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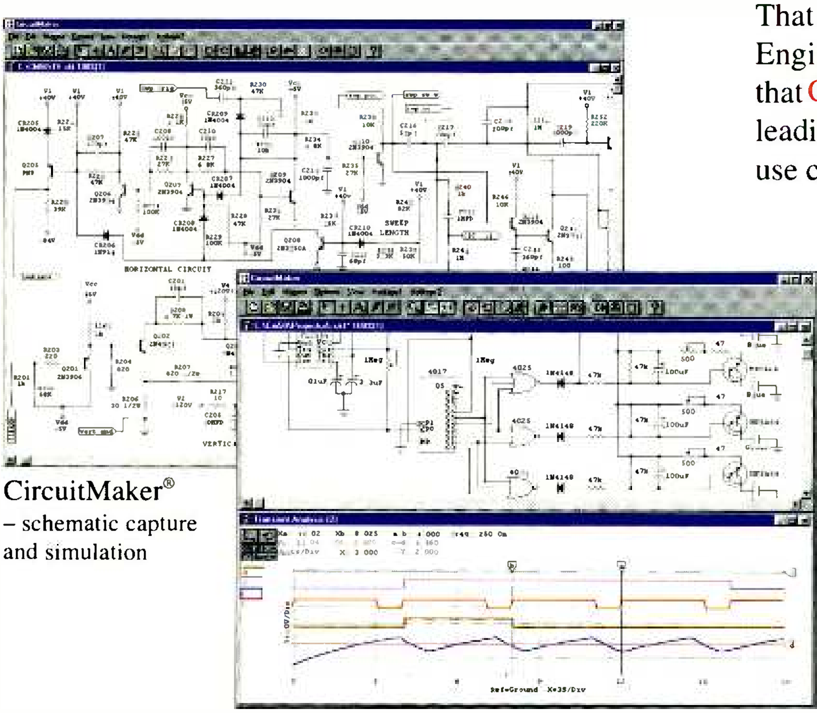

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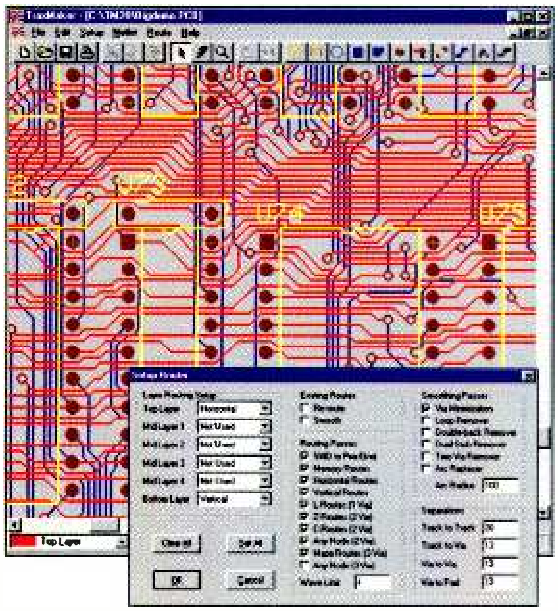

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EDITORIAL

Between Earth and Mars

This past July, after a nearly 21-year absence, Man's presence returned to Mars in the form of the Mars Pathfinder mission. For days, the Nation and the World seemed transfixed, first by the technical difficulties that threatened to derail the entire mission, and then to the breathtaking photographs of the Martian surface, including some whimsically named rocks including "Yogi," "Barnacle Bill," "The Couch," and so on.

Unfortunately, it sometimes seems that the collective Human consciousness is possessed with the attention span of a gnat. The comedian's jokes came quickly, but that was expected, and besides, they occasionally were even funny.

But soon after, some other, more disappointing rumblings started to make the rounds. Comments like: "Gee, it's just a bunch of rocks," "We have more pressing needs at home," "A huge waste of money and resources," and the like were soon heard in conversations, and, even worse, in the op-ed pages of some newspapers and magazines.

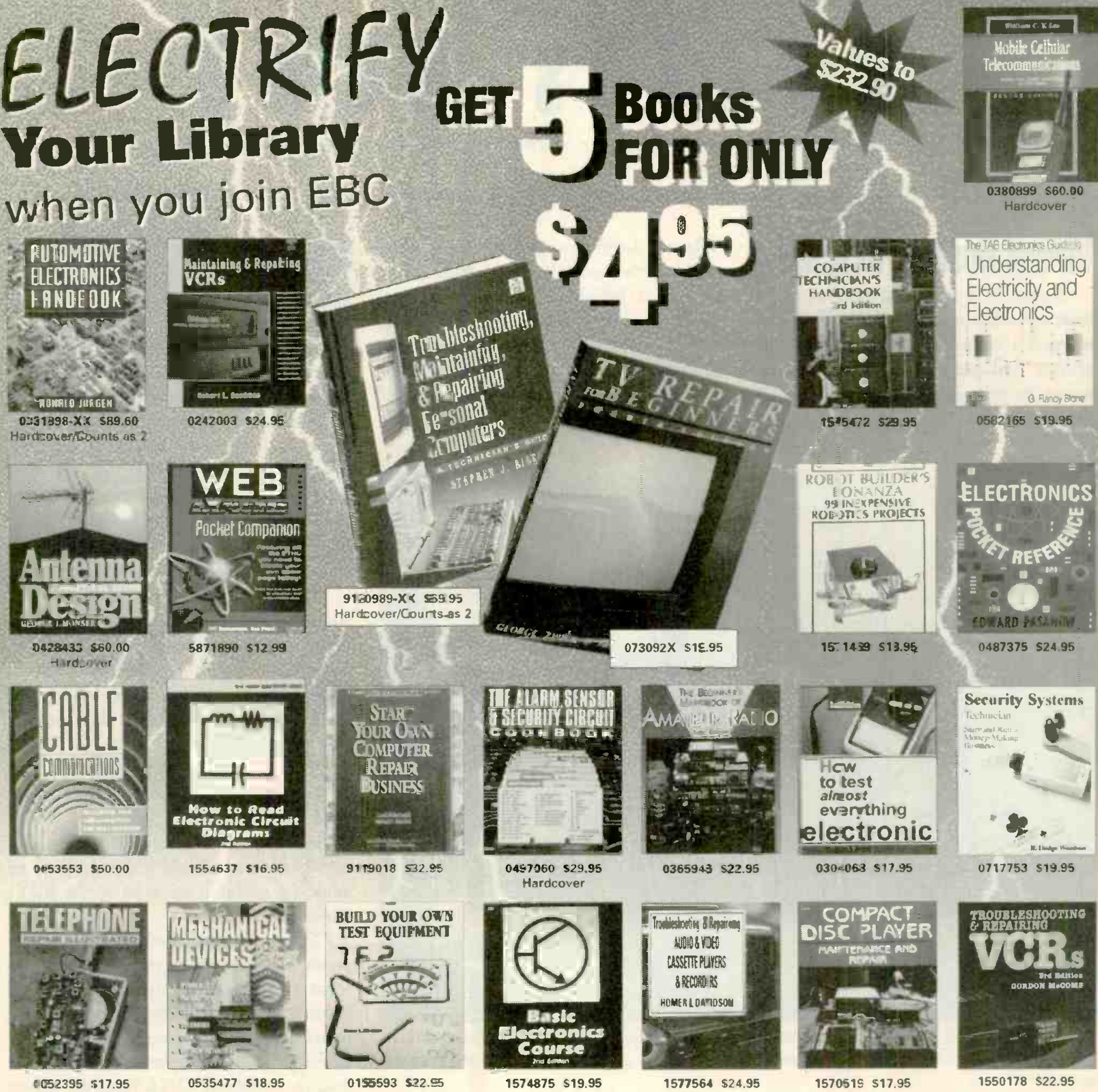
That is unfortunate, and perhaps truly tragic. In this writer's opinion, the Pathfinder mission represents some of the best aspects of the Human spirit: That is the ability to question and to wonder . . . Who are we? What are our neighbors like? Are we alone? If that ability has begun to wither, if our quest for knowledge has been replaced by a quest only for what benefits each of us personally and immediately, we as a species may be in big trouble.

Do the authors of the negative comments speak for the bulk of humanity? I hope not—I know that they certainly do not speak for me. Still, for the non-scientific, non-technical community, some letdown should not come as that big a surprise. After all, just weeks earlier, many of those same newspapers and magazines were trumpeting the impending landing with hype and hyperbole that was beyond what the science could possibly deliver. The fact that the mission gave scientists and geologists reams of information that they could not have obtained in any other way was not readily apparent to the common person. To many, it was indeed just a bunch of rocks, and not much different than what was seen before, or could be seen in the deserts of our own planet, so the natural question to ask is: "Why did we spend all that money?"

The funny thing is, we didn't. Estimated at around $266 million, the entire mission cost each of us around a dollar. Most of us will pay many times that to see some far less-important entertainment—and in some cases, entertainment that turns out to be far less interesting.

Carl Laron

Carl Laron
Editor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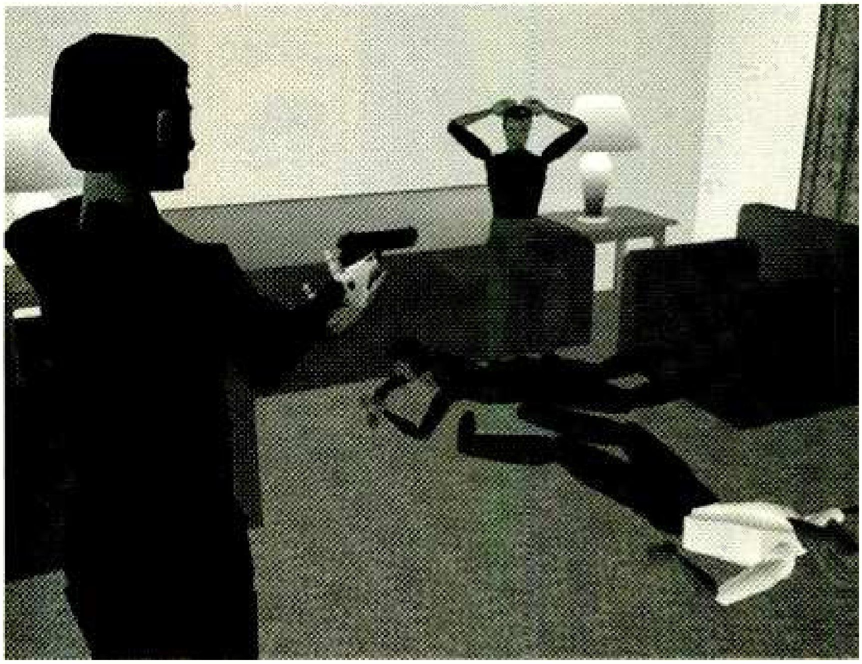
WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Virtual Hostage Rescues

Researchers at Sandia National Laboratories (Albuquerque, NM) have prototyped a virtual-reality simulation that allows two-person law enforcement teams to grip guns, don virtual-reality glasses, and burst into the "environment" of hostage-takers and their victims. The simulation, called VRaptor—Virtual-Reality Assault Planning, Training, Or Rehearsal—is intended to widen access to such training while reducing cost. The participant has to determine who the hostages are, save them, take prisoner the kidnappers who surrender, and shoot those who fire weapons.

Human participants represented by graphical figures interact with four virtual-reality characters—two men and two women—in a sparsely furnished apartment. The trainees are monitored by sensors placed on their backs and hands. VRaptor doesn't give detailed images, but rather provides important visual clues, such as a falling or rising body, lifted arms, or an outthrust weapon. "The advantage is that multiple participants can appear in embodied forms within a common, shared virtual environment," says Sandia researcher Dan Shawver. "They can experience situations in which they otherwise would have no opportunity to practice effective responses."



IN THIS SCENE, A TERRORIST, wearing a white shirt, lies on the floor after being shot by a law-enforcement officer, left. The terrorist had raised his gun at the officer in the previous scene.

Since the scenes are not preprogrammed, the unpredictable outcomes arise from the decisions the trainer makes for each session based upon the actions and reactions of the participants. Project leader Sharon Stansfield says, "It's less like a video game and more like a flight simulator. It familiarizes law enforcement teams with scenarios." She says the VR system is better than existing training systems in "shoot houses," where kidnappers are played by pop-up mannequins.

Magnetite-Producing Bacteria

Astrobiology scientists at NASA Ames Research Center for the SETI Institute report that desert varnish, a shiny coating on the surface of certain rocks, is home to a common mineral-producing bacteria. This is the first direct evidence that biological processes play a role in the formation of the shiny clay-metal glaze that covers rocks found in extreme climates, such as the desert.

The finding is important in that it suggests that desert varnish contains magnetite—a biologically produced, magnetic mineral—which means that it could be a useful paleobiomarker. Paleobiomarkers are fossils that indicate past signs of life.

"Desert varnish, via magnetite, might be a particularly useful paleobiomarker because the extremely dry, oxidizing environment of the desert is akin to that of other planets," said Melisa White, an associate research scientist at the SETI institute.

The team identified the magnetite-producing bacteria by growing scrapings from the desert varnish in a bacterial culture medium and then attracting the microbes with a magnet. They are now in the process of further confirming the data by extracting DNA from the desert varnish and comparing it with that from the magnetite-producing microbes.

Superconducting-Wire Development Team

With the goal of producing longer superconducting wires, which could help revolutionize electrical devices and power transmission, Los Alamos National Laboratory (Los Alamos, NM) has signed an 18-month, $3-million Cooperative Research and Development Agreement with 3M (St. Paul, MN). As part of the agreement, Los Alamos will join 3M, Southwire Company, and Oak Ridge National Laboratory to develop high-temperature, thin-film superconducting wires that could be used in prototype superconducting motors, generators, power cables, and other electrical device that might be introduced early in the 21st century.

Superconducting materials, which could greatly reduce costs and improve efficiency of power transmission, lose nearly all electrical resistance when chilled to very low temperatures. "High-temperature" superconductors lose resistance at or near the temperature of liquid nitrogen (–320° Fahrenheit).

"Los Alamos' Superconductivity Technology Center has been on the cutting edge of superconductor development—most recently with the introduction of a high-temperature, high-current-density, flexible superconducting tape," said Dean Peterson, leader of Los Alamos' Superconductivity Technology Center. "It seems fitting that we would be included in an initiative that could usher in the next millennium with the introduction of products that could revolutionize the way this nation and the world delivers power."

That superconducting tape has a current density of nearly one-million amperes per square centimeter at liquid-nitrogen temperatures. Its current density is close to 100 times greater than anything that had previously been developed. Current density is a measure of the amount of current that can travel through a cross section of a material. Number 12 copper wire, commonly used in many households, carries less than 800 amperes per square centimeter.

To date, Los Alamos researchers have been able to produce one-meter lengths of the "Super Tape," made of a thin film of the superconducting ceramic compound yttrium, barium, and copper oxide deposited on a strip of nickel and cubic zirconia. One-meter lengths are too short for most industrial applications. The agreement with 3M will explore ways to produce long lengths of the tape at low costs without losing its superconducting properties.

The R&D team will also explore ways to capitalize on an Oak Ridge superconducting development known as Rolling-Assisted, Biaxially Textured Substrates (RABITS). RABITS, made with a technique in which superconducting films are deposited on metals to produce high-temperature superconducting tapes, also have shown current densities of one-million amperes per square centimeter.

"If there is a way to scale up production of the Los Alamos and Oak Ridge technologies for commercial use, their potential in applications like motors, generators, transformers, current limiters, underground power cables, and magnetic-energy storage is incredible," said William Coyne, senior vice president of 3M research and development. "Products using electrical wiring could be vastly improved. For instance, transformers could be produced at half the weight and operate without oil, and far more efficient motors would run more quietly and produce double the output."

The use and development of superconducting materials in the next 20 years might play a key role in helping meet the world's ever-increasing demands for electricity.

"Super-V" LCD

Sharp Corporation has developed a color TFT (thin film technology) liquid crystal display (LCD) for use in desktop monitors for personal computers and engineering workstations. The Super-V (Super-View) LCD, a proprietary Sharp TFT LCD, simultaneously achieves breakthroughs in viewing angle and contrast as well as brightness and low power consumption. Conventional technologies require trade-offs between those feature pairs; one feature could be emphasized only at the expense of the other.

The Super-V LCD has a wide viewing angle of 140 degrees horizontal and 110 degrees vertical. The 20.1-inch diagonal, SXGA-compatible (1280×1024) LCD is comparable in size to a 22-inch CRT, with a depth measuring just 10 centimeters (3.9 inches). Power consumption when used as a desktop monitor is approximately 40 watts.

Future applications for the Super-V LCD include presentation boards in meeting rooms, information displays for art museums, and high-resolution HDTV wall-hanging televisions.

Electronics Research Center

LG, a leading South Korean industrial group, will be establishing a research and development center in Princeton, NJ. The LG Electronics Research Center of America (LGERCA) will focus on digital multimedia and consumer electronics. Over the next five years, LG plans to invest $40 million in the lab. LGERCA will be headed by Dr. Mark Simpson, who has held senior research positions with Adobe Systems, Apple Computer, and Xerox Corporation, and he will oversee a staff that will grow to over 20 by the end of the year.

The plan is to develop technology for network devices—an emerging category of products, which will bring new services and features to appliances, such as telephones and televisions; to develop software for embedded systems and network applications; and to conduct research on digital image and video processing. LGERCA will also serve as liaison for the collaboration that LG companies have with the Sarnoff Corporation, a world leader in digital and video consumer electronics techniques. One reason Princeton was chosen was because of its proximity to the Sarnoff Corporation. EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Crystal Clear

I would like to build the FM Stereo Transmitter (**Electronics Now**, June 1997) and the CallDirector (**Electronics Now**, May 1997), and I need to find 4.864-MHz and 10.240-MHz crystals. I also need to know if the 3.58-MHz crystal in the CallDirector is the same as a 3.579545-MHz crystal. I would like to experiment with a 38-kHz crystal, too. It would be really pleasant to find all of these at one store since it would save me a lot of shipping and handling costs. Thanks in advance.

A.J. BUSH
via Internet

A good one-stop source for crystals is JAN Crystals, 2341 Crystal Drive, P.O. Box 06017, Fort Myers FL 33906-6017; Tel: 1-800-JAN-XTAL. You might also try your local RadioShack store; they can get a wide range of common crystals for you via their special order program. And yes, you can use a 3.579545-MHz crystal for the 3.58-MHz crystal specified in the CallDirector article.—Editor

Beyond my Command

In past issues of **Electronics Now** I have seen many circuits and applications that allow a PC to communicate with or control other devices via its serial or parallel port using BASIC commands (in particular, the ones by JJ Barbarello are among the best of this type I've ever seen). These days, however, I am using Windows 95, and I don't have access to a standard BASIC program. I can write programs in Microsoft Visual Basic (versions 3 and 5), but I can't seem to find the similar commands. Can you help?

PETER S. MAY
Eaton, IN

What Mr. Barbarello is doing is writing a data pattern directly to the data output port connected with LPT1. That is why he uses the address 888 (decimal for 378—the hexadecimal address of LPT1:).

While writing directly to the hardware, although frowned upon, is done in DOS, trying that in a multi-tasking environment like Windows is a major mistake. Microsoft has built into Windows an API—application-programming interface. Many different services are built into Windows to handle many different tasks from mouse status to handling multiple child and parent windows.

Buried in there is a routine for sending data to an I/O port. A good reference book on the Windows API will show you exactly how it should be coded. You could also check some of the Visual Basic Newsgroups on the Internet. If someone else has not already asked (or answered) that question, you could post one yourself. Another source of information is the Microsoft Knowledge Base at www.microsoft.com.

A word of warning—trying to run a direct-control project like the ones developed by Mr. Barbarello might not work quite as well under Windows. The response time could be affected by how many different tasks the computer is trying to juggle at the same time. Windows 95 should give you a much better response, especially if you compile a true Windows 95 application. Windows 95 is much better at multitasking than Windows 3.1. If you upgraded your computer to Windows 95 from Windows 3.1/MS-DOS, you might have Microsoft QBASIC still hiding in you DOS folder. Although QBASIC is just an interpreter, it runs well under Windows 95.—Editor EN

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Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Digital Volume Controls Found

In June, a reader asked about a pushbutton-operated digital volume control. Jim Shand (Aptos, CA), Steven Herbold (via e-mail), and Franklin J. Miller (**Electronics Now's** Audio Editor) wrote to point out that Dallas Semiconductor and Xicor make ICs that do this. Xicor calls them EEPOTs or E²POTs (electrically erasable potentiometers).

Figure 1 shows how to use the simplest chip of this type, the Dallas Semiconductor DS1669. The chip contains a string of resistors, a set of analog switches that connect the output to the tap between any two resistors along the string, and digital support circuitry, including a non-volatile memory. You change taps by pressing the up or down buttons (which auto-repeat if held down more than one second), and the chip remembers its setting if powered off and then on again.

The voltages on all three terminals of the resistor string must be between +5V and ground, or close to that range. You can use ground-referenced audio signals if the amplitude is low (less than 0.4-volt peak-to-peak according to our experiments). Better yet, build the volume control into your circuit at a point that is biased above ground, such as the collector of a transistor, and you'll have no problems.

The DS1669 comes in three versions, with resistances of 10k, 50k, and 100k ohms. You can use it with all kinds of signals, not just audio.

How to use a more sophisticated volume-control chip, the Dallas Semiconductor DS1802, is shown in Fig. 2. That IC provides two stereo channels with log-taper potentiometers. As shown in the figure, the circuit uses separate "up" and "down" pushbutton switches to set the volume for the two channels, but if you ground pin 7, S1 and S2 become balance controls, with S3 and S4 controlling volume to both channels in unison. To prevent pops and crackles, the chip waits until the audio waveform crosses zero before changing position. The DS1802 does not retain its setting when powered off; instead, it sets itself to minimum volume every time it is powered up. Also note that Fig. 2 shows normally-open pushbuttons; those are correct, even though Dallas' data sheet shows them as normally closed.

Why use a digital volume control? Maybe because you like pushbuttons or because you need to control the volume using a microprocessor. But the best reason might be that there's no mechanical wiper to get dirty or wear out. Potentiometers are among the least reliable parts in modern electronic equipment, especially if there's sand, dust, or anything corrosive in the environment; these digital pots aren't bothered by sand or chemicals.

Both the DS1669 and the DS1802 have serial interfaces for microprocessors. You can purchase these chips directly from Dallas Semiconductor by calling 800-336-6933 or 972-371-4000; they take credit cards. Data sheets are available from http://www.dalsemi.com or by writing to Dallas Semiconductor, 4100 Spring Valley Road, Suite 302, Dallas, TX 75244. Similar Xicor products are described on the Web at http://www. xicor.com. You can contact Xicor at 3333 Bowers Avenue, #238, Santa Clara, CA 95054.

A Dot of A Different Color

Q *I have a rather extensive home theater system that includes nine channels of amplification from three different amplifiers. I'd like to construct a novel VU meter system to display outputs of several of the amplifier channels.*

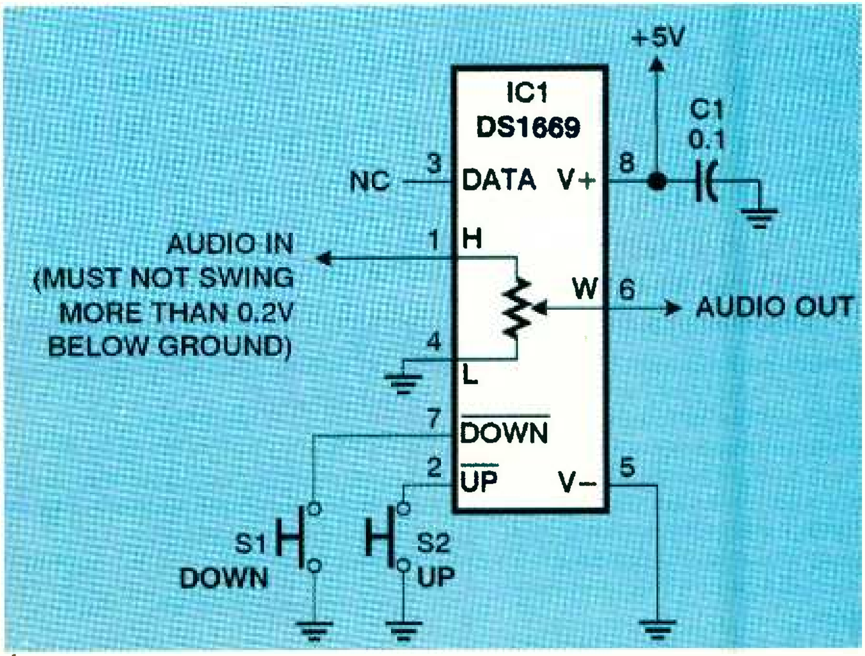

FIG. 1—THE DALLAS SEMICONDUCTOR DS1669 IC acts as a pushbutton-controlled potentiometer. The device comes in 10k, 50k, and 100k versions, and retains its setting when power is removed.


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17056 FCS604A..............$44.95 $39.95
Jameco ABS Speedy Boxes
Will not crack or split when drilled or punched. PCB mounting slots on all four sides and the lid has a lip for precision fit (adds 0.4" height). Complete with four screws and lid. All sizes below are for interior dimensions. • Black ABS plastic
Part No. Size (L x W x D) 1-9 10-49 50-99
18921 3.1" x 2.0" x 0.9" $2.25 $1.95 $1.59
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18892 6.0" x 3.5" x 1.9" ...2.95 2.69 2.39
18905 7.5" x 4.3" x 2.3" ...3.49 2.95 2.49
1 and 3 Axis Accelerometer Modules and Interface Card
Crossbow
• For motion sensing, vibration analysis and other acceleration applications
141575
141583
Part No. Description Price
141591 1 axis accelerometer..........$89.95
141575 3 axis accelerometer..........159.95
141583 Digital interface card..........199.95
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Get excellent audio and visual clarity in your monitoring applications.
• 4-channel transmission/receiving modules
• Supports NTSC format
• VCR ready for recording
• Transmission distance up to 200 meters
• Weight: 6.7 lbs. • One-year warranty
Part No. Description Price
135976 900MHz observation sys. ..$329.95
Jameco Laser Pointer Kit
• Power requirements: 2 AAA batteries (included)
• Some soldering required
• Size: 4.5"L x 1.0"W x 0.6"H
Class IIIa Laser Product
• Weight: 0.4 lbs. • One-year warranty
Part No. Description Price
121339 Laser pointer kit ..... SALE $35.95
NetMouse
New innovative way for browsing the Internet! With the magic button feature you can easily scroll through your Windows® and documents.
• Includes software and PS/2 pin adapter
• Weight: 0.5 lbs. • One-year warranty
Part No. Description Price
141815 4-button serial mouse SALE $29.95
4-Button Joystick with View Control
• IBM PC/XT/AT or 100% compatible
• Rotary control for extra thrust, 4 fire buttons for easy access, x and y axis trim controls
• Size: 10"L x 7"W x 9"H • Weight: 3.1 lbs.
Part No. Description 1-4 5-9
141364 4-button joystick ...$49.95 $44.95
High Luminous Intensity White LEDs
Optic
Part No. Size 1-9 10-99 100 1000
142885 T1 ....$4.95 $4.49 $3.95 $3.49
142893 T1¾...4.95 4.49 3.95 3.49
Hyper Peppy Robot Kit
• Changes course when comes in contact or hears a loud sound
Part No. Description Price
140863 Robot kit..........................$24.95
Unipolar Stepper Motor Driver Kit
• Will drive unipolar stepper motors rated at 6-30VDC @ 1.25A (or less)
• Drives 5, 6 or 8 lead unipolar stepper motors
29 pc. Kit
• Standard and wave drive
• Output: 50V max. • Weight: 0.07 lbs.
• Size: 2.6"L x 1.9"W x 1.0"H
Part No. Product No. 1-4 5-9
139109 DK-109................$29.95 $26.95
Speech Recognition Circuit Kit
• Speaker dependent
• External RAM support
• Maximum 40 word recognition at .96 seconds word length
41 pc. Kit
• Requires 9VDC battery • Weight: 0.6 lbs.
Part No. Description 1-4 5-9
141401 Speech kit.............$99.95 $89.95
Making Your Own Printed Circuit Board Book
Design and create your own printed circuit board inexpensively and reliably. (37 pages)
• Size: 8.5" x 11"
• Weight: .05 lbs.
Part No. Description 1-4 5-9
141524 Making PCBs Book $14.95 $13.49
U.S. Robotics 14.4 kbps Data/Fax Internal Modem
SPECIAL
• Supports 14.4 down to 300 bps of data
• Compatible with ITU-T standard
• System requirements: 486 or Pentium®, Windows® 3.xx to Win® 95, 4MB RAM, 2MB hard disk space • One-year warranty
Part No. Description Price
139871 14.4 int. modem.. Special $34.95
139 Piece LED Hardware Assortment
LED panel lenses and circuit mounts
• Red, yellow, green, blue and clear lenses
• Mounts and pre-wired solderless LED indicators
• LED PCB mounts, sockets and standoffs
• Size: 8.5"L x 4.5"W x 1.5"H • Weight: 0.4 lbs.
Part No. Description 1-4 5-9
140759 LED hardware kit.. $22.95 $19.95
Jameco Solderless Breadboards
• Low static plastic body – CMOS safe
20773
• Nickel plated clips designed to withstand up to 5,000 insertion cycles
Part Number Contact Points Size L x W Pricing 1-9 10-49
94457 100 6.5 x 0.4 .....$2.49 $2.25
20600 400 3.3 x 2.1 ....4.95 4.49
136910 960 5.5 x 2.8 .. Closeout 7.95
136901 1,600 5.5 x 2.3 ......21.95 19.95
20669 630 6.5 x 1.4 ....5.49 4.95
20722 830 6.5 x 2.1 ....7.95 6.95
20757 1,360 6.5 x 3.1 ......11.95 10.95
20773 1,660 6.5 x 4.3 ......17.95 15.95
20790 2,390 6.9 x 5.8 ......22.95 20.49
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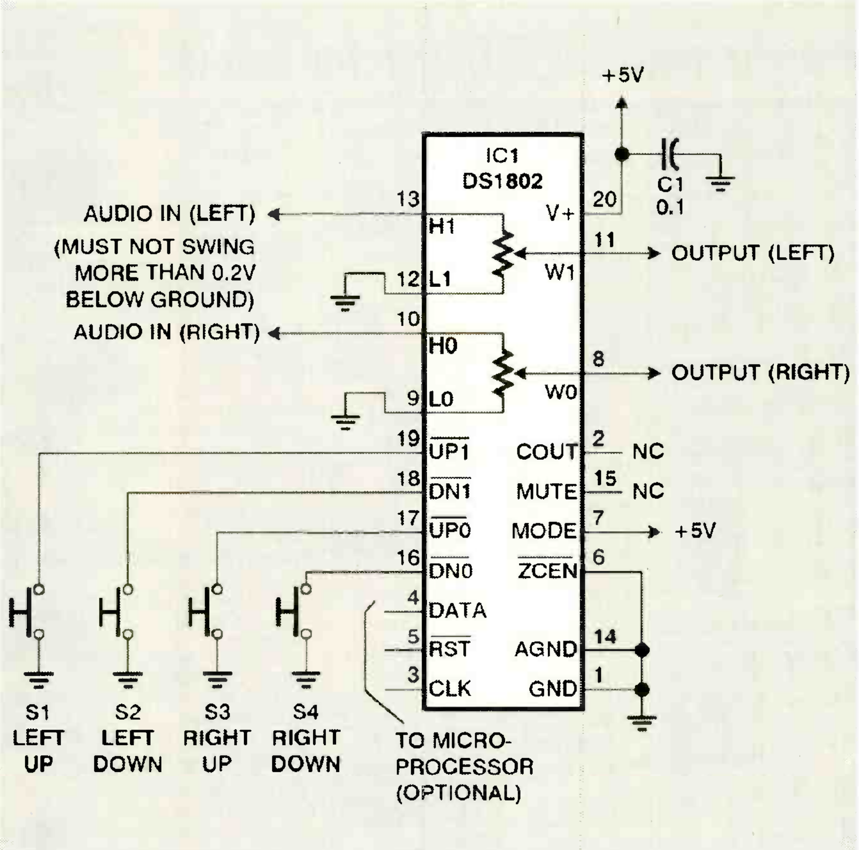

FIG. 2—THE DS1802 IS A HIGHER-PERFORMANCE audio-volume control that offers two channels, log taper, low noise, and zero-crossing detection.

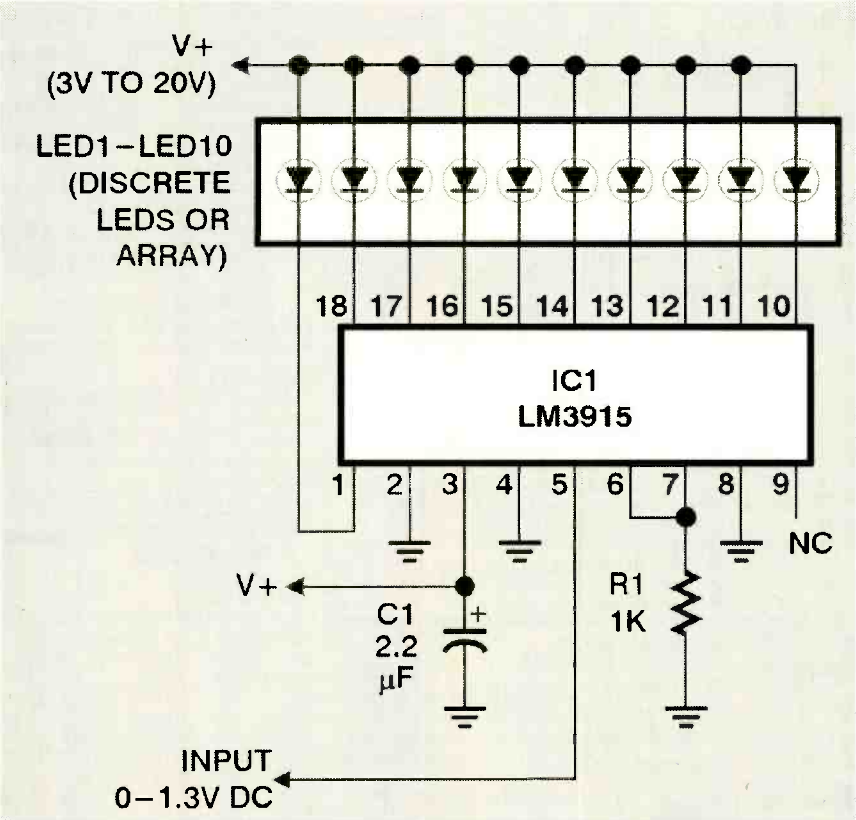

FIG. 3—HERE'S A BASIC MOVING-DOT display built around the LM3915. Note that grounding pin 9 provides a bargraph display.

Can you tell me how to use the National Semiconductor LM3915 integrated circuit in a "moving dot" display using two-color LEDs? My desire is to have a moving red dot on a green background to display amplifier output. — P. D., Portsmouth, NH

A The LM3914, 3915, and 3916 ICs let you use a row of LEDs as a meter, either in moving-dot or in bargraph mode. The LM3914 is linear; the LM3915 is logarithmic (hence good for audio work); and the LM3916 more closely matches the behavior of a VU meter.

Figure 3 shows the basic circuit. National Semiconductor's data sheets, available from http://www.natsemi.com, tell you in detail how to supply the input, which can be taken across a speaker through a resistor network.

Your idea of a moving red dot on a green background is a good one, but because green LEDs look brighter than red ones, you might want to do it the other way around, as a moving green dot on red.

Figures 4 and 5 will help you to implement your idea. As Fig. 4 shows, the LM3915 contains a switching transistor and current limiter for each LED. By putting a 10k resistor in place of the LED, you can obtain a logic-level output, which you can then feed to a pair of CMOS inverters, as shown in Fig. 5. The polarity across the LED reverses depending on the logic level, making it switch from one color to the other. Which color is "high" and which color is "low" depends on which way the two-color LED is inserted, of course. If it alternates rapidly between green and red, it will look yellow. Note that while Fig. 5 specifies a 74HC04 CMOS hex inverter, you could also use a 74HCU04, 74HCT04, or, for a wider range of supply voltages, 4049.

Disk Drives and Flybacks

Q *In April, a reader asked how to use a 16-bit IDE disk drive in an 8-bit PC XT. A suitable adapter, with onboard BIOS, is available as part #10268 from Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002 (Tel.: 800-831-4242) for about $55.*

Now for my question: Where can I get schematics and parts such as flybacks for older TTL computer monitors? I've tried many *places and no one has been able to help. — Steve Fuesting, Effingham, IL*

A Thanks for the tip! Jameco has a number of hard to find parts for older computers, even Apple IIs.

As to your question, the trouble with TTL monitors such as the IBM Monochrome Display is that they're completely obsolete—you can get a complete used monitor cheaper than you can get any spare parts, and if you look in the right places, people are giving old monitors away.

The schematic of the IBM Monochrome Display was published in the *IBM Personal Computer Technical Reference* (1982). It's a single page with no explanatory text. Some newer IBM monitor service manuals can be purchased from http://www.us. pc.ibm. com/cdt/hmm.html, and Service Editor Sam Goldwasser's excellent notes on monitor repair are online at http://www .paranoia.com/~filipg.

Apart from that, there's not much information available. Magazines such as *Computer Hotline* and *Nuts and Volts* used to carry ads for monitor parts and repair guides, but in recent issues the pickings have become very slim. As a last resort, go to the newsgroup sci.electronics. repair and post your questions; if anyone on earth knows, you'll probably find them there.

Half A Digit?

Q *I recently started a course in electronics and am puzzled by a term used when describing the features of digital multimeters. Can you explain what is meant by a "4½ digit display"? — I. J., Trinidad & Tobago*

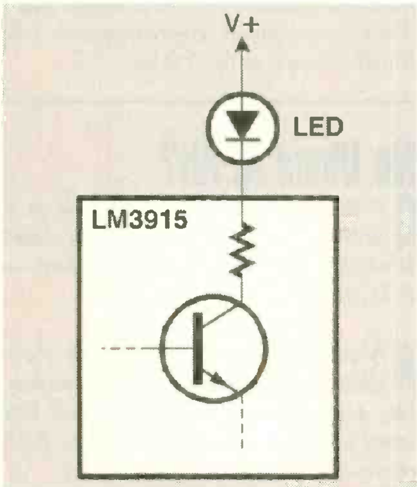

FIG. 4—EACH OF THE LM3915's outputs features an internal switching transistor and a current limiter, which is shown here as a resistor.

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at http://www.gernsback.com for information and files relating to our magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups sci.electronics.repair, sci.electronics.components, sci.electronics.design, and rec.radio.amateur.homebrew. "For sale" messages are permitted only in rec.radio.swap and misc.industry.electronics.marketplace.

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www. motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online.

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1992 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

Electronics Now and many other magazines are indexed in the *Reader's Guide to Periodical Literature,* available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549 Tooele, UT 84074.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use: NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League (Newington, CT 06111; http://www.arrl.org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

A Certainly. A "half digit" is a digit that goes only from 0 to 1, not 0 to 9. Thus, a display that goes up to 19999 (not 99999) is a four-and-a-half digit display. It's more than four digits but less than five.

Most digital multimeters (DMMs) have $3\frac{1}{2}$ digits, i.e., they go from 0000 to 1999 (with the decimal point freely movable).

A few DMMs have a "$\frac{3}{4}$ digit" that goes from 0 to 3. Thus, a $3\frac{3}{4}$-digit display goes from 0 to 3999.

Audio Time Delay

Q *I am looking for a 0–3 second monophonic audio-delay circuit to use with a PA system for special effects and to compensate for distant speaker placements. Would it be better for this processing to occur before or after the amplifier? Would passive or active circuitry be preferred? —D.F.C., Concord,OH*

A The processing should definitely be done ahead of the amplifier so that it doesn't have to deal with high power levels. Active circuitry will be necessary—an LC delay line long enough for 3 seconds would be enormous and would lose nearly all of the signal.

Instead, use bucket-brigade devices. These are analog memories that record a signal level and play it back after a time delay. As the name implies, the memory consists of many cells, and the signal is passed from one to another until it reaches the end.

Panasonic bucket-brigade devices and data books are available from Digi-Key (701 Brooks Ave. S., Thief River Falls, MN 56701; Tel.: 1-800-DIGIKEY). Call them for a free catalog. They're on the Web at http://www.digikey.com. Oddly, Panasonic semiconductor data sheets do not appear to be on the Web yet.

Flip-Flop Tip

Q *In your February issue, your Q&A column addressed a question about erratic flip-flops. The writer used a 7473, which, as I recall, had a peculiarity that was not well documented. For the chip to function as described in the truth table, the J and K inputs must not change while the Clock input is high. Could that have been the reader's problem? —*
R. A. Browning, N. Las Vegas, NV

A That's right—the 7473 is easily disrupted by momentary changes in J and K at times when it ought to ignore them. This effect is called "ones-catching" and, in their book, *The Art of Electronics*, Horowitz and Hill warn that it "can have dire consequences for the unsuspecting." They recommend edge-triggered J-K flip-flops such as the 74112.

No Ohms At All?

Q *What does a zero-ohm resistor do in a circuit? How do you measure zero ohms? What is a zero-ohm resistor used for? — P. D., Warren, RI*

A A zero-ohm resistor conducts electricity with no appreciable resistance, like a plain piece of wire. (It still has some resistance, of course—maybe 0.01 ohm—but it's too small to notice.)

You can measure zero ohms with any ohmmeter—it's the reading you get if you touch the probes together with no resistor between them.

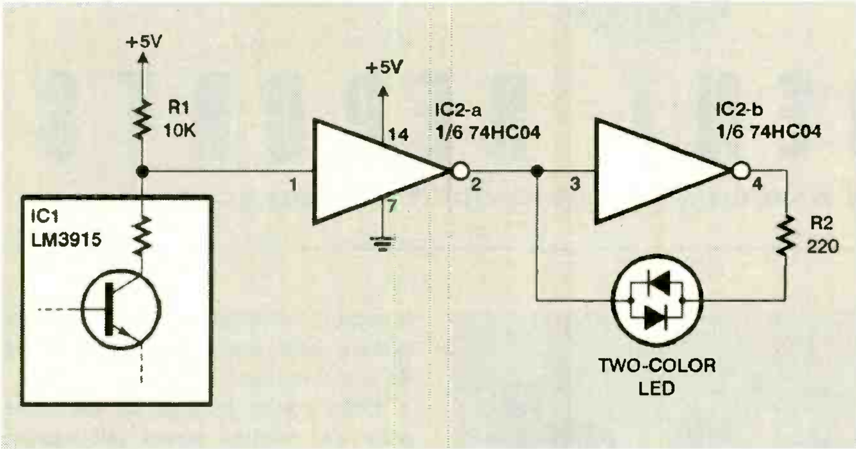

FIG. 5—TO GET A TWO-COLOR LED to switch colors rather than just lighting up, drive it with a pair of CMOS inverters as shown here.

Zero-ohm resistors sound like a joke, but they really exist for use as jumper wires. Unlike plain wires, they can be placed in PC boards by automated machinery designed to insert resistors. Their insulated coating is tougher than the insulation on ordinary wire. Sometimes a single-sided board needs a few jumpers to make connections across the traces. Sometimes an engineer specifies a resistor, but then finds out that a direct connection is better. In either case, zero-ohm resistors come to the rescue.

How Does It Know?

Q *How does a pixel on a video screen react to a light pistol on a video game, and how does the information return through the tuner to the video game? — D.K., Lancaster, TX*

A Actually, the communication takes place in the opposite direction than what it looks like. That is, the light pistol doesn't affect the video screen; the screen affects the light pistol.

The light pistol contains a photocell that sees the electron beam scanning the CRT. Although a TV screen seems to glow continuously, only one spot on it is at full brightness at any particular instant. The screen is scanned so rapidly that our eyes can't see the bright spot flying across it, but a photocell can.

The CPU in the video game knows, moment by moment, exactly what part of the screen is being scanned—after all, it's generating the image. So when the light pistol sees the bright spot go by, it notifies the CPU and the CPU can deduce exactly what part of the screen the light pistol is aimed at.

Writing to Q&A

As always, we welcome your questions. The address is Q&A, Electronics Now Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication). *If you are asking about a circuit, please include a complete diagram.* EN

EQUIPMENT REPORTS

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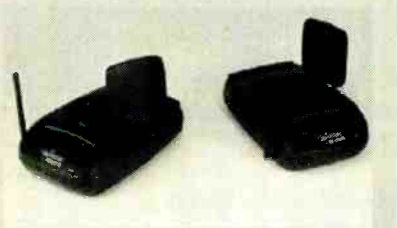


Audio/video re-broadcasters have always been popular and sought-after accessories, even when FCC regulations made their sale and use questionable. Their legal status has long since been clarified, and purchasing a unit these days is no more difficult than going down to your local retailer and paying your money. Unfortunately, what you can purchase often leaves the buyer disappointed.

There are a few reasons for that. One, the bands used by the majority of the available products, 900 MHz, has become increasingly crowded as it is also used by such things as cordless telephones, baby monitors, and the like. The result is interference, and picture and sound degradation. The second is that few if any offer a way to control the source unit. For instance, in the case of a cable box, to change channels one would have to physically go to the box, or within range of its remote control—not at all convenient if you are on a another floor or on the other side of the house.

That's all past now, thanks to a product from RF-Link Technology (411 Amapola Ave., Torrance, CA 90501; Internet: www.rflinktech.com). That product, the Wavecom Sr. (which the company says stands for Wireless Audio Video Everywhere Communicator), combines a 2.4-GHz audio/video re-broadcaster with a 400-MHz remote-control extender to provide a product whose performance surpasses anything in its category that this reviewer has seen thus far. Aside from home use, the product also has important applications in the security and monitoring fields; more on that later. For those who don't need the remote-extender function, there's also the Wavecom Jr., which lacks that function and costs less.

Details

The Wavecom Sr. is a three-piece assembly consisting of a transmitter, receiver, and IR mouse. The transmitter and receiver appear identical at first glance though their functions can not be interchanged. Each is in black, resembles a small answering machine, and measures 6.9 by 4.4 by 1.8 inches. Each sports two antennas. One, which somewhat resembles a micro satellite dish (and measures less than 3 inches square), handles the audio and video. The second, which is a mast that's about 3½ inches tall, handles the remote-control signal. The antennas swivel and turn, allowing flexibility in positioning for best results, and the larger A/V antenna can be folded flat to the unit for storage or transport. The tiny IR mouse measures about 1 by ½ by ½ inches.

The transmitter is placed near the source unit. It requires baseband video and line-level audio (stereo) inputs. The IR mouse plugs into the transmitter and is placed in front of the source unit such that its signals will reach that unit's IR sensor; usually somewhere in front and close by will work. The receiver is placed near the remote TV or monitor. It outputs baseband video and line-level (stereo) audio, but also offers a standard RF (coax) output.

Once you've hooked up the three units and applied power (all needed accessories including A/V cables and two 12-volt AC wall-mount transformers are included), you're nearly set to go. The unit offers four selectable operating channels, and you'll have to be sure that both the receiver and transmitter are set to the same one. There are two reasons for the multiple channels. One, it allows up to four receiver/transmitter pairs to operate simultaneously over the same area. Two, in some set-ups, somewhat better performance might be obtainable using one channel over another. To see if that's the case for you, simply switch both units through all four channels and observe the results.

Performance

All of the foregoing is wonderful, but ultimately useless if the system does not perform as claimed. To test the unit, we set it up in what to us seemed like a typical, if not demanding, application. For the signal source, we used a DSS receiver located in a living room. The remote receiver was a high-end 20-inch stereo monitor located in an upstairs bedroom that was diagonally across the house.

So how did it perform? In short, nearly perfectly. Under normal conditions, no notable degradation in either video or audio quality was noted during the test period. Further, the remote-control extender worked flawlessly.

That's not to say that the potential for problems does not exist. For one thing, because of the frequencies used, interference from objects passing between the transmitter and receiver are possible. That can be effectively combated by placing the unit as high up as possible, which was done in our test set up. Second, and perhaps more serious, the frequencies used are very susceptible to interference from microwave ovens, especially ones

continued on page 24

BY FRANKLIN J. MILLER

Setting up the Audio Oscillator

NOW THAT' YOU'VE COMPLETED ASSEMBLING YOUR AUDIO OSCILLATOR, YOU NEED TO ALIGN YOUR UNIT FOR OPTIMUM PERFORMANCE. THE OUTPUT LEVEL MUST BE SET FOR +18DBM, OR 7.95 VOLTS. THAT CAN BE DONE WITH ANY METER that can read AC volts. Most meters will read this value accurately at low frequencies—say 100 Hz. Set your oscillator to +18 dBm which is its maximum output, and the output frequency to 100 Hz (note: if your voltmeter can read true rms, any output frequency within the range of the meter will do).

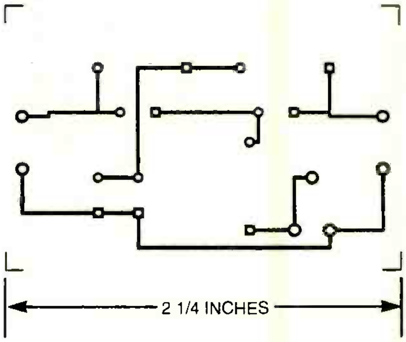
The adjustment is made using trimmer potentiometer R22, which is located in the center of the PC board, toward the front; see Fig. 1. Set R22 so that your meter reads 7.95 volts (+18 dBm). Be as accurate as possible. This adjustment sets the accuracy of the output levels that are set by the precision resistors.

The second and last adjustment is needed to minimize total harmonic distortion plus noise (THD +N). It is made using R21, the 15-turn trimmer potentiometer located in the upper left hand corner of the main PC board. If you are lucky enough to own or can borrow a THD + N analyzer, just connect it to the oscillator's output and adjust potentiometer R21 to obtain the lowest THD + N level possible.

A Notch Filter

If you do not own a THD + N analyzer, I have designed a simple twin-T bridge filter circuit for you to use to set R21. Figure 2 shows the circuit. While the circuit is simple enough that you can build your unit on a piece of perf board, A PC board makes things neat and simple; a suitable foil pattern is provided here. If you chose to use that foil pattern, the corresponding parts-placement diagram is shown in Fig. 3.

Regardless of your construction technique, be sure to observe proper construction practices. One note about the circuit itself: For proper operation, all components must be close tolerance. That means 1% or better resistors and capacitors. Now, the resistors are no problem, but where do you get the capacitors? Unfortunately, the answer is to use 5% or 2% polypropylene units and match them to 1% or better. Even the resistors should be selected for as close a match as possible. In particular, the closer the match between C1 and C2, C3 and C4, and R1 and R2, the deeper the notch you will be able to obtain, and the better the results. Note



IF YOU CHOSE TO USE A PC BOARD, here's a suitable foil pattern.

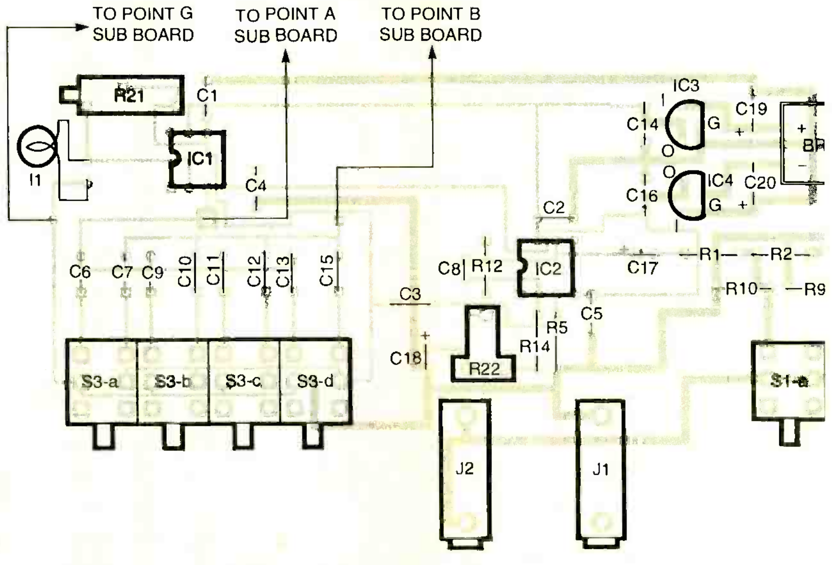


FIG. 1—HERE IS PART OF THE parts-placement diagram from last month's column. It shows the locations of R21 and R22.

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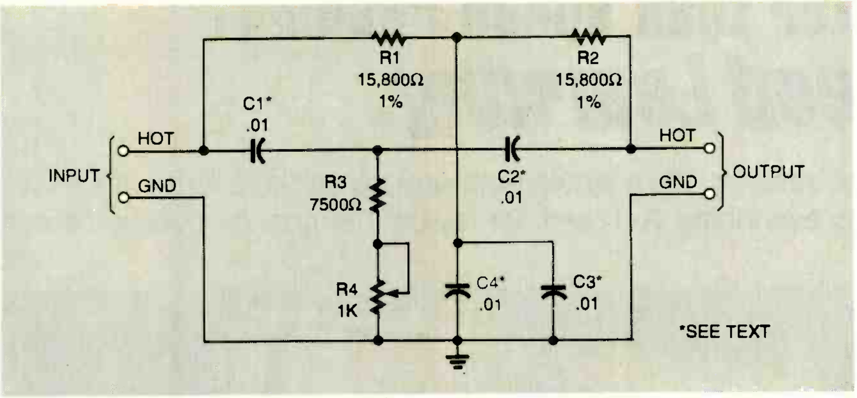

FIG. 2—THE TWIN-T FILTER CIRCUIT is simple and straightforward. It is important that the resistors and capacitors be closely matched for best results.

that the kit available from the supplier mentioned in the Parts List contains prematched units.

The trimmer potentiometer, R4, is used to set the notch for maximum depth. In my prototype, I was able to get a 40-dB notch. Since we are reading voltage at the output, the 40-dB delivers an output of 0.795 volts, which is an excellent notch for this simple circuit.

Next, connect the output of the oscil-

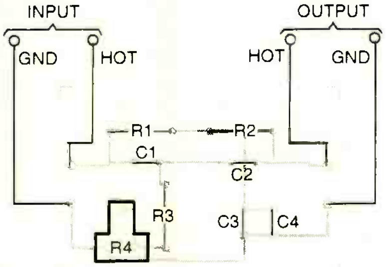

FIG. 3—USE THIS PARTS-PLACEMENT DIAGRAM when assembling the twin-T filter's circuit board.

PARTS LIST FOR TWIN-T FILTER

R1, R2—15,800-ohm resistor, ¼-watt, 1%
R3—7500-ohm resistor, ¼-watt, 1%
R4—1000-ohm potentiometer, Digi-Key D4AA-13ND or equivalent
C1–C4—0.01-µF capacitor, polypropylene, 1%, see text
PC or perf board, wire solder, etc.
The following is available from Franklin J. Miller, 2100 Ward Dr., Henderson, NV 89015: Complete kit of parts for the T-Filter, $12. Kit includes drilled solder mask; solder-plated PC board; pre-matched resistors and capacitors; and all other board-mounted parts.

lator to the input of the filter, and the output of the filter to the input of the oscillator. Use one-conductor shielded cable for the connections, with the shield running between the ground inputs and outputs on all three pieces of equipment.

Set the audio oscillator for +18 dBm at a frequency of 100 Hz. If you are using a meter that reads true rms, set the output frequency to 1 kHz. Set R21 on the oscillator until the meter reads a voltage of 0.795 volts or lower. Please take your time to make this adjustment—it will be the standard for all future audio tests you make with the instrument.

The final step is to go back to R22 and readjust it as there is some interaction between the two settings. The most important measurement is the output voltage of 7.95 volts or +18 dBm. If the oscillator has a small amount of distortion (which you will see if you use a THD +N analyzer), don't worry too much about it; it should not effect most of the tests that we will be making.

Audio Testing

Testing audio gear almost always requires some sort of test fixture or some related devices to make the correct test. So our first step will be to take a look at the accessory items that you might want to construct. To get reliable and repeatable test results you need to be able to duplicate the setup at any time. The test fixtures described here make that easy to do. They may be an investment in time and money in the beginning, but over the long haul they will save you much more than you spend.

The first fixture you need is a load resistor to use when checking the output of a power amplifier. You need a simple terminating resistor for active line-level devices. The values are 600 ohms for professional equipment (use a 604-ohm, 1% resistor for that). For consumer type gear use a 10,000-ohm, 5% unit. For the speaker outputs, you'll need power resistors; use 8-ohm, 5% units rated at the same power as the amplifier. That could be anywhere from several watts to several hundred watts.

Up to 20 watts or so, that is not a problem, but what do you do for higher output ratings? The answer is to combine units in parallel and/or series as needed to get 8 ohms at whatever wattage. For example, combining two 8-ohm, 20-watt resistors in series, and placing them in parallel with two other 8-ohm, 20-watt resistors yields 8 ohms at 40 watts. Use non-inductive resistors where possible for this, though for larger amps you might find it more economical to use wire-wound units. EN

EQUIPMENT REPORTS

continued from page 18

that suffer from poor shielding. In our test, using the microwave did cause a few bursts of heavy interference (hum bars etc.) While that interference source can be controlled in a single-family home, there is potential for problems when used in an apartment/condo situation.

Applications

The obvious applications are in home audio/video set ups. In particular, the Wavecom Sr. is ideal for use with DSS, and can, in some instances, eliminate the need for, and cost of, a second receiver.

However, the unit can also find other uses. For instance, when used with a video camera, it is ideal for surveillance and monitoring situations. For example, it could be used to monitor a baby's room on any TV set in the house, or to monitor the front entrance in a home or office. Since up to four channels can be in operation at any one time, it can be effective in monitoring the goings-on throughout a small warehouse or plant. And none of those applications require costly wiring or special installation.

The RF-Link Wavecom Sr. costs $249.95; the Wavecom Jr. (without remote-control extender) costs $199.95. For more information, contact the manufacturer directly, or circle 15 on the Free Information Card. EN

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Wireless Color Surveillance System

American Innovations' WSS-300 Wireless Color Surveillance System is the solution for the person or business who needs to have their eyes in two places at once. It can be used as a child monitor, as a security system, or to monitor on-the-job performance. The WSS-300 has a range of up to 300 feet, and is capable of penetrating walls, floors or ceilings.

The Wireless Surveillance System is housed in a compact AM/FM cassette-radio (11-inches wide by 6-inches high, 3½ inches in diameter), incorporating both the camera and transmitter. (Due to camera placement, the cassette player can't operate.) With a super low sensitivity rating of 2 lux, as well as built-in backlight compensation, the high-resolution (380 lines) color camera and the FCC-approved transmitter deliver consistently sharp video images to the designated receiver. In addition, the state-of-the-art, circular-polarized directional transmitting and receiving antennas maximize the signal range and minimize interference.

The WSS-300 comes complete with a working AM/FM radio, the color camera, the transmitter, and a four channel FCC-approved receiver. Also included is the video cable to connect to your VCR or monitor, an A/B switch to select between receiver and cable/antenna reception, coax cable, power adapter to provide 12 VDC power to the receiver, and an easy-to-follow instruction book.

CIRCLE 20 ON FREE INFORMATION CARD

The WSS-300 Wireless Color Surveillance System has an introductory price of $895.

AMERICAN INNOVATIONS, INC.
119 Rockland Center
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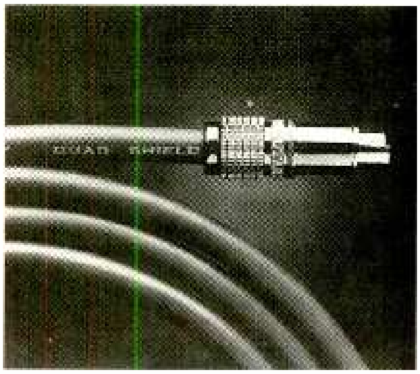
Nanuet, NY 10954
Tel: 914-735-6127
Fax: 914-735-3560
Web: http://www.spysitecom.

Quad-Shielded Super-Video Cable

Tributaries' Quad-Shielded SCV S Silver Series S-Video Cable is intended for use with high-quality Super-Video sources, such as DSS receivers, DVD players, laserdisc players and S-VHS VCRs. Even at distances over 20 feet, Tributaries' S-video cable with "quad shielding" delivers uncompromised signal transfer.

"Quad shielding" consists of *two* silver-plated center conductors, each with a dedicated aluminum/Mylar wrap and an oxygen-free, high-conductivity, copper-braided shield within a second aluminum/Mylar wrap and another shield. Heavy-duty, gold-plated brass "S" connectors, soldered with high-silver-content solder, further enhance signal integrity.

The SCV S is available in one to three meter lengths, as well as custom lengths. Suggested retail prices: $75 for one meter, $100 for two meters and $125 for three meters.



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Shortwave Receiver

The R.L. Drake Company's SW2 shortwave receiver is microprocessor controlled and has continuous coverage from 100 to 30,000 kHz, allowing the user to listen to AM-broadcast, amateur, citizen-band, and shortwave bands. Full AM and single-sideband operation give complete coverage of all world-band broadcasts. The SW2 cleans up fading

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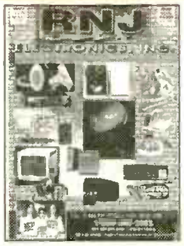

RNJ Electronics, Inc. New 1997 Catalog

RNJ Electronics, Inc., a distributor of electronic products since 1981, is now offering their new 1997 catalog. The catalog contains 136 pages of test equipment, TV and VCR repair parts, electronic kits, instructional videos, tools & soldering equipment, CCTV systems, commercial sound & intercom systems as well as parts and accessories. In addition the catalog also contains breadboarding aids, digital trainers, as well as A/V carts, screens and projectors. ***$2.00***

For a catalog call 1-800-645-5833.

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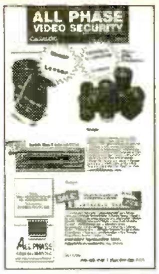

All Phase Video Security Inc.

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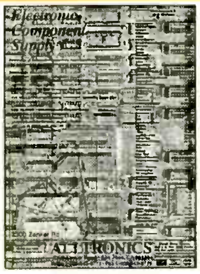

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Distributor of electronic components from franchised manufacturers and overstocked sources, operating over-the-counter service. Distributors for: American Antenna - antennas; American Hakko - soldering irons, desoldering systems; Amidon - toroids, baluns; Centurion - two-way antennas, batteries; Circuit Works - conductive IC pens for PC board repair; ICO-Rally - tubing, sleeving, insulation, terminals, cable ties; KLM - antennas; Larsen - antennas; LMB Heeger - metal cabinets, chassis boxes. ***$2.00***

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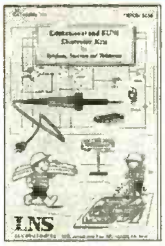

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Tired of the same old electronic projects? Then take a look at the latest catalog from LNS Technologies Inside you'll find exciting & educational kits including a solid state laser, a laser light show, an electromagnetic levitator, a secret voice disguiser, a hall-effect digital compass, a solid-state message recorder and many more high-tech items. Each kit comes with a drilled PC board, all necessary parts and easy to understand instructions. The kits are perfect for teachers, students or hobbyists and make great science projects. ***$1.00***

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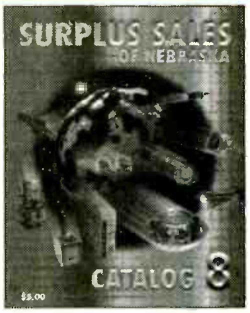

Surplus Sales of Nebraska "Hard-To-Find" Parts Catalog

Surplus Sales of Nebraska has released its latest catalog, Catalog 8. The catalog features Collins parts, vacuum capacitors and relays, high-voltage components, high power transmitter parts, rack cabinets, power supplies, test equipment and much more.... The catalog is priced at $5.00 in the US. A $5.00 rebate is offered on the first order from the catalog.

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Antique Radio Classified is antique radio's largest-circulation monthly magazine. A typical 100-page monthly issue contains articles and hundreds of classifieds for old radios, TVs, ham equipment, hi-fi, art deco and transistor radios, telegraph, books & more. We also offer price guides and books on repair and restoration and guides for the novice collector. Antique Radio Classified is your link to the world of collecting old radios. Sample: ***$4.00***

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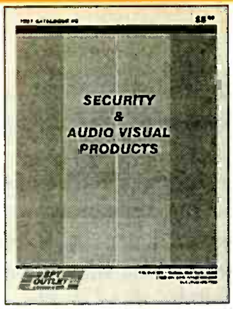

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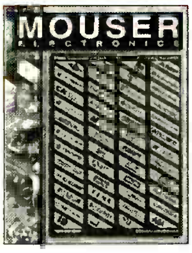

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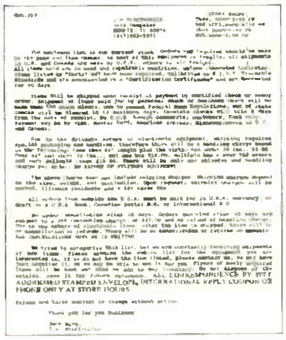

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signals by using selectable sideband synchronous detection. There are 100 programmable channel memories; 32 of them are preprogrammed for the most popular global broadcast stations such as the BBC, Monitor Radio, Radio Havana, Radio Moscow, and the Voice of America.

Tuning can be done either with a tuning knob, tuning buttons, or by direct numeric entry. All tuning controls are conveniently located on the front panel of the receiver, along with an adjustable RF-gain control and an extra-large LED display. The LED display shows both the receive frequency and meter band designation.

On the rear panel there are dual antenna input terminals, which provide for connection of either a coaxial 50-ohm feedline or a wire antenna to the receiver. The SW2's 12-volt capability, combined with an optional mount antenna, allows the receiver to be used in vehicles as well.

The SW2 shortwave receiver by Drake has a suggested retail price of $499. An optional infrared remote control can be purchased for an additional $49.

CIRCLE 22 ON FREE INFORMATION CARD

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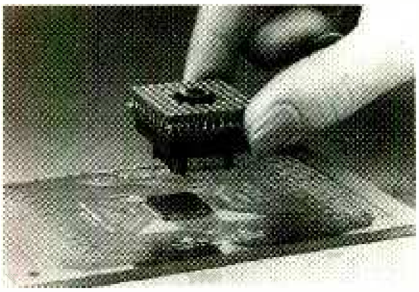
Low-Profile IC Test Clips

ITT Pomona's low-profile IC test clips make it easy to connect test instruments to the industry's latest high-density TQFP (thin quad flat package) and SQFP (small quad flat package) surface-mounted devices.

The 100-pin Model 6150, 144-pin Model 6151, and 176-pin Model 6152 test clips provide spring-loaded contacts spaced at 0.5mm to assure positive electrical contact with each pin tested. Mechanical fingers specifically designed to hold on to thin TQFP chips assure positive retention in both vertical and horizontal positions. The patented chip design allows the user to test an on-board, surface-mounted device while the host board is inserted into a standard-spaced computer or system slot. Signals can then be sampled during normal system operation. The board-level space requirements for each test clip are only about 2-mm greater than the space required for the chip itself.

The test clips are the first products available that allow reliable testing of state-of-the-art TQFP and SQFP devices used in PCMCIA cards, pagers, and portable computers. Their compact design facilitates testing on small, densely populated boards with a minimum of noise and cross-talk.

The Models 6150, 6151, and 6152 cost $385, $465, and $512, respectively.



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ITT POMONA ELECTRONICS
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Data-Acquisition Software

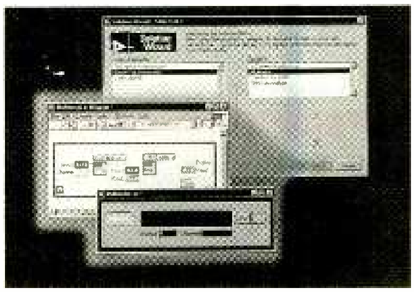
National Instrument's LabVIEW 4.1 data-acquisition (DAQ) and analysis software package is easier to use than previous versions. With the addition of DAQ Wizards on the Windows platforms, DAQ development is streamlined through automatic, point-and-click program generation. Users simply describe their measurement connections and LabVIEW generates a ready-to-run program that meets their specifications. It takes only a few minutes to generate programs in native LabVIEW "G" source code. Version 4.1 also adds an online tutorial for Windows users, automated links to important LabVIEW sites on the World Wide Web, and an Object Linking and Embedding (OLE) automation interface for automated report generation via HiQ for Windows 95/NT.

LabVIEW 4.1 will be available for Windows 3.1/95/NT PCs, Macintosh/Power Macintosh computers, Sun SPARCstations, and HP workstations, as well as Concurrent Computer real-time systems. Only the Windows platforms will have the new DAQ Wizards.

With the DAQ Solution Wizard, users describe their application through a series of dialog boxes. By selecting from a list of common options, such as analog input, digital I/O, file I/O, etc., users quickly build a recipe for their DAQ solution. When the user is finished describing the system, LabVIEW generates a ready-to-run application in its patented "G" programming environment, which users can further customize and enhance. LabVIEW 4.1 also offers the Solutions Gallery, a collection of virtual instruments—including an oscilloscope, a multimeter, a function generator, a data logger, a transducer measurement system, and a signal analyzer—for common applications.

The DAQ Channel Wizard allows the user to simply fill in the blanks to define the signal types, connections, and transducer equations. Users can then reference the channel name for the input signal throughout the applications, with all of the conversion processes performed transparently.

LabVIEW 4.1 is priced starting at $995; existing LabVIEW for Windows users can upgrade to Version 4.1 for $295. Mac, Sun, HP, and Concurrent users can upgrade for free.



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CRT Analyzer and Restorer

The CR7000 "BEAM-RITE" CRT Analyzer and Restorer from Sencore tests all CRTs, including computer monitors, video displays, televisions, projection

Continued on page 36

BY SAM GOLDWASSER

Troubleshooting and Repairing a Microwave Oven

THE PAST COUPLE OF TIMES WE HAVE EXPLORED THE WORKINGS OF A MICROWAVE OVEN AND SOME OF THE THINGS THAT CAN GO WRONG. NOW IT IS TIME TO ROLL UP OUR SLEEVES AND GET DOWN TO SOME PRACTICAL TROUBLESHOOTING. We will also look at some sources for the replacement parts you may need.

Testing the Oven

If cooking just seems to take longer than you think is normal, a quick check of the actual microwave-power available can eliminate unnecessary troubleshooting! Measuring the precise number of degrees a known quantity of water increases in temperature for a known time and power level is a very accurate test of the microwave power. A couple of minutes with a container of water and a thermometer will conclusively determine if your microwave oven is weak or you are just impatient.

The following procedure comes from a Litton microwave handbook: Fill a one liter (L) plastic container with cool water Measure the temperature of the container (in degrees C). Place the container in the microwave and heat on high for 1 minute. Measure the temperature of the water (again in degrees C). The oven power can then be found from: oven power = temperature rise in degrees C multiplied by 70. Note that a plastic container rather than a glass one is used to minimize the energy loss by conduction from the water to the container. Also, if the water is boiling when it comes out (100 degrees C) the test is invalid. Run the test again using colder water to start.

If there is any significant discrepancy between your measurements and the specified microwave power levels—say more than 10%—there may be a problem. Possible causes of low output power include a weak magnetron (likely if your oven has seen hard service over the last 15 years), intermittent connections (particularly to the magnetron filament), or a controller problem.

Before we get our hands inside an oven however, the following warning must be repeated:

WARNING! Microwave ovens are probably the most dangerous consumer appliance to service. They use high voltage—up to 5000 volts—at high current levels. Even with the power off, there is a high-voltage capacitor that can produce quite a kick. This capacitor must be discharged before touching anything in the microwave generator circuitry. If you have the slightest doubt about your ability to work safely, stop right here. A $150 microwave oven isn't worth your life!

Getting Inside

Note that in almost all cases opening the case of a microwave will void any warranty, at least in principle. However, you probably should return any unit still under warranty for service rather than attempting the following yourself.

The first step is to unplug the oven! Usually, the sheet metal cover over the top and sides is easily removed after unscrewing a bunch of Phillips-head sheet-metal screws. Most of these are on the back but a few may screw into the sides, and often they are not all the same! At least one of the screws will include a lockwasher to securely ground the cover to the case. Make note of any differences in screw types. It is important to get the same screws back into the same holes when you are done. Once all of the screws have been removed, the cover will then lift up and off. If it doesn't lift off easily, look for a screw you did not find the first time. Note how fingers on the cover interlock with the main cabinet—these are critical. They ensure against microwave leakage after reassembling the oven.

Discharge the high-voltage capacitor as described in the in the August 1997 installment of Service Clinic. This is very important and is the first step to perform immediately after removing the case from any microwave oven or any time you need to go near the internal wiring after it has been plugged in. Do not overlook this step—your life may depend on it!

A schematic showing all of the power-generation components is usually glued to the inside of the cover. A typical example of such a schematic is shown in Fig 1, which also appeared in last month's installment. How much of the controller circuitry is included varies, but is likely to

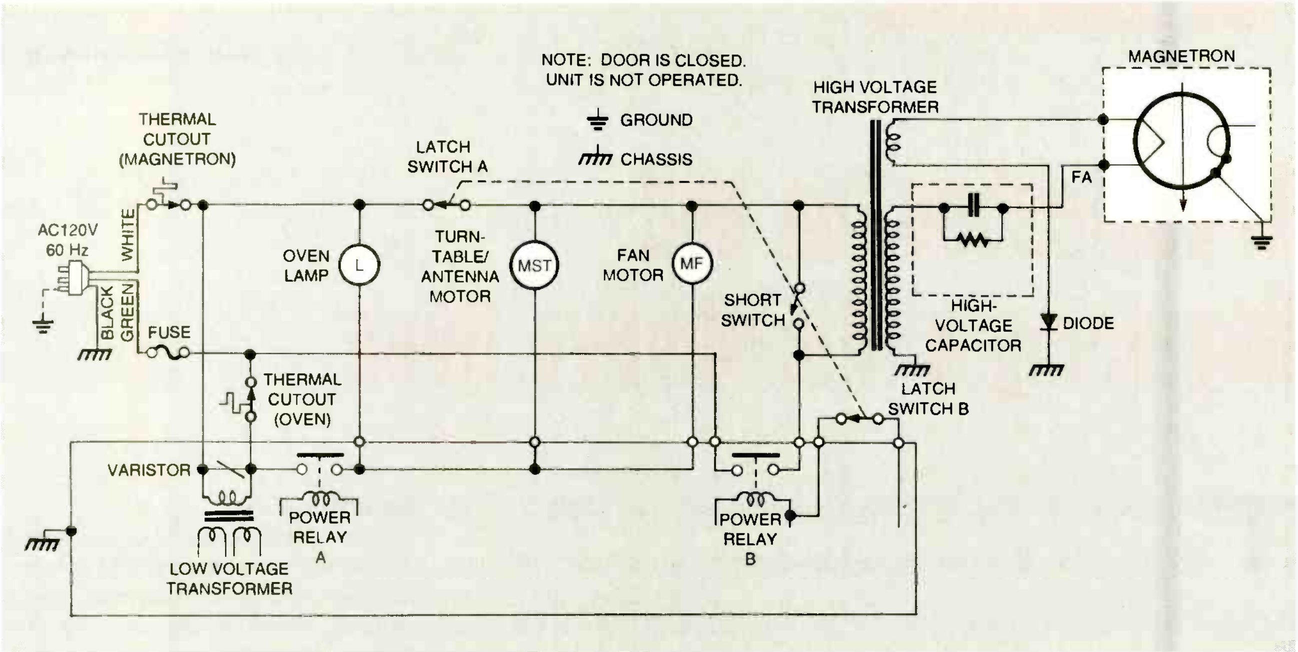


FIG. 1—HERE'S A TYPICAL MICROWAVE OVEN SCHEMATIC like the one likely to be found pasted inside the unit's cover; this schematic also appeared in last month's installment of this column.

be minimal. Fortunately, all the parts in a microwave can be easily replaced and most of the parts for the microwave generator are readily available from places like those mentioned later on in this article.

Later on, when the repair is complete, reassemble the oven in reverse order. Be sure that you do not pinch any wires when reinstalling the cover. Fortunately, the inside of a microwave is relatively wide open and that is not difficult to avoid. Make sure that all of the metal fingers around the front edge engage properly with the front-panel lip. That is critical to avoid microwave emissions should the waveguide or magnetron become damaged in any way. Confirm that the screws you removed go back in the proper locations, particularly the one that grounds the cover to the chassis.

Testing the Main Fuse

If the oven is dead, the main fuse is the place to start. Locate and remove it. Usually it is a 1 by 1¼ ABC ceramic type. Test it with an ohmmeter. It should read zero ohms. If it is blown, suspect problems with the interlock switches, high-voltage capacitor, or high-voltage wiring. If the fuse is good, but the oven makes a loud humming sound when you attempt to cook, suspect the magnetron or high-voltage diode. Sometimes the fuse is open for no good reason at all. A replacement fuse may be all that is needed. But check for other problems first; there is usually a reason why a fuse blows.

Interlock Switches

With the oven unplugged (and a new fuse installed if the original was blown), put an ohmmeter across the AC input just before the interlocks. Open and close the door slowly several times—there should be no significant change in resistance. If you spot any change at all, it should be no more than a few ohms. If your reading approaches zero while opening or closing the door, check the interlock switches and door alignment. (You may need to disconnect one side of the transformer primary since its resistance is a fraction of an ohm. Refer to the schematic pasted inside the cover.)

High-Voltage Components

WARNING: If you haven't already done so—and you should have—with power disconnected, discharge the high-voltage capacitor before going further!

If the oven passes the test for interlocks and door alignment, the Triac (if used) might be defective. There could also be a wire shorting to the chassis. However, the most likely problems are in the microwave generator. Use an ohmmeter to quickly determine if the capacitor, high-voltage diode, or magnetron are a dead short (look for an open magnetron filament too).

Testing the High Voltage Diode

If the high-voltage diode has failed, it can be either shorted or open. A shorted high-voltage diode is likely to cause a loud hum from the high-voltage transformer when a cook cycle is initiated. The main fuse will probably not blow.

An open high-voltage diode will result in AC instead of DC across the magnetron with a peak negative value (the only one that matters) about half of what it should be. The result will likely be little or no detectable heat but no other symptoms.

The resistance measured across the leads of the high-voltage diode should be greater than 10 megohms in at least one direction, when the diode is disconnected from the circuit. However, its forward-voltage drop will be too great (6 volts or more) for a DMM to test properly. The high-voltage diode can be tested with a DC power supply (even a wall adapter that delivers an output of at least 12 to 15 volts), a series resistor (to limit current), and your multimeter. This will determine proper behavior, at least at low voltages.

Figure 2 is the schematic of a simple high-voltage diode test set up. The voltage drop in the forward direction should be at least 6 volts with a few milliamps of current, but might sometimes be somewhat higher (8 volts or more) with a few hundred milliamps. If it is not shorted, it is fairly safe to assume, for now, that the diode is good.

Testing the High-Voltage Capacitor

A shorted high-voltage capacitor will blow the fuse instantly. An open high-voltage capacitor will result in no heat, but no other symptoms. The following assumes no internal rectifier or other circuitry with the exception of a bleeder resistor. Adjust procedures accordingly if your oven is different.

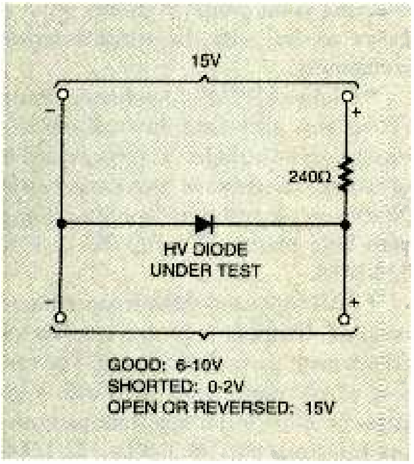


FIG. 2—TESTING A HV DIODE is difficult with a standard DMM so use this setup to accomplish the task.

The resistance measured across the terminals of the high-voltage capacitor should be very high—several megohms for a bleeder resistor. If it is less than 1 megohm, the capacitor is definitely shorted. Unfortunately, a high resistance does not prove that the capacitor is actually functional—it just shows that it is not shorted with no voltage across it. If you have a capacitance meter, check it for proper value (should be printed on the case), but even that does not prove that it will not short when full voltage is applied. Substitution is the only sure test.

Testing the Magnetron

Being the heart of a microwave oven, the magnetron is likely to be an expensive replacement part. Therefore, it would be nice to determine reliably if your magnetron is indeed defective. A magnetron with an open filament will result in no heat, but no other symptoms. The bad connection might be internal (in which case the magnetron will need to be replaced) or external at the filament terminals (which might be repairable).

A magnetron with a short between the filament/cathode and anode is likely to cause a loud hum from the high-voltage transformer and/or magnetron when the cook cycle is initiated, but the main fuse will probably not blow. A magnetron with other faults might cause a variety of symptoms including erratic or low output power or intermittent operation. Unfortunately, there is no totally definitive way to determine if a magnetron is good without actually powering it under operating conditions. However, the following tests will catch most problems:

- You should read infinite resistance between the filament connections to the case, and a fraction of an ohm between the filament terminals with the wiring disconnected from the magnetron. While measuring resistance from filament to chassis, gently tap the magnetron to determine if there is an intermittent short. The most common magnetron failure mode is the filament shorted to the case but that might only show up under power.
- Evidence of arcing (visible blackening around ventilation holes in base or a burnt odor) usually indicates a bad magnetron.
- Melting or other damage to the antenna cover (bull-nose or bullet) might be the result of arcing due to problems in the oven cavity or waveguide (perhaps operating with nothing in the oven) or a defective magnetron. If any other problems are corrected, the bull-nose piece itself can be pulled off and replaced if you can locate one. (However, the bull-nose is only visible after removing the magnetron from the waveguide or by using a dental mirror through the microwave window from inside the oven cavity.)

Replacement Magnetrons

Both original and generic replacement magnetrons are available. Going direct to the oven manufacturer will guarantee a compatible magnetron, but is by far the most expensive option. For a typical oven, such a replacement could be more than half the cost of a similar new oven. In some cases (like Sears), you may need to convince their service department that you are qualified to be poking around inside one of their appliances before they will consider selling one to you, In some cases, original magnetrons may also be available from parts suppliers—like MCM Electronics—at somewhat less ridiculous prices. They will be identified as original or genuine along with the manufacturer and their part number.

Generic replacement magnetrons are available for the majority of microwave ovens. These will almost certainly be much less expensive than original parts. Essentially, there is only one type of actual device (at least for any similar power range). The differences are mostly mechanical. However, quality may vary. In some cases, the generic variety may actually be better than the original. See the parts sources listed near the end of this article for details.

Testing the High-Voltage Transformer

A shorted winding or short between a winding and the core/chassis in the high-voltage transformer might result in a blown fuse, loud hum, overheating, audible arcing, a burnt aroma, or simply no heat. An open winding is likely to cause no heat, but no other symptoms. Disconnect terminals as required to make the following tests:

- The resistance of the primary should be 0.1 to 0.5 ohms (0.2 ohms is typical).
- The resistance of the filament winding is likely to be so low that it will not be detectable with your multimeter. The only measurement you can easily make is to be sure that there is no short to the chassis.
- Typical resistance readings for the transformer's high-voltage secondary are in the 25- to 150-ohm range (depending on the power rating of the oven) at the high-voltage connection to chassis. An open would be an obvious failure. However, a winding-to-winding short likely would not cause enough of a resistance change to be detected.

Testing the high-voltage transformer more fully is difficult without fancy equipment. Only major short circuits can be identified in the transformer with an ohmmeter, since the nominal resistance of the windings is unknown. However, open windings (not very likely) can be located and other faults can be identified by the process of elimination.

Wiring and Connections

Inspect the wiring—especially between the magnetron, high-voltage transformer, and other components of the high-voltage circuits—for signs of arcing and excessive heating or burning. Arcing may be the result of the wire scraping against a sharp sheet-metal edge due to poor placement and or vibration. A bit of electrical tape may be all that is needed to effect a repair.

Since the magnetron filament in particular uses high current, any resistance at the crimp-on connections will result in heating, weakening of the lug, more heating, and eventual failure or erratic operation. Those connections should not be loose—you should have to work at removing them. However, note that some lugs are of the locking variety and require that you push a little tab before you can release them. Check for loose, burnt, or deteriorated lugs in the filament circuit (not just the magnetron). It may be possible to repair those if they are not too far gone (*i.e.*, vaporized).

Thermal Protectors and Fuses

There are two types of devices that may be in your oven that you need to know about. Thermal protectors are thermostats that open a set of high-current contacts at a preset temperature. They should reset when they cool off. However, like a relay or switch, the contacts sometimes deteriorate.

Thermal fuses will open at a preset temperature but do not reset. They blow and need to be replaced. At room temperature, both types should read as a dead short with an ohmmeter (disconnect one terminal as there might be low-resistance components or wiring that might otherwise confuse your readings). Replacements are available. You must match both the temperature and current ratings. If you suspect a bad thermal protector in the high-voltage transformer primary, clip a 100-watt light bulb or AC voltmeter across it and operate the oven. If the thermal protector is functioning properly, there should never be any voltage across its terminals unless there is actual overheating.

The Triac or Power Relay

Your oven may use either a Triac or relay (or conceivably a combination of both) to control power to the microwave generator. In rare instances, there may even be a relay on the high-voltage side as well. A Triac could fail in a variety of ways. A shorted Triac would result in the oven coming on as soon as the door is closed. It might also cause the power level to always be on high no matter what the touchpad setting.

An open Triac, or one that didn't respond to the gate, would result in no heat and possibly other things like the fan and turntable not working as well. A Triac that didn't turn off would result in the parts of the oven continuing to run even after the timer counted to zero. A Triac that had one half shorted would result in a blown fuse due to it acting as a rectifier pumping DC through the high-voltage transformer. A Triac where one half doesn't properly turn off would result in the main fuse blowing when the cook cycle completed.

One quick way to test a Triac is to measure the resistance across the MT1 and MT2 terminals (the power connections) with an ohmmeter. If good, you should read a high resistance. A reading of a few ohms means a bad (shorted) Triac. But since Triacs can fail in other—possibly peculiar—ways other than shorting, substitution or bypassing may be necessary to rule out all possibilities. If a Triac is the cause of your problems, replacements are very easy to find and substitutions are straightforward.

A defective relay can result in a variety of symptoms. A relay with its contacts welded (stuck) closed would result in the oven coming on as soon as the door is closed or the power level being high no matter what the touchpad setting. A relay that doesn't close (due to defective contacts or a bad coil) would result in no heat and possibly other things like the fan and turntable not working. If the relay is totally inoperative, test for voltage to the coil. If the voltage is correct, the relay may have an open coil. If the voltage is low or zero, the coil may be shorted or the driving circuit may be defective.

If the relay makes a normal switching sound, but does not correctly control its output connections, the contacts may be corroded, dirty, worn, welded closed, binding, or there may be other mechanical problems.

Obtaining Replacement Parts

A local appliance store may have common parts such as oven light bulbs and fuses. For anything like an interlock switch or magnetron, you will probably have to go to a national distributor. The following are good sources for all kinds of consumer-electronics replacement parts, including common microwave-oven parts:

- MCM Electronics (VCR parts, Japanese semiconductors, tools, test equipment, audio, consumer electronics including microwave oven parts and electric range elements, etc.) Tel: 1-800-543-4330; Fax: 1-513-434-6959.
- Dalbani (Excellent Japanese semiconductor source, VCR parts, other consumer-electronics parts, car stereo, CATV.) Tel: 1-800-325-2264; Fax: 1-305-594-6588.
- Premium Parts (Very complete VCR parts, some tools, adapter cables, other replacement parts.) Tel: 1-800-558-9572; Fax: 1-800-887-2727.

The following suppliers have Web sites with on-line catalogs and list a very extensive selection of microwave-oven parts. There is a chance that the first two may not want to sell to the general public. However, it is definitely worth checking as the public Web sites imply a desire to deal with the entire Internet community.

- Global/MPI/All Appliance Parts (Their web site—http://www.allapplianceparts.com—includes a very extensive selection of microwave oven parts; nearly 50 different magnetrons are listed along with little photos of each!) Tel: 1-800-325-8488.
- AMI (Appliance Maintenance International. Distributor of major appliance replacement parts. Extensive on-line catalog of microwave-oven parts with Web pages for other major-appliance parts under construction.) Tel: 1-800- 522-1264; Fax: 1-800-442-3601; e-mail: microwav@netins.net; Web: http://www.netins.net/showcase/microwav.
- Electronix, Corporation (Magnetrons, interlock switches, lamps, glass trays, diodes, thermal fuses, couplers, latches, rivets, stirrers, fans, waveguides, and more.) Web: http://www. electronix. com/

Wrap Up

You are now "experts" at microwave oven repair. Don't believe me? OK, you are wise. However, with the information given in this and the previous two installments of Service Clinic, and what can be found at the Repairfaq (see below) and Microtech (http://www.yup.com/microtech) Web sites, you should be able to deal with most common problems. Just think logically and above all else, heed the safety guidelines.

For a more in-depth treatment, there is at least one comprehensive book that might be available in your local public library: *Microwave Oven Repair*, 2nd Edition, by Homer L. Davidson, TAB Books, a division of McGraw Hill, Inc., 1991, Blue Ridge Summit, PA 17294-0850.

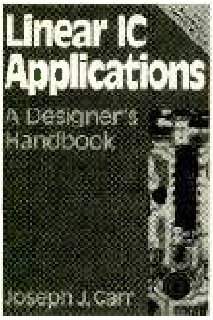
That's all for now. Until next time, if you have any specific questions, you can contact me directly at sams@stdavids.picker.com. For general information on electronics troubleshooting and repair, you can visit my Web site at http://www.repairfaq. org. EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Linear IC Applications: A Designer's Handbook

by Joseph J. Carr
Butterworth-Heinemann
225 Wildwood Avenue
P.O. Box 4500
Woburn, MA 01801-2041
Tel: 617-928-2500
Fax: 617-933-6333
$47.95



CIRCLE 338 ON FREE INFORMATION CARD

A fiction voiced by many observers of the electronics world is that analog electronics, the domain of the linear IC, is dead, and digital electronics is taking over. It is true that digital electronics is growing rapidly and has already taken over many functions previously performed in analog circuits. However, that doesn't mean that analog electronics is ready to die. There are still jobs that are either best done by analog circuits or where they are more cost-effective. In fact, demand for analog electronics is increasing and there is a worldwide shortage of skilled personnel.

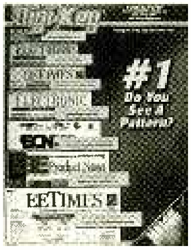
This book addresses that shortfall and equips the reader to apply linear ICs in a wide range of settings, and is filled with practical applications of linear IC circuits, mostly based on op-amps. Designing circuits for applications and design principles are covered thoroughly. But more than that, the principles of design for each class of circuit are transferable to other projects that are similar in function. Aimed at electronics engineers, the handbook prepares them to apply linear ICs anywhere.

Each of the ten chapters is organized in an easy-to-learn manner, with objectives and a pre-quiz; followed by explanations of different circuits, design problems, and solutions, with examples and illustrations; and ending with a summary, a recap, student exercises, and problems. Subjects included are: nonlinear applications, signal-processing circuits, measurement and instrumentation circuits, integrated circuit timers, IC data-conversion circuits, audio applications, communications applications, analog multipliers and dividers, active-filter circuits, and troubleshooting discrete and IC solid-state circuits.

Free supplemental software is available on the Butterworth-Heinemann Web site.

Catalog #974Q

Digi-Key
701 Brooks Avenue South
Thief River Falls, MN 56701-0677
Tel: 1-800-344-4539
Fax: 218-681-3380
Web: www.digikey.com
Free



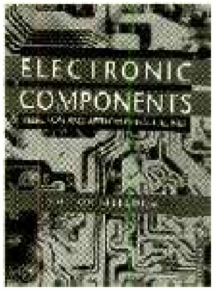
CIRCLE 339 ON FREE INFORMATION CARD

The latest catalog from Digi-Key contains 480 pages filled with tools and parts for electronics hobbyists and professionals. Products are grouped into fifteen categories: connectors, cable assemblies, and IC sockets; semiconductors, ICs, transistors, diodes, and rectifiers; crystals and oscillators; inductors, coils, and filters; capacitors; audio products; resistors, potentiometers, thermistors, and ZNRs; switches; wire; tools, solder, and hardware; fuses; fans; batteries; transformers, power supplies and test equipment; and optoelectronics, LEDs, LCDs, lasers, and displays.

Many major manufacturers' products are represented. This catalog features many new products, such as logic ICs from Toshiba, flash memory and EPROMS from Advanced Micro Designs, surface-mount inductors from Panasonic, digital panel meters from Jewell, and 7-segment LED displays from Lumex.

Electronic Components Selection and Application Guidelines

by Victor Meeldijk
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 800-225-5945
Web: http://www/wiley.com
$95



CIRCLE 340 ON FREE INFORMATION CARD

Aimed at electronics engineers and technicians, sales staff, marketing personnel, and other electronics professionals, this source book incorporates a vast amount of current information from thousands of catalogs, reference books, textbooks, newsletters, trade papers, and journals. The information is organized logically and cross-referenced to provide easy access to crucial component specifications and instructions. Clear, direct presentations make even complex technical information comprehensible for non-technical professionals as well as for those with electronics backgrounds.

The book helps users select the best component for any application. It covers the entire spectrum of electronic components in use today. The book explores the latest innovations and trends in the field, and covers all aspects of component design and application. .It helps electronics professionals understand the

Continued on page 40

BY JEFF HOLTZMAN

The Internet, Java, and Hype-Aplenty

VIEW THIS AS THERAPY. I'M IN A BAD MOOD (;-)). I'M REALLY TIRED OF . . . CERTAIN THINGS. I'M GOING TO TELL YOU WHAT BUGS ME (COMPUTER-WISE, OF COURSE). THEN YOU CAN TELL ME WHAT BUGS YOU. I'LL COMPILE A LIST AND PUBLISH IT here. Then we'll all feel better. So, to get the ball rolling, ... the two at the top of my list are Java and the Internet. As you might suspect, it's not the things themselves that bug me, but the hype surrounding them. Let's take 'em one at a time.

The Internet

The Internet bugs me because during the past two years, society has transformed it from a nice quiet private little postal and information service for geeks and nerds into a huge, crowded, noisy, over-commercialized shopping mall cluttered with the kinds of people I would never have anything to do with in "real" life. O give me a home....

Why is that? An analogy occurred to me. The computer has swallowed everything it has touched, for example, digital typography, audio and video processing (still underway), and corporate secretarial pools. Maybe it is now the computer itself that is begin subsumed within a larger revolution.

A related aspect is loss of innovation. There is precious little innovation involved in anything to do with the Internet. Experiencing life through a browser may seem innovative to some, but I find the paradigm simple-minded, and the implementation atrocious. What passes for innovation—HTML, spinning globes, click-and-go, so-called electronic commerce (EC)—to me resemble warmed up leftovers more than a hearty meal for a grownup.

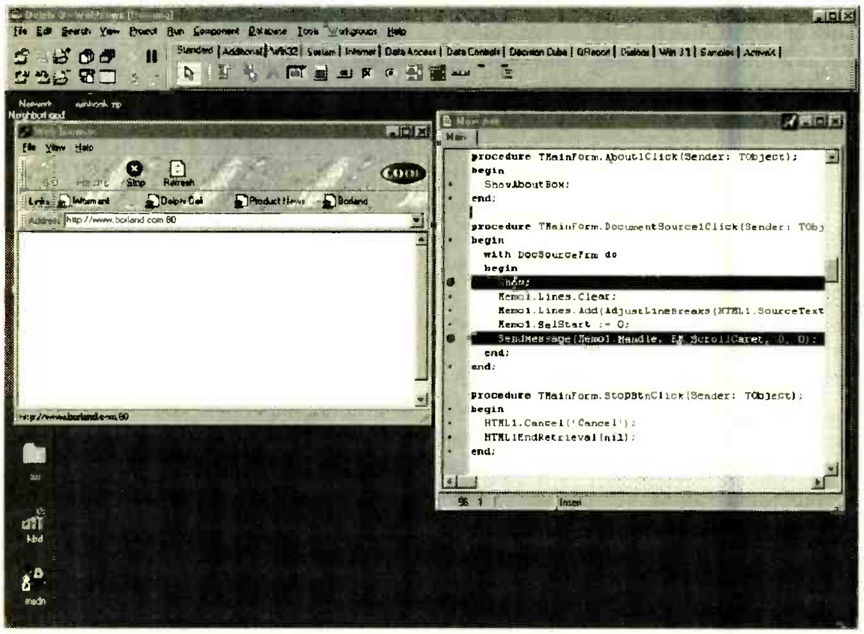
Actually, that's not true. EC is not leftovers; it's the driving force behind most of what's happening on the Internet today. Don't get me wrong. Having access to solid information, be it tech support, computer science, or anything in between, is great. But blatant commercialism and greed are clogging the airwaves and polluting the paradigm.

The latest instance of this is so-called push technology, which is being discussed everywhere from trade journals to Time magazine. Push is a means for vendors to shove commercial advertising down our throats via the browser paradigm. We already have major bandwidth problems. Now they want to start running sewage through the supply lines. What's wrong with this picture?

OK; that's enough for now. Let's turn to Rant Number Two.

Java

Java is a programming language based on C++, but without some of the dangerous features of the latter, primarily pointers and dynamic memory management. Java is going to change the world, according to the hucksters. Sun Microsystems ("the network is the computer") promises "write once, run anywhere," but recent



DELPHI 3.0 IS FASTER, more powerful, and easier to use than any other rapid-application development system, but can it save Borland?

reports indicate that even the initial implementations of the Java Virtual Machine (the thing that makes Java programs platform independent) show compatibility problems, not to mention wide disparities in performance.

Personally, I would be surprised if those platform-specific discrepancies don't increase as JVM vendors (Microsoft, IBM, NetScape, etc.) tweak the code to enhance performance or provide special capabilities. Microsoft has unabashedly and overtly stated its intention to do just that. It is making the Win32 API available to Java developers. Said developers will then wittingly or otherwise start to take advantage of said platform-specific APIs. The result is that pretty soon Windows Java programs won't run anywhere else.

Then, as long as MS owns those programmers—*i.e.*, sells them the tools—it doesn't care what language they code in. And coincidentally enough (or, maybe not), the company is working hard at integrating all its development tools, from C/C++ to Basic to Java, into a single development environment. Sure, you can probably write "pure" Java programs in Developer's Studio, but will you be able to resist the temptation to enhance performance or capabilities by dropping into native APIs?

Meanwhile, all those budding Java developers are busy producing some pretty compelling applications. Let's see, Corel Corp., is rewriting WordPerfect and related apps in Java. Now there's a compelling activity, one bound to turn the tide against Microsoft Office. Then there are all those wonderful applets running in our browsers presenting scrolling headlines, spinning globes, and so on. Oh, and every computer game ever written is being ported to Java. Yes sirree, I always wanted to play Tetris in my browser, and no thanks, I don't want to play it if it happens to be written in C or Delphi. I only want to play games written in Java.

Huh? I don't think so. The vast majority of people know nothing and could care less about the language the programs they use are written in. Do I care about the brand of wrench used to tighten the lug nuts on my car? Noooo!

The Java "standard" has been under Sun's control from the beginning. The company is making moves to gradually release chunks of it to impartial international-standards organizations. But Sun still wants to maintain overall evolutionary control. No one ever accused Microsoft of employing tactics like that. No sir, not Microsoft; and not Sun either—right?

I read a comment recently in which someone stated that the biggest benefit Java may bring is to introduce object-oriented programming to the mainstream of programmers. That truly would be a benefit, but doesn't that thereby relegate Java to the status of a teaching language, much like Pascal? Never mind the fact that there are more than 600,000 Delphi/Pascal programmers out there, including yours truly, producing real-world applications to solve real-world problems. So I think that Java may catch on in that sense, but that it will never attain the status the hypesters would have us believe.

Is learning Java a good career move? I wouldn't suggest investing everything you've got (either financially or emotionally) into Java. But once you get past the trivial stuff, Java, Delphi, and C++ are so similar that a thorough grounding in one will make learning another relatively quick. Java may be getting the headlines, but for now, C/C++ is what appears in the classifieds.

Small(er) Rants

One thing I really do like about NT 4.0 is the Task Manager (TM). You can view it by right clicking the taskbar. TM displays summary information about the applications and processes currently running. It also provides graphs and numeric indicators of memory and CPU utilization. You can configure TM to display an iconic version of the CPU utilization chart in the taskbar. That way you can keep tabs on how busy your system thinks it is.

It is instructive to watch that graph during various types of operations, such as modem downloads, LAN-based file copies, and simply running application programs. It is especially interesting to watch the graphs associated with certain application programs, for example, Microsoft Visual SourceSafe 4.0, and Microsoft Access version 7.0. Loading either program pegs the meter at 100%, even in an idle state.

RESOURCES

Delphi 3.0
Borland Intl., Inc.
100 Borland Way
P.O. Box 660001
Scotts Valley, CA 95067-0001
Tel: 800-233-2444
Internet: www.borland.com.

Delphi 3.0

Speaking of Delphi, Borland has just released version 3, and it is a major upgrade.

A new (to Delphi) technology called Packages allow applications and run-time libraries to be segmented more intelligently. Under prior versions, a simple "Hello world" application took up on the order of 200K of memory. Now such a program can be compiled in 10K. Not that many people really care about efficiency anymore; but Internet downloads of ActiveX controls can happen at an acceptable rate using Packages.

And speaking of ActiveX, Delphi 3 now fully supports the underlying architecture, COM (Component Object Model). COM is a serious attempt by Microsoft to deploy objects that can communicate across language boundaries (*e.g.*, Delphi to C++), process boundaries (MyApp to YourApp running on the same machine), and, using Distributed COM (DCOM), machine boundaries (MyApp on my machine to YourApp running on your machine), while also providing a robust means of component versioning and evolution. COM/DCOM does not yet provide much in the way of cross-platform support, but Microsoft has enlisted third parties to aid in ports to a variety of mainframe and UNIX environments.

That means Delphi can create ActiveX controls for decorating Web pages (so there, Java!). It also means that Delphi can create complex database and manufacturing systems that distribute a variety of processes across multiple machines. For example, I am in the final stages of a custom publishing system written in Delphi that literally distributes custom database, "manufacturing," and management/control modules across an NT 4.0 network. The manufacturing module uses a proprietary scripting language to build up high-level page descriptions, which are then compiled into PostScript and fed to a queue manager, and eventually to a high-speed tabloid-format color laser printer.

Delphi 3 includes a fancy code editor, like that in the latest release of Visual Basic (VB), that provides context-sensitive syntax help for Object Pascal, Windows API calls, and even your own routines. VB supports only internal syntax assistance.

There are tons of smaller new features, including more and better Internet components (oh joy), and more and better components for creating apps that look like Microsoft apps (oh joy). There is also an amazing device Borland calls a "decision cube" that allows you to embed an extremely powerful cross-tab report generator (with graphing) into your apps and dynamically establish query parameters, perform roll-ups and drill-downs, and so forth.

Although not quite as fast as C/C++, the code produced by Delphi runs like lightning in comparison with other environments like Visual Basic (despite recent Microsoft's claims to the contrary). And the new package technology blows VB's run-time engine out of the water in terms of storage and download efficiency.

Delphi is fully object oriented, supports pointers and dynamic memory allocation, and can call (and be the object of any callback of) any Win32 API. Delphi can build console-mode apps, but they run only under Win32 (*i.e.*, a "DOS box"). Borland has basically frozen development on the 16-bit version, which is included with the 32-bit versions. Delphi has its own component architecture, called VCL, but Delphi 3 can compile just about any VCL control into an ActiveX control with little or no recoding. Delphi also has strong interoperability with Borland's C++ Builder, which more or less puts a C++ engine inside the Delphi IDE.

I have spent the better part of the past year working in Delphi, and I have extremely ambiguous feelings about it. On one hand, I love Pascal as a language; it is by far the most elegant computer language I have ever used. Delphi's IDE (Integrated Development Environment) has a slick look and feel that is unmatched by any in any language I have ever used. The new version supports debugging DLLs directly under the IDE.

On the other hand, Borland has experienced deep troubles the past few years, and is not out of the fire yet. Late last year, Microsoft managed to lure the chief Delphi architect, who had been with the company for more than a decade. Since then, there has been a steady brain drain. In fact, Borland has taken Microsoft to court over what it calls Microsoft's anti-competitive practices in this area.

When Delphi first came out about two years ago, there was little interest in it in my part of the country. Interest gradually grew to the point where finding work was easy. But interest has definitely been on the wane the past few months, at least prior to the introduction of Delphi 3. We'll see if that makes any difference.

Otherwise, and I hate to say it, Visual J++ is looking more and more appealing. Let me know what bugs you; contact me via e-mail at jkh@acm.org. EN

NEW PRODUCTS

continued from page 28

TVs, and oscilloscopes. The CRT tester's full dynamic range allows for the testing of older CRTs as well as the new models. Simply connecting one of the six supplied adapters allows the user to test virtually all the new CRTs without resetting setup switches. It also tests all three guns of color CRTs and displays the results simultaneously with interpretation-free "Good/Bad" results.

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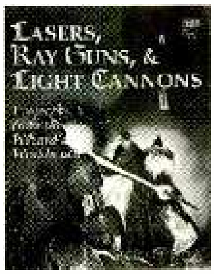

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This 413-page paperback book is geared to the hobbyist, either expert- or student-level, and shows how to build over 88 laser and optics projects using inexpensive, easy-to-obtain components. Those projects include building a laser ray gun, putting on a professional light show, creating holograms, as well as performing dozens of experiments. Other construction projects can detect intruders around a perimeter, measure precisely the speed of light, perform laser "snooping," transmit data with lasers, and carry your voice over a beam of light.

The projects are presented with step-by-step simple instructions, and many clear illustrations accompany the instructions. The complete and field-tested plans include many projects that are suitable for science fairs.

The book is organized into 25 independent modules. There is scientific history and theory, as well as instructions for the projects themselves, both basic and advanced. In addition, there are chapters on tools for laser experimentation, buying laser parts, and computer-controlled laser projects. Appendixes guide you to other sources and suggested reading, and the book has a complete index and glossary.

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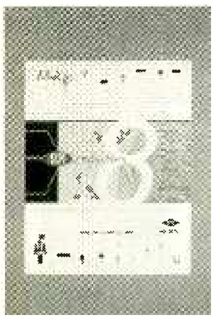
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The entire catalog can be accessed directly on NTE's Web site, noted above.

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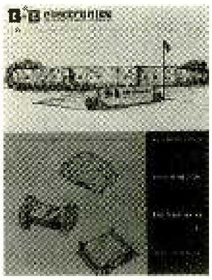
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This 40-page catalog shows solutions to computer serial-port connection problems. Port-mounted Interface Converters allow you to connect incompatible interfaces and communicate at distances of up to 4000 feet. New product highlights include a 5-port smart switch, which may be daisy-chained to connect up to 17 devices to one serial port; a port reverser; signal conditioning modules; pH electrodes; a variety of bridge-type outputs; optoisolators; surge protectors; and security devices. Also featured are digital multimeters designed to read low-voltage communications-line signals, some with built-in memory and the ability to download to a PC. Three new PCMCIA Cards for parallel, serial and multiport applications are shown.

The entire catalog can also be accessed directly on the Web site noted above. EN

BUILD THE MARINELIFE ACOUSTIC SENSOR

Eavesdrop on the sounds of the deep with this simple, handheld device!

BILL GREEN

In truth, the silent deep is far from silent—the raucous deep would be a better name. Most of us are aware that marine mammals make sounds or noise for communication, searching for food, self-defense, or other reasons. Shrimp, for example, make a clicking or popping sound that might be caused by the movement of the parts of their shells, legs, or jaws. A certain breed of fish, called a Drum, makes a sound very much like, well, a drum.

Man-made devices, such as boat motors and ship engines add to the noise of the marine environment. In fact, the oceans are so filled with sounds and noises, it can be difficult (or impossible) to determine what the various noises are. A safe assumption is that any marine life that is much larger than a microscopic organism will make noise.

A swimmer or diver in the ocean will not hear much in the way of sound, except perhaps during a close encounter with a medium or large marine mammal such as a whale or dolphin. The sound is there, but we can't hear much of it because our ears are designed to work in air rather than water.

Most of us have heard of the marine-sonar and passive-listening devices that were developed before World War II. Their use was, and is, essential in both submarine and anti-submarine warfare. It is known that schools of fish and marine mammals would often foul up those sonar operations. We can use that fact to listen to, or eavesdrop, on the denizens of the deep.

The MarineLife Acoustic Sensor project described here is an electromechanical listening device that works on the same principle as the passive sonar devices in submarines. It has the same basic components: an acoustic transducer, a high-gain amplifier, and connections for headphones, speakers, or a tape recorder. It is small, lightweight, compact, and battery operated. Those features make it easy to use the MarineLife Acoustic Sensor in a large boat, a small boat, a rowboat, or even a canoe. You can even use it off a pier or a bridge.

About The System. The MarineLife Acoustic Sensor is built around an LM386 high-gain audio amplifier. That IC is able to drive a 4-, 8-, or 16-ohm speaker or headphones with at least 250 mW of power.

The tricky part of the system is the receiving transducer. It will be immersed in a hostile saltwater environment, so it must be waterproof. A regular microphone could be made waterproof, but that would interfere with the microphone's sensitivity. Any transducer for listening to underwater sounds must be quite sensitive, so a waterproofed microphone would be useless for our needs.

However, a device exists that is almost perfect for the job at hand. It is a piezo-electric transducer, which is usually used to make sound. It can also act as a sound receiver. It consists of a thin, round, brass disc, a little under 1½-inches in diameter. Bonded to the surface of

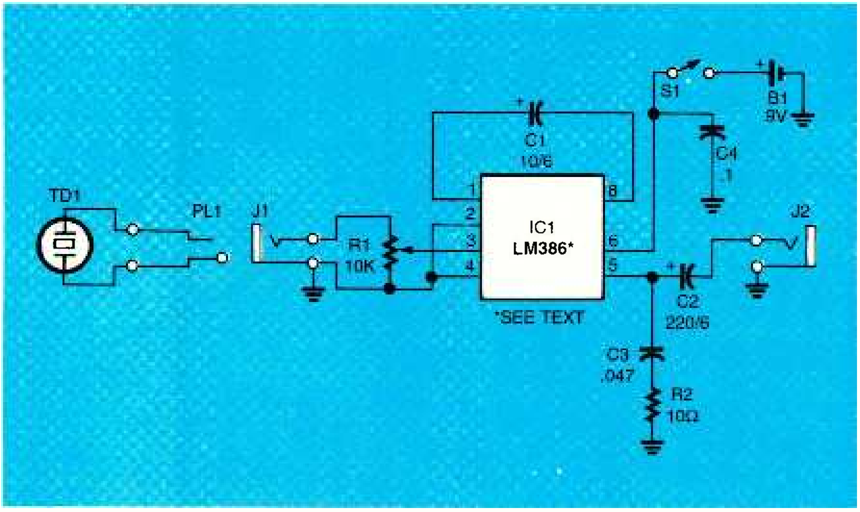


Fig. 1. The MarineLife Acoustic Sensor is a simple headphone amplifier built around an LM386 amplifier chip. A piezo-ceramic transducer picks up sound from the water. There are two different versions of the LM386, depending on what voltage battery you will be using.

PARTS LIST FOR THE MARINELIFE ACOUSTIC SENSOR

Capacitors

C1—10-µF, 6-WVDC, electrolytic
C2—220-µF, 6-WVDC, electrolytic
C3—0.047-µF, ceramic-disc
C4—0.1-µF, metal-film

Resistors

R1—10,000-ohm potentiometer (integral with S1—see text)
R2—10-ohm, ¼-watt, 5% carbon-film

Additional Parts and Materials

IC1—LM386N-1 or LM386N-3 audio amplifier, integrated circuit (see text)
B1—6- or 9-volt battery
J1, J2—Mini stereo or mono phone jack
S1—Single-pole, single-throw switch (integral with R1—see text)
TD1—Piezo-ceramic disc, see text
Battery clip, case (RadioShack 270-211 or similar), label, knob, PC board, potting compound, wire, solder, hardware, etc.

the brass disc is a thin ceramic wafer of barium titanate. The wafer is coated with a thin layer of silver that forms a second contact. Like a quartz crystal, the barium titanate will physically vibrate when an AC signal is applied to it. It will also generate a voltage when pressure is applied to it—just like a microphone. That piezo-electric effect is perfect for a waterproof acoustic sensor. With a cable attached to the two plates (the brass and the silver), we can amplify the generated voltage and hear the vibrations that are striking the sensor. Encapsulating the sensor with an insulating and waterproofing material will ressult in a marine acoustical transducer. It will be very sensitive, waterproof, and able to withstand the harsh saltwater environment of the ocean.

About The Circuit. The schematic diagram in Fig. 1 shows that the heart of the circuit is, as previously mentioned, IC1, an LM386 audio-amplifier IC. The inverting input is grounded and the input signal from J1 is fed to the non-inverting input through volume control R1. The overall gain of IC1 is set by C1. The output, pin 5, is AC-coupled to J2 by C2. The output of IC1 is bypassed to ground with C3 and R2. That will prevent radio-frequency interference from affecting the circuit. Additional protection from AC signals is provided by C4.

Construction. The circuit for the MarineLife Acoustic Sensor can be built on either a perfboard or a printed-circuit board. If you choose to use the PC board approach, a foil pattern has been provided. Should you choose to use the foil pattern, the parts-placement diagram in Fig. 2 should be followed for the correct component location and wiring.

The usual precautions for handling semiconductors should be followed during assembly. Be sure to observe the polarity of the electrolytic capacitors when inserting them into the PC board. If those components are installed backwards, the circuit will be destroyed and the capacitors might explode!

There are two versions of the LM386 that can be used in the MarineLife Acoustic Sensor. The LM386N-1 is rated for a 250-mW output with a 6-volt supply, while the LM386N-3 can put out 500 mW at 9 volts. The LM386N-1 will draw

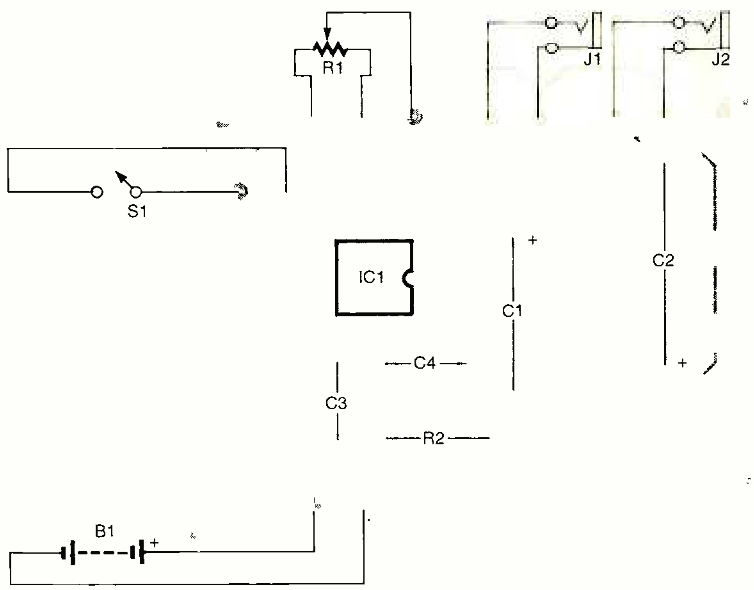


Fig. 2. Use this parts-placement diagram if you are going to use the foil pattern included here.

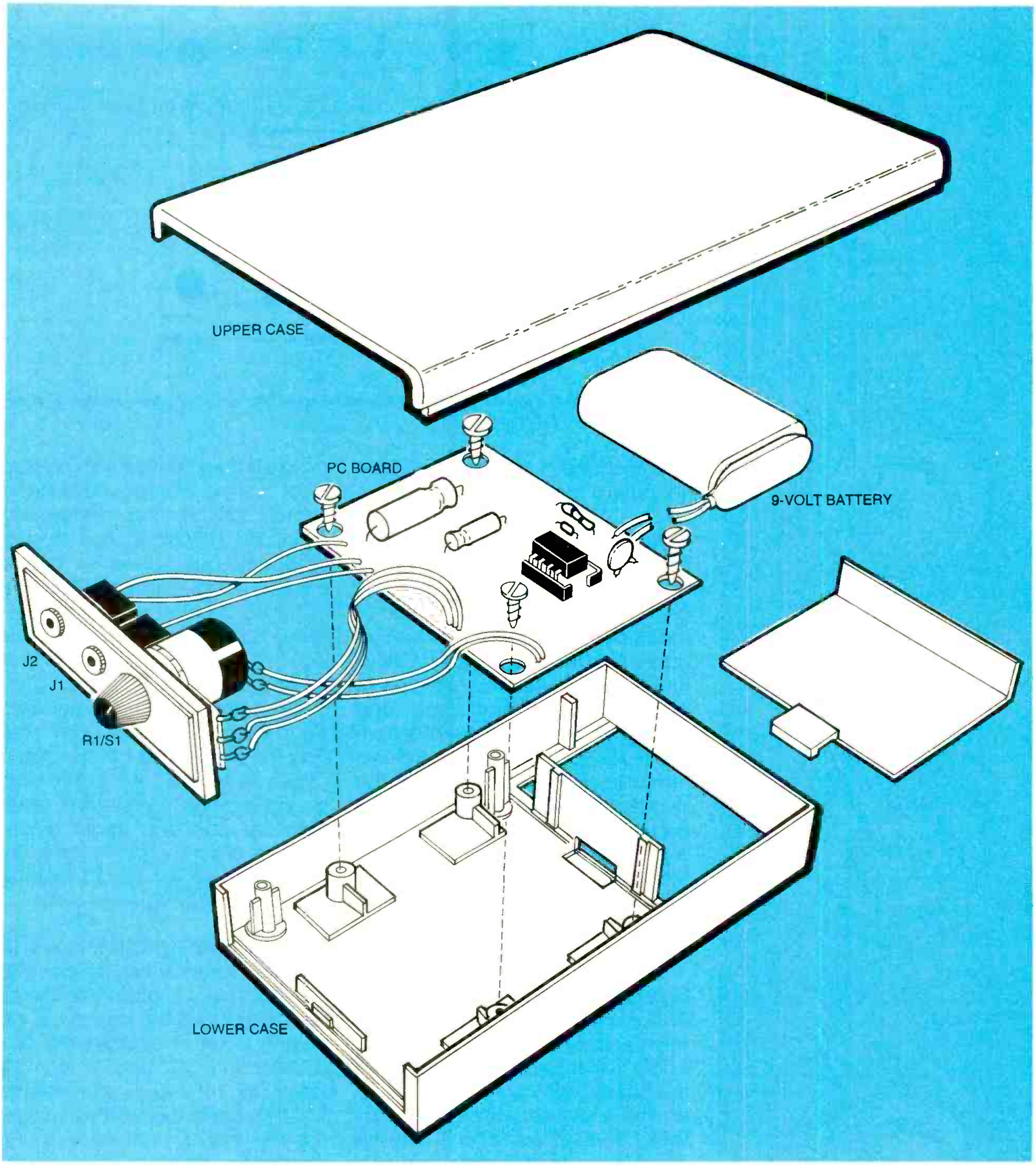


Fig. 3. The MarineLife Acoustic Sensor fits easily into a hand-held case that includes a battery compartment. Using a potentiometer with an integrated on-off switch for R1 and S1 makes operating the Acoustic Sensor easy.

less power from a 9-volt battery. That part will give you longer battery life, but the sound will not be as loud. As with most designs, there is a trade-off between performance and economy. As either will work, the choice is yours.

Select a suitable case to hold the PC board, battery, and controls. One type of case is a split-type with an accessible battery compartment. Those types of cases sometimes come with a removable end panel. Having such a panel makes drilling the holes for the jacks and controls easy. A suggested arrangement using that type of case is shown in Fig. 3.

If you use stereo jacks for J1 and J2, be sure to wire both channels together. That way, both mono and stereo plugs can be used—especially with stereo headphones. Switch S1 can be either a separate switch or integral to R1. The second arrangement is preferred and lets the MarineLife Acoustic Sensor be

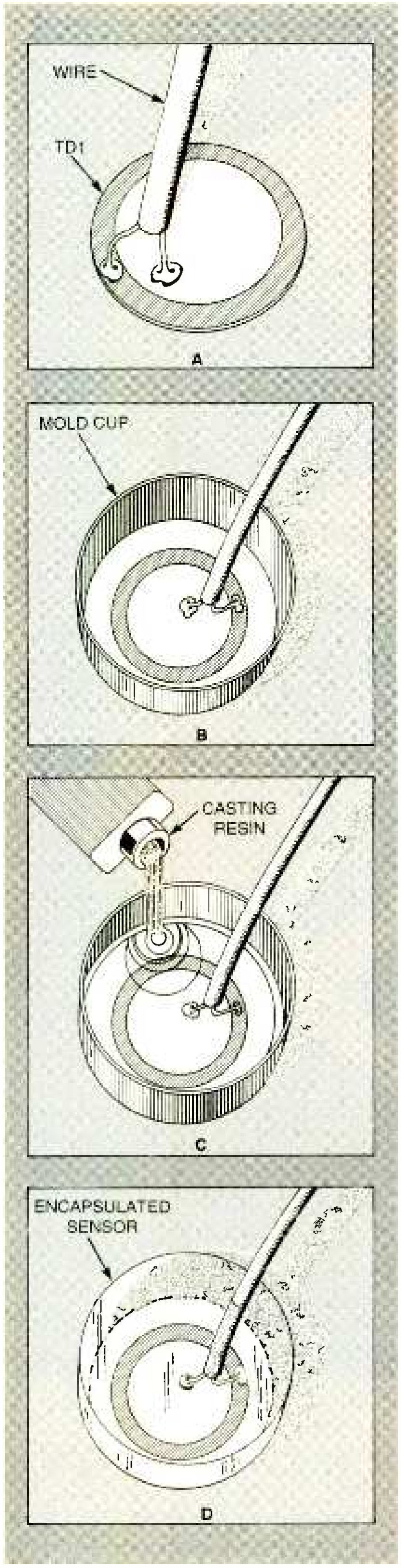
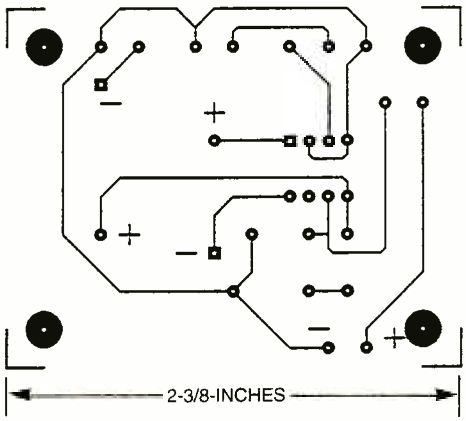


Fig. 4. The acoustic sensor itself is simply a barium-titanate transducer with an audio cable attached to it (A). To assemble the sensor, place the transducer in a plastic cup (B). The brass side should be facing down. Fill the cup with potting compound or acrylic casting plastic (C). After the compound cures, remove the mold (D). The sensor is then ready to go.



Here's the foil pattern for the MarineLife Acoustic Sensor. The circuit is simple enough to fit on a small, single-sided PC board.

operated like a radio—the volume knob turns the unit on and off.

Building the Sensor. The barium titanate disc used for TD1 can be salvaged from a piezo buzzer. They are also available from various mail-order sources. The transducer cable is a single-conductor vinyl-jacketed shielded microphone or audio cable. It should be long enough to reach to the water from wherever you plan to use the system. You should also consider the depth of the water in which you will be using it. A 100-foot cable is not excessive and will not attenuate the signal enough to notice. However, that's a lot of cable to deal with, especially when rolling and unrolling it.

Strip one end of the wire about 1 inch and separate the shield from the inner conductor. Strip the end of the exposed center conductor about 1/8 inch. Tin both the wires and the braid. Carefully tin a small area on the brass disc and on the silvered back of the wafer. Solder the shield braid to the brass and *very* carefully solder the center conductor to the silver. Do not overheat the silver, and do not stress or bend the cable at the disc. The silver coating is very delicate, and will peel off the disc with very little effort. Follow Fig. 4A for that procedure.

A small plastic or metal cup about 1-inch deep and large enough in diameter to hold the sensor will be used as a mold. Place the disc in the cup so that it is flat against the bottom (Fig. 4B). The mold will then be filled with an electrical potting compound such as ScotchCast. Potting compounds might be difficult to find through mail-order companies, so a well-stocked local electronic supplier might be a better source. An alternative is to use a clear acrylic-casting resin that is available from most art and craft supply stores.

The compound is mixed according to the manufacturer's directions. Pour the compound into the cup as shown in Fig. 4C. After the compound is cured, remove the sensor from the cup and solder a plug onto the other end of the cable. The completed sensor should look like the illustration in Fig. 4D.

Testing. Testing the MarineLife Acoustic Sensor is very simple. With S1 off, connect a battery to the circuit and plug in the transducer into J1 and a set of headphones or a speaker into J2. Turn S1 on and rotate R1 to one-quarter volume. Tap the transducer with your fingertip. You should hear some sound. Gradually advance the volume control until the maximum comfortable volume is reached.

Using the Sensor. Of course, you will need a source of underwater sound to perform the final checkout of the system. Either the ocean of a saltwater aquarium will do. Simply dunk the sensor into the water and start listening. Although the author has not tested the MarineLife Acoustic Sensor in fresh water, it should also work there. Ω

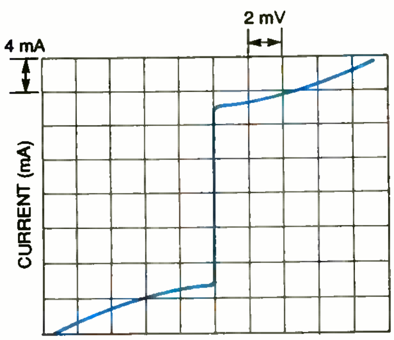
A NEW VOLTAGE STANDARD

DOUGLAS PAGE

Learn how superconductor technology is being used to create a new, programmable, and super-accurate AC-based voltage standard.

Scientists at the government's National Institute of Standards and Technology (NIST) have made an advance in low-temperature superconducting electronic technology that could lead to replacement of the DC-voltage standard with a fast, programmable, AC-voltage standard. The new standard would make use of the AC Josephson effect, where an alternating current at a known frequency is applied across a Josephson junction and the current-voltage curve that results exhibits equally spaced, constant-voltage steps. A Josephson junction is made up of two superconducting electrodes with a thin barrier between them, usually an insulator of a normal metal.

"This device will have worldwide impact on instrument manufacturers who require improved standards for calibrating D/A and A/D converters, international standards laboratories, and industrial and military standard laboratories," says researcher Samuel Benz, of NIST's Boulder, CO, laboratory. "The average customer may not notice, but the programmable voltage standard may ultimately improve the ability of power companies to accurately measure the power delivered to consumers."



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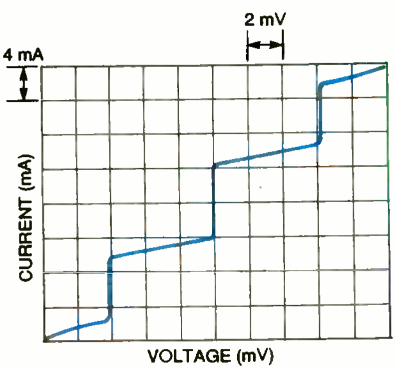

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Fig. 1. The current-voltage characteristic curve for a 400-junction series SNS array at 4°K with no microwave power applied (A) and at 7.5 GHz (B).

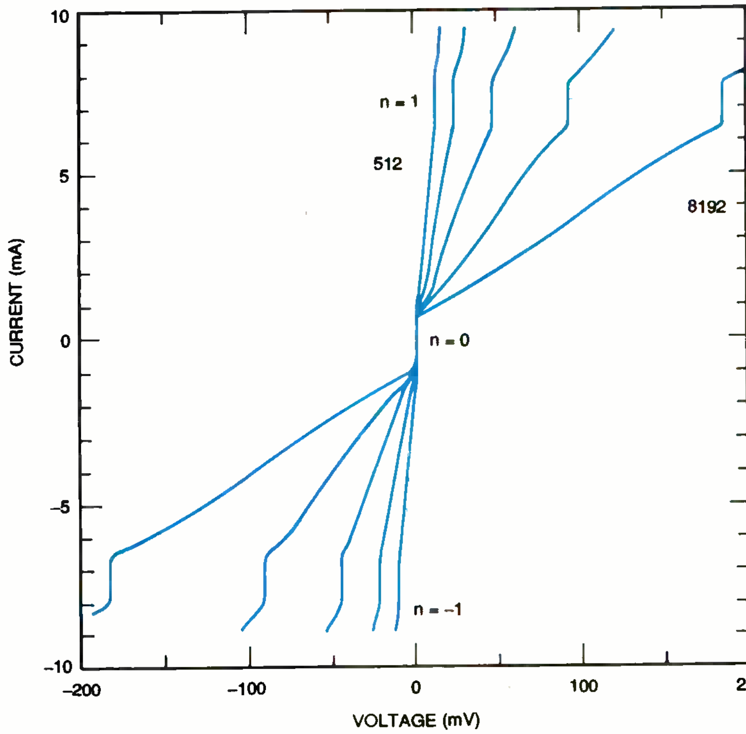

Fig. 2. Here are the current-voltage curves for each of the different arrays (512, 1024, 2048, and 4096 junctions) and for the all the arrays connected in series (8192 junctions) when biased by an 11-GHz microwave waveform. The power and junction uniformities were sufficient to operate all segments at the same microwave power and DC bias. That is the ideal operating condition for a programmable voltage standard.

Creating a New Standard. Figure 1 shows the voltage-current characteristic curves for a 400-junction superconductor-normal-superconductor (SNS) array. Scientists at NIST's Electromagnetic Technology Division have fabricated and tested arrays of 4,096, 2,048, 1,024 and 512 SNS junctions using niobium-paladium and gold-niobium. They also have built a microwave circuit that provides uniform microwave power distribution so that each junction has constant voltage steps with the same bias-current range. Each array showed constant voltage steps of at least 1 milliampere amplitude with the same applied microwave power (see Fig. 2). When all the arrays were measured in series, the power distribution was sufficiently uniform to achieve milliampere-wide steps.

With a four-fold increase in the number of junctions, the researchers believe it should be possible to demonstrate a programmable voltage standard with a range of plus-or-minus one volt, 15-bit resolution, and

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30-bit accuracy. Eventually, that could be used to replace the DC voltage standard.

The Advantages. AC voltages are presently calibrated using thermal converters, which are detectors that convert AC voltages at a certain frequency to DC through heating. Such standards are not fundamental, as the accuracy of the thermal converters relies on the ability to accurately compute the AC/DC conversion. The physical properties and temperatures of each device affect the accuracy, so that each converter must be independently calibrated. Currently, the accuracy of thermal converters is about 0.5 ppm for frequencies below 1 kHz.

A programmable AC Josephson standard, on the other hand, would be a fundamental standard based solely on voltage accuracy. For the first time, such a standard will enable independent checking of thermal converters.

"We have invented a novel Josephson-junction technology," Benz said, "based on Nb-PdAu-Nb junctions that will enable higher-frequency waveforms to be generated and more current to be drawn from them by external loads. The results [we're getting] demonstrate for the first time that large arrays of superconducting-normal-superconducting junctions can be fabricated with uniform characteristics and that uniform microwave power can be coupled to them.

"We are now in the process of fabricating the first 1-volt programmable voltage standard based on these SNS junctions. We hope this array of 32,768 junctions will demonstrate programmable voltage-standard operation with a range of plus-or-minus 1-volt, 33-microvolt resolution, and better than 0.5-ppm accuracy."

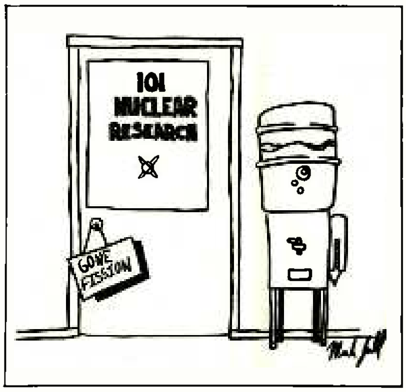
According to Benz, SNS junctions have several advantages over resistively shunted tunnel junctions. First, their higher critical current ($I_C > 1$ mA) provides greater stability against thermal fluctuations, greater output current, and faster slew rates. Second, their lower characteristic voltages ($I_C R$, where R is the junction resistance) imply lower operating frequencies, which enable -20-μV resolution and less expensive microwave electronics.

The third advantage of SNS junctions is that they are available in high-T_C technology so the devices might be operated at higher temperatures. The primary disadvantage of SNS junctions over the unshunted tunnel junctions used in the existing DC-voltage standard is that their high microwave losses complicate the problem of providing uniform AC-power distribution to each junction in the device.

NIST has been developing Josephson DC-voltage standards with fundamental accuracy using superconducting electronic technology since implementation of the first Josephson voltage standard in 1972. DC-voltage standards were developed to enable primary voltage-standard calibration accuracy in any laboratory, which has provided improved accuracy for U.S. instrument manufacturers. Improved accuracy translates into improved instrument quality, which means more foreign and domestic sales.

DC Josephson voltage standards are also used by the military for high-accuracy calibration of sensitive equipment. Last year, a team from the USAF Standards Laboratory at Newark AFB, OH, visited the NIST Boulder, CO, lab for a briefing on the new system's potential capabilities.

"We're very impressed by this new technology," said Capt. Roger Wood, a metrologist at the Air Force Aerospace Guidance and Metrology Center. "This system has the potential to replace several electronic measurement standards while reducing our test uncertainties. And perhaps most importantly, we would no longer have to rely on NIST traceability for these standards. One of our goals is to increase our organic measurement capability and thus reduce our reliance on NIST certified standards." Ω



RECRUITING TOMORROW'S ELECTRONICS TECHNICIANS

While the demand for electronics technicians is increasing, the pool of qualified workers is shrinking. Here's what we can—and must—do about it.

JOEL GOLDBERG, PH.D CET, CA

We'll begin this article with just one, seemingly simple question: "What makes a good electronic service technician?" However, the answer is not at all simple.

For example, discussions with employers who are looking for electronic service technicians reveal that they require a person, or persons, who have the ability to troubleshoot. Those people must understand the basic electronics theories we all know and respect. In addition, they must be able to apply those theories as they analyze circuits and systems requiring repair. Further, today's electronics technicians must also have good communications skills and be adept at interpersonal relationships. Finally, they must be willing to keep up with the rapidly changing technology we are experiencing by attending training sessions provided by manufacturers and other sources dedicated to our industry.

For an individual who has mastered the concepts listed above, the earning potential is very strong. If you don't believe it, just take a look at the numbers and types of consumer-electronics products produced and sold over the past few years. Information provided in the booklet *U.S Consumer Electronics Sales & Forcasts 1992-1997*, published by the Consumer Electronics Manufacturers Association (CEMA), which is part of the Electronics Industry Association (EIA), tells this tale: Annual factory sales of consumer-electronics products reached \$47,408,000,000 in 1992, and \$63,143,000,000 in 1995. By 2000, sales were estimated to reach \$85,952,000,000.

These days few, if any, homes are without some form of consumer-electronics product, and the largest growth in the consumer electronics industry has occurred in the past two decades. Almost every type of product has shown an increase in

The author thanks the faculty, staff and students at Oakland County, Michigan's Southeast Technical Center for their willingness to permit me to enter their electronics classroom and take the photographs I have included in this article. The efforts of teacher Fred Schelter (seen in these photographs) in working with local industries has placed graduates in positions in the electronics industry.

sales. For 1996, estimated household penetration of goods was almost 98% for all television receivers (and 97% for color receivers), 98% for home radios, and 96% for corded telephones.

While the efforts on the part of the electronics industry to produce better products with fewer failures have met with good success, things still break and fail, so the potential for servicing those products is unlimited. Despite that, however, fewer and fewer people are choosing to enter the servicing profession. To compound the problem, without constant training, current electronics technicians face the threat of obsolescence.

EIA Efforts. Fortunately, the situation is not hopeless. A variety of efforts are presently taking place in an attempt to provide the qualified technical support required for service.

The EIA provides training about new and upcoming circuits and systems for educators and for those presently employed in the electronics-service industry. That program has been in effect and successful for many years. The EIA has sponsored competitive programs through VICA (Vocational Industrial Clubs of America), and the International Society of Certified Electronic Technicians (ISCET) has offered an Associate entry-level certification to entry-level technicians for many years.

However, those excellent efforts are directed toward those who are currently enrolled in electronics programs at the high schools, community colleges, technical colleges, and technical schools throughout the country. Those efforts could fall short if nothing is being done to encourage young people to enter those programs in the first place.

For years, many of those who teach electronics have presented a very traditional curriculum. The result of that approach has, in many schools, reduced enrollments and even forced the closing of electronics programs. In my 20 years of visiting and evaluating educational systems throughout the central part of the United States, I have seen this reduction in program enrollment and removal of electronics programs in a great number of our educational institutions. If the United States is to provide trained and qualified electronics technicians for our service industry, then the industry along with educators have to work to encourage people to train for entry-level employment in the electronics field.

Computers and their peripherals provide yet another servicing opportunity for the young electronics technician

Standards and Certification. Fortunately, things are beginning to change. The EIA is in the process of developing a set of national skills standards for the industry and education. This project is thorough and covers all aspects of the knowledge required for servicing electronics products, including technical skills, use of test equipment, electronics theory, mathematics, interpersonal relationships, mechanics, and communications. When those standards are adopted and placed in the curricula of our educational institutions, those who graduate will be quickly employed by industry.

There also is a national movement to establish a set of measurable standards for certification of electronics technicians. Much of the work has been accomplished by ISCET. Their present testing system is the largest in the country. ISCET also has the greatest number of Certified Electronic Technicians (CETs) at this time. Other groups are also involved in the certification process and, while not as large as ISCET, are providing a needed service to those in the industry. Still other efforts are being developed by the EIA and other qualified certification groups throughout the United States.

The Major Need. All of the above is wonderful, but it is not enough. What is lacking, in my opinion, is a concentrated effort on the part of the electronics industry to provide recruiting information and programs for our youth. Materials available from the EIA include brochures and videos that show what kinds of jobs are available in the service industry. Unfortunately, those materials can only be used by those who are aware that they exist and know how to obtain them. That is also true for materials available from other industry sources.

What's needed is a major marketing campaign to "sell" our young people on the importance of learning how to diagnose and repair electronic devices. That program must also be directed at the parents of our youth, since they do have a major influence on their direction and future.

There are many potential ways to do that. For example, the electronics industry spends millions of dollars annually to advertise electronic products. As we move into the 21st century, data provided by this industry informs us that we will be using many more electronic devices, some of which are still in the developmental stages. My suggestion is to divert a small percentage of the funds currently used to sell products and use it to market the need for more trained electronics technicians. Specifically, use those funds to encourage our youth to enroll in electronics programs at their local schools and colleges. That, to this writer, would pay off in the future when more trained electronics service technicians will be in demand by the industry.

Secondly, I would encourage the service dealers, both individually and through their local and or regional associations, to adopt a local high school's electronics program. If the local school does not now have a program, spend some time with their faculty and the guidance counselors to convince them that one is needed. Get to know the local technical-education teachers. Show them that there is a great need for an electronics curriculum in their school.

While you are learning about their school facilities and whatever program they may have had in the past, or even now have, talk about what you consider to be important to you and your company. In other words, what skills and knowledge would you be looking for when you interview a potential employee. Almost all vocational programs in the public sector are required to have an advisory committee made up of those in the specific industry. Consider offering your services to this committee either as a member or as an advisor to the committee. The purpose of those committees is to provide guidance to the curriculum and keep it relevant to the needs of the industry employing graduates from the specific educational program. Most educational institutions will welcome your input and eagerly consider any advice you can offer.

A third way to show that there is a need for trained electronics-service technicians is to meet with the State Employment Agency. Express your concerns about the lack of trained potential employees. Tell them what your needs are. Be specific when you describe your requirements. Efforts on this level may best be conducted by your state and local associations rather than on an individual basis.

Become a Mentor. Moving away from the need to encourage people to enter the field of electronics servicing, let us look at some additional methods of recruiting. Once a student is enrolled in an electronics program, we need to be able to show them why the servicing field is so important. One way to accomplish that is through a program of mentoring. A mentor is one who "adopts" an individual and provides leadership and guidance to that person. Our Federal Government is now doing that though a program that utilizes both mentors and cooperative education. Those in the service industry could identify one or more potential electronic graduates and bring them into their service facilities. Those people would be receiving some on-the-job training and recognize the need for further electronics studies. Often the student who has "seen the light" will grow into one of the individuals who will rapidly advance in the industry.

Several years ago, I had a student enrolled in our electronics program who was, to say the least, an average student (he earned C grades continuously). Mathematics was not one of his better subjects. He convinced one of our co-op counselors to send him to IBM. He returned one day and proceeded to inform me that our curriculum was inadequate. His reasoning was that we did not teach calculus in our program. He had discovered a need for that subject and was teaching himself all about it. My response to him was simply "If we had tried to teach calculus, you probably would have left our program." The student agreed with my analysis. However, this student had discovered a need and pursued it. The important component in all of this is that his efforts as a co-op student provided him with the incentive and recognition of the need to learn calculus. The rest was up to him. That holds true for all studies. We must provide a need to know and then learning will be accomplished.

A lone student at work at his bench. Efforts are needed to fill this classroom and others like it around the country.

Where are the Educators? My final question is: "Where are we going to obtain qualified teachers to provide this training?" Most of the individuals wanting to enter the field of electronics service can earn much more money directly in that field

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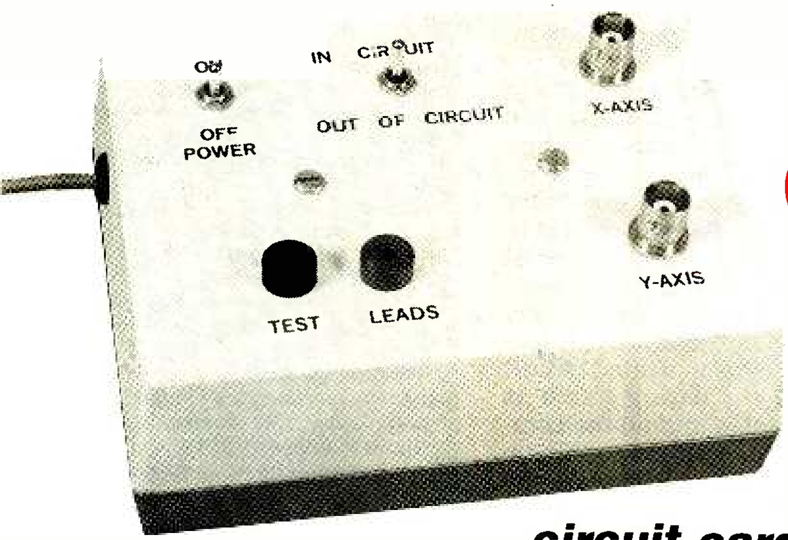


QUICK-TEST COMPONENT TESTER

Find bad components in-circuit on a crowded circuit card. Build this inexpensive, yet very useful tester in a single evening.

JAMES MELTON

IN TODAY'S WORLD OF ELECTRONICS, technicians sometimes forget or have never learned the older methods used to troubleshoot components. The result is that they spend way too much time working on a problem that a more experienced technician would quickly locate. Today, as always, time is money, and if you spend too much time on simple problems, you are not making as much money or profit as you could. By saving time you might also be able to reduce the charges to your customer. There are several old-time methods for finding trouble in electronic circuits that still apply to the most modern of electronic marvels.

One such troubleshooting method calls for injecting an AC signal into a component, and then reading the voltage produced across the component and the current flowing through it on an oscilloscope. Many test instruments have been sold that perform this task. The advent of more and more digital, CMOS, mega-transistor logic modules that must be replaced as a unit has made these testers harder and harder to find, and people who know how to use them are becoming scarce.

With a *Quick-Tester* and an oscilloscope, you can determine the status of capacitors, resistors, diodes, transistors, SCR's, Zener diodes—in fact just about any bipolar junction device—either in-circuit or out-of-circuit. Therefore you can pinpoint the defective component on a board, eliminating unnecessary and often damaging desoldering of good, but suspect components from densely packed circuit boards. Best of all, the tester can be built from readily available components found in the barest of scrap boxes.

Experienced troubleshooters will tell you that 90 percent of the problems in electronic gear arise in two major areas: the power supply, and then any circuit sections that interface the circuit board to the outside world, such as the power transistors, sensors, driver or interface IC's. Many circuits will continue to operate to some degree with a bad power supply. But when supply voltage dips or rises, or if there is too much AC ripple on the supply, the circuit can act up at unpredictable times. The problem may appear to be a bad component, yet you will find it extremely difficult to trace this kind of power supply problem to a specific bad component on the board. Many electronic assemblies can be repaired by simply testing the power supply first, to be sure it is doing its job.

All the interface components of a printed-circuit board are subject to a variety of unusual stresses: stray static charges, connectors wired wrong, and lightning or other surges that can also damage components. The *Quick-Tester* shown here

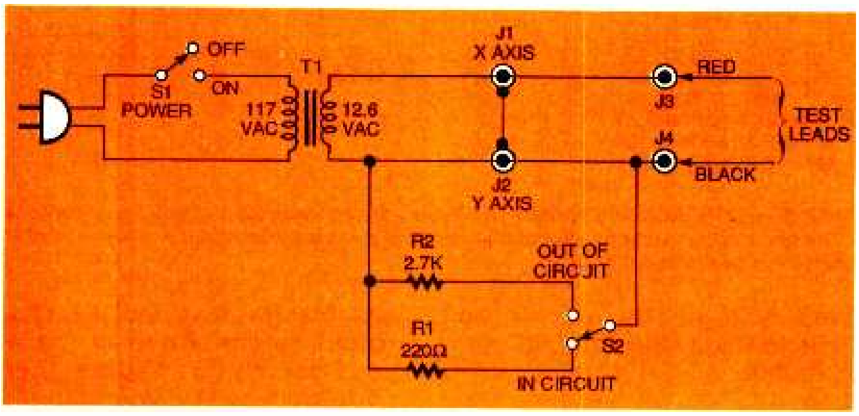


FIG. 1 — FULL SCHEMATIC OF THE instrument. When you use it to check components it creates a specific signature waveform on your scope.

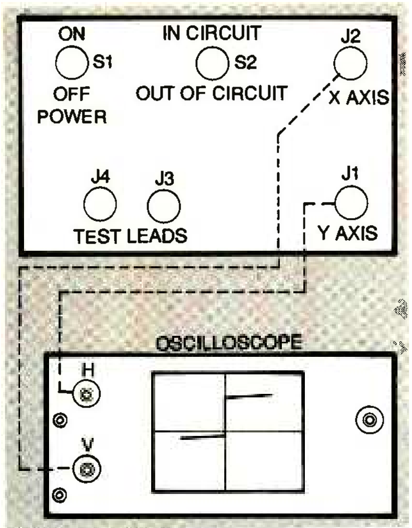


FIG. 2 — HOW TO CONNECT THE TESTER to your scope.

will help you to quickly and efficiently locate the bad component.

Inside the tester

The circuit is shown in Figure 1. There are two BNC connectors for the oscilloscope inputs, two banana jacks for the test leads to the component under test, two resistors, two switches, one line cord and one transformer. Once you have assembled your tester you will need an oscilloscope to view the waveforms. No special construction techniques are required to assemble this device. There are not enough components to justify a printed circuit board. All the wiring inside is point to point, and all the components are mounted to the top (lid) of the box. Since all the components come out of the box with the lid, there are fewer connecting wires to break, and troubleshooting will be that much easier. Anyway, build your test box as shown, then connect it to the components you wish to test as shown in Fig. 2. The polarity of the leads will affect the diagram shown on the oscilloscope (reverse the leads and the trace turns upside down), but the actual polarity of the device or the leads is not important as far as troubleshooting is concerned.

PARTS LIST

R1—220 ohms, 1/4 watt, carbon film resistor
R2—2,700 ohms, 1/4 watt, carbon film resistor
J1, J2—BNC jacks
J3, J4—Banana jacks
S1—SPST toggle switch
S2—DPST toggle switch
T1—Transformer: primary 120 volts, secondary 12.6 volts, 10 mA or greater
Miscellaneous: Case, line cord
Note: The following are offered by SolarWorks, 2747 Wentworth Drive, Grand Prairie, TX 75052.
- **Kit of all parts mentioned in the parts list is available for $45.00 plus $3.00 S&H.**
- **Fully assembled and tested *Quick-Tester* is available for $55.00 plus $3.50 S&H.**

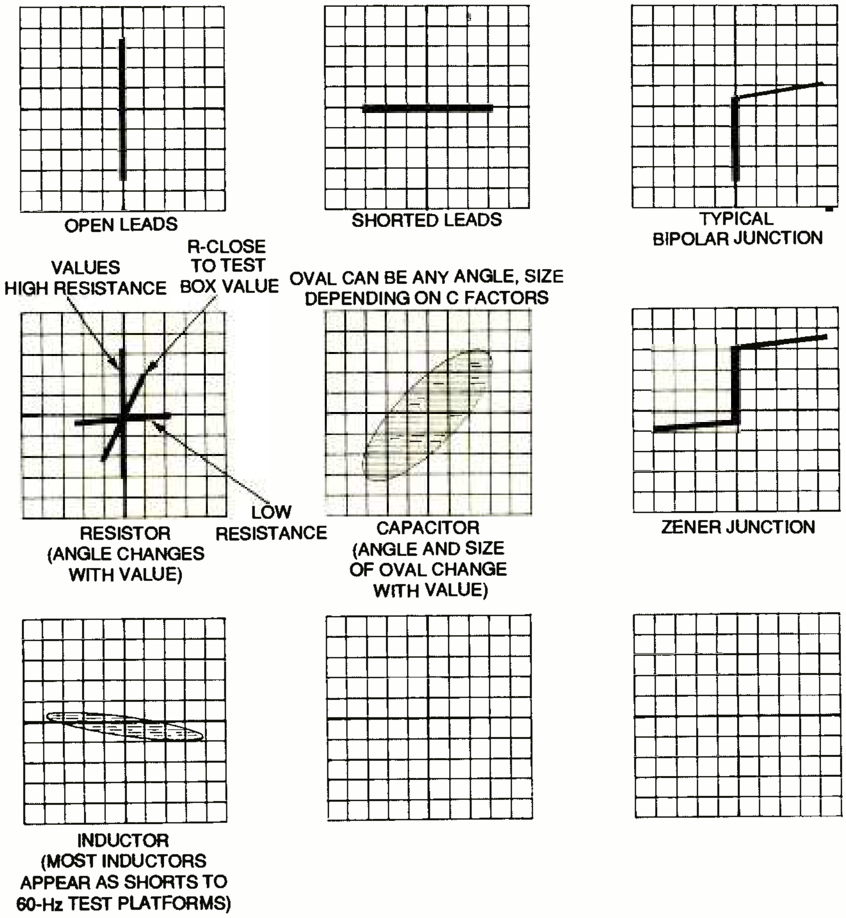


FIG. 3 — TYPICAL WAVEFORMS THAT you will see when testing good components. The blank scope screens should be used to draw in the traces you find when use the tester on new components.

How to put it to work

This test box allows you to place an AC voltage across the DUT (Device Under Test) and measure the voltage across it and the current through it simultaneously. As you can see from the circuit diagram in Fig. 1, the black test lead can be considered to be the ground lead, and the red can be considered to be the positive or active test lead. Connect your oscilloscope as shown in Figure 2. For this explanation, let's assume that the DUT is a Zener diode with a reverse voltage rating of 6.3 volts. If this diode is hooked up as shown in Fig. 2, you can see that as the voltage becomes more positive on the red lead, the diode will allow the voltage to rise and there will be no current flow. This will cause the scope vertical input (Y) to rise, and it will go straight up, because there is no current flow.

At some point near the Zener voltage, current will start to flow through one of the resistors (in circuit or out) and the voltage will slow or stop rising as the current goes up. This will have the effect of putting a small voltage on the X axis (horizontal) input of the oscilloscope, and the trace will then move in a positive direction (to the right) for the rest of the half cycle of AC. On the reverse cycle, the opposite occurs. You will be able to see the Zener knee voltage quite clearly (as shown in Fig. 3) and you will also see a knee in the opposite direction as the voltage passes through the normal or diode junction of the Zener in the forward biased mode.

When testing any junction devices, the procedure is the same, but the waveforms will be slightly different in values according to the breakdown vootages of the DUTs. The point of this procedure is to become familiar with the expected waveforms. With practice you will be able to identify components without looking at the waveform chart simply because there are not that many waveforms to remember.

Other discrete devices that you will encounter and will want to test include capacitors, resistors and inductors. See Fig. 3 to see the waveforms for each of these devices.

You've got to think

One important note about using the *Quick-Tester*. When you use it to test components in a circuit, you must analyze the circuit to figure out why you have a particular waveform on your scope. In most cases, the really odd waveforms are the result of mixing two or more components in parallel (or perhaps in series inside a component) when using the unit. It is perfectly normal to see a capacitor across the base-emitter junction in a transistor circuit, and when you check that junction you will see a combination of the two discrete waveforms on the screen. Do not let that pattern throw you; just learn what it looks like and go on to the next piece to be tested. Ω

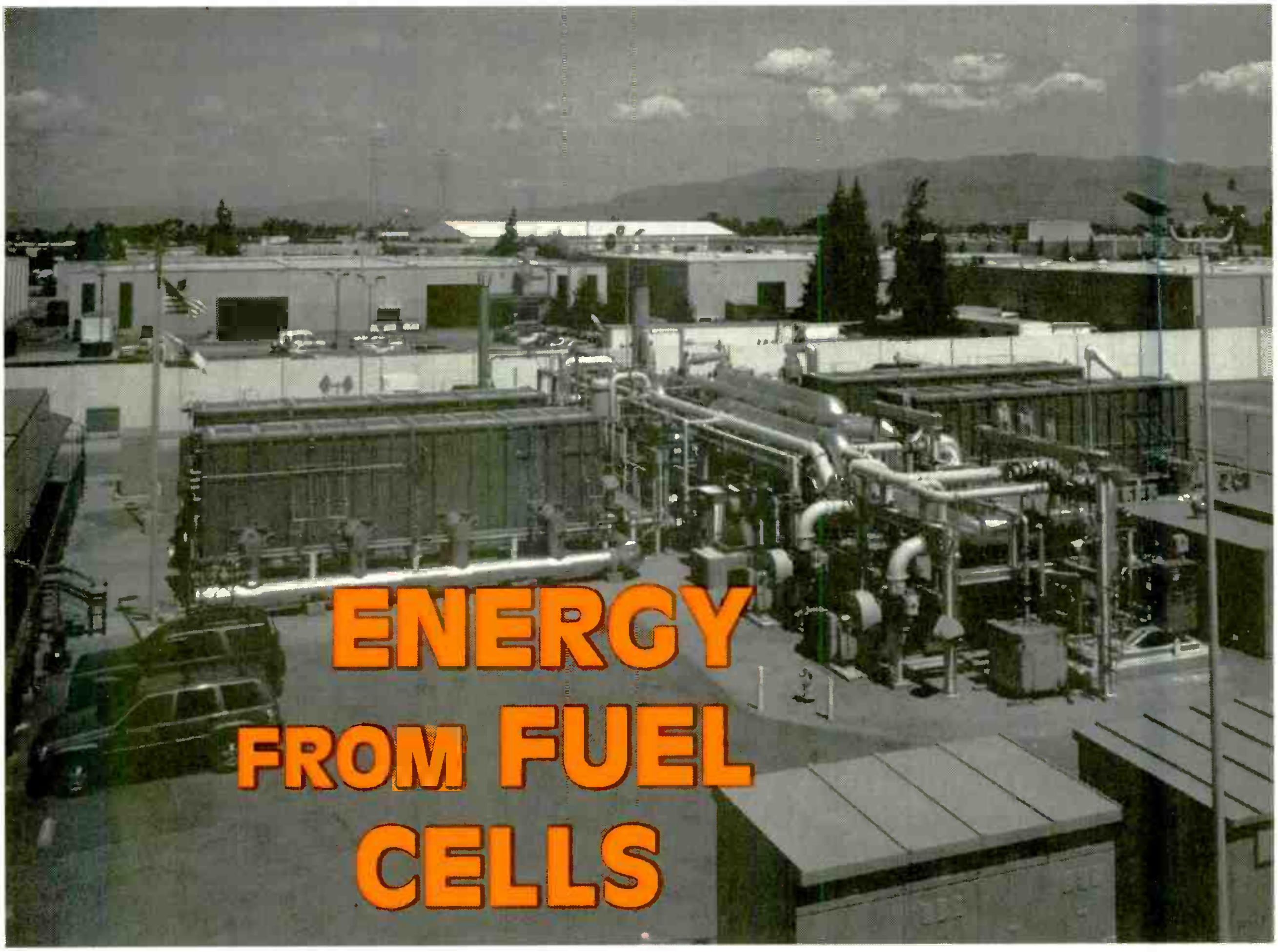
ELECTRONICS TECHNICIANS

(continued from page 52)

and not in education. Do we need to develop a cooperative work program for educators? A cooperative salary schedule would make the field of education more attractive. How many of our teacher-education facilities are even providing the training for electronics instruction? That, too, has shown a distinct drop in enrollment and the elimination of vocationally oriented teacher-education programs across our nation.

I suggest developing a cooperative program between industry and education where the educational institutions can provide the expertise in curriculum development, how people learn, and the use of instructional technology. The community college or technical college can provide the required electronics-specific education to the potential educator, and industry can provide the necessary hands-on experience with state-of-the-art equipment for both future educators and those presently employed in electronics education. The three groups, working hand in hand, can provide a qualified and well-trained individual to teach the future generations of electronics technicians.

Getting it Done. None of the suggestions presented here will occur without the total involvement of all facets of our industry and our educators. We need a national movement to support such endeavors. Without it, we will never provide the people required to service the rapidly growing number of electronics products owned and used by consumers. I call upon the entire electronics-service industry and its manufacturers to work together with educators and our educational system to develop and deliver the materials necessary to meet this demand. The present need as well as the future need for qualified electronics-service personnel is not going to diminish—it can only increase. Only through a joint effort will this critical need be met and the future of this very important industry be continued. Ω



ENERGY FROM FUEL CELLS

As fuel reserves dwindle, research is turning to ways to extract the most energy from what remains, and to do so at a reasonable cost.

ALVIN SYDNOR

Few of us think about our energy supply—unless it is disrupted—but we all rely on the things it makes possible, including cooking, lighting, and heating. However, we are living in a time of dwindling resources, including the fuels we need to create energy. In light of that, our technological challenge is clear: we must learn how to extract the maximum energy from our fuels economically and efficiently, while minimizing harm to the environment.

Classically, a fuel is considered the storehouse of the sun's energy. In "fossil fuels," the energy is usually liberated through burning. But the intermediate processes in that conversion are very inefficient. For example, the conversion of fuel to electricity in a steam turbine involves a number of steps: Fuel is first burned to produce heat. Pressurized steam then does work by turning large turbines. Finally, the turbines power an electrical generator. At each step, some energy is sacrificed.

With today's technology, electrical energy is the most convenient form of energy to handle, and can be very easily converted to mechanical power or heat. For that reason researchers have been intensely interested in finding ways to produce electricity directly, resulting in much higher efficiencies.

An Ideal Power Source. The efficiency of various energy converting devices and systems are compared in Fig. 1. As seen in that figure, the internal-combustion engine can approach efficiencies of 25%–30%. But that does not take into account the mechanical linkage necessary to power an automobile; when that is added, efficiency falls to about 15% for the total system.

Steam turbines, on the other hand, can approach efficiencies of up to 45%, and high-temperature gas turbines are rated at as high as 40%. However, it is clear that whenever heat is a part of the energy-conversion cycle, there is a definite limit to the efficiencies that may be obtained. Those efficiencies are further limited by any moving parts in the generator or overall system.

However, a quick glance at Fig. 1 clearly shows that one technology offers superior efficiency. That technology is the fuel cell. It achieves its high efficiency because the fuel cell contains no moving parts and the small amount of heat produced is not part of the conversion cycle.

Essentially, a fuel cell is simply a continuous-feed primary cell. In it, positive and negative charges are separated during a chemical reaction. The electrodes provide a purely catalytic action, speeding up the reaction without being consumed by it. Unlike a battery, the fuel cell doesn't require recharging. Instead, it is "refueled" by a continuous infusion of hydrogen or other fuel. Actually, in theory, any oxidation-reduction reaction could form the basis of a fuel cell, but in practice, only certain ones prove to be suitable.

The fuel cell is not a new development. The first use of a fuel cell in a land vehicle (a 15 kW unit installed in a tractor) occurred in 1959. In 1963, fuel cells reached space in the Gemini program. And 1996 saw the opening of an 1.8-megawatt power plant (the largest to date) in Santa Clara, CA; more on that later.

Fuel-Cell Theory. The principle behind the fuel cell is actually the reverse of the chemical process called electrolysis. Electrolysis produces chemical change by passing current through an electrolyte, a solution capable of acting as a conductor. For example, if electrodes are suspended in water and a current is passed between them, hydrogen gas will form at the cathode (negative terminal) and oxygen gas will appear at the anode (positive terminal).

While experimenting with electrolysis in 1839, Sir William Grove discovered that the reverse was also true. He brought hydrogen and oxygen together under controlled conditions and produced water and electric current. Thus, we credit Grove with the discovery of the fuel cell.

The first fuel cells used hydrogen and oxygen. Many other chemical reactions that produce electricity are now being used, but for a basic understanding of the fuel cell we will examine the hydrogen unit.

As shown in Fig. 2, a fuel cell contains two electrodes separated by an electrolyte. Hydrogen (the fuel) is available at the anode and oxygen (the oxidizer in the chemical reaction) is at the cathode. As the two gases are applied to the electrodes, separate reactions take place. When hydrogen is passed over the anode, electrons are generated and can be made to do electrical work through an external circuit. At the cathode, the electrons join with the oxygen to produce hydroxl ions, which travel through the electrolyte to complete the electrical circuit.

A closer look at the chemical reactions in a fuel cell will further explain the process. At the anode, hydrogen gas is absorbed in the

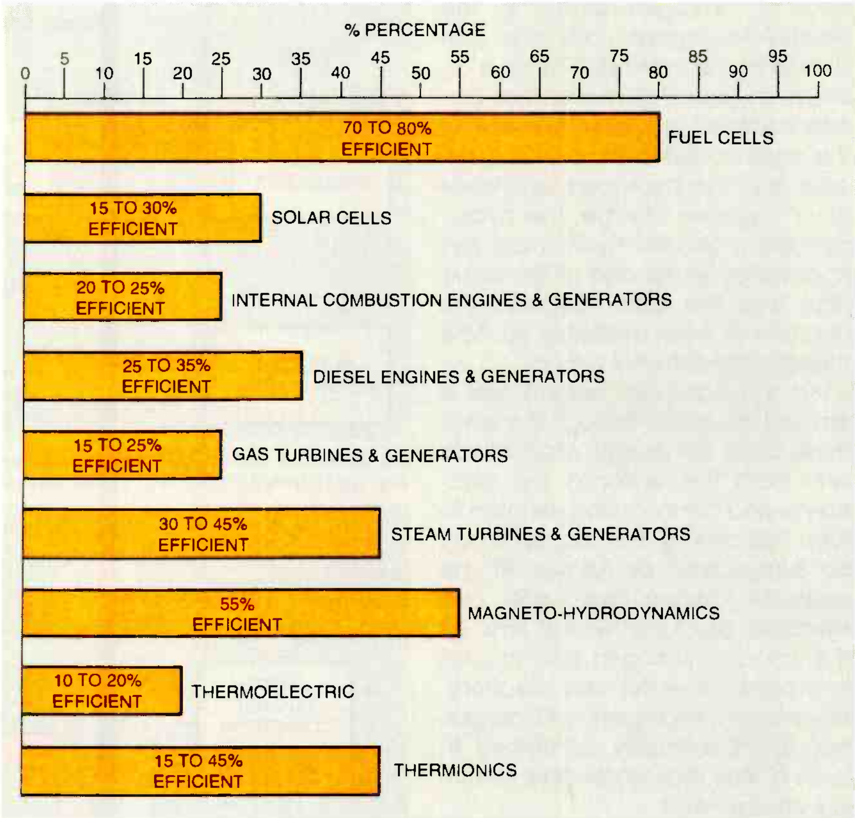


Fig. 1. Because they use no moving parts and do not require heat to be applied during the conversion process, fuel cells are the most efficient sources of electrical power devised to date.

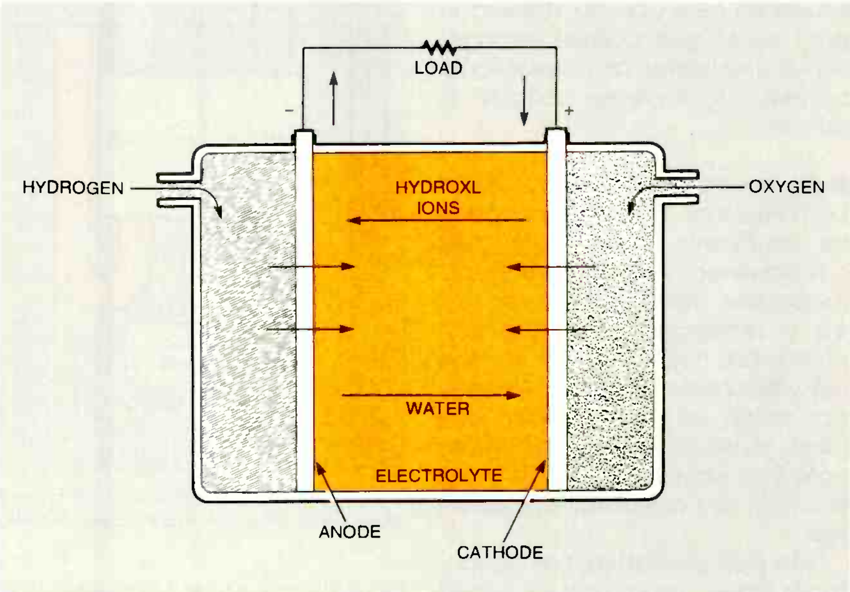


Fig. 2. In a hydrogen-oxygen fuel cell, hydrogen joins with hydroxl ions at the anode to create water, freeing electrons to do work. At the cathode, oxygen reacts with water in the electrolyte and electrons from the external circuit to form hydroxl ions.

form of hydrogen atoms. In the electrolyte, hydroxl ions are produced at the cathode. An ion is an atom or group of atoms that has either gained or lost an electron. In this case an extra electron is available and the hydrogen ions takes on a negative charge. The hydrogen atom and the hydroxl ions join to produce water and at the same time free the extra electron. This electron is now available to flow through the external circuit.

At the cathode, oxygen gas is similarly absorbed through the electrode. Here, the oxygen atom reacts with both the water in the electrolyte and the incoming electron to form hydroxl ions. The reactions can be summarized as follows: At the cathode, oxygen plus water plus electrons produce hydroxl ions. At the anode, hydrogen plus hydroxl ions produce water and electrons. In summary, hydrogen and oxygen can be continually combined in such a way that water and electrical energy result.

The output of a fuel cell is a low-voltage, high-current DC source. Individual cells can be stacked in both series and parallel arrangements, the same as conventional batteries, to increase voltage or current.

Batteries vs. Fuel Cells. It should be noted that conventional batteries are closely related to the fuel cell. However, the battery is self-contained and must either be discarded or recharged when its stored energy has been used up. The fuel cell will continue to produce electrical energy as long as fuel is supplied. However, it is important to note that when no current is being drawn, a fuel cell does not expend fuel.

The storage battery has advantages where high power is needed over a short period of time. The fuel cell is more practical for applications where moderate power is needed over longer times. A combination of the two, with the fuel cell charging the storage battery between uses, could capitalize on the strong points of both.

Other Fuels. As noted earlier, the hydrogen-oxygen fuel cell was first to be produced and received most of the early research efforts. In its basic form as described, it is not too difficult to follow the progress of chemical events. However, even the first successful cells were more sophisticated than our example.

For instance, the hydrogen and oxygen gases do not readily interact at room temperatures. Some cells operate at a much higher temperatures (250 to 500 degrees F) and use a chemical catalyst in the electrodes to help the reactions along.

These days, development has shifted to systems that operate on fuels other than hydrogen. For one thing, hydrogen is a dangerous fuel that is not easily transported. Hydrocarbon fuels, on the other hand, seem ideal because of their availability. A cell using fuel oil or natural

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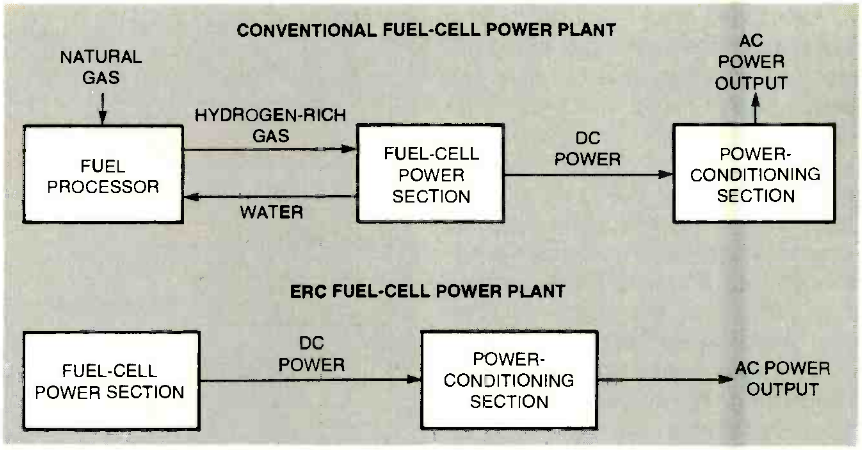

Fig. 3. The ERC fuel cell offers an advantage over other designs because it can process the fuel (natural gas) internally. Other cells require an external process to extract hydrogen from natural gas.

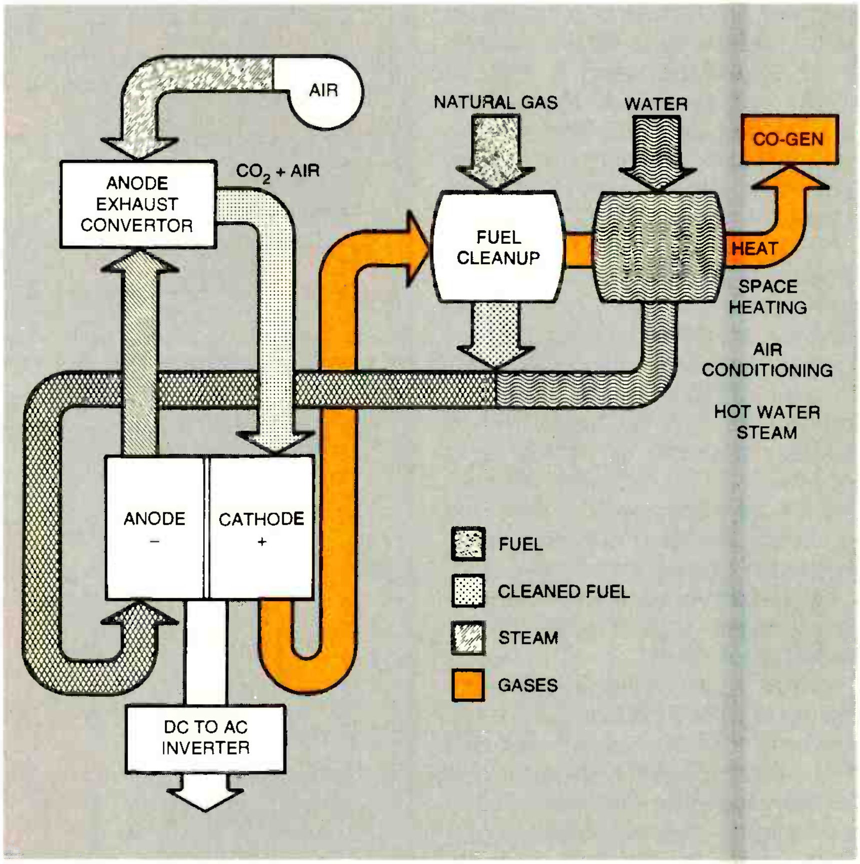

Fig. 4. This simplified block diagram shows how the Santa Clara Demonstration Project power plant works. The plant, which opened in 1996, is rated to produce 1.8 megawatts of power.

BUILD A SOLAR-CHARGE CONTROLLER

Harness the sun's energy to charge batteries with this easy-to-build controller.

BLAKE REED

With energy costs continually rising, using photovoltaic panels to get "free" electricity from the sun has become an intriguing concept. However, the cost of setting up such a system can be high enough to cancel out any potential savings. The most costly part of a system is the solar panel itself. Other than shopping around for good used or surplus panels, there is not much that can be done in the way of lowering costs in that area.

Just buying a panel and connecting it to a load is the simplest way to set up a solar power station, but that arrangement will not work very well. The more traditional way is use the panel to charge a battery and draw energy from that battery. That will compensate for any fluctuations from the panel's output, which can occur from passing clouds or the changing angle of the sun as it crosses the sky during the day. Storing the sun's energy in a battery will also let you use power at night.

If we study how a storage-type photovoltaic generating system is designed, some cost-cutting methods might be incorporated, making such a system affordable to the average person.

Designing a Solar-Energy Station. Surplus and used panels are in-

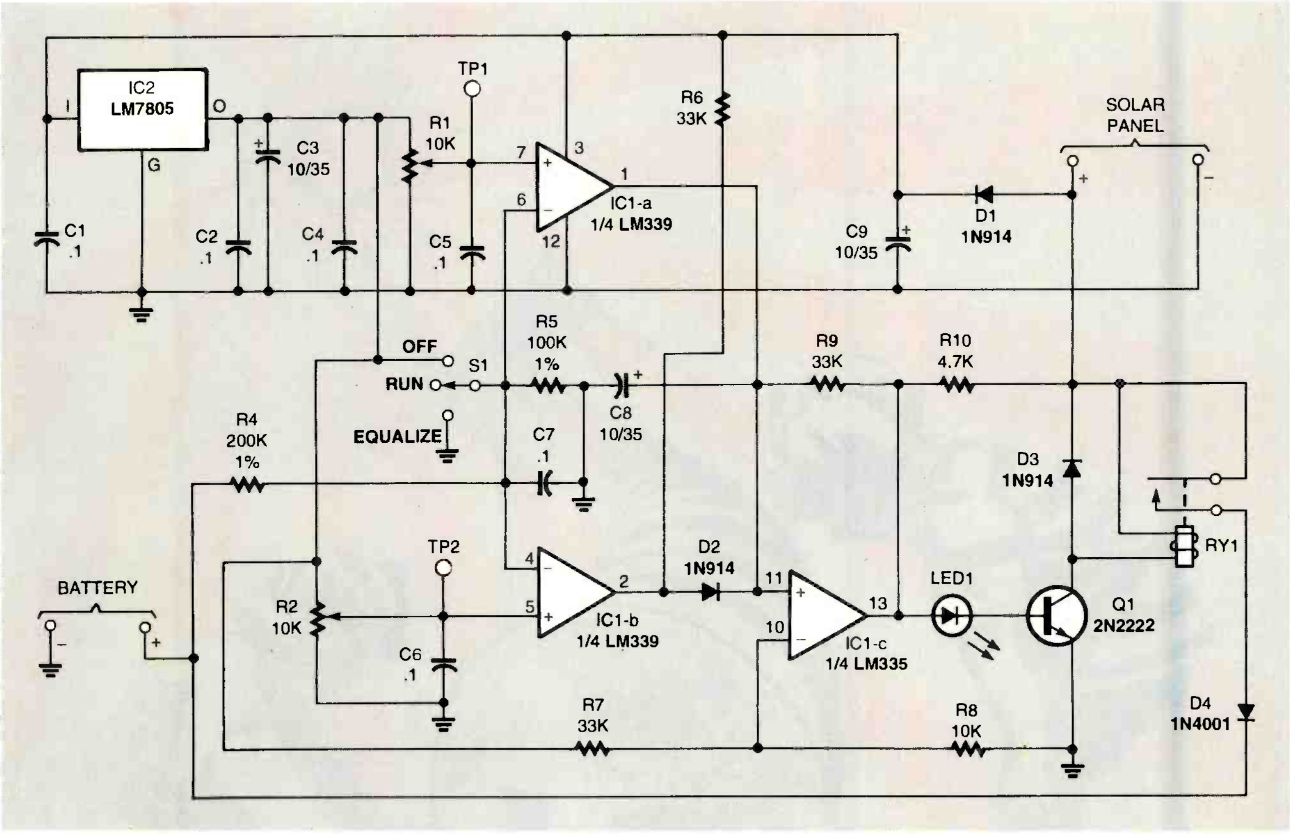

Fig. 1. The Solar-Charge Controller is a simple comparator circuit that connects a solar panel to a battery when it senses that the battery voltage is getting too low.

creasingly appearing on the market at reasonable prices. Often, new panels are "seconds" from the manufacturers. Those panels usually work fine but don't quite meet all of the manufacturer's specifications. Used panels, on the other hand, often come from solar-electric power stations. When the panels have dropped to 80% of their original rated output, they are replaced. Although the panels no longer put out their rated power, they can still put out plenty of energy and will continue to do so for many years. The power loss on panels is a logarithmic function, so it is unlikely that a decrease of power would be noticed by the average home user, even after 20 or 30 years of service. Those panels are often very reasonably priced and have the best "bang for the buck."

As we've said previously, the output of the panels will fluctuate during the day depending on the amount of sunshine falling on the panel. Solar panels are typically designed to put out about 16 volts. The output voltage can run as high as 28 volts on an extremely bright day, depending on the particular panel used. Those types of panels will work well when charging a 12-volt battery system while allowing for some losses.

Using a charge controller when charging batteries from a solar panel is required to keep the batteries from being overcharged. Overcharging batteries, especially gel cells (which cannot tolerate any amount of overcharge), will greatly shorten their life. The charge controller monitors the battery's condition and connects the solar panel when the battery needs charging and disconnects the panel when the battery is full.

There are many types of controllers available with different features such as keeping the batteries at their best "float-charge" voltage or the ability to compensate for temperature changes. Such controllers are often very expensive—over $200 for a fancier high-current unit. Spending a small fortune on a controller is probably the last thing someone wants to hear after shelling out big bucks on a panel and batteries.

The charge controller presented here is a very basic unit that will meet most needs. In fact, it can be used to maintain a battery from just about any power source so long as the charging voltage is less than 30 volts DC and the charging current is within the capability of the controller. In addition to running a photovoltaic generator, the controller is very handy for keeping an RV battery up to snuff over the winter or for keeping the ham-shack battery ready at all times. In those cases, a wall transformer can be used as the power source instead of a solar panel.

The charge controller is designed to handle charging currents up to 1 amp. By changing three components, currents up to 20 amps can be handled. All components are available at any RadioShack for about $26. That cost will rise to about $46 if the controller is modified to handle 20 amps. If the unit is hard wired into a photovoltaic generator station, a case and terminal block might not be needed, lowering the cost a bit.

Drawing a small amount of

power over a long period can easily drain a battery, especially if it has a small capacity. Powering the controller from the solar panel will not drain any power from the battery. Besides, if there is no sun, there is no reason to turn on the controller. The modified 20-amp controller, on the other hand, uses up to 100 mA when the panel is charging the battery. Because of that amount of current draw, it makes no sense to use the high-power version in a low-power station. The high-power controller would use up a majority of the panel's output current, leaving little or no energy to charge the battery. For any panel with more than a 1-amp capacity, the 20-amp controller should work well.

TABLE 1

Battery Type	Float Voltage	Turn-off Voltage
Deep-cycle lead acid (single)	13.4	14.6
Deep-cycle lead acid (two in series)	13.3	15.0
Gel cell (single)	13.5	14.1
Gel cell (two in series)	13.7	14.4
PbCa (lead calcium)	13.2	14.3
NiCd (single)	14.0	16.0
NiCd (two in series)	14.5	16.0

Solar-Panel Ratings. Most solar panels are rated by the power they can produce. Unfortunately, a wattage rating is very deceiving and doesn't tell what the actual useful power will be. The reason for that is that solar panels are constant-current devices. Their output current remains about the same as long as the load voltage is below what the panel can produce. An average solar cell can produce about 0.45 volt, which drops as the panel gets hot. As the voltage drops, the total wattage will drop since the current remains the same. Therefore, a 12-volt panel will always have considerable overhead, typically running 16 volts or more. That will compensate for the voltage drop on very hot days. It also guarantees that full charging current will be available for a battery pack, whose voltage can vary from 12 to 16 volts.

The panel rating is usually the total power available at the maximum current (which is constant) and the maximum voltage under ideal conditions. To show how those ratings work in the real world, let's look at the author's setup: The panel is rated at about 87 watts, producing about 5.27 amps at 16.5 volts. The battery pack being used runs on average at about 12.6 volts while charging. That means that the actual useful power produced by the panel to charge the batteries is a bit over 66 watts. The 22-watt difference is lost by the voltage drop across the charge controller's diode (3.7 watts), the resistance of the cables, and heating on the panel itself (which reduces its output voltage).

The power lost in the diode and cables is not much of a concern as removing those losses will not result in more useful power, only more heat across the panel. The only limitation to the losses is that they must be low enough to keep the overall system voltage (battery + cable + diode) less than the solar panel's output voltage under worst case conditions. To calculate the useful power of a panel, take the current of the panel times the voltage of the battery used and multiply that by the sun hours each day. That will give the number of useful watt-hours a day from the panel.

Batteries. The type of battery used for a solar power system is very important. Although there are many inexpensive automobile batteries available, they are not suitable. The reason for this is that they are designed to supply high current for a very brief period and then to be recharged right away, such as what happens when starting a car. If they are discharged and not recharged until the next day, they will fail very rapidly. A better choice is an RV or a marine trolling-motor battery. Those batteries are designed for many discharge and recharge cycles. One of the best batteries for a solar station is a golf-cart battery. They are designed for a high capacity and very heavy discharge/recharge cycles. As those batteries are 6-volt devices, two should be wired in series to make 12 volts.

Although the internal construction of those batteries is somewhat different, they are all variations of lead-acid battery technology. They all require periodic maintenance such as adding water and cleaning the terminals. Lead-acid batteries have a habit of generating hydrogen while being charged. Hydrogen in a great enough concentration and a spark can easily cause a very nasty explosion. The acid itself can cause severe burns or damage if any is spilled or a leak develops. It is a good idea to put lead-acid batteries into a sealed box that is resistant to acid and is vented to the outdoors if the batteries are kept indoors, which is the preferred setup. Here's why:

The best place to keep a battery is in a stable temperature environment. A battery's output capability drops considerably when the temperature drops. As much as 70% of a battery's power capability can be lost in extreme cold. The capacity will return when the temperature returns to normal. Extreme heat can greatly shorten the life of the battery. The other problem with having the battery outdoors is that the voltage at which the battery is fully charged changes with temperature. That could cause the battery to either be under- or overcharged when very cold or hot. An advantage to having the battery indoors is to keep losses in the wiring to a minimum. As with the solar panel wiring, the losses in the power cables can be significant. That is even more of a problem for the battery cabling as the currents used by the loads are often many times greater than those of the solar panel. It is therefore best to have the batteries as close as possible to the loads in a weatherproof environment.

For indoor use, it is best to use sealed batteries like gel cells. Those types of batteries do not generate enough hydrogen to cause any problems, unless they are overcharged, in which case they will be destroyed quickly. They have no liquid acid that can spill or leak. In addition, their terminals do not corrode and they work well together when there are several in a pack. Unfortunately, gel cells are very expensive unless they can be found on the surplus market. Great care must be taken when buying surplus batteries as it is very easy to get bad ones.

Gel cells often can not take a charge current of more than $^1/_{10}$ of their rated capacity. A 50-amp-hour battery, for example, should not be charged with more than 5 amps. Doing so may cause the battery to dry out and fail in a short period. It is best to have a battery amp-hour capacity that is greater than 10 times the maximum output of the solar panel.

There are also other types of batteries that can be used, such as NiCd and lead-calcium. The voltage characteristics of those batteries are slightly different from those of the standard lead-acid batteries. Be aware that there are even minor differences between lead-acid and gel-cell batteries. Some of those differences are shown in Table 1. Because of those differences, use only one type of battery in a system. Do not mix batteries—even mixing manufactures of batteries can cause problems. It is best to use batteries that, after having a full charge and sitting for awhile, have the same voltage and have the same rated capacity.

Most deep-cycle batteries are useful for a defined number of cycles. That is the number of times the battery can be taken down to the fully discharged state (about 1.8 volts per 2-volt cell for most lead-acid batteries) and recharged before having to be replaced. That can vary from less than 500 to over 1500 times depending on the battery's construction. In most solar applications, the battery is discharged throughout the day and night and then recharged the next day. If the battery is fully discharged each time, it can be expected to last only as long as specified by the manufacturer. Even though a cycle number such as 500 may seem good, cycling the battery once a day will mean the batteries will have to be replaced about every 16 months—a very expensive procedure. Fortunately, the cycle life of the battery increases logarithmically as the depth of the cycle decreases. Discharging the battery by only 30% of its total capacity greatly increases its life. Most manufactures recommend discharging only to the 30% level so a 100-amp-hour battery is effectively only useful for 30 amp-hours. It is even better to cycle the battery to only its 15% level. That allows for some slop in the load usage, a couple of cloudy days, and much greater battery life.

The total capacity of the battery required for a solar system must take into account several factors, such as discharge factor, solar panel output, average sun-hours per day, and battery load (whether it is an everyday load or only occasional). If the power is to be used every day, it is best to be sure that the load doesn't use any more than the solar panel's daily output. A 5-amp panel that gets 5 hours of full sun a day means up to 25 amp-hours of power can be used every day. At that rate, the battery capacity should be at least 83 amp-hours for a 30% discharge rate, or preferably 167 amp-hours at a 15% rate. That will allow for a day of no sun without discharging the battery too much.

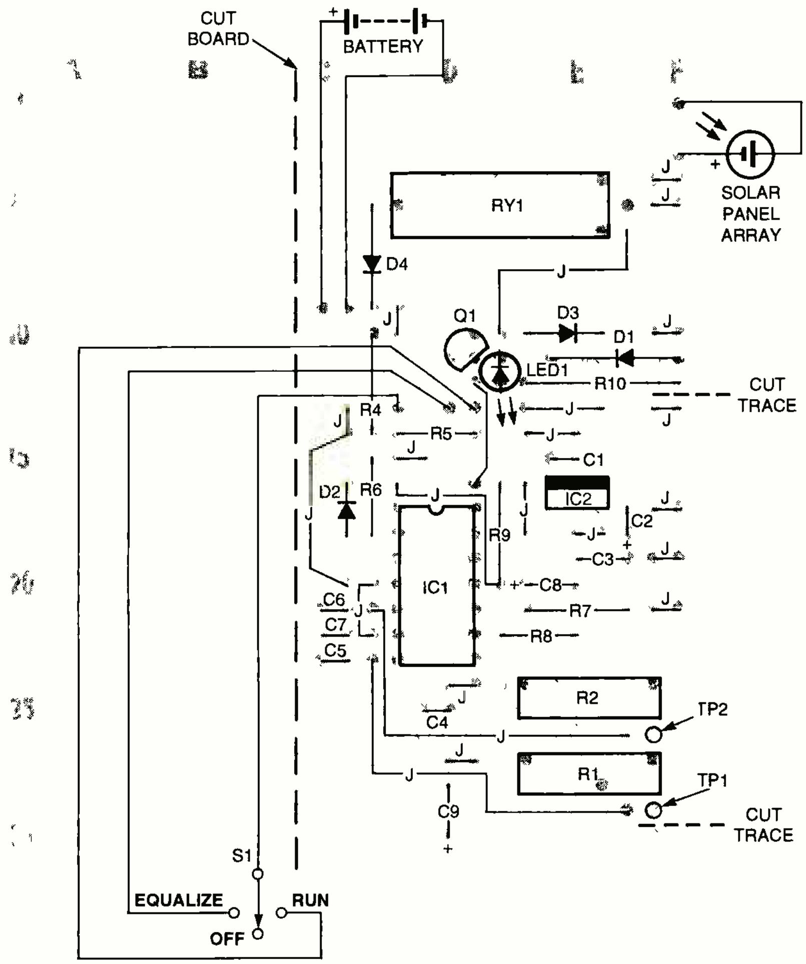

Fig. 2. The controller circuit is simple enough to lay out on perfboard. This layout is the author's design. Based on RadioShack's 276-168 universal breadboard, the unused portion of the board can be cut off if it is not needed. Don't forget to cut the trace that runs along line "F" at the two places shown.

Circuit Description. The heart of

the schematic diagram in Fig. 1 is a set/reset flip-flop circuit. That flip-flop is made from the comparator gates in IC1. When the battery voltage drops below the turn-on trip point set by R2, RY1 is turned on. That connects the solar panel to the battery, charging it up. The relay remains on until the battery voltage gets to the turn-off point set by R1. At that point, the battery is fully charged. The relay is then turned off and remains off until the battery voltage drops back down to the turn-on point.

The controller is powered from the solar panel through D1. Filtering of the power supply is done by D1, C9, and C1. However, drastic voltage variations might occur each time RY1 connects or disconnects the panel from the battery. It was found on early prototypes that high-frequency pulses from the switching of RY1 caused IC1 to latch.

Power for IC1 comes directly from the solar panel. A 5-volt regulator, IC2, is used as a voltage reference for the trip points. The components associated with RY1 (R10, Q1, D3, and D4) are connected directly to the unfiltered solar panel instead of the filtered power on the board after it has gone through diode D1. Those components don't need a clean power supply.

Battery voltage is divided to $^1/_3$ of its actual voltage by R4 and R5. The turn-on and turn-off points can be set as high as 5 volts, so the maximum battery voltage that the controller can handle is 15 volts. All voltage comparisons occur within the range of the reference (5 volts) which is well within IC1's common-mode voltage range. The battery input is filtered by C7 to keep noise from affecting the circuit.

The charging cycle is centered on IC1-c. When the battery is not being charged by the solar panel, the output of IC1-c is low. No voltage flows through LED1 or Q1, so RY1 is off, disconnecting the solar panel from the battery. Feedback resistor R9 holds the input to IC1-c at a low level, keeping the circuit in an off state.

While the battery voltage is above the turn-on level set by R2, IC1-b remains grounded. When the battery voltage drops below that voltage, the output of IC1-b goes high. The voltage from pull-up resistor R6 flows though D2 to the non-inverting input of IC1-c. The ground signal from R9 is overridden, and pin 11 of IC1 is pulled above the reference voltage set by R7 and R8. The output of IC1-c goes high, letting current flow through R10 to LED1 and Q1. That, in turn, closes the contacts of RY1. The solar panel is then connected to the battery through the relay contacts and D4. The purpose of D4 is to prevent cur-

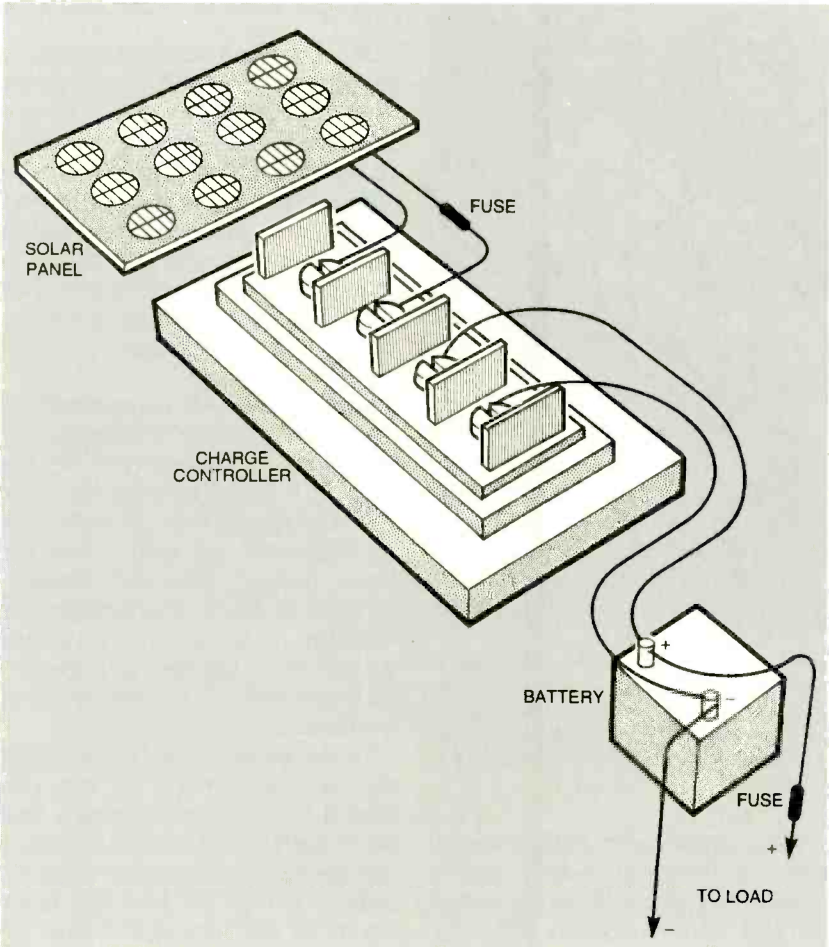

Fig. 3. Wiring up a solar-panel generator is quite straightforward. It's always a good idea to put fuses between a source of power and its load.

PARTS LIST FOR THE SOLAR-CHARGE CONTROLLER

SEMICONDUCTORS

IC1—LM339 quad comparator, integrated circuit
IC2—LM7805 5-volt regulator, integrated circuit
Q1—2N2222 NPN transistor
D1–D3—1N914 silicon diode
D4—1N4001 silicon diode
LED1—Light-emitting diode, red

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—10,000-ohm, 15 turn trimmer potentiometer
R3—Not used
R4—200,000-ohm, ¼-watt, 1% (see text)
R5—100,000-ohm, ¼-watt, 1%
R6, R7, R9—33,000-ohm.
R8—10,000-ohm
R10—4,700-ohm

CAPACITORS

C1, C2, C4–C7—0.1-µF, ceramic-disk
C3, C8, C9—10-µF, 35-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—Single-pole, double-throw, center-off toggle switch.
RY1—12-volt relay, single-pole, single-throw, 1-amp contacts
PC board, terminal strip, double-sided foam tape, enclosure, wire, hardware, etc.

rent flow from the battery back to the solar panel and controller. That keeps the battery from powering the controller at night and eliminates the danger of a short circuit.

As the battery is charged, its voltage increases. Once the voltage rises above the level set by R2, the output of IC1-b returns to a low state. The state of IC1-c is held on by R9. The battery will continue to charge until the battery voltage reaches the turn-off point set by R1. At that point, IC1-a goes low. That pulls the input to IC1-c low, turning off IC1-c. Current stops flowing though LED1 and Q1, so RY1 switches off. The solar panel is disconnected from the battery and stops charging it. Diode D3 suppresses the voltage spikes generated by the relay coil when it is turned off. Resistor R9 holds IC1-c in a low state again, and the cycle repeats. Capacitor C8 helps keep RY1 from chattering due to any transients caused by the switching.

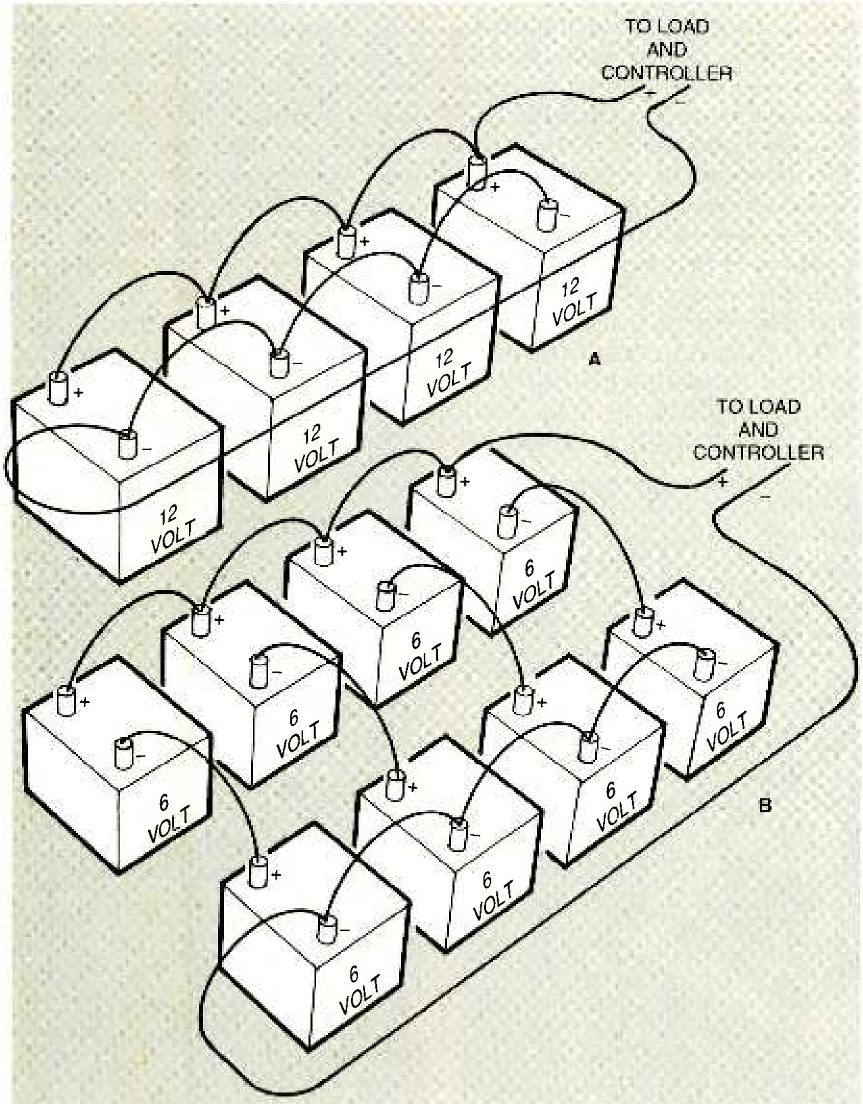

Fig. 4. If you want to use several batteries wired together in a pack, these diagrams show how to hook them together. For 12-volt devices, simply wire all the positive and negative terminals together (A). If you are using 6-volt batteries, connect pairs together to make 12-volt assemblies that are paralleled (B). In either case, don't connect the load to both terminals of one battery, or that battery will work too hard and fail first. Instead, use the terminals at opposite corners of the pack to spread the load evenly across all of the batteries.

The control switch S1 is a single-pole, double-throw switch with a center-off position. When the switch is in the center position, the controller operates normally. When it is set to the grounded position, the circuit will always see the battery's voltage as zero. The controller will then try to continuously charge the battery. That is used on occasion to briefly overcharge the batteries in a multi-battery pack to equalize them. Equalizing the batteries will make sure they are all at the same state of charge. Equalizing should only be done occasionally and with great care in order not to damage the batteries. Setting the switch to the equalizing position briefly and then returning it to the center-off position will start the charging cycle. That can be used to "top off" a partially discharged battery that is not low enough to trigger a full charging cycle. When S1 is set to the other position, the circuit will always see the battery as being fully charged. That will prevent the controller from charging the battery. That allows the battery to be disconnected from the circuit without having the relay oscillate or having any unconnected battery leads laying around with power on them. Depending on the solar panels used, severe shocks or fire hazards could result otherwise.

PARTS LIST FOR THE 20 AMP UPGRADE

R10—2,200-ohm, 5%, ½-watt resistor
RY1—12-volt relay, double-pole, double-throw, 10-amp contacts
BR1—Bridge rectifier, 25-amp, 50-volt
Wire, solder, etc.

Construction. All components for the solar-charge controller are available at RadioShack. No special parts or PC boards are needed. The circuit can be built easily on a perfboard with trace patterns, making assembly easier. A suggested component-placement diagram is shown in Fig. 2. That placement diagram is based on RadioShack's 276-168 universal perfboard.

The layout in Fig. 2 also allows the unused portion of the perfboard to be trimmed down, making it easier to fit in an outlet box. If the board is going to be used that way, it is best to trim the board down to size before installing any components. To do that, place the board in a vise with the desired breakpoint at the top of the vise

jaws. The portion of the board that will be used for the circuit should be between the vise jaws. That will protect the usable part of the board if the board does not snap cleanly. Put pressure on the board just above where it comes out of the vise jaws and the board should break cleanly along the desired line. Be sure to make the two trace cuts shown in Fig. 2 before adding any components.

Placing IC1 on the board first will act as a reference for placement of the other components. Using a socket for IC1 is not necessary. In fact, if the controller is placed outdoors or in an unheated area, a socket might cause intermittent problems after several years. After confirming that IC1 is installed in the correct direction, fold pins 3 and 12 of IC1 over so that they touch the traces running between the legs of IC1 before soldering it in. That will connect the power and ground lines to the IC.

Install the fixed resistors next. The lead of R8 that connects to pin 9 of IC1 should be folded over so that it also connects to pin 10. Save the leads clipped off the resistors after soldering them in. They will be used for the jumpers later.

When installing the capacitors, place them as shown in the parts-placement diagram. Pay attention to the polarity of C3, C8, and C9. If those components are installed backwards, the board might fail or the capacitors could explode. Again, save the clipped-off leads. The polarity of D1–D4 and LED1 should also be double-checked before installing them. The lead from the cathode (band side) of D2 is folded over to make a connection with pin 1 of IC1.

The flat side of LED1 is installed facing toward Q1. If it is installed backward, RY1 will not be able to turn on. If you want, LED1 can be connected with leads and mounted on the case for easier viewing. Install Q1 and RY1 as shown.

Use the leads clipped off the installed components for the jumpers that connect straight from hole to hole without any bends. The jumpers that must bend around components or corners should use any convenient insulated wire, such as 26-gauge wire or wire-wrap wire. Two jumpers share connecting points with a resistor and another jumper. It is best to use small gauge wire, like 30-gauge wire-wrap wire, for those connections. When installing the jumpers that go to R1 and R2, be sure to route them so they don't get in the way of installing the pots. Use a short piece of component lead for the test points at the pots. Adding the test points will be necessary if the board is being installed in an outlet box, otherwise it will be difficult to calibrate the controller.

SUPPLIERS OF SOLAR PANELS AND ACCESSORIES

Caleb Wholesale Products
8015 Carrisa Hwy.
Santa Margarita, CA 93453
(805) 475-2128

Jade Mountain
P.O. Box 4616
Boulder, CO 80306-4616
(800) 442-1972
(303) 449-6601

Sierra Solar Systems
109 Argall Way
Nevada City, CA 95959
(800) 517-6527
(916) 265-8441

At this point, the trimpots are installed. Fold the lead on each pot closest to the board edge so that they connect with the power trace. Fold the center leads so they connect to the trace the jumper wire connects to before soldering in the pots. Finally, install IC2 as shown.

Use 5-inch lengths of insulated wire to connect S1 to the board as shown. If you only need to force the controller either on or off, you may substitute a single-pole switch for S1. A push-button switch can be used to the ground connection in place of a center-off switch if you only want to top off the battery charge as discussed before. If you can find one, a center-off toggle switch with a momentary position would make a good combination switch for both disabling the controller and topping off the battery charge with one control.

If you are mounting the controller in a case, use 5-inch lengths of at least 22-gauge wire to connect the circuit board and the connector together. If the board is going to be hard-wired into the system, it is best to use wire as short and as heavy as possible. It is especially important to keep the leads between the board and the battery as short as possible. The controller will see any voltage drop developed across those leads as a part of the battery's voltage, causing it to turn off too early.

Verify that all the solder connections are properly made and that all polarized components are installed correctly. Check that the wiring on the board matches the schematic diagram. Once that is done, the controller is ready for testing and installation.

Testing. For testing the controller and setting the turn-on and turn-off points, it is best to use a 12-volt, low-current (100 ma to 1 amp) power supply instead of a battery. If there is a problem with the circuit, a battery can supply enough current to cause significant damage.

Set S1 to either the on or off position and connect the power supply to the connector for the solar panel leads. Connect a voltmeter to the circuit ground—the tab on IC2 works well. Measure the voltage on TP1 and adjust R1 for a reading of 4.7 volts. That sets the controller to disconnect the solar panel when the battery voltage reaches 14.1 volts. Connect the meter to TP2 and adjust R2 for a reading of 4.15 volts. That sets the controller to turn on at 12.45 volts, which is just below the point at which a gel-cell battery sits when fully charged. If you are using batteries of a different technology or different voltages, it is easy to calculate the values for TP1 and TP2—just take the values desired and divide by 3.

When S1 is set to the equalize position (always on), LED1 and RY1 should turn on. Measure the voltage at the battery leads on the terminal block; it should be about 0.7 volts less than the power supply voltage. With S1 in the off position, there should be no voltage on the battery connections.

If you also have a variable power supply available, connect it to the battery leads. As the variable supply is adjusted up and down, RY1 and LED1 should turn on at 12.45 volts and off at 14.1 volts. If the controller passes all tests, it is ready to be permanently mounted in whatever box you will be using.

The board is best mounted on the inside of the box lid and a terminal block mounted on the outside. Either screws or double-sided foam tape can be used to hold the board in place. Be sure to allow enough clearance between the board and the lid if a metal box is being used. Two layers of foam tape will give plenty of clearance if that method is being used. Once the board is mounted, wire it up to the terminal block and close the box. The controller is now ready to be put into operation.

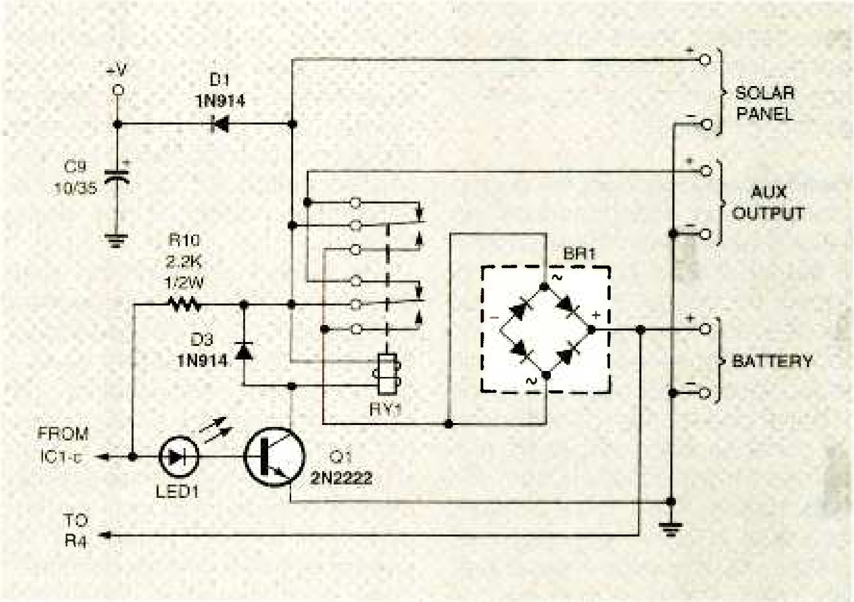

Fig. 5. By changing R10, RY1, and D4 to the components shown here, the controller will be able to handle currents up to 20 amps. Diode D4 is replaced by BR1. An extra set of contacts on RY1 let the solar panel drive an additional load when it is not recharging the battery. Of course, that load will be disconnected when the battery is being charged.

Installation. A few things need to be said about the wiring between the controller, the solar panel, and the battery, especially if high currents are going to be used. Those wires should be as large and as short as practical in order to keep losses to a minimum. As current flows through a wire, a voltage drop is developed across it due to the wire's resistance. Higher currents yield greater voltage drops. The controller will see the voltage drop as being part of the battery's voltage and turn off the charge current too soon. It is easy enough to limit the voltage drop between the controller and the battery if both items are mounted near each other. With a shorter wire, the voltage drop will not be as great.

The wire coming from the solar panel, on the other hand, is more likely to be a much greater length, so the losses will be more significant. There is no sense in losing power in the cable if it is not necessary. The size of the wire required depends on the length as well as how much current is going to be run through it. For example, a 12-gauge wire has a resistance of 0.001619 ohms per foot. In a 50-foot cable, the total resistance will be 0.1619 ohms—50 feet for the positive wire and 50 feet for the negative wire. A 10-amp load will create a voltage drop of 1.619 volts, which comes out to 16.19 watts of wasted power—quite a considerable amount. It should be noted, however, that solar panels are designed to put out extra voltage to allow for some cable loss. Even so, it is always good engineering practice to keep losses in any power-generating system to a minimum. Therefore, the smallest wire size recommend is 12 gauge for runs up to 50 feet and currents up to 5 amps. The author's installation uses 8-gauge wire. If your particular setup will be using more than one solar panel, a multi-conductor AC cable from a hardware store or RV supply house will allow one cable to be used with a bank of panels. Each panel can be wired to its own individual wire pair, or the wires can be connected in parallel for less voltage drop.

The general arrangement for a solar generating station is shown in Fig. 3. The controller is simply connected between the solar panel and the battery. As an added safety precaution, fuses should protect the positive wires between the solar panel and the charge controller, and between the battery and whatever load will be connected to the system.

For more storage capacity and charge current capacity, several batteries can be connected in parallel. Figure 4 shows the preferred way of wiring them together. Again, note that the wires between the batteries should be as large in diameter and as short as possible to keep losses to a minimum. For most applications, it is best to use a minimum of 8-gauge wire, especially if a 120-volt AC inverter that is larger than a couple hundred watts will be used. Keep the cables short enough so that they can not touch the opposite polarity terminal on any of the batteries when disconnected. That allows a battery to be replaced without the potential for a direct short across the batteries. Also, be sure the positive and negative cables do not cross over each other anywhere. This is for additional safety. If the wires get hot enough to melt the insulation if there is too high a load, the batteries will not be able to become directly shorted through the cables. Not allowing the positive and negative cables to cross could prevent a bad situation from turning into an even worse one.

The positive and negative connections that go to the controller and the load should not be connected to the same physical battery. One lead should connect to the first battery while the other connects to the last battery as shown in Fig. 4A and Fig. 4B. That wiring technique, called *reverse return*, keeps all of the batteries in the pack balanced. If both output wires are connected to one battery's terminals, the other batteries will not work as hard. Those batteries will receive less of a charge, and those that are closer to the connections will fail prematurely.

Modifications. As shown, the charge controller can accommodate about any battery with the exception of the NiCd type. For that type of battery, replacing IC2 with a 7806 will allow the controller to function up to 18 volts, allowing its use with NiCds. When using a different type of battery, set the turn-off voltage of the controller according to the recommendations obtained from the manufacturer. If that is not possible, the values in Table 1 can be substituted if you know the type of battery. If neither of those methods can be used, the turn-on set point can be found experimentally. Charge the battery pack to its turn-off point and let it sit for awhile before measuring the voltage again. The turn-on point should be set just below that reading.

If a 20-amp controller is desired, simply replace R10, RY1, and D4 as shown in Fig. 5. The diode is replaced with a bridge rectifier, which is less expensive than a pair of 25-amp diodes. Using a double-pole relay allows an auxiliary output to be connected directly to the solar panel when the battery is not being charged.

For more information on solar and other alternative energy parts and equipment, getting a catalog from one of the suppliers listed is recommended. The catalogs are full of solar devices, wind generators, water-turbine systems, batteries, and inverters. They also contain many products that can be run directly off a 12-volt system with no inverter required. Some companies carry such items as fluorescent lamps, refrigerators, and even washing machines. The catalogs often have a great deal of information on setting up a system such as tables and work sheets for determining the size of solar panel and battery pack for running the loads desired. Those catalogs are well worth the $4 or $5 that is charged for them. Most times, the catalog price will be refunded with the first purchase.

The Solar-Charge Controller is a great project for maintaining the charge on batteries whether they are used in a solar panel station or elsewhere. You might not be able to thumb your nose completely at the monthly electric bill, but you can certainly put a dent in it! Ω

FUEL CELLS

(continued from page 58)

gas can be operated almost any place in the world without the complications that arise in transporting hydrogen.

A Fuel-Cell Power Plant. On June 3, 1996, the Santa Clara Demonstration Project (SCDP) formally dedicated the world's largest direct fuel cell power plant. The Santa Clara Demonstration Project represents a unique collaborative effort between the public and private sector. The fuel cells themselves were manufactured by the Fuel Cell Manufacturing Corporation, which is a wholly owned subsidiary of Energy Research Corporation. (ERC).

Most fuel cells require the hydrogen from natural gas to be extracted in a separate process. The ERC fuel cell can process the fuel inside the fuel cell itself, where the fuel is immediately consumed to generate electricity. The two approaches are compared in Fig. 3. It is believed that the direct system offers the potential for a simpler and more efficient power plant as compared to other types of fuel cells.

The power plant in Santa Clara is rated at 1.8 megawatts net (it actually reached 1.9 MW AC net). It contains more than 4000 individual cells, grouped into 16 stacks, each capable of producing approximately 1.25 kW of DC power. The direct current from the fuel cells is converted to AC in a power conditioning unit prior to being fed into Santa Clara's distribution system. A block diagram of the SCDP system is shown in Fig. 4, and a photograph appears at the beginning of this article.

The SCDP system is just the first utility-scale demonstration of a direct fuel-cell power plant. The next generation power plant will be a 2.85 MW packaged unit that is expected to be available by the turn of the century. By increasing the size of the fuel cells in the stacks, as well as the height of the stacks, and compressing the plant layout, the overall space will be decreased by 90 percent, yet the proposed power plant will produce an additional megawatt of power. Ω

BY DON LANCASTER

Measuring Low-Voltage Signals, Reading Web-Site Log Files, and More

TAKE YOUR CHOICE OF A LARGE "PETROVOLTAIC" ROCK, A JUNK ELECTROLYTIC CAPACITOR, OR ANYTHING ELSE HANDY; MEASURE THE VOLTAGE ACROSS IT; AND RECORD THOSE VARIATIONS AGAINST TIME AND YOU WILL SEE A FEW MILLIVOLTS of diurnal and other mysterious cycles. Depending on where you look on the Web, you'll find conclusions that what you have seen is scalar gravity waves, Uncle Louie's ghost, overunity zero-point energy sources, extraterrestrial communications, or new geological phenomena.

Of course, what you are usually seeing is nothing more than plain old noise. But such a mundane answer will rarely satisfy your typical pseudoscience "practitioner."

The crucial difference between serious research and pseudoscience is this: Whenever a real scientist or a real engineer gets a controversial or a strange result, they promptly spend monumental amounts of time and effort in *proving themselves wrong*. That is, finding out exactly where and how their measurements lied. Your pseudoscience practitioner instead runs out and starts gathering investors or getting on late night talk shows. That's because those folks are genuinely convinced they are "right" and often insist it is up to the rest of the world to drop everything they're doing, just to find out that an obvious and "not even wrong" mistake was made. So, I guess it may be way past time to review . . .

Measuring Low-Level Signals

It is trivially easy to trash up *any* low-voltage measurement, especially when high impedances are involved. I've summarized some steps you can take to avoid several more glaringly obvious problems in Fig. 1. Some problem areas are . . . .

• **Know your op-amps**—Typical op-amps have an input DC-offset error of a few millivolts. At higher gains, offset can cause several *volts* of output error or level shift. That offset is highly time and temperature dependent. Op-amp noise very much depends upon your source impedance and goes sharply up at very low frequencies. A badly chosen "low-noise" op-amp can end up much noisier than a regular one.

• **Always work differential**—If you use a balanced or differential circuit, your input signal appears as the difference across an opposed pair of amplifying devices. Any interfering or common-mode signals that bounce both inputs up and down together will be pretty much ignored. A multiple op-amp instrumentation amplifier circuit is particularly adept at processing low-level differential signals.

• **Carefully shield and guard**—Sensing leads to any input should always be as short as possible and be carefully shielded against both electric and magnetic fields. Analog and digital grounds have to be kept strictly separate. It is extremely important to prevent any ground trace noise from ending up in series with your sensed input! The finest shielding of all comes from driven guards, where shielding is actively powered from a unity-gain and low-impedance copy of the actual input signal. That forces zero volts (and thus zero current) between signal and shield.

• **Know your noise floor**—If you turn up any amplifier loud enough, you will get output every time, and a lot of it will not appear to be all that random. You'll usually see thermal noise from the input resistance, first-stage noise additions, hum, interference, local radio stations, excessive bandwidth, microphonics, poor shielding, nearby computers, and anything electronic within a few miles. Always be able to show your noise floor and know your signal-to-noise ratio.

• **Quickly go digital**—The more analog parts to your circuit, the more possibilities there are for noise, drift, and interference. Always do your digital conversion as early as possible at the lowest possible level. Analog Devices has a number of signal conditioning chips that are ideal for that.

• **Isolate**—Long test leads or excessive electronics near what is being sensed can very much affect what you'll see. One option is to build your sensing electronics as small as possible, and then opto-isolate them using an IRDA driver or whatever. Special isolation amplifiers are also available through Burr Brown and others that will nearly completely isolate a front-end sensor from the rest of your system.

• **Suspect all capacitors**—Electrolytic capacitors are a witches' brew of chaotic and nonlinear electrochemistry. They should never be used in low-level

NEED HELP?

Phone or write all your US Tech Musings questions to:

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Synergetics
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Tel: 520-428-4073

US e-mail: don@tinaja.com
Web: http://www.tinaja.com

1 – Know your opamp's offset, offset drift, noise voltage, and noise currents.

2 – *Always* use balanced differential inputs in an "instrument" configuration.

3 – For lowest noise, carefully match your opamp to your source impedance.

4 – Effective electric and magnetic shielding is a must.

5 – *Never* permit *any* ground currents in series with your inputs.

6 – Thoroughly separate all of your analog and digital grounds.

7 – Consider using active guarding instead of grounded shields.

8 – Know your system noise floor and noise sources, both external and internal.

9 – Restrict bandwidth to only that needed for an effective measurement.

10 – Convert to digital as near to the front end and at as low a level as possible.

11 – Suspect *all* capacitors. *Never* use an electrolytic in a low level signal path!

12 – Isolate low level circuitry with optocouplers or special isolation amps.

13 – Consider using carriers, lock-in amps, sync demods, or autocorrelation.

14 – *Always* assume controversial results are dead wrong. *Blame yourself first!*

15 – *Always* use *Ockham's Razor* to seek the simplest explanations.

16 – *Always* seek independent third party verification.

17 – *Never* jump to conclusions!

FIG. 1—MY GUIDELINES for lab measurement of low-level signals can prevent you from being fooled.

signal or filter paths. Other capacitors have "bounce-back," memory, and electret effects that depend upon the previous charge history. Some respond more than others to temperature, motion, voltage, stress, humidity, or pressure. Any could act as microphones, seismometers, or even as piezo actuators.

•**Watch circuit details**—Op-amps have gain and phase margins that might become unstable with certain loads and certain feedback combinations; know all those margins! Supply pins should always be well bypassed and decoupled as close to your chips as possible. Prevent all unintentional feedback through careful PC-board routing that keeps outputs far away from any inputs.

• **Consider a carrier**—By modulating a desired signal onto an input carrier, drift and excess low-frequency noise can often be eliminated. Narrow-band filtering can also end up being much easier. While such techniques were once called lock-in amplifiers, modern applications apply digital autocorrelation, phase-locked loops, or sync demods.

• **Don't jump to conclusions**—Even when you're cleanly measuring some low voltage, a signal can easily have a wildly different source than you think it does. Always examine the simplest and most obvious possible answers first, and always seek an independent check of some sort to fully verify that what you think you have is really there.

You can find more on dealing with "too good to be true" results in HACK 87.PDF, and more on pseudoscience stuff in the Pseudoscience Library Shelf and the Oddball Pseudoscience links. All of that can be found on my http://www.tinaja.com Web site.

A Self-Zeroing Op-Amp!

As we've just seen, all operational amplifiers have an unavoidable input offset. A typical offset in a low cost op-amp might be 5 millivolts, with a temperature drift of 100 microvolts per degree C.

One cause of that offset is a slight and unavoidable mismatch between the bipolar transistors or FET devices on the non-inverting and inverting inputs. At high gains, such an offset can generate several volts of DC output offset.

One way to measure the offset of a higher gain op-amp is to simply short your inputs and measure your output level. Some op-amps bring out offset-adjustment pins that let you purposely introduce an unbalance to take out most of the offset as long as the temperature doesn't change.

Well, Texas Instruments has just gone a giant step further with their TLC4502 *self-calibrating* op-amp; see Fig. 2. That chip looks and behaves like

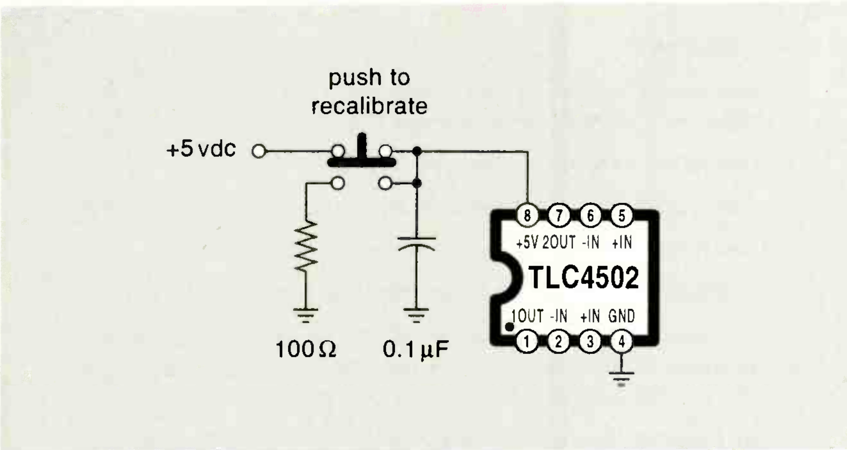

FIG. 2—THE TLC4502 LOOKS AND ACTS like any other $2 dual operational amplifier, except it automatically measures and then cancels out its input offset on power up. Run time offsets are an astonishingly low 50 microvolts maximum with a temperature drift of under 1 microvolt per degree C.

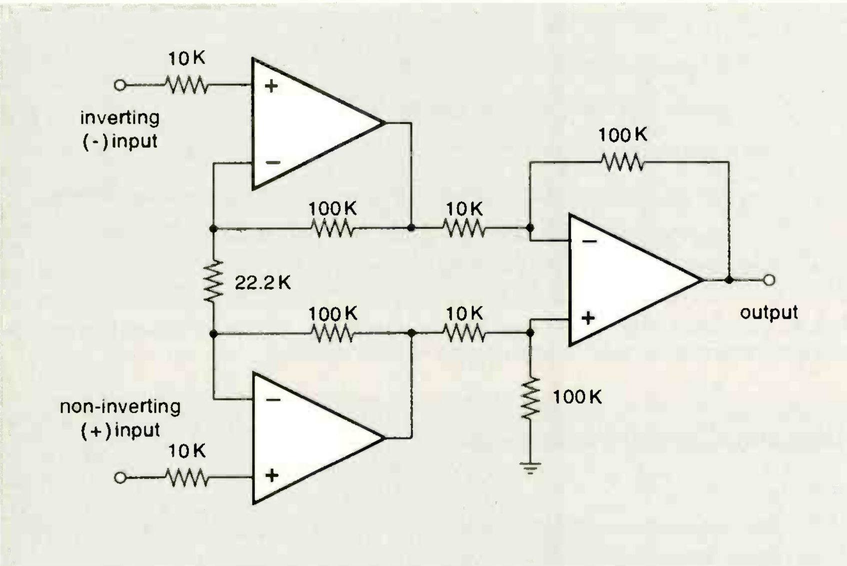

FIG. 3—THIS INSTRUMENT OP-AMP has balanced differential inputs, extreme input impedance, and identical phase delay on both inputs. Values shown give a voltage gain of 100. Use 1% resistors.

nearly any other $2 small-outline, dual rail-to-rail op-amp, except for a key difference: On power up, a special routine is entered that temporarily shorts the op-amp inputs. At the same time, the output is opened. The input offset voltage is then measured and digitally saved. A mere 0.3 seconds later, the op-amp returns to "normal" behavior, but with input offsets of 50 microvolts and an offset drift of a really amazing 1 microvolt per degree C! That's a 100:1 improvement, and it gets better.

The unity gain slew rate is 2.5 volts per microsecond, the noise is 12 nanovolts/$Hz^{0.5}$ at 1 kHz, and the supply current is only 1.5 milliamps per amplifier. Open-loop gain is 120 decibels. The large pulse settling time is around 20 microseconds, and small pulses can settle ten times faster. Harmonic distortion is 0.08 percent, specified at a gain of ten. Inputs can be at ground. Output impedance is less than a tenth of an ohm. Output short-circuit protection is built in and self-resetting. Supply voltage is +4 to +6 volts. Input offset current and input bias current are less than 500 *pico*amperes! The input resistance is an outstanding twelve *million* megohms. You can recalibrate any time by removing the supply voltage. And those specs just scratch the surface.

What all that tells us is that we have an amazing quantum leap in op-amp technology here, especially for cost-sensitive, higher impedance uses at mid audio frequencies. Lots of use examples appear on the data sheet (available on line at www.ti.com), including several instrument amplifiers, current sources, and peak detectors. A clone of their classic instrument amplifier appears here as Fig. 3.

New Technical Book Source

Butterworth-Heinemann has opened a new technical paperback series in their Newnes offprint. Many dozens of new and updated titles from an international stable of well-known authors appear in their new free catalog. Several titles I have found rather interesting are *The Basic Stamp* by Kuhnel and Zahnert; *Introduction to Fiber Optics*, by John Crisp; and Lou Frenzel's reissued *Crash Course in Electronics Technology*.

Also, my *Active Filter Cookbook* and *CMOS Cookbook* are stocked at your favorite bookstore as Newnes titles. Autographed copies are also available from my Synergetics Press. Similarly, the *TTL Cookbook* is available locally as a Macmillan title or from Synergetics Press. The Newnes Web site can be found through www.bh.com

Hand Bookbinding Resources

I just wrote up a major update on "book-on-demand" publishing as RESB N66.PDF (on www.tinaja.com). The bottom line is that nearly all of the tools and needed techniques are in place for successful low-end publishing-on-demand.

The Hewlett-Packard 4M+ or 5M+ make acceptable duplexing printers, while their 5SiMX is absolutely ideal. And the cute little Alps MD2010 makes a great cover printer.

Binding options are still somewhat limited, so big bucks remain to be made for you if you could come up with a simple and low cost home or smaller scale binding solution. Meanwhile, there is always the obvious route of traditional classic hand binding.

I have just run across a bunch of nonobvious tools in this arcane field, so I thought we would cover some of those in our resource sidebar. I suspect that the ultimate BOD solution will end up as a mix of hand-crafted and commercial techniques, so there's lots to study here.

More on all this is found in my *Book-on-demand Publishing Kit*, per my nearby Synergetics ad, or on the BOD library shelf of www.tinaja.com.

Measuring Web-Site Hits

Actually, "hits" is a monumentally over-inflated concept. For a "hit" is any access to any site at any time for any reason. Your typical visitor will often create a dozen or more hits as background wallpaper, images, bars, buttons, or whatever are grabbed. But that does not tell you exactly how many left-handed Brazilian cat-fanciers visited your site at 2 A.M. last Tuesday.

Instead of hits, you usually want to know how many user sessions there were. There are all sorts of hit-analysis software of varying cost and quality out there, and your ISP may also offer custom reporting services. Most of this software is based on reading one or more log files that are obtained from your ISP.

Details are shown in Fig. 4. A log file picks up an entry every time your site gets accessed for any reason. Thus, one line of a log file is one Web-site hit. It may be useful to split the log-file line into a grouping of four or more records. You can then mix and match the records to extract useful information.

The examples that follow refer to an older Apache server. Details may differ with newer technology, but the concept of a readable and extractable log document remains.

The first record is the URL address. That is usually a "words" style URL, such as charlie.icjb.com. Sometimes you

The ACCESS log–

Each text line in the access log file consists of a site *hit*.
A hit is one access to a site requesting a single page or file.

A typical *name addressed* hit line may look like this...

drooper.mcb.com - - [01/Jun/1997:20:15:06] "GET / file5.pdf HTTP/1.0" 200 14234

Or a hit line might use a *nuemric address* such as...

145.65.224.42 - - [01/Jun/1997:20:15:06] "GET / file5.pdf HTTP/1.0" 200 14234

Either way, everything up to the first "-" is the client doing the requesting. Everything in the brackets is the time and date. Everything in quotes is the requested action, followed by the requested protocol.

The three-digit number that follows is the HTML error or status code. Code "200" is a normally filled request and is followed by the number of bytes transferred. Other codes do not transfer bytes and are followed by a hyphen.

The ERROR log–

Each line of an error log reports one client problem.

Here is an error line caused by some network difficulty...

[Thu Jun 19 16:19:31 1997] send timed out for 143.86.15.97

Here is an error line caused by a possible bad link on your site...

[Thu Jun 19 16:21:11 1997] access to usr/home/finedemo failed for scott.mmn.edu

In either case, the initial brackets hold the time and date. The rest of the line explains the problem and the client that was involved.

FIG. 4—READING HTML LOG FILES from an Apache server. Newer servers may include additional information, such as referral sites or client software.

HAND BOOKBINDING RESOURCES

SUPPLIERS

Amazon Books
Box 80387
Seattle, WA 98108
(800) 201-7575

Bookbinders Warehouse
31 Division Street
Keyport, NJ 07735
(908) 265-0306

Bookmakers
6001 66th Avenue
Riverdale, MD 20737
(301) 459-3884

Colophon Book Supply
3046 Hogan Bay NE
Lacey, WA 98516
(206) 459-2940

Dover Publications
31 E 2nd Street
Mineola, NY 11501
(516) 294-7000

Gane Brothers
1400 Greenleaf Avenue
Elk Grove Village, IL 60007
(800) 323-0596

Gaylord Brothers
PO Box 4901
Syracuse, NY 13221
(800) 634-6307

Light Impressions
439 Monroe Avenue
Rochester, NY 14607
(800) 826-6216

Lindsay Publications
PO Box 538
Bradley, IL 60915
(815) 935-5353

Talas
568 Broadway
New York, NY 10012
(212) 219-0770

BOOKS

The Art of the Handmade Book, Flora Fenimore, Chicago Review Press, 1992.
Basic Bookbinding, AW Lewis, Dover Publications, 1985.
Binding and Finishing, Geoff Porter, Chapman & Hall, 1991.
Binding and Repairing Books by Hand, David Muir, Arco, 1978.
Book Binding Made Easy, Karen Moore, University Publishing, 1994.
Book Binding: Its Background & Technique, Edith Diehl, Dover, 1985.
Bookbinding: A Manual of Techniques, P. Richmond, Trafalgar Square, 1995.
Bookbinding with Adhesives, Tony Clark, McGraw-Hill, 1995.
Bookworks; Making Books by Hand, Gwenyth Swain, Carolrhoda Books, 1997.
The Craft of Bookbinding, Manly Banister, Dover Publications, 1994.
Creative Bookbinding, Pauline Johnson, Dover Publications, 1990.
Cover to Cover: Creative Techniques Making Books, S LaPlants, Lark, 1995.
Glue-Binding Your Books, David A Wilson, Lorien House, 1990.
Hand Bookbinding: A Manual of Instruction, Aldren A Watson, Dover, 1996.
Handmade Books: An Intro to Bookbinding, R Shepherd, Arthur Schwartz, 1995.
Handmade Books: A Step by Step Guide, Kathy Blake, Little Brown, 1997.
Making Books by Hand: A Step by Step Guide, McCarthy, Rockport Pub, 1997.
The Making of the Book: A Sketch, A. Cox, Oak Knoll, 1986.

WEB SITES

www.amazon.com www.redmark.co.nz holly.colostate.edu www.lindsay.com

NAMES AND NUMBERS

Alps Electric
3553 North First Street
San Jose, CA 95134
(408) 432-6000

Analog Devices
PO Box 9106
Norwood, MA 02062
(617) 329-4700

Astec Semiconductor
255 Sinclair Frontage Road
Milpitas, CA 95035
(408) 263-8300

Burr-Brown
6730 S Tucson Blvd.
Tucson, AZ 85706
(520) 746-1111

Cards of Wood
PO Box 310
Belmont, MI 49306
(616) 887-8257

Chip Scale Review
3099 Orchard Drive
San Jose, CA 95134
(408) 383-3653

Crafters Choice
11248 Playa Court
Culver City, CA 90230
(800) 421-6692

Dicker International
225 Broadway, Suite 2000
New York, NY 10007
(212) 962-3232

e.g. Software/WebTrends
621 SW Morrison #1025
Portland, OR 97205
(502) 294-7025

Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112
(800) 854-7179

NESDA
2708 W Berry Street
Ft Worth, TX 76109
(817) 921-9061

Newnes
313 Washington Street
Newton, MA 02158
(617) 928-2500

Pericom Semiconductor
2380 Bering Drive
San Jose, CA 95131
(800) 435-2336

Philips Technical Training
PO Box 555
Jefferson City, TN 37760
(800) 851-8885

Synergetics
Box 809
Thatcher, AZ 85552
(520) 428-4073

Texas Instruments
PO Box 809066
Dallas, TX 75380
(800) 336-5236

might see a "numbers" URL such as 201.114.162.212. It is tricky to tell which country a numbers URL comes from. The URL record is everything up to the first "[" in the log file line.

The second record is the exact date and time of day, and is everything from your first "[" in the log file to the first "]". The third record is the action that was requested—usually a page or a graphic to be downloaded. That entry is always bracketed by quotes, and usually starts with "GET."

The final record is everything from the second quote to the end of the log line. That usually consists of a code number followed by a hyphen or a numeric. Code "200" indicates the "successful transfer" and is followed by the number of bytes downloaded. Other codes usually include 001 for interrupted, 304 for "use previous cached information," 403 for forbidden, and 404 for not found. Figure 5 shows those and other codes.

An error file might be separate or included as part of the main log file. The error file lists only problem hits. Such as a send timeout or possibly a read timeout from slow Web routers. Or an access error, possibly caused by mis-entry or a site foul-up.

Error files are particularly useful to pin down problems with your Web site, such as missing, misspelled, or misdirected links. Sadly, an error file cannot normally pin down a broken external link from your site.

There are two fields in an error-log line entry. The first is a date set in brackets. The second is the problem that has occurred. If a problem keeps happening from several different visitors, chances are it is your fault and not theirs. If the problem isn't that obvious, you can always go back into the main log file to find where these folks just came from. Odds are good the problem is on the previous page hit of yours.

On certain newer servers, there's sometimes a third magic file or entry known as a referral log. That one will reveal to you the immediately previous site your visitor came from and is very useful for tracing how effective site links or ad banners are. You might need to make special arrangements through your ISP to access the referral logs, and there may be an extra charge because more comm or access time might be needed.

One highly useful indirect method of measuring site popularity (and a great ego trip) is to determine how many other sites have active links to yours. One easy way to find possible referral links is with the find URL links feature of Hotbot. Another route is to use Alta Vista, prefixing with link:. Access to these are found on the Web Resources page of www.tinaja.com.

One fairly impressive commercial analyzer is Web Trends sold by e.g. Software. This package nicely presents an amazing amount of detail. Free 15 day trials are available.

I have written a custom Web site analyzer, though it is mostly for Apache servers and in Postscript, of course. It's available free at www.tinaja.com/psutils/websitan.ps.

To use the analyzer, read it in an editor or word processor and change all the filenames and variables as appropriate. Then send it to either Acrobat Distiller or GhostScript.

This routine could be useful any time you are after highly specialized information, such as watching a new and obscure page moving on up through the ranks. It is certainly a great PostScript-as-language demo.

New Tech Lit

Unusual data books for this month include an *Astec Semiconductor Data Book* on power supply chips and the *Pericom CMOS Data Book* on many chips, including bus switches. From Analog Devices, there's the *Accelerometer News* newsletter.

From Lindsay Publications comes a new compendium on *Hot Air Engines*. It's

001 –	incomplete
200 –	successful transaction
201 –	created
202 –	accepted
203 –	partial information
204 –	no response
301 –	moved
302 –	found
303 –	method
304 –	use previous cache
400 –	bad request
401 –	unauthorized
402 –	payment required
403 –	forbidden
404 –	not found
406 –	incomplete
500 –	internal error
501 –	not implemented
502 –	temporary overload
503 –	gateway timeout

FIG. 5—SOME HTML error codes.

a well done reprint collection of some 17 patents from 1871 to 1959. Sadly, however, hot-air engines are just that: First because they get misapplied to woefully inefficient, low-temperature-differential applications, and secondly, because there is a magic part called a regenerator that nobody has ever figured out how to make. Regenerators have to be short and fat and long and thin—and that's besides being both an excellent conductor and an excellent insulator. Nonetheless, we've now got a fine historical document on a monumental engineering rathole. More on other engineering ratholes is stashed in RATHOLES.PDF on www.tinaja.com.

One source for Bliss Electronics musical greeting card modules is Dicker International. An interesting Web site on TV closed captioning can be newly reached at www.caption.com/caption-info.html. The key engineering standards document is EIA #608.

One pricey source for any standard is at Global Engineering Documents. Our new trade journal of the month is *Chip Scale Review*. A brand new *ProService* directory and yearbook is offered by NESDA. From Philips, a new *Technical Training Catalog* on VCR/ camcorder service and such.

Genuine wood microveneers, thin enough for laser printing, are offered by Cards of Wood. There's all sorts of obvious modelmaking possibilities here. Prices start at a dollar per sheet. Free samples of a wide variety of low energy magnets are available by way of Crafter's Choice.

For the fundamentals of starting up your own tech venture, check out my *Incredible Secret Money Machine II*. Per my nearby Synergetics ad. You can also preview the introduction on my web site. Full catalogs are available online at www.tinaja.com, or can be gotten via phone, snail-mail, or email.

My Web site is now getting some 125,000+ hits per month, so we are now accepting surprisingly low-cost, commercial banner ads. For details see http://www.tinaja.com/advt01.html.

As usual, most of the mentioned items should appear in the "Names & Numbers" or the "Hand Bookbinding Resources" sidebars. Be certain to check those before you dial up my no-charge US technical helpline that you'll find in the "Need Help?" box. EN

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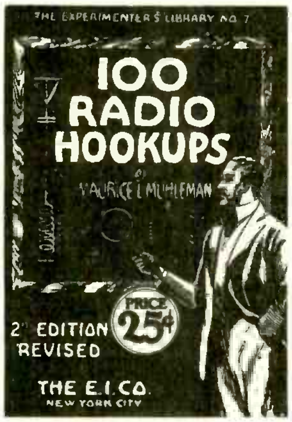
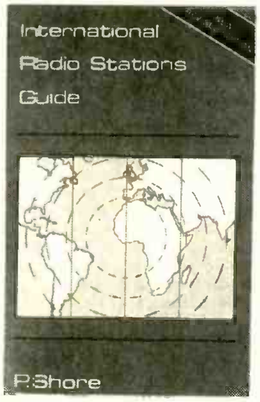
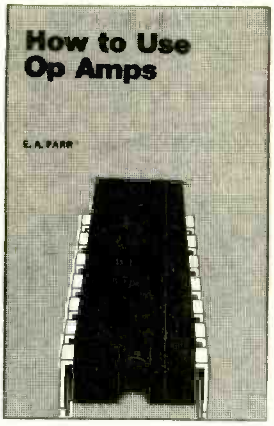


First published in May, 1923 this popular booklet went into reprint editions nine times. It is packed with circuits, theory, antenna installation and tips on consumer radio receivers that were popular in the early 1920's. Antique radio buffs and those inquisitive about the early days of radio will find this booklet an exciting, invaluable and excellent reference into the minds of early-day radio listeners. Sorry, we cannot honor the original 25-cent cover price.

☐ INTERNATIONAL RADIO STATIONS GUIDE—BP255 —$9.95



Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed as a guide for listening tothe complex radio bands. Includes coverage on Listening to Shortwave Radio, ITU Country Codes, Worldwide Radio Stations, European Long Wave and Medium Wave Stations, Broadcasts in English and more.



☐ HOW TO USE OP AMPS —BP88—$5.95

The engineer's best friend is the op amp. This basic building block is found in many circuits, analog and digital alike. The op amp finds many useful purposes such as: oscillators, inverters, isolators, high- and low-filters, notch and band-pass filters, noise generator, power supplies, audio, MIDI, and much more. Prepared as a designer's guide, some limited math is used, however engineers and hobbyists alike find it a useful text for their design needs.

☐ WIRELESS & ELECTRICAL CYCLOPEDIA —ETT1—$5.75

A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period. Take a look at history and see how far we have come. And by the way, don't try to order any of the radio parts and receivers shown, it's very unlikely that it will be available.

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7¼L x 2½H
The built-in controller allows you to do text and graphics.

Alphanumeric—parallel interface

16x1	$7.00	20x2	$10.00	40x1	$8.00
16x1 (lg. char.)	$10.00	20x4	$15.00	40x2	2 for $20.00
16x2	$7.00	20x4 (lg. char.)	$10.00	40x4	$20.00
16x2 (lg. char.)	$10.00	24x2	$10.00	4x2	$5.00
16x4	$15.00	32x4	$10.00		

5V power required • Built-in C-MOS LCD driver & controller • Easy "microprocessor" interface • 98 ASCII character generator • *Certain models are backlit, call for more info.*

Graphics and alphanumeric—serial interface

size	Mfr.	price	size	Mfr.	price
640x480 (backlit)	Epson	$25.00	480x128	Hitachi	$10.00
640x400 (backlit)	Panasonic	$20.00	256x128	Epson	$20.00
640x200	Toshiba	$15.00	240x128 (backlit)	Optrex	$20.00
480x128 (backlit)	ALPS	$10.00	240x64	Epson	$15.00
			160x128	Optrex	$15.00

6" VGA LCD 640X480, Sanyo LMDK55-22 **$25.00**

LASER PRODUCTS

HeNe Laser Head (10Mw max. output) TEMOO. 15.5" long MFG: NEC **$99.00**
Laser Power Supply (for HeNe tube) **$89.00**

LASER SCANNER ASSEMBLY $19.00
Assembly intended for a laser printer. Includes laser diode, polygon motor (6 sided) and misc. optics and lenses.

LASER DIODE (5mW) with collimator **$20.00**

VISIBLE LASER DIODE: 5mw at 670nm **$15.00**
Index guided. Threshold current 40 ma typical.

3 and 4mW, 1,300nm LASER DIODES, 5.6mm package, $15.00
Mitsubishi Electric part number ML701BIR-E21A, General specs are:
1. Vop=1.25, Beam Divergence 25.6° x 28.6°; 2. Tc=24°C, Iop=19 to 20mA, ITH=10.7mA; 3. Wavelength range between 1,280nm and 1,330 nm

POLYGON MOTOR UNIT & DRIVER $79.00
Ten-sided first surface mirror mounted on an armature that spins at 125 revolutions per second yielding a beam sweep rate of 1250 sweeps per second. The driver for the polygon unit requires 24 volts and plus and minus 12 volts to operate. There is also an f-theta lens in front of the polygon scanning mechanism with a three inch diameter. Great for optical experiments, etc. Very high quality units. (MFR: JAPAN ELECTRONICS)

NETWORK

Proteon ProNet-4 Model p1347 Token Ring Board $49.00
16 bit • 4 Mbps • IEEE 802.2 and 802.5 compatible • twisted pair • interoperable with IBM Token Ring network

POS & BAR CODE

MAGNETIC CARD READER $25.00
Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

HP bar code wand (HBCS 2300)....................$25.00

POWER SUPPLYS

SWITCHING POWER SUPPLYS $12.00 or 2 for $20.00 115/230 Volts
73 WATT (2) 4 pin power connectors attached • Dim: 8.5" L x 4.5" W x 2" H
Output: +5V @ 2-9.75, A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A
68 WATT Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A
60 WATT Dim: 8¾ x 4¼ x 3 • Output:5V @ 6A + 12V @ 1A - 5V @ 1A - 12V @ 1A

CHARGE COUPLED DEVICES

"The Spy In The Sky" $29.00 MATRIX TYPE

Thomson 576X550 pixel CCD
400-1,100nm resolution and responsivity. **$500.00 Original cost device**

Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V) $29.00
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um².
Ceramic 24 pin DIP package • Mfr: Sony, Part# 016AL

LINEAR TYPE

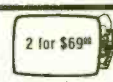
4096 element CCD $15.00
1024 element CCD $10.00
2048 element CCD $10.00 • 1728 element CCD $10.00

MONITORS

Non-Enclosed TTL

Comes with pinout. 12V at 1.4 Amp input • Horizontal frequency 15Khz. • Ability to do 40 and 80 column.
5 inch Amber $25.00 • 7 inch Amber $25.00
9 inch Amber or Green $25.00

5" COLOR MONITOR $39.00



• Flat Faceplate • 320 x 200 Dot Resolution • CGA & Hercules Compatible
• 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
• Open Frame Construction • Standard Interface Connector • Degaussing Coil included • Mfr. Samtron

9" monochrome SVGA MONITOR $79.00
Fully Enclosed – Tilt and swivel type. **Mfr: WEN**

MISCELLANEOUS

ADAPTEC 4070A (RLL) OR 4000A (MFM), SCSI Controller, your choice $25.00

IBM 370 option XT and AT emulation boards $25.00

HACKER CORNER

US made Micronics 486 VLB ALL in ONE $69.00 or 2 for $129.00 motherboard, supports 3.4 or 5V CPU, at either 25 or 33 mhz basic clock. Can use AMD or Intel from 486SX25 thru 486DX4-100 to HOT new AMD 5X86-133 cpu. On board SVGA video. On board 1 meg video ram expandable to 2 meg with ATI Mach 2 chip set. On board 2 high speed serial ports, 1 printer port, floppy and IDE hard drive controller. On board 256K cache. Uses 72 pin simm memory. Landmark speed rating of 479 with AMD chip.

Board will not fit standard All in One case because of non standard location of riser board. VLB riser board is included with motherboard.

COLOR CCD CAMERA $149.00
• 12 VDC • 1/3-inch, CCD area image sensor • 514 (horizontal) x 491 (vertical) • 2:1 interlaced • 15.734 kHz (horizontal), 59.94 Hz (vertical) • 330 horizontal and 350 vertical lines • 10 lx • 1V, NTSC signal format • Lens: 1/3-inch, fixed focus (F:2.8 f:5.6) • Dimensions: (W) 67 (2.63) x (H) 34 (1.45) x (D) 112.6 (4.43)

SONY Miniature Color LCD Display (LCX005BKB) $29.00
• 1.4 CM (0.55 inch) Diagonal Full Color Display • Built In Horizontal and Vertical Drivers • Delta Dot Pattern for High Picture Quality - 537 dots (H) x 222 dots (V) • Compatible with NTSC & PAL Format and Sync Inputs • 12 VDC Operation with -1 to +17 V RGB Signal and Driver Input Voltage • Excellent Display for Virtual Reality Projects, Viewfinders, and Miniature Test Equipment Displays • Pin Outs and Specification Included • Unit Requires Clock, Synchronization and Video

CELL SITE TRANSCEIVER $79.00 2 for $149.00
These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 HMz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receivers, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

Encased Black & White Composite CCD Camera with Adapter
IR viewing to 1000 nm 7 ½ L x 2 ¾ W x 1 ¾ H
Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **$89.00**
Great for: entryway security/remote monitoring, video conferencing/desktop video conferencing **2 for $159.00**
This miniature camera is perfect for multimedia computer applications as well as security and surveillance. NTSC output allows use with all popular video digitizing boards for Apple Macintosh and Microsoft video for Windows. Connects directly to any composite monitor or VCR with "video" input. Its razor-sharp wide-angle lens focuses from two inches to infinity and its state-of-the-art CCD technology accurately captures 16 level grayscale images for Quick Time movies and still pictures. Records at 30 frames per second and 260 lines resolution with excellent low light capability. Uses 12VDC (adapter supplied) and standard RCA cable.

POINT OF SALE BANK TERMINAL $39.00 or 2 for $69.00
• LCD Display 20 Char. x 4 Line • Printer 16 Column Dot Matrix - Epson • 24 Key Domed Membrane Keypad • Intel 80C32 Processor • 2 PCMCIA Sockets (ICC Slots) • Dallas DS1287 Realtime Clock • 2 Solid State Buzzers (Piezo Electric) • 4 Crystals • Rockwell Modem Chip • Telephone Line Interface (4 Pin "RJ" Connector) • RS-232 Interface (8 Pin "RJ" Connector) • NI-CAD Battery Pack Inside
Note: We have not been able to bypass an access code in the software. Thus, while time of day and other introductory things are displayed on LCD, the full original capabilities of this unit cannot be guaranteed. Also, we do not have a source for the smart cards that were to go in the PCM CIA sockets. Requires 12 volt adapter for power. (Not included) Dimensions: 9-1/2L x 6-1/4W x 2-1/2 D • Original cost over $450.00

.6" COMPOSITE MINIATURE COLOR DISPLAY $99.00
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These meters feature rugged steel backs, U-clamp flush mounting, fade proof lithographed metal dials and glass fronts. Dimensions: 2"(D) x 1.5"(D). Accuracy 5%

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Rolled over front basket offers attractive appearance. Rubber surround, reinforced cone and 1" voice coil provide 48Hz~6KHz response and 60/100W RMS/peak power capacity. 8ohm.

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Order #	Type	(ea.)
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Your Choice $19.95

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72-7043	-30~0~30 Amp

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MCM AUDIO SELECT™

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Order #	(ea.)
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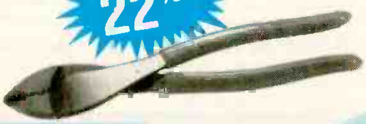

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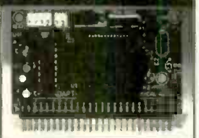

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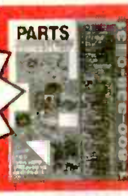

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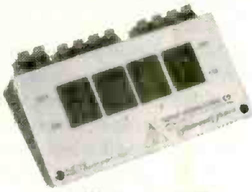

Control up to 4 pairs of speakers with this compact speaker selector switch. Features circuit protector, heavy duty rocker switches, spring loaded terminals, and silver plated switch connectors. Includes one pair of amplifier inputs. Load to amplifier is minimum 4 ohms (with 8 ohm speakers) or 220 ohms with all speakers switched off. Net weight: 1 lb.

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#EN-309-030	$22.50 EACH	$15.00 EACH

Peak Instrument Co.

"The Woofer Tester"

Peak Instrument Co. proudly introduces "The Woofer Tester". Just ask any loudspeaker engineer, and they will tell that the only way to design enclosures of the correct size and tuning is to measure the Thiele-Small parameters for the actual drivers to be used. The reason? Manufacturers published specs can be off by as much as 50%! But until now, measuring the parameters yourself required expensive test equipment and tedious calculations, or super expensive measurement systems ($1,200 to $20,000). The Woofer Tester changes all that. Finally, a cost effective, yet extremely accurate way to derive Thiele-Small parameters, in only minutes! The Woofer Tester is a combination hardware and software system that will run on any IBM compatible computer that has EGA or better graphics capability and an RS232 serial port. The Woofer Tester will generate the following parameters. Raw driver data: Fs, Qms, Qes, Qts, Vas, BL, Re, Le, SPL @ 1W/1m, Mmd, Cm, and Rm. Sealed box data: Fsb and system Q. Vented box data: Fsb, ha, alpha, and Q loss. The Woofer Tester system includes hardware, test leads, serial cable, AC wall adaptor, detailed instructions, and software.

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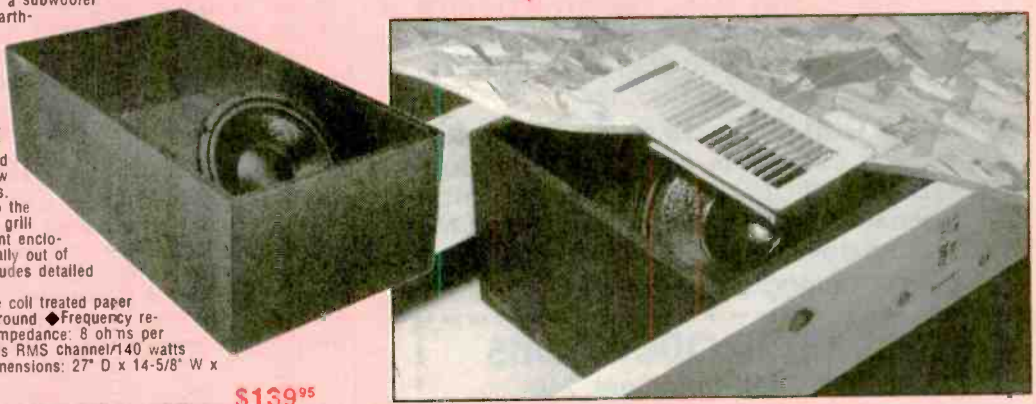
Home Theatre In-Floor Subwoofer

Dayton Loudspeaker Co.®



To fully appreciate the potential of movie soundtracks, a dual voice coil subwoofer is a must! Many film special effects are extremely demanding in the low frequency range and require a subwoofer that can duplicate explosions, earthquakes, even the footsteps of Tyrannosaurus Rex! This subwoofer fits the bill by featuring a 10" dual voice coil woofer for true stereo operation and high pass filters for your main speakers. The most unique feature of this subwoofer is the fact that it is designed to be mounted in between the floor joists in new and existing home constructions. Simply mount the in-floor sub to the joists and mount a heat register grill above opening in subwoofer front enclosure. The subwoofer is now totally out of view and ready to rumble! Includes detailed installation manual.

Specifications: 10" dual voice coil treated paper cone woofer with poly foam surround ◆Frequency response: 30-100 Hz ◆Nominal impedance: 8 ohms per coil ◆Power handling: 100 watts RMS channel/140 watts max ◆SPL: 89 dB 1W/1m ◆Dimensions: 27" D x 14-5/8" W x 9" H ◆Net weight: 29 lbs.

#EN-300-445 .... $139.95 EACH

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Don't let the price fool you. This meter is a digital multimeter designed for engineers and hobbyists. Equipped with 5 functions and 19 ranges. Each test position is quickly and easily selected with a simple turn of the FUNCTION/RANGE selector rotary switch. ***Rubber Boot Included***

Our Best Offer Ever on a High Quality Full Sized DMM

General

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery (NEDA 1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

$19.00 any qty

DC Voltage (DCV)

Range:	*Resolution:*	*Accuracy:*
200mV	100μV	±(1%rdg+2dgts)
2000mV	1mV	
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	*Resolution:*	*Accuracy:*
200μA	100nA	±(1.2%rdg+2dgts)
2000μA	1μA	
20mA	10μA	
200mA	100μA	
10A	10mA	±(1.2%rdg+2dgts)

Overload Protection: mA Input. 2A/250V fuse.

AC Voltage (ACV)

Range:	*Resolution:*	*Accuracy:*
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

Resistance (Ω)

Range:	*Resolution:*	*Accuracy:*
200Ω	100mΩ	
2000Ω	1Ω	
20KΩ	10Ω	±(1.2%rdg+2dgts)
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Switchable Scope Probe Sets

(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP 9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

CAT NO	DESCRIPTION	PRICE EACH 1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe Set DC~150MHz	24.95	21.95	18.62

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12" NEW!	12.78	10.65	8.52

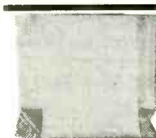
Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12" NEW!	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12" NEW!	22.09	18.35	14.68

Developer



This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

Removeable Hard Drive Racks

The ideal solution for protecting highly sensitive data. Or, buy one computer and allow individual users to keep their hard drive with their own applications and set-ups. Just turn the system off, lift the handle and the hard drive pops right out. Key lock included to avoid accidental or unauthorized removal. Includes hard drive activity LED's. Rack includes mounting hardware, keylock, front panel LED, convenient pull out handle. Made from high impact ABS plastic. Fits in 5.25" bay.

Features: • Ideal for Hard Drive Portability • Solve Software Data Security Issues • Carry Your Hard Drive Between Home and Office • Each User Can Have His or Her Personal Hard Drive

CAT NO	DESCRIPTION	PRICE
SpecialHDRACK-IDE	For IDE Hard Drive	$14.95

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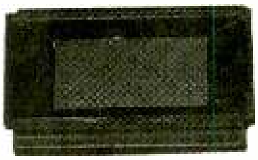
CIRCLE 332 ON FREE INFORMATION CARD

Digital Panel Meters (LCD & LED)



Don't let the prices fool you. These digital panel meters are not surplus, so even if you design them into an ongoing manufactured product, you can be assured of continued availability. These high quality digital panel meters are decimal point selectable with guaranteed zero reading at zero volts input.

Applications Include:

- Voltmeter
- Thermometer
- pH Meter
- dB Meter
- Watt Meter
- Current Meter
- Capacitance Meter
- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

PM-128: 3-1/2D LCD Digital Panel Meter
PM-129: 3-1/2D LED Digital Panel Meter

Features

- 200mV Full Scale Input Sensitivity
- PM-128 - Single 9VDC Operation
- PM-129 - Single 9VDC Operation
- Decimal Point Selectable
- PM-128 - 13mm Figure Height
- Automatic Polarity Indication
- Guaranteed Zero Reading for 0 Volt Input
- High Input Impedance (>100Mohm)

Specifications - PM-128/PM-129

Maximum Input	: 199.9mV DC
Maximum Display	: 1999 counts (3-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: PM-128 - LCD Display PM-129 - LED Display
Measuring Method	: Dual-Slope Integration A/D Converter System
Overrange Indication	: "1" Shown in the Display
Reading Rate Time	: 2-3 Readings per sec.
Input Impedance	: >100 Mohm
Accuracy	: +-0.5% (23+-5°C, <80% RH)
Power Dissipation	: PM-128 - 1mA DC PM-129 - 60mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: PM-128 - 9V DC PM-129 - 9V DC
Size	: 67mm x 44mm

3-1/2 Digit LCD 3-1/2 Digit LED 4-1/2 Digit LCD

PM-328: 4-1/2D LCD Digital Panel Meter

Features

- 200.00mV Full Scale Input Sensitivity
- Single 9V DC Operation
- Decimal Point Selectable
- 11mm LCD Figure Height
- Automatic Polarity Indication
- Low Battery Detection and Indication
- High Input Impedance (>100 Mohm)

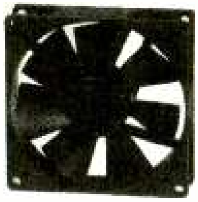
Specifications - PM-328

Maximum Input	: 199.99mV DC
Maximum Display	: 19999 counts (4-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: LCD Display
Overrange Indication	: "1" Shown in the Display
Input Impedance	: >100 Mohm
Accuracy	: +-0.05% (23+-5°C, <80% RH)
Power Dissipation	: 1mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: 9V DC
Size	: 67mm x 44mm

AS LOW AS $5.25 ea.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25	100	250
PM-128	3-1/2 Digit LCD Panel Meter	$ 9.90	$ 7.09	$ 6.40	$ 5.86	$ 5.25
PM-129	3-1/2 Digit LED Panel Meter	11.49	9.54	8.67	7.95	6.95
PM-328	4-1/2 Digit LCD Panel Meter	19.88	16.40	14.90	13.66	11.93

Ball Bearing 12V DC Fans



These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

INDUSTRY BEST PRICING!

CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

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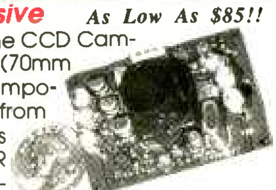
We stock high quality 60/40(Sn%/Pb%), .031" and 63/37, .031" diameter. This is prime JIS certified solder that we maintain as a regular stock item (it is not "Left-overs, Rejects or Surplus") and you can buy it from us at a fraction of the price that you are used to.

Tired of Paying Inflated Prices for Solder?

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

As Low As $85!!



This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connecting three wires: red to 12V, black to ground (power & video) and brown to video signal output.

Power Supply Regulating Kit for CA-H34 This simple kit is designed to fit onto the back of the CA-H34 CCD camera. It resolves the problem of hooking up the camera to an UNREGULATED supply (which damages the camera) by providing safe regulated power from any 12V-14V DC supply. It also provides regulated 12V DC from a 12V AC source.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$99.00	$85.00
A34	Power Supply Regulating Kit	$6.95	-----

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- Quality light-weight pencil iron

$36.95

SOLDERLESS BREADBOARD
830 tie points. MB102PLT model features 3 binding posts and aluminum backplate.

Part No.	1-9	10+
MB102	5.95	5.00
MB102PLT	8.95	8.00

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HIGH PERFORMANCE #060501 $5.25

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Goldstar 9020
20MHZ $339.00

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60 MHZ
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WITH CAP/FREQUENCY/ TRANSISTOR TESTER
Model DM645 $34.95

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#060836

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MAN72 C.A Red 0.3"
MAN74 C.C Red 0.3"

PAD-234 DIGITAL/ ANALOG TRAINER
Complete portable workstation. Variable and fixed power supplies, function generator, digital I/O, rugged design, high impact case.
Assembled $145.00 Kit $95.00

HIGH QUALITY TOOLS
With Cushion Grips and Return Spring
Needle Nose Pliers $2.95
Wire Stripper $1.50
Diagonal Cutter $2.95

POWER SUPPLIES
0–30 VDC, 0–3 Amp. Built-in current limiting, overload protected, constant voltage and current operation.

01PSGP4303A	Analog Display	$169.00
01PSGP4303D	Digital Display	206.00

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LM741 10 Min. .... 27¢ ea.
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PN2222 10 Min. .... 6¢ ea.
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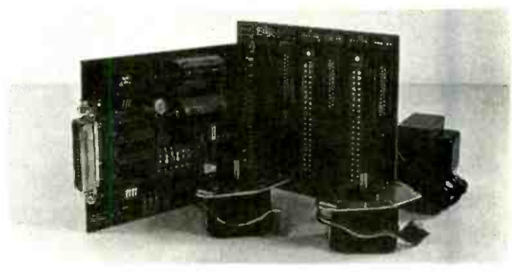

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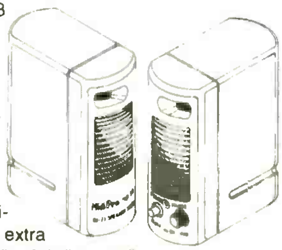

Midipro # MD58 Amplified stereo speakers for computer/multimedia use. 3 watts RMS/ 12 watts peak full range 8 ohm speakers. Beige cabinets, ported for extra response. 7.24" x 2.95" x 4.75". Operates on 6 volts. Includes cables. Requires either 4 C cell batteries or 6 to 12 volt power adapter (not included).

CAT # SK-58 $14.95 pair

Above speaker set including *DC POWER ADAPTER/BATTERY ELIMINATOR*

CAT# SK-58A $17.95 per set

SMALL NEODYMIUM RARE EARTH MAGNETS

Semi-circular, irregularly-shaped magnets. Shiny finish with a polarity marking dot. 0.93" long x 0.3" x 0.07" thick. Powerful for their size.

$1.00 each **CAT# MAG-30**

160 pcs. - $100.00

5 amp Solid State Relay

C.P. CLARE / Theta J # JTA2405-3 Compact, TTL compatible, optically isolated solid state relay for loads up to 5 amps @ 240 vac. 0.8" x 0.82" x 0.56" high epoxy block with a 1.4" long metal mounting flange. 1.19" mounting centers. 0.062" dia. x 0.175" high pins. Can be pc mounted or pins can be wrapped and soldered. UL and CSA listed.

Input: 4 - 8 vdc - Load: 5 amps @ 240 vac

$6.00 each **CAT# SSRLY-2405**

10 for $55.00

Ultrabright LED

PAINFULLY BRIGHT RED LED

2500 to 4000 mcd @ 20 ma. These T 1 3/4 (5 mm diameter) red LEDs are significantly brighter than conventional LEDs. At close range, they are painful to look at. They are great for attention getting displays that can be seen from a distance. Water clear in off-state.

CAT # LED-42 2 for $1.20

10 for $ 5.00 • 100 for $ 45.00
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Twist-On F-56 Connector

Twist-on co-ax connector for RG-6 cable. **CAT #FTO-56R**

100 for $15.00

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S-VHS VIDEO CORD

4' cable with miniature 4 pin mini DIN plugs on both ends.

CAT# CB-363

$2.00 each

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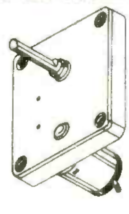
12 Vdc 100 RPM Motor



ECM # 66175
Reversible 12 Vdc permanent magnet motor. 100 RPM, no load. Gear assembly is 2.73" x 3" x 0.53". 0.25" diameter flatted shaft is 0.8" long. Motor and gear assembly depth is 2" excluding drive shaft. Four mounting holes tapped for 10/32 screws.

CAT # DCM-85 $12.00 each

410 UF, 300 VOLT PHOTOFLASH CAP.

Rubycon # 1A2304A
0.7" dia. X 1.7" long. Right angle PC or solder leads on 0.25" centers.

CAT# PPC-410

$2.00 each

10 for $18.50
200 for $320.00

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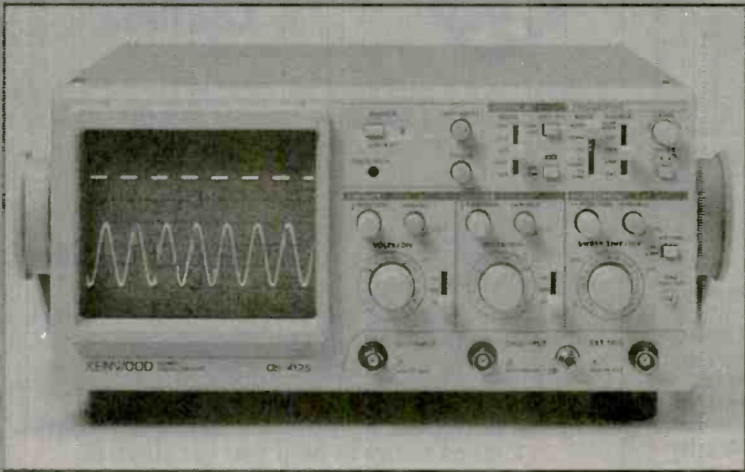

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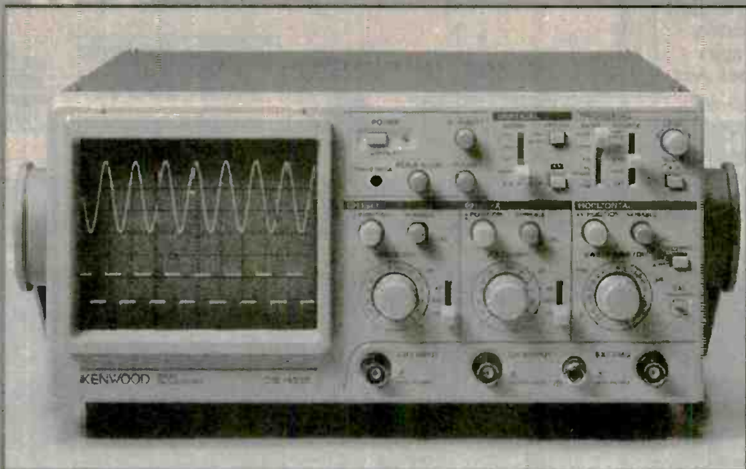

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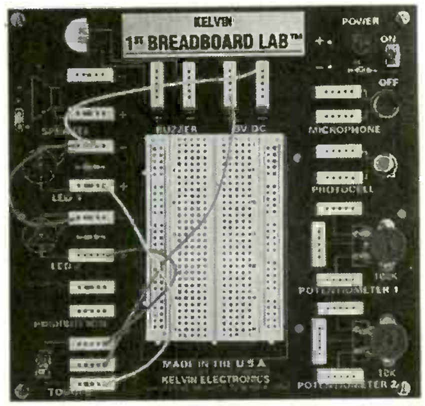

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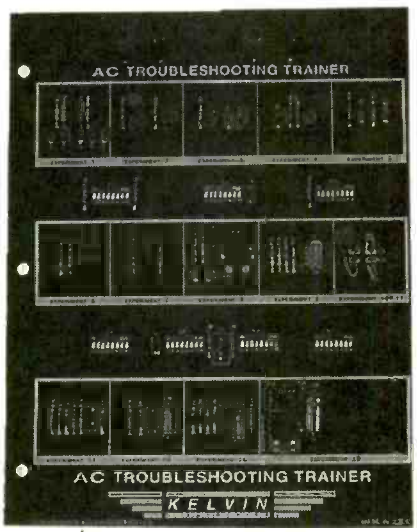

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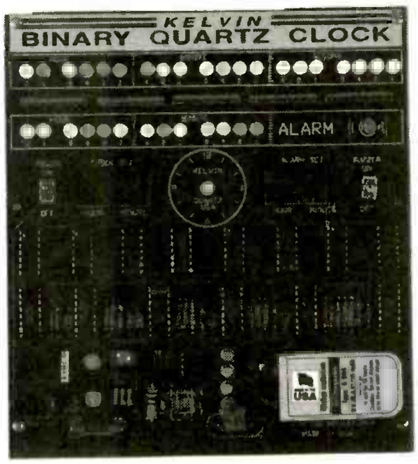

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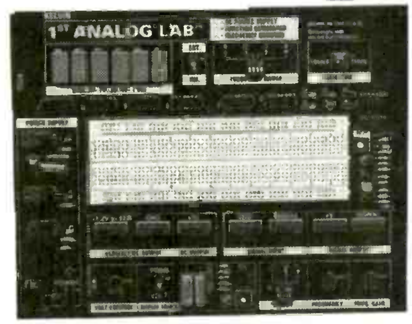

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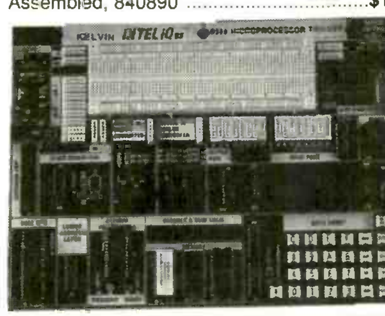

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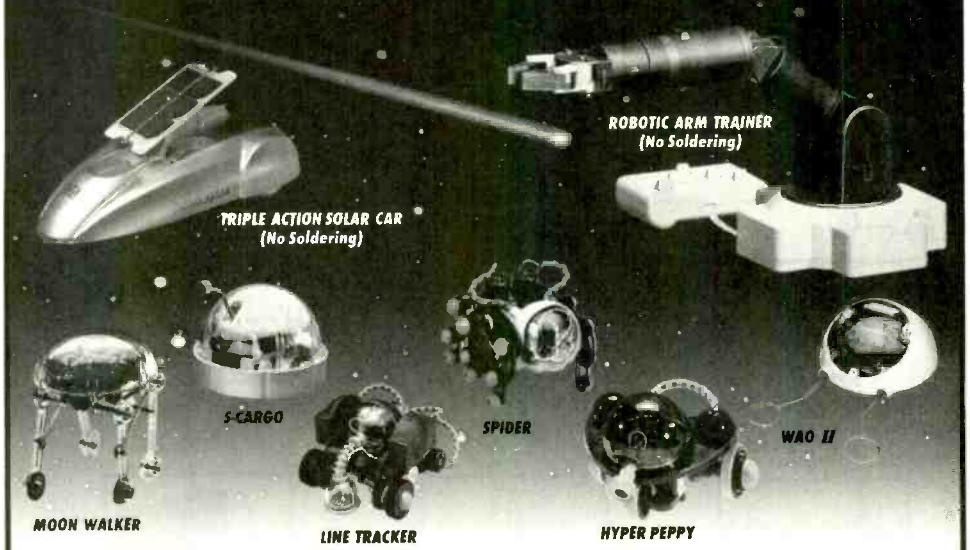

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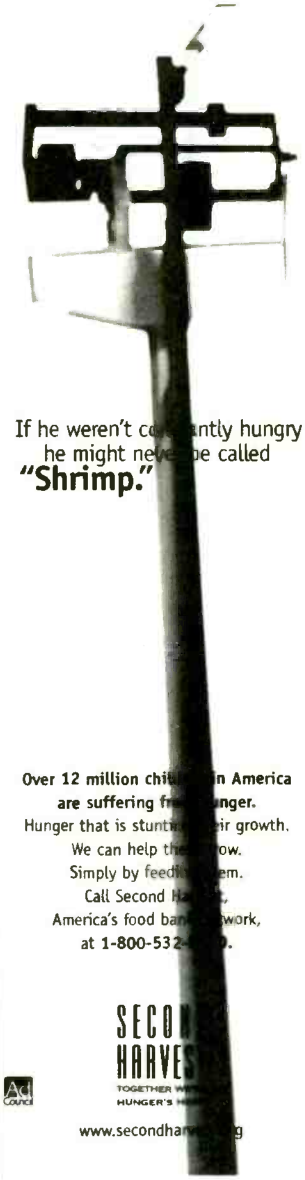

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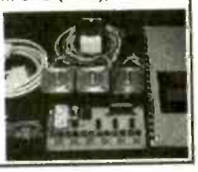

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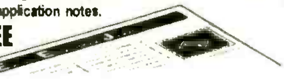

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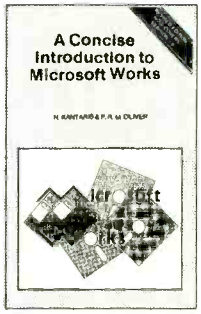

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