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June 1990

Radio-Electronics
Vol. 61 No. 6

BUILD THIS

TECHNOLOGY

CIRCUITS

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DEPARTMENTS

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AND MORE

ON THE COVER

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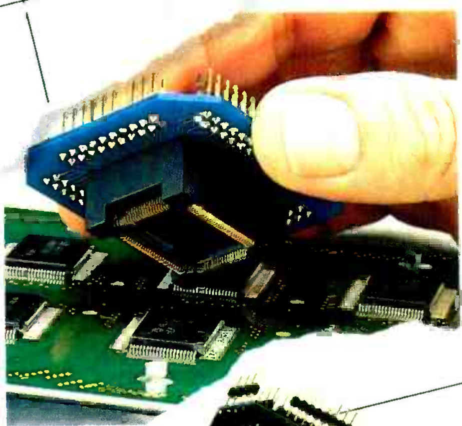

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WHAT'S NEWS

Radalert reaches Russia

As part of *perestroika*, and in light of the lingering problems created by fallout from Chernobyl, the Soviet government has decided to encourage the production and distribution of radiation detectors for Soviet citizens. The Radalert nuclear radiation monitor (featured in **Radio-Electronics**' June and July 1988 and June 1989 issues) won a recent government-sponsored design competition in the Soviet Union, surpassing 45 other contestants. That resulted in the signing of a Protocol of Intention for Joint Venture by a Soviet group and International Medcom (Sebastopol, CA), the manufacturers of the Radalert. Under the terms of the proposed venture, the Radalert and similar radiation detection instruments will be mass-produced in the Soviet Union under a licensing agreement with International Medcom.

A Radalert monitor was used to measure the radiation level at the Chernobyl plant in April 1989. Three years after the accident, a radiation level of 4067 CPM—about 250 times the normal background radiation level here at **Radio-Electronics**' offices—was recorded.

International Medcom has been active in the United States as well. The company's RMS-2 monitor and detection system was displayed to the Energy Committee of the Massachusetts Legislature last spring, for possible use in monitoring emissions at the Pilgrim and Yankee Rowe nuclear plants in that state. That system, as well as the Radalert, also will be used by environmental groups to keep tabs on radioactivity levels that are near nuclear plants and test sites.

TOM COCHRAN OF THE NATURAL RESOURCES DEFENSE COUNCIL holds a Radalert monitor on the grounds of the Chernobyl nuclear facility in the Soviet Union. The radiation level displayed (4067 CPM) is approximately 250 times higher than normal, three years after the accident occurred there.

New solid-state laser puts out 1,000 watts

In a feat they compare to breaking the four-minute mile in running, scientists at General Electric Research and Development Labs in Schenectady, NY. have developed a solid-state laser that has achieved one-thousand watts average output. The new laser is a neodymimum-doped yttrium-aluminum-garnet (Nd:YAG) face-pumped laser, which happens to be a direct descendant of a device patented by GE physicists 17 years ago, which put out only 10 watts of power.

According to Joseph P. Chernoch, who invented the original device in 1972 and who led the team that demonstrated the new device, the face-pumped laser is second to none for industrial cutting and drilling because of its combination of high power and good beam quality (a measure of how much the beam spreads out). In addition, it generates light of a one-micron wavelength that is particularly well absorbed by metals. The device can readily cut or drill through more than two inches of nickel-based superalloys, far beyond the reach of other known lasers.

GE's new laser compensates for distortions introduced by other types by using a slab, rather than a rod, of lasing material and by using a highly effective cooling approach. The slab is a precision-machined Nd:YAG crystal that measures about 1 × ¼ × 8 inches. Light is pumped into the faces of the crystal (hence the name "face-pumped laser") by a pair of ultra-high-intensity flashlamps that are energized by the system's 17,000-watt power supply. High beam quality is maintained by directing the laser beam through the slab along a zigzag path (the beam reflects internally off the slab's highly polished faces) that enables the beam to "see" a uniform averaged selection of stressed material, which eliminates the thermal distortion. **R-E**

GE R&D CENTER ENGINEER ANGEL L. ORTIZ, JR puts the face-pumped laser to work drilling holes in a ½-inch thick plate of superalloy; in other tests it's managed to drill through more than two inches of superalloy. The solid-state laser's average power output of 1,000 watts from a single laser head opens the door to development of industrial laser systems that can cut and drill space-age metals and alloys with unprecedented speed and precision.

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **20,000,000 stereo TV's.** At least 20,000,000 TV sets equipped for *M*ultichannel *T*elevision *S*ound (MTS) stereo and second audio channel reception have now been sold, indicating that at least one American home in every five can receive television programs in stereo. Last year was MTS stereo's biggest year, when more than 6,000,000 stereo-equipped sets were sold, representing 27.8% of all color TV set sales. That is an increase of almost a million sets over the 5,100,000 stereo sets sold in 1988, which represented 25.2% of that year's sales. In addition, about 1,800,000 VCR's sold in 1989 were able to receive MTS stereo broadcasts, up from 1,400,000 in 1988.

• **Welcome back, Majestic.** Old-timers will soon see another familiar old brand back in television stores. That is Majestic, which is being revived as a label sold to independent retailers through distributors. The revival of Majestic follows the similar reincarnation of the Crosley brand (**Radio-Electronics**, August, 1989). Like the new Crosley brand, the new Majestic is no relation to its namesake. The new Majestic brand is being made for a distributor organization by another old TV name—Wells-Gardner of Chicago, one of the oldest private-label TV manufacturers—from chassis and subassemblies understood to be made by Zenith. The new Crosley, as we reported earlier, is made by North American Philips. Other pioneer brands which have been revived by new parents include Capehart, Dumont, Emerson, and Symphonic.

• **Exit CD Video.** Speaking of names, one that never caught on has been dropped. Philips and its affiliated record label, PolyGram, have abandoned their effort to promote "CD Video" as the new name for the optical videodisc. They adopted the name back in 1986, when the laser videodisc's fortunes were at a low ebb, in hopes that the magic of the audio CD would rub off onto the videodisc. One added attraction of CD Video was a new 5-inch version that contained up to 6 minutes of video and 20 minutes of digital audio. The 5-incher never caught on, but combination CD and videodisc players brought a revival of the videodisc, which is becoming increasingly popular. Now Philips and other manufacturers have agreed on a single name: "Laserdisc."

• **Sky Cable.** Activity on the direct satellite broadcasting front indicates that a television revolution will soon be under way. Two groups have announced plans for new satellite ventures. U.S. Satellite Broadcasting signed an agreement with GE Astrospace to acquire a three-channel satellite to broadcast directly to home antennas, with Nationwide Insurance as a partner.

A second announcement stirred up much more publicity. A consortium consisting of NBC, Cablevision Systems, and Rupert Murdoch's News Corporation said they will launch a high-powered direct satellite service in 1993 with up to 108 channels. Using three satellites in the same orbital slot as US. Satellite Broadcasting's bird, "Sky Cable" will provide as many as 128 channels. The Sky Cable consortium said the 200-watt power of its transponders will make it possible for homes to use small flat antennas measuring about 12 inches square. Transmission from the earth to the satellite will be digital, but the satellite will send out analog video signals. It was estimated that receiving antennas plus receivers for the satellite will cost $200 to $300.

It's called "Sky Cable" because the sponsors hope to make it available through local cable operators for a monthly fee, but if consumers wish to purchase the equipment and pay the satellite broadcaster directly they may do so as well.

Both NBC and the News Corp. (Fox Broadcasting) insisted that none of their network programs would be broadcast on the satellite, and Cablevision said the system would be a supplement to cable and not a replacement. But it was difficult to see what function terrestrial broadcasting or cable would serve when 128 channels could be picked up from satellites with a small investment on the part of the public, and there was some feeling that investments in the billion-dollar project by its network and cable sponsors was a defensive maneuver—just on the chance that direct satellite broadcasting might make broadcasting and cable obsolete. **R-E**

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LINES OF RESOLUTION

Please tell me something about the horizontal resolution of the NTSC system. According to the standard, there are 525 horizontal lines per frame, but my VCR only puts out 230 lines. Is that lines per field or lines per frame? Sony ED Beta machines claim to have more than 500 lines and some studio cameras are rated at above 600 lines—more than the NTSC standard. How can a TV display more than 525 lines? And could you explain what difference there is between a "composite video output" and a "video output?"—M. Hart, Burbank, CA

I can understand your confusion but you shouldn't feel too bad because the whole issue of video resolution is confusing. Even some friends of mine who use the video business to pay the rent don't have a clear understanding of exactly what the numbers mean. Let's start with a bit of history.

The whole idea of using numbers of lines to measure resolution had its beginnings in the lens business. As lens making progressed from broken bottle bottoms to fluoride coating and lasers, a standard was developed to measure the amount of detail a lens could transmit. As you've probably guessed, the unit that was chosen was the number of lines per millimeter.

A "line of resolution" is defined as an equal amount of white and black area as shown in Fig. 1. A typical resolution chart would have a series of lines that get thinner and more closely packed as you move across the chart. In practice, the lens would be pointed at the chart and the projected image would be examined to see at what point it became impossible to see individual lines. That point would be designated as the resolving power of the lens.

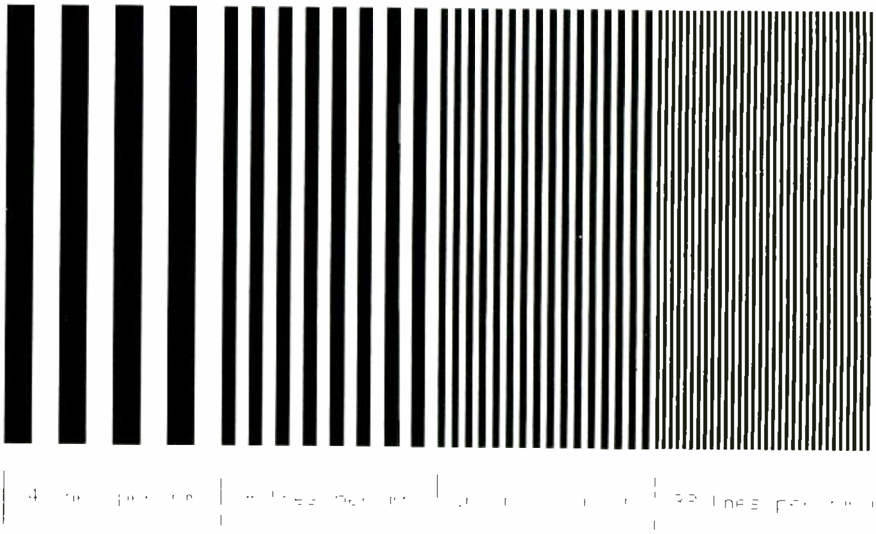

FIG. 1

It should be obvious to you that there's a problem with this method since lenses don't have equal resolving power at every point on the glass. That is due, in part, to theoretical consequences of the optical paths of the light, and also with practical considerations of grinding glass; a lens is usually much sharper at the center than it is at the edges. That's why the published resolution of a lens is specified for a particular point on the lens—usually the center where the image is the sharpest.

The lines-of-resolution method of measuring the sharpness of a lens was carried over to most of the industries that were involved in the business of reproducing images. That includes printing, film, and video. Each industry is concerned with the amount of detail that they can reproduce, but they also have characteristics that differ from the lens business. So, while they all refer to lines when they talk about resolution, they aren't all talking about the same thing. In short, the video industry has made too much use of the word "line."

You're correct in saying that the NTSC standard calls for 525 lines per frame, but you didn't go far enough. Standard NTSC video doesn't just call for 525 lines per frame, it's that way by definition. Each field contains 262.5 lines, and two fields make one frame of video. A video signal that puts out anything other than that just isn't conforming to the NTSC standard. The signal timing may be such that you can display it on an NTSC-standard monitor, but that means that it's really only "NTSC compatible."

Now, with that out of the way, exactly what does it mean to say that some video device puts out 200, 300, 500, or 600 lines? What it means is that there are two different kinds of lines: the first is a line of video and the second is a line of resolution. And what, you may well ask, do they have to do with each other? Absolutely nothing!

The way to understand how the lines of resolution in video relate to the lines of resolution used in optics is to realize that video resolution deals with the number of dots on

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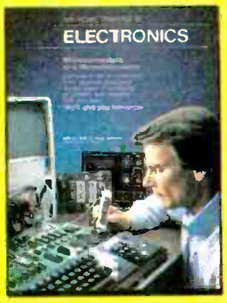

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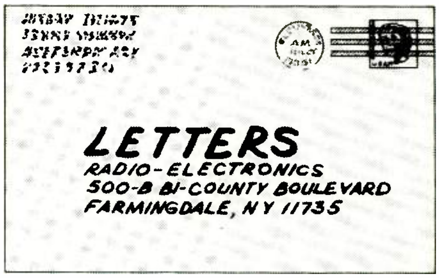
each individual horizontal line of video. Your VCR can put out 230 lines of resolution, but what that really means is that it can display up to 230 individual dots on each line. Imagine that, using a video camera and a resolution chart similar to the one in Fig. 1, you made a tape showing a few seconds of 200 vertical lines, then 201, 202, 203, etc., on up to and past 230. When shown on a TV, the image would look like vertical lines, but it would really be a series of dots. As soon as the number of lines passed 230, the image from your VCR would become a gray blur rather than a series of individual lines.

To get electronic about things, the resolution of a video device is a direct function of the bandwidth—the more quickly it can turn dots on and off, the higher the bandwidth and the better the resolution on each line. As a rule of thumb, you can say that there about are eighty lines of resolution per megahertz of bandwidth. Sony's ED Beta VCR claims to have more than 500 lines of resolution (we know that really means 500 individually distinguishable dots per horizontal line) at about 9.3 MHz...and that brings out another point worth mentioning.

Our 80-line-per-megahertz rule doesn't seem to work with the Sony because we haven't talked about all the other parts of the signal. A portion of the bandwidth has to be used for the various subcarriers, IF, color, and so on. And don't forget that not all of the horizontal line of video is used for picture—more than 16% of each line is reserved for the horizontal interval where you'll find such goodies as burst and horizontal sync. Another factor to consider is the capability of the recording media. Metal tape can handle a higher bandwidth (which is another way of saying it has a higher frequency response), but even the best tape in the world just can't handle the maximum resolution deliverable by the ED Beta machine.

As far as what the difference is between the "video" and "composite video" outputs, I think we're dealing with a lack of standard. Composite video is a single signal containing both picture information and sync, while a plain video signal may just contain only the picture information. **R-E**

LETTERS



SAP ZAPPED

In his February "Video News" piece on multichannel sound, David Lachenbruch forgot one important thing: The average consumer cannot operate a stereo TV set.

WRC-TV channel 4 (Washington, DC) rebroadcast NOAA weather audio on their SAP channel as a public service. After two days the SAP channel was turned off. The switchboard had been inundated with calls and the FCC reported that they had several hundred calls complaining of interference on channel 4.

The station then ran an endless tape loop explaining that the SAP channel was selected and the viewer should consult his owner's manual for instructions on how to return to program audio. Again the phone calls poured in. Some viewers even insisted that the station send someone to "fix" their TV sets.

Finally, after three or four weeks, the calls began to taper off. At that point, the station began to broadcast NOAA audio again. The phone calls returned, in increasing numbers each day. After a week, the SAP channel was turned off for good.

I suspect that the SAP channel will never be used for anything other than regular-programming audio.
ROBERT FUTSCHER
Alexandria, VA

CORRECTIONS

• R & R Associates was listed as a source for the printed-circuit board in the article entitled "Ion Meter" (**Radio-Electronics**, March 1990). Unfortunately, an error appeared in the address. The correct address is R & R Associates, **3106** Glendon Avenue, Los Angeles, CA 90034—*not* "31066" as was printed. (Perhaps the extra digit wouldn't make a difference in most places, but we've been informed that on Glendon Avenue—which was once featured in a television-news filler as one of the most confusing streets in Los Angeles—residents have enough problems with even properly addressed mail.) Sorry for the added confusion.

• In our Universal Descrambler story (**Radio-Electronics,** May 1990), the parts list contained a couple of errors. First, the correct part number for IC9 is CD22402E. Also, there were two C39's; the 47 pF NPO is actually C34. In Fig. 3, what's shown as pin 16 of IC4-c is actually pin 14. The unlabeled capacitor above IC4-d is C45. In Fig. 4, polarity switch S3 should go to +5 volts, not ground.

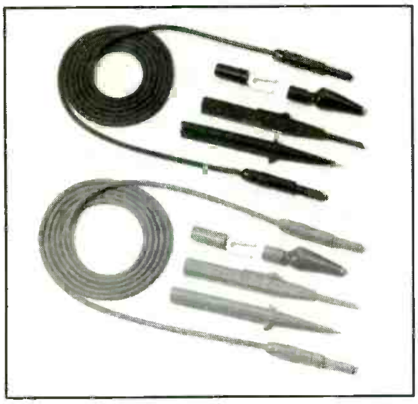
THE CORRECT WAVEFORM

I am writing to congratulate you on an excellent article, "Glitches in the Power Line" (**Radio-Electronics**, April 1990). In all the magazines and books I have ever read, only *Radio Engineering* by Terman showed correct waveforms for rectifiers and filters. Now **Radio-Electronics** has become number two, with Fig. 2 in the article. Usually the waveform of part (a) is shown while the filter and load are intact, but in truth that waveform is correct only with no filter and no load or with purely resistive load only, as the article correctly pointed out. The shapes and phasing of parts (b) and (c) are about as nearly correct as the drawing scale would permit. I have pointed out errors shown in respected handbooks to editors who refuse to correct their figures.

The rest of the article is very interesting, and it was obviously written by someone who knows the facts.
KENNETH E. STONE
Cherryvale, KS

COMPARING CD PLAYERS

I must take issue with Dwayne Rosenburgh's letter in the March issue regarding Larry Klein's December "Audio Update" column, which dealt with sonic differences between CD players. Rosenburgh believes that the ABX tests to which Klein refers prove only that there are no significant differences between expensive CD players and that a "$1500 unit will always sound better than a $300 model." Rosenburgh is overlooking the fact (mentioned in the column) that two sets of ABX tests were conducted. The second dealt with costly players, but the first set dealt with machines ranging in price from a $450 Emerson (frequently discounted to $200) to a $1400 Meridian. On both occasions the ability of listeners to differentiate between any two CD players to a statistically significant degree, 75% of the time, with music as opposed to test signals, was rare. As a case in point, listeners could distinguish between the Emerson and a $13000 reference Sony 26 out of 40 times with orchestral music and 21 out of 40 times with jazz. The same listeners could distinguish the Sony from the Meridan 21 out of 40 times with orchestral music and 20 out of 40 times with jazz. The averages were thus 51% and 59% for the Meridian and the Emerson, respectively. A 50% average could be achieved by pure chance. The only conclusion we can reach from those tests is that there are subtle sonic differences between CD players, but the differences between cheap and expensive players are no great-



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TEST PROBES INC. 9178 Brown Deer, San Diego, California 92121. Call toll-free for catalog: 1-800-368-5719.

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TEST PROBES INC. Call toll-free for catalog: 1-800-368-5719.

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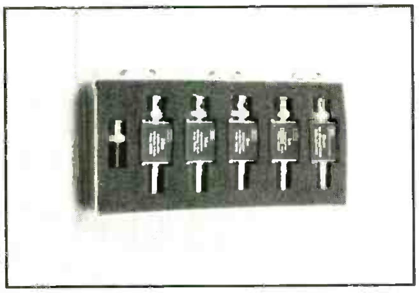

BNC ATTENUATOR KIT

Contains 4 attenuators — 3dB, 6dB, 10dB, 20dB; 1 feedthrough and 1 termination. Thick-film circuitry for low reactances. Rugged design resists shock and lasts longer. Rectangular shape stays put on the bench. **Impedance:** 50Ω **Frequency:** 1GHz. **Maximum Power**: 1kW peak, 1W avg. **VSWR** 1.2:1. Attenuator Accuracy:±0.2dB. Terminations Resistance Tolerance: ±1%. $150.
TEST PROBES INC. Call toll-free for catalog: 1-800-368-5719.

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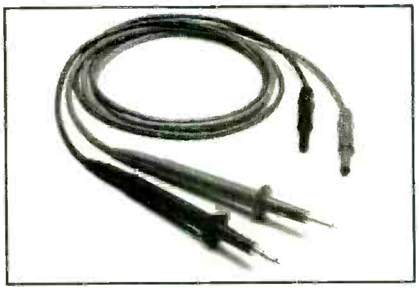

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CIRCLE 123 ON FREE INFORMATION CARD

er than the differences between any two expensive players. On the second testing, listeners expressed a subjective preference for a $750 Denon over a $2500 Tandberg.

TOM GORDON
Berkeley, CA

TAPE-DECK SPEED

As a long-time audio hobbyist, I've followed Larry Klein's articles for many years. I particularly agree with his contention that there is no discernible audio difference in the sound quality from CD players over a wide range of retail prices. I work with people who contend that my hearing must be hopelessly messed up because I hold that view! They claim that the differences are easily heard, as are the differences between (even new) pre- and power-amplifiers. None of them, however, can agree on precisely what constitutes "the best" or "the most accurate" sound. All they know, they say, is that different pieces of equipment sound "different."

I strongly disagree. I can readily hear pronounced differences between different brands and models of phono cartridges and loudspeakers, but I find that those whose specifications show their responses to be flatter, with low harmonic and phase distortion over the widest frequency range, sound the most natural. Few, if any, of the mid- to high-priced models produce unpleasant sound reproduction.

The real problem, I believe, is that no sound recording and production system I have ever heard can come close to making me think that there is a live acoustic instrument, voice, or scene being listened to. I can walk into a crowded disco and know instantly if the band is live or recorded. Loud acoustic instruments are absolutely unmistakable even in a high-nose environment. Recorded sound is no more real than a photograph. I know only what the original probably sounded like, just as I can appreciate a picture as a reasonable representation of the original scene. No more, no less.

I fully support the ongoing efforts of all audio researchers in their quest for "real sound." Great strides have been made, and the equipment that is widely available today represents superb value and high reliability. For the same money I spent on a receiver 15 years ago, I can buy one today whose performance and reliability are tremendously improved.

I'd like to suggest a simple method to determine whether a tape deck is running at the wrong speed, or if its speed is varying over the long or short term. I have noticed that few, if any, low- or medium-priced cassette decks include tape-speed accuracy in their specs. Since tape speed determines absolute playback pitch, accuracy is very important. I've recorded a 440-Hz tone on normal tape, using the most expensive cassette deck I could find. I play back the tape on the cassette player to be tested, and check the frequency with a guitar tuner—a relatively cheap device that can be found at any musical instrument store. The indicator (LED or meter needle) quickly shows if the playback machine is running at the same speed as the machine on which my tape was recorded, and if there is any noticeable speed variation on playback. A speed difference or variation of ±0.25% (1 Hz) is readily

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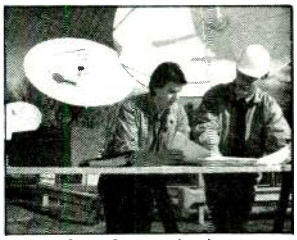

Data Communications

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Avionics

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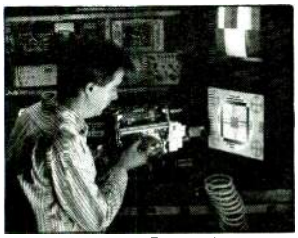

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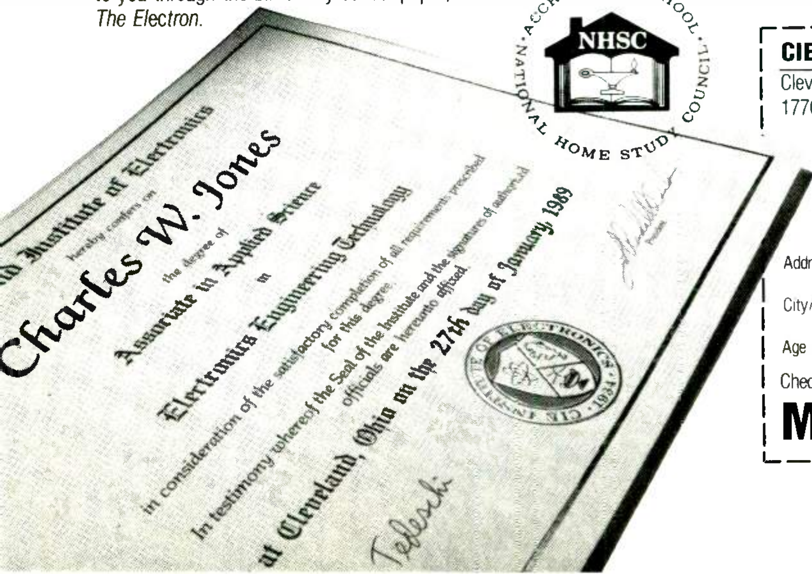

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seen. Speed adjustments are made as easily as tuning a guitar string (provided the user knows which pot to turn) just by watching the meter and setting it to 0, or 440 Hz.

Is this a recognized method of assessing cassette-tape speed? If so, do you know where I can obtain a pre-recorded tape with the 440-Hz tone at exactly the correct speed?
GEOFF SALE
Burnaby, B.C., Canada

Thanks for your comments and kind words. I agree wholeheartedly with most of your comments. Your technique seems reasonable to me, although I can't be sure without trying it (which I'm not set up to do at this time). For very high quality reference tapes of all types, request a catalog from Magnetic Reference Laboratories, 229 Polaris Avenue, Suite 4, Mountain View, CA 94043 (415-965-8187).—Larry Klein, Audio Editor

THERMOELECTRIC ENTHUSIAST

I am one of those "arcane" engineers who thinks that thermoelectric modules are one of the greatest things to hit the planet in a long time (*Hardware Hacker*, **Radio-Electronics**, January 1990), along with the U.S. space program, the French railways, and the U.S. submarine fleet. For one thing, the hot side of the thermoelectric module can always be kept at an ambient temperature by water cooling its heat sink. (My unit runs at 5°F above ambient with an extremely small "hot" sink and *air* cooling.) My unit was put into service in 1976 and has an excellent refrigeration record. Also, eliminating compressors, freon, plumbing ammonia, CO_2, and ozone destruction more than compensates for any supposed limitations. And finally, yes, my unit does make ice, at about the same rate and time as my freon refrigerator.
J. LINDNER
San Jose, CA

PCjr DOCUMENTATION

I was pleased to read in Shawn Bobbit's letter (*Letters*, **Radio-Electronics**, February 1990) that he recently purchased an IBM PCjr, and was sorry to learn of his difficulty in obtaining technical information regarding the PCjr. In fact, technical literature is available for all of IBM's Personal Computers, including the PCjr. The "Hardware Technical Reference Manual for the PCjr" is listed in the current directory of technical literature for IBM's PC's. A call to the toll-free number (800-IBM-PCTB) confirmed that the manual is currently available.

I hope this information comes in handy for Mr. Bobbitt and other **Radio-Electronics** readers.
JOHN R. SOMMA
IBM Corporation
White Plains, NY

LEFT-RIGHT IMBALANCE

In regard to Larry Klein's discussion on L-R speaker imbalance, I have found that the problem is often due to the values of the capacitors in the crossover networks; they shift over time. Also, all connections from the amplifier output to the speaker itself must be good. A poor connection anywhere in the line will cause a considerable loss of power to that speaker.
JOHN S. COX
Vancouver, BC
R-E

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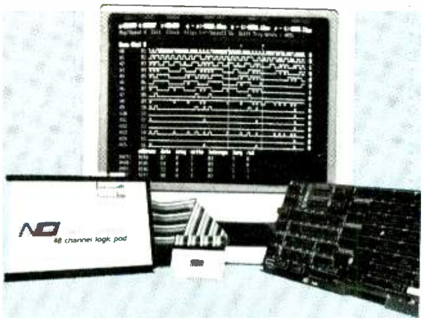

ONE OF THE OFTEN-IGNORED RESULTS of the "computer revolution" is that PC-based instrumentation is rapidly taking over many phases of product development. Today, an engineer working at his PC can design, debug, and test a new product. A good example of how it's happening is the *PA480* PC-based logic analyzer from NCI (6438 University Drive, Huntsville, Alabama 35806).

The *PA480* consists of a main logic-analyzer card, an interface cable, and an acquisition pod. The main card plugs into a free slot of a PC. A DIP switch allows the user to change the address at which the card resides to avoid conflicts with other boards that may be installed in the computer. After the board is installed, a 60-conductor flat ribbon interface-cable is attached to it at the computer's rear panel. The other end is attached to the pod.

NCI PA480 COMMAND MENU Copyright (C) 1989

Assembly	Display disassembled microprocessor instructions
Numerical	Display trace as numerical data
Diagram	Display timing diagram
Record	Store or load setups and traces to and from disk
Format	Set up clocks, channel names, field formats, card address
Trigger	Set up trigger values and trigger delay
Sequence	Set up sequence of occurence of triggers
Go	Go start tracing

Note Commands are entered by typing the first letter of the command.
Esc always exits to the next highest command level (H) for help

FIG. 1

Using the analyzer

Once the simple mechanical installation is complete, the computer is powered up, the pod is connected to the circuit of interest, and the operating software is run. While the software is dependent on the particular pod being used, a representative example of the main or command menu is shown in Fig. 1.

The best way to explain the operation of the analyzer is to look at each of the main menu commands, although not necessarily in the order they're presented. The first one we'll look at is the GO command, which initiates the acquisition of data and the generation of a new *trace*, the pictorial display of data.

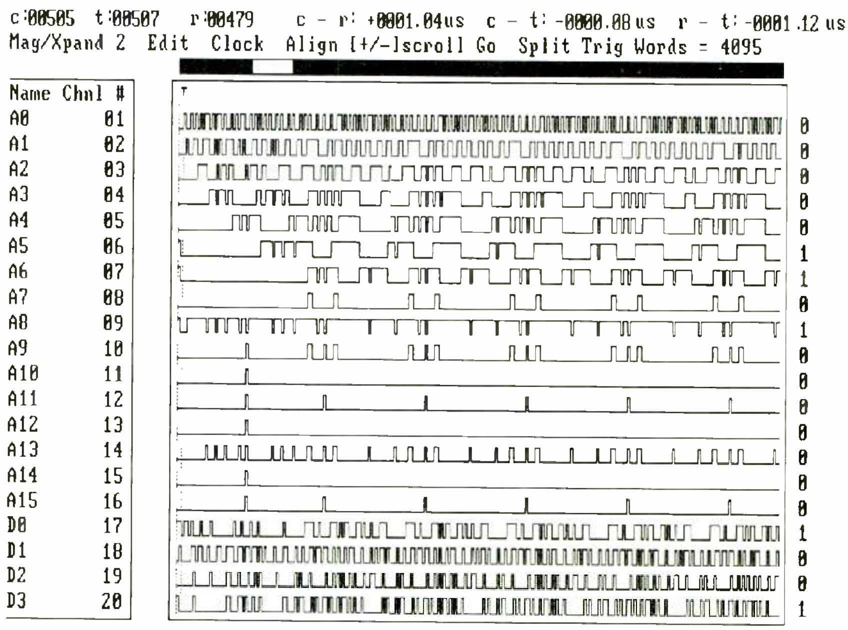

FIG. 2

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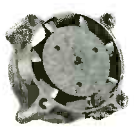

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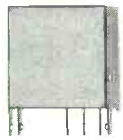
Operates On 12VDC

Tiny, tough and efficient! Rated 150 mA. 1 9/16 x 1 9/16 x 13/16". #273-244

IR Detector

3.49



Module operates on 5VDC, board mountable. 5/8 x 1/2 x 19/32". With data. #276-137

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Install and remove 6-pin to 40-pin DIPs without damage. Works with LSI, MSI, and DIP devices. Both tools are groundable. #276-1581

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(1) **99¢**

(2) **8.99**

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3-Amp "Barrel" Type Diodes

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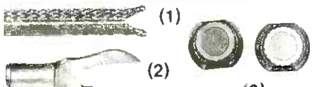
Type	Peak Inverse Voltage	Cat. No.	Pkg. of 2
1N5400	50	276-1141	.99
1N5402	200	276-1143	1.19
1N5404	400	276-1144	1.29

Speaker Stuff



(1) **MEGACABLE™.** Hi-wattage, 12-gauge. #278-1268 . . . **Per Foot 99¢**
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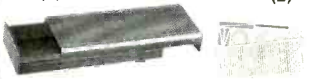
Dress It Up



(1) **Classy Two-Piece Enclosure.** Accepts PC board and 9V battery. 5 5/8 x 2 1/4 x 1 1/16". #270-257 . . . 4.99
(2) **Project Labels.** Four 7 7/8 x 3" sheets of rub-on letters and symbols. #270-201 . . . . **Set 2.99**

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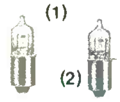

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(1) **HPR50.** For 4-cell flashlights and 6-volt lanterns. #272-1189
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(6) **1/8" Plug.** #274-857 . . . . . 2.79
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(8) **3-Conductor 1/4" Inline Phone Jack.** #274-859 . . . . 3.99

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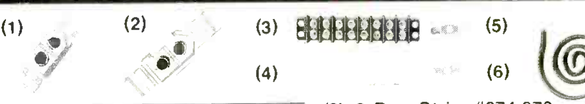
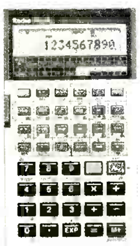


Fig.	Pos.	Type	Amps	Cat. No.	Each
1	2	Male	20	274-151	.99
-	6	Male	15	274-152	1.69
-	12	Male	12	274-153	1.99
-	2	Female	20	274-154	.99
2	6	Female	15	274-155	1.69
-	12	Female	12	274-156	1.99

(3) **2-Row Strip.** #274-670 . . . 1.99
(4) **Jumper.** 8-pos. #274-650, 1.59
(5) **45° T-Lugs.** #274-645 . . 4/79¢
(6) **Dual Solder-Lug Adapters.** #274-644 . . . . **Pkg. of 4/79¢**
(7) **Heavy-Duty Bonded Wire.** 25 ft., 2 x 18-gauge. #278-1250 . . 3.99

Engineering Calculator



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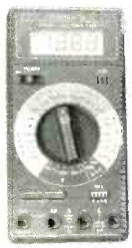

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Electromechanical —Counts to 99,999

One count per 12VDC pulse, pushbutton reset. Mounts in 1 11/16 x 1" hole. Depth: 1 13/16". With leads and data. #277-222

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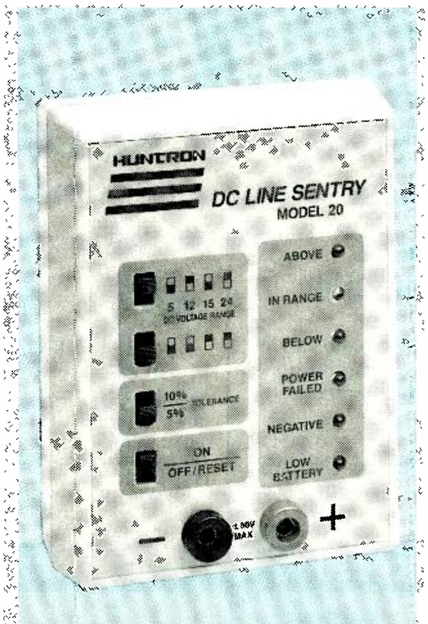


Huntron DC Line Sentry Voltage Monitor

Keep tabs on low-voltage DC power supplies.

CIRCLE 11 ON FREE INFORMATION CARD

ONE OF THE MOST DIFFICULT PROBLEMS for the technician to diagnose is the intermittent one. Often, the most effective way to catch the problem is sheer luck. In the absence of luck, expensive test equipment—such as storage scopes or chart recorders—must be called into action.

While intermittent problems can appear anywhere in a circuit, their causes can often be tracked back to the power-supply section. That's the idea behind the *DC Line Sentry* from Huntron Instruments, Inc. (15720 Mill Creek Blvd., Mill Creek, WA 98012). The *DC Line Sentry* lets you keep tabs on a power supply without calling out the "heavy artillery." It's an easy-to-use voltage monitor that can detect and "remember" whether a power supply stays within specified limits during the time it is monitored. If the power supply passes the test, yet an intermittent problem occurs, then you know to look elsewhere for the source of the trouble.

The *DC Line Sentry* is housed in a gray plastic case that measures roughly 4½×3¼×1½ inches and weighs about ½ pound. It's powered by a 9-volt alkaline battery. The front panel contains two input banana jacks, four slide switches, and 6 LED indicators.

To use the unit, the supplied test leads are inserted in the input jacks, and are hooked to the supply under test. A pair of switches is used to select one of the four test voltages: +5, +12, +15, and +24 volts. A third switch is used to select either a 5% or 10% tolerance range, and the fourth switch powers up the tester.

When the tester is turned on, the green IN RANGE LED should flash to indicate that everything's OK, and the *DC Line Sentry* is monitoring the voltage. If however, you accidentally hooked up the test leads backward, the red NEGATIVE LED would flash. You would then have to switch the leads and reset the tester with the power switch by turning it off and on.

The *DC Line Sentry* can detect any out-of-range condition with a duration greater than 50 milliseconds. If the supply voltage goes above the set limit, the ABOVE LED will flash. If the voltage then returns to its correct value, both the IN RANGE and ABOVE indicators will flash. As you might expect, an under-voltage condition will start a BELOW LED flashing, and a power failure will flash the POWER FAILED indicator.

A sixth LED is used to indicate battery condition. When the battery gets weak, the LOW BATTERY LED flashes. The indicator remains on steadily when the battery must be replaced. The estimated lifetime for a 9-volt alkaline battery is 2000 hours. That should be long enough to catch all but the most stubborn power-supply intermittent.

Huntron's *DC Line Sentry* is certainly not a revolutionary new piece of test gear. There is other equipment that can duplicate its functionality. Even some high-end digital multimeters can capture slow power-supply glitches.

Yet the *DC Line Sentry* has its advantages: It's extremely easy to use, and it lets the more expensive alternatives be used for more demanding tasks. With a suggested retail price of $125, it should find many applications in which it can prove its cost-effectiveness. **R-E**

LOGIC ANALYZER

continued from page 18

Once the data is acquired, there are several different ways to display it. The DIAGRAM command displays the captured data in the form of a timing diagram, as shown in Fig. 2. It should look familiar to anyone who has ever examined a data book or seen a logic analyzer in action.

A pair of cursors (which are barely visible at the left side of the diagram in Fig. 2) help to make measurements easier. Notice the numbers down the right side of the display. They indicate the value of the trace at the cursor position. As the cursor is scrolled through the display, those numbers change, as do the numbers across the top of the screen the indicate the position of the cursors and trigger, and timing differences between them.

The ASSEMBLY command displays any data that has been captured as disassembled microprocessor instructions. The command is specific to the pod being used. For example, if you used a 8088 pod, and captured data from the data bus of an operating 8088 microprocessor, you could display those data as the microprocessor's mnemonics.

The NUMERICAL command displays the data in a user-chosen numerical format, which is entered from the FORMAT menu. The user can divide the data from various channels into eight user-defined fields. For example, 16 channels could be used to examine the address bus of a microprocessor, while another 16 channels gathered data from the data bus. Each grouping of input channels can have an 8-character name, and the data can be displayed in hex, binary, octal, decimal, or ASCII formats.

Switching to the RECORD menu allows trace data, numerical data, setup conditions, and the like to be stored or recalled to or from disk. It is one of the features that become simple on PC-based systems.

The TRIGGER menu allows up to 16 trigger words to be entered, while the trigger SEQUENCE menu provides a powerful trigger selection and editing menu.

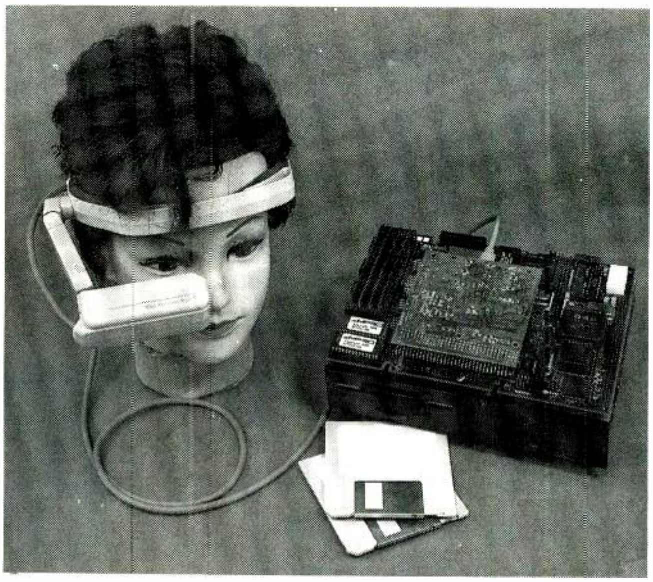
The trigger sequence can have up to 16 levels, and can use a total of 16

continued on page 87

NEW PRODUCTS

MINIATURE COMPUTER SYSTEM. *Ampro's MiniModule expansion board* couples their *Little Board/386, /286,* or */PC* single-board computers to *Reflection Technology's Private Eye* display (**Radio-Electronics**, February 1990) to form a complete system that takes up less space than a standard 5¼-inch disk drive. The Private Eye display uses proprietary technology to create an image of a 12-inch monitor in a miniature package that measures just 1.2 × 1.3 × 3.2 inches and weighs about 2 ounces. When held to the eye or mounted on a headset for hands-free viewing, the image appears to float in space in front of the viewer's eye with quality and resolution matching that of a PC display.

The new MiniModule/Private Eye provides the electronics to drive the Private Eye as an IBM CGA-compatible graphics display when used with any PC- or AT-based application software and one of Ampro's Little Board single-board systems. It features rugged, industrial-grade design, a wide operating temperature range (0–70°C), and CMOS construction for low power consumption (less than 0.5 watts) from the +5-volt supply. Each MiniModule is a 3.5 × 3.8-inch circuit board that attaches directly to a single-board system and interfaces via PC-bus-compatible signals.



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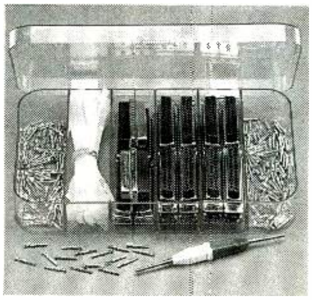
The small size and low power consumption open the door for a wide range of portable applications for the MiniModule/Private Eye with single-board systems, including telecommunications, portable terminals, mobile data displays, portable data-entry and -retrieval systems, medical electronics, industrial controllers, and maintenance and repair work.

The MiniModule/Private eye is priced at $250.00 in quantities of 100.—**Ampro Computers Inc.**, 1130 Mountain View/Alviso Road, Sunnyvale, CA 94089; Tel. 408-734-2800.

RS-232 CONNECTOR KIT. The 272-piece *RS-232 Commercial Connector Kit* from *Jensen Tools* is designed to simplify on-site fabrication and maintenance of RS-232 cable connectors. It can be used to make straight null-modem hookups and economical patchcord connections between keyboard and TNC for packet radio, and for many other DB25 patchcord applications. The kit includes 16 plug (male) and 6 receptacle (female) 25-pin connectors, one insertion/extraction tool, 50 cable ties, and a compact plastic storage box. Connector hoods are available separately.



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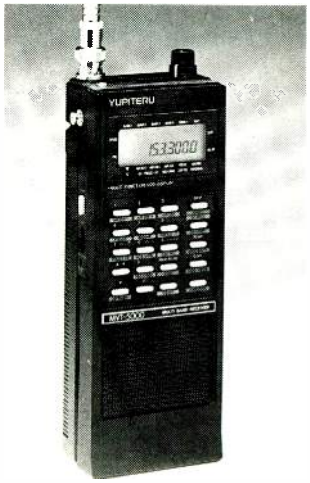
The RS-232 Commercial Connector Kit costs $69.50.—**Jensen Tools Inc.**, 7815 South 46th Street, Phoenix, AZ 85044; Tel. 602-968-6231.

MULTI-BAND RECEIVER. Providing continuous frequency coverage from 25–550 MHz and from 800–1300 MHz, *ACE Communication's MVT-5000* 100-channel hand-held receiver allows reception of civil and military aviation bands plus all public-service bands. AM or narrow FM reception modes are selectable at any frequency. Twenty front-panel keys allow programming of 100 scan memory channels. Pairs of upper and lower limits for bands to be searched can be stored in ten separate search memory locations. RAM memory is backed up by a long-life lithium battery. The *MVT-5000* offers an energy-saving "sleep" mode, in which the computer will actually power down all operating circuits and display the word "sleep" on the LCD, and power up only periodically to check for active transmissions.

The compact radio measures 7 × 2½ × 1½ inches and weighs only 13 ounces. It includes a 120–12-volt wall plug adapter/charger, a fused DC cigarette-lighter charger cord, a telescopic antenna, a carrying case, and AA-size rechargeable batteries.

The *MVT-5000* hand-held receiver has a suggested retail price of $499.00.—**ACE Communications**, Monitor Division, 10707 East 106th Street, Indianapolis, IN 46256; Tel. 317-842-7115.



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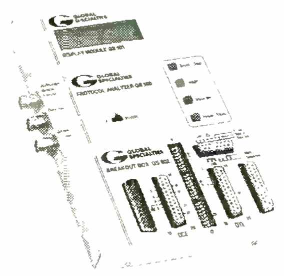
POCKET-SIZE DIGITAL MULTIMETER. *A.W. Sperry's DM-4200A* 3½-digit, rotary-switch digital multimeter offers pocket-size portability without skimping on features. It incorporates nine functions on 33 ranges. The instrument provides a diode-test function, battery test, and HFE transistor test. It features an instant continuity

CIRCLE 29 ON FREE INFORMATION CARD

buzzer, a built-in test stand, overload protection, 150-hour battery life, and recessed input terminals designed for safety. The *DM-4200A*, which comes with one set of test leads, a battery, and one installed fuse plus a spare, costs $64.95.—**A.W. Sperry Instruments Inc.**, 245 Marcus Boulevard, Hauppauge, NY 11788; Tel. 516-231-7050.

PROTOCOL ANALYZER SYSTEM. Designed for use in troubleshooting asynchronous serial data-communications systems, *Global Specialties' GS500* portable analyzer has extensive diagnostic capabilities to assist you in baud-rate analysis, data word format, ASCII or hex data monitoring, and test-data generation. It can operate in both automatic and manual modes, and is small enough for field-service applications. When it's connected to a standard oscilloscope, it provides a 32-character display.

When combined with the *GS501 Display Module* and the *GS502 Break-out Box*, the *GS500* is transformed into a complete portable, hand-held system, requiring no oscilloscope. The break-out



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box provides full breaking and patching of 25 lines, plus data monitoring of the analyzer's transmit and receive lines. Using the test-data generation mode, the system can be used to check the operation of printers, terminals, and other devices when a transmitting device is not available. The battery-powered system will typically operate for 100 hours.

The *GS500* analyzer, *GS501* display, and *GS502* break-out box cost $179.95, $99.95, and $119.95, respectively.—**Global Specialties**, 70 Fulton Terrace, New Haven, CT 06512; Tel. 203-624-3103.

HAND-HELD UNIVERSAL TIMER/COUNTER. A 10-digit frequency counter from *Optoelectronics* incorporates high-speed ASIC and custom LCD technology to provide direct-count frequency capability (1-Hz resolution in one second) to over 150 MHz. The model *UTC 3000* features switched prescalers to maximize resolution for frequencies to over 2.4 GHz, and multiple preamplifiers for maximum usable sensitivity to allow efficient antenna pickup measurements. A 16-segment bargraph displays input signal level to ensure reliable counting and to aid in RF security sweeps.

Front-panel controls include pushbuttons for gate selection (four gate times), function, and input selection, and also has hold, prescale, and direct-count select switches. Calibration and bargraph adjustments are accessible from the front panel, which also features a gate LED and a power switch. In addition to the frequency

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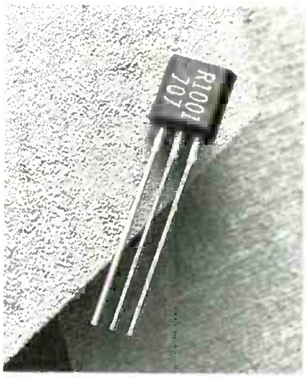
and bargraph display, the custom 120-segment LCD has annunciators for function, gate time, number of cycles averaged, units, and low battery voltage.

The *UTC 3000's* universal timer-counter functions include period, period average, time interval, time-interval average (0.1-ns resolution), and ratio. Both 50-ohm and 1-megohm input amplifiers are provided. The overall range is 10 Hz to 2.4 GHz. With its field-installable internal Ni-Cd battery pack (providing up to two hours operation) and its compact size (approximately 4 × 5⅓ × 1⅓ inches), the unit is highly portable. A 110-volt, 60-Hz wall plug adapter/charger is included. Options include four different antennas, three probes, a precision 0.2-ppm TXCO time base, a carrying case, and a second parallel battery pack to extend portable operation time.

The *UTC 3000* hand-held universal counter timer costs $375.00.—**Optoelectronics, Inc.**, 5821 N.E. 14th Avenue, Fort Lauderdale, FL 33334; Tel. 305-771-2050.

DIGITAL TRANSISTORS. For use in switching circuits, drivers, interface circuits, and inverters, and for interfacing with electromechanical systems, the "KSR" series of transistors from *Samsung* have built-in bias resistors. Eliminating the need for external bias resistors in their application



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circuits results in a significant saving of space.

There are 28 transistor types—half are NPN devices and half are PNP—available in three different styles of plastic packages. The *TO-92* and *TO-92S* packages have three long parallel leads extending from the bottom. The compact *SOT-23* is a plastic surface-mount package with minimal parasitic capacitance and inductance. Its small-outline package has gull-wing-shaped leads for base and emitter on one side and for the collector on the other side.

Unit prices are 5 cents apiece for the *TO-92* and *TO-92S* packages, and 6 cents apiece for the *SOT-23* packages, in quantities between 100 and 999.—**Samsung Semiconductor**, 3725 North First Street, San Jose, CA 95134-1708; Tel. 408-343-5400.

INFRARED DETECTOR. While conversion of infrared light to visible light is not new, most converters require batteries or other power supplies for infrared detection. *Com/Way Satellite Systems' IR Detection Card* makes use of a recent technological development to passively detect infrared light. The detector is a business-card-size device that has transmissive phosphor crystals heat-seal laminated at its center. Those crystals emit an orange glow when subjected to infrared light. The cards allow quick checking of remote-control devices for TV's, VCR's, satellite receivers, etc. They also can

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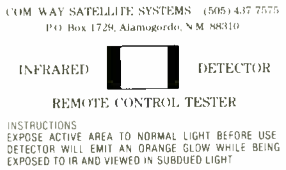
be used as warning sensors in laser labs, as they will flash if scanned by a laser beam.

The *IR Detection Card* costs $6.95 for a single sample. Custom printing is available on orders of 500 or more.—**Com/Way Satellite Systems**, P.O. Box 1729, Alamorgordo, NM 88310.



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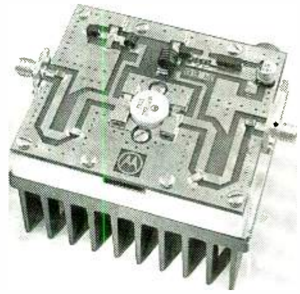
UHF POWER TRANSISTOR. Offering outstanding broadband characteristics and rugged packaging, the *MRF650* UHF power transistor is *Motorola's* first RF device to offer guaranteed gain and efficiency specifications at three frequencies—440, 470, and 512 MHz. Survival is guaranteed for severe load mismatches even when the device is subjected to high supply voltage and input signals 2 dB above normal. The transistor is packaged in the popular 6-lead flange.



CIRCLE 34 ON FREE INFORMATION CARD

The *MRF650* provides 50 watts of output power, higher than 55% collector efficiency, and more than 5-dB gain while operating from a 12.5-volt power supply. Suggested applications are in 12.5-volt base-station, commercial, and industrial amplifiers, and as a final amplifier in mobile radios.

The *MRF650* UHF power transistor is priced at $27.75 in quantities of 100 or more.—**Motorola, Inc.**, E-114, 5005 East McDowell Road, Phoenix, AZ 85008. **R-E**

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BUILD YOUR OWN UNIVERSAL COMPUTER INTERFACE. *By* B. Chubb. *309 pp., illus., softcover.* Guiding you from theory to step-by-step assembly instructions, this lively manual shows you how to construct a computer interface and hook it up to virtually any IBM or IBM compatible personal computer, including the XT, XT-286, AT, and System/2 Model 30.
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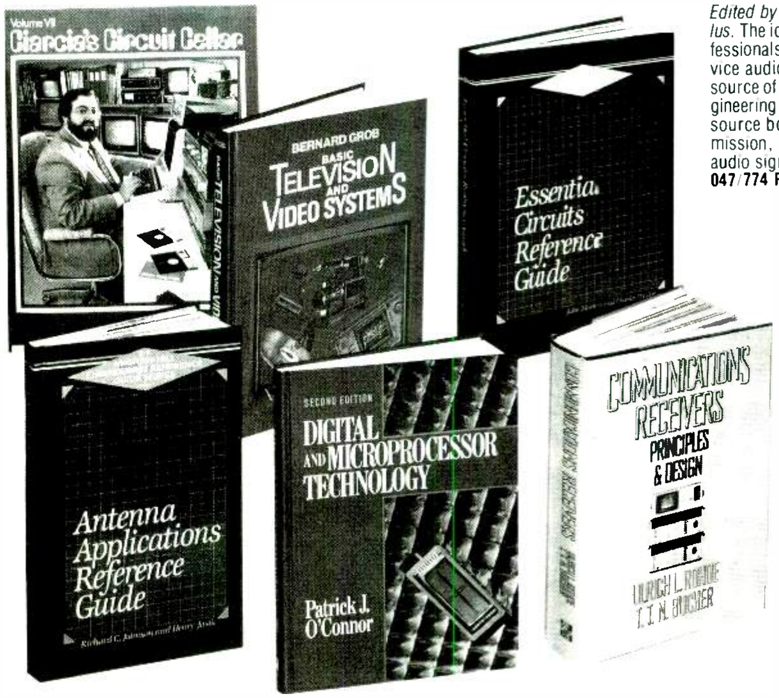

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Build the Lawn Ranger

Now you can sit back and watch your lawn mower cut the grass by itself!

Raymond Rafaels

PICTURE THIS—YOU'RE SITTING IN A HAMMOCK ON A WARM SUNDAY afternoon listening to your favorite radio station. You watch in amusement as your personal robot completes the last of your weekly chores. Only a dream? Not any longer, because now you can build a personal robot that can perform the world's most dreaded chore—lawn mowing. In the next few issues of **Radio-Electronics**, we will explain how you can build the Lawn Ranger, a patented battery-powered robot that can cut grass automatically while you and your friends watch in amazement.

The Lawn Ranger is *not* a remote-control lawn mower. It is a robot that can actually "see" the grass while it cuts. It may seem hard to believe, but the Lawn Ranger really can cut grass by itself. You may have already seen the Lawn Ranger on television or in periodicals such as the New York Times, USA Today, Machine Design, or others. Now, you can easily build and use the Lawn Ranger for your yard, or even start your own lawn maintenance business.

General description

The design of the Lawn Ranger is surprisingly simple. It consists of an aluminum frame, two electric cutting motors, two electric drive motors, a plastic top, a sensor assembly, two 12-volt batteries, and an electronic control system.

The metal frame provides the basic structure of the robot and is composed of ¼-inch thick 9091 aluminum. Attached to the frame are two caster wheels located in the front, and two geared drive wheels located at the rear. Each drive wheel is connected to a 24-volt DC gear motor through a spur gear interface. That "direct drive" approach allows the robot to be propelled by a durable drive system that does not rely on chains or belts.

The Lawn Ranger uses four permanent-magnet 24-volt DC motors. The two drive motors come with an internal gear box for speed reduction. The two cutting motors are synchronized by a timing belt to prevent the blades from coming in contact with each other.

The red top is molded from sturdy ABS plastic. For safety, a pressure sensitive bumper switch is attached to its outer edge. That switch will automatically shut the Lawn Ranger off if it comes in contact with trees or other obstacles. An additional push button shut-off switch is mounted on top of the robot for easy access by the operator.

The sensor assembly consists of 15 infra-red sensors mounted in front of the Lawn Ranger. Those sensors "see" your grass and provide critical

Lawn Ranger is a registered trademark of Technical Solutions, Inc.

TABLE 1—GRASS SENSOR DATA

Sample #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Byte 1								Byte 2						
	Sensor #														
1	1	1	0	1	0	1	0	1	0	1	0	0	0	1	0
2	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0
3	0	1	0	0	1	1	1	0	1	0	0	0	1	0	0
4	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0
5	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0

ward, the START signal will turn Q1 on and bring the STOP MOVE line low. When the robot shuts down, pin 8 of IC4-c and pin 6 of IC3-d will go low. That deactivates the input power relay.

Input/output

The CPU board uses two Z8420 parallel input/output or PIO chips labeled IC9 and IC10. Each chip has two 8-bit I/O ports that are software programmable. Bit 7 of Port B on IC10 is programmed as an output. That output line provides a gating pulse that is used to sample the sensor data. When the line goes high, the sensors are enabled and sensor information is passed to the motor-controller board for amplification. After the sensor data is amplified, it is sent to IC10 on the CPU board.

The bits of Ports A (0–7) and B (0–6) of IC10 are defined as inputs that are used to receive the sensor data. IC10 transfers the information to the Z80 microprocessor over the data bus for processing.

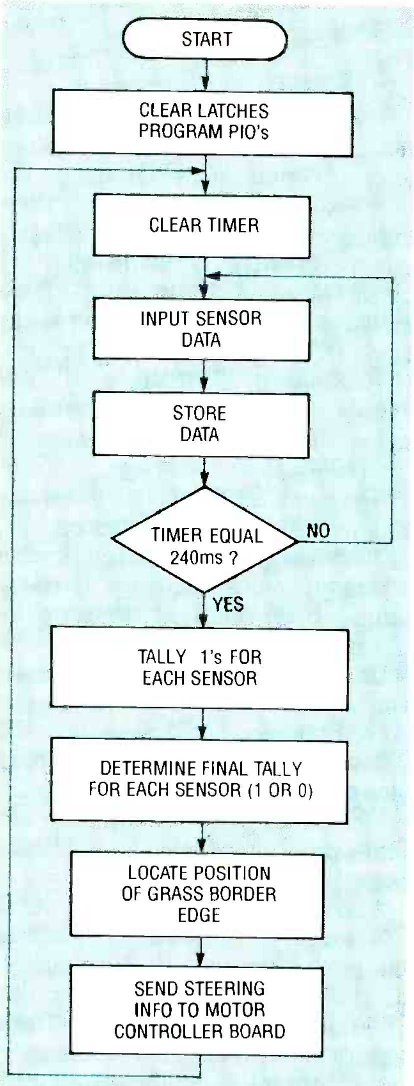

FIG. 5—SIMPLIFIED FLOW CHART of the computer program.

CPU construction and test

It is recommended that you use a PC board for the CPU, and you can either purchase one from TSI (it's a plated-through board that's hard to make—see ordering information), or you can make one from the artwork provided in PC Service. Also, the 2732A EPROM is preprogrammed and is available only from TSI. Using the parts-placement diagram of Fig. 7, first solder the IC sockets to the board, then solder the remaining components. Then, carefully push all the IC's into their respective sockets. And remember, that some of the IC's are CMOS, which must be handled carefully. Figure 8 shows a fully assembled CPU board.

Apply +5 volts to TP4 and ground to TP6. Place a scope probe at pin 34 of IC10; the scope should display a 1-kHz square wave. If you don't have a scope, verify that the voltages on pins 9, 10, 12, 13, 14, and 15 of IC9 read 0-volts DC. Now, as you temporarily ground pin 15 of IC10, recheck IC9 for 5 volts on pins 10, 13, 14, and 15, and 0 volts on pins 9 and 12.

If your board passes those tests, it

All resistors are ¼-watt, 5%, unless otherwise indicated.
R1, R2—1000 ohms
R3–R7, R12, R15, R17—2200 ohms
R8—not used
R9, R10, R19, R20—3300 ohms, SIP
R11, R18—3300 ohms
R13—22,000 ohms
R14—470,000 ohms
R16—47,000 ohms
R21—120 ohms
Capacitors
C1, C12—100 µF, 25 volts, electrolytic
C2, C3, C5–C9, C11, C13, C15, C16, C18—0.1 µF, ceramic
C4—56 pF, ceramic
C10—10 µF, 16 volts, electrolytic
C14—not used
C17—1 µF, 35 volts, electrolytic
Semiconductors
IC1—Z84C00-4PS microprocessor
IC2—74HCT04 hex inverter
IC3—74LS08N quad 2-input AND gate
IC4—74LS00N quad 2-input NAND gate
IC5—74LS32N quad 2-input OR gate
IC6—2732A 4K×8 EPROM (must be purchased from TSI)
IC7, IC8—2114L-2 1K×4 RAM
IC9, IC10—Z84C20-4PS parallel I/O
D1—1N4148 diode
Q1—2N3904 NPN transistor
Other components
XTAL1—2-MHz crystal
J5—10-pin IDC connector
S1—7-position DIP switch
TP1–TP6—individual pins or scraps of component leads
Miscellaneous: IC sockets
Note: The following items can be purchased from Technical Solutions, Inc., P.O. Box 284, Damascus, MD 20872 (301) 253-4933: PC boards for the CPU, motor-controller, power board, and motherboard, $39 each; programmed EPROM, $39 (contains computer program and firmware license); grass sensors, $8.99 each; hand-held manual controller kit, $39; full CPU-board kit, $129 (includes EPROM, PC board, and all parts); full kit for motherboard, $69 (contains PC board and all parts); kit for power board, $149 (contains PC board and all parts except DC/DC converters); full kit for motor-controller board, $169 (includes PC board and all parts); Lawn Ranger demo VHS tape, $19 (refundable for orders of $100 or more). Please add $8.00 for S/H (U.S. orders). Maryland residents add sales tax.

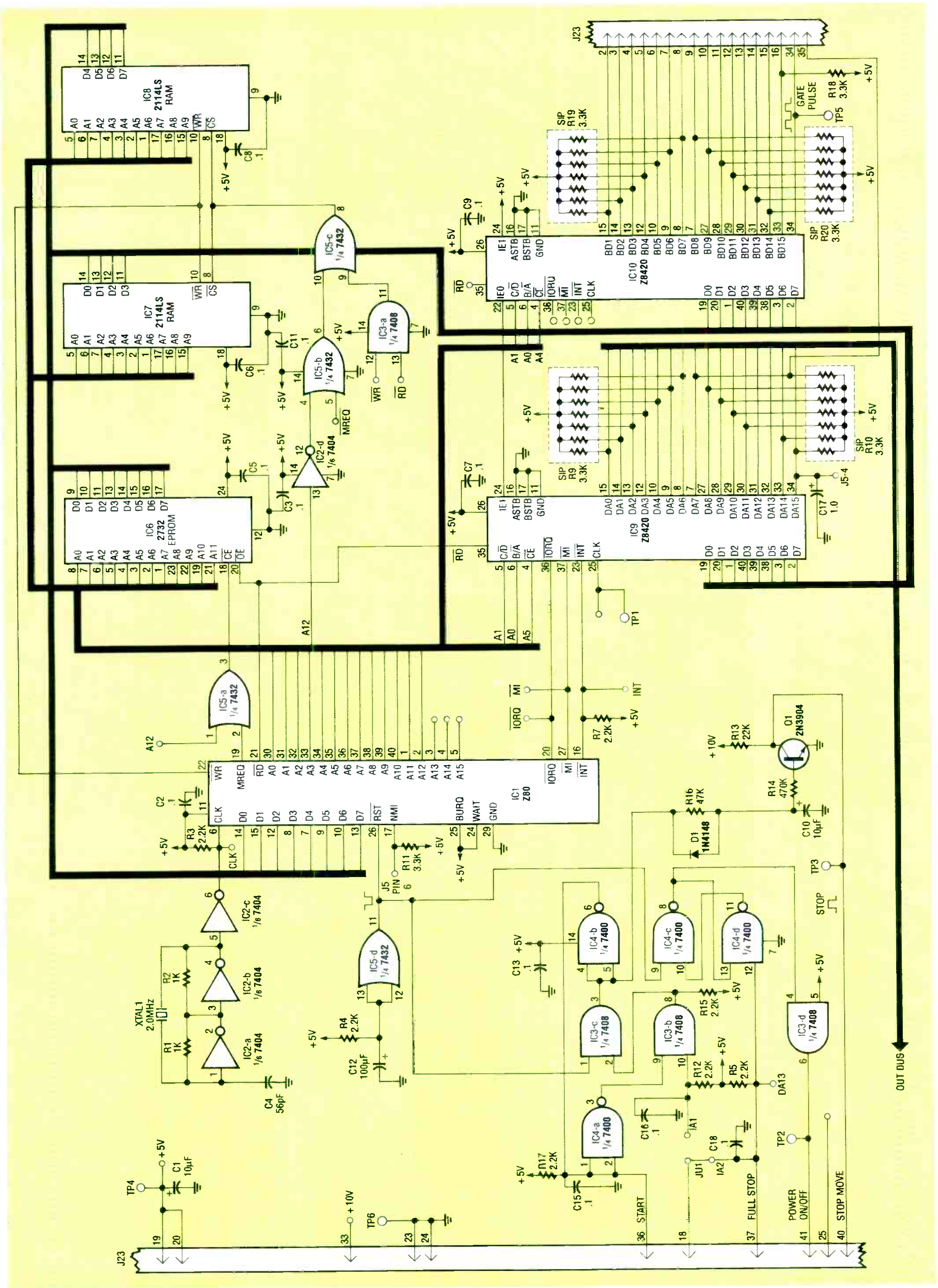

FIG. 6—SCHEMATIC DIAGRAM of the CPU board. Its purpose is to input all sensory information, and then tell the Lawn Ranger where to go.

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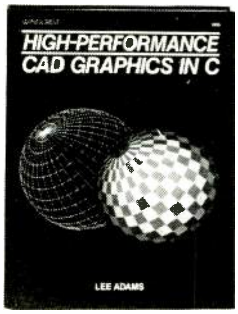

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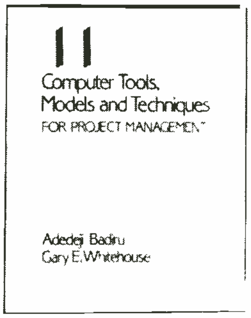

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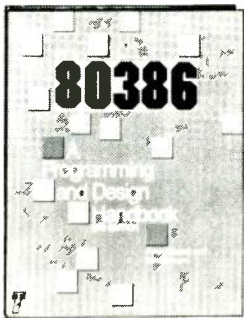

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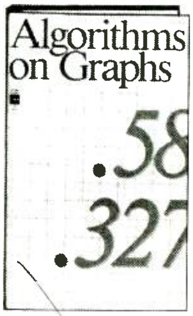

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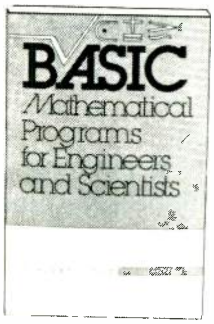

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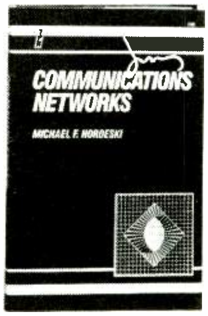

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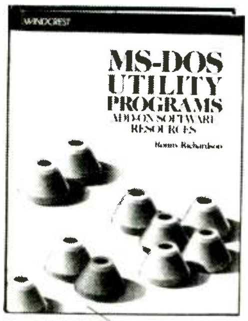

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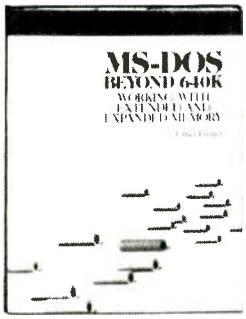

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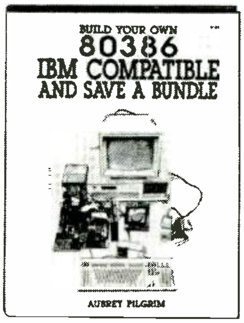

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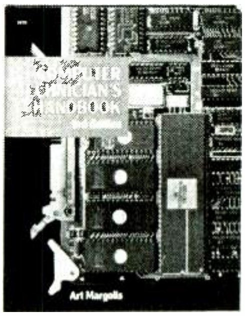

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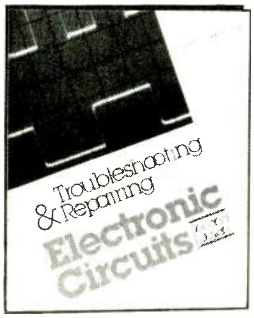

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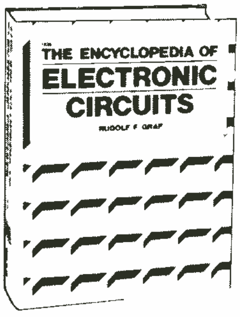

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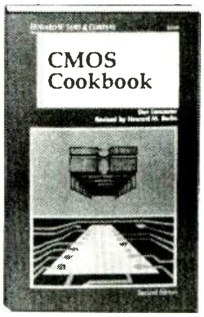

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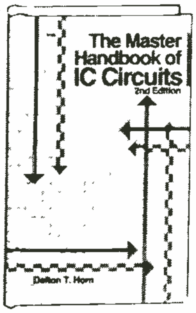

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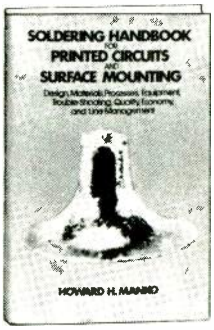

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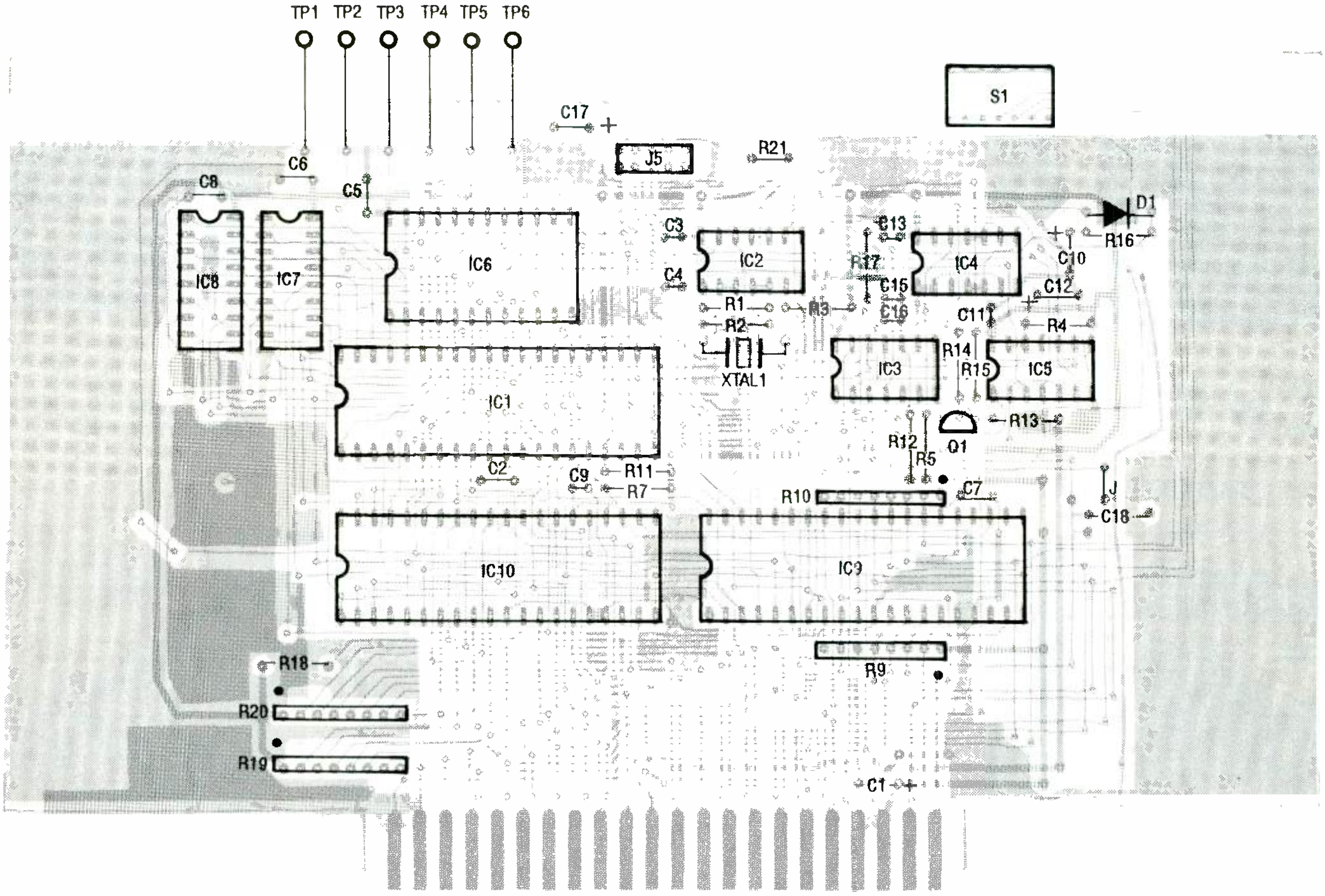


FIG. 7—**ASSEMBLE THE COMPONENTS** according to this parts-placement diagram.

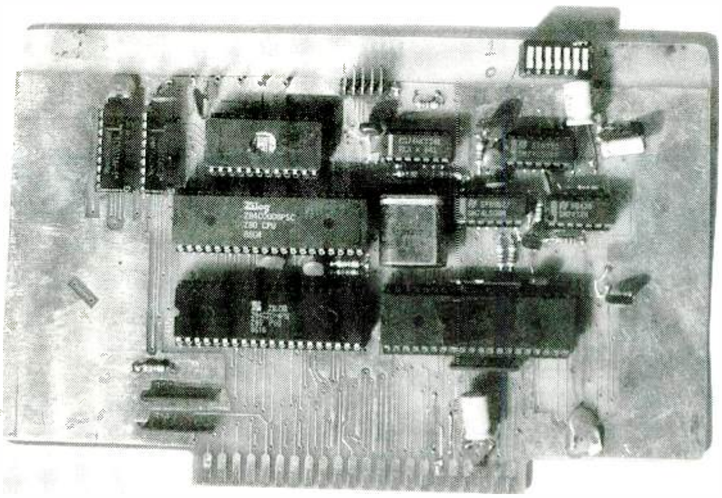


FIG. 8—FULLY ASSEMBLED CPU BOARD.

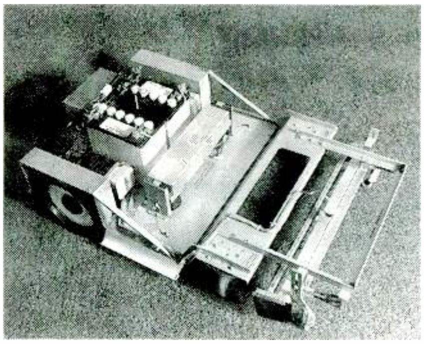


FIG.9—THE COMPLETE LAWN RANGER unit. We will get to the mechanical assemblies in later issues.

should be functioning properly. More extensive testing of the CPU can be performed after the motor controller, power board, and motherboard are assembled and tested.

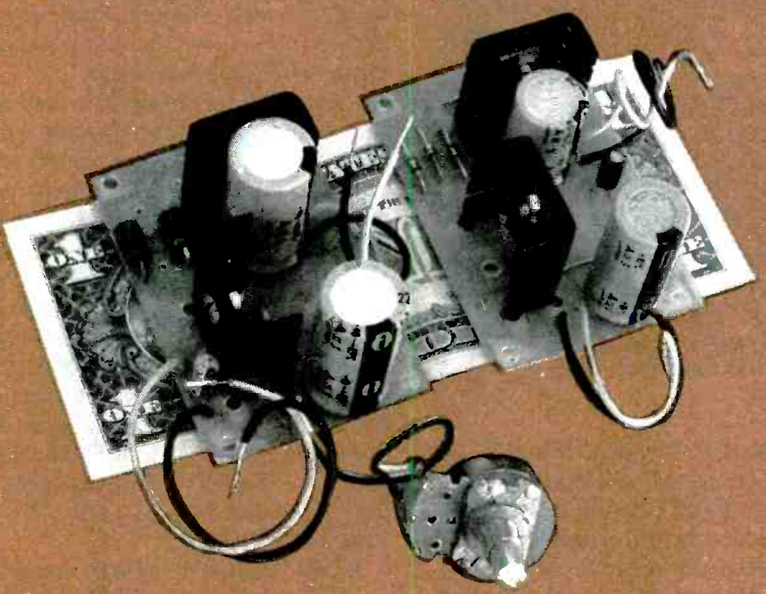
Still to come

In the next couple of issues of **Radio-Electronics** we will explain how you can finish building the Lawn Ranger. As far as the electronics portion goes, we've still got to build the motor-controller board, the power board, and the motherboard, which holds all of the other boards together. Then we have to build and wire the sensor assembly, put together the mechanical frame, and connect everything together.

By the way, for a sneak preview look "under the hood," of what the Lawn Ranger will eventually look like, Fig. 9 shows the complete mechanical assembly, without the cover. You can see that everything fits together in a nice, compact package.

For those of you who still doubt the Lawn Ranger's capabilities, a VHS demo tape can be purchased, showing the unit in action; it's sure to make you a true believer. The cost of the tape is refundable with an order (see the Parts List for details). **R-E**

BUILD A GENERIC LINEAR POWER SUPPLY BOARD



Why go through the trouble of designing a custom power supply every time you build a new project? This single PC board can fill all of your power-supply needs!

JOHN WANNAMAKER

ARE YOU TIRED OF LAYING OUT YET ANother PC board for some special power supply? Here's a possible solution to lessen the trauma: the EZ-DC generic power-supply PC board, designed to give you a choice of one or two linear supplies on a single 2 × 3-inch PC board. The layout is very versatile, and while one supply produces a fixed-positive voltage, the other can have any value desired. The choices are:

- Two fixed-positive supplies.
- One fixed-positive, and one adjustable-positive supply.
- One fixed-positive, and one fixed-negative supply.
- One fixed-positive, and one adjustable-negative supply.

Of those configurations, the supplies can be either half-wave or full-wave, when a transformer with a center-tapped secondary is used, or you can build a single full-wave bridge of either polarity. You can also make it adjustable or not, as you prefer. Dual isolated grounds are possible. For the TO-220/221A regulators, there are four different 3-terminal pinout configurations, which made the layout of the EZ-DC quite challenging. Whether or not to rotate the regulator 180° helped reduce the reconfiguration problem to one of selective placement of jumpers.

The EZ-DC is a good basis for a bench supply. With two PC boards, you can build two fixed-positive sources, an adjustable-positive source, and an adjustable-negative source, all with or without isolated grounds. Each supply provides for a milliammeter to be inserted at its regulator input. In one supply on each PC board, the meter replaces a jumper. In the other, two adjacent pads are provided for meter leads. The foil connecting the two pads has to be cut with a razor blade or X-acto knife to use the meter; the point is marked by an arrowhead and an "X."

Different power-supply types

• Separate fixed-positive full-wave supplies with common grounds. Figure 1 shows a dual, full-wave, fixed-positive supply, using a common ground. Fig. 1-*a* shows the pinouts of the two regulators, Fig. 1-*b* shows the schematic, and Fig. 1-*c* shows the parts placement diagram. Supply #1, on the lower half of the PC board, is always fixed positive. Supply #2, on the upper half of the PC board, can be varied in configuration, and is, in this case, also fixed positive. Since the center-tapped transformer supplies equal voltages to each regulator, the most efficient arrangement is for both IC's to regulate to identical (or nearly so) voltages, such as +12 and +15 volts.

Where the difference is considerable, as between a +5- and a +12-volt supply, the lower voltage regulator must drop 7 volts more than the higher one, and its load current must be limited accordingly. Since the voltage drop across the regulator is multiplied by the load current to determine the regulator power dissipation, the lower the voltage, the more current that's available. The less power consumed by the regulator, the more that's available to the load.

However, there has to be some drop across the regulator or it won't work. This is nominally 2 volts for the 78XX/79XX fixed-voltage series, and about 2.5 volts for the LM317/LM337 adjustable models. Also, the regulator needs a standby current of

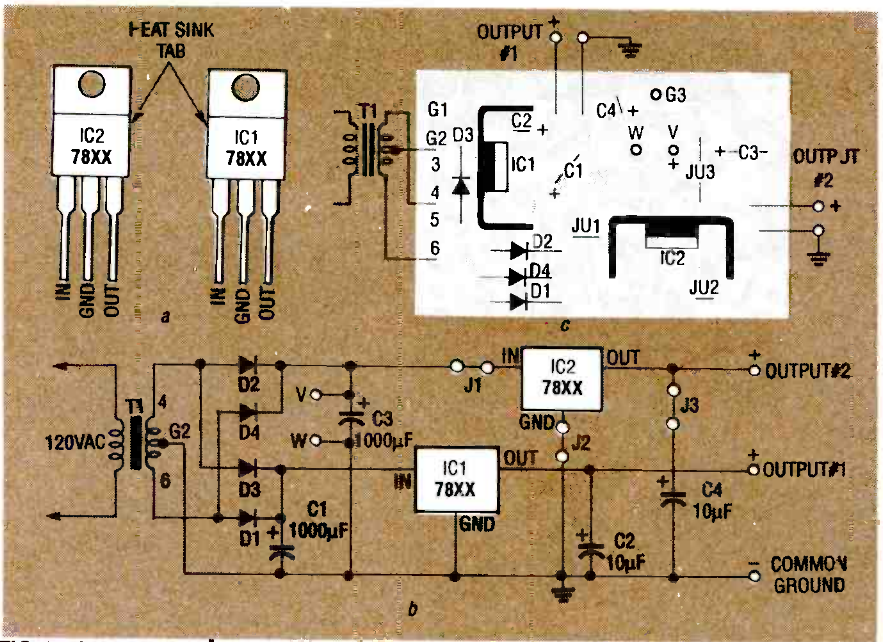


FIG. 1—A DUAL SUPPLY, WITH TWO fixed-positive sources. The pinouts of IC1 and IC2 are shown in (*a*), the schematic is shown in (*b*), and the parts placement diagram is shown in (*c*), with supply #1 on the bottom, and supply #2 on top. This same order of (*a*)–(*c*) is used throughout all succeeding figures, except Figs. 4 and 7.

3–10 milliamps, ignored here. Expect any current monitoring at the provided points to reflect this error.

A milliammeter would be inserted in supply #2 in place of jumper JU1, with the negative terminal connected nearest to the heatsink when monitoring a positive supply. In supply #1, connect the meter to the two pads near the right wing of the lower heatsink. Cut the foil between these two pads at point X as already mentioned. The negative meter lead goes to the pad nearest to IC1. Two pads V and W on both PC board and schematic are unused here. Extra filtering capacitance can be added here for supply #2, or these points can provide unregulated voltage for noncritical circuits. Pay attention to the polarity at point V which depends on the polarity of supply #2; point W is ground.

- **Separate fixed-positive and fixed-negative full-wave supplies.** In Fig. 2, supply #1 is fixed-positive as before. The difference is how supply #2 is jumpered, to accommodate a fixed-negative regulator, like the 79XX/79MXX series; the "M" denotes medium-power versions, which are harder to find. Since load currents of less than 500 milliamps are suggested to prevent overheating, you should try to find the "M" versions, if possible. Again, due to the transformer's equal voltage distribution, equal but opposite polarity regulators would be most efficient. Some general information on selecting the transformer will be given later.

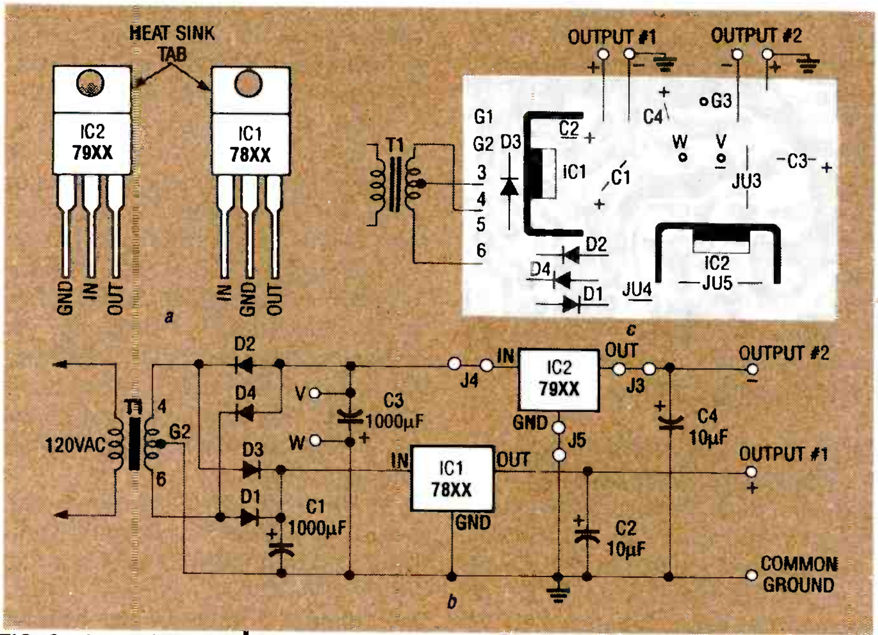


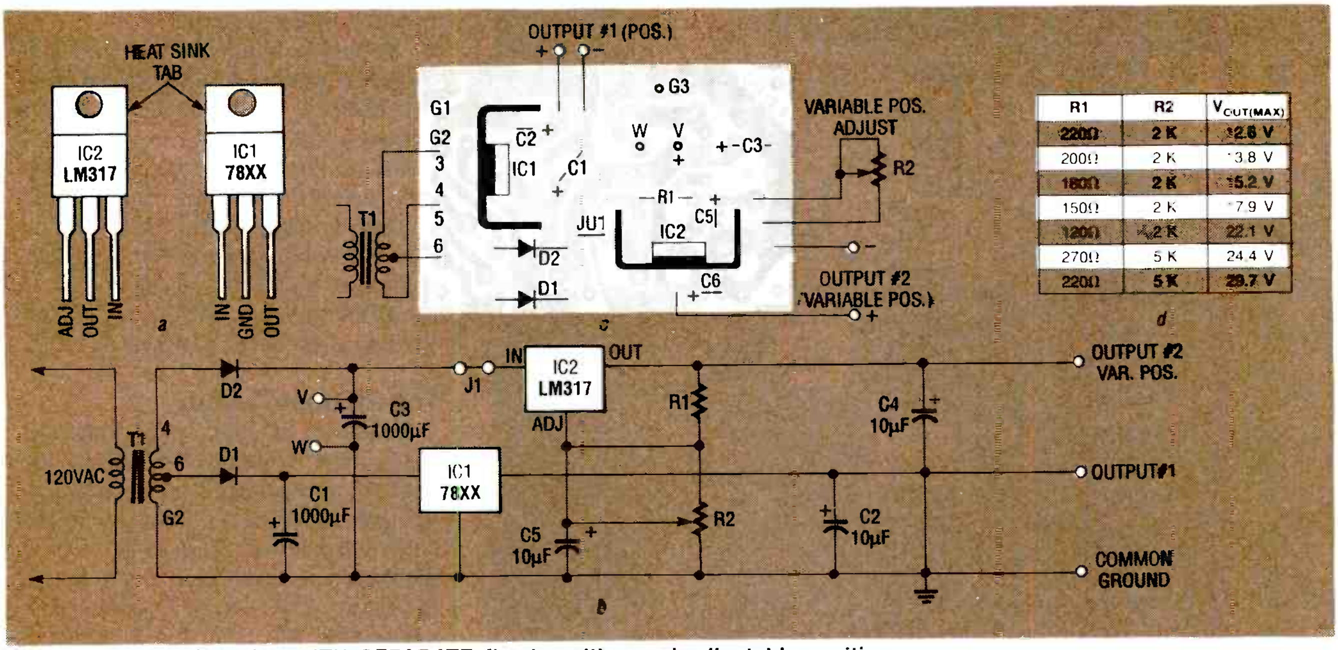
FIG. 2—A DUAL SUPPLY, WITH SEPARATE fixed-negative and fixed-positive sources. The organization of (*a*)–(*c*) is that of Fig. 1, but supply #2 has been made negative by reversing D2, D4, C3, and C4, and using a 79XX for IC2 in stead of a 78XX.

- **Separate fixed-positive and adjustable-positive half-wave supplies.** Figure 3 shows supply #2 with an adjustable regulator in a half-wave configuration, where both it and the heatsink are rotated 180° from the fixed regulator position. Don't use this version in applications where the load current exceeds 200 milliamps. Extra capacitance at V and W will give a smoother input to the regulator, but strains the transformer and diodes due to the higher half-wave charging currents. The accompanying table in Fig. 3-*d* shows $V_{2(MAX)}$, for different values of R1 and R2.

While current demands could be excessive, the voltage distribution with this arrangement may be advantageous. With one end of the winding grounded, the center tap supplies modest voltage for a low-voltage fixed supply, and the other end provides double that voltage from the adjustable supply. Where higher current is required, the diode and transformer arrangement shown in Fig. 4 is suggested instead.

- **Separate fixed-positive and adjustable-positive full-wave supplies.** The more features you want in any piece of equipment, the more it's going to cost, and the EZ-DC is no exception. The best transformer arrangement, shown in Fig. 4, uses two transformers with center-tapped secondaries, or a single transformer with dual center-tapped secondaries, if you're able to find one. The relevant segment of schematic is shown in Fig. 4-*a*, and the relevant segment of the parts placement diagram is shown in Fig. 4-*b*.

Supply #1 always has the layout shown in Fig. 1, and you can take the layout for supply #2 from any other version you prefer, in any of the figures. For example, copy the upper part of Fig. 2 for a fixed-negative supply (remember to reverse D2 and D4),



R1	R2	$V_{OUT(MAX)}$
220Ω	2 K	12.6 V
200Ω	2 K	13.8 V
180Ω	2 K	15.2 V
150Ω	2 K	17.9 V
120Ω	2 K	22.1 V
270Ω	5 K	24.4 V
220Ω	5 K	29.7 V

FIG. 3—A DUAL SUPPLY, WITH SEPARATE fixed-positive and adjustable-positive sources. Supply #2 is now made adjustable-positive, changing the jumpers as indicated, changing IC2 to an LM317, adding potentiometer R2, and shifting the other parts as shown. Also, only D1 and D2 are used, and the secondary of T1 is rewired. The accompanying table in (*d*) shows $V_{2(MAX)}$, for different values of R1 and R2.

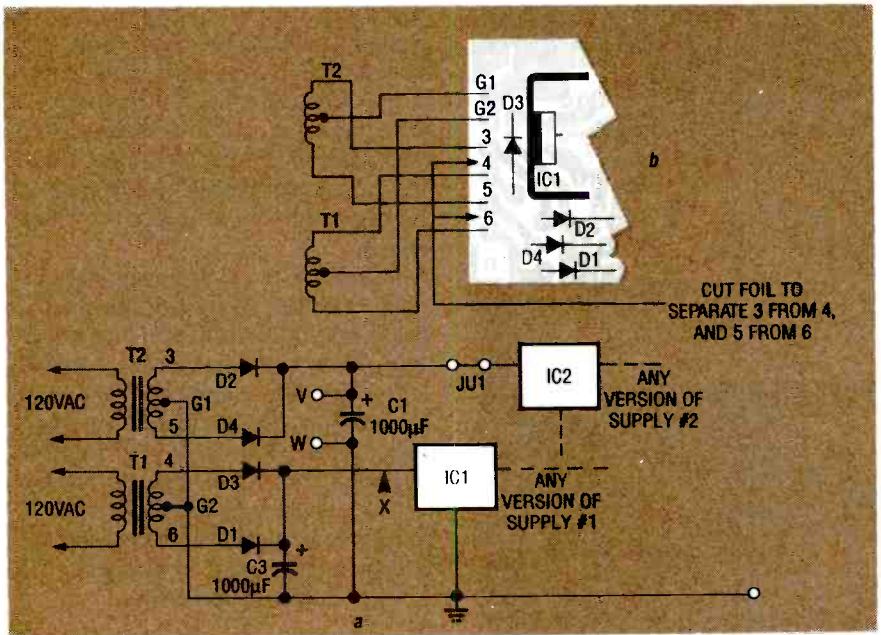


FIG. 4—DUAL FULL-WAVE RECTIFICATION for a fixed-positive supply #1, using either two single-secondary transformers, or a single dual- secondary version; (*a*) is the relevant segment of schematic, (*b*) is relevant segment of the parts placement diagram. Only the lower half of the PC board (supply #1) is shown; you can design the upper half (supply #2) as you wish. For example, copy the upper half of Fig. 3 for an adjustable-positive supply, or the upper par of Fig. 5 if you want an adjustable-negative dupply (remember to reverse D2 and D4).

or the upper part of Fig. 3 for an adjustable-positive supply, or. If you'd rather calculate your own values than use those provided in the table accompanying Fig. 3, use the following formula:

$$V_2 = 1.25 \text{ volts} \times [1 + (R2/R1)].$$

For best results, keep: R1<240 ohms. There's no way to control the minimum output, which should be about 1.25 volts.

● **Separate fixed-positive and adjustable-negative half-wave supplies.** A version with dual half-wave supplies, one fixed-positive and the other adjustable-negative, is shown in Fig. 5. It's got the same limitations as the version shown in Fig. 3. For the greater current a full-wave supply can provide, use the rectifier arrangement shown in Fig. 4 (reversing D2 and D4), with the layout shown in Fig. 5. If you use a transformer with no center tap, D1 is connected as shown by the dashed lines. In that case, jumper pad 3 to pad 5 with JU7, and remove the connection to pad 6.

The output pad is closer to the heatsink than you might prefer, but all patterns have multiple output points. Examine the foil pattern and select your own output pad. Always select a ground nearest the filter capacitor's ground connection to minimize hum, and use separate grounds for each supply.

● **Separate fixed-positive full-wave supplies with isolated grounds.** The arrangement for isolating the grounds between full-wave recitifiers is shown in Fig. 6. While this version has dual fixed-positive supplies, that needn't be the case. Use any version for supply #2 you want, but watch the diode polarities. Cut the foil at the "Z" by the ground foil, and then the transformer secondary pads, isolating 3 from 4, and 5 from 6.

Arrowheads on the foil side show the exact points to cut. If you connect the supplies in series, the total output voltage is the sum of both. You can assume both regulators to be passing identical currents, but not necessarily dissipate the same power, since their regulator drops may differ.

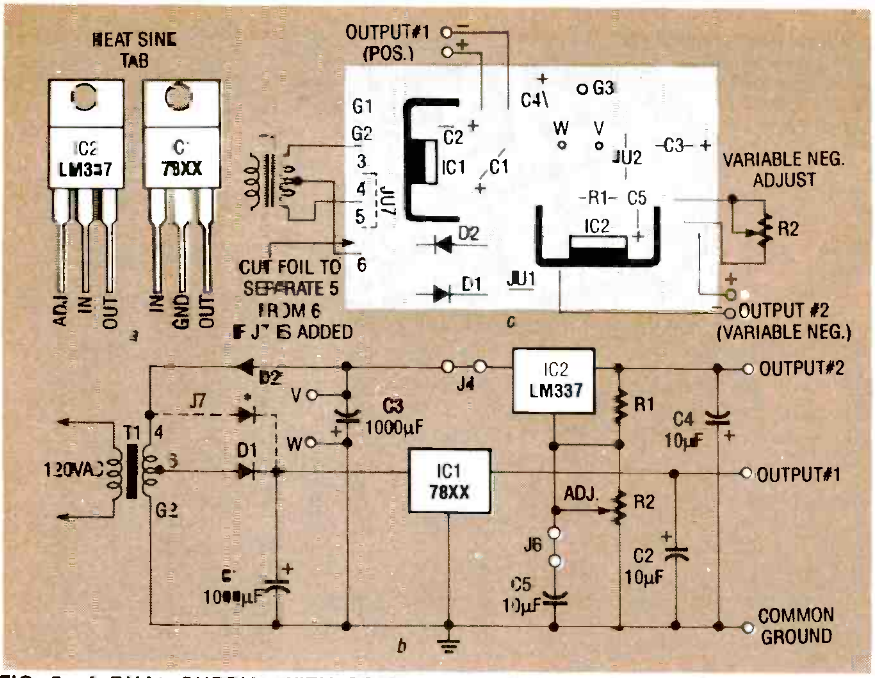


FIG. 5—A DUAL SUPPLY, WITH COMBINED fixed-positive and adjustable-negative sources; it has the same limitations as Fig. 3. For greater current, use the full-wave approach of Fig. 4, with the layout shown here. The D1 shown using dashed lines is connected this way for a transformer with no center tap. In that case, jumper pad 3 to pad 5 with JU7, removing the connection to pad 6.

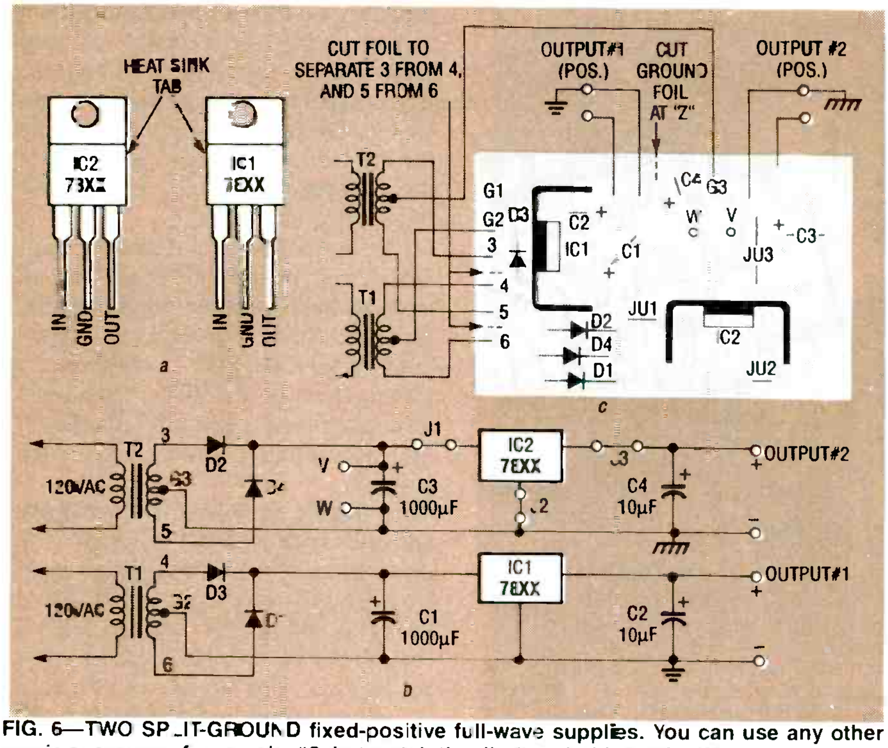


FIG. 6—TWO SPLIT-GROUND fixed-positive full-wave supplies. You can use any other version you want for supply #2, but watch the diode polarities. With a razor blade or X-acto knife, cut the ground foil at the "Z." Then, cut the transformer secondary pads at the arrowheads, isolating 3 from 4, and 5 from 6. If you connect the supplies in series, the total output voltage is the sum of both. Assume both regulators pass identical currents, but don't necessarily dissipate identical power, since their regulator drops may differ.

• **A single full-wave bridge supply.** The connections for a full-wave bridge are shown in Fig. 7. Figure 7-*a* shows the relevant segment of the schematic, and Fig. 7-*b* shows the relevant segment of the parts placement diagram. Don't forget JU8 where an electrolytic would normally go. Again, use the top of the PC board for any version, whether positive, negative, fixed, or adjustable—but note the the diodes are shown for a positive supply and must all be reversed if yours is negative.

• **Separate fixed-positive and adjustable-positive supplies from a car battery.** Figure 8 assumes that you use a standard +5-, +6-, or +8-volt regulator for IC1, and an adjustable version for IC2; the output of the second regulator is adjusted by R1 and R2. The accompanying table in Fig. 8-*d* gives V_2 to within 50 millivolts for different values of R1 and R2, but you can also use the previous formula.

The PC board layout

To ensure that the wide ground foil holds hum to under 1 millivolt, the best soldering layout was sacrificed; you may need to use more heat and solder than usual. Use 4-40 or 6-32 machine screws in the corner holes for mounting. One corner is attached to the ground foil as a metal spacer to electrically connect the PC board to a metal chassis. If you don't want to use it, cut it away.

The heatsinks are electrically connected to the middle pin of each regulator. For a fixed-positive model, it's ground, but it's different in each case; for example, it's the unregulated input in the adjustable-negative model. A little heatsink silicone grease will help transfer about 20% more heat, and can be worthwhile—especially if the regulators are sourcing very high current.

If you use the recommended heatsinks with the three through-the-PC board tabs, be careful you don't bend them underneath and cause a short. Space was left hoping to avoid this, but watch it. The regulators are fairly close to the edges of the PC board to possibly heatsink to a metal cabinet with a screw. Measure the tab's potential, to be sure it's grounded, and use insulation if needed. If you want full 1-A load current, use a fan.

Selecting components

Don't consider the following the last word on how to select power-supply parts. This is an abbreviated method to keep you from going very wrong with practical advice from personal observations. The transformer is a good starting point because they're "iffy," at best. Consider the secondary voltage; for example, a 10-volt secondary. With little or no load, you may measure up to 12 volts. If the line voltage is 5% high, you'll measure 12.6 volts. Isn't that reasonable with

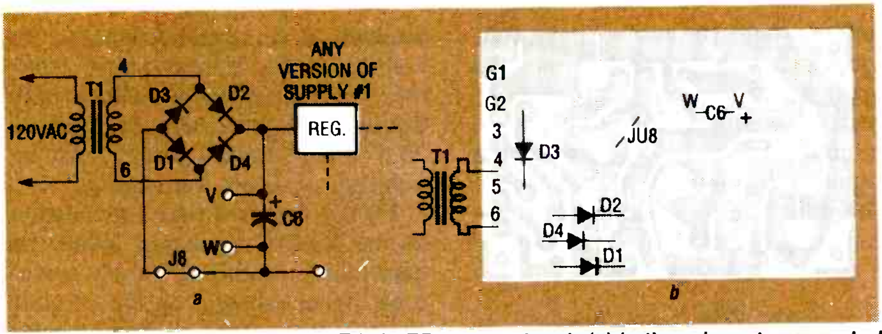
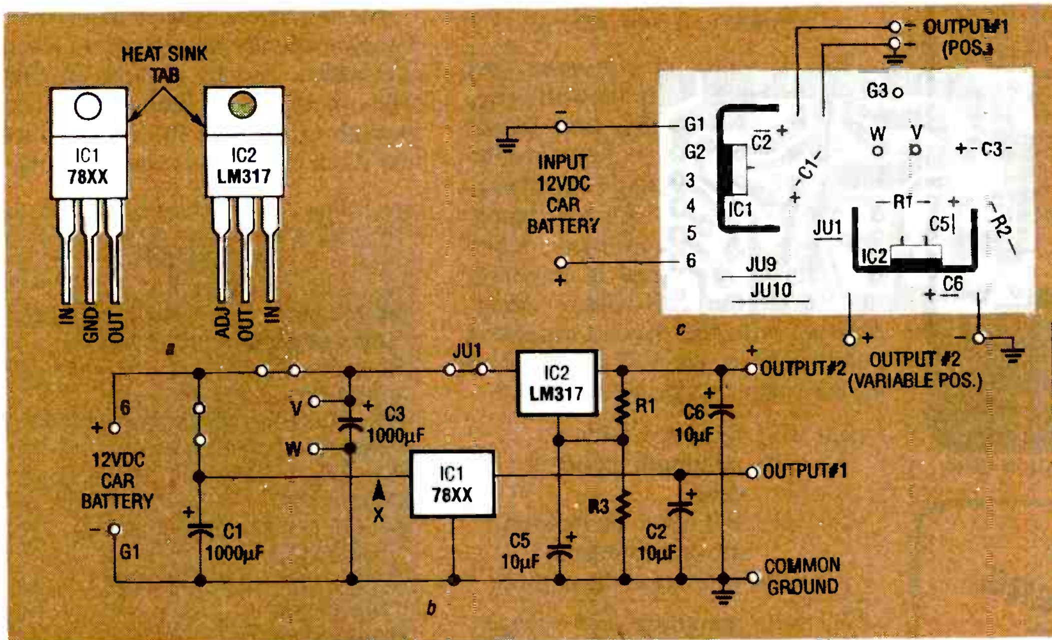


FIG. 7—A FULL-WAVE BRIDGE RECTIFIER as supply #1; (*a*) is the relevant segment of schematic, (*b*) is the relevant segment of the parts placement diagram. Remeber to reverse D1–D4 for a fixed-negative version. The connections for a full-wave bridge are shown in Fig. 7, and don't forget to add JU8. You can also make supply #2 on top any version, whether positive, negative, fixed, or adjustable.



R1	R2	V_{OUT}
220Ω	270Ω	2.8 V
220Ω	330Ω	3.1 V
220Ω	470Ω	3.9 V
220Ω	560Ω	4.4 V
220Ω	680Ω	5.1 V
220Ω	820Ω	5.9 V
220Ω	1 K	6.9 V
220Ω	1.2 K	8.0 V
150Ω	310Ω	8.8 V
220Ω	1.5 K	9.7 V

d

FIG. 8—REGULATING THE VOLTAGE FROM a car battery; the assumption is that IC1 is a standard +5-, +6-, or +8-volt regulator, and that IC2 is adjustable, but set to a non-standard value by R1 and R2. The accompanying table in (*d*) gives V_2 to within 50 millivolts for different values of R1 and R2, but you can use the formula given in the text.

no load? What's the figure at full load? Try several yourself and see.

In ten transformers sampled, only one was precisely correct at rated load. The average high was 7.56% off, the worst was 12.7%, and these were at the rated 120-volt primary input. Those sampled came from a variety of suppliers, most with a rating of 1 amp or higher. If you order a transformer, you can't be sure what you'll get until you measure it. Since you're dealing with peak value, it may look even worse. What you thought would be merely 14.14 volts may more likely be 15–17.8 volts peak.

The peak value is important, because the electrolytics need to be rated accordingly and the regulator drop is partly dependent on it. Also, a center tap may not always be at the exact electrical center of the secondary winding; about 3% error was the worst observed. Assuming a transformer secondary voltage 20% above its rated value is realistic, but don't depend on it. As for RMS current, rate the transformer at 1.2 times the maximum expected load current for full-wave center-tapped, and 1.8 times for a bridge.

The diode voltage ratings should be twice the peak transformer voltage. While you might get by with diodes rated at the maximum load current, you should use ones with *at least* double that limit, for safety, especially for half-wave. The diode will dissipate heat through its leads and the PC board foil, so short leads are best.

The only generalization that can be made about the voltage drop across a diode is that it increases with current under forward bias. Thus, not quite all the peak transformer voltage is perceived by the electrolytic. Close to rated current, a diode drops about 0.8 volts, and 0.5 volts at low currents. Since the diode normally conducts to recharge the electrolytic, assume a worst-case drop of 1.2 volts. This is the figure to use with either half-wave or full-wave center-tap. With a bridge, two diodes conduct in series, so two drops must be added, for a worst-case of 2.4 volts.

The electrolytic perceives the secondary voltage, minus the diode drop(s). Unless you're right on the edge of a electrolytic's voltage rating, ignore the diode drop(s) and use electrolytics rated at least equal to peak transformer voltage. In practice, electrolytics are built for safety, so one with a 25-volt rating won't explode if 25.01 volts is used. How much you can get away with depends on the specific electrolytic or individual luck, so don't try it unless desperate. The current into and out of the capacitor causes heating; an electrolytic of large diameter will heat more than two smaller ones with the same capacitance when in parallel, due to less surface area per microfarad.

For an infinitely large capacitor, a constant voltage would be observed at the regulator's input. Most fixed regulators function properly with a 2-volt drop, and 2.5 volts for adjustable versions, so select the electrolytic to get as close to these regulator drops as possible.

Since no electrolytic has infinite capacitance, the regulator voltage isn't constant. The average input voltage varies with load current, and the ripple voltage increases in peak-to-peak value with current. At its lowest value during worst-case ripple, the regulator drop must be at least 2 volts. The following formula for the minimum required electrolytic size in μF is a good approximation:

$$C_{filter} = 6000 \times I_{load}/V_{rippple}.$$

For example, if maximum load current is 0.5 amp, and ripple voltage is 2 volts P-P, the minimum electrolytic size is:

$$C_{filt} = 6000 \times 0.5/2 = 1500\ \mu F.$$

This is valid for full-wave, but needs to be doubled for half-wave. Now, work backwards, from output back to transformer, to determine the minimum peak voltage the transformer has to deliver. For now, ignore any over-voltage condition, since that's mainly important in determining the electrolytic's voltage rating. Starting with the desired regulated output voltage, say +12 volts, add up all the voltage drops present:

12.0 volts	regulated output
2.0 volts	minimum regulator drop
2.0 volts	P-P ripple (somewhat arbitrarily selected)
+1.2 volts	worst case diode drop
17.2 volts	minimum peak voltage from transformer secondary

Multiplying this sum by 0.7071 gives 12.16 volts, the minimum tolerable RMS secondary voltage. This works well with a normal 12.6-volt secondary, but with only a 3% cushion for a low line-voltage condition. With the extra voltage the transformer provides, it should be efficient—for a linear supply. If the figures are too high for a standard transformer, consider using extra capacitance to achieve smaller ripple.

If you can select the transformer from several already on hand, or can afford a little extra cost, a transformer with twice the anticipated current rating could mean an extra volt or more in the secondary voltage. A higher secondary voltage will manifest itself as a higher regulator drop, causing more heating for any given load. This problem is insoluble when using an adjustable regulator to provide from 1.25–25 volts.

A clean 27.5 volts would have to be available at the regulator input to accommodate the highest output. However, when adjusted downward to only 2 volts, the regulator drop increases to 25.5 volts. Output current must be reduced to prevent overheating.

Finally, here's a little information on the TO-220 regulators. While the adjustable models can handle somewhat higher voltage, consider 35 volts as a maximum for all. This includes the fixed versions from 5–15 volts, inclusive. This same 35-volt figure was kept in mind as a capacitor rating when considering component sizes.

The regulators protect themselves by automatically shutting down when overheated, and by current limiting when shorted. This limit may still be enough to damage the transformer and diodes. You can consider a regulator as a 1.5-watt device with no heatsinking, a 5-watt device with fairly good heatsinking, and a 12-watt device with excellent heatsinking and air circulation.

To get a rough idea of safe operation, let one operate under worst-case conditions for five minutes, and then applying a tiny drop of room-temperature water to the top of the its heatsink tab. Even if a heatsink is attached, apply the water only to the top of the tab—awkward, but possi-

(Continued on page 58)

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise indicated.

R1—150–270 ohms (see Figs. 3 and 8)

R2—2000- or 5000-ohm cabinet-mounted potentiometer

R3—270–1500 ohms (see Fig. 8)

Capacitors

C1, C3, C6—1000 μF, 16 volts, electrolytic

C2, C4, C5—10 μF, 30 volts, electrolytic

Semiconductors

D1–D4—1N4004 or 1N5404 silicon rectifier diode or equivalent

IC1, IC2—78XX, 79XX, LM317, and/or LM337 3-terminal TO-220 voltage regulators (see text)

Miscellaneous: one or more copies of the PC board (see PC Service), suitable cabinet, red and black banana jacks, one or more 3-terminal regulator heatsinks (JAMECO part number 6030B), ⅟₃₂-inch and ⅛-inch drill bits, wire, solder.

BUILD THIS PROGRAMMABLE CRYSTAL-CONTROLLED PULSE GENERATOR

Build a single-chip pulse generator using a programmable crystal oscillator IC.

PETER A. LOVELOCK

UNTIL RECENTLY, BUILDING AN INEXPENSIVE, calibrated frequency source has generally involved dividing the output from a crystal oscillator to the specific frequency desired. Figure 1 shows a 1-MHz crystal oscillator feeding a series chain of TTL decade counters to illustrate the technique.

A significant improvement is provided with the recent advent of the Statek Corp. (512 N. Main St., Orange, CA 92668) PXO series of Programmable Crystal Oscillators. These are hybrid IC's with on-board crystal oscillators mounted in 16-pin DIP's, drastically reducing the total PC board space and power required.

All members of the PXO series are identical internally, differing only in the base crystal frequency. The user can select any one of 57 different frequency-divider ratios, using two internal, series frequency counters, each with three TTL-compatible external taps for setting the divider ratios.

Figure 2 is a block diagram of the PXO-1000; it has an a 1-MHz internal crystal, and two internal programmable frequency dividers, with ratios available to let the user select output frequencies ranging from 0.0083 Hz–1 MHz. The IC was also made with provision for using an external source to provide a base frequency that differs from any of the standard manufactured values of the PXO chips.

These IC's also allow either computer control of the frequency selected, by varying the logic levels of the taps, or manual control using either DIP or rotary switches. The PXO-1000 has ±100 ppm accuracy and ±0.015% stability at room temperature, and consumes only 3.5 milliwatts, or 0.7 milliamps at 5 volts DC. The other standard available base crystal frequencies are 326.68 kHz (the PXO-32768), 600 kHz (the PXO-600), and 768 kHz (the PXO-768).

The PXO-1000

The drawback to the divide-by-N counter shown in Fig. 1 is the need for eight separate counters and a separate crystal oscillator. If 7490 divide-by-10 counters are used, the circuit will take up about 7 square inches on a PC board, and draw 45 milliamps at 5 volts DC for each IC. Thus, the dividers draw $P = I \times E = 8 \times 45 \times 5$ volts DC = 1.8 watts, and the oscillator an additional 0.1 watt, a total of 1.9 watts, a load that makes battery operation impossible.

By contrast, the PXO-1000 shown in Fig. 2 uses under 1 square inch of PC board real estate, and only 3.5 milliwatts—perfect for battery operation. The output is available on pin 11 (f_{OUT}), and the external clock for special cases can be applied to pin 12 (EXC). Both clocks are fed to the clock-select logic, allowing selection between either one depending on the state of pin 13 (CSEL), the internal clock if low, the external clock if high.

The output of the clock-select logic feeds the two internal programmable counters. They're in series, so the total frequency division factor is the product of the two. The first can be set to divide by 1, 2, 3, 4, 5, 6, 10, or 12, while the second divides by a power of ten, ranging from $1–10^7$, inclusive.

There are eight possible settings for each, since there are three control bits for each and $2^3 = 8$. If all the divider ratios were unique, there'd be 8×8 or 64 distinct frequency divider settings possible. However, since *both* the first and second counter can divide by 1 and 10, seven of those 64 factors will be duplicated.

The PXO-1000 is programmed using pins 2–4 ($P_3P_2P_1$) and pins 5–7 ($P_6P_5P_4$); these are the frequency counter control bits. Setting any of them to V_{CC} constitutes a logic high,

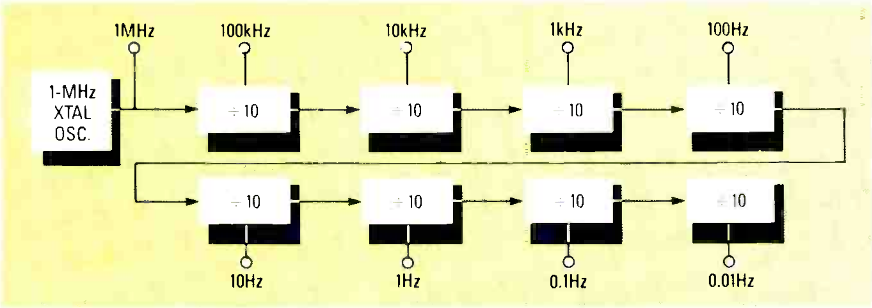


FIG. 1—GENERAL PURPOSE PULSE GENERATOR needs a 1-MHz crystal oscillator driving a chain of high-power TTL decade counters like the 7490 4-bit decade counter.

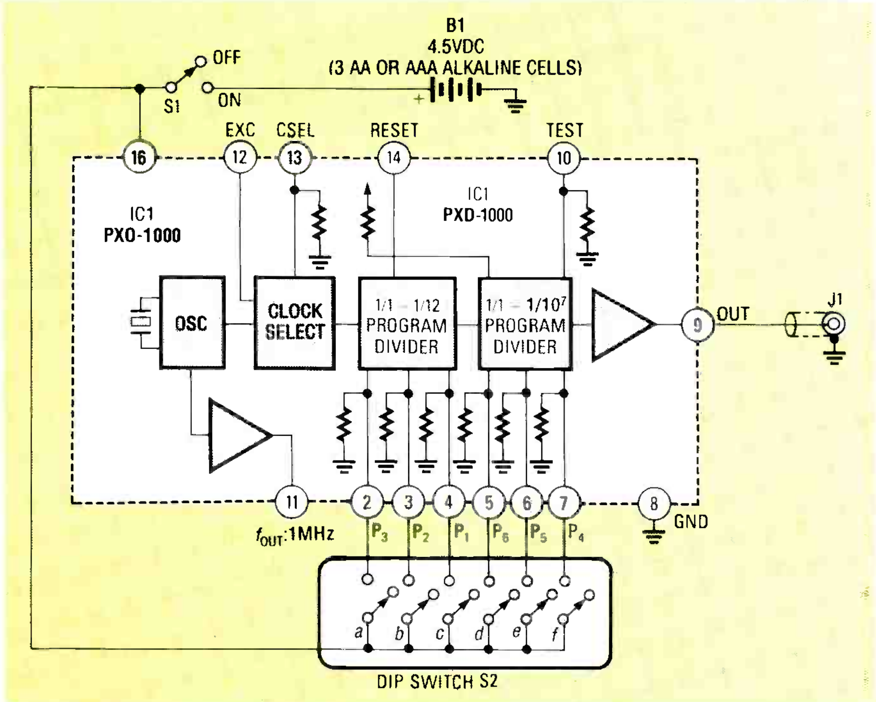


FIG. 2—BLOCK DIAGRAM OF PXO-1000 IC programmable frequency divider with internal 1-MHz quartz crystal oscillator. Frequency division ratios are selected by setting DIP switch S2; 57 distinct frequencies in the range from 0.0083 Hz–1 MHz can be generated. Each of the SPST switches a–f in S2 control a single bit from among pins 2–7 ($P_3P_2P_1$ and $P_6P_5P_4$), the select lines for the two counters. Here, a +4.5-volt DC supply using B1 provides power.

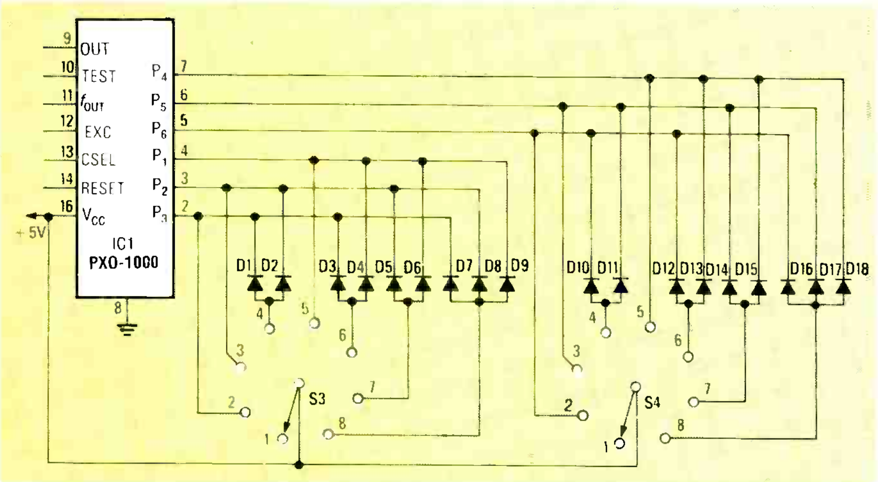


FIG. 3—ROTARY SWITCHES AND DIODE MATRIX D1–D18 set the frequency counters of the PXO-1000, eliminating DIP switch S2 in Fig. 2. D1–D18 act to block incorrect bits from among pins 2–7 ($P_3P_2P_1$ and $P_6P_5P_4$) from being set high. D1–D9 acts with S3 to control $P_1P_2P_3$, while D10–D18 acts with S4 to control $P_4P_5P_6$. S1, the ON/OFF switch, and J1, both present in Fig. 2, have been omitted, but would be needed here.

and ground to a logic low. The frequency division effect of pins 2–7 ($P_3P_2P_1$ and $P_6P_5P_4$) is summarized in Table 1.

The settings of pins 2–4 ($P_3P_2P_1$) *aren't* in directly ascending order for the first counter. At the low end, the frequency division factor jumps from 1 for a setting of 000 to 10 for 001, and back down to 2 for 010, while at the high end, the factor jumps from 6 for 110, to 12 for 111. However, the settings for pins 5–7 ($P_6P_5P_4$) *do* go in order, and the binary number corresponding to these three bits is the exponent of the power of 10 for the frequency division factor involved. Thus $P_4P_5P_6 = 100$ is binary for 4, or a division factor of 10^4.

If the eight possible settings for the two 3-bit groups are arranged as an 8×8 matrix, the output frequencies appear as the 64 entries in Table 2. As mentioned above, seven frequencies are duplicated, so there are only 57 distinct frequencies. In Fig. 2, they are generated by programming the two counters using DIP switch S2. Thus, the entries for row two are shifted one column left from those of row one.

For example, to generate 100 kHz, you can use settings of either $P_1P_2P_3P_4P_5P_6 = 000001$ or 001000. As a more general example, $P_1P_2P_3P_4P_5P_6 = 100010$ causes division by $4 \times 10^2 = 4 \times 100 = 400$. Since the crystal frequency is 1 MHz, the output frequency is $f_{OUT} = 1$ MHz/400 = 2.5 kHz.

Figure 3 shows an alternative manual approach using rotary switches S3 and S4 to control diode matrix D1–D18, if you find using a DIP switch awkward. In this case, S3 selects the decade frequencies from 0.1 Hz–1 MHz, while S4 selects the eight output divisions from 1/1–1/12, determining the final output frequency, as shown in Table 2. Also, you can see that the +4.5 volts DC from battery B1 in Fig. 2 has been replaced in Fig. 3 with +5 volts DC, which is also acceptable.

If you're only interested in 0.1 Hz–1 MHz using the second counter, then exclude S3 and D1–D9, leaving pins 2–4 ($P_3P_2P_1$) open. Likewise, if you're only interested in division by the integer factors provided by the first counter (1, 2, 3, 4, 5, 6, 10, and 12), you can similarly exclude S4 and D10–D18, leaving pins 5–7 ($P_6P_5P_4$) open. The parts placement diagrams

TABLE 1—PXO-1000 FREQUENCY DIVIDER PROGRAMMING CODES

P_1	P_2	P_3	DIVIDER RATIO	P_4	P_5	P_6	DIVIDER RATIO
0	0	0	1/1	0	0	0	1/1
0	0	1	1/10	0	0	1	1/10
0	1	0	1/2	0	1	0	$1/10^2$
0	1	1	1/3(*)	0	1	1	$1/10^3$
1	0	0	1/4	1	0	0	$1/10^4$
1	0	1	1/5(**)	1	0	1	$1/10^5$
1	1	0	1/6	1	1	0	$1/10^6$
1	1	1	1/12	1	1	1	$1/10^7$

Notes: (a) 33.3% duty cycle (*);
(b) 40% duty cycle (**);
(c) All others 50% duty cycle.

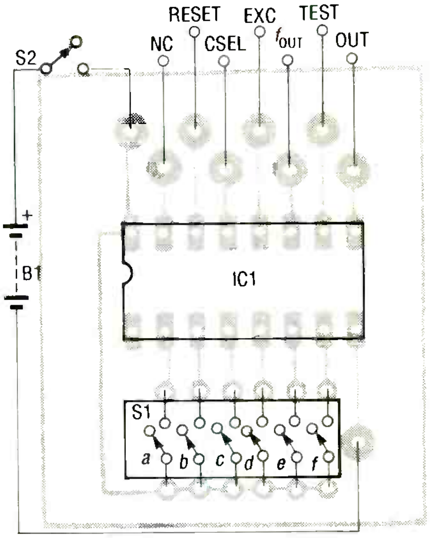


FIG. 4—PARTS-PLACEMENT DIAGRAM for the dip-switch version of the PXO-1000 circuit.

for the PC boards and the part layout for the DIP- and rotary-switch versions of the PXO-1000 are shown in Figs. 4 and 5, respectively. The PC foil patterns for both versions are shown in PC Service.

Note that pins 10–15, the special function pins of the PXO-1000, are unused. Should you wish to use them, several have already been discussed. Of the remainder, pin 10 (TEST), when set high, multiplies the output frequency by 1000, except when the product of the programmed divider ratios for each counter is under 0.001. Pin 14 (RESET) resets both counters when set low, and sets pin 9 (OUT) low. Also, all inputs except pins 12 (EXC) and 14 (RESET) have internal pull-down resistors, whereas pin 14 (RESET) has an internal pull-up resistor.

Construction

Both the DIP- and rotary-switch versions in Figs. 2 and 3 can be installed in small plastic or metal enclosures with three AA or AAA

TABLE 2—PXO-1000 DIVIDER FREQUENCIES

			S_4	1	2	3	4	5	6	7	8
S_3	S_2		P_4	0	0	0	0	1	1	1	1
			P_5	0	0	1	1	0	0	1	1
	P_1	P_2	P_6 / P_3	0	1	0	1	0	1	0	1
1	0	0	0	1 MHz	100 kHz	10 kHz	1 kHz	100 Hz	10 Hz	1 Hz	0.1 Hz
2	0	0	1	100 kHz	10 kHz	1 kHz	100 Hz	10 Hz	1 Hz	0.1 Hz	0.01 Hz
3	0	1	0	500 kHz	50 kHz	5 kHz	500 Hz	50 Hz	5 Hz	0.5 Hz	0.05 Hz
4	0	1	1	333.3 kHz(*)	33.3 kHz	3.33 kHz	333.3 Hz	33.3 Hz	3.33 Hz	0.33 Hz	0.033 Hz
5	1	0	0	250 kHz	25 kHz	2.5 kHz	250 Hz	25 Hz	2.5 Hz	0.25 Hz	0.025 Hz
6	1	0	1	200 kHz(**)	20 kHz	2 kHz	200 Hz	20 Hz	2 Hz	0.2 Hz	0.02 Hz
7	1	1	0	166.67 kHz	16.67 kHz	1.67 kHz	166.67 Hz	16.67 Hz	1.67 Hz	0.167 Hz	0.0167 Hz
8	1	1	1	83.3 kHz	8.3 kHz	833.3 Hz	83.3 Hz	8.3 Hz	0.83 Hz	0.083 Hz	0.0083 Hz

Notes: (a) 33.3% duty cycle (*);
(b) 40% duty cycle (**);
(c) All others 50% duty cycle.

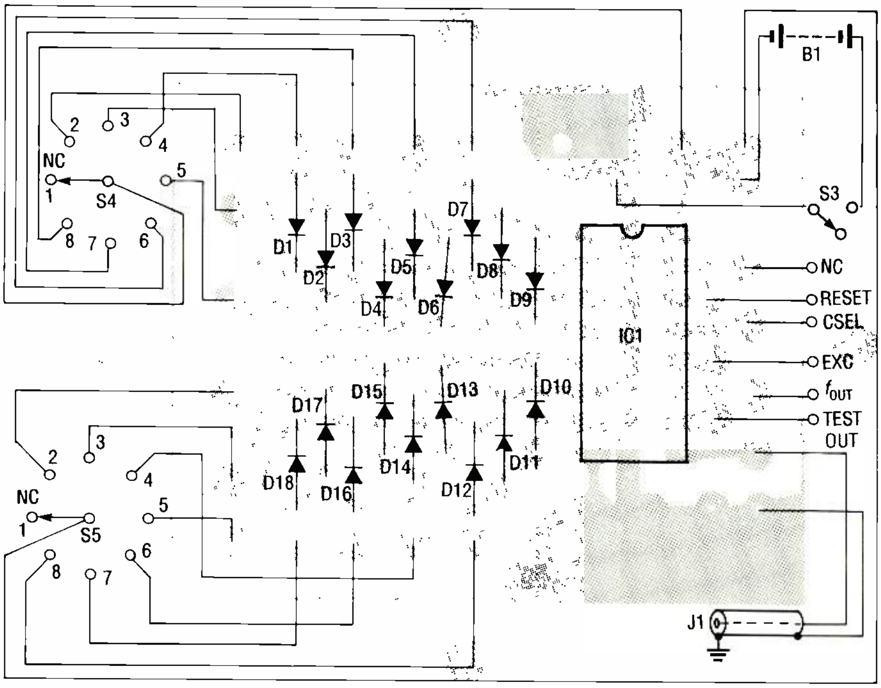


FIG. 5—PARTS-PLACEMENT DIAGRAM FOR THE ROTARY-SWITCH version of the PXO-1000 circuit.

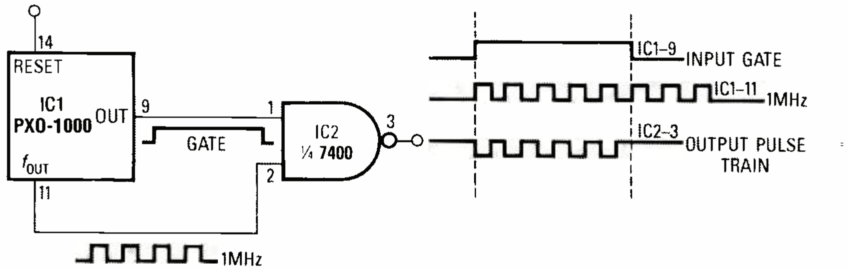


FIG. 6—AN APPLICATION OF PRECISION LOGIC GATE TIMING using the PXO-1000. If you program 10 kHz, NAND-gate IC2 is enabled on each positive half of the output square wave, for a pulse width of 50 µs. That lets 50 1-MHz square wave pulses from pin 11 (f_{OUT}) of the PXO-1000 pass though IC2 until pin 9 (OUT) goes low on each bottom half of the square wave. In that case, IC2 is disabled, giving a precise gate time. When both inputs go high, the output goes low, inverting the 1-MHz square wave.

alkaline cells. Maximum supply voltage for the PXO-1000 is +6 volts DC. Since the PXO-1000 draws 1 milliamp, three AA cells give hundreds of hours of use.

Mount the PXO-1000 in a low-profile 16-pin DIP socket. Mount both rotary switches and an ON/OFF switch for B1 on the front panel.

The PXO-1000 internal crystal oscillator is available on pin 9 (OUT). It's buffered for TTL or CMOS loads, but you should *never* connect it to a load drawing over 1 milliamp. If you don't know how much current will be used, put a 5K ¼-watt resistor from pin 9 (OUT) to J1 to limit current. Note that J1 only appears in Fig. 2, not Fig. 3, but you'll need it in both versions.

You may also want a large coupling capacitor from pin 9 (OUT) to the center post of J1, although it'll distort even a low-frequency square-wave output. Use a 3-cell AA or AAA battery holder for B1, a suitable case, and ¼-inch spacers to keep the board from shorting.

Applications

What can you do with all these frequencies? As mentioned earlier, the range of 0.01 Hz–1 MHz in decade steps can be used for a variety of calibrations, while some other applications may not be as apparent. For example, 5 Hz can drive a clock motor, 1, 25, and 50 Hz are a useful general-purpose time base, 100 Hz–10 kHz are useful for audio, 25 kHz is in the ultrasonic transducer range, 500 kHz–1 MHz is useful for digital applications.

By using period instead of frequency, or T = 1/f, you can perform precision logic timing, as shown in Fig. 6. If you program 10 kHz, NAND-gate IC2 is enabled on each positive half of the output square wave, for a pulse width of 50 µs. That lets 50 1-MHz square wave pulses from pin 11 (f_{OUT}) of the PXO-1000 to pass though IC2 until pin 9 (OUT) goes low on each bottom half of the square wave. In that case, IC2 is disabled, letting you pick a precise gate time. If both inputs go high, the output goes low, inverting the 1-MHz square wave. **R-E**

PARTS LIST

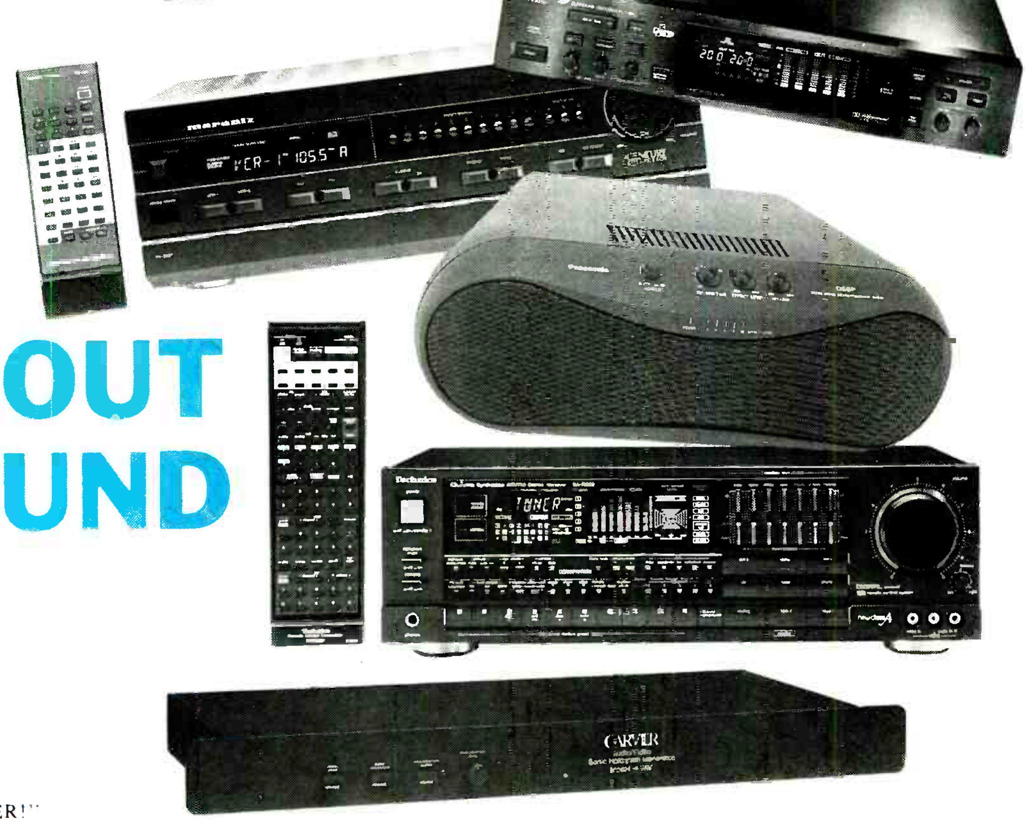
Semiconductors:
D1–D18—1N4148, switching diodes
IC1—PXO-1000, programmable crystal oscillator
IC2—7400 quad TTL NAND gate (see text about precision timing application)

Other components:
B1—4.5-volt DC supply using three 1.5-volt DC AA or AAA alkaline cells (optional; a 5-volt DC supply could be used instead)
J1—RCA phono jack (for both the DIP- and rotary-switch versions)
S1—miniature SPST toggle switch (for either the DIP- or rotary- switch versions)
S2—DIP switch with 6 SPST switches (for the DIP-switch version)
S3, S4—SP12T rotary switch (for the rotary-switch version)

Miscellaneous: PC board (see PC Service), 3-cell AA or AAA battery holder, suitable plastic box with aluminum cover (for either the DIP- or rotary-switch versions), wire, solder, knobs (for the rotary-switch version), ¼-inch spacers, and hardware.

Note: The Statek PXO-1000 is available from Ryno Electronics, 1637 North Brian Street, Orange, CA 92667, (714) 637-0200, for $12.00 postpaid. An etched and drilled PC board (for the rotary-switch version only) is available from R&R Associates, 3106 Glendon Avenue, Los Angeles, CA 90034, for $3.00 postpaid. For both items, California residents include appropriate sales tax.

Everything you need to know about the varieties of surround sound, in the theater and at home.



ALL ABOUT SURROUND SOUND

JOSEF BERNARD

"MOVIES ARE BETTER THAN EVER!" screamed the advertising banners in the middle of the 1950's as theatrical audiences dwindled and stay-at-home TV audiences grew. Hollywood tried everything it could think of to maintain its hold on the vanishing moviegoer: Cinerama, 3-D, CinemaScope, VistaVision, Todd-AO, six-track stereo sound, eight-track stereo sound, Smell-O-Vision (no kidding!), and other schemes now better forgotten. One or two of the concepts and techniques that were introduced during that period proved to have some worth and they or their descendants are with us still today. The stereo and surround sound we enjoy from our audio and video equipment at home are among the benefits that have been derived, at least in part, from the motion picture industry's frantic '50's efforts.

Early attempts

Of the early efforts to provide realistic sound in a theatrical environment, perhaps the best remembered (if it is remembered at all) is Walt Disney Studios' *Fantasound*, a fourteen-track process that was used for Leopold Stokowski's orchestral accompaniment to 1940's animated *Fantasia*. Each member of an array of microphones spread out before the orchestra picked up the sound emanating from its region. The signal from each mike was recorded on its own soundtrack and during playback was reproduced by a speaker positioned behind the screen in a location corresponding to that of the mike during recording. The effect was a realistic spread of the orchestra before the theatrical audience.

With the cinematic wide-screen spectaculars of the '50's came multitrack stereophonic—actually, surround—sound. Mike Todd's wide-screen extravaganza *Around the World in 80 Days* included such effects as a train (with the theatergoer as passenger) crossing a rickety old bridge; you could hear the steam engine in front of you and the clickety-clack of the wheels on the rails being reflected from the girders of the bridge on either side of you as you passed them. Wow!

At home, in the late '50's and early '60's, record players (there weren't many audiophiles with turntables back then) and a very few tape recorders went stereophonic. By that time it had been realized that a more-or-less convincing soundstage could be recreated in front of the listener from just two channels of sound, one carrying left-ear information and the other carrying that for the right ear. The term "binaural" was sometimes used in place of "stereophonic," but its use soon became reserved for a specific method for stereophonic recording and listening, one with which most people did not wish to become involved because of its inconvenience.

The binaural technique, which enjoys a very limited—but extremely spirited—popularity today requires special recording techniques, and binaural recordings must properly be auditioned through earphones. Only two microphones are used. The idea is to reproduce as closely as possible the sound of a performance (or environment) as it is perceived by the ear. To this end, binaural recording techniques have used models of the human head (and ear) fitted with microphones (see Fig. 1), and even microphone mounts that were affixed to real, live, human heads. When prepared properly and with care, a binaural recording can provide the listener with a surround sound experience that includes not only front, sides and rear, but up and down as well. Earphones must be used to deliver the sound directly to the ear and preserve the phase relationships of the signal as recorded.

In the late 1970's, home discophiles could have their choice of two systems for four-channel recordings (SQ and QS), with two speakers in front and two behind (see Fig. 2). Both used matrixing systems to encode the quadraphonic (sometimes spelled "quadriphonic") signals on black vinyl records, and required new designs in cartridges and styli to retrieve the signals from the record grooves. The two systems offered to the public were incompatible and that, together with a surfeit of gimmicky recordings similar to the "Ping-Pong Stereo" ones that fortunately disappeared quickly from the two-channel scene, caused the quadraphonic movement to founder and sink with only a few diehard survivors left today. There weren't many people who wanted to listen to the Tijuana Brass while sitting right smack in the middle of the band; maybe just a few frustrated horn players.

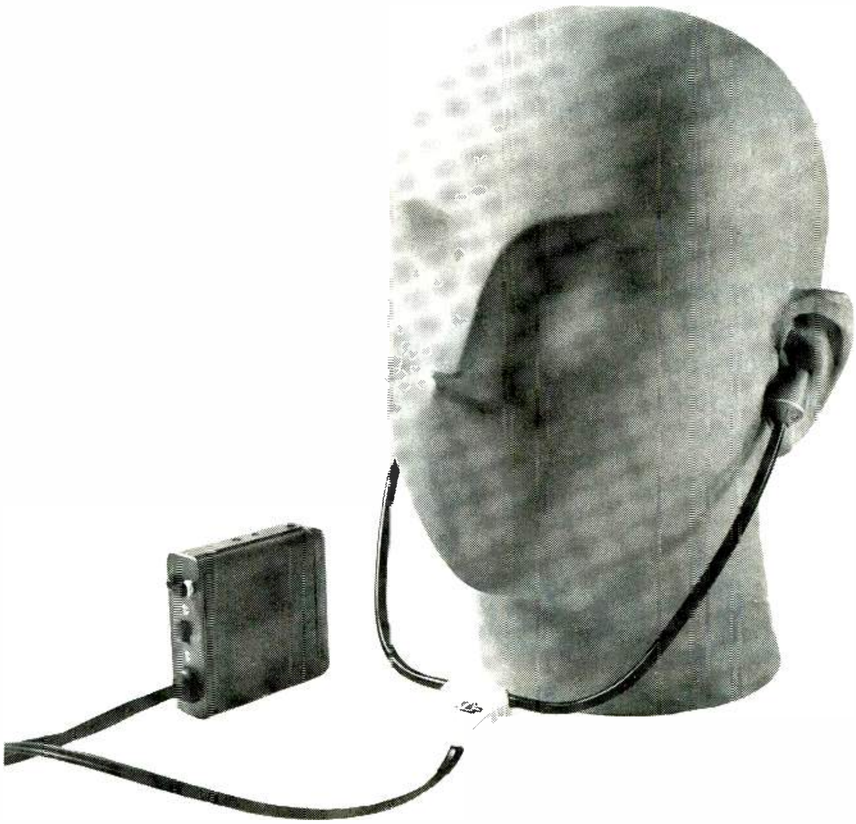


FIG. 1—IN TRUE BINAURAL RECORDING, a mechanical replica of the human head and ears ensures the proper capture of phase relationships. This is the *MKE 2002* binaural dummy-head stereo-microphone setup from Sennheiser. To hear the special stereo effects, the recording must be listened to with high-quality headphones.

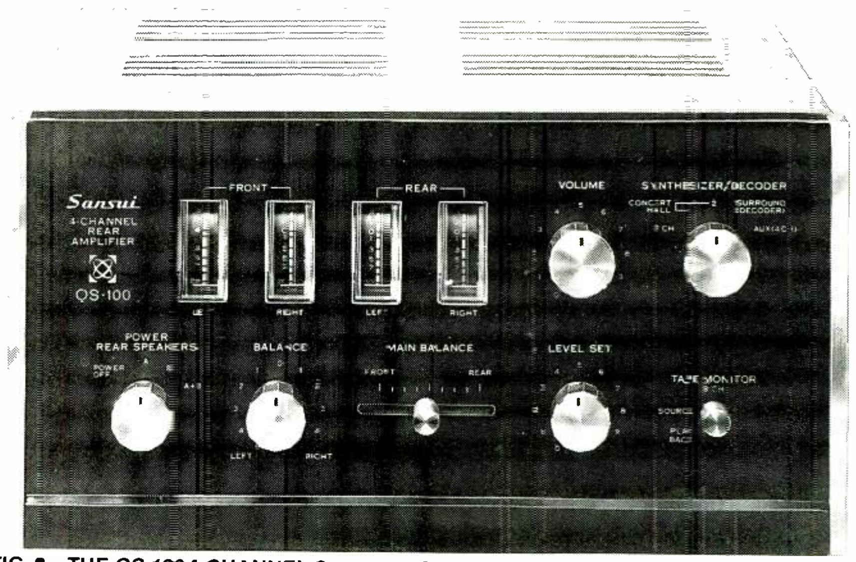


FIG. 2—THE *QS-100* 4-CHANNEL Converter/Synthesizer/Amplifier from Sansui. This is an example of a quadraphonic amplifier in the QS format.

Extracting ambience

After the failure of quadraphony, the place and purpose of surround sound were reexamined and it was decided that, for the most part, audio channels in addition to the front two conventionally used for stereo should be subordinate to them. It would be OK to have more than two channels, but the main audio information should come from in front of the listener and the secondary channels used more to provide a feeling of ambience—to recreate the original (or a simulated) recording environment.

In the 1970's, a simple way to recover ambience information from conventional stereo recordings was proposed. That ambience information—which consists largely of sounds from outside the soundstage located between the stereo microphones (assuming, for the sake of simplicity, that just two are used)—may simply be sound reflected from the walls and ceiling of a concert hall, or it may come from sources such as instruments positioned intentionally outside the bounds of the soundstage, as illustrated in Fig. 3. One of the ways that the ear pinpoints sound sources is by determining phase relationships. If, for example, the sound waves heard from a pair of speakers by the left and right ears are in phase, the sound source is perceived as being between the two speakers. If the

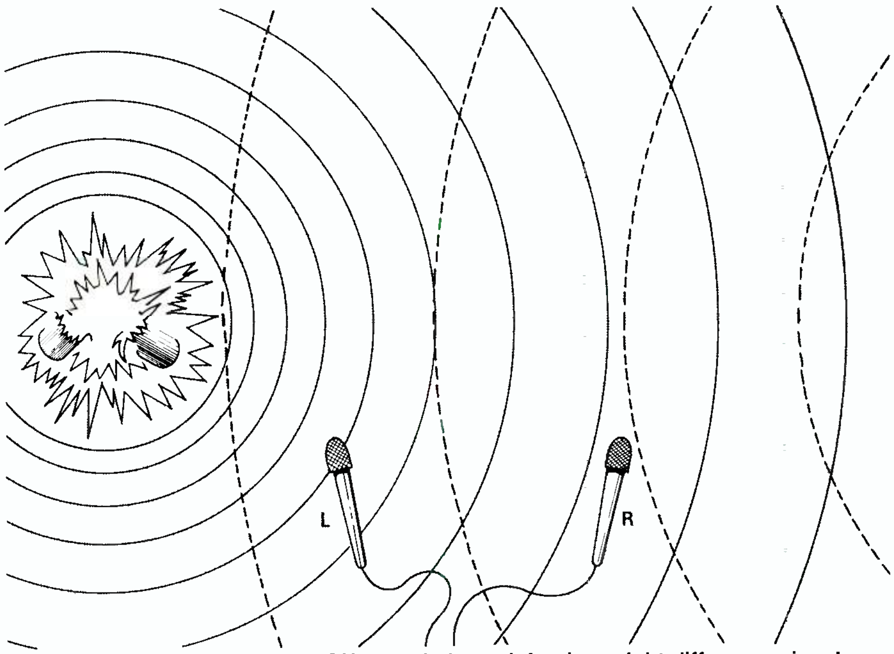


FIG. 3—AMBIENCE INFORMATION recorded as a left-minus-right difference signal can be used to expand a soundstage and even to localize sounds coming from beyond the bounds set by the locations of the microphones or speakers.

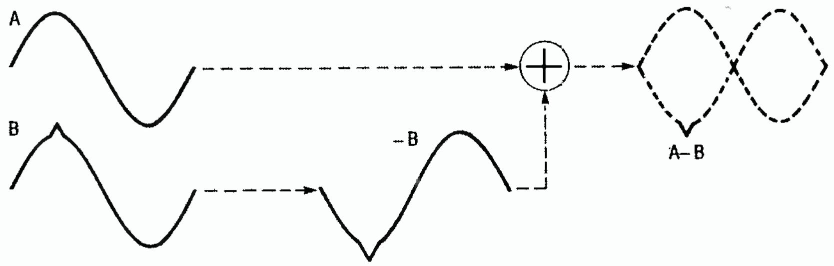


FIG. 4—BY INVERTING THE POLARITY of one of a pair of signals and then summing the two, you can obtain the difference between them.

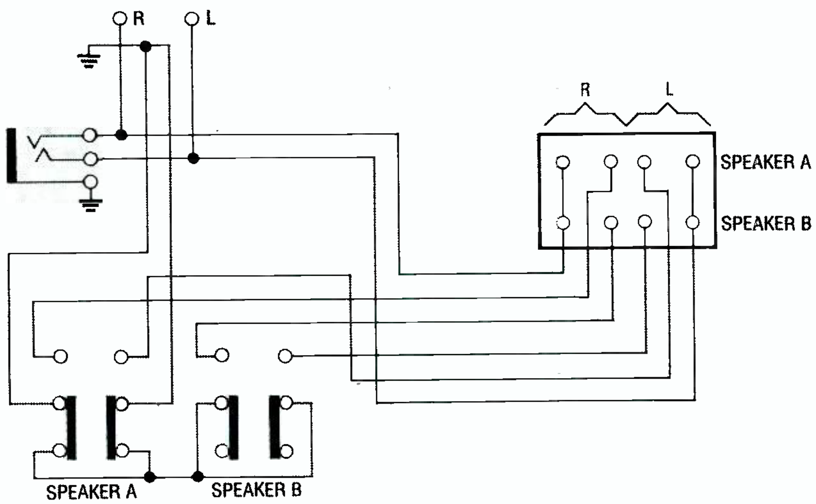


FIG. 5—THE MATRIX SURROUND CIRCUIT used in receivers such as Teac's *AG-75* extracts ambience information from a pair of stereo signals by finding the difference between them.

waves are out of phase, the sound seems to come from "beyond" the speakers, and some recordings intentionally include out-of-phase material to provide special auditory effects.

Out-of-phase information can be described mathematically as the difference between the left and right signals, or L – R. The relationship between an "L" waveform and an "R" one is depicted in Fig. 4. By inverting the phase of the right signal—thereby creating a " – R" one—and adding that signal to the normal "L" one, the "L – R" difference signal representing ambience information is obtained. By connecting a third (ambience channel) speaker between the "hot" speaker terminals of a stereo amplifier, an L – R signal is obtained and reproduced through that speaker. If you place the speaker behind you, and adjust its volume so that it's unobtrusive, recordings that contain a goodly amount of natural ambience material will take on a spaciousness that can make you feel a lot more like you're listening to a performance in a real performance environment rather than your living room.

Matrix surround sound

A number of today's stereo receivers include a feature called "matrix surround sound," or just "matrix surround," the "sound" having disappeared somewhere. The term "matrix" refers to the way the signals are combined to obtain the "surround" signal. The process is a passive one—there is no special encoding or decoding matrixing circuitry used. Figure 5 shows a circuit used in one matrix-surround receiver. When the A SPEAKERS button is engaged, normal stereo sound is heard from the speakers connected to the A terminals; when the B SPEAKERS switch is closed, the output of the amplifier is fed to a second set. When both switches are closed, the A speakers reproduce the normal stereo signal; what goes to the B-s speakers, however, is now the difference between the left- and right-channel signals. It turns out that matrix surround is nothing more than a "ready-to-use" version of the "third channel" ambience system described above. Place the B speakers behind you, and you have an ambience synthesizer. You also get a free surprise, which is a subject to which we'll return.

Some sound equipment also boasts a "Hall Surround" mode. While there is definitely a Ray Dolby involved in Dolby Surround (see below), there is no Mr. Hall of the same prominence involved in audio processing. The term "hall" refers simply to a large room (as a concert hall); presumably time delay or reverb effects are added to the rear channel sound to give a feeling of spaciousness.

Sonic holography

In photography, holography is a process that yields three-dimensional images from a single piece of film without the need for special viewing apparatus (as opposed to the older method that requires a separate picture for each eye—the system used, for example, by View Master reels). Sonic holography produces a sonic image having depth, and a degree of surround effect, using just a pair of stereo speakers.

Sonic Holography, which is a technique patented by Carver Corporation, works on the principle that when we listen to a pair of stereo speakers the phase relationships contained in the recorded or broadcast material are muddied by right-channel sound "leaking" to the left ear, and left-channel sound similarly showing up at the right. What the process does (see Fig. 6) is to inject some degree of out-of-phase right-channel information into the left-channel signal (and vice-versa). If that is done with the right time delay, the out-of-phase right-channel signal mixed with the left-channel one will arrive at the ear at the same time as the right-speaker "leakage" does, and the in-phase and out-of-phase signals will cancel one another. What's left will be pure left- and right-channel sound as engineered, providing a sense of depth and expanse otherwise impossible in a two-speaker system.

Material that contains a lot of natural or synthetic L − R information can be astonishing when heard through a sonic-holography system. The soundstage appears to extend far beyond the backs of the speakers—indeed, the speakers almost seem to disappear—and "offstage" sounds often seem to originate from places far beyond the left-right bounds of the conventional stereo soundstage.

The original Carver sonic holography process requires some effort to make it work at its best. Speaker positioning is extremely critical to the effect, and speaker-to-listener distances must be measured extremely carefully, and the corresponding left and right ones matched to within an inch or so of one another. The benefits of sonic holography also are restricted to only one or two listeners at a time. The effect is heard only from a highly sensitive "sweet spot," and moving just a foot or so out of it destroys the illusion.

In some of its equipment Carver now offers what it calls a Precognition Matrix, which is intended to broaden the sonic-holograph soundstage created from motion picture soundtracks. The precognition circuitry works by detecting the (normally inaudible to the ear) rise in noise-floor level when additional tracks are mixed into the stereo master. By changing the mix of left and minus-right-channel information, the apparent soundstage can be widened dynamically to follow that of the material being reproduced, allowing more listeners to benefit from the sonic holography process. Because the change in noise-floor level occurs several milliseconds before the actual onset of the new audio material, the processor can respond without missing a note of music or other material.

For those who want everything (or nearly everything), Carver also produces an AM/FM stereo receiver that incorporates both Sonic Holography *and* Dolby Pro Logic Surround, which will be discussed below.

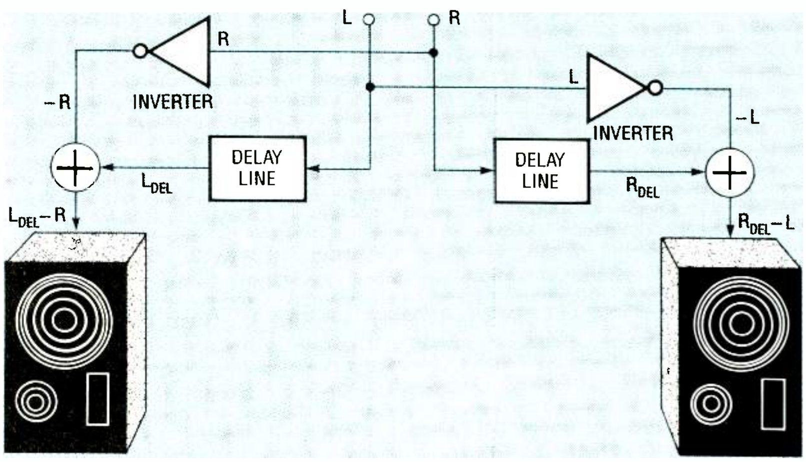


FIG. 6—CARVER'S SONIC HOLOGRAPHY process compensates for signal "muddying" that occurs during ordinary stereo reproduction by using signal cancellation techniques.

Other two-speaker systems

There are several other single-ended systems that attempt to recreate a measure of ambience from just the information contained in the two channels of an ordinary stereo signal.

The system that seems to have attracted the most attention of late is the SRS system developed by Hughes Aircraft and licensed by Sony for use in some of its television receivers. Basically, the process extracts the L − R ambience information and processes it through frequency, timing, and phase adjustments to simulate the way the recorded information would have been perceived by the human ear. The effect is an artificial analog of the binaural process described earlier, using loudspeakers instead of earphones. The Hughes SRS system is described in detail in the September 1989 issue of **Radio-Electronics.**

Most "simple" surround systems, though, are just variations—and minor ones, at that—of the L − R matrix process. Sometimes the term "digital" gets thrown in, but the digital portion of these processes often has to do just with creating the out-of-phase L − R signal, and maybe adding some time delay for increased "spaciousness."

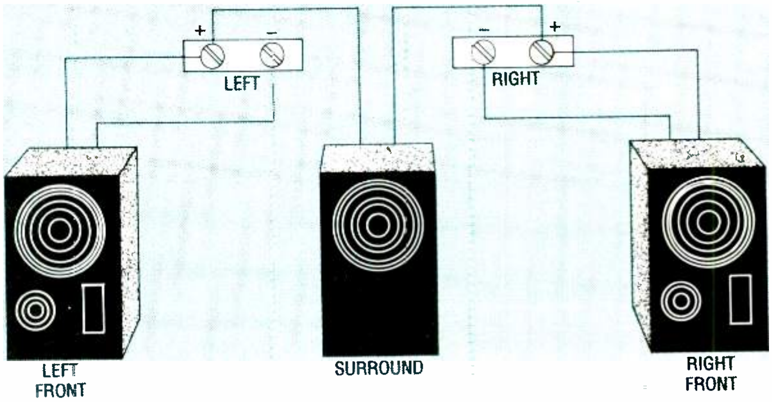
Dolby Stereo

Although it has been in use since 1975, Dolby Stereo, one of a number of audio processes to come from the laboratories headed by Ray Dolby, first came to national cinematic attention with George Lucas' *Star Wars* in 1977. Anyone who's seen the full-blown version of that film will never forget the opening scene, where the massive battle cruiser looms onto the screen, appearing—to both eye and ear—to come from behind and above the theatergoer. What an introduction to Dolby Stereo!

Movies with stereo soundtracks—most of them musicals—were not rarities prior to that, but the Dolby process added one or two things to mere lateral directionality. The first was Dolby A noise reduction, which (as you'll know if you ever heard the *Star Wars* soundtrack cranked way up, as it was in most theaters) gave optical-soundtrack sound a much greater dynamic range than it had enjoyed before. The second, and perhaps more significant from an entertainment point of view, benefit of Dolby Stereo was that it added, in a rather elegant and easy-to-achieve manner, *true* stereo. That is, the sound field, which had previously been zero-dimensional (monophonic) or one-dimensional (conventional stereo), now took on another dimension and gained front-to-back depth as well. The word "stereo" derives from the Greek word meaning "solid," and with Dolby Stereo, movie sound fields took on solidity.

Although there is a six-track version of Dolby Stereo, in which each soundtrack carries discrete (non-matrixed) information for a single output channel, the process used for most theatrical releases requires only two tracks. With the Dolby process, those two tracks can provide up to four channels of sound. Figure 7 shows how Dolby Stereo works. The left and right channels contain the usual left- and right-channel information; a movie theater without a Dolby Stereo decoder (or a home videotape viewer using just a stereo VCR) would perceive a nearly-normal left- and right-channel soundtrack. (With only monophonic facilities, the two channels would be mixed to produce a single composite output.) With a Dolby decoder, though, two more channels of sound become available. The first is a front-center channel. This is a mixture of the left- and right-channel signals—a composite mono signal in effect—that fills in the audio "hole" that might be perceived by a moviegoer sitting close to the center of a wide screen.

The really interesting part of a Dolby Stereo soundtrack, though, is the fourth, surround, channel. It is encoded on the stereo tracks as "L − R." "Wait a minute!" you say. "That's the same information that you can extract from ordinary stereo for a matrix-surround rear channel system. What's the big deal?" The big deal, it turns out, is in *what* information is encoded in that difference signal. Matrix surround uses natural, or at least natural-sounding, ambience information. What the Dolby process uses is much more controlled. However, for the curious, a method for obtaining a surround effect from Dolby-encoded material without the use of a decoder is described in the box above. It's primitive, but effective.



DOLBISH SURROUND

Once you know how Dolby Surround information is encoded on a stereo soundtrack—namely in the form of an L − R difference signal—it is easy to extract it. While surround decoders bearing the Dolby "double-D" logo contain extra circuitry to provide such things as bandbass filtering and Dolby-B noise-reduction decoding, you can have surround sound—using the Dolby-encoded information—from your stereo VCR or other stereo source such as an over-the-air or cable broadcasts of films containing surround-encoded material for about $25—including the cost of the speaker!

The easiest method to reproduce the L − R "surround" signal, whether it contains natural ambience information or Dolby Surround programming, is simply to subtract the right-channel signal from the left-channel one at the speaker terminals. You can do that by connecting a speaker, which will become your rear surround speaker, between the two positive ("+") speaker terminals as shown in the figure. Signals common to both channels will not be reproduced (or will be reproduced at a reduced level), but the differences between the two—the L − R information—will. Since that is exactly what the Dolby process uses, the third speaker reproducing that signal will become the surround device.

The process is not perfect (otherwise there would be no market for the more complex and expensive devices being sold as Dolby Surround decoders), but it will give you pretty amazing results from good material at a rock-bottom price.

If you connect the surround speaker directly to your amplifier's usual speaker-output terminals, you should use an L-pad in the line to let you control the level, and thereby the balance, of the surround effect sound. You don't want the effect to be overwhelming; most of the time there should be so little of it that you're not aware it's there, although if you were to eliminate it suddenly you would be struck by its absence as the soundfield collapsed.

Be careful when adding a third speaker to your system in that way. Putting the impedance of the extra speaker across that of the other two will change the impedance of the entire system, and may reduce it below the minimum impedance recommended for your amplifier. At very low output levels that may not matter, but at higher ones it can put an unacceptable strain on the amp.

A slightly more complex way, but one reeking less of brute-force, to obtain surround sound using that method would be to mix the line-level signals from a pair of your amplifier's tape output jacks in the same way you would combine the speaker-output ones—by using the two inner conductors of the TAPE OUT cables—and feed that signal to a separate small mono amp driving the surround speaker. **R-E**

Cinematic sound is an extremely artificial medium—even such a simple effect as the sound of an actor's footsteps as he walks from one side of a scene to the other is much more easily created on an engineering con-

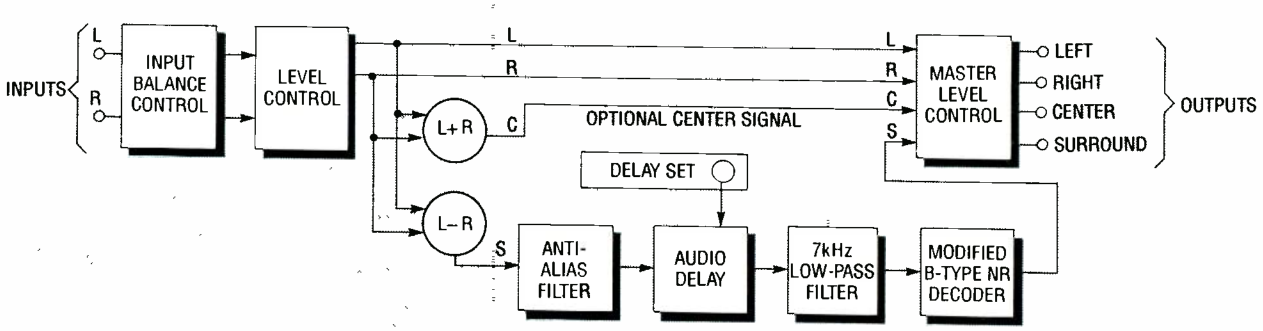


FIG. 7—THEATRICAL DOLBY STEREO encodes four channels of sound on two soundtracks. The Dolby decoder derives a center channel by summing the left and right channels, and surround information by subtracting the right from the left.

sole with a couple of pan pots than on the soundstage during filming. Most of a film's soundtrack is realized in post-production—and that tightly controlled environment makes it relatively easy to put on the surround track exactly what is wanted, without having to rely on natural material.

If you listen carefully to a plain stereo playback of a Dolby Stereo soundtrack, you can frequently detect the presence of the surround effects—they appear to come from outside the speakers' soundstage, the way out-of-phase ambience information may. That is clearly evident in a film such as *Back to the Future*, when the time-travelling DeLorean comes *swooshing* toward or away from the camera. If all four channels of sound are reproduced, you hear the car moving from front to rear, or vice-versa. In plain-vanilla stereo, though, you can plainly hear the car noises coming from the far-left and far-right—off-stage, as it were.

In creating an L − R surround signal, the Dolby Stereo process does two things. The first is to cut off the rear-channel signal at 7 kHz. That is done for several reasons. The first has to do with eliminating signal leakage and distracting crosstalk from the surround channel. Another big reason has to do with economy. There is no need for high fidelity in a surround channel—most of the time the sound there is for "presence"—that is, you are only unconsciously aware of it. The track is meant to be unobtrusive, not to have you constantly aware of its presence. It's only if the surround channel should suddenly fail that you should become consciously aware of its presence (or absence).

That limited frequency response is the reason behind those cheap-looking, PA-type speakers you may have noted in movie theaters equipped for Dolby Surround. It's not that the theater-owner is a cheapskate; simply that there is nothing on the surround track to justify the expense of a better speaker. As far as low frequencies go—the rumble of the engines of the Empire spaceship, for example—they are carried as ordinary left and right information. Since your ears cannot determine where frequencies below about 120 Hz originate, they can be reproduced from low-frequency drivers located anywhere. The visual content of the film will cue you as to where the sound is supposed to be coming from.

The second thing that is done to the rear-channel signal is to encode it using a modified form of Dolby B noise reduction. The modification consists of adding only five dB of processing instead of the normal ten dB. The use of Dolby B provides a degree of noise reduction and assists in reducing front-channel signal leakage, while the low level of processing prevents the encoded surround signal from significantly altering the nature of the left- and right-channel signals heard up front.

In the decoding process, a third element is added to Dolby Stereo: time delay. A delay of between 15 and 30 ms is added to the rear-channel signal to take advantage of a phenomenon known as the Haas effect. The Haas effect causes the mind to identify the source of a sound as that from which it is first heard and to ignore the same sound arriving later at the ear. That "first arrival" effect ensures that front-channel sounds are clearly identified as originating from before the viewer, even if they also come from behind him to some extent. Dolby Stereo decoders also make use of steering logic, discussed below, to add further directionality to the decoded soundtrack.

Before leaving the theatrical Dolby process, we should mention one called "THX." THX is a trademark owned by George Lucas' Lucasfilm (the name has its origin in the title of Lucas' first feature-length work, a science-fiction film called *THX-1138*). All it refers to is a "guaranteed minimum" quality of sound in a particular theater from an ordinary Dolby Stereo soundtrack. THX engineers check and adjust the sound-reproduction equipment in a "THX" theater to meet specific standards of performance. It's just quality control for movie-sound reproduction. Unless you can get a THX engineer to come out to your living room, THX will do nothing for you at home.

Dolby Surround and Pro Logic

Dolby Surround is the name given to one of the two home versions of Dolby Stereo. It starts with the same two stereo soundtracks that are on the film (now on longitudinal or Hi-Fi tracks on a videocassette). And, as is done in theatrical installations, the surround channel is dematrixed, Dolby-B decoded, and time delayed before being amplified and fed to a pair of rear speakers. Only one surround speaker is actually necessary, but two—reproducing the same surround signal—give a "fuller" effect. To derive a monophonic center channel, useful in preventing a center "hole" when the left and right speakers are widely separated, some Dolby Surround decoders mix the left- and right track information. That is not, strictly speaking, necessary, since center information appears equally on both tracks and can be heard appearing from a "phantom" speaker situated

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KIT REPORT: *HEATH'S AD-2550 SURROUND SOUND PROCESSOR*

If you're looking for a fun way to upgrade your audio/video system to include Dolby Surround, Heath's *AD-2550* might be the way to do it. It might also be the perfect way to get yourself back into electronics construction if you've been letting your skills lapse.

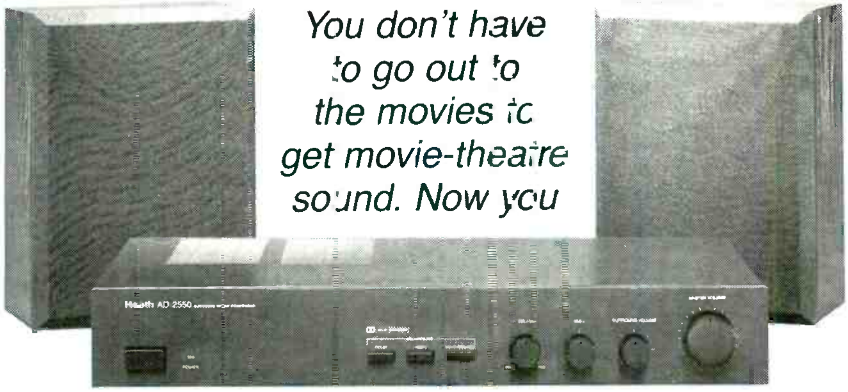
The processor is very easy to build. Although we wouldn't recommend it as a first project, anyone with even minimal kit-building experience, or anyone who has ever built a project from plans published in *Radio-Electronics* should have no trouble.

Most of the work involves assembling one large PC board. There's plenty of room to work, and the supplied instructions and silkscreened boards make things as simple as possible. When the board assembly is complete, the final work involves installing it in the metal cabinet and hooking up the power transformer.

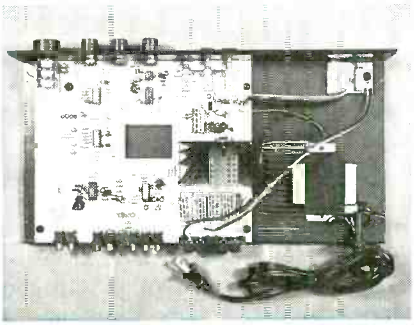
Our total assembly time was about six or seven leisurely hours. Alignment takes only a few minutes, and can be accomplished either with or without test equipment. Did it work the first time we turned it on? If you have to ask, you've never build a Heathkit!

Surround features

When you're finished with the assembly work, you're left with a full-featured surround-sound processor. The *AD-2550* accepts left- and right-channel inputs and offers a wide assortment of outputs. First, because the processor includes a 20-watt audio amplifier, direct speaker outputs are available for connection to surround speakers. Line-level surround-channel outputs are also offered. Line-level outputs for left front and right front are provided for connection to a separate amplifier, or to a stereo TV/monitor. A center-channel output is provided for installations where front-speaker separation produces a sound that is too wide for the screen. It helps to keep the dialogue of on-screen actors sounding as if it's coming from the screen, not off to the side. A line-level subwoofer output feeds the low-frequency (under 70 Hz) sounds to a separate amplifier for room-rattling effects.



You don't have to go out to the movies to get movie-theatre sound. Now you can bring it home to your living room!



EVERYTHING THAT'S NEEDED to produce professional results is included with the kit.

Three different surround modes are provided by the Heath processor. First, of course, is true Dolby Surround. "Music surround" adds synthetic surround effects to stereo audio recordings to give them more depth. A "mono enhance" mode synthesizess stereo-with-surround effects.

Front-panel controls include a power switch, three pushbuttons for choosing the appropriate surround mode, and four rotary potentiometers. First is the DELAY control to set the amount of time delay between the front and rear speakers to give your room a larger feel, even if you must place the surround speakers close to your listening position. The NULL control balances the left- and right-channel signals that are processed by the surround circuitry. It can compensate for some poorly-encoded material. Two volume controls—one for the surround output and the other for all outputs—let you perfectly adjust the balance of the front and rear speakers.

Our tests showed that the decoding circuitry performed flawlessly upon completion. But the real test didn't come until we gave it a trial run with some real test material, including *Indiana Jones and the Last Crusade*. Surround sound can make a dramatic difference. The soundstage becomes instantly larger, and, if we're allowed a little exaggeration, even the picture seems bigger!

Movies that are encoded with Dolby surround can, of course, be de-

(Continued on page 88)

MOST OF THE ASSEMBLY work is done on a large PC board.

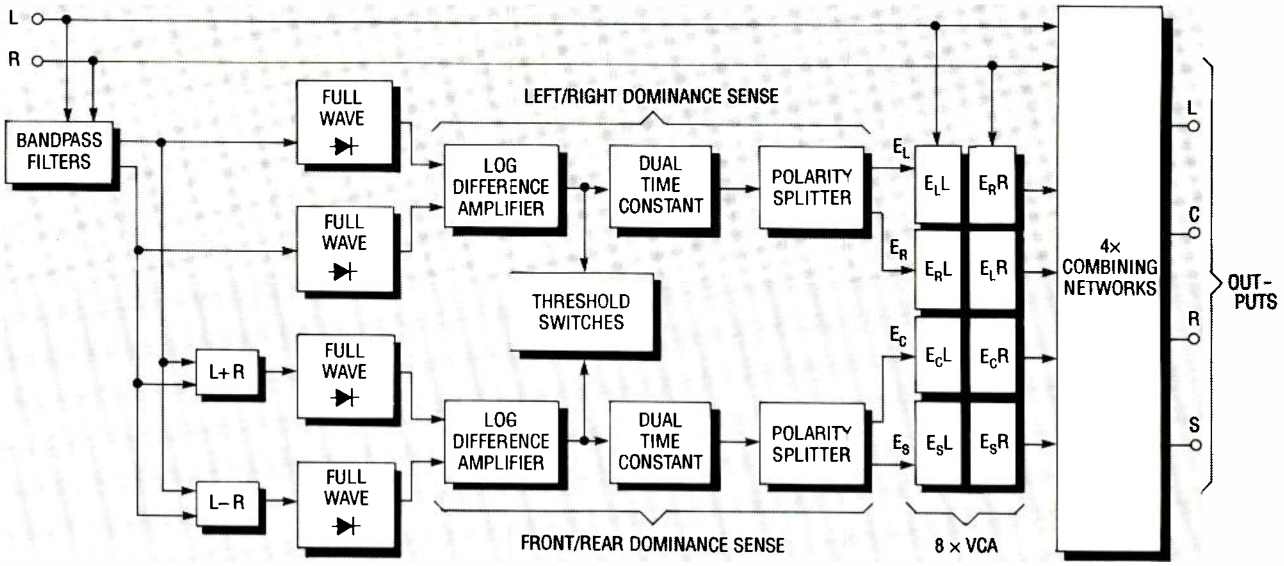


FIG. 8—THE ADAPTIVE MATRIX used in the Dolby Pro Logic Surround process can provide up to 30 dB of separation between opposite or adjacent channels. That affords an extremely high degree of directionality.

between the two front ones. A few Dolby Surround processors can also output a front-and-back mix to side speakers. Finally, most processors on the market also feature a subwoofer output. That has nothing to do with the Dolby process; it's more a convenience than anything else.

Dolby Pro Logic Surround is the ultimate in Dolby Surround processing. While the original Dolby Surround process is primarily a passive one (all the equipment does, essentially, is decode the matrixed information), Pro Logic decoders contain active circuits that provide a surround effect as good as—if not better than—that in the best movie theater. The active addition to a Dolby Pro Logic decoder is known as steering logic.

The purpose of the steering logic circuitry in a Dolby Pro Logic decoder is to sense the direction of soundtrack dominance—that is, to determine from what direction the loudest sound on the track seems to originate—and to generate control signals that increase gain in the appropriate (left, right, center, surround) combination of channels to give a directional vector. Figure 8 illustrates the workings of the adaptive matrix within a Pro Logic decoder. By comparing the left and right and center and surround signal pairs, and taking the logarithms of their values (logarithms are used, in part, because human senses work in a logarithmic rather than linear fashion), a pair of bipolar control signals is generated, which are used to adjust the gain of eight voltage-controlled amplifiers (four for each input channel). The outputs of those VCA's, together with the original left- and right-channel signals, provide a total of ten control signals. When those signals are applied to the four output channels, a total of forty summed directional components are available. Separation between any pair of channels—adjacent or opposite—is 30 dB, compared to Dolby Surround's 3 dB of adjacent separation, and 40 dB of opposite separation.

Pro Logic decoders are two-speed devices. When only one sound source is dominant, they run in their "slow" mode. But when there are two distinct sound sources (by definition, only one can be "dominant" at a time), the Pro Logic circuitry goes into a "fast," time-division multiplexing mode where it gives its attention first to one source, and then to the other. It switches back and forth between the two so quickly that its efforts are unnoticed by the listener.

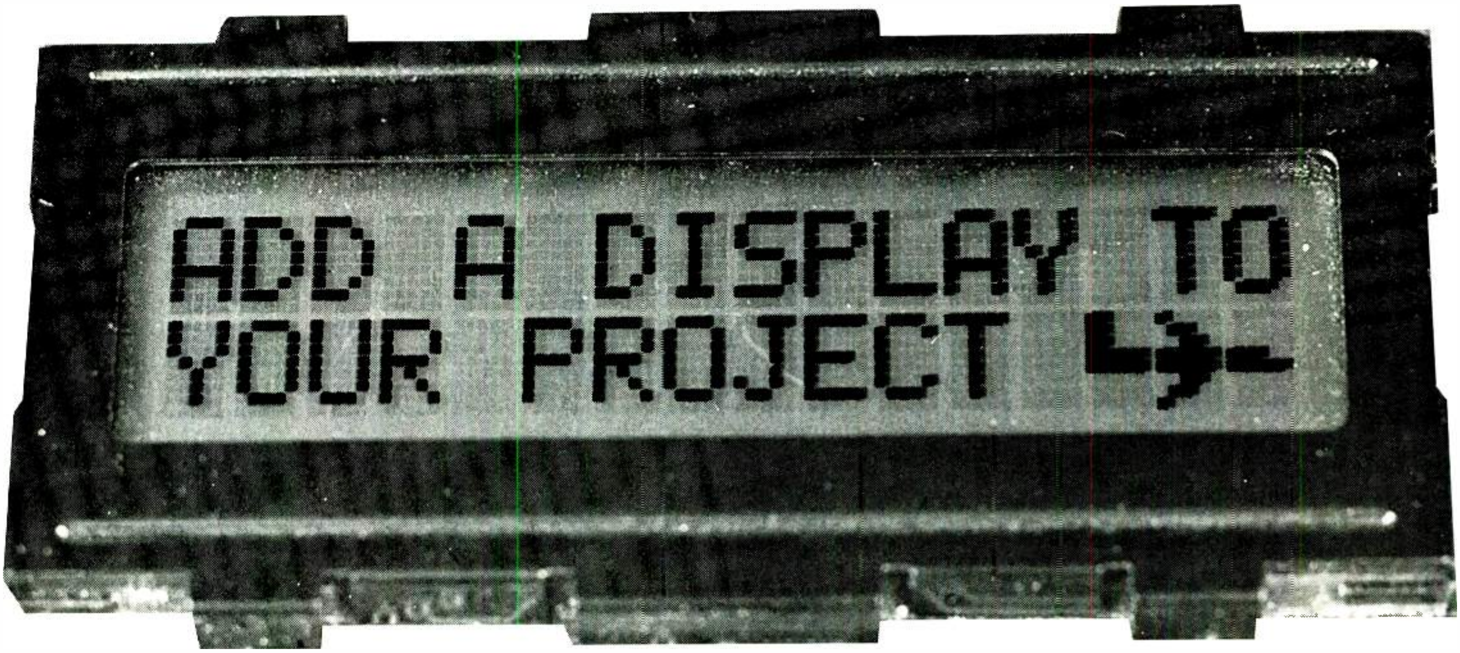
Dolby Pro Logic decoders include as a matter of course center-channel and subwoofer outputs. As is the case with the surround channel, the center-channel amplifier and speaker need not have the frequency response of the equipment used for the left and right channels. High- and low frequencies will be reproduced by those systems and by the subwoofer, if one is used. With a good-quality hi-fi-soundtrack videotape, and with even a modest array of home sound equipment, you can experience a quality of cinematic sound at home that you would be hard-pressed to find in any theatrical environment. **R-E**

GENERIC POWER SUPPLY

continued from page 46

ble. If the water dries smoothly, from the edges inward, or forms fine bubbles, you're probably safe. However, if the water boils off immediately, there's trouble. It's not a terribly scientific method, but it's free. Check a second time, waiting a full minute after drying for heating recovery.

The 78XX/78MXX versions are fixed-positive models. For example, a 7812 is a positive 12-volt model that can provide at least 1 amp of output current—but only when the regulator drop is low enough to avoid overheating. The suffix "T" specifies a TO-220 case, but catalogs often omit this and specify the case type elsewhere. The 79XX/79MXX versions are fixed-negative models. The LM317/LM317M models are adjustable-positive, and the LM337/LM337M are adjustable-negative. They're all very reliable, and can take considerable abuse. **R-E**



The days of LED indicators and segmented displays are numbered. Now you can add an alpha-numeric LCD to your home project easily and inexpensively.

STEVEN AVRITCH

HAVE YOU EVER AVOIDED A PROJECT BEcause it required a display that could handle numbers, letters, and symbols? Have you ever given up on a project because the display had to be at least 10, 20, maybe even 40 characters long?

You can solve all of those problems by using a simple and inexpensive alpha-numeric LCD module which contains a controller chip that does most of the work for you! This article will show you how to use LCD's with a simple microcontroller- or microprocessor-based design. Note that most small LCD modules use the Hitachi HD44780 LCD controller chip (see block diagram in Fig. 1). This article will therefore be limited to a discussion of LCD modules that use, or are compatible with, the HD44780 controller format. Common LCD modules include those manufactured by Optrex, Epson, Hitachi, Amperex, and Densitron.

Multi-character readouts are usually constructed using individually wired, multiplexed display segments. The host microprocessor sequentially flashes the desired character on each digit of the display, one at a time. The microprocessor is fast enough so that the naked eye sees the display as it should appear. That method of multiplexing the digits of a display is often used because it reduces the amount of external hardware required compared to non-multiplexed systems. However, multiplexing requires the microprocessor to continually update the display, and the amount of external wiring must be increased as additional digits are added (see Fig. 2).

For example, a 10-digit numeric display requires approximately 100 wires and over 20 components. (A 10-digit alpha-numeric display requires even more wires.) The equivalent display (including alpha-numerics) implemented with an LCD module would require only 10 wires and 2 components: the LCD module and a potentiometer for contrast control. Using an LCD module, a designer can add a display containing up to 80 characters with as little as 10 wires, 7 of which connect the display module to the host microcontroller/processor, plus 1 power, 1 ground, and 1 LCD drive wire for contrast control. That's all!

The software interface between the host and the display module is just as simple as the wiring. The display modules automatically handle all refresh and multiplexing functions. The host needs only to write the data to be displayed and a few control codes (such as display on, display off, scroll left, scroll right, etc.) to the module; the on-board LCD controller chip does the rest.

LCD modules have not been used heavily in the past because of their high costs. However, the cost of the modules has since dropped considerably, and they are now commonly found in many of the popular electronics supply houses. For example, a 32-character display (2 lines, 16 characters per line, 16 × 2) is available from Digi-Key for approximately \$23. Similar displays can be obtained through surplus houses for approximately \$8–\$10.

Most of the small, inexpensive LCD modules contain a Hitachi HD44780 LCD Controller chip. That means that most of LCD modules follow the same standard format, have the same 14-pin interface, and are therefore compatible and interchangeable. The HD44780 is capable of controlling any size display up to 2 lines long and 40 characters wide with the same hardware interface. Commonly available display sizes include 16 × 1, 16 × 2, 20 × 2, 24 × 2, and 40 × 2 formats. That means that you

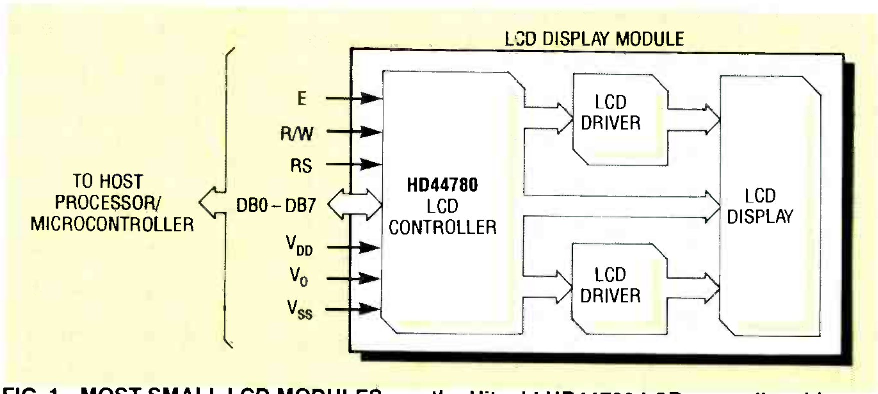


FIG. 1—MOST SMALL LCD MODULES use the Hitachi HD44780 LCD controller chip.

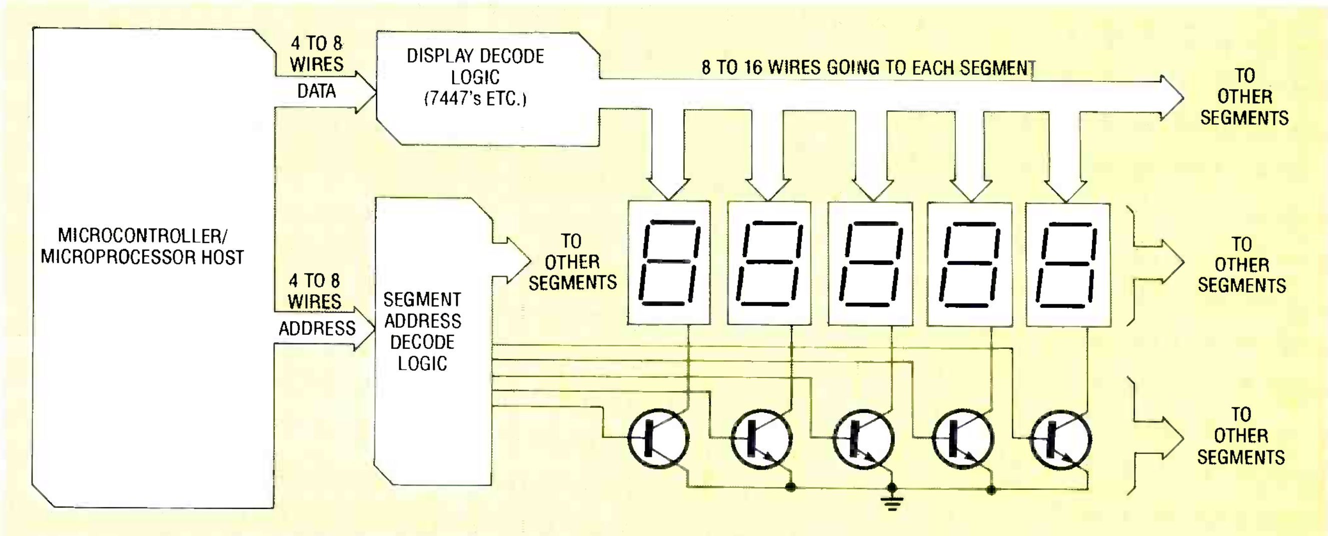


FIG. 2—MULTIPLEXING REQUIRES the microprocessor to continually update the display, and the amount of external wiring must be increased as additional digits are added.

can change the size of your display by simply plugging in a larger module. No other hardware modifications are required; only the software drivers specific to the application would need to change.

The LCD modules recognize standard ASCII code for letters (upper and lower case) and numbers in addition to a variety of symbols including ?, !, $AK, %, and ', just to name a few. In all, the LCD module supports 192 alpha-numeric characters and 32 special symbols. The modules also allow you to customize up to 8 user-defined characters of your own. On one home project the author customized three characters that, when displayed together, formed an airplane as can be seen in the photo.

The LCD modules are dot-matrix type displays with each character being formed from a 5-dot-wide by 7-dot-high block (5 × 7 font) or a 5-dot-wide by 10-dot-high block (5 × 10 font). The font is selected by issuing a control command as discussed later in this article.

There is also a cursor line under each character. The 5 × 10 font is better suited for certain lower-case letters such as g, y, and p (i.e. letters with descenders that go below the line that they're written on). Figure 3 shows examples of letters formed using the 5 × 7 and 5 × 10 dot-matrix formats for comparison. It should be noted that the 5 × 10 matrix font limits the display to one line regardless of whether the LCD module is a one-line or two-line display.

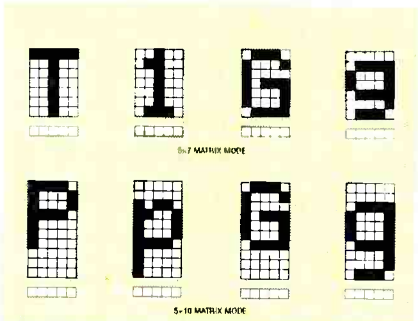


FIG. 3—HERE ARE SOME EXAMPLES of letters formed using the 5×7 and 5×10 dot-matrix formats.

Features of LCD modules

The LCD modules support a variety a display features that can accommodate just about any application. The following is a brief description of their features:

- Display on/off—allows the user to turn the display on and off from the host processor.
- Cursor on/off—user may select to display the cursor or suppress it.
- Cursor blink—the user may select a steady cursor or a blinking cursor. The character above the cursor also blinks.
- Scroll left/right—scrolls the data on the display.
- Return home—returns the cursor to the home position (address 0) and returns the display to the original position (if it had been previously scrolled)

Software interface

The software interface between the LCD module and a processor or microcontroller is relatively simple. There are two basic types of software operations: control operations (i.e. display on/off, cursor blink/noblink, etc.) and data operations. The control operations set up the features of the display, while the data operations write the actual data to be displayed to the LCD module.

The LCD module's on-board HD44780 controller chip contains 80 bytes of display RAM and is capable of supporting up to a 40 × 2 display (each byte of display RAM corresponds to a digit of the display). Smaller LCD modules simply do not

display the full 80 bytes of RAM. The display RAM is organized in the following format:
LINE 1:
Character position: 1 2 3 4 5 6 7 8 9...40
RAM address 0 1 2 3 4 5 6 7 8...27(hex)
LINE 2:
Character position: 1 2 3 4 5 6 7 8 9...40
RAM address 40 41 42 43 44 45 46 47 48...67(hex)

Smaller modules simply do not display the upper character positions associated with the upper addresses. For example, a 16×2 display uses addresses 00–0F (hex) for line 1 and 40–4F (hex) for line 2.

The HD44780 also contains 64 bytes of character-generator RAM. That is used to store the character patterns of the 8 user-defined characters (8 bytes per character). Once a user-defined character is set up in character-generator RAM, it may be accessed just as any other regular character. NOTE: in the 5×10 matrix mode, only four user-defined characters are supported, with each character requiring 11 bytes of character-generator RAM.

Software drivers

The host must contain two basic software drivers to support the LCD modules, the Control Write and Data Write drivers. The minimum functions that the software drivers must perform are:

Control Write:
- Sets up DB0–DB7 with the desired control code
- Sets the R/W line to logic zero
- Sets the RS line to logic zero
- Strobes the ENABLE line

Data Write:
- Sets up DB0–DB7 with the desired character
- Sets R/W line to logic zero
- Sets the RS line to logic one
- Strobes the ENABLE line

The user may also read data and control signals from the HD44780. Control Read and Data Read drivers are similar to the write drivers except that the R/W line is set to a logic one. Refer to Table 1 for a complete listing of the control codes and status flags available with the HD44780 LCD controller chip.

Subroutines for the MC68705

The following subroutines show the software drivers for data and control writes. The examples shown here are written in Motorola 6800-series assembler code and are targeted for the MC68705 microcontroller. These short routines can be easily translated into other assembly languages that can be used with other microcontrollers/microprocessors.

The Data Write subroutine (Listing 1) displays letters and symbols. The ASCII code of the letter/symbol to be displayed must be loaded into the Accumulator before calling the Data Write subroutine. Before the Control Write subroutine (Listing 2) can be called, the code of the control operation to be performed (from Table 1) must be loaded into the Accumulator.

Display initialization

The first operation that the software

LISTING 1

```
DISLET    STX    TEMPX      SAVE INDEX REGISTER
          STA    PORTA      PUT CHARACTER ON BUS
          BCLR   1,PORTB    SET R/W TO WRITE
          BSET   2,PORTB    SET RS TO DATA
          BSET   0,PORTB    TURN ON ENABLE
          BCLR   0,PORTB    TURN OFF ENABLE
          BCLR   2,PORTB    SET RS TO CONTROL
          LDX    #$20       \
DELAY1    DECX               \  DELAY 120 us
          BNE    DELAY1      /  ASSUMING 1 us
                            /   CLOCK
          LDX    TEMPX      RESTORE INDEX REGISTER
          RTS               RETURN FROM SUBROUTINE
```

LISTING 2

```
CONTROL   STX    TEMPX      SAVE INDEX REGISTER
          STA    PORTA      PUT CONTROL CODE ON BUS
          BCLR   1,PORTB    SET R/W TO WRITE
          BCLR   2,PORTB    SET RS TO CONTROL
          BSET   0,PORTB    TURN ENABLE ON
          BCLR   0,PORTB    TURN ENABLE OFF
          LDX    #$FF       \
DELAY2    DECX               \
          BNE    DELAY2       \
          CMP    #$02          \ DELAY FOR CONTROL
          BHI    DELAY4        /
DELAY3    JSR    ENDCNTL      /
          DECX               /
DELAY4    LDX    TEMPX      RESTORE INDEX REGISTER
ENDCNTL   RTS               RETURN
```

LISTING 3

```
INIT      LDA    #$01       CLEAR DISPLAY
          JSR    CONTROL
          LDA    #$02       RETURN DISPLAY TO HOME POSITION
          JSR    CONTROL
          LDA    #$38       SET UP FOR 2 LINES, 8 BIT INTERFACE,
                                AND 5X7 MATRIX FORMAT
          JSR    CONTROL
          LDA    #$06       SET UP FOR CURSOR SHIFT WITH DATA WRITE
          JSR    CONTROL
          LDA    #$0C       SET UP FOR DISPLAY ON, CURSOR OFF,
                                AND STEADY CURSOR (NO BLINK)
          JSR    CONTROL
          RTS               RETURN FROM SUBROUTINE
```

LISTING 4

```
CGINIT    LDA    #$40       SET UP FOR WRITES TO CG RAM
          JSR    CONTROL
          CLR    DATCNT     CLEAR BYTE COUNTER
NEXT      LDX    DATCNT     LOAD BYTE COUNTER
          LDA    PLANE,X    LOAD CG RAM DATA INTO ACCUMULATOR
          JSR    DISLET     WRITE BYTE TO CG RAM
          INC    DATCNT     INCREMENT COUNTER FOR NEXT BYTE
          LDA    DATCNT     \
          CMP    #24        / 24 BYTES WRITTEN ?
          BNE    NEXT
          LDA    #$80       SET UP FOR WRITES TO DD RAM
          JSR    CONTROL
          LDA    #$02       INITIALIZE DISPLAY TO HOME POSITION
          JSR    CONTROL
          RTS               RETURN FROM SUBROUTINE
```

TABLE 1—CONTROL OPERATIONS

Instruction	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description and execution time
Clear	0	0	0	0	0	0	0	0	0	1	Clears Display Returns cursor to home position (1.64 ms)
Home	0	0	0	0	0	0	0	0	1	X	Return cursor to home position Return shifted display to home position (40 μs)
Mode	0	0	0	0	0	0	0	1	I/D	S	Control automatic RAM address INC/DEC and whether display shifts on writes (40 μs)
Display ON/OFF	0	0	0	0	0	0	1	D	C	B	Controls display ON/OFF Controls cursor ON/OFF Cursor blink ON/OFF (40 μs)
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	X	X	Sifts cursor and/or display without changing display RAM (40 μs)
Function set	0	0	0	0	1	D/L	N	F	X	X	Set interface to 4 or 8 bits Set number of display lines Sets character font (40 μs)
Set CG RAM address	0	0	0	1	Address (CG)						Set address for subsequent writes to character generator. (CG) RAM. (40 μs)
Set DD RAM address	0	0	1	Address (DD)							Set address for subsequent writes to display (DD) RAM (40 μs)
Read busy flag & address	0	1	BF	Address Counter							Read status of busy flag (BF) and present address counter value (1 μs)
Write data to CG or DD RAM	1	0	Data to be written to DD or CG RAM. DD/CG destination based on last "set DD/CG RAM address" control command								Writes data to HD44780 (40μs)
Read data from CG or DD RAM	1	1	Data read from DD or CG RAM. Source of data (CG or DD) based on last "set DD/CG RAM address" control command								Reads data from HD44780 (40 μs)

I/D = 1: Increment address pointer on each subsequent read/write
0: Decrement address pointer on each subsequent read/write

2 = 1: Shift cursor with display
0: Hold cursor fixed

S/C = 1: Shift display (without changing DD RAM)
0: Shift cursor only

R/L = 1:Shift operations occur to the right
0: Shift operations occur to the left

DL = 1: 8-bit data-bus interface
0: 4-bit data-bus interface

N = 1: 2-line display
0: 1-line display

F = 1: 5 × 10 dot character font
0: 5 × 7 dot character font

BF = 1: Busy
0: Not busy

must perform is the initialization of the display. Initialization includes clearing the display and issuing the appropriate control commands that set the display up with the desired features. The INIT subroutine (Listing 3) is a sample initialization routine for a 16 × 2 display. The INIT routine sets the display up for 2 line, 5 × 7-font format, 8-bit interface mode, and suppressed cursor. Also, the INIT routine sets up the display to shift the cursor one position to the right on every data write.

Note: The display module requires 10 milliseconds to initialize after power is applied. The host, therefore, must wait at least 10 milliseconds before writing to the display following the power-up of the module.

CG RAM initialization

The CGINIT routine (Listing 4) illustrates the operations required to set up 3 of the 8 user-defined characters. The characters defined in the routine form an airplane when displayed together. Table 2 illustrates how each of the three user-definable characters are generated. Listing 5

continued on page 80

LISTING 5

```
PLANE   FCB  $00
        FCB  $00
        FCB  $00
        FCB  $1C
        FCB  $1F
        FCB  $00
        FCB  $00
        FCB  $00
        FCB  $10
        FCB  $0C
        FCB  $06
        FCB  $1F
        FCB  $1F
        FCB  $06
        FCB  $0C
        FCB  $10
        FCB  $18
        FCB  $18
        FCB  $18
        FCB  $1F
        FCB  $1F
        FCB  $00
        FCB  $00
        FCB  $00
```

HARDWARE HACKER

Electronic Levels
Low Cost Memory
New Form of Matter
Cases and Enclosures
LaserWriter Tech Info

DON LANCASTER

Low-cost memory

SOMEONE AT LONG LAST HAS DONE something right for a change. Hacker friendly too. A giant *Yea Team!* and a sixpack of *attaboys* to all of the folks at *Dallas Semiconductor,* a manufacturer of innovative new integrated circuits.

Dallas has set up a free 24-hour direct-order line with no hassles and no minimums. If you want one or two of their chips at 3:42 in the morning, just whip out your VISA card and give them a call. For next day delivery.

What's really sad is that virtually all of those other "good guy" innovative chip manufacturers invariably use by far the most Neanderthal and the most hacker vicious of the old-line distribution channels.

So here and now, I issue an outright challenge to all the rest of the "good guys"—*Maxim, Sprague, Linear Technology, Samsung, Mitsubishi* (who has far and away the most mesmerizingly awful reps and distributors in the industry, bar none), *Signetics, Reticon, SGS, Statek, Teltone, Rohm, Intersil, Sony, Siemens, Philips,* et. al.

For your own good, please, please, find out why *Dallas* is laughing all the way to the bank. And please set up your own direct order lines that do not go out of their way to kick sand in the collective faces of your most promising future customers. Your present distributors are your worst enemy.

As usual, please observe that all of our referenced sources do appear in either the upcoming *Cases and Enclosures* resource sidebar or in the *Names and Numbers* box. Please do check out the sidebars before using our free help line. And please do make all your product and your literature requests to anyone listed in either sidebar specific, rather than general.

We return you now to our column already in progress....

LaserWriter information

It appears that *Apple Computer* has gone far out of their way to prevent you from ever getting any useful parts or technical service information on their *LaserWriter* printers. Outside of the limited "white book" *LaserWriter Reference* on all of those connections and the commands (in stock here at *Synergetics*), virtually nothing at all is available from them on their printers. Such stupidity ends up monumentally short-sighted.

Fortunately, *Hewlett-Packard* is as hacker-friendly as *Apple* is hacker-vicious. The *Canon* CX and SX engines used by both companies in their printers are nearly identical. Over 95 percent of the mechanical parts are fully interchangeable. And HP, like *Dallas Semiconductor*, also has a free VISA order line with overnight express delivery.

HP has a pair of outstanding service and repair manuals that are directly applicable to the *Apple* printers. Their manual #33440-90920 is for the older CX engine as used on the *LaserWriter* and *LaserWriter Plus*. Their manual #33440-90904 is for the newer SX engine that is used on the *LaserWriter NT* and *LaserWriter NTX*.

Unfortunately, HP sells only the replacement modules, and rarely goes down to the individual component parts level. Thus, you can get a fuser assembly from them, but not a fuser roller. One source I've found useful for any and all *LaserWriter* parts on any level is *Don Thompson,* who also stocks detailed repair literature, low-cost rebuilds, toner supplies, and the handy and useful repair tools. One additional source for a LaserWriter schematic is *Bomarc Services.*

As we have seen before, you can easily refill your own SX or CX toner cartridges in two minutes for $7.50. The job is much simpler than properly packaging your cartridge for shipping to a commercial refilling service.

Besides *Don Thompson*, another major source of refilling supplies that I personally use is Arlin Shepard of *Lazer Products.* Arlin also now offers "infinite life" recoated SX drums. One I'm now using is on its 14th refill.

From what I have been able to determine, much of the rest of the toner refilling industry is an outright zoo. We have people selling you shoe polish and calling it drum recoating, others gold plating things that do not need gold plating, and yet others who are making useless

NEED HELP?

Phone or write your **Hardware Hacker** questions to:

Don Lancaster
Synergetics
Box 809-RE
Thatcher, AZ, 85552
(602) 428-4073

"gapping" adjustments that try and compensate for the shoddy quality of the toner.

For a good glimpse into the entire toner refilling industry, check out the highly interesting and informative *Recharger* trade journal. Full details on the toner cartridge reloading appear in previous columns (**Radio-Electronics**, April 1989) and in my *Hardware Hacker II* book-on-demand published reprints.

Low-cost memory

In case you have not met them before, *Dallas Semiconductor* has a mind-boggling array of cheap and innovative new circuits that cry out for hacker use. They are very heavy into such things as clocks, non-volatile memory, supervisory watchdogs, FCC legal "plug-and-go" telephone modules, and the short-range RF remote controls.

One typical example is their DS2222 *EconoRAM,* shown in Fig. 1. This is a 256-bit nanopower memory that is easily made non-volatile with a tiny backup battery. It is intended for intelligent credit cards, public-transit tickets, security-access control, trade-show customer identification, long-term data acquisition, and user ID keys. Or anywhere else you want to cheaply store a few bits of information that has to be nanopower, compact, and highly portable.

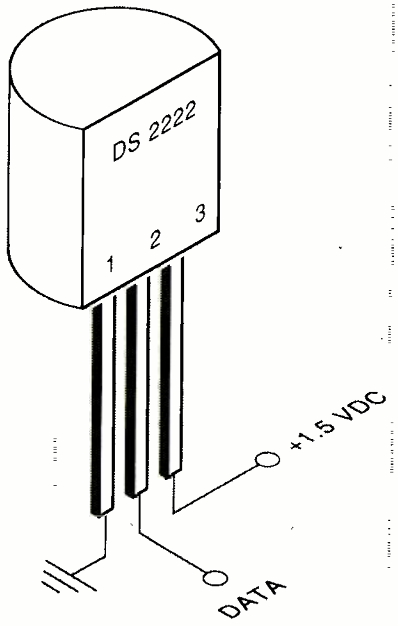


FIG. 1—THE ECONORAM is a micropower memory of 256 bits. These can cost less than a quarter each in quantity. Amazingly, all addressing, data transfers, and all read/write control are done through a single very busy pin!

The cost is under a quarter in large enough quantities. Supply voltage is between 1.2 and 4 volts DC. Standby operating current is a mere 100 nanoamperes. Less than one milliampere is needed for a read or write operation. A typical small coin cell is good for 100 million transactions over several years of operation.

What boggles the mind is that there are only *three* pins on the DS-2222. Power, ground, and a single pin that, believe it or not, performs all of the addressing, data transfer, and control of reading and writing.

You just about have to use a host microprocessor or personal computer to read or write to the chip, since the process is so involved. Here's how it usually works:

To read or write any one bit, all bits must get read or written. Figure 2 shows details. Your host controller provides a high output and then issues a string of 264 pulses. The timing can be any interval longer than 60 microseconds per pulse.

Each pulse event begins when the output drops from supply to ground. When writing, a logic one must last between 1 and 15 microseconds. A logic zero must last at least 60 microseconds. And so, the *length* of your write pulse determines whether you enter a one or a zero.

When reading, you have your host hold the output low for between 1 and 15 microseconds. The EconoRAM should respond by remaining low for another 15 microseconds if a zero is stored, and by immediately going high if a one is stored. Thus, to read, bring the output low for 15 microseconds. Wait 5 microseconds. Then sense the one or zero.

The first 8 bits in your sequence are called the *command word.* The first five are all ones to write, or all zeros to read. That is followed by a pair of zero bits which allow a later memory expansion. The eighth header bit is always a one.

The remaining 256 bits are your data, arranged in a sequentially addressed order, which is much like how a shift register would work. To change a single bit, you first read all of the bits, store them in host memory, and then rewrite all of the bits, changing what you want on the fly.

Obviously, this RAM is best suited for long-term storage applications only occasionally read from or written to. A 5K pull-up resistor is recommended when writing or reading. The output pin is TTL compatible.

Now for the tricky part. To first initialize your EconoRAM, you send it 264 write zero states. That automatically resets the internal address counter. After that you send a new sequence to do whatever reading or writing you care to. Remember that you must go completely through a sequence each and every time or the EconoRAM will get confused.

Four EconoRAM's are easily used together for a full 1K that should be enough for a complete name, address, and account number. All you do is change the address bits in your command string through 00, 01, 10, or 11. As many as 32 bits could also get permanently factory written in for a positive and genuinely non-volatile message header.

Let me know what new hacker uses you might come up with using this innovative new approach to small memory needs.

Cases and enclosures

For this month's resource sidebar, I thought we'd round up some low-cost products and materials that let you design your own electronic cases and enclosures.

Obviously, if you just need a plain old box, your local *Radio Shack* has several bargain priced ones in stock, as does *Mouser Electronics,* as well as nearly all of our other fine **Radio-Electronics** surplus advertisers. The trick is to find something beyond a plain-jane box that looks sharp, makes a clear statement you can relate to, and isn't outrageously expensive.

Let's briefly run down the major case and enclosure manufacturers: *Bud,* of course, who is pricey, very old line and uninspired; *Vero* having a foreign look about them; *Hammond* with a good selection of ABS minicases; *Polycase* who feature the wall-mounted and plug-in stuff; *PacTec* with an incredible variety of sloping small consoles; *Keystone* for built-in battery compartments and standoffs; *Serco* for some fancier, highly styled boxes; and *Vector* who are both low cost and look it.

Want to wrap your own instead? Figure 3 shows you three of my own favorite home-brew packages from way back when. While most of the *Zero Manufacturing* cases are ludicrously expensive, they also offer a line of plain old deep-drawn aluminum boxes (Fig. 3, top) with rounded corners in zillions of sizes that are reasonably priced. These anodize beautifully, and many models have lids which exactly provide an outside or an inside fit. And the photographic dialplate materials from either *Metalphoto* or *Fotofoil* can integrate beautifully with these cases.

For dozens of examples of these, check into the back issues of **Popular Electronics** and **Radio-Electronics** in the 1965–1975 time frame.

Vinyl clad materials are used by all the big folks. Getting them in small quantities can be a real hassle. Instead, you simply go on down to your local *Yellow Front* or an equivalent yuppy pseudo-surplus store, buy some fake Naugahyde by the yard, and glue it onto plain old aluminum or steel. The "clamshell" design (Fig. 3, middle) is easy to do. You can simply sand the bottom half to get a satin finish, and glue vinyl

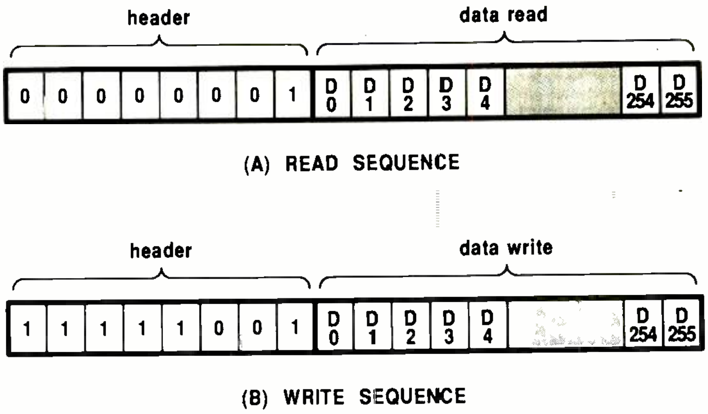
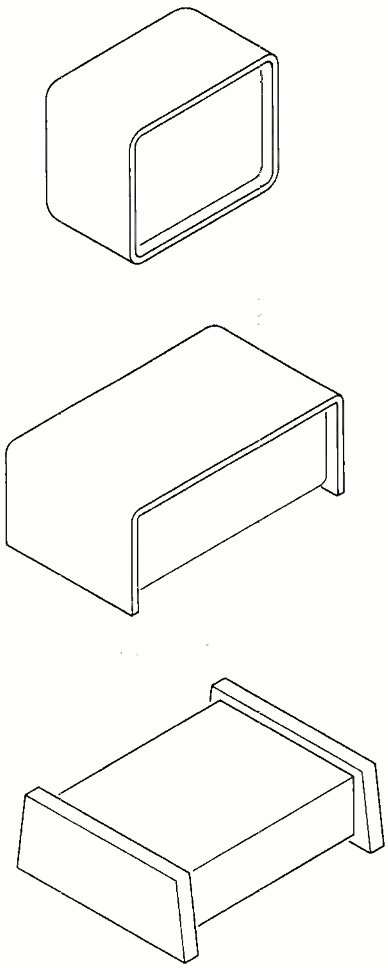


FIG. 2—THE ECONORAM GETS INTERROGATED by use of 264 sequential timing pulses. Once started, the sequence must get completed in its entirety. See the DS2222 data sheet for additional details.



The **ZERO BOX** uses a deep drawn aluminum shell and looks particularly good with a Metalphoto dialplate. Shallow versions can also be used face up. These anodize beautifully.

The **VINYL CLAMSHELL** has a brushed aluminum chassis and a cover coated with glued-on decorator vinyl. Tilting end brackets can also be added, as can ventillation holes.

The **WOODEN END RAIL** ploy uses exotic wood caps that have suitable grooves routed in them. The chassis itself can be painted aluminum or a polished brass or chrome.

FIG. 3—HOMEBREW CASES FROM the "golden age" of hardware hacking. All of these are easily built, yet can produce outstanding professional results.

onto the upper half to get a professional final result.

The *wooden rail* ploy (Fig. 3, bottom) is both easy to hack and looks great. Just get yourself some exotic wood from *EDLCO* or *Constantine* (Cocobolo or Wenge are fine choices), mill some slots in it with a hobby motor tool, slide in a bent metal frame, and you are home free.

I've found a local blacksmith or sheet-metal shop to be real handy at times, so you'll want to find a good one of these on your own. Better yet, see if you can't find a horse trailer or hitch works. They have the machinery to properly cut and bend the heavier stuff without costing an arm and a leg. And there's usually enough scrap on the floor under the shear.

Four interesting package support outfits are the *Fomeboards* people which do stock all sorts of beautiful prototyping sheet materials; *Coburn* who is heavy into unusual finishes such as prismatics, glow-in-the-darks, diffraction gratings, foils, etc; instant dust-on flock materials from *DonJer,* and the *Ultra-Suede* from *Red Spot,* a textured urethane finish having a soft fuzzy suede or smooth leather touch.

All the enclosure and packaging people advertise in most of the free electronics trade journals. *Electronic Component News* seems about the best for cases and such. Two other trade journals with useful fit and finish ideas in them include *Electronic Packaging* and *Appliance.*

CASE AND PACKAGING RESOURCES

Appliance
1110 Jorie Blvds, CS 9019
Oak Brook, IL 60522
(708) 990-3484
CIRCLE 225 ON FREE INFORMATION CARD

Coburn
1650 Corporate Road West
Lakewood, NJ 08701
(201) 367-5511
CIRCLE 226 ON FREE INFORMATION CARD

Constantine
2050 Eastchester Road
Bronx, NY 10461
(212) 792-1600
CIRCLE 227 ON FREE INFORMATION CARD

DonJer Products Co
Ilene Court Building 8
Belle Mead, NJ 08502
(800) 336-6537
CIRCLE 228 ON FREE INFORMATION CARD

EDLCO
PO Box 5373
Asheville, NC 28813
(704) 255-8765
CIRCLE 229 ON FREE INFORMATION CARD

Electronic Component News
1 Chilton Way
Radnor, PA 19089
(215) 964-4345
CIRCLE 230 ON FREE INFORMATION CARD

Electronic Packaging
1350 East Touhy Avenue
Des Plaines, IL 60018
(708) 635-8800
CIRCLE 231 ON FREE INFORMATION CARD

Fomeboards
2211 North Elston
Chicago, IL 60614
(312) 278-9200
CIRCLE 232 ON FREE INFORMATION CARD

Fotofoil/Miller Dial
4400 North Temple City Blvd
El Monte, CA 91734
(818) 444-4555
CIRCLE 233 ON FREE INFORMATION CARD

Hammond
1690 Walden Avenue
Buffalo, NY 14225
(716) 894-5710
CIRCLE 234 ON FREE INFORMATION CARD

Keystone Electronics Corp
31-07 20th Road
Astoria, NY 11105
(718) 956-8900
CIRCLE 235 ON FREE INFORMATION CARD

Metalphoto
18531 South Miles Road
Cleveland, OH 44128
(216) 475-0555
CIRCLE 236 ON FREE INFORMATION CARD

Mouser Electronics
11433 Woodside Avenue
Santee, CA 92071
(800) 346-6873
CIRCLE 237 ON FREE INFORMATION CARD

PacTec
Enterprise & Executive Avenues
Philadelphia, PA 19153
(215) 365-8400
CIRCLE 238 ON FREE INFORMATION CARD

Polycase
4726 Superior Avenue
Cleveland, Ohio 44103
(216) 391-0444
CIRCLE 239 ON FREE INFORMATION CARD

Red Spot
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Evansville, IN 47703
(812) 428-9100
CIRCLE 240 ON FREE INFORMATION CARD

Serco
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Covina, CA 91723
(818) 331-0517
CIRCLE 241 ON FREE INFORMATION CARD

Vector Electronic Co
12460 Gladstone Avenue
Sylmar, CA 91342
(818) 365-9661
CIRCLE 242 ON FREE INFORMATION CARD

Vero
1000 Sherman Avenue
Hamden, CT 06514
(203) 288-8001
CIRCLE 243 ON FREE INFORMATION CARD

Zero Halliburton
PO Box 3339
Pacoima, CA 91333
(818) 897-7777
CIRCLE 244 ON FREE INFORMATION CARD

Electronic inclinometers

The folks at *Wedge Innovations* are now retailing intelligent electronic levels that display your choice of degrees, pitch, slope percent, level & plumb, autocalibration, and even a simulated bubble. The suggested list price is under $80. Related electronic protractors are being offered by *Lucas Sensing Systems.* I just thought we might take a quick look at some of the principles of electronic level sensing. You can easily build your own level sensor for under $4.

In general, there are two popular ways of telling which way is up. One quite expensive method is the *vertical gyro.* That is simply a gyroscope that is spun up while level and stays that way when the world around it moves. Two surplus sources of vertical gyros include *Fair Radio Sales* and the folks at *C&H Sales.*

A much simpler method is the *inclinometer.* As Fig. 4 shows us, an inclinometer can be as simple as a plumb bob and a protractor. Your gravity-sensing plumb bob usually points straight down. As the protractor is rotated, its slope angle can be read.

There have been several older attempts at getting an electrical output of an inclinometer. Obviously, you can simply wipe a potentiometer, but stiction, wear, and hysteresis can end up as problems. Other early schemes used mercury, but

NAMES AND NUMBERS

Bomarc Services
Box 113
Casper, WY 82602
(307) 237-3361
CIRCLE 245 ON FREE INFORMATION CARD

C & H Sales
2716 East Colorado Blvd
Pasadena, CA 91107
(213) 681-4925
CIRCLE 246 ON FREE INFORMATION CARD

Dallas Semiconductor
4350 Beltwood Parkway South
Dallas, TX 75244
(214) 450-0400
CIRCLE 247 ON FREE INFORMATION CARD

Don Diers
4276 North 50th Street
Milwaukee, WI 53216
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that's a hazardous element that's both poisonous and rather low in impedance.

Figure 5 shows you another early attempt at an electronic inclinometer. This one is known as an *electrolytic sensor*. You place three probes in a conductive liquid in a sausage-shaped enclosure. As the sensor tilts from level, the deeper probe's resistance drops, while the shallow one will increase. A simple op-amp bridge circuit can convert the differential resistance into an output voltage.

One obvious choice for a liquid is bromine, one of those few elements that remain liquid at normal temperatures. Two older sources of the electrolytic level detectors are *Hamlin* and *Spectron*. These devices are both fragile and expensive.

Most of the bets these days, though, are on the *capacitance inclinometer* shown in Fig. 6. That one is simple, cheap, low power, and clean.

Picture an insulated enclosure the size and shape of a Magician's fake silver dollar. The rear of the enclosure is a grounded metal plate. The front consists of a pair of butterfly-shaped capacitor plates. The case gets filled exactly halfway with a magic liquid that is an inert insulator, has a high dielectric constant, a medium viscosity, is non-wetting, non-corrosive, and has a very high vapor pressure. Propylene is one possible choice.

After filling, your case is sealed. When level, each of those butterfly

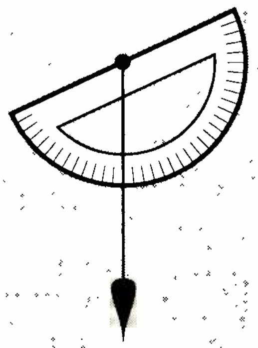


FIG. 4—THIS SIMPLE INCLINOMETER can be created by using nothing but a plumb bob and a protractor. You sight along the base of the protractor base and then read the angle.

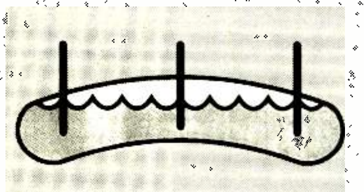


FIG. 5—AN ELECTROLYTIC LEVEL is one older electronic inclinometer. As the device tilts, the bridge resistance between the sensing pins will change. Bromine is one possible liquid.

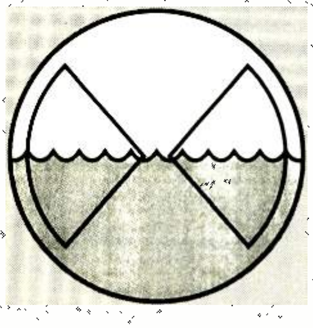


FIG. 6—CAPACITIVE LEVEL SENSOR is the one most often used today for electronic levels and inclinometers. As the device tilts, the high dielectric constant of the liquid will change the differential capacitance on the plates.

plates will be immersed just as deep in the dielectric liquid. As the sensor tilts, one plate goes deeper and the other will become shallower, thus changing the capacitance. The higher the dielectric constant of the liquid compared to air, the more profound the capacitance change.

To sense, you let each wing of the butterfly set your pulse width of a monostable built out of a pair of 555 timers or one single 556 and measure the time difference between the two to determine the angle.

To get fancier, place a pair of the sensors back-to-back and sharing a common ground. That gives you two big advantages: First, your sensed capacitance change is now doubled, which should give you more accuracy. Better yet, your *cross axis sensitivity* should drop dramatically. That will happen because an unwanted forward or reverse tilt increases the depth on one side and decreases it on the other.

The shape of the plates determines the linearity of the capacitance versus the slope angle. Sometimes, you may like to purposely change the plate shape to get a non-linear response. One use might be to automatically calculate compound miter cut depth on a table saw.

It seems to me that you could easily make up a capacitance sensor using nothing but a pair of printed circuit boards, a spacer and a large O-ring. The bottom board would form the ground plane. The spacer would have a hole in it somewhat larger than the O-ring and would act as a compression stop, setting a fixed width. And the top one would have the butterfly pair on it.

Er, on second thought, why don't you tell me? For this month's contest, either (A) show to me an eminently hackable design for the capacitance inclinometer, or (B) dream up a new use for an electronic angle measuring device. There will be all the usual *Incredible Secret Money Machine* book prizes, with an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two going for the best entry of all.

New tech literature

A brand new form of matter known as an *aerogel* got written up in the February 16th, 1990 issue of *Science*, page 807. Aerogels are rigid inorganic solids that have roughly the density of air and look like so much solidified smoke. They transmit light but block heat, electricity, and sound.

You can make aerogels from mine tailings dumps. Important early uses are expected to be brand new types of superinsulation and for the live capture of meteors. Neat stuff.

The new Data books for this month include the *Data Communications Handbook* from *National*, a *Memory Data Book* from *Sharp*, and a *Discrete Semiconductor Condensed Catalog* from *Philips*.

Free samples of their new 75ALS176 differential bus transceivers as well as their new *Widebus* family chips are available from *Texas Instruments*. The folks at *R&D Electronics* have an interesting new surplus flyer which includes cheap ultrasonic motion detectors and lots of assorted hacker project cases. A wide selection of new and used antique radio vacuum tubes is available through *Don Diers*. And, rebuilt military infrared viewers are available from *Stano Components*.

One of the more popular CAD/CAM circuit-analysis programs for the high-end engineering workstations goes by the name of *SPICE*. For this month's free new software, nearly all of those integrated-circuits houses are crawling all over themselves to see who can get their free *SPICE* macromodule simulation disks out there firstest and fastest. Early entries include *Linear Technology, PMI*, and *Motorola*.

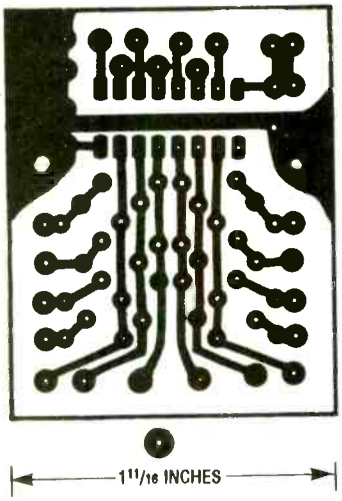
The free *Linear Technology* disk includes a simulation and macromodel of their ultra-low-noise op-amp we looked at last month. Additional info on *SPICE* often shows up in the free engineering design trade journals, such as *MicroCAD News*.

A free *Designing With Plastics; The Fundamentals* booklet is obtainable from *Hoechst Celanese*.

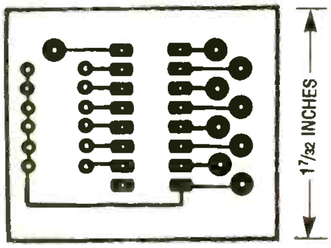
Turning to my own products, I am now self publishing nearly a dozen titles using my new *book-on-demand* PostScript technology. Four of them that you might find interesting are the *Hardware Hacker II* reprints, my *Ask The Guru* volumes I and II, and my brand new *LaserWriter Secrets* book-disk combo.

I've also started up a major new PostScript and desktop publishing BBS on *Genie*. Our goal is to have a thousand free downloads very soon. Finally, I've got a new and free mailer for you that includes dozens of insider hardware hacking secret sources. Write or call for a copy. **R-E**

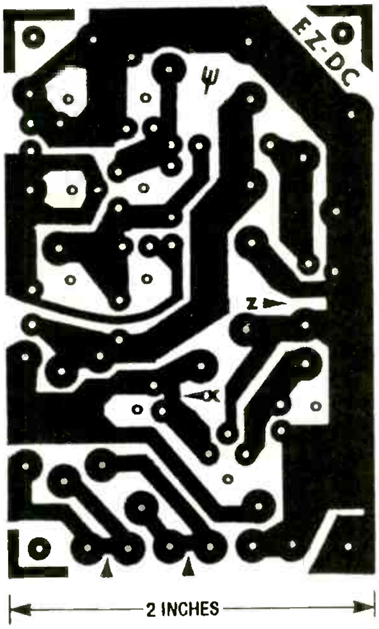
PC SERVICE



PX0-1000 WITH ROTARY-SWITCH programming and a diode matrix.



PX0-1000 FREQUENCY DIVIDER with DIP-switch programming.



BUILD A GENERIC POWER SUPPLY using this PC board.

Do You Know the ABC's of Camcorders?

Memories can last a lifetime when you have a camcorder by your side. Today's camcorders are smaller and lighter than ever before, and have a variety of features that make it easier to preserve such memories as your child's first birthday party or a family reunion. The following quiz will tell you how much you know about camcorders. Score 10 points for each question you answer correctly.

1. Which of the following is *not* a consumer camcorder format?
- (a) Beta
- (b) VHS-C
- (c) 8mm
- (d) VHS
- (e) All of the above are camcorder formats

2. Camcorders are becoming more popular every year. How many camcorders were sold in 1989?
- (a) 1,495,889
- (b) 4,290,000
- (c) 6,200,202
- (d) 2,300,000

3. The best-selling type of camcorder is
- (a) VHS-C
- (b) 8mm
- (c) Full-size VHS
- (d) Beta

4. Which of the following are features found on a camcorder?
- (a) Power zoom
- (b) Automatic focus
- (c) Flying erase heads
- (d) High-speed shutter
- (e) All of the above

5. The 8mm format is the fastest growing segment of today's camcorder market. Is it possible to play an 8mm videotape at home if you have a VHS VCR?
- (a) No
- (b) Yes – simply connect your 8mm camcorder to the inputs on your television

6. What is the purpose of a flying erase head on a camcorder?
- (a) Faster erasing of tapes
- (b) Smoother transitions between scenes
- (c) Longer recording capability
- (d) Brighter colors

7. What does it mean when a camcorder has a low lux rating?
- (a) The camcorder can not be used at excessive heights
- (b) The camcorder's controls are located on the lower half of the unit
- (c) The camcorder can be used in low light situations
- (d) The camcorder can only be used in a very bright situation

8. True or false: Headcleaners are not necessary for camcorders.

9. Camcorders were first demonstrated to consumers in:
- (a) 1955
- (b) 1962
- (c) 1980
- (d) 1978

10. A variety of camcorder formats, including Super VHS-C, ED Beta and High Band 8mm, provide consumers with horizontal resolution of between 400 and 500 lines. This means that consumers experience:
- (a) Improved picture quality
- (b) A choice of black and white or color pictures
- (c) Darker pictures
- (d) Better sound

TURN IT ON IN THE 90s

Electronic Industries Association
Consumer Electronics Group

Answers: 1) e. 2) d. 3) c. 4) e. 5) b. 6) b. 7) c. 8) False 9) c. 10) a.

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Finally, a video signal!

ONCE UPON A TIME, YOU COULD GET into electronics without having to spend a lot of money. A pair of pliers, some wire, a busted radio, and a soldering iron, and bingo!—three days later you'd have a variable interossiter (and who remembers what that was?). Well, unfortunately, things change. Variable interrositers went the way of tubes and Metaluna is as far in the past as it is in the future. A real interest in electronics today means having to dig deeper into your pocket.

Even though the video circuits we've been working on together are only simple ones to demonstrate basic ideas, you really need more than a multimeter and power supply to learn from it. There's often just no way to get by without an oscilloscope. It's particularly valuable when you're doing video stuff because, when something doesn't work properly the first time, you can look directly at the waveform and immediately see where you've got a problem.

Now, I know that "inexpensive" is a relative term, but there are scopes advertised in R/E that can be picked up for under $300. You may be limited in bandwidth and short some of the bells and whistles found on more expensive models but, unless you're doing some gee-whiz rocket-scientist type stuff, a scope with a 30-MHz bandwidth is more than adequate for a great many applications—including video.

I've made a point of illustrating things step by step so far, but drawings can show only so much—and they can show you only what things look like if everything is working OK. Since we all know that the chances of that happening first shot out of the box are about as good as finding intelligent life on Pluto, the drawings won't be representative of the waveforms being produced on *your* breadboard. And, if that isn't enough, not having a scope to start with means you don't have any way to tell how close your circuit is to the drawing in the first place. The classic chicken and egg problem—but one that's easily solved by getting a scope.

So where were we?

Believe it or not we're almost finished with our video circuitry. I'm the first one to admit that it's grown to occupy lots of real estate on the breadboard. If you find that upsetting, remember that in the bad old days before IC's, sync generators like the one we're building took up a lot more room, and cost a whole lot more than a handful of IC's.

There are IC's available that can replace most of the hardware we've been assembling. However, as with most special-purpose IC's, the price you pay for using one dedicated IC in place of some MSI stuff is a loss of circuit flexibility.

Since we're designing the timing generators and one-shots, we can set the pulse widths, delays, and scan frequencies to be anything we want. Admittedly, we're after NTSC, but it wouldn't take a lot of modification to generate PAL, EGA, VGA, or any other type of video we want. Also, building a sync generator can show you a lot more than just how video works—it can also show you how to make video not work.

That isn't as screwy as it sounds, since having video not work is exactly what happens when the friendly folks at your local cable company scramble a channel, or when the latest videotape is copy protected in some way. I'm not saying that the circuit we're building will solve those things, but it will help you understand what's going on. And that's the first step to coming up with a solution. More on this intriguing subject later—now it's time to put the finishing touches on the hardware.

Making video

Everything we've done so far has been aimed at generating the two sync pulses that are being produced at the outputs of the 4528. Both the horizontal and vertical pulses are needed to control the deflection circuitry in the TV, but they have to be combined into a composite signal in order to be used to make NTSC-compatible video. And we have to make provisions in the circuitry to be able to add some picture information to the signal, as well.

Even though video is usually thought of as an analog signal, the sync component is essentially digital. After all, it's really nothing more than either high or low. So there are several ways we can combine the separate sync signals, such as resistors and diodes in a home-made Mickey Mouse gate arrangement, standard gates, and others. The choice is really yours.

Even though both of our sync signals are being derived from the master clock, they're being generated by separate circuitry using the two halves of a 4528 (**Radio-Electronics**, May 1990). And since we're producing a vertical sync pulse that's three horizontal lines long, the horizontal sync generator is going to keep producing pulses even during the time that the vertical sync pulse is being generated.

In order to avoid potential problems, we can prevent that from happening by putting a low signal on the clear inputs (pins 3 and 13) of the 4528. That prevents the inverted outputs (pins 7 and 9) from going low. (Remember that the sync pulses are active low.)

The simple way to make sure that only one type of sync pulse is generated at any one time is to modify the connections made to the 4528 as shown in Fig. 1. By gating the vertical sync generator with horizontal sync and the horizontal sync generator with vertical sync, there's no possibility of signal conflict. During the period that vertical sync is being produced, the horizontal sync generator is disabled. There's really no

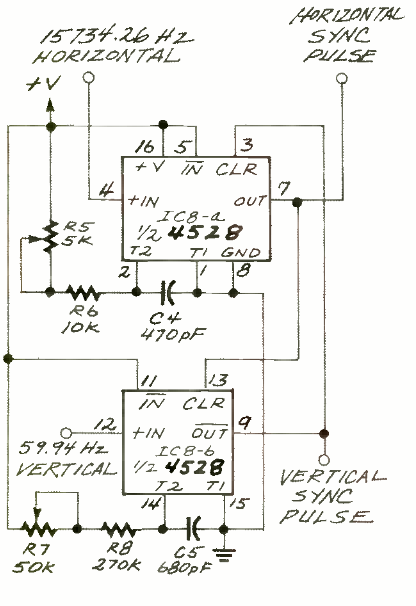


FIG. 1

reason for us to do the same thing to the vertical sync but it can't hurt anything, so we might as well. If you have a scope, you can try it both ways and see how it works.

Since we've eliminated the possibility of having two different sync signals show up at the same time, we can safely produce a *composite* sync signal. For reasons you'll see in just a second, I like to use gates. The requirements aren't very strict since

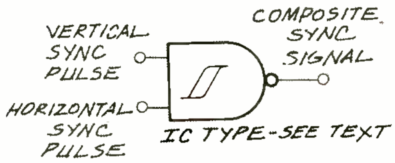


FIG. 2

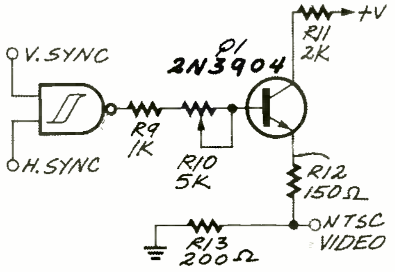


FIG. 3

we've made sure that both signals can't be low at the same time.

We want a low to be produced only when either of the sync signals go low—the rest of the time we want a high. You would think we can use a simple AND gate but, as it turns out, it's easier to first produce an inverted version of sync. That's because the inactive sync level (5-volts) has to be at 0 IRE, or about 0.3-volts DC, and the easiest way to translate levels is with a bunch of resistors and a transistor. And, the transistor will invert the signals applied to the base (since it operates as a switch), so we're better off feeding it with an inverted version of sync.

By the way, there's no reason why you can't use the non-inverting outputs of the 4528 and feed those into an AND gate to combine them. I used the inverting outputs because I prefer to have NAND gates on the board. You never know what you'll be adding to the circuit, and inverting gates are more useful.

Even though Fig. 2 uses a 4093 to combine the sync signals, you can use a 4011, or any other plain NAND gate. The 4093, however, is a Schmitt-trigger part and will produce nice, crisp pulses, even if there's a bit of noise at the inputs. Since noise is always a potential problem on solderless breadboards, it's better to be safe than sorry.

All that's left for us to do is design a circuit to translate the digital signals to NTSC standard. Remember that right now our circuit is making a 5-volt swing, and that is slightly beyond the NTSC-standard 1-volt range...to put it mildly.

The circuit shown in Fig. 3 will take the composite sync at the output of the 4093 and cut it down to NTSC levels. You can use the trimmer to fine tune the voltage level at the output. Just remember that the high (inactive) part of the signal should be at 0.3-volts DC to meet the NTSC specs.

Now that we're producing a signal that can be fed into any video input, we can start to play around with it. Try putting video on the screen and seeing what can be done to scramble it.

When we finish this off next month, you'll have a really good idea of how to look at broadcast video. In the meantime, try to get your hands on a scope (if you don't have one already), and take a look at what's fed into the back of your TV set. By the way, most scrambling methods aren't really that complicated, and as soon as you see what's been done, you can figure out what you have to do to fix it. Now that really sounds terrific. **R-E**

AUDIO UPDATE

LARRY KLEIN,
Audio Editor

Receivers vs. separate components

IN A SENSE, THE RECEIVER IS THE COMPOnent that separates audiophiles from "mere" music listeners. (Or, if you will, the men from the boys.) Music listeners own receivers; audiophiles don't. At one time, the decision to go for separate components (tuner, preamp, and power amplifier) instead of an all-in-one receiver was a rational choice, but time and technology have shifted the parameters of the ballgame somewhat. So for readers shopping for an amplifier and tuner either to upgrade some older equipment or as a first-time buy, here are some historical notes and pros and cons to be used in making the receiver vs. separates decision.

Audio evolution

When hi-fi left the labs and broadcast studios and went public in the early 1950's, the early audiophile could choose dozens of tuners and numerous amplifiers in various configurations. Some power amplifiers had "remote" preamplifiers attached via a powering cable; others were available as integrated amplifiers or as separate power amplifiers with output powers ranging from 8 to 22 watts. However, all-in-one receivers were very rare, possibly reflecting an effort to differentiate the early hi-fi components from the various large, multi-tube radio chassis that were also available for do-it-yourselfers.

By the time stereo records appeared in late 1958, receivers were an established alternative format whose single chassis was easier to install and cheaper to manufacture, and eliminated the tangle of unreliable interconnecting cables. However, if you wanted appreciable power from both of your stereo channels, the receiver had a problem. Remember that *all* equipment in those days used tubes, and power-output tubes required output transformers. Wide-range, low-distortion output transformers were necessarily large and heavy—as were the power transformers supplying the filaments and the plate currents of the four output tubes. This meant that stereo receivers tended to be large, hot, and heavy. And if you wanted powers higher than about 20 watts, they got significantly larger, hotter, and heavier. I remember one moderately high-powered and expensive Fisher receiver that struck me as an effective advertisement for separate components—it took an incredibly strong man to lift it!

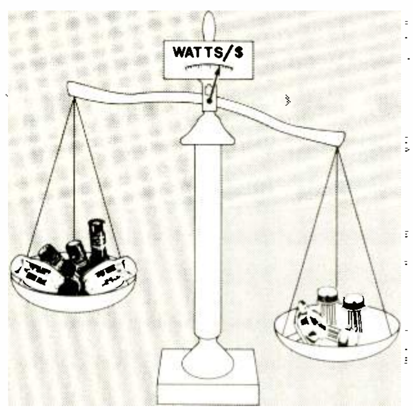


FIG. 1—INTEGRATED CIRCUITS give you a lot more watts for your dollar.

Transistorization

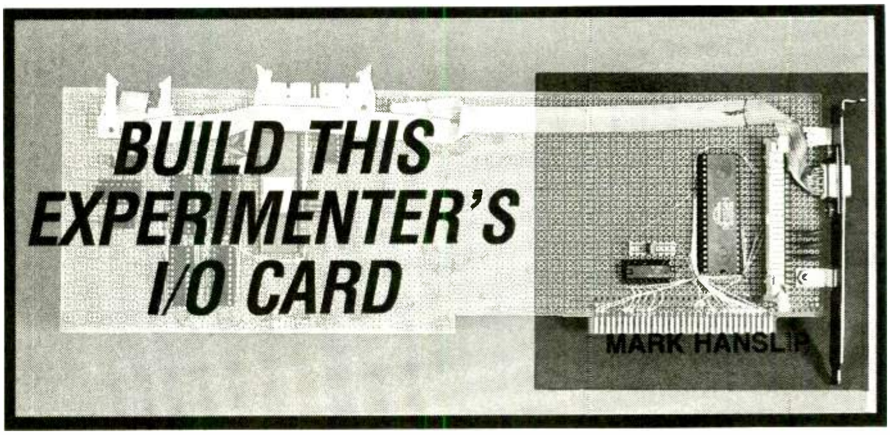
Aside from the other benefits wrought by the transistorization of audio, it brought high-power receivers into the realm of practicality. The low output impedance of the power transistors eliminated the need for the two output transformers. That in turn not only enabled the designers to reduce the cost, weight, and size of their products but also served to improve amplifier bandwidth and stability. The amplifier and tone control stages also benefitted from the low impedance of the solid-state circuitry; the hum and RFI problems that had always plagued high-gain tube circuits were substantially reduced. The net result of all those advantages—plus the cost reduction that resulted from the use of a single chassis and power supply—was that the receiver shortly became the best-selling electronic audio component.

The elements of choice

Given all the factors discussed above, why haven't separate power amplifiers, tuners, and preamplifiers vanished from the marketplace? There are several nonrational reasons why otherwise rational audiophiles (myself included) prefer separates.

A few words about the irrational elements first. It didn't take years on a psychoanalyst's couch for me to realize that there's some snobbery at work in at least two areas of my buying behavior. For example, I've always used the inadequate performance and poor reliability of U.S.

continued on page 79



BUILD THIS EXPERIMENTER'S I/O CARD

MARK HANSLIP

A computer by itself can't do much; it needs some way of communicating with the outside world. It needs to be able to sense external conditions (a switch closure, for example), and it needs to be able to control circuitry (a relay, for example). The principles of interfacing those types of devices are not difficult; we'll show how easy it is by building an experimenter's card for the IBM PC expansion bus.

The card contains three eight-bit parallel ports, but is built from just a few components, thereby making construction simple and inexpensive. We'll describe several circuits for interfacing LED's, switches, and other devices to the card, as well the software required to configure and use the I/O ports. We'll also show you how easy it is to set up and use the card with simple BASIC programs.

The 8255 PPI

The heart of the design is the 8255 Programmable Peripheral Interface, or PPI. The 8255 was originally designed for use with the 8080 microprocessor, but it is also used with 8088 designs including the PC family.

The 8255 has three eight-bit TTL-compatible I/O ports (A–C), and it can operate in three different modes. Depending on the mode, the lines in each port act differently.

In Mode 0, Ports A and B can operate as either inputs or outputs, and Port C is divided into two four-bit groups, either of which can operate as inputs or outputs.

In Mode 1, Ports A and B can again act as either inputs or outputs. However, the two four-bit ports in Port C are used for handshaking and control purposes in conjunction with Ports A and B. In Mode 1, the Port C lines might be used to strobe data (supplied on either Port A or port B) into a printer, and to detect its "busy" signal.

Last, in Mode 2, Port A is used for eight-bit bidirectional bus I/O, Port C is used for control and status information, and Port B is not used at all. For further details on operating modes, consult Intel's *Microsystem Components Handbook*, Volume 2.

You select among the various modes by writing a value to a special control port; Table 1 shows the control-port values required to achieve various I/O combinations. Our examples all work in Mode 0.

The PC interface

With Intel microprocessors, communications between the CPU and various devices is accomplished through I/O (Input/

(Continued on page 75)

EDITOR'S WORKBENCH

68000 News

I heard from an old friend, Peter Stark, recently. Peter is one of the world's more accomplished 6800/68000 hackers. You may recall his series on building a 68000 computer that uses IBM-PC style display adapters, I/O cards, case, keyboard and power supply. The series ran from May 1987 to September 1988, and PT-68-K2 kits are still available (see Vendor Information below for more information). Peter wrote the operating system that controls the PT-68-K2.

Anyway, it seems that one of the older 68xxx magazines has cut coverage of hobbyist/hacker systems, so Peter is beefing up his own newsletter, trying to take up the slack. If you're interested in 68xxx systems, contact Stark-K Software Systems Corp., P.O. Box 209, Mt. Kisco, NY 10549. Tell 'im I sent you.

System Analyzers

What's inside your home computer? You're probably intimately familiar with it. But what about your office PC? What about your coworker's PC (you know, the cute little blond who's always coming to ask you for advice)? What about the six, twelve, or hundred PC's that you provide service and support for? Maybe you know, maybe you don't. Most of the time you don't care, but when you're installing new hardware or software, you do care, desperately. Several products have come to market recently that purport to provide useful information on PC internals: System Sleuth 2.0 (by DTG) and Manifest (by Quarterdeck Office Systems).

Manifest's main purpose is to help optimize memory usage; System Sleuth provides most of the information that Manifest does, along with a wealth of information on other PC subsystems, as well as several useful utilities.

Manifest can display the contents of just about all types of system memory, including conventional, extended, expanded, and even the CMOS memory in AT's. Of course, the program doesn't just provide raw hex dumps; instead, it provides nicely formatted, organized listings of memory usage, interrupts hooked by various programs, I/O port usage, and more.

The program pops up onscreen in several panels. You move a pointer up and down a list in the left panel to select the type of memory, and left and right in the upper panel to select particular details of that type of memory. You can also make your selections with a mouse.

Manifest's most useful display shows how interrupts are used by programs located in the first megabyte of memory. For example, in Fig. 1, you see the hex segment in the left column, the program located there, and the interrupts it claims last. By pressing F3, the display changes to a sequential listing of interrupt vectors (00–FF), the address in memory where each vector points, and the program that "owns" that vector.

You can load Manifest as either a transient program or as a TSR. In the latter case, the program uses more than 100K of memory, but it could still be useful when trying to track down competition for interrupts among several different programs.

System Sleuth provides a similar display, as shown in Fig. 2. System Sleuth also provides a sequential listing of interrupt vectors, but without addresses and owners.

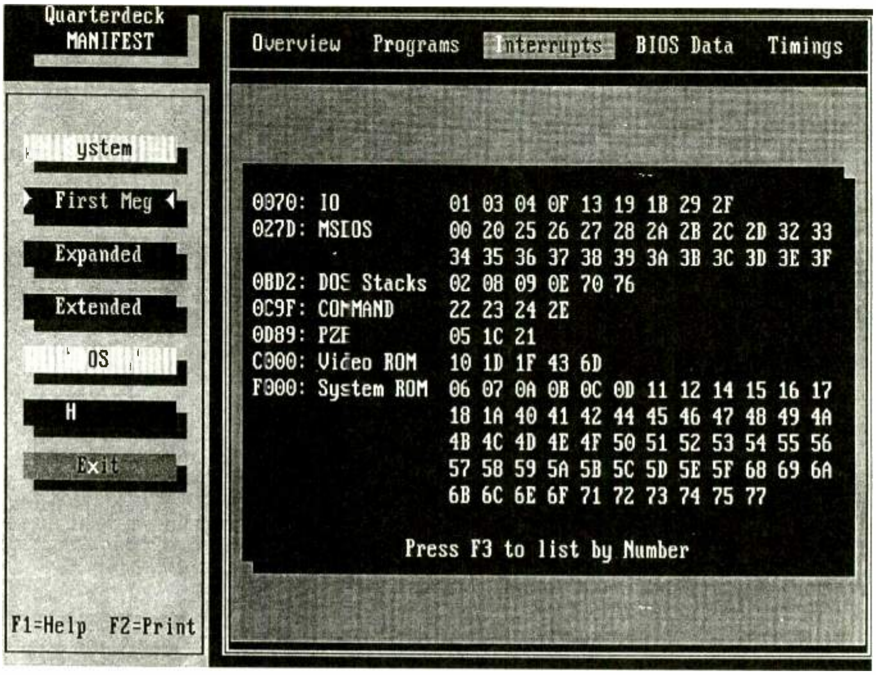


FIG. 1

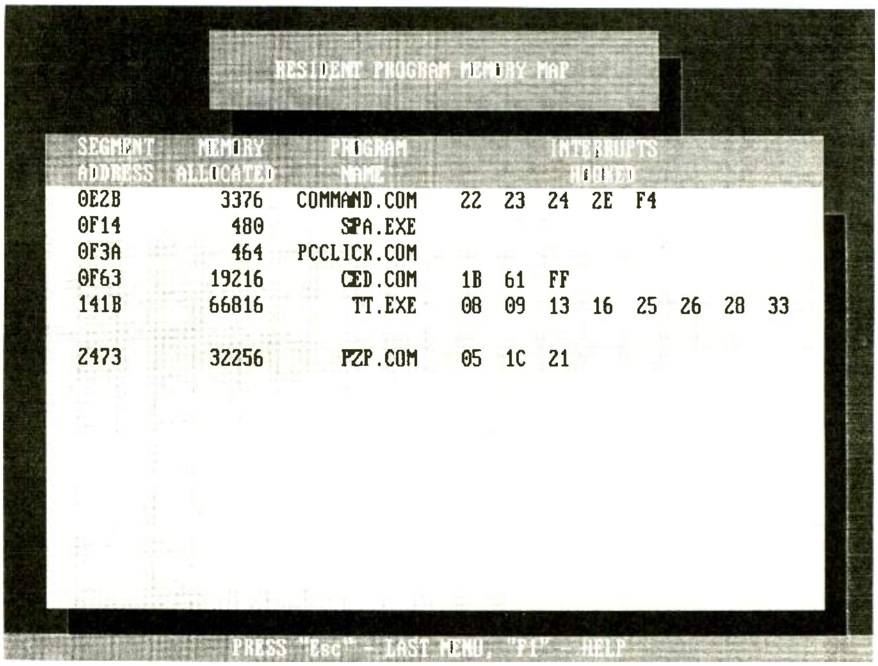


FIG. 2

Manifest provides a nicely formatted display of the BIOS data area (0040:0000); System Sleuth doesn't do that, but it does provide a hex/ASCII display routine that lets you view any area of memory beneath 1 MB. Manifest measures the access speed of various areas of memory (0–640K, video RAM, video ROM, etc.) and reports values relative to a stock PC/XT. System Sleuth has nothing comparable. Manifest also shows each byte in CMOS memory; again, System Sleuth has nothing comparable. All in all, Manifest has more powerful memory reporting and ratings capabilities.

On the other hand, System Sleuth includes functions for reporting on hard disk drive health. Various menu items provide information on the number of disk drives, and the physical characteristics of each drive (things like bytes/sector, sectors/cluster, sectors/track, etc.). You can view a hex/ASCII dump of a disk file, and even test a disk for bad sectors.

System Sleuth also includes

several external utility programs, including one that finds files across multiple disk drives, another that searches for duplicate file names (also across multiple drives), another that deletes files with certain file names (*.bak, *.tmp, etc.), routines to save and get the data stored in CMOS memory, and an EMS emulator that uses 286 extended memory. The company is adding additional utilities all the time; they tell me a disk cache is next.

I ran Manifest and System Sleuth on several different machines, and had problems with both programs on my AST Premium/286. It has built-in EMS 4.0 hardware that is controlled by AST's EMM driver. I also use a memory manager called Move'em (made by Qualitas, the 386MAX people) to load several device drivers and TSR's into high memory (above the video adapter but below the 1 MB mark). The problem was that I simply could not run either Manifest or System Sleuth on the AST with Move'em installed; the machine crashed every time. That's completely unacceptable; no diagnostic program should ever crash any machine.

However, I had no trouble running either program on several other machines, including a Tandy 1100 FD "notebook" computer, a Dell System 300 (386), and a 33-MHz Intel 386 system. (Both 386's were running 386MAX.) Interestingly, both programs were smart enough to figure out that the CPU in the Tandy is a V20, not an 8088.

I learned a few tricks from Manifest's "Hints" section. One showed me how to map another 32K of EMS memory into an unused area of the VGA video adapter range and thereby load a TSR up there. Another saved me about 3K of additional low DOS memory. All in all, I now boot with about 130K of TSR's, but still have 592K of free contiguous DOS memory, all with a VGA adapter that runs graphics just fine.

VENDOR INFORMATION

- PT-68-K2 (68000 kit prices start at $200), Peripheral Technology, 1710 Cumberland Point Drive, No. 8, Marietta, GA 30067. (404) 984-0742.
  CIRCLE 271 ON FREE INFORMATION CARD
- System Sleuth 2.0 ($149.95), DTG, 7439 La Palma Ave., Suite 278, Buena Park, CA 90620-2698. (714) 994-7400.
  CIRCLE 272 ON FREE INFORMATION CARD
- Manifest ($59.95), Quarterdeck Office Systems, 150 Pico Blvd., Santa Monica, CA 90405. (213) 392-9701.
  CIRCLE 273 ON FREE INFORMATION CARD

Reports

Both Manifest and System Sleuth can print partial or comprehensive reports of their findings. You must print System Sleuth's reports via the menus, but you can get them from Manifest either via the menus or in a command line mode. For example, if you start the program like this:

CMFT S O

you'll get a listing to the screen of the System Overview; similar reports are available for each category and sub-topic, or all categories and sub-topics. The command line mode could be useful if you wanted to print reports for several PC's. Just create a batch file with the desired command lines and then run it on each machine.

Both programs come with on-line help. Manifest's help system consists of a single screen of information for each topic; System Sleuth includes quite a bit more information, mostly tutorial in nature, that should be useful for those still getting up to speed on device drivers, different kinds of memory, etc. Of course, the information provided is no substitute for an IBM Technical Reference manual.

Manifest comes with a very well written and produced manual that is tutorial in nature. System Sleuth's manual is not so well produced, and it mostly duplicates the information in the help screens. However, if you know a little about DOS, both manuals are superfluous.

All in all, Manifest's strength is information about memory; System Sleuth takes a more systematic approach. Manifest's user interface and documentation is also more polished. But where it counts (resolving interrupt conflicts), both programs deliver.

System Sleuth lists for about $150, and Manifest for about $60; I've already seen Manifest discounted via mail order to about $40.

It may be worth pointing out that neither program will help with the truly tough problems: machines that won't boot, hardware conflicts between adapters trying to use the same interrupts or I/O ports, etc. There you'll be forced to dig out manuals and compare and contrast jumper and DIP switch settings. CD

I/O CARD

continued from page 73

Output) ports. Just as each house on a street has its own address, each piece of hardware connected to an Intel processor has its own port address. For example, serial port COM1 is located at address 03F8h. IBM's Technical Reference Manuals list the specific port addresses associated with specific pieces of hardware.

Our project uses 32 port addresses between 0200h and 02FFh. In order to avoid conflict with other devices, those 32 addresses can start at one of eight locations in that range; you select the desired starting address via a jumper block, as shown in Table 2. Both hex and decimal values are shown; if you're programming in BASIC, you'll probably find the decimal values useful.

As shown in Fig. 1, the address ranges are decoded by IC2, a 74LS138 demultiplexer. The 74LS138 takes three inputs and decodes the various combinations thereof into eight exclusive outputs. The IC also has one active-high (G1) and two active-low ($\overline{G2A}$ and $\overline{G2B}$) enable inputs.

TABLE 1—8255 PORT CONFIGURATION

Control Word		Port		
Hex	Decimal	A	B	C
80	128	Out	Out	Out
82	130	Out	In	Out
85	133	Out	Out	In
87	135	Out	In	In
88	136	In	Out	Out
8A	138	In	In	Out
8C	140	In	Out	In
8F	143	In	In	In

TABLE 2—JUMPER POSITIONS AND PORT ADDRESSES

	Address	
Position	Hex	Decimal
1	200	512
2	220	544
3	240	576
4	260	608
5	280	640
6	2A0	672
7	2C0	704
8	2E0	736

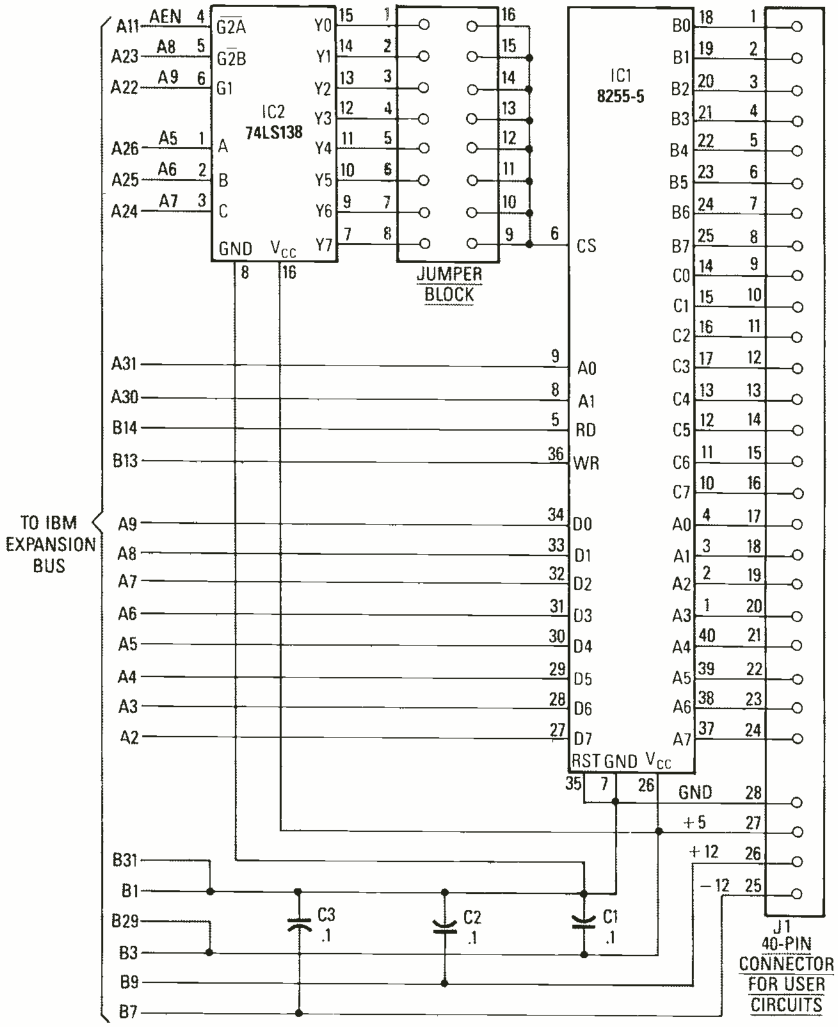


FIG. 1—ADD THREE 8-BIT PARALLEL PORTS for I/O experiments using this simple circuit. The jumper block lets you assign port addresses from 0200h to 02FFh.

Address lines A8 and A9 drive the control inputs, along with AEN (Address Enable), which is low when the microprocessor can access the expansion bus. When A8 and AEN are low and A9 is high, IC2 will decode address lines A5–A7, providing a single active-low output. In that way, the 256-byte page of I/O space beginning at 0200h is divided into eight 32-byte chunks. The eight outputs of IC2 are brought to the jumper block, which passes one enable signal on to the 8255.

The 8255 itself has only 4 ports. Port A is always at the base address, port B is at base + 1, port C is at base + 2, and the control port is at base + 3. Lines A0 and A1 select which port is addressed, and $\overline{RD}$ and $\overline{WR}$ determine whether data is read or written, respectively.

For example, if you short jumper position three, the base address would be 0240h, so you would access Port A at 0240h, Port B at 0241h, Port C at 0242h, and the control port at 0243h.

Construction

The circuit is built on a standard prototyping card for the 8-bit IBM PC bus. All required parts are standard items that can be obtained from most mail-order suppliers. Component placement isn't critical, but lead lengths should be minimized. (See Fig. 2). To avoid damage dur-

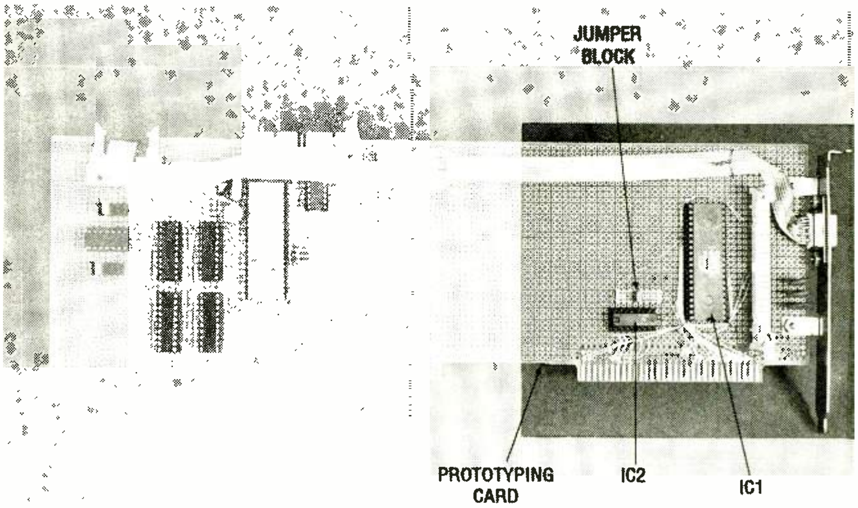


FIG. 2—THE AUTHOR'S PROTOTYPE was used to burn EPROM's, control a model railroad setup, and more.

ing construction, it's best to use sockets for all IC's. Neither IC used in this project is particularly sensitive to static damage, but you can never be too careful. The author found it convenient to use red wires for power and ground connections, white for bus connections, and blue for connections from the 8255 to the output connector.

Start with the 6 wires that run from the bus connector to IC2. (By the way, looking at the component side of your motherboard, the "B" side of each expansion slot is on the left and the "A" side on the right, and the connectors are numbered from 1 to 31 from the rear of the board to the front.) Take your time, and check each solder joint for shorts with adjacent pins.

Then connect the eight wires from IC2 to the jumper block, continue with the eight data-bus wires from the bus connector to the 8255, then the six control wires to the 8255. Then connect the 24 wires from the port outputs of IC1 to J1. The author used a 40-pin header connector for J1 in the prototype. Many projects require a source of +5 volts, so power and ground lines are also brought to J1.

PARTS LIST

IC1—8255A-5 parallel interface
IC2—74LS138 3-to-8 line decoder
C1–C3—0.1 µF
J1—40-pin header connector
Jumper block (2 rows, 8 positions)
PC bus prototyping board
Sockets, wire, etc.

Programming examples

The following examples assume that the jumper is in position three, so that the 8255 is connected to port 0240h.

When power is first applied, ports A, B and C are all configured as inputs. To reconfigure the port, you must write the appropriate value to the correct port. For example, by connecting eight LED's to Port A as shown in Fig. 3, you could view the binary counting sequence using this program:

```
10 OUT 579,128
20 A=0
30 OUT 576,A
40 A=A+1
50 IF A 255 GOTO 20
60 GOTO 30
```

If one LED doesn't seem to light, run this program:

```
10 OUT 579,128
20 OUT 576,255
```

All of the LEDs should light. If one doesn't, check your wiring.

Reading input values is just as simple. The following program would continually read and display the contents of port B, to which various switches (Fig. 4-a, Fig. 4-b) and sensors (Fig. 4-c) might be connected:

```
10 OUT 579,130
20 A=INP 577
30 IF A
40 GOTO 20
```

That program sets up Port B for input, and then reads the value of the port. If the value is less than 255 (in other words, if at least one line is low), the value is printed.

The 8255's inputs and outputs are TTL compatible, meaning they don't have much current-carrying capacity. To drive heavier-duty devices, use a transistor, as shown in Fig. 5-*a*, or add a relay, as shown in Fig. 5-*b*.

More Ideas

Now that you understand the basics, the sky's the limit. What else could you do?

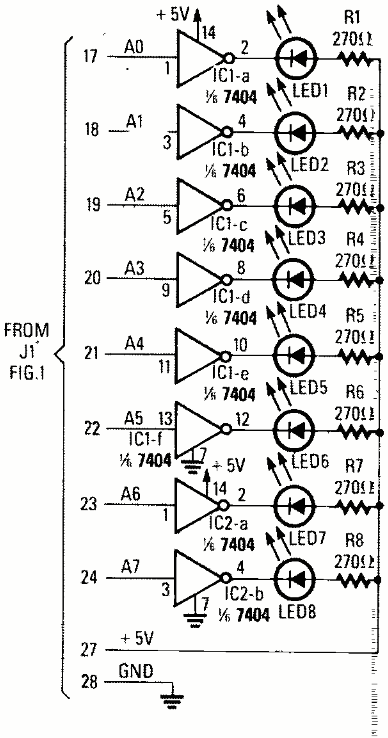


FIG. 3—FOR OUTPUT DISPLAY, add eight LED'S, eight resistors, and two 7404's.

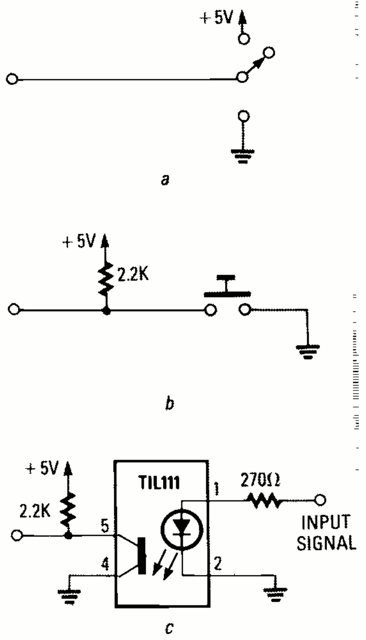


FIG. 4—FOR INPUT, add a toggle switch (a), a pushbutton switch (b), or an opto-isolator (c).

• How about building a robot? Output ports could be configured for motor control, voice synthesis, robotic arm control, etc. Input ports could be used to read bumper sensors, voice recognition, or keypad input.

• Or build a burglar alarm: Input ports would read data from window and door switches, and from motion detectors. Outputs would control lights, a siren, and a telephone dialer.

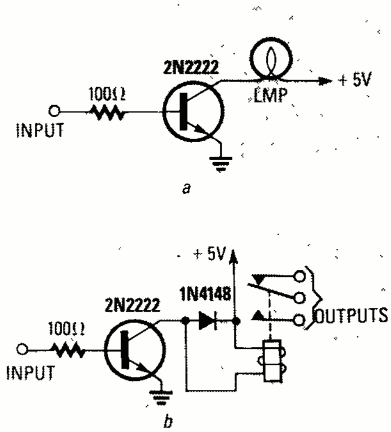


FIG. 5—FOR HIGH-CURRENT OUTPUT, use a transistor to drive a lamp (a) or a relay (b).

• Or build a home heating system. One port would be dedicated to motors that would open and close heating vents, control blower motors, etc. Input ports would read thermometers in each room and outside the house. A real-time clock would be used to turn heat on in the morning and off in the evening. You could include a wind speed gauge, controls for a solar hot-water heater, and even calculate your energy savings.

• Or build a scoreboard, a light show, or an IC tester. How about a computer-controlled popcorn popper or a dog food dispenser? The author has used his card to run a plotter, an EPROM programmer, and a model-railroad demonstration.

Another thing you could try building is an automatic home lighting system. Input ports could monitor doorways with pressure-sensitive switches or infra-red beams. The system would sense someone entering or leaving the room, and turn the lights on and off accordingly. The system would have to keep track of how many people were in the room, turning the lights off only after the last person leaves.

For some projects, three ports may not be enough. In that case, just connect a second 8255, wiring all lines except cs in parallel to IC1. Connect the cs line of the second 8255 to a different position on the jumper block—and enjoy 48 lines of digital I/O! ◆CD◆

AUDIO UPDATE

continued from page 72

cars to justify owning foreign-made vehicles. And to tell the truth, I'd be somewhat embarrassed to admit owning a standard U.S. family car. In the same sense, I'd feel that I had blown my credentials as an "Audio Maven" if word got around that I used a receiver in my main system.

But aside from emotional predispositions, what valid reasons are there for choosing separate components? Output power is one. Given the extended dynamic range of compact discs, the advantage of having at least 100 watts per channel of clean power on tap seems inarguable. The sense of ease and openness, and the bass solidity all testify to the sonic virtues of high power.

Today, the top power available in a receiver is about 130 watts per channel. For many people that is probably more than adequate, but for those who want their music very loud and very clean when heard through medium-to-low efficiency speakers, 200 watts is an absolute minimum. That explains why the 1990 stereo buyers' guides list dozens of 300- and 400-watt-per-channel amplifiers. Incidentally, I have clipped a 200-watt-per-channel amplifier trying to reproduce a solo piano at live sound levels, so the desire for ever higher amplifier power *does* have a genuinely rational basis given certain listening circumstances.

Upgrading

The essence of being a totally dedicated audiophile (which I am not) is the never-ending pursuit of the holy grail of "perfect" sound reproduction. In practice, that means constant upgrading—or at least replacement—of existing components in hopes of coming ever closer to sonic perfection. The pursuit is encouraged by several small circulation "underground" audio magazines, such as *Stereophile* and *The Absolute Sound*. Their detailed reports on each new high-end (meaning *very* expensive) preamplifier and power amplifier becomes Holy Writ for the dedicated audiophile seeking to determine each product's precise place in the hierarchy of sonic perfection. Page after page will be devoted to what is almost a frequency-by-frequency analysis of each audio product's sound quality.

If the reviewed product appears to offer some real or imagined advantage over his existing equipment—which was the best available only four or five months ago—the dedicated audiophile buys it as soon as his finances permit. Incidentally, some excellent power amplifiers are available for about $2 a watt, meaning that a 200-watt-per-channel amp can be had for about $800. One can also spend $16,000 (!) for a 200-watt-per-channel amplifier, but I think that the joy of owning such a product has little to do with its sound *per se*.

I shouldn't exclude FM tuners

from the upgrading process, although most audiophiles are aware that the broadcast stations are far more responsible for tuner sound quality than any other factor. In any case, it is obvious that owning a receiver makes piecemeal component replacement impractical. Receivers also tend to complicate matters when something goes wrong electronically. If a separate tuner goes bad, the rest of the system is still functional while the tuner is in for repairs. And even a defective preamp won't stop the music if the power amp has accessible input-level controls.

The bottom line

So, after all of the above, what do I recommend? As I indicated, I think it comes down to how loud you like your music and the efficiency of your speakers. If you want to reproduce music at natural volume levels, then 200+ watts per channel is what you need. But if your taste, you wife, your neighbors, or your budget doesn't permit such audio extremes, then a high-powered receiver may comfortably fit your requirements.

If possible, listen to the receiver under consideration with the speakers you are going to use it with. Then, listen to the same speakers at the same preferred volume level driven by a significantly higher power amplifier. If the sound quality is about the same, then a receiver is the way to go.

R-E

ADD A DISPLAY

continued from page 62

TABLE 2—USER DEFINABLE CHARACTERS

CHARACTER CODES (DD RAM DATA) 7 6 5 4 3 2 1 0	CG RAM ADDRESS 5	4	3	2	1	0	CHARACTER PATTERN (CG RAM DATA) 7	6	5	4	3	2	1	0
0 0 0 0 0 0 0 0 (00 HEX) ACCESSED BY ASCII CODE 00 (HEX)	0	0	0	0	0	0	X	X	X	0	0	0	0	0
	0	0	0	0	0	1	X	X	X	0	0	0	0	0
	0	0	0	0	1	0	X	X	X	0	0	0	0	0
	0	0	0	0	1	1	X	X	X	1	1	1	0	0
	0	0	0	1	0	0	X	X	X	1	1	1	1	1
	0	0	0	1	0	1	X	X	X	0	0	0	0	0
	0	0	0	1	1	0	X	X	X	0	0	0	0	0
	0	0	0	1	1	1	X	X	X	0	0	0	0	0

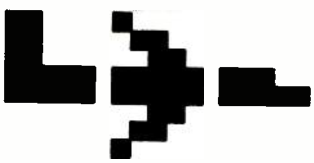
NOSE SECTION

CHARACTER CODES (DD RAM DATA) 7 6 5 4 3 2 1 0	CG RAM ADDRESS 5	4	3	2	1	0	CHARACTER PATTERN (CG RAM DATA) 7	6	5	4	3	2	1	0
0 0 0 0 0 0 0 1 (01 HEX) ACCESSED BY ASCII CODE 01 (HEX)	0	0	1	0	0	0	X	X	X	1	0	0	0	0
	0	0	1	0	0	1	X	X	X	0	1	1	0	0
	0	0	1	0	1	0	X	X	X	0	0	1	1	0
	0	0	1	0	1	1	X	X	X	1	1	1	1	1
	0	0	1	1	0	0	X	X	X	1	1	1	1	1
	0	0	1	1	0	1	X	X	X	0	0	1	1	0
	0	0	1	1	1	0	X	X	X	0	1	1	0	0
	0	0	1	1	1	1	X	X	X	1	0	0	0	0

BODY SECTION

CHARACTER CODES (DD RAM DATA) 7 6 5 4 3 2 1 0	CG RAM ADDRESS 5	4	3	2	1	0	CHARACTER PATTERN (CG RAM DATA) 7	6	5	4	3	2	1	0
0 0 0 0 0 0 1 0 (02 HEX) ACCESSED BY ASCII CODE 02 (HEX)	0	1	0	0	0	0	X	X	X	1	1	0	0	0
	0	1	0	0	0	1	X	X	X	1	1	0	0	0
	0	1	0	0	1	0	X	X	X	1	1	0	0	0
	0	1	0	0	1	1	X	X	X	1	1	1	1	1
	0	1	0	1	0	0	X	X	X	1	1	1	1	1
	0	1	0	1	0	1	X	X	X	0	0	0	0	0
	0	1	0	1	1	0	X	X	X	0	0	0	0	0
	0	1	0	1	1	1	X	X	X	0	0	0	0	0

TAIL SECTION



COMPLETE AIRPLANE

ORDERING INFORMATION

The following items are available from Simple Design Implementations (SDI), P.O. Box 9303, Forestville, CT 06010 (203) 582-8526: Experimenter's kit (contains 16×1 OPTREX LCD module, programmed MC68705P3, contrast-control potentiometer, PC board, IC socket, software listings, schematic, and instructions), $29.95 + $3 S/H; Same experimenter's kit with 40×1 display, $39.95 + $3 S/H; Programmed MC68705P3 and instructions, $15.95 + $2.50 S/H.

shows the 24 data bytes that must be written to CG RAM to form the three user-defined characters that form the airplane.

Displaying actual data

Once the display has been properly initialized, displaying data is as simple as writing out the proper ASCII codes with a series of Data Write operations. Remember, the "SET DD RAM ADDRESS" command must precede the data operations to ensure that the data goes to DD RAM and not CG RAM. Similarly, data writes to CG RAM must be preceded by a "SET CG RAM ADDRESS" command. For example, the routine in Listing 6 will display the message "PLANE" (assuming that the user-defined Character Generator RAM is set up as defined in Listing 5).

Next month

Due to space limitations, that's all we have room for this month. Next month we will continue our discussion on LCD modules, and cover some of the different kinds of interfaces, including hardware, microcontroller, and microprocessor. **R-E**

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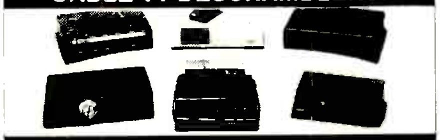

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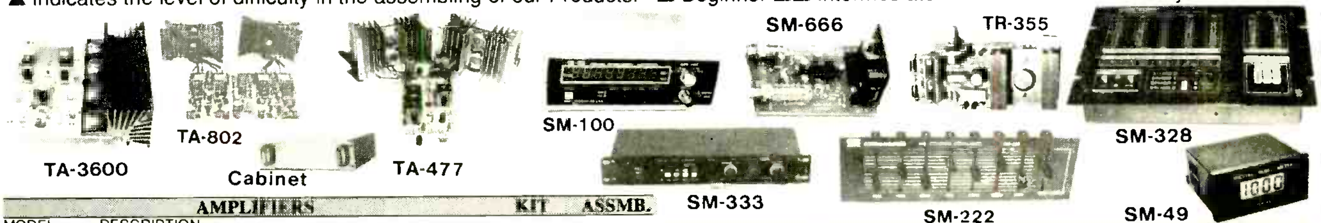

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TA-802	80W+80W DC Stereo Main Power Amp ▲▲	45.94	59.72
TA-820A	60W+60W OCL DC Pre-Main Stereo Amp ▲▲	40.39	49.37
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LG-1925	5"	19"	11½	TA-477, TA-800, TA-1500, TA-1000A	33.00
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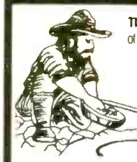

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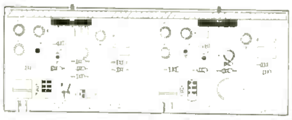

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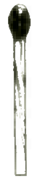

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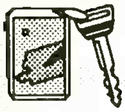

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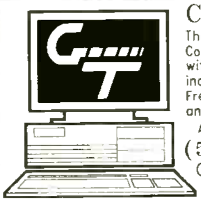

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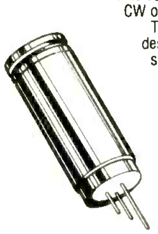

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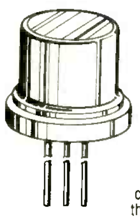

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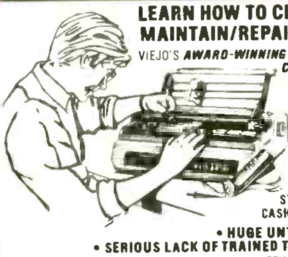

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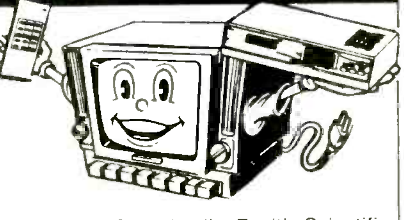

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74HC02	35	74HC133	50	74HC257	55
74HC04	.35	74HC137	75	74HC259	60
74HC08	.35	74HC138	70	74HC273	80
74HC10	.35	74HC139	45	74HC354	95
74HC11	40	74HC153	55	74HC373	80
74HC20	.35	74HC154	1.75	74HC374	80
74HC30	35	74HC157	50	74HC533	1.35
74HC32	35	74HC162	55	74HC534	1.35
74HC51	45	74HC163	55	74HC573	2.50
74HC58	50	74HC164	80	74HC595	2.50
74HC74	40	74HC174	60	74HC640	2.00
74HC75	40	74HC175	60	74HC4002	50
74HC85	70	74HC194	70	74HC4020	1.10
74HC86	40	74HC221	90	74HC4066	60
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74HC109	.40	74HC242	75	74HC4538	1.40
74HC112	40	74HC244	80	74HC4543	1.40

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74LS00	17	74LS112	29	74LS241	65
74LS01	17	74LS113	33	74LS242	65
74LS02	17	74LS114	33	74LS243	65
74LS03	17	74LS122	70	74LS244	65
74LS04	17	74LS123	45	74LS245	75
74LS05	17	74LS125	35	74LS246	1.40
74LS08	17	74LS126	35	74LS247	1.00
74LS09	17	74LS132	39	74LS243	65
74LS10	17	74LS136	35	74LS251	45
74LS11	20	74LS137	90	74LS253	45
74LS12	27	74LS138	39	74LS257	39
74LS13	25	74LS139	39	74LS258	45
74LS14	36	74LS145	70	74LS259	1.20
74LS15	25	74LS147	1.00	74LS260	45
74LS20	17	74LS148	90	74LS266	55
74LS21	22	74LS151	39	74LS273	75
74LS22	22	74LS153	39	74LS279	39
74LS26	23	74LS154	1.50	74LS280	1.70
74LS27	23	74LS155	55	74LS283	55
74LS28	26	74LS156	45	74LS290	80
74LS30	17	74LS157	35	74LS293	80
74LS32	17	74LS158	20	74LS298	65
74LS37	26	74LS160	29	74LS299	1.25
74LS38	26	74LS161	49	74LS320	2.00
74LS40	17	74LS162	49	74LS322	3.00
74LS42	35	74LS163	49	74LS323	2.40
74LS48	65	74LS164	45	74LS365	39
74LS51	17	74LS165	65	74LS366	39
74LS54	22	74LS166	95	74LS367	39
74LS73	25	74LS169	90	74LS368	39
74LS74	24	74LS170	80	74LS373	75
74LS75	29	74LS173	49	74LS374	75
74LS76	29	74LS174	39	74LS377	75
74LS83	45	74LS175	39	74LS386	45
74LS85	.45	74LS181	1.40	74LS390	1.10
74LS86	22	74LS190	49	74LS393	75
74LS90	39	74LS191	49	74LS398	2.50
74LS92	45	74LS192	65	74LS446	2.00
74LS93	45	74LS193	65	74LS541	1.40
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81LS98	1.40	74LS196	55	74LS668	1.45
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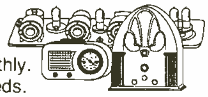

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LOGIC ANALYZER

continued from page 21

different trigger words. Up to three triggers can be OR-ed together on each level. It is possible to enter some rather complex triggering schemes, with conditional branches, loops, and the like. Trace recording can be turned on and off on any level so that only the data that is of interest—not, for example, a 1,000-count loop—is stored.

The *PA430* 48-bit × 4096-word, 25 MHz logic analyzer board costs $1595. Either a general purpose pod or a microprocessor disassembly pod is required for operation. They run from $495 to $695.

Because we have limited space in which to describe the analyzer, we have only scratched the surface of its capabilities and features. We were very impressed with its operation, and think it deserves a serious look from anyone contemplating the purchase of a logic analyzer—and a serious look from some of the competition as well. **R-E**

KIT REPORT

continued from page 57

coded from standard stereo TV broadcasts. However, some network TV shows are beginning to incorporate surround techniques as well. Surround sound can even show up where you'd least expect it. Our local public television station supplied the surround channel with music as they conducted a pledge drive in the front speakers.

The *AD-2550* is priced at $199. A pair of surround-channel speakers are also available from Heath for $49.95. In our opinion, the processor provides *better*-than-movie-theater conditions. We get full control over the sound, and in our living room, the popcorn is *fresh*! **R-E**

READER HELP READER

• A friend gave NORMAN JUST a Knight color pattern/generator, model *KG-685*, but the owner's manual, parts list, and schematic were missing. The unit needs some replacement parts and repairs. If you have any information on that model, please send it to *1926 Nocturne Drive, Louisville, KY 40272*.

• After subscribing to **Radio-Electronics** for 25 years, CHARLES BROCKMAN is in need of the schematic for a Teledyne model *RA-618* AM/FM receiver. If you have one, or can advise him of a source, please write to him at *2602 Woodlawn, Ennis, TX 75119*.

• BRUCE KLIMISCH has an RF generator, EICO model number *369*. It's in kit form, with no assembly information. He'd like to receive an instruction manual at *808 MacBeth Circle, Lakeville, MN 55044*.

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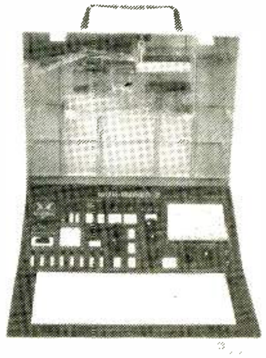
Prototype Design Stations

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

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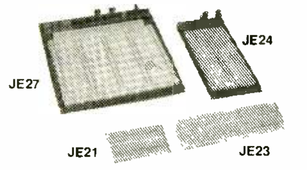

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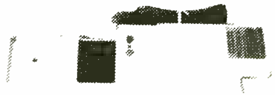

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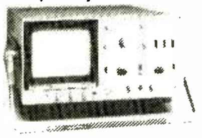

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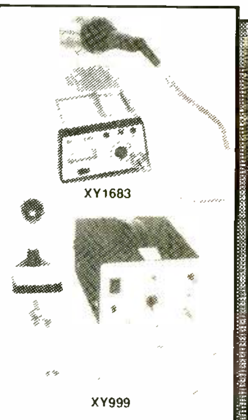
Soldering and Desoldering Stations



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

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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**

30 Watt Electronic Temperature Controlled Desoldering Station • Electronic temperature control from 212° to 842°F • Self-contained high rotary vacuum pump

XY999 .... **$279.95**

Metex Digital Multimeters

General Specs:
• Handheld, high accuracy • AC/DC voltage, AC/DC current, resistance, diodes continuity, transistor hFE
• Manual ranging w/ overload protection

M3650, 3650B & M4650 only:
• Also measure frequency and capacitance

M4650 only: • Data hold switch • 4.5 digit

M3610 3.5 Digit Multimeter **$49.95**
M3650 3.5 Digit Multimeter w/Frequency & Capacitance **$69.95**
M3650B Same as M3650 w/Bargraph......... **$74.95**
M4650 4.5 Digit w/Frequency, Capacitance and Data Hold Switch **$99.95**

Multimeter Specials

M80:
• AC/DC voltage, AC/DC current, resistance, diodes, continuity & frequency • Full auto-ranging on DC voltage • High/low semi-autoranging for AC/DC current and ohms • Data hold switch • Extra-large display

M80 3.75 Digit Multimeter **$59.95**

M3900:
• AC/DC voltage, AC/DC current resistance, diodes, continuity, dwell angle and engine RPM • High surge voltage protection

M3900 3.5 Digit Multimeter **$59.95**

51-Piece Electronic Tool Kit

The MS305 provides the tools needed for building, repairing and general maintenance of most electronic equipment. A convenient and durable carry-along combination lock case safely protects and secures this 51-piece tool kit. From the digital multimeter to the desoldering pump this kit is the perfect item for technicians and electronic enthusiasts.

Tools Included in Kit

- 10' measuring tape
- Electric tape
- 6" long tweezers
- 7" brush and scraper
- 7" fine point probe
- 7" slotted probe
- Rosin core solder
- 30 watt soldering iron
- Desoldering pump
- Soldering stand
- Stainless steel scissors
- Utility components box
- 8 pcs. hex key wrench
- Digital Multimeter
- Round needle file
- Flat needle file
- 6" adjustable wrench
- Utility knife with extra blade
- Bent needle nose pliers
- Diagonal cutting pliers
- 5.25" needle nose pliers
- 6 piece precision screwdriver set
- Brush
- 10 piece screwdriver set: 5 Slotted & 5 Phillips
- Flat nose pliers
- Carrying case: 17.63"W x 12.5"D x 3.5"

MS305...**$119.95**

Partial Listing • Over 4000 Components and Accessories in Stock! • Call for Quantity Discounts

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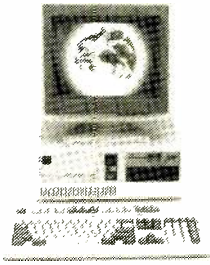
JCAD Digitizer Tablet **$199.95**
Stylus Two Button Stylus.... **$39.95**

Jameco 20MHz 80386 Desktop Computer Kit

- *Fully IBM Compatible*
- *Free! Concurrent 386 Disk Operating System Software Included*
- *Free! QAPLUS Diagnostic Software Included!*
- *Free! WORDSTAR EASY Word Processing Software Included!*
- *1Mb RAM Included, Expandable to 8Mb onboard, 16Mb with optional expansion board*
- *8/16/20MHz Keyboard Switchable Operation*
- *AMI BIOS ROMs Included*
- *Fliptop Case w/200 Watt Power Supply*
- *MiniScribe 3.5" 40Mb RLL Hard Disk Drive*
- *1.2Mb Floppy DSHD Disk Drive*
- *22.0 Norton SI Rating*
- *101-Key (Enhanced) Keyboard*



Shown with VGA Option (not included)
JE2057 VGA Monitor and VGA Card....$559.95
(See Below)

JE3550 20MHz 80386 Compatible Kit.................................... **$1599.95**

Casper Amber & Paper White Monitors

These flat screen 14" monitors feature an anti-glare screen and are ideal for desktop publishing and CAD applications. Resolution: 720 x 348. The GM1468 features four shades of gray and a dual mode option which allows you to use it with CGA or Monochrome adapter cards.

GM1468 Paper White Dual mode ...**$119.95**
GM1489 Amber Monochrome........**$109.95**

Logitech ScanMan Plus Scanner

- IBM PC/XT/AT Compatible
- 4" Scanning Window
- 32 Shades of Gray
- Includes Software
- 400DPI

SCANP.................**$219.95**

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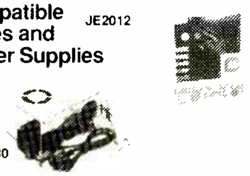
MSER Serial Mouse & MouseWare Software **$79.95**
MBUS Mouse w/Bus Board & Mouse Ware Software **$89.95**
MPS2 PS/2 Mouse & MouseWare Software **$74.95**

IBM Compatible Cases and Power Supplies



JE2012
JE1030

JE1010	Flip-Top Standard PC/XT Case	$39.95
JE1011	Slide Standard PC/XT Case	$39.95
JE1030	150 watt PC/XT Power Supply	$59.95
JE1032	200 watt Baby AT Power Supply	$89.95
JE1035	300 watt AT Power Supply	$139.95
JE2011	Vertical Case w/300W Pwr Supply	$249.95
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

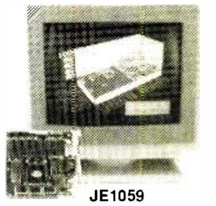
EGA & Multiscan Monitor Packages

Casper 14" EGA monitor and EGA card package (720 x 350 max. resolution)

JE1059 EGA Monitor & EGA Card **$459.95**

Relisys 14" Multiscan monitor and EGA card package (800 x 600 max. resolution)

JE2057 Multiscan Monitor & EGA Card **$559.95**



JE1059

JAMECO IBM PC/XT/AT COMPATIBLE CARDS

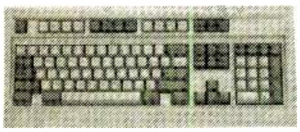
JE1043	360K/720K/1.2Mb/1.44Mb Floppy Disk Controller Card (PC/XT/AT)	$49.95
JE1050	Monochrome Graphics Card w/Parallel Printer Port (PC/XT/AT)	$49.95
JE1052	Color Graphics Card w/ Parallel Printer Port (PC/XT/AT)	$49.95
JE1055	EGA Card w/ 256K Video RAM (PC/XT/AT)	$139.95
GC1500	Orchid 8-Bit VGA Card w/256K Video RAM (PC/XT/AT)	$169.95
JE1057	8/16-Bit VGA Card w/256K Video RAM (PC/XT/AT)	$199.95
JE1060	I/O Card w/ Serial, Game, Printer Port & Real Time Clock (PC/XT)	$59.95
JE1062	RS232 Serial Half Card (PC/XT/AT)	$29.95
JE1065	I/O Card w/ Serial, Game and Parallel Printer Port (AT)	$59.95
JE1071	Multi I/O Card w/ Controller & Monochrome Graphics (PC/XT)	$119.95
JE1077	Multi I/O Card w/ 360K/720K/1.2Mb/1.44Mb Floppy Controller (AT)	$74.95
JE1081	2Mb Expanded or Extended Memory Card (zero-K on-board) (AT)	$109.95

MEI 100-Key Microtype Keyboard

• IBM PC/XT/AT/386 Compatible • Saves an amazing 60% of the desk space used by equivalent standard keyboards

MIRU....................**$129.95**

IBM PC/XT/AT Compatible Keyboards



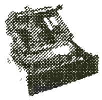
FKB4700

JE2015 84-Key Standard AT Style Layout.......... **$59.95**
FKB4700 101-Key Enhanced Layout w/12 Function Keys.. **$69.95**

MiniScribe Hard Drives & CMS Tape Back-Ups

Part No.	Capacity	Style	Average Speed	Format	Drive Alone	W/8-Bit (XT) Controller	W/16-Bit (AT) Controller
M8425	20Mb	3.5"HH	68ms	MFM	$224.95	----------	----------
M8425XT	20Mb	3.5"HH	68ms	MFM	----------	$269.95	----------
M8425AT	20Mb	3.5"HH	68ms	MFM	----------	----------	$339.95
M8425F	20Mb	3.5"HH	40ms	MFM	$249.95	----------	----------
M8438	30Mb	3.5"HH	68ms	RLL	$249.95	----------	----------
M8438XT	30Mb	3.5"HH	68ms	RLL	----------	$299.95	----------
M8438AT	30Mb	3.5"HH	68ms	RLL	----------	----------	$389.95
M8450	40Mb	3.5"HH	46ms	RLL	$329.95	----------	----------
M8450XT	40Mb	3.5"HH	46ms	RLL	----------	$369.95	----------
M8450AT	40Mb	3.5"HH	46ms	RLL	----------	----------	$429.95
M3085	70Mb	5.25"HH	20ms	MFM	$599.95	----------	----------
M3085AT	70Mb	5.25"HH	20ms	MFM	----------	----------	$699.95

M8425



M8450XT

QFA500

DJ10 40Mb Tape Drive with up to 120Mb capability (includes one TB40 Tape) **$299.95**
QFA500 150Mb Tape Drive with up to 500Mb capability (includes one TC150 tape)....... **$1049.95**

Floppy Disk Drives & Diskettes

Mitsubishi

MF353B 3.5" 720Kb Internal Drive ..**$99.95**

Toshiba

356KU 3.5" 1.44Mb Internal Drive **$109.95**

TEAC

FD55B 5.25" 360Kb Half Ht **$89.95**
FD55G 5.25" 1.2Mb Half Ht **$99.95**

3.5" & 5.25" Diskettes (10 per box)

DSDD 5.25" DSDD (360Kb).......... **$6.95**
DSHD 5.25" DSHD (1.2Mb)........ **$13.95**
3DS 3.5" DSDD (720Kb)......... **$16.95**
3HD 3.5" DSHD (1.44Mb)........ **$34.95**

Sony 3.5" 720Kb Disk Drive

- IBM PC/XT/AT Compatible
- Double-sided, double-density
- Documentation included

MPF11 Disk Drive **$69.95**
SMK 5.25" Installation Kit for MPF11 ....**$14.95**

Hard & Hard/Floppy Disk Controller Cards

Computer Type	MFM Hard Part No. / Price	RLL Hard Part No. / Price	MFM Hard/Floppy Part No. / Price	RLL Hard/Floppy Part No. / Price
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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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