engineer them back into BASIC, or else use the original listings as they appeared in the *Byte* article.

Even though there's still an awful lot of slop left in the code, I was quite pleased with both the final results and their speed under



```
/problastcreate {mark /counter 0 def probabilities {128 mul round cvi  
{transforms counter get} repeat /counter counter 1 add def} forall  
counttomark 128 sub neg dup 0 gt { [1 0 0 1 0 0] repeat} {pop} ifelse} /problast  
exch def} bind def
```

```
/doit {problastcreate 1 1 20 {problast rand -24 bitshift get transform 2 copy  
moveto 0.001 10 rlineto} repeat newpath numdots {problast rand -24 bitshift  
get transform 2 copy moveto 0.001 0 rlineto stroke} repeat} bind def
```

```
% /// demo - remove before use. ///
```

```
/numdots 6000 def % increase for denser image; decrease to print faster
```

```
/transforms [  
[0.5 0 0 0.5 0 0]  
[0.5 0 0 0.5 1 0]  
[0.5 0 0 0.5 0.5 0.5]  
] def
```

```
/probabilities [ .33 .33 .34 ] def
```

```
1 setlinecap 0 setlinewidth 200 300 translate 100 dup scale doit  
showpage quit
```

FIG. 4—A SERPENSKI TRIANGLE STRANGE ATTRACTOR done using *PostScript*. While you can enter this into any word processor on any computer, a printer that accepts *PostScript* is needed for your final output.

PostScript. I elected to create a custom probability table once ahead of time, rather than making slower individual probability selections on the fly. Providing for 128 entries in the table, rather than the expected 100, gives us some further speedup and simplification. But a lot more cries to be done.

When you are experimenting with them on your own, be sure to change the numdots variable to something in the high thousands for your original fast-printing samples that will image in a few seconds to a minute or two. Later on, you could increase numdots as high as you need to for top-quality final images that might take hours to print in their larger sizes.

One other "gotcha:" The six-element matrices used by the original fractal people and PostScript differ slightly. To get from one to the other, simply *interchange the second and third numbers in the array*. Never mind why.

There are some amazingly bizarre things about the fern image of Fig. 5. First and foremost, larger sizes of the fern original are hauntingly beautiful. In fact, I've never seen *any* PostScript code image *anywhere* that comes even remotely close.

Second, the smaller pieces of the fern are definitely *not* a smaller, or *selfsimilar* copy of your whole picture. Unlike ordinary pictures, as you magnify, additional and uniquely different detail appears. But that is what fractal stuff is all about.

Third, although an apparently random process is used that picks four tasks by using random probabilities in random orders, you always end up with the *same* final image! That will happen regardless of which random numbers get used in which order.

That is a stunning example of a *strange attractor*, otherwise known as the holy grail of fractal-ism. As you might expect, others are seeking out the possible strange attractors thought to underlie the stock-market prices and weather patterns.

Despite that, a sick random-number generator will definitely not perform. You have to use a good one. Short repetition se-

quences appear to be a no-no. Many more details are in my *Apple Assembly Cookbook*.

Fourth, believe it or not, the *entire* fern is coded as only 28 numbers in a tiny data array! There's no difference whatsoever between your Serpenski triangle and the fern, except for the 28 numbers.

Nor is there any other difference between those and untold billions of other wildly different images. We thus have an absolutely incredible picture-compaction scheme going on here. For a full-page PostScript fern, the data compaction can approach 300,000:1! Unfortunately, though, your image-regeneration times do get out of hand with compaction levels that are that high. You can forget about real time. In theory, by going to just a few more numbers, we can create *any* image at all. Which gets heavy fast.

Fifth, and finally, the image really does look just like an authentic Black Spleenwort Fern. Now, Black Spleenwort Ferns have

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been around for a rather long time, and they sure are pretty, but nobody ever accused them of being very bright. Could the exact same process be used by the real fern to teach itself how to grow?

To me, the odds are overwhelming that that does seem to be the case. We thus appear to be tampering with some heavy-duty stuff here.

What really astounds me over the fern, though, is that you do *not* really draw it. All you have to do is *let it out*, and it leaps out of its cage with a vengeance. I guess that is where the "strange" in *strange attractors* comes from in the first place.

Oh yes, if you do find the strange attractor that underlies stock-market prices and send it to me, I'll be most happy to send you *five* of my money machine books. I might even consider a free *tinaja quest* as well.

Help wanted

How about you helping me for a change? I'm having trouble finding some sources of cheap stock plastic metric gears, especially the *Module 1.0* size. Any suggestions? Yes, *Stock Drive Products* carries them, but at five times what I want to pay for them. A free book for your trouble.

New tech literature

Several manufacturers are newly turning to videotape product introductions. *Tektronix* has bunches of scope and spectrum-analyzer tapes available for you. And *Sprague* has a free new "videotech paper" on a full bridge motor driver.

Speaking of *Sprague*, they also have a unique new UGN3055U Hall-effect device. The \$1.60 parts are *addressable*, which means that up to thirty of them can share the same two-wire series query line.

From the *Philips* branch of good old *Signetics*, a fat new data handbook on *RF Power Transistors* and a very detailed ap note on all those popular 74HC4046 phase-locked loops.

The *SGS* people have a free soapbox full of EPROM samples, while *Texas Instruments* has a new free evaluation printed-circuit board for their TL7770-5 supply



```
/problastcreate {mark /counter 0 def probabilities {128 mul round cvi
{transforms counter get} repeat /counter counter 1 add def} forall
countmark 128 sub neg dup 0 gt { [1 0 0 1 0 0] repeat} {pop} ifelse /problast
exch def} bind def
```

```
/doit {problastcreate 1 1 20 {problast rand -24 bitshift get transform 2 copy
moveto 0.001 10 rlineto} repeat newpath numdots {problast rand -24 bitshift
get transform 2 copy moveto 0.001 0 rlineto stroke} repeat} bind def
```

```
% /// demo - remove before use. ///
```

```
/numdots 6000 def % increase for denser image; decrease to print faster
```

```
/transforms [
[0 0 0 .16 0 0]
[.2 .23 -.26 .22 0 1.6]
[-.15 .26 .28 .24 0 .44]
[.85 -.04 .04 .85 0 1.6]
] def
```

```
/probabilities [.01 .07 .07 .85] def
```

```
1 setlinecap 0 setlinewidth 200 300 translate 30 dup scale doit
showpage quit
```

FIG. 5—A FRACTAL FERN DONE IN POSTSCRIPT. Note that only 28 data values are needed to completely define this image. But what's really astounding is that you don't really "draw" this fern—instead, you simply let it out!

voltage supervisor chip.

Here we go again. Bright blue light-emitting diodes have been newly announced by *Sanyo*. Is that yet another false alarm? Time will tell.

Stock-market quotation decoders and support software are now available from *DATArx*. *Lightwave* is a new, free fiber-optics trade journal. And the *Quick Shooter* is a low-cost plastic injection molding machine from *Haygeman Machine*. That one uses a drill press for an injection ram.

Turning to my own products, I've recently upgraded and improved my book-on-demand printed *Hardware Hacker II* reprints, covering all of my hacking columns that have appeared in **Radio-Electronics**. I've also recently

released a similar *LaserWriter Secrets* test covering my *LaserWriter Corner* columns over in *Computer Shopper*.

As always, this is your column and you can get technical help and off-the-wall networking per that *Need Help?* box. The best calling times are weekdays 8-5, *Mountain Standard Time*. Let's hear from you. **R-E**



AUDIO UPDATE



LARRY KLEIN,
AUDIO EDITOR

The Audio Answerman strikes again!

BECAUSE THIS COLUMN IS WRITTEN FOR the casual hi-fi user, rather than the dedicated audiophile, all the column topics—including the following Q's and A's—are chosen to be helpful and/or informative. For this month's column, I've chosen two questions, one practical and the other mostly theoretical. Let me know how you feel about this format.

Recording Balance

Q. When I'm recording a disc or FM program on my cassette deck, I notice that the right- and left-channel recording-level indicators seldom read the same. Sometimes one is higher; sometimes the other. Should I try to balance the channels using the recording-level controls, or simply let things fall as they may? On some of my dubbed tapes the right-to-left balance seems just fine; on others, the sound seems to come mostly from one side or the other. Is there any way to make sure that things are adjusted correctly?

A. First of all, keep in mind that properly adjusted stereo recording-level indicators show exactly the same readings only when identical signal voltages are fed to them by the source or by the tape being played. Given the normal signal variations between the right and left channels of a wide-range stereo recording, the readings should coincide frequently, but momentarily.

Over the years, I've occasionally encountered recordings and FM programs that, for one reason or another, sounded off-center, and



I'm sure that a recorder's meters would have confirmed what I heard. But on the vast majority of recordings, the signal levels in the two stereo channels will provide a balanced sound stage and average out to about the same reading on both meters.

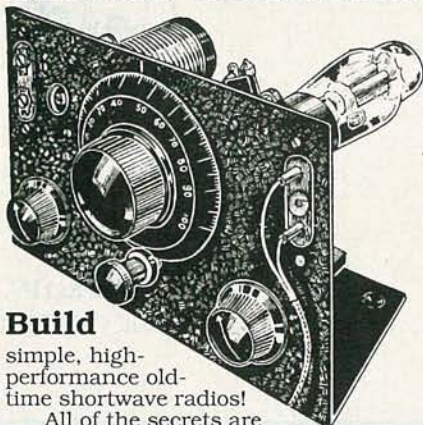
There's an easy way to check the internal balance of your recording circuits. With your record-level controls set similarly, feed a mono signal simultaneously into both channels and check for identical meter indications. If you can't get a mono signal at the tape-output jacks by switching your preamp to mono, and if you can't switch your tuner to mono, you will need to use a single-male/double-female Y connector. When plugged into your amplifier's right or left tape-

output jack, it will provide the same mono signal source to both tape-input channels.

Assuming that you find a balance problem within your recorder, clean and demagnetize its heads and, most important, try recalibrating its recording-bias controls—assuming that its instruction manual tells you how. (I fixed an unbalanced Nakamichi by doing just that.) If those suggestions don't help, call or drop a note to your recorder's manufacturer explaining the problem and the steps you've already taken to handle it. He may be able to assist you over the phone, or at least provide the address of the nearest authorized repair shop.

Although the question is about lack of recording balance, it

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This is a compilation of shortwave construction articles from "Short Wave Craft" magazines published in the 20's & 30's. It's wall-to-wall "how-to."

Included are circuit diagrams, photographs, and design secrets of all shortwave receivers being manufactured in 1934 including some of the most famous: SW-3, the SW-5 "Thrill Box", the deForest KR-1, the Hammurand "Comet Pro", and many more.

Also included is a new chapter showing how you can use transistors to replace hard-to-find vacuum tubes. You'll even see the circuit that was lashed together on a table top one night using junk box parts, a hair curler and alligator clips. Attached to an antenna strung across the basement ceiling and a 9 volt battery, signals started popping in like crazy. In a couple of minutes an urgent message from a ship's captain off Seattle over 1500 miles away was heard asking for a navigator to help him through shallow water!

These small regenerative receivers are extremely simple, but do they ever perform! This is a must book for the experimenter, the survivalist who is concerned about basic communication, shortwave listeners, ham radio operators who collect old receivers, and just about anyone interested in old-time radio.

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wouldn't hurt to point out that an audible right-left system unbalance can come about through misadjustment of speaker-system midrange controls. Because the ear is most sensitive to mid frequencies (4 kHz or so), a pair of speakers whose midrange-level controls are adjusted differently will sound unbalanced. Objectively, one will be playing louder than the other despite the fact that the same signal level is fed to both.

Reflected speaker sound

Q. I've read several articles about live-end/dead-end listening rooms, in which the loudspeaker end of the room is heavily damped with acoustical absorption material and the listener's end is fairly reflective. That is said to improve a speaker's response and imaging properties. Can such a setup be used with speakers that intentionally reflect sound from the rear walls, such as electrostatics, planars, or conventional speakers with rear-firing radiators?

A. Ideally, a loudspeaker's sound-radiation pattern—which, indirectly, is what we are talking about here—should be designed with a particular recording-microphone setup in mind. Since that is impractical given the variety of recording practices, the best that the speaker designer can do is to design a system that will present a reasonable stereo image with most program material and in most of the rooms in which it is likely to find itself. In a conventional listening room, the speaker sound that reaches a listener's ears consists of the direct sound from the drivers plus a large amount of early- and late-arriving reflections bounced from the walls, floor, and furniture. If a speaker's immediate environment has sufficient acoustical absorption, most of those early reflections will be soaked up or severely attenuated. The late-arriving reflections from the more distant walls will be relatively unaffected. The advocates of such an arrangement state that its advantages include the preservation of accurate directional cues and instrumental detail.

Speakers designed to radiate multidirectionally or with strong

rear radiation obviously shouldn't be installed in a non-reflective location, since they intentionally use the adjacent walls to deliver large percentages of reflected (and, therefore, delayed) sound to the listener's ears. As noted by German acoustic researcher Helmut Haas in 1951, as long as the interval between the delayed and direct sounds doesn't exceed 40 to 50 milliseconds, the ear fuses the two into a single event. The delayed sound is heard as an echo only when the 50-millisecond delay is exceeded.

An unexpected psychoacoustic effect of delays of between 5 and 30 ms is to "expand" the perceived sound source. Not only does the sound increase in volume, but it also takes on—in Haas' words—a "pseudostereophonic quality." (That pseudo-stereo effect probably accounts for the widened sound stage provided by a popular speaker design that employs eight small rear drivers and one forward-facing one.) Incidentally, a speaker system's sound reflected from a nearby rear wall has little in common with the reflections in a concert hall from walls perhaps 50–100 feet away—despite the efforts of some manufacturers to imply that their deliberately reflective speakers mimic the acoustics of concert halls.

For good reasons, open-back dipolar and omnidirectional systems (which have included some of the best speakers on the market) and rear-radiating speaker systems are necessarily more placement-critical than conventional forward-radiating types. The problem is to arrive at a spacing from adjacent surfaces that enables the reflected energies to make a positive—rather than destructive—contribution to the sound and stereo image perceived by the listener.

Which type of speaker design is the best? My feeling is that as long as recording techniques (and room acoustics) are not standardized, most otherwise well-designed systems will sound good on most recordings. In truth, speakers that radiate substantial energy rearward have special installation constraints, but their advocates will tell you that they are more than worth it. **R-E**

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SHORTWAVE RADIO



STANLEY LEINWOLL

The future of shortwave broadcasting

MORE THAN 130 COUNTRIES currently operate international shortwave broadcasting services. Many of them use shortwave broadcasting as an instrument of their foreign policies. The United States, the Soviet Union, and Great Britain alone carry approximately 6,000 frequency hours daily to every continent on Earth in every major language, and also many minor languages.

In addition, a large number of countries, including Brazil, Argentina, the People's Republic of China, Mexico, the USSR, and many developing countries use shortwave for domestic broadcasts. Those national services are aimed primarily toward large rural and suburban audiences.

Because of the popularity and versatility of the shortwave spectrum, the number of frequency-hours scheduled for High-Frequency (HF) broadcasting has quadrupled since the end of World War II, from about 8,500 frequency hours to more than 35,000 today. And as technology has advanced, the standard transmitter power has increased from 50-100 kW in the late 1940's to 250-500 kW in the 1980's.

Rapidly growing demand for a limited number of frequencies, coupled with a power race, has resulted in increasing chaos in the HF broadcast bands. The 9-MHz band (9500-9770 kHz) has been monitored at four different locations in Europe. The results are summarized in Fig. 1, which shows occupancy during the period from February 13-17, 1989.

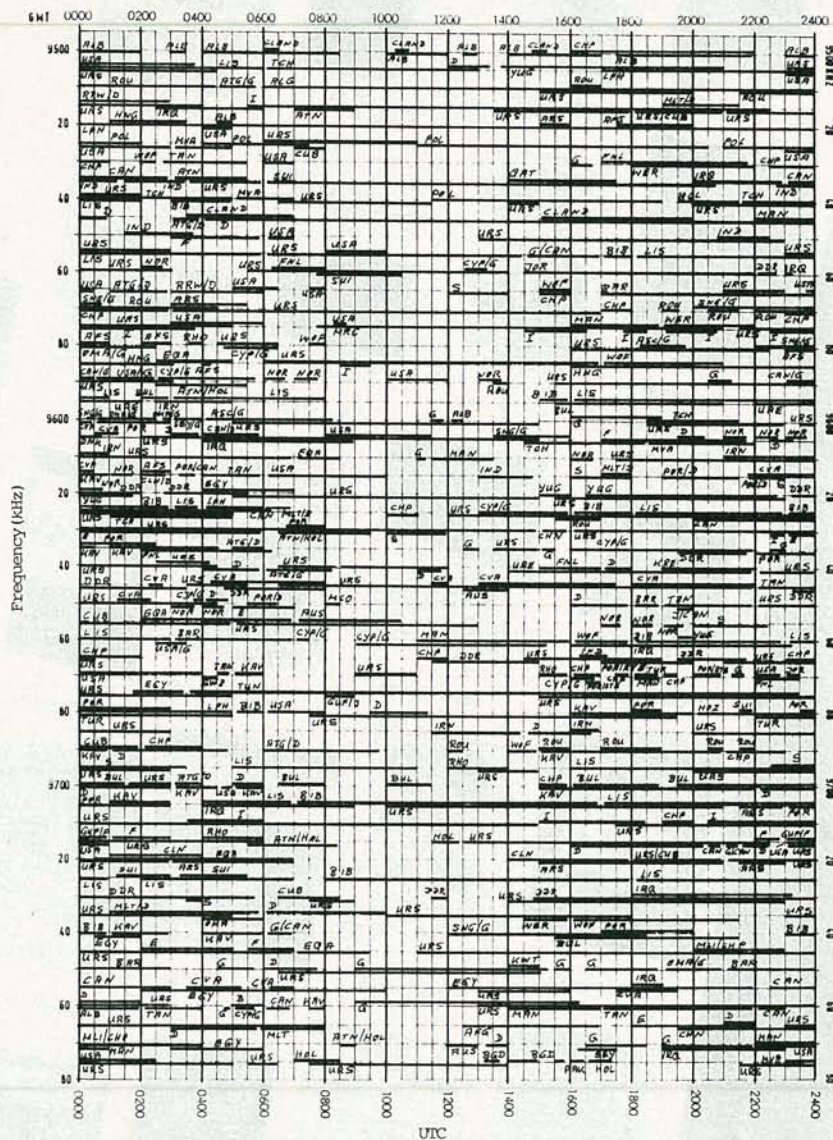


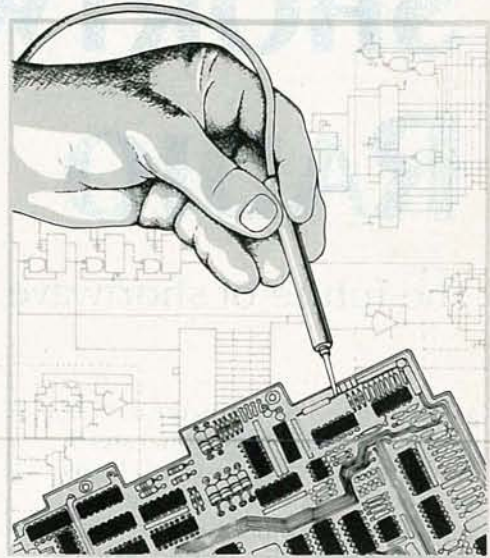
FIG. 1

The solid horizontal lines show actual users, and the frequency is shown vertically along the mar-

gins, in 5-kHz increments. It can be seen that, during prime broadcasting hours, virtually all frequen-

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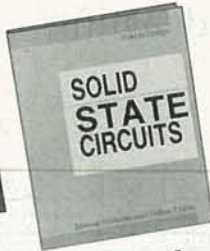
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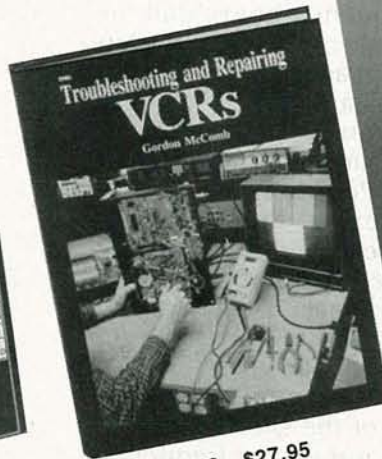
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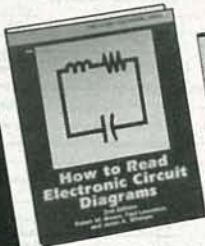
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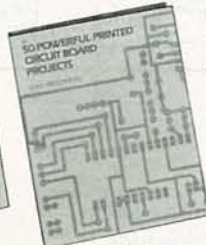
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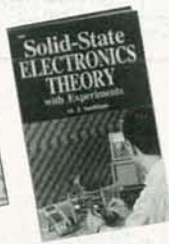
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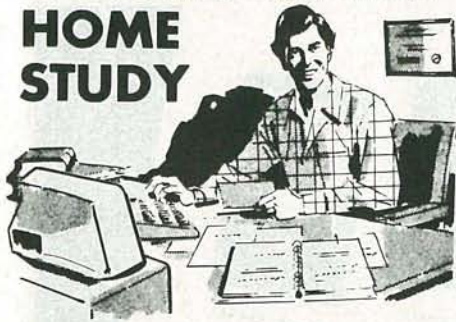
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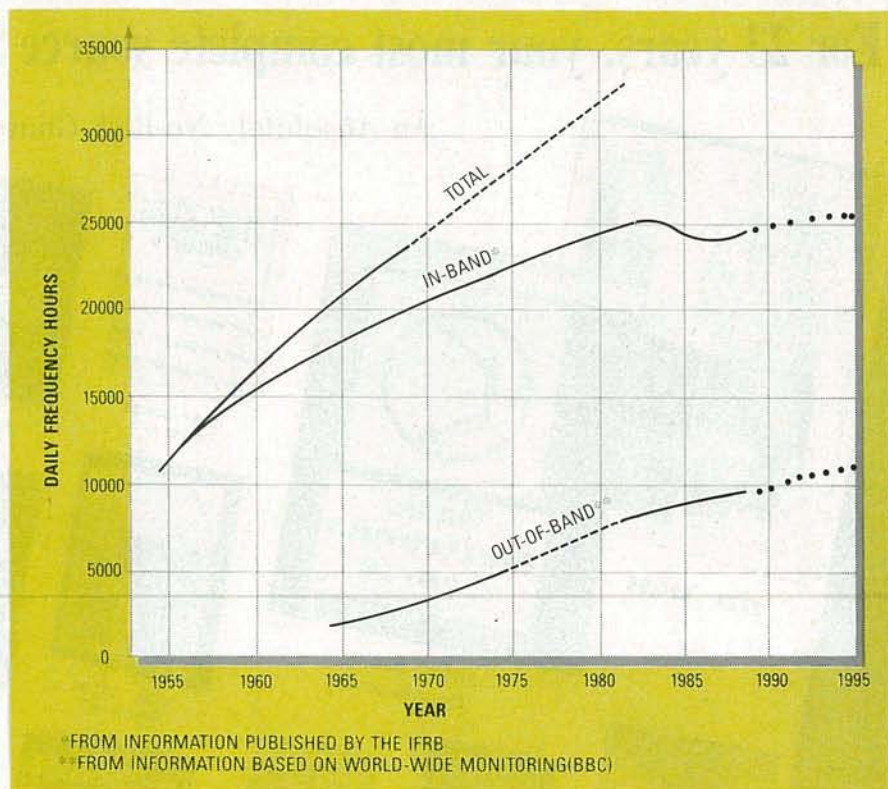


FIG. 2

TABLE I

Kilohertz Pre-1979 WARC	Bandwidth	1979 Kilohertz Spectrum	Bandwidth	Implementation Date
5950 - 6200	250	5950 - 6200	250	—
7100 - 7300	200	7100 - 7300	200	—
9500 - 9775	275	9500 - 9900	400	July 1, 1994
11700 - 11975	275	11650 - 12050	400	July 1, 1989
none	—	13600 - 13800	200	July 1, 1989
15100 - 15450	350	15100 - 15600	500	July 1, 1989
17700 - 17900	200	17550 - 17900	350	July 1, 1989
21450 - 21750	300	21450 - 21850	400	July 1, 1989
25600 - 26100	500	25670 - 26100	430	January 1, 1982
Total Spectrum	2350kHz		3130kHz	

cies are occupied by at least one broadcaster. In many cases, two or more broadcasters use the same frequency simultaneously.

For more than forty years broadcasters have been grappling with the problem of increasing congestion in a severely restricted spectrum. One method of alleviating serious overcrowding is to expand the supply of the broadcast frequencies. That can be accomplished by an appropriate radio conference with the authority to re-allocate spectrum for the broadcasting service. The last such

conference was held in 1979; the World Administrative Radio Conference (WARC-79) was convened in Geneva for approximately ten weeks.

WARC-79

The less-developed countries at WARC-79 opposed the loss of a fixed shortwave spectrum but, at the same time, wanted a high-frequency broadcast planning conference. Their position was that the developed countries had control of the high-frequency broad-
continued on page 100

DRAWING BOARD



ROBERT GROSSBLATT

The world of video

BEFORE WE GET INTO CIRCUITS AND stuff, there's a piece of follow-up business I have to take care of. If you're a regular reader, you'll remember that we ran a contest some months ago to see who could come up with a good way to use the space left empty in the EPROM character generator we designed.

There were lots of entries and lots of ideas, but the best one came from Randall Logan of British Columbia, Canada. He used the remaining space in the EPROM to build an automatic hex to decimal converter that still left enough room in the EPROM for the character codes we worked out as our circuit was being developed. The circuit details are on page 72 of the September 1989 issue of *Radio-Electronics*.

Since it's the height of tedium to generate the code for the EPROM, Randall wrote a BASIC program to create the data. He sent me a copy of it and, as promised, I'm sharing it with all of you—it's shown in Listing 1. Although the program is written for an IBM or compatible, it won't take a lot of work to convert it to the BASIC dialect used by other computers. The program is well-commented so you shouldn't have any trouble figuring out how it works and what you'd have to do to change it.

Just about the only reason for changing it would be to match the data outputs of the EPROM to your seven-segment display. The segment assignments (a, b, c, etc.) are pretty much standardized, but sometimes it's easier to lay out a PC board by switching the order of

the EPROM data pins. In any event, you've got the circuit and now you've got a program to generate the data for the EPROM.

As a last note on the subject, the program will create a file 2049 bytes long. The extra byte comes about because BASIC (at least IBM BASIC) adds an "end of file mark" (1Ah), whenever it writes a data file. It isn't a big deal since the first 2048 bytes are the ones going into the EPROM, but being aware of the extra byte (as well as knowing why it's there) means there's just one less thing to worry about.

And now for something com-

pletely different.

In going through the mail I've received recently, it's evident that video is a really popular subject. Lots of readers are fascinated by the hardware but haven't gotten their hands dirty because they're not familiar with video signals, terminology, and hardware requirements. Over the next few months we'll go through some video basics together. We'll take apart the NTSC standard and examine the individual parts of the waveform. Once we know what we're looking at, we'll see what has to be done to design video circuitry. It's

LISTING 1

```
100 REM THIS PROGRAM WILL GENERATE A 2048 BYTE BINARY FILE (EPROM.DAT)
105 REM CONTAINING THE DATA REQUIRED FOR THE EPROM IN THE
110 REM BINARY TO HEX/DECIMAL CONVERSION CIRCUIT AS SHOWN IN THE
120 REM SEPTEMBER ISSUE OF RADIO ELECTRONICS, PAGE 72
130 REM
140 REM WRITTEN BY RANDALL LOGAN, 1989
150 REM
160 REM DESCRIPTION OF VARIABLES
170 REM B=NUMBER BASE (10 OR 16)
180 REM N=NUMBER TO CONVERT (0-255)
190 REM P=SELECTED DIGIT POSITION WITHIN NUMBER (0-3)
200 REM D=DIGIT VALUE (0-9) FOR DECIMAL #'S AND (0-15) FOR HEX #'S
210 REM V=TEMPORARY WORKING VARIABLE
220 REM S( )=CHARACTER SEGMENT DATA (16 ELEMENT ARRAY)
230 REM Z=USED TO DETERMINE IF LEADING ZERO BLANKING IS REQUIRED
240 REM
250 CLS
260 DIM S(16)
270 REM READ SEGMENT DATA FOR ALL 16 CHARACTERS (0-F) INTO ARRAY
280 FOR I = 0 TO 15:READ S(I):NEXT
310 DATA 63,6,91,79,102,109,125,7,127,111,119,124,57,94,121,113
320 REM
330 REM NOW GENERATE BINARY FILE FOR EPROM PROGRAMMER (EPROM.DAT)
340 REM
350 OPEN "EPROM.DAT" FOR OUTPUT AS #1
360 FOR B = 10 TO 16 STEP 6
370 FOR N = 0 TO 255
380 V = N
390 FOR P = 3 TO 0 STEP -1
400 D = INT(V / (B ^ P)): Z = Z + D
410 V = V - D * (B ^ P)
415 REM LINE 420 BLANKS LEADING ZEROS (FOR DECIMAL VALUES ONLY)
420 IF Z = 0 AND P > 0 AND B = 10 THEN PRINT #1, CHR$(0); : GOTO 440
430 PRINT #1, CHR$(S(D));
440 NEXT P
450 Z = 0: REM RESET ZERO BLANKING TEST VALUE
460 NEXT N
470 NEXT B
480 CLOSE #1
```

complicated enough to be interesting and just hairy enough to be fun.

Who could ask for more?

Some video basics

Back in 1953, a group of relatively unknown people sat down together and made some decisions that affected the lives of every person in this country (and some other countries as well). That sounds like the beginning of a trashy spy novel, but it's not—it's the beginning of the television standard. The people who made the decision were known as the National Television System Committee, and they established the color-TV standard known as NTSC. There are lots of jokes about what the initials stand for (Never The Same Color, etc.), but whatever you might think of it, NTSC video is (in the United States) the name of the game.

All the video circuitry in a television set is designed with one job in mind—to control the movement of the electron beam that scans across the inside of the picture tube. The video signal that moves the dot on the screen and determines how bright it will be is one of the most complex signals in common use. The key to knowing how video works and making sense out of video hardware is understanding all the component parts of the video waveform.

All video, either broadcast NTSC or high-resolution computer, is made up of the same basic elements. As a simplified explanation, the electron beam in the picture tube scans across the screen from left to right and back again. When it reaches the bottom right of the screen, it moves to the upper left and starts another trip back and forth across the screen. The rate at which it travels left to right, and how often it moves back to the top right of the screen are all defined in the NTSC standard.

The video signal fed to a TV set has two basic jobs. The first is to control the beam's movement, and the second is to control the brightness of the beam. The former tells the TV where to put the picture and the latter tells the TV what picture to put there.

Even though the video circuitry

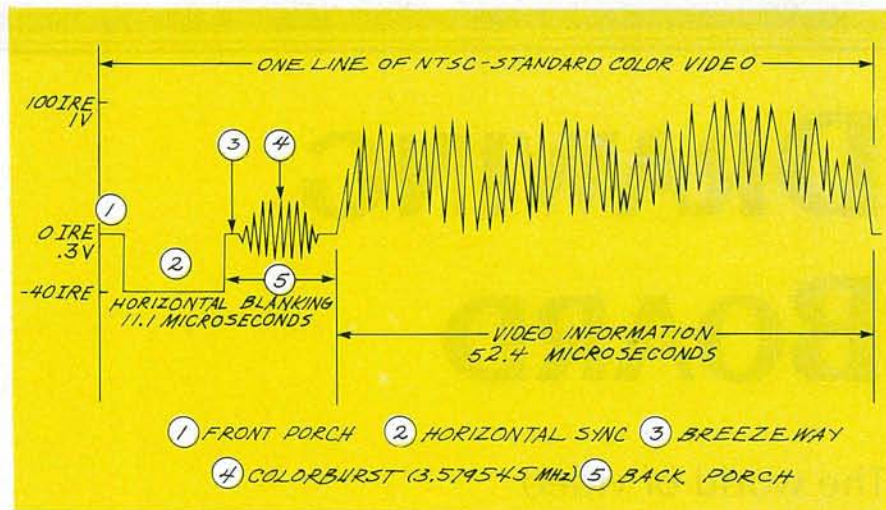


FIG. 1

in a television set is constantly moving the beam around the screen from left to right and top to bottom, there's no way to guarantee that the movement is going to be at the precise rates required by the NTSC standard. As we all know, nothing is forever; components age, values drift, and it wouldn't be long before a TV—no matter how well made—would go out of alignment.

Most television sets move the dot around the screen at rates that are close to the NTSC standard, but they have built-in slop factors. That means that there's enough latitude in the TV's control circuitry to enable it to be adjusted to strict NTSC timing. Older television sets had horizontal and vertical hold controls, but most of the newer sets do it automatically.

The horizontal and vertical control of the television image is the job of two components of the NTSC signal known, appropriately enough, as horizontal sync and vertical sync. The former tells the electron beam to move back (or flyback) to the right edge of the screen and the latter causes the beam to move back to the upper right hand corner.

Before we look at the big picture (sorry about that), let's take a look at the most basic unit of the video signal—a horizontal line. The NTSC standard calls for 525 lines of video for each *frame* (the entire picture), and there are two *fields* per frame.

The horizontal line

The whole video signal is really a

series of repeated horizontal lines of control and picture information. The NTSC standard allows a total time of about 63.5 microseconds for each line, so a bit of arithmetic tells us that the frequency is about 15.75 kHz. I'm using approximate numbers because the exact value is different for color and black and white. That rate is referred to as the "horizontal scan frequency," and during each cycle the video signal is controlling the placement of the image and carrying the image information, as well.

The illustration in Fig. 1 shows you exactly what's happening in each horizontal line. The left-hand side of the picture corresponds to the trailing edge of the horizontal sync pulse, which is labeled as "2" in the drawing. As you can see, about 20% of the line time is devoted to control signals, and each part of that section has its own name and allowable duration.

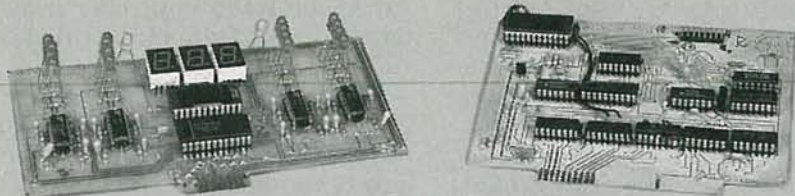
Most television sets "overscan" the image. That means that a bit of the left and right edges of each line take place outside the screen area—think of it as slightly zooming in on the line. That's done for a variety of reasons; most important, it makes sure that the only part of the image you'll see on the tube is picture information—the control data is always off screen.

If you're looking at a color image, the first important piece of information sent on each line is the colorburst signal. That is about 8 to 10 cycles of a 3.579545-MHz clock, and it's used as a standard to

continued on page 91

COMPUTER DIGEST

BUILD THE PORT-A-MATIC



Keep tabs on your expansion bus.

ROBERT GROSSBLATT

There are lots of reasons for the PC's popularity, and if you pop open the case you'll find eight of them on the motherboard. IBM's decision to provide relatively complete details on the architecture of the machine was an invitation for designers to create add-on hardware for the PC. As things stand now, there are after-market products for the PC family that can do just about anything you can imagine—and a lot you can't.

No matter what kind of peripheral you plug into the bus, chances are that the microprocessor (8088, 80286, 80386, even the 80486) will talk to it through an I/O port. Peripherals include video adapters, serial and parallel ports, the keyboard, floppy- and hard-disk controllers, and more. Since Intel microprocessors can address many ports (even the lowly 8088 can address 65,536 different ones), you'd think that port-address conflicts would never occur.

Think again.

IBM has reserved specific ports for specific purposes, and as PC's

have evolved, additional ports were reserved. The devices using those ports make the computer more powerful, but they also make it easier to configure something incorrectly.

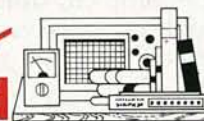
The Port-A-Matic makes it easy to keep track of I/O operations because it provides a real-time indication of which ports are being accessed. The Port-A-Matic provides a three-digit hex display of the port address, and it lights a discrete LED to provide a 1-of-16 indication of which device is connected to the port. Another discrete LED tells you whether the CPU is doing a read or a write to the port. You can easily customize the circuit so that the discrete LED's light up for a desired I/O port. Even though the Port-A-Matic is a fairly complex circuit, you should be able to build it for well under \$75. PC-board patterns will be published in PC Service.

The PC bus

Since the Port-A-Matic lives in one of the PC's expansion slots

continued on page 84

EDITOR'S WORK- BENCH



Floppy Heaven

I just found the ultimate floppy-disk controller: the newly released CompaCard IV (CC4) from MicroSolutions (see Fig. 1). I've been searching for something like it for a couple of years; MicroSolutions has really come through.

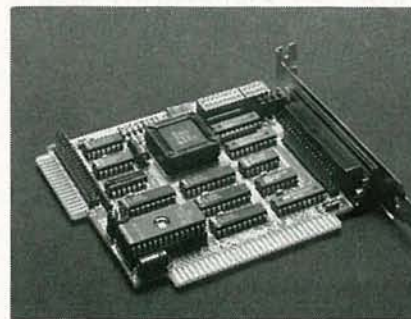


FIG. 1

What I've long been looking for is a controller that allows three internal drives and that also has a DB-37 connector for an external drive—in my case, an Irwin 785 tape-backup unit.

Why do I want three internal drives? I get review software in all four of the standard formats (360K, 720K, 1.2MB, and 1.44MB), so I need high-density versions of both 3.5-inch and 5.25-inch drives. However, for trading files with friends and business associates, I need a 360K drive, because 1.2MB drives can't reliably write to 360K diskettes. (Actually, they can write reliably enough; the problem is track mis-alignment when one

drive tries to read a disk formatted on another drive. I've had no problem trading either of the 3.5-inch disks.

Other controllers typically allow two internal drives only, or two internal and two external drives. However, the latter supply only the external DB-37 connector, so it's impossible to connect a third internal drive with a standard 34-pin edge connector. MicroSolutions sensibly solved that problem simply by wiring an additional 34-pin dual-row header connector in parallel with the DB-37.

So connecting a third (and fourth) drive internally is now as simple as connecting the first two drives; Just attach a power connector and a normal 34-conductor data cable and you're ready to roll.

If that's all there were to the CompatiCard IV, I'd be impressed, but there's more; several items will be particularly interesting for owners of older PC and XT compatibles without built-in support for high-density 5.25-inch drives or 3.5-inch drives of either density.

Advanced features

The most innovative feature is support for a new 2.8MB diskette format. No, the format is not IBM endorsed—but as of this writing (early October), there are rumors that IBM will soon introduce a 2.8MB format using the same vertical recording format as MicroSolutions'.

To handle the increased amount of data stored on a 2.8MB disk in a reasonable amount of time, the data transfer rate has been quadrupled (compared with that of a standard 360K drive) to 1 Mbit/second. The drives, however, are expensive (about \$450), as are the diskettes (about \$10).

No one knows if yet another diskette format can catch on. However, the CC4 is still a good buy because not only does it look forward to the future, it goes a long way toward maintaining compatibility with past formats.

Upgrading PC's and XT's

You can't use high-density

drives on most PC's and XT's because their floppy-disk controllers work only at a single data transfer rate (250 kHz), and high-density drives need 300- and 500-kHz rates.

Even with the right controller, there may be software problems; the BIOSes of older machines don't know how to handle the additional tracks and sectors of high-density drives. You may be able to get around the BIOS problem by installing a 360K drive as drive A, and loading a software driver via CONFIG.SYS to access a high-density drive as drive B or higher. But you wouldn't be able to install the high-density drive as drive A, unless you gave up the ability to boot from A. The reason is a classic Catch-22; you can't load the driver until you've loaded the driver to know how to load the driver.

Anyway, the CC4 solves that problem by including an on-board EPROM that occupies 2K of the address space above the video adapters; that EPROM can be viewed as a BIOS upgrade for older PC/XT models that allows them to access the newer high-density floppy-disk drives. The only limitation is that the EPROM software applies only to the first two drives; if you add a third (or fourth) drive, you'll have to load a device driver, which occupies about 4.5K of memory.

The ROM allows another neat trick, the ability to boot from any floppy drive attached to the card. For example, I have a 1.2MB drive-A, a 1.44MB drive-B, and a 360K drive-E (drives C and D are hard disks). If at any time I want to boot from the 360K drive, all I have to do is put a formatted 360K system disk into the drive and the CC4 handles the rest. At that point the 360K drive becomes drive A, and the original drive B remains as it was. To access the 1.2MB drive, I'd have to load a copy of DRIVER.SYS (which comes with DOS 3.3) when booting.


The CC4 can also function as a secondary controller. In that configuration, you'd leave your existing floppy controller alone, and move a jumper on the CC4 so that data would flow via a different set

of I/O ports. A software driver would then handle the dirty work of transferring data in the usual fashion.

Incidentally, if you've got an AT compatible with a standard Western Digital combined hard/floppy controller (model number 61-000107-00, as shown in the upper left corner of the board), you can disable the on-board controller simply by moving the shorting block from pins E2 and E3 to pins E2 and E1. What you're really doing is assigning the WD board to a different set of I/O port addresses. I do that because the Irwin controller must work off the normal address range.

MicroSolutions has bent over backward attempting to make the CC4 flexible and easy to configure. For one, the configuration DIP switches are located at the top of the card, so you don't have to remove it from your PC to change settings. Also, you can choose from six interrupt levels, three DMA channels, four I/O port ranges, two drive-speed settings, and seven EPROM address ranges. A special set of jumpers allows you to supply power to external drives, if necessary. You can even connect an 8-inch drive to the CC4!

The CC4 also comes with several useful utility programs. One allows you to format diskettes in the background (i.e., while running your word processor or another application); another allows you to format high-density disks if you're running an early version of DOS.

In short, there's no doubt that the CompatiCard IV is the most versatile floppy-disk controller on the market. Highly recommended.—Jeff Holtzman 

Slick!
**A Drawing-Management
System for AutoCAD**

If you're a regular AutoCAD user you know that it doesn't take much time at all for your hard disk to fill up with drawing files. They can be completed jobs, works in progress, or libraries of

blocks to insert in new drawings. The one thing they have in common is a that they all have to be available all the time—it's a well known fact that the more drawings you produce, the more drawings you have to have on hand.

Managing your store of drawing files gets to be a full-time job since the DOS limitation of eight-letter file names can put a real strain on anyone's imagination. And while the difference between TRANS835.DWG and TRANT835.DWG may be remembered for about two minutes after you've created the files, things get somewhat obscure six months down the line.

Although there are several third-party AutoCAD utilities around to help you manage drawings, none of them are as versatile or convenient as Slick!. Not only does it give you a painless way of dealing with drawings, but after you've used it for a while, you'll wonder how you ever managed without it.

Slick! is available in four versions ranging in price from \$95 for the most basic version to \$250 for the top of the line. But even the least-expensive package can save you lots of time and brain damage as soon as you begin using it.

When you run Slick!, you're presented with a graphic representation of your disk—directories on the left and files on the right. As you scroll through the directories, Slick! will list the DWG and SLD files on the disk. When you find the ones you're looking for, you can view as many as four files on the screen at once by moving the cursor to the file list and tagging the files you're interested in. The tagged files can be displayed in a variety of selectable windows similar to the viewports found in AutoCAD Release 10. Once you get the files on the screen, all the Slick! commands are accessed through several pull-down windows at the top of the screen.

You can zoom and pan in any of the drawings and, if you're looking at a 3D drawing, you can also change the viewpoint just as you would with AutoCAD's VPOINT command. You can also get a list

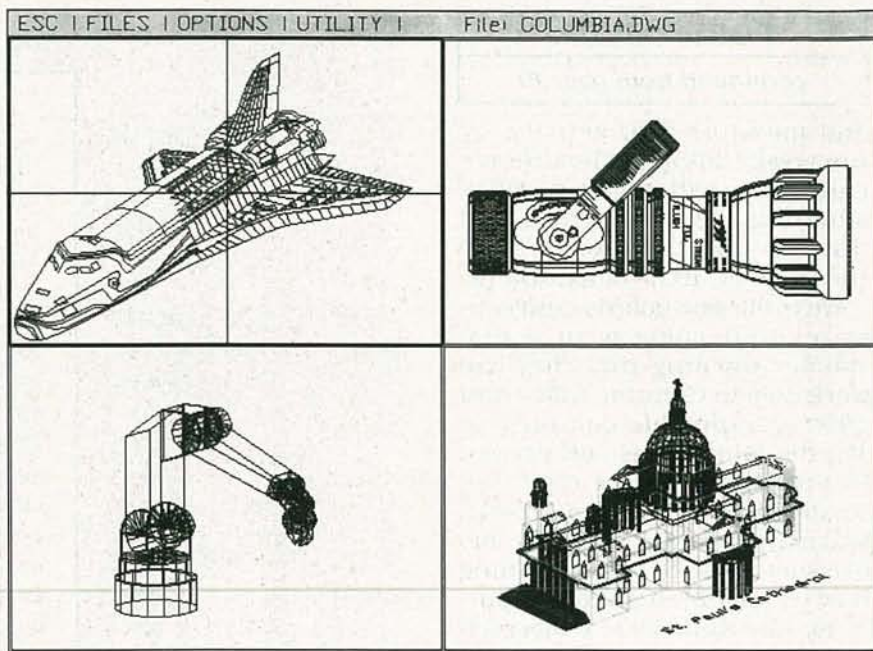


FIG. 2

of the layers and blocks in the drawing and have any of them displayed on the screen as well. Slick! also gives you the ability to copy, rename, or delete files as you're viewing them. That comes in really handy when you're doing disk housekeeping since it's nice to look at a drawing before you delete it.

One of Slick!'s neatest features is being able to scroll through drawing files on the graphics screen. Choosing the files option will give you a list of the drawings in the current directory and choosing one of them will cause it to be immediately drawn on the screen in the current window. Slick! puts drawings on the screen from three to ten times faster than AutoCAD so it doesn't take long to scroll through a di-

rectory's worth of files. And since you can select viewports while you're looking at a drawing, you can display the full drawing in one window with three different zoomed views of it in the other windows at the same time (see Fig. 2).

Don't overlook the fact that Slick! will display both AutoCAD and AutoSketch slides, as well as drawings, and you can zoom and pan around slide files with the same resolution you get with drawing files. No matter how much you zoom in on a slide file, a straight line stays straight and text stays readable—no jaggies. That's really useful for 3D drawings since we all know about the limitations of AutoCAD's HIDE command. You'll wait forever for AutoCAD to remove hidden lines, only to have the resulting image disappear as soon as you issue the next command.

If you make a slide of the drawing after AutoCAD has removed hidden lines, you can use Slick! to view the SLD file. That will let you pan and zoom to any part of the image you want to examine with no loss in resolution. Try doing that in AutoCAD!

Of course, being able to get an image like that on the screen isn't as useful as getting it on paper. That brings us to the more ad-

continued on page 90

ITEMS DISCUSSED

- CompatiCard IV (\$149), MicroSolutions, 123 W. Lincoln Highway, DeKalb, IL 60115. (815) 756-3411.
CIRCLE 48 ON FREE INFORMATION CARD

- Slick! (Level 1, \$95; Level 2, \$150; Level 3, \$195; Level 4, \$250), CAD Systems Unlimited, 5201 Great America Parkway #443, Santa Clara, California 95054.
CIRCLE 47 ON FREE INFORMATION CARD

PORT-A-MATIC

continued from page 81

and monitors CPU activity, we can't really talk about how the circuit works without first understanding the bus signals that drive it—and that brings us to the issue of "IBM compatibility."

We've all seen boards (and software) that come with a disclaimer warning that they will work only in *Genuine IBM's and 100% compatible computers*. The disclaimer is usually printed in end-of-the-world type and plastered prominently on the box and in the manual. There are lots of issues involved in determining how compatible a given computer is, but what we're concerned with is hardware-compatible expansion slots. As in BIOS-level compatibility, there are degrees of compatibility at the hardware level, as well, since signal timing is just as important a consideration as the signal itself. A line that goes active either too soon or too late might as well not go active at all.

The Port-A-Matic was designed to be tolerant of minor variations in bus timing (within limits), and has worked without problem in several XT and AT machines including those built around the 80386. The Port-A-Matic does not work in IBM PS/2 Models 50 and above (those with the micro-channel architecture ((MCA) bus).

For non-MCA machines, the 62-pin bus (shown in Fig. 1) of the original PC is IBM's standard I/O channel. When IBM introduced the AT, that bus was enlarged by adding another 36-pin edge connector to accommodate the additional lines needed by the 80286. However, the Port-A-Matic uses only the original bus. In Fig. 1, the lines that the Port-A-Matic uses are marked with an asterisk. You can plug the Port-A-Matic into either an 8- or a 16-bit slot.

Since all standard IBM I/O devices, and most peripheral cards as well, use only the first 2048 (0800h) I/O ports, the Port-A-Matic watches only address lines A0-A9, the lower 10 address

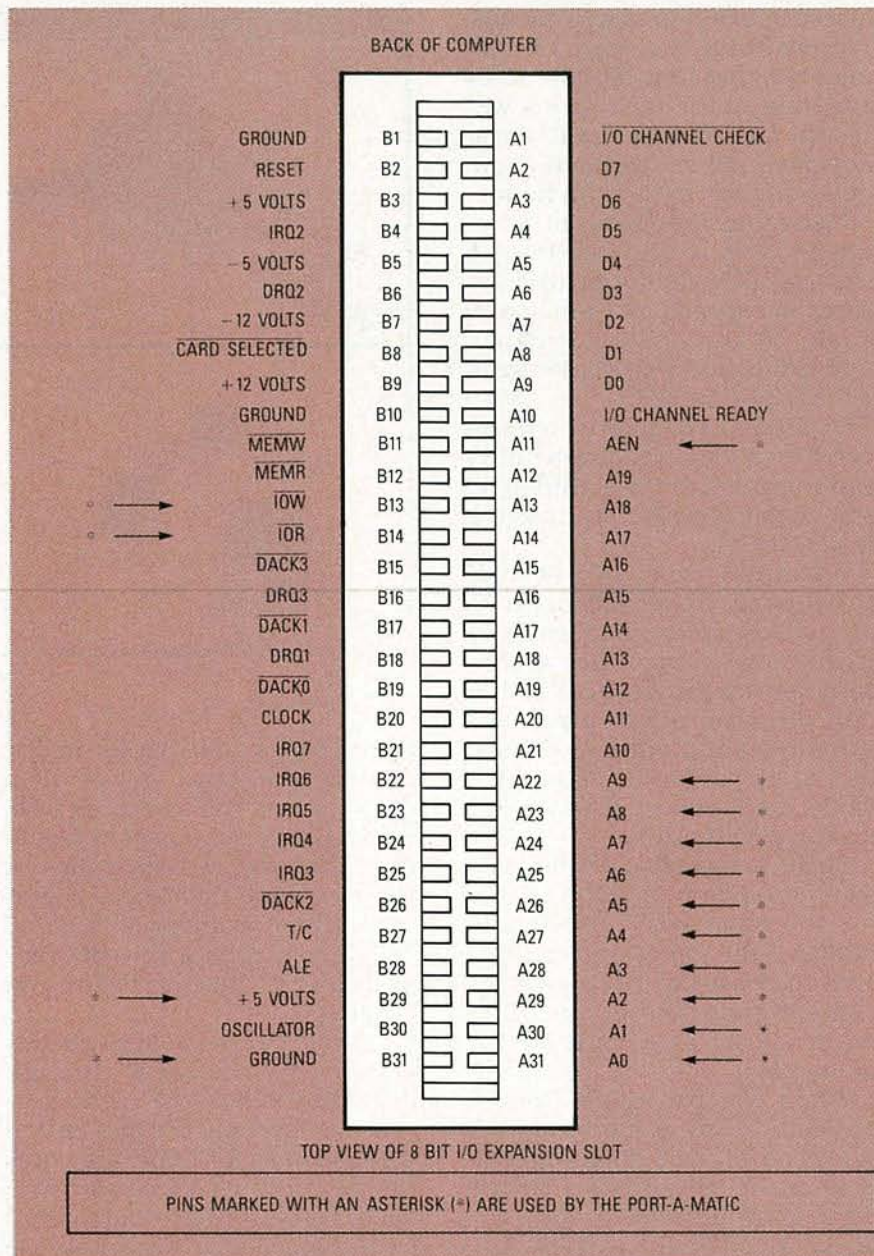


Fig. 1. THE 8-BIT BUS CONNECTOR of the original PC has 62 pins for address, data, and control lines.

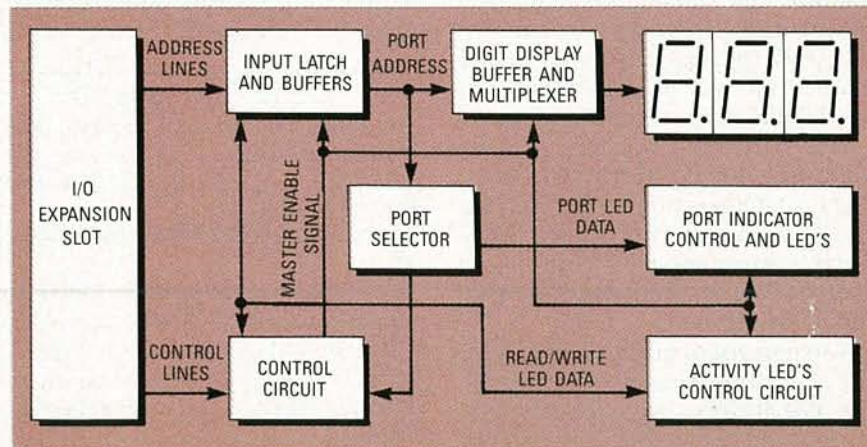
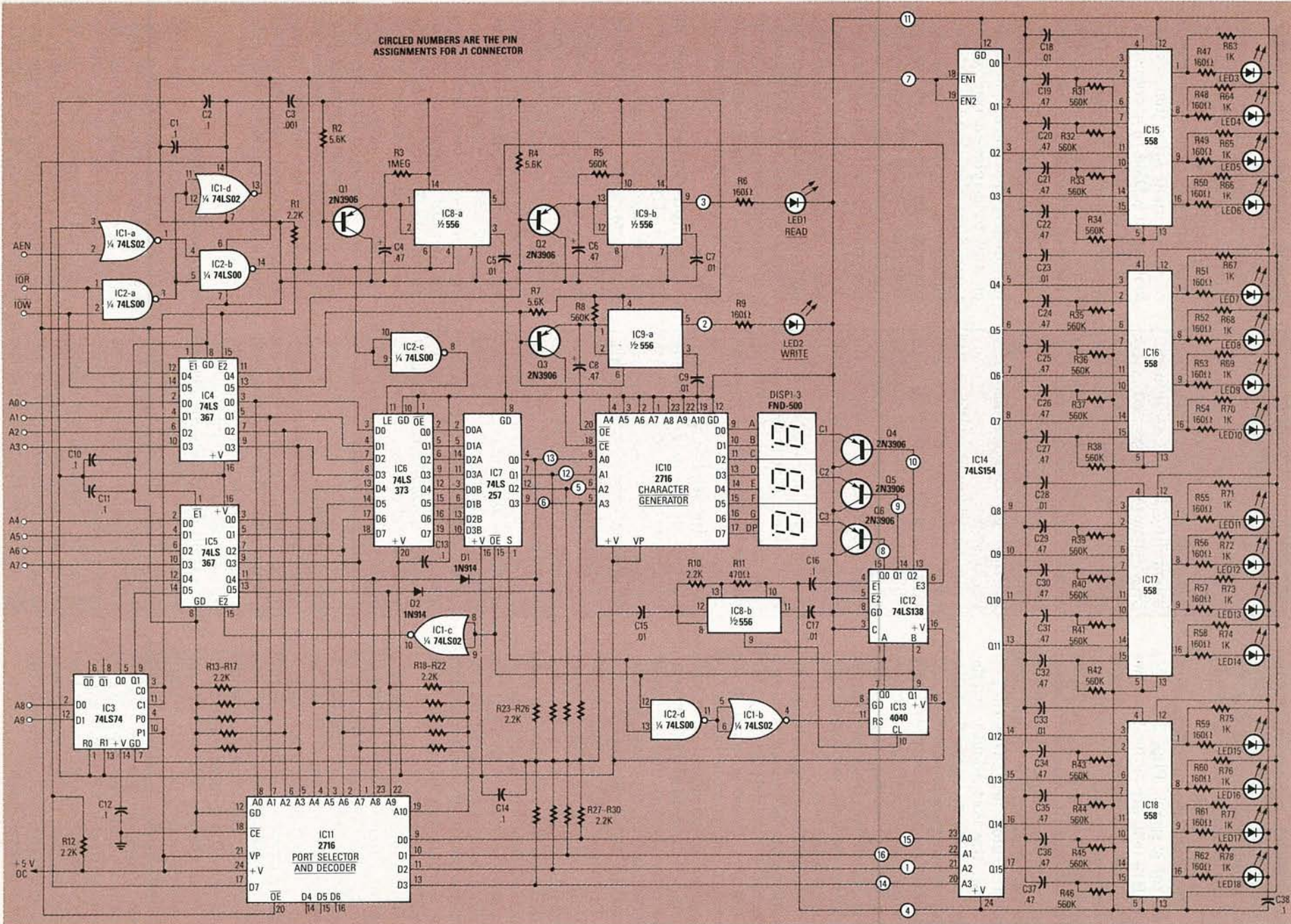


Fig. 2. BLOCK DIAGRAM of the Port-A-Matic. It is designed to be as compatible as possible with IBM-type computers.

CIRCLED NUMBERS ARE THE PIN ASSIGNMENTS FOR J1 CONNECTOR



85 Fig. 3. COMPLETE SCHEMATIC DIAGRAM of the Port-A-Matic.

lines, which appear on expansion-bus pins A22—A31. Power and ground are supplied to the board through pins B29 and B31, respectively.

The card also monitors three control signals. Pins B13 ($\overline{\text{OW}}$) and B14 ($\overline{\text{OR}}$) are active-low lines that indicate when the microprocessor is either writing or reading an I/O port, respectively. (Recall that the microprocessor has separate signals to indicate reading and writing to and from main memory and I/O ports.)

Last, the Port-A-Matic needs AEN (pin A11), an active-high line that lets expansion-card circuitry know that the computer is performing a DMA (Direct Memory Access) operation, the speedy transfer of data from one place to another without microprocessor intervention.

PC and XT compatibles (and some older AT compatibles) normally use the Intel 8237 as a DMA controller. However, most of the new AT compatibles (both 80286 and 80386 varieties), use VLSI chip sets instead of discreet components; the functions originally performed by the 8237 are carried out inside the VLSI's.

During a DMA operation, all other controlling devices must relinquish their use of the bus, otherwise bus contention and garbled data will result. The microprocessor is put to sleep by a signal that gets routed on the motherboard, and any controller on the expansion bus gets notified by a high on AEN.

The Port-A-Matic is only a monitoring circuit—it doesn't have to take control of the bus to do its job. Even so, the Port-A-Matic still has to pay attention to AEN because some DMA operations involve I/O addressing, and they happen so frequently that the Port-A-Matic's display would flicker without meaning if it decoded them. Whenever AEN becomes active, the Port-A-Matic ignores whatever appears on the bus. If that sounds like a drawback, it's not. The board would work perfectly if it didn't ignore AEN, but the display would be meaningless. So the board was designed to be selective about the ports it responds to.

PC PORT ADDRESSING

Even though IBM-compatible PC's use I/O ports for many types of operations, there's a surprising lack of standards. Most of the ports reserved by the computer for basic operations (keyboard, video, disk, etc.), use addresses that remain constant from machine to machine, but when it comes to printer and communications ports, things begin to get considerably less consistent.

The first serial and parallel ports (COM1 and LPT1) are usually located at 03F8h and 03BCh, respectively, and COM2 appears at 02F8h. However, other ports are less clearly defined. LPT2 can be at 0278h, 0378h, or other addresses. Ports COM3, COM4, and LPT3 are even less clearly defined.

In order for Port-A-Matic to decode those ports, you must find out exactly which addresses are used by your hardware. You can usually obtain those addresses from the documentation that came with your peripheral cards; alternatively, various software tools can help.

The best program of that nature is DIAGS.EXE. It was written by Joan Riff and is in the public domain, so you should be able to find it by logging onto your favorite bulletin board. It's a complex program, but the accompanying documentation (DIAGS.DOC) is well written and covers every aspect of using the program.

How it works

Now that we know what signals the Port-A-Matic uses, let's see how it works. The block diagram in Fig. 2 gives an overview of circuit operation. The ten address lines from the I/O slot are always present at the Port-A-Matic's input buffers, but the only data that the board pays any attention to is whatever happens to be there during an I/O operation. When the control circuit senses that a port is being accessed, it latches the address in the buffers, then checks the address

against the table that is stored in the port selector.

If there's a match, the control circuit is notified, but that's not the end of the story. The Port-A-Matic still has to check the state of AEN to make sure that it's not looking at a DMA operation.

If the circuit sees that there's no DMA operation going on (AEN is low), it asserts a master enable signal that causes the rest of the Port-A-Matic to process the data.

The address in the input latch is transferred to the display buffer and multiplexed out to the three-digit hex display. At the same time, the master enable signal will cause one of the two activity LED's (READ or WRITE) to light up. The data coming from the port selector will also be decoded and the LED associated with that port will also light up. All of that activity is controlled by timers, so the Port-A-Matic will display each valid port address for about a half a second. A complete schematic of the Port-A-Matic is shown in Fig. 3.

The input buffers consist of IC3—IC5. Those 74LS367's contain two groups of buffers in a single package, one four bits wide and one two bits wide, and each section has its own output-enable pin. The four-bit sections in IC4 and IC5 handle the lower eight address lines. The two-bit section in IC4 is used as the buffer for the $\overline{\text{OR}}$ and $\overline{\text{OW}}$ signals coming from the PC bus. That leaves the two-bit section of IC5; although it's devoted to the two upper address lines, A8 and A9, you can see in the schematic that they are handled differently. The reason for that will become clear after we examine the rest of the circuit; but in a nutshell, doing things the way we did simplified the design and reduced the parts count.

High address lines

Both A8 and A9 are connected to IC3, a 74LS74 set up as a two-bit data latch. When the Port-A-Matic detects a valid address, the master enable signal clocks whatever happens to be on A8 and A9 into IC3, and that data is presented to the input pins of the two-bit section of IC5. Setting up

the address buffers that way represents a design compromise, because the 74LS74 is just a pair of D flip-flops, not a true latch. The price you pay for using it in that manner is that, contrary to what everybody tells you, the data at the input doesn't show up at the output when the chip is clocked. Instead, that data actually appears one clock pulse later.

That could have serious consequences for the Port-A-Matic since it means that there's a possibility of missing a one-time-only port access by the computer. Fortunately, as we'll see, there's a relatively easy fix for that. For now, it's important just to be aware of the problem.

The control circuit is made up of a handful of gates and passive components, along with IC11, the EPROM containing the port selection look-up table. The control circuit's job is to issue the master enable signal—a low-going pulse at the output of IC2-b.

When an I/O operation takes place, it causes the output of IC2-a, a NAND gate, to go high. That signal is in turn fed to one leg of IC2-b, another NAND gate whose job it is to issue the master enable signal. It's also inverted by IC1-d, a NOR gate set up as a simple inverter, and the resulting low enables the outputs of the four-bit sections of IC4 and IC5, which thereby causes the lower

eight bits of the address bus to show up at the corresponding address inputs of IC11, the port-selector EPROM. The same signal from IC1-d also enables the outputs of the EPROM.

We'll get into the details of the look-up table later; for now it's only important to know that bit 7 of each table entry is used as the enabling toggle for port addresses. In particular, that bit will be cleared for a valid address and set for an invalid address.

The D7 line of the EPROM is fed back to IC1-a, one input of a NOR gate; the other leg of the gate is connected directly to AEN from the bus. If either input to IC1-a is high, either the EPROM says to ignore that address, or the computer is doing a DMA operation. (Actually both may be true.) In any case, the output of IC1-a will be low and, since it's connected to the other leg of IC2-b, no master enable signal will be issued.

If, however, a high is issued from IC1-a, that high is fed to IC2-b, and since the other leg will also be high (because IC2-a detected an I/O operation), the output of IC2-b will go low.

That is the master enable signal that the Port-A-Matic has been waiting for; when it's received the rest of the circuit will be activated.

Before we continue, however, let's take another look at what's happening with A8 and A9, the two high-order address lines from the bus.

If it's the first time a particular I/O address has shown up on the bus, the states of A8 and A9 won't be clocked through IC3 and then show up at the inputs of IC5. That is because the 74LS74 is clocked by the master enable signal, and that won't be generated until a valid I/O address shows up at the address pins of IC11, the port selector EPROM. In other words, we need the master enable signal in order to produce the master enable signal.

The situation, however, isn't as ridiculous as it seems. A circuit design, like most other things in life, is the product of inspiration, realization, and compromise. You begin with a list of design criteria and, once there's some

working silicon on the bench, you have to weigh real-world practicalities against breadboard idealism.

It would certainly be possible to redesign Port-A-Matic to eliminate the problem, but the price would be an increase in circuit complexity, parts count, and cost. And those considerations are just as important as circuit operation. Further, increasing the parts count increases the possibility of unforeseen circuit glitches, and raises the power requirements. And the more complex the circuit, the more complex the PC board.

For all those reasons, we decided to come up with a better solution. The solution involves making a relatively minor operational compromise in the circuit, and it involves using a bit of creative construction in building the look-up table. However, before we can get into building the look-up table, we have to know how the rest of the circuit operates. So, for now, let's just assume that an I/O address has been put on the bus, the Port-A-Matic has checked the port-selector EPROM, and the master enable signal has been generated.

The master enable signal

Once a valid address is detected, the main job of the master enable signal is to load the address data into the display buffer, activate the display timers, and turn on the display.

The master enable signal from IC2-b is inverted by IC2-c, and the resulting high triggers the latch-enable input of IC6, a 74LS373 octal latch. The data stored there is then presented to IC7, a 74LS257 quad two-input multiplexer—the electronic equivalent of a four-pole, two-position rotary switch. By putting a high or low on the select control (pin 1), one of the two sets of input lines will be routed to the output pins. You can tie the 257 directly to a bus because a low on the output-enable (pin 15) "floats" the outputs (effectively removes them from the bus). That feature is important because the display section can handle only eight inputs, but the

DATA AND STATUS PORTS

Most I/O operations actually involve the use of several sequential port addresses for data, status, control, etc. We programmed the prototype to respond only to data ports. The reason is that if you programmed the same LED number into all addresses associated with COM1 (for example), the least significant digit of the display would flicker so rapidly that it would be all but impossible to read. So unless you have a particular reason to monitor control and status ports, you'll find it's more useful for Port-A-Matic to respond only to the data port.

circuit must deal with ten lines (A0–A9).

Since we're only using three seven-segment digits for the display, one question is: Why should we bother with display multiplexing at all? Multiplexing is a good way to reduce parts count, but the break-even point is about three digits.

The reason is that we need a hex, rather than a decimal, display. That means using a character generator that can decode all the numerals from 0 to 9, as well as the hex digits A to F. Unfortunately, such character generators are hard to find. Motorola makes one, and HP has some smart, self-latching hex displays, but both solutions are expensive, and the parts are hard to come by in small quantities. So we built our own; here's how.

The Port-A-Matic divides the ten address lines into three groups: A0–A3, A4–A7, and A8–A9. The multiplexing control circuitry is composed of IC8-b (half of a 556 dual timer), IC12 (a 74LS138 decoder), IC13 (a 4040 counter), and several gates.

The basic multiplexing clock is provided by IC8-b. It drives the 4040 and the resulting binary count drives the 74LS138's select pins. That puts a series of sequential lows on the bases of the display pass transistors (Q4–Q6), and each of the digits will thus light up in turn. Gates IC2-d and IC1-b decode the binary count from the 4040 and provide a reset pulse for the counter whenever the count reaches three.

Multiplexing the display isn't much use unless the data being fed to the display is multiplexed as well. The data and the display must be synchronized so that the right data is presented to the display inputs when the right display is illuminated. The two outputs of the 4040 that drive the 74LS138 also control the order in which the address data is fed to the display circuit. As long as the Q1 output of the 4040 is low, the outputs of IC7 (the data multiplexer) will be enabled. In addition, the same line that enables IC7's outputs is inverted by IC1-c, so the outputs of the

CHOOSING EPROM'S FOR THE PORT-A-MATIC

Much of Port-A-Matic's operation depends on the proper functioning of IC11, the port-selector EPROM. Every I/O operation performed by the computer is checked by IC11 to see whether the Port-A-Matic should respond to the port address on the bus.

Not only does IC11 play a major role in the circuit, it has only a limited amount of time to do its job, and the duration of that time may be critical. The reason is that even though the 8088 takes between eight and ten clock cycles to perform an I/O operation (unless the hardware or software slows things down by adding wait states), the address remains valid on the computer's bus for even less time than that.

Even though computer timing is measured in microseconds and EPROM timing is measured in nanoseconds, using a standard 2716 (with a 450-ns access time) can cause instability in the Port-A-Matic's display. That's because the master enable signal isn't issued until IC11 has approved the port address, but the computer doesn't wait around patiently until that judgment is made.

If the EPROM is too slow and

the computer is too fast, the master enable signal could be issued just as the computer was beginning another I/O operation. That would cause the Port-A-Matic's display to change to a second address after showing the one that triggered it in the first place. The second address is usually related to something like an interrupt request, RAM refresh, and so on.

The problem can be eliminated by using a faster EPROM for IC11. There's no hard and fast formula for calculating how fast an EPROM you should use, but if the problem shows up, you can clear it up by switching to a different EPROM.

The fastest 2716 that's easily available is a 2716-1, with an access time of 350 nanoseconds. If that's still too slow, you could switch to a 2732A, since they're available with access times as low as 200 nanoseconds, which should be fast enough for even a real screamer personal computer like a 33-MHz 386 machine.

You can plug a 2732 directly into IC11's socket, but the look-up table must be burned into the top half of the EPROM, since the extra address pin is tied high on the board.

two-bit section of IC5, the buffer that handles A8 and A9, will be disabled.

When the first digit is enabled, IC7 is enabled, IC5 is disabled, and the lower four address lines are routed to the character generator and the display. When the second digit is lit, IC5 remains disabled, and IC7 sends the second group of address lines (A4–A7) to the character generator. When the last digit is lit, IC7 is disabled and IC5 is enabled, thereby causing the signals from A8 and A9 to be routed to the character generator through D1 and D2. The two diodes are needed to isolate the outputs of the two-bit section of IC5 from the outputs of IC7. That arrangement is necessary because the

4040 runs constantly, whether or not the Port-A-Matic has detected a valid I/O address.

If the diodes weren't there and the outputs of the two-bit part of IC5 were connected directly to the inputs of the character generator, the A8 and A9 inputs of the port selector EPROM would see data from both IC5 and IC7. That might also cause it to ignore a valid address and okay an invalid address.

LED selection

One really useful feature of the Port-A-Matic is its ability to assign a particular LED to a particular port address. It's a lot easier to see what your computer is doing by having the Port-A-Matic light an LED you've la-

belled COM1 than waste some brain space by remembering that COM1 is assigned to port 03F8h. The LED assignments are made in the EPROM look-up table. If a valid I/O address shows up on the bus, the EPROM enables the control circuitry and also sends the stored LED number to IC14, a 74LS154 four-to-sixteen line data selector. When the master enable signal shows up at IC14's enable inputs (pins 18 and 19), one of IC14's outputs will go low, thereby triggering a one-shot that lights the corresponding LED for half a second.

All of the one-shots are built using 558 quad timers. The 558 has open-collector outputs, so pull-up resistors (R63-R78) are used on all outputs.

Two additional LED's, LED1 and LED2, indicate I/O activity, \overline{IOR} and \overline{IOW} , respectively. The LED's are controlled by separate halves of IC9, a 556 dual timer. The I/O activity data is stored in the two-bit section of IC4 (D4 and D5); when the master enable sig-

nal appears, that data is passed to the input pins of IC9. Since \overline{IOR} and \overline{IOW} from the bus are both active low, and only one can be active during a given I/O operation, a single low will be sent to the corresponding half of IC9.

The master enable signal triggers a similar one-shot (IC8-a), whose output pulse enables IC12, the 74LS138 that multiplexes the three display digits. The Port-A-Matic sends data to the display circuit constantly, but the digits themselves are only illuminated when the master enable signal triggers IC8-a.

The three one-shots (IC8-a and both halves of IC9) are quite similar. The transistors that control their inputs let an input trigger interrupt the one-shot's internal timing.

The one-shot (IC8-a) controlling the display multiplexer is more responsive than the ones in IC9 because IC8-a's reset input (pin 4) is also controlled by the master enable signal. Every time a new I/O address is validated by

ORDERING INFORMATION

A set of two double-sided printed circuit boards is available for \$38.95 from Systems 80 Instruments Ltd., c/o CF Liebert, Inc., P.O. Box L, Blaine, WA 98230. The two programmed EPROMs (2716-1, 350 ns) as described in the article are also available from Systems 80 for \$19.95. All prices include shipping and handling.

the port selector EPROM, the master enable signal will reset the one-shot.

The look-up table

As mentioned before, the lower eight address lines are handled in a straightforward manner, so we can be sure that they will always be properly sent to the lower eight address pins of the port selector EPROM. But there's no way to tell what data will be at the EPROM's two upper address lines (A8 and A9, pins 23 and 22). But since we're dealing with digital data, it's misleading to say that the data there will be indeterminate. Actually, there are only four possibilities, zero through three. And we've already seen that confusion will exist only the first time the address shows up on the bus.

The reason that's not significant is that most I/O operations involve accessing the same port over and over. The trick to correctly decoding the upper two address lines is to make sure we take all the digital possibilities into account when we build the look-up table.

For example, suppose we want to decode port 03F8h, and that we want to assign it to LED12. If there was no problem with the address lines, we would put a 0Ch at location 03F8h in the EPROM. When the port is accessed, the low state of bit 7 will enable the rest of the control circuitry and the C in the lower half will be passed on to IC14, so LED12 will light up.

In order to make that happen, regardless of what data is present at the EPROM's A8 and A9 inputs during the first access of port 3F8h by the computer, we also

PARTS LIST

Resistors

All resistors are 1/4-watt, 5%, unless otherwise noted.

R1, R10, R12-R30	2200 ohms
R2, R4, R7	5600 ohms
R3	1 megohm
R5, R8, R31-R46	560,000 ohms
R6, R9, R47-R62	160 ohms
R11	470 ohms
R63-R78	1000 ohms

Capacitors

C1, C2, C10-C14, C16, C38	0.1 μ F, monolithic
C3	0.001 μ F, silver mylar
C4, C6, C8, C19-C22, C24-C26, C29-C32, C34-C37	0.47 μ F, 35 volts, Tantalum
C5, C7, C9, C15, C17, C18, C22, C28, C33	0.01 μ F, monolithic

Semiconductors

IC1	74LS02 quad NOR gate
IC2	74LS00 quad NAND gate
IC3	74LS74 dual D flip-flop
IC4, IC5	74LS367 hex buffer
IC6	74LS373 octal D latch
IC7	74LS257 quad 2-input multiplexer
IC8, IC9	556 dual timer
IC10	2716 EPROM 2K X 8, 450 ns
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have to store an 0Ch at every location in the look-up table that might be checked. And that means programming 0Ch at locations 00F8h, 01F8h, and 02F8h, as well as at 03F8h.

The practical effect of doing that will be that the Port-A-Matic will correctly decode an access to port 3F8h regardless of what states are present at the port selector's A8 and A9 pins. The consequence is that one display digit may flicker the first time a port is accessed.

You might think that that

would make it impossible for you to decode two ports whose address differs only in the upper digit—02F8h and 03F8h, for example. Not true.

Remember that the reason for putting the same data at four locations in the look-up table is to be certain that the master enable signal will be generated no matter what data is present at the EPROM's A8 and A9 lines the first time a port address is put on the computer bus. Since the control circuitry only cares about the state of the EPROM's D7 line, the

master enable signal will be produced whenever that line is low. The EPROM data in the lower four bits only determines which LED will light up.

So, for example, if you wanted any access of port 02F8h to light LED3, and any access of port 03F8h to light LED 12, you would store 03h at EPROM location 02F8h and 0Ch at EPROM location 03F8h. The values at 0F8h and 1F8h can be anything as long as the high bit is low.

Unfortunately, we're out of space. See you next time. **CD**

WORKBENCH

continued from page 83

vanced versions of Slick!. Everything described so far, (and more), is part of the basic \$95 version. The other versions do still more.

Slick! can use all the standard display cards that are supported by AutoCAD (CGA, EGA, VGA, and Hercules), and has simple command-line switches to directly support higher screen resolution with more than fifty other video cards. The Level-2 version of Slick! will also support any ADI display driver. If you run AutoCAD with an ADI driver, Slick! Level-2 will give you the same on screen resolution as AutoCAD.

The Level-3 version of Slick! (\$195) won't support ADI displays, but it will print your drawings (or slides) on either an HP Laserjet or an Epson-compatible printer. The prints aren't just screen dumps—the program does the same type of vector to raster conversion that AutoCAD does when it prints a file. Slick's printer setup screen lets you set the plot origin, size, and orientation, and can send the result to either the printer for a hard copy or a file for storage.

The top-of-the-line version of Slick! is Level-4 (\$250), and that one has both the ADI and printer options.

You can run Slick! from the DOS prompt, but the real power of the program becomes evident

by running it while you're still working in AutoCAD. The manual shows you how to modify the ACAD.PGP file so you can run SLICK directly from AutoCAD's command line, and being able to scroll through a directory of blocks means that you don't have to remember the difference between TRANS385.DWG and TRANT385.DWG—you can see it on the screen.

Slick! works extremely well, saves a lot of time, and CAD Systems Unlimited is a great company to deal with on the phone. If you only have the bucks to buy a single AutoCAD accessory, Slick! is the one that you must get. It's by far the most useful CAD utility that you can possibly own.—Robert Grossblatt **CD**

DRAWING BOARD

continued from page 80

determine both the hue and saturation of the colors displayed on the TV. The two elements, hue and saturation, are usually referred to as "chrominance" or "chroma."

A separate colorburst signal is sent for each line of video and they're all exactly in phase with each other. That's obvious if you realize that inconsistencies would result in color shifts from line to line. (That might make for some interesting pictures, but it's not the kind of stuff sponsors shell out bucks to transmit.)

The picture information immediately follows the back porch and, for the next 52 microseconds or so, the electron beam travels across the screen painting a line of varying color and brightness. The color you see depends on the relative phase difference between the video signal and the colorburst signal in the back porch. The brightness, referred to as the "luminance," is simply a function of the voltage level.

If you look at the voltage scale on Fig. 1, you can see how the voltage varies during a line of video. NTSC video calls for a peak-to-peak signal voltage of 1 volt but, instead of volts, the video signal is usually referred to in IEE (Institute of Electrical and Electronic Engineers), or IRE (Institute of Radio Engineers) units. That scale divides the 1-volt range into 140 parts with zero-IRE corresponding to about 0.3 volts. The full scale goes from -40 IRE to +100 IRE units. When you hear a person refer to 50 units of video, they're using the IRE scale.

The reason things are done like that is that there has to be some way to distinguish between control signals and picture information. The NTSC solution was to reserve the area from 0 to 0.3 volts for the control signals and the rest of the space (0.3 to 1 volt) for picture. If the luminance is at 0.3 volts or 0 IRE, the picture will be black—100 IRE will give you white. Everything in the middle will be seen as varying shades of gray or color. The area below 0 IRE is usually referred to as "blacker than black."

Once the end of the picture information is reached, the electron beam is turned off for about 1.5 microseconds (the front porch), and then a horizontal sync pulse is sent. The location and duration of the pulse (4.7 microseconds) is critical to proper placement of the horizontal line on the screen since that causes the electron to move back to the right side of the screen and start a new line.

Messing around with the horizontal sync is a popular activity with the people who dream up ways to scramble TV pictures. If the pulse isn't there at exactly the right time, the television set has no way to identify the start of a new line of video. As a result, the TV will do horizontal retraces at somewhat random intervals and instead of watching a recently released movie, you'll be looking at some images that really belong on a *variable intersitter* (and how many of you know what that is?).

When we get together next time, we'll talk about vertical sync and start to design some video hardware. It should be fun. R-E

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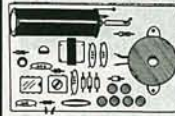
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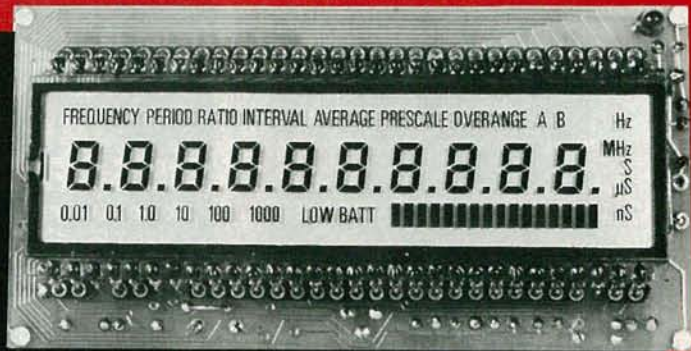
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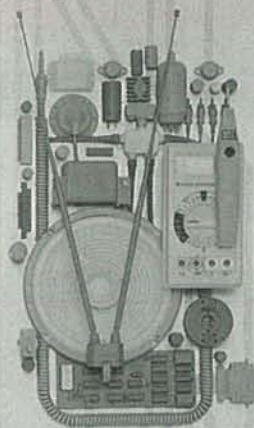
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CD PLAYERS

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disc. That reduction in speed maintains a constant linear velocity and constant rate of data flow as the disc is played. In fact, adding mass to the disc may exacerbate an imagined speed problem by making it more difficult for a player to change rotational speed when it needs to. Furthermore, since data from a CD is buffered in memory before being acted on, the effects of any speed variations, real or imaginary, disappear anyway for all practical purposes.

Quite a few players include such features as optocoupling between stages, separate power supplies, special chassis, and optical/digital outputs. The first three are intended to keep one section of a player from affecting, and interfering with, the workings of another. Optocoupling (converting an electrical signal to light, and then back to electricity again to convey it from one stage of the device to another) is said to eliminate interstage interference and to

transfer digital waveforms more accurately than more conventional hookup techniques. Separate power supplies, too, promise cleaner operation, the idea being that fluctuations arising in one power supply from the demands of one part of a player's circuitry will not affect the performance of the other parts. Some chassis are touted for their abilities to reject or absorb vibration, thus making it easier for a player to track the disc it's playing. Finally, optical/digital outputs can convey the output of the player—still in digital form—to an amplifier equipped with digital inputs, thus, in theory, presenting it with a purer signal for processing and amplification. Transferring the digital signal in the form of light rather than electricity also prevents contamination in the form of hum or other electrical noise.

The efficacy of any, or all, of those features can be demonstrated only if the rest of an audio system is capable of reproducing the supposed benefits, and appreciated only if your ears are capable of discerning them. That, in the end, will be the final proof of the pudding. R-E

ASK R-E

continued from page 14

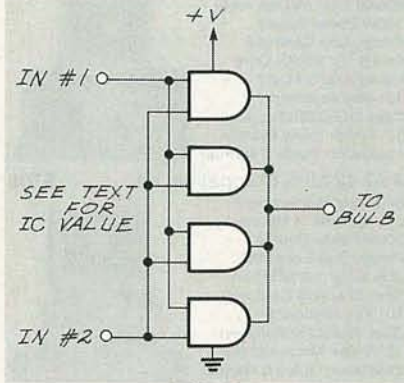













FIG. 2

A much easier way to do the job is shown in Fig. 2. I've ganged the four AND gates in a single package in parallel to provide a bit of extra drive for the output transistor (or relay). You should use CMOS parts, as they're perfectly happy working from twelve volts. Using a TTL part means having to add a 5-volt regulator to the circuit and that's a good way to make things more complicated. R-E

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SHORTWAVE RADIO

continued from page 78

casting spectrum, and formal a priori planning was their only means of obtaining a fair share of shortwave frequencies.

Ultimately, WARC-79 arrived at a solution: there would be a 33% increase in the amount of spectrum allocated to high-frequency broadcasting in exchange for the convening of a two-session high-frequency broadcast planning conference.

Table 1 indicates how the high-frequency broadcasting allocations were expanded at WARC-79. The important 6- and 7-MHz bands were not expanded at all, in spite of the protests of the United States and 21 other administrations. The little-used 26-MHz band was reduced by 70 kHz.

WARC-79 stipulated that the use of the expanded bands would be regulated by provisions agreed to at the broadcast-planning conferences, fixing the dates of availability in two stages: Frequencies above 10 MHz would become available on July 1, 1989; frequencies below 10 MHz would become available July 1, 1994. However, some movement into the 1979 expansion bands commenced immediately after WARC-79, and has continued ever since.

Broadcast-planning conferences were held in 1984 and 1987, and a third is expected to be convened in the early 1990's (see WARC-84, *Radio-Electronics*, November 1984; and HFBC-87, *Radio-Electronics*, February 1988). However, many formidable obstacles remain.

- The desires of smaller, less-developed countries to have guaranteed protected access to the HF broadcasting spectrum have yet to be satisfied.
- There is insufficient spectrum to satisfy the needs of broadcasters, large and small alike. The popularity of the medium has never been greater, and more administrations than ever before see it as an essential adjunct to their foreign-policy goals.
- During the next several years there will be preparations for another broadcasting conference. It

will be necessary for it to find a way of fitting a sufficient number of requirements into the planned portion of the spectrum. That, just by itself, will be a formidable task.

It is therefore likely that neither the broadcasters seeking equitability in the planned portion of the spectrum, nor those with a substantial number of assignments in the coordinated portion of the bands will find the next planning exercise entirely acceptable.

Figure 2 is reprinted from a European Broadcasting Union report entitled *Statistics of the Occupancy of the HF Bands for Broadcasting*. It indicates, in daily frequency hours, how HF broadcasting has grown between 1954 and 1981. More-recent data, provided by the BBC, also plotted on Fig. 2, indicates that in-band broadcasting has tapered off in recent years. However, an analysis of out-of-band broadcasting clearly indicates that it has continued to increase. Projected growth to 1995 is shown with dotted lines.

At present, more than 60 countries are operating out-of-band. The WARC-79 expansion bands are already largely occupied. Moreover, about 50 administrations are broadcasting in portions of the 6-, 7-, and 9-MHz bands allocated to other services, including the aeronautical and maritime mobile, the amateur, and the fixed services.

Figure 2 is particularly significant because it indicates that broadcasters appear to have grown impatient battling for reliable frequencies in the allocated portions of the spectrum. Instead, they are moving out-of-band, in search of clear channels in relatively non-congested areas of the spectrum. That may be the most disquieting aspect of our look at the future of HF broadcasting.

The future

Broadcasters are now operating in portions of the HF spectrum allocated to virtually every other service. It is feared that the trend toward *de facto* band expansion will continue. There are several reasons for that:

- Relatively inexpensive shortwave receivers which tune the entire shortwave spectrum continu-

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ously, from 3 to 30 MHz, have become available.

- As sophisticated communications techniques (satellite, scatter, etc.) become less costly, their use will expand into developing areas of the world. Consequently, the need for HF frequencies to carry fixed services will decrease, enabling some of the less-developed countries to make more use of out-of-band frequencies.

- Several Asian and European administrations, having little or no amateur services of their own, have found the amateur 40-meter band to be fertile ground.

- There is no prospect of legal band expansion taking place in this century. Any re-allocation of spectrum to the shortwave broadcasting service will have to await the re-accommodation of services currently using the spectrum.

The elements of a bandless HF broadcasting spectrum are therefore in place. Remedial actions taken by the next HF Broadcasting Conference will, it is hoped, effectively stem the tide in the twenty-first century.

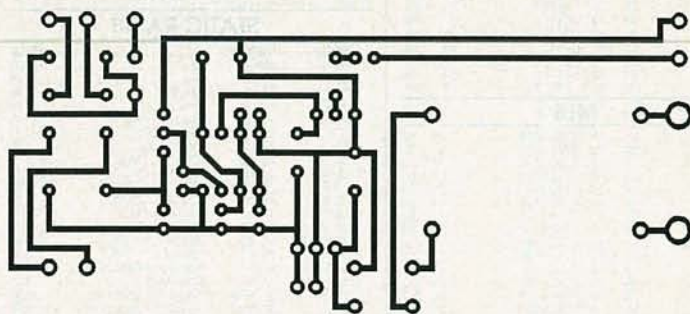
R-E

AUDIO MUTE

continued from page 44

the grounds of J2 and J4, but leave both pairs separate.

That isolates the two channels, but make certain that there's no accidental short between the two channels, like a solder splash. Thus, only in the case of two mono sources, should there be three separate grounds; the main one for the audio-muting circuit, the one for the J1-J3 channel, and a separate one for the J2-J4 channel. (Figs. 1-3 show the two grounds that would normally be present for stereo audio.)



Audio-muting circuit's solder-side foil pattern

Construction

This is a very simple project to build. The parts-placement diagram is shown in Fig. 2, and the foil pattern is shown below. You might, however, want to build the circuit on either breadboard or perfboard. You can stuff the PC board in any order, and you might want to use sockets for Q1, Q2, and IC2, even though they weren't used in the prototype. When you're finished building the circuit, check for mistakes like solder splashes, or diodes, transistors, or IC's inserted backwards. The completed board can be installed in any suitable case.

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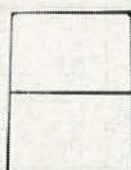
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sensitivity: 1 mV/div

57020 Oscilloscope.....\$399.95
Wide measuring range • Measured
true hold function

57102 Frequency Counter \$299.95

Cometheus 9600 Baud Modem



100E External 9600 Baud \$749.95
100B Internal 1200 Baud \$49.95
100B Internal 2400 Baud \$99.95

Metex Digital Multimeters

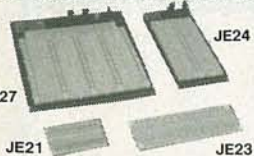
Metex General Specs:
Handheld, high accuracy
AC/DC Voltage, AC/DC
Current, Resistance, Diodes,
Continuity, Transistor hFE
Manual ranging w/overload
protection



M4650
3650, 3650B & M4650 only:
Also measure frequency and capacitance
M4650 only: • Data Hold Switch • 4.5 Digit

3610 3.5 Digit Multimeter \$49.95
3650 3.5 Digit Multimeter w/Frequency &
Capacitance \$69.95
3650B Same as M3650 w/Bargraph \$79.95
M4650 4.5 Digit w/Frequency, Capacitance and
Data Hold Switch \$99.95

PROTOTYPING PRODUCTS Jameco Solderless Breadboards



JE24
JE27
JE21
JE23

Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
E21	3.25 x 2.125	400	0	\$4.95
E23	6.5 x 2.125	830	0	\$6.95
E24	6.5 x 3.125	1,360	2	\$12.95
E25	6.5 x 4.25	1,660	3	\$17.95
E26	6.875 x 5.75	2,390	4	\$22.95
E27	7.25 x 7.5	3,220	4	\$32.95

Prototype Design Stations

WM2

WM1 & WM2 Features: • Removable solderless breadboard • Variable and fixed DC power supply • Multi-frequency signal generator • Analog multimeter • 8 bicolor LEDs (red & green) • 8 logic switches • Logic probe • Lighted power switch • Fuse overload protected • Sturdy ruggedized case

WM1 Special Features: • 4 potentiometers • Built-in speaker

WM2 Special Features: • Pulse Generator • Binary coded decimal (BCD) to 7-segment decoder/driver • DB25 connector • Frequency counter (1Hz to 1MHz)

WM1 Analog Prototype Station \$199.95

WM2 Digital Prototype Station \$249.95



IBM Compatible Cases and Power Supplies

JE2012



JE1030


JE1010 Flip-Top Standard PC/XT Case \$39.95
JE1011 Side Standard PC/XT Case \$39.95
JE1018 Side Baby AT Case \$59.95
JE1030 150 watt PC/XT Power Supply \$59.95
JE1032 200 watt Baby AT Power Supply \$89.95
JE2011 Vertical Case w/300W Pwr. Supply \$279.95
JE2012 Mini-Vertical Case w/200W Pwr. Supply \$149.95
JE2014 Flip-Top Baby XT Turbo Case \$69.95
JE2019 Flip-Top Baby AT Case \$69.95

Display Monitors and Packages

AMBER 12" Amber Monochrome \$99.95
HD55H 14" RGB 640 x 240 \$249.95
M9070S 16" Multiscan Monitor 1280 x 800 \$1099.95
TM5154 14" EGA 720 x 350 \$369.95
JE1059 TM5154 EGA Monitor & EGA Card \$459.95
TM5156 14" VGA 720 x 480 \$399.95
JE2060 TM5156 VGA Monitor & VGA Card \$529.95
TM5157 14" Multiscan 800 x 600 \$469.95
JE2057 TM5157 Multiscan Monitor & EGA Card ... \$559.95




A.R.T. EPROM Programmer



• Programs all current EPROMs in the 2716 to 27512 range plus the X2864 EEPROM • May be operated by any RS232 port w/terminal emulation • Fully intelligent • ASCII command driven • Menu driven software included
EPP \$179.95

UVP EPROM Eraser



• Erases all EPROM's • Erases 1 chip in 15 Min. and 8 chips in 21 min. • Maintains constant exposure distance of 1" • Special conductive foam liner eliminates static build-up • Built-in safety lock • UV intensity: 6800 UW/CM²
DE4 \$69.95


Jameco IBM PC/XT/AT Compatible Keyboards



JE2017

JE2015 84-Key Standard AT Style
Layout \$59.95
JE1016 101-Key Enhanced Layout
with 12 Function Keys \$69.95
JE2016 111-Key Enhanced with Solar
Powered Calculator \$79.95
JE2017 104-Key Enhanced with Trackball
(140 DPI Resolution) \$99.95

Soldering and Desoldering Stations



XY1683
XY999

60 Watt Digital Display Soldering Station • Electronic temperature control from 200° to 878°F • Temperature displayed on easy to read .560"H 3-digit LED readout • Nichrome heating element
XY960 \$99.95
60 Watt Analog Display Soldering Station • Electronic temperature control from 200° to 878°F • Cartridge heating element for a longer life of the soldering tip
XY1683 \$59.95
60 Watt Analog Display Soldering Station • Electronic temperature control from 200° to 878°F • Ceramic heating element for a steady temperature and long life
XY2660 \$89.95
30 Watt Electronic Temperature Controlled Desoldering Station • Electronic temperature control from 212° to 842°F • Self-contained high rotary vacuum pump
XY999 \$279.95

Hard & Hard/Floppy Disk Controller Cards

Computer Type	MFM Hard		RLL Hard		MFM Hard/Floppy		RLL Hard/Floppy	
	Part No. / Price	Part No. / Price	Part No. / Price	Part No. / Price	Part No. / Price	Part No. / Price		
8088 (PC/XT) @ 3:1 Interleave	XTGEN\$79.95	1004A27X\$89.95	JE1044\$109.95					
80286 (AT) 386 @ 2:1 Interleave	1003VMM1\$129.95	1003VSR1\$149.95	1003VMM2\$149.95	1003VSR2\$169.95				
80286 (AT) 386 @ 1:1 Interleave	1006VMM1\$149.95	1006VSR1\$169.95	1006VMM2\$169.95	1006VSR2\$189.95				

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3 to 6 Vdc MOTOR with GEARBOX

Probably designed for child's toy. Lever selects 2 forward and one reverse speed. 1st gear approx. 120 rpm/6vdc, 2nd gear approx. 300 rpm/6vdc, Reverse approx. 120 rpm/6vdc.

3.35" X 1.75" X 3.25"
CAT# DCM-10 \$6.00

4 AA BATTERY PACK (USED)

Four AA nickel cadmium batteries connected in series to make a 4.8 volt pack. Batteries are in a 2 X 2 configuration with a 2 pin connector attached. The four batteries can be separated into single AA size solder tab nickel cadmium batteries or resoldered into other configurations.

SPECIAL SALE PRICE - ~~WERE \$4.00 per pack~~ NOW \$3.00 per pack
CAT# NCB-41AAU

6 VOLT D.C. 9.5 AMP/HOUR GEL-CELL

Elpower# 695
6 volt, 9.5 amp/hour rechargeable gel-cell battery.
4.25" X 2.75" X 5.5".
Quick connect terminals.
CAT# GC-695
\$15.00 each

12 VOLT DC MINI FAN

Howard Industries# 3-15-810. Operates on 12 Vdc, 0.10 amp, 1.0 watt. Compact plastic housing, 0.35" square X 1.275" thick, 9 blade fan. Two 9" pigtail leads.
CAT# CF-121 \$9.00 each

115 VAC COOLING FAN

STANDARD SIZE COOLING FAN. Features die cast metal housing for strength and durability. IMPEDANCE PROTECTED 4 1/16" square X 1 1/2" deep.
Factory new 120 Vac fans. CF1-N \$9.50 each

WALL TRANSFORMERS

ALL PLUG DIRECTLY INTO 120 VAC OUTLET

6 Vdc @ 200 ma. CAT# DCTX-620 \$2.25
9 Vdc @ 250 ma. CAT# DCTX-925 \$2.50
18 Vac @ 1 amp. CAT# ACTX-1885 \$3.50

LED'S

STANDARD JUMBO DIFFUSED T 1-3/4 size

RED CAT# LED-1 10 for \$1.50 • 100 for \$13.00
GREEN CAT# LED-2 10 for \$2.00 • 100 for \$17.00
YELLOW CAT# LED-3 10 for \$2.00 • 100 for \$17.00

FLASHING LED

with built in flashing circuit operates on 5 volts...

RED \$1.00 each
CAT# LED-4 10 for \$9.50
GREEN \$1.00 each
CAT# LED-4G 10 for \$9.50

BI-POLAR LED
Lights RED one direction, GREEN the other. Two leads.
CAT# LED-6 2 for \$1.70

LED HOLDER

Two piece holder.
CAT# HLED 10 for 65¢

RELAYS

12 VOLT D.C. COIL S.P.D.T.
Omron# G2E-184P 4 Amp contacts 335 ohm coil. Sugar cube size. .61" X .42" X .44" high. P.C. mount with pins on DIP spacing.
CAT# RLY-787 \$1.50 each

5-6 VDC SIP REED RELAY

Electrol
"Blue Boy"
BBS1A05A10
5-6 Vdc, 500 ohm coil. S.P.S.T., normally open reed relay. 0.5 amp contacts. SIP configuration. 1" X .375" X .3".
CAT# RRLY-SIP5 \$1.10 each • 10 for \$10.00

PHOTO FLASH CAPACITOR

Rubycon# FKX
200 mfd. 330 volts.
0.79" diameter X 1.11" high
Solder loop terminals.
CAT# PPC-200 \$3.25 each
10 for \$30.00 • 100 for \$275.00

22/44 PIN CONNECTOR

.156" pin spacing, 0.200" between double rows, gold contacts, P.C. mounting.
SPECIAL. Same as AMP# 2-530655-6.
CAT# EBC-1G \$1.00 each • 10 for \$8.00

SOUND AND VIDEO MODULATOR

The UM1361-1. Designed for use with T.V. computers. Can be used with video cameras, games or other audio/video source. Built in A/B switch enables user to switch from T.V. antenna without disconnection. Operates on channel 3 or 4. Requires 12 Vdc. Hook up diagram included.
CAT# AVMOD \$5.00 each

LIGHT ACTIVATED MOTION SENSOR

This device contains a photocell which senses sudden change in ambient light. Could be used as a door annunciator or modified to trigger other devices.
5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included)
CAT# LSMD \$5.75 per unit

1/4 WATT RESISTOR KIT

Ideal for the workshop, this 1/4 watt resistor kit contains 10 pieces each of 42 of the most popular values (420 pieces total). Includes a divided box and a parts locator.

VALUES in this kit are:
1 ohm, 10 ohm, 39 ohm, 47 ohm, 51 ohm, 68 ohm, 100 ohm, 130 ohm, 150 ohm, 180 ohm, 220 ohm, 330 ohm, 470 ohm, 560 ohm, 680 ohm, 1K, 1.2K, 1.5K, 2K, 2.2K, 2.7K, 3K, 4.7K, 5.1K, 5.6K, 10K, 15K, 22K, 30K, 33K, 39K, 47K, 56K, 68K, 100K, 120K, 150K, 220K, 470K, 1 MEG, 5.1 MEG, 10 MEG

The resistors alone would sell for \$21.00.
Complete kit • CAT# REKIT-14 \$17.00

XENON TUBE

1" long flashtube prepped with 3 1/2" red and black leads. Ideal for electronic flash or strobe projects.
CAT# FLT-3 2 for \$1.00

PIEZO WARNING DEVICE

Murata Erie # PKB8-440
High pitched audible alarm. Operates on 3 - 20 Vdc @ 20 ma. 1" high x 7/8" dia. P.C. board mount.
CAT# PBZ-84 \$1.75 each

NICKEL-CAD BATTERIES (RECHARGEABLE)

SPECIAL! AAA SIZE
Panasonic! P-18AAA
1.2 volt @ 180 MAH
CAT# NCB-AAAX \$1.50 each
10 for \$13.50 • 100 for \$125.00

AA SIZE

1.25 volts 500 mAh
CAT# NCB-AA
AA SIZE \$2.20 each WITH SOLDER TABS
CAT# NCB-SAA
C SIZE \$4.25 EACH
1.2 volts 1200 mAh
CAT# NCB-C
D SIZE \$4.50 each
1.2 volts 1200 mAh
CAT# NCB-D

TRANSISTORS

ORDER BY PART #

PN2222 NPN TO-92 5 for 75¢
PN2907 PNP TO-92 5 for 75¢
2N3055 NPN TO-3 \$1.00 each
MJ2955 PNP TO-3 \$1.50 each
MJE2955T PNP TO-220 75¢ each
MJE3055T NPN TO-220 75¢ each
TIP31 NPN TO-220 75¢ each
TIP32 PNP TO-220 75¢ each
TIP121 NPN TO-220 75¢ each
TIP126 PNP TO-220 75¢ each

TIL-99 PHOTO TRANSISTOR

TO-18 case with window. For wide-angle viewing applications. Spectrally and mechanically compatible with TIL-31B. CAT# TIL-99 \$1.00 each • 10 for \$9.00

TIL-31B PHOTO DIODE
TO-18 case with window. Infrared emitting photo diode. CAT# TIL-31B \$1.00 ea. • 10 for \$9.50

N-CHANNEL MOSFET

RF-511 TO-220 case
CAT# IRF 511
\$1.00 each • 10 for \$9.00
LARGE QUANTITY AVAILABLE

L.E.D. FLASHER KIT

Two L.E.D.'s flash in unison when a 9 volt battery is attached. This kit includes a p.c. board, all the parts and instructions to make a simple flasher circuit. A quick and easy project for anyone with basic soldering skills. CAT# LEDKIT \$1.75 per kit

TELEPHONE COUPLING TRANSFORMER

Multi Products International# A19N-HO-1D/1
Primary 600 ohm
Secondary: 600/600 ohm
.77" X .61" X .63" high.
6 p.c. pins on .187" centers.
Primary inductance: 300 mH min., at 1kHz, 1 volt.
CAT# TCTX-1 \$1.25 each • 10 for \$11.00

OPTO SENSOR

U shaped package with mounting ears. 1/8" opening. 3/4" mounting holes. CAT# OSU-6 50¢ each
10 for \$4.50 • 100 for \$40.00

OPTO ISOLATOR

Sigma# 301T1-1281. Signal applied to the input is coupled by means of light to isolated photo conductive cell. High reliability switching. 12 volt input.
CAT# OP-301 \$1.50 each

A.C. LINE CORDS

Black 6ft., 18/2, apt-2
NON POLARIZED PLUG
CAT# LCAC 2 for \$1.00 • 100 for \$45.00
POLARIZED PLUG
CAT# LCP-1 60¢ each • 100 for \$50.00

14.7 VOLT TRANSFORMER

Sprite Industries# CS-510A. 14.7 volt, 60 Hz, 8.82 Va. 1.61" high X 1.95" X 1.47". Mounting holes on 2.32" centers.
CAT# TX-147 \$3.00 each
10 for \$27.00 • 100 for \$250.00

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Bent leads, carbon comp. and carbon film.
CAT# GRES \$1.00 per assortment

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LOAD: 10 amp @ 240 Vac
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- TILT/SWIVEL BASE • FRONT MOUNTED POWER SWITCH

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- MCT-RLL RLL CONTROLLER \$89.95
- MCT-FH FLOPPY/HARD CONTROLLER \$139.95
- MCT-AFH 286/386 FLOPPY/HARD \$149.95
- MCT-AFH-RLL 286/386 RLL CONTROLLER \$199.95

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HARD DISKS KITS

- 21.4 MB \$199
- 32.7 MB \$219
- 42.8 MB \$339
- 65.5 MB \$389
- 80.2 MB \$569



SIZE	MODEL	AVG. SPEED	FORM FACTOR	DRIVE ONLY	XT KIT	AT F/H KIT
21.4MB	ST-225	65 MS	5-1/4"	\$199	\$249	\$309
32.7MB RLL	ST-238	65 MS	5-1/4"	\$219	\$279	\$379
42.8MB	ST-251-1	28 MS	5-1/4"	\$339	\$389	\$449
65.5MB RLL	ST-277-1	28 MS	5-1/4"	\$369	\$449	\$549
80.2MB	ST-4095	28 MS	5-1/4"	\$569	—	\$679
122.7MB RLL	ST-4144R	28 MS	5-1/4"	\$699	\$759	\$859
21.4MB	ST-125	40 MS	3-1/2"	\$259	\$299	\$373
32.1MB RLL	ST-138	40 MS	3-1/2"	\$289	\$339	\$429

157.5MB ESDI DRIVE KIT \$1049

- 5-1/4" HARD DISK, FLOPPY/HARD CONTROLLER, CABLES, MOUNTING HARDWARE & SOFTWARE. 1355-PKG

1.44MB 3-1/2" DRIVE \$99⁹⁵

- ULTRA HIGH DENSITY
- READ/WRITE 720K DISKS, TOO
- FDD-1.44X BLACK FACEPLATE
- FDD-1.44A BEIGE FACEPLATE
- FDD-1.44 SOFT SOFTWARE DRIVER \$19.95

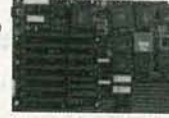


- 1/2 HEIGHT FLOPPY DISK DRIVES:**
- FD-55B 5-1/4" TEAC DS/DD 360K \$99.95
- FD-55G 5-1/4" TEAC DS/HD 1.2M \$129.95
- FDD-360 5-1/4" DS/DD 360K \$69.95
- FDD-1.2 5-1/4" DS/HD 1.2M \$95.95

MOTHERBOARDS 20MHZ 386 \$699

UPGRADE!

- 16/20 MHZ
- 16 MB RAM CAPACITY - 8MB ON BOARD(OK), 8 MB RAM CARD
- USES 256K OR 1MB SIP RAMS
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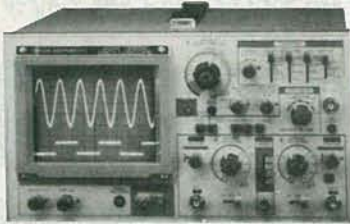


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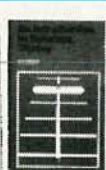
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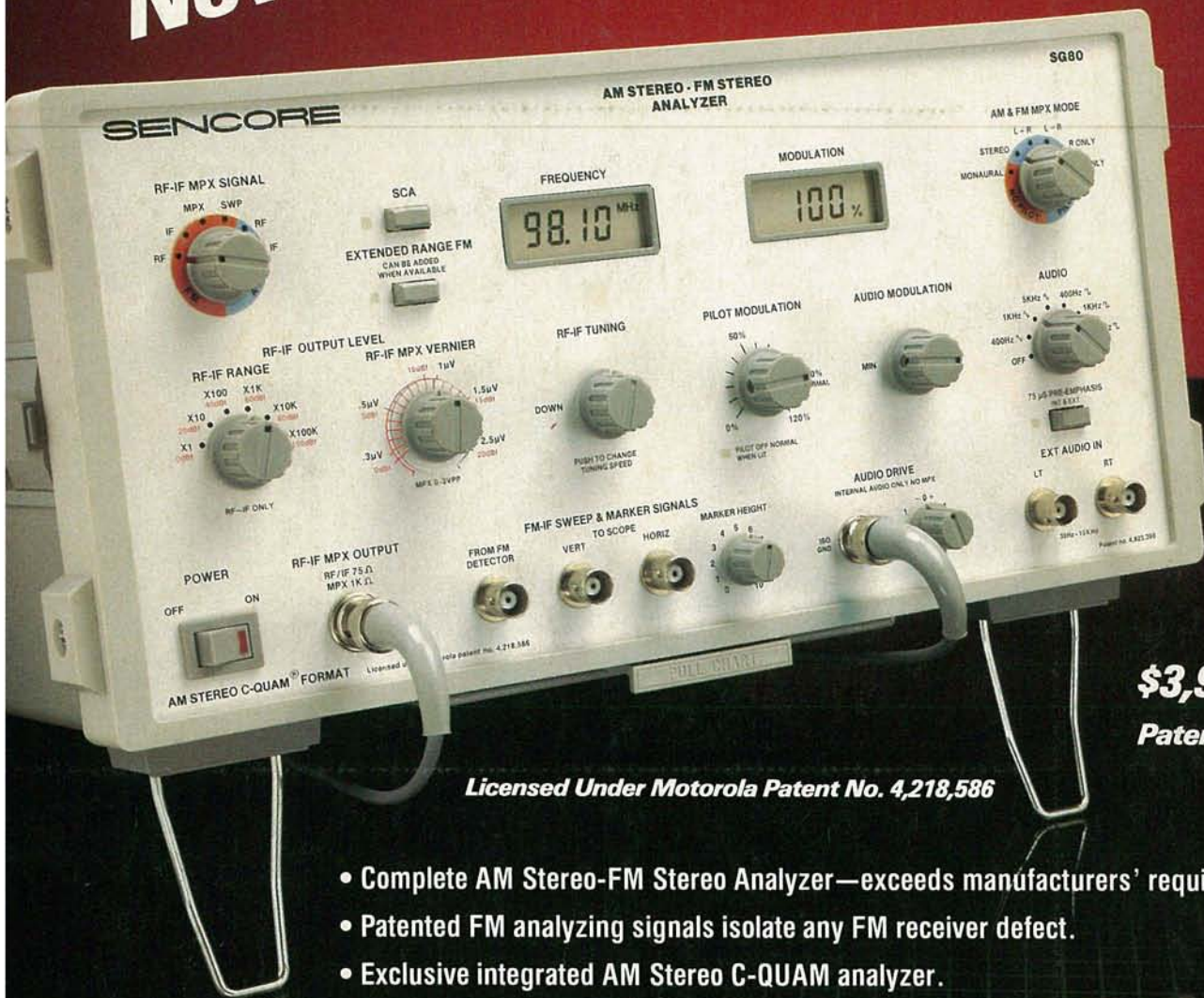
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