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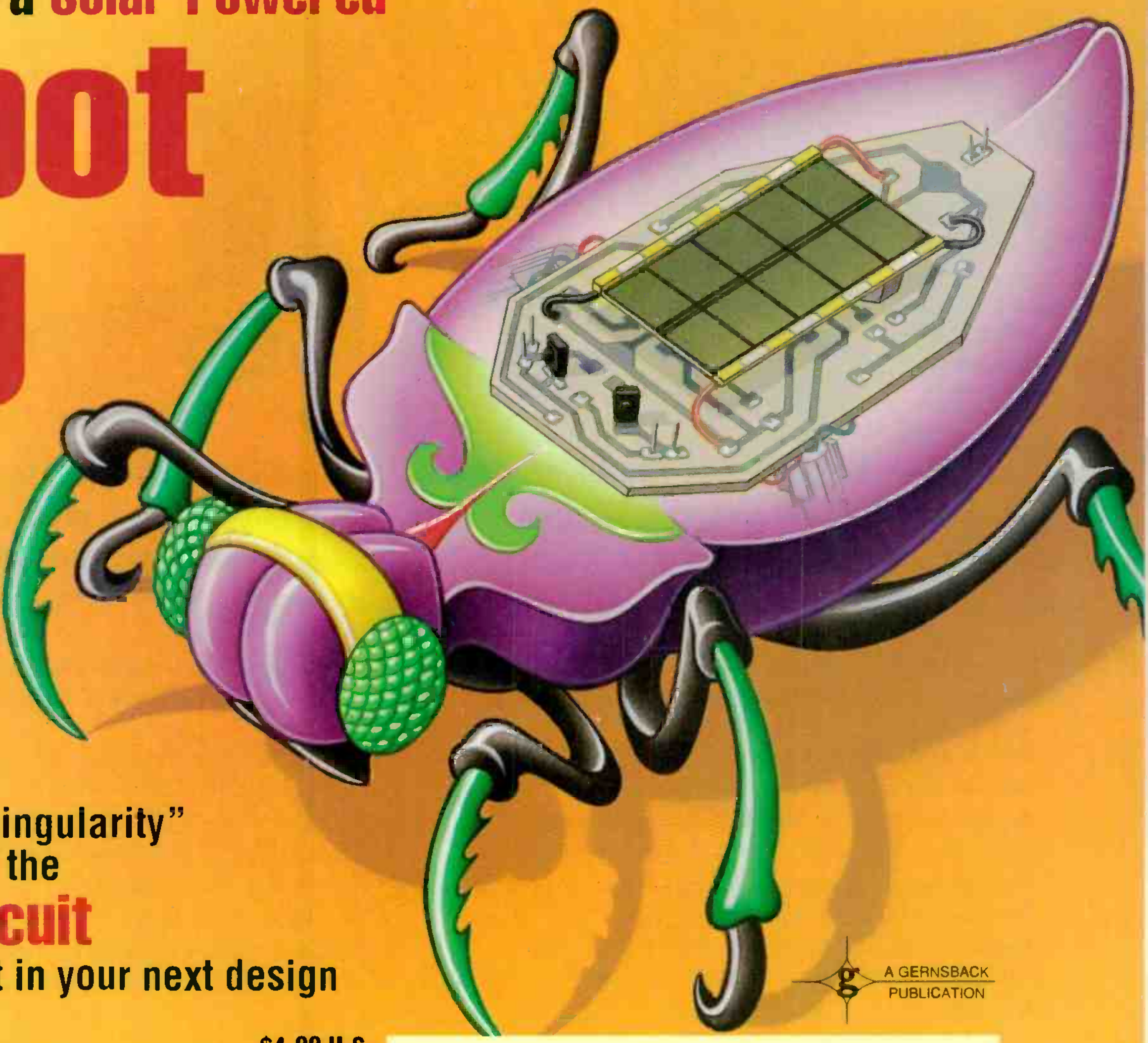

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Electronics NOW
Vol. 69 No. 11

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ON THE COVER

TECHNOLOGY

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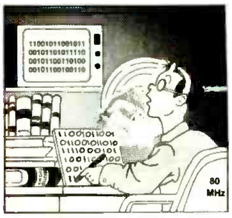

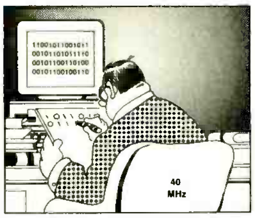

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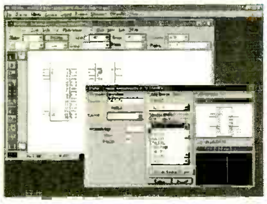

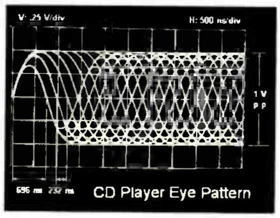

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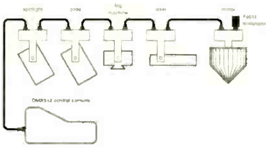

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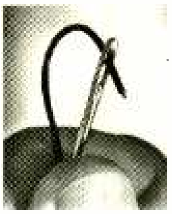

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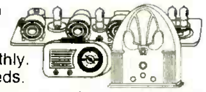

EDITORIAL

Try This One

Sometimes the old ideas are the best ones. For example, years (and I do mean years) ago, our predecessor **Radio-Electronics** had an occasional feature called "Try This One." In it, readers sent in their workbench tips and hints, and the best ones were published for all to see.

Well, over time and for reasons that are now long forgotten, that feature disappeared, which is truly a shame. For one thing, while not all the ideas would work for everyone, there were lots of gems that I am sure others would not have thought of on their own. Also, it gave our readers a way to feel more a part of the magazine.

For a long time, I'd been worried about a lack of reader participation in **Electronics Now**. I was not sure if it was a lack of interest, an unhappiness over our direction, or what. My editorial in the July issue (Who Are You? What Do You Want?) helped answer that dilemma: It was just that nobody at this end asked!

Well, since asking worked once (we are still getting mail), let's try again. Do you have a workbench tip or trick that you think others could use and benefit from? If so, why not send it in! What we are talking about here are things like ways of making plated-through holes on home-made boards, creating third hands or other assembly jigs to make stuffing a PC board easier, ways to take measurements in inconvenient spaces, unusual ways to use tools to do special jobs, and so on. Just about anything that could make the life of a builder, servicer, or experimenter easier is fair game.

And, you might ask, what's in it for you? Well, aside from seeing your name in print and having the satisfaction of helping your fellow electronics hobbyists and professionals, we are offering a bribe! We will pay $25 for any items we use. If you include a photograph that is suitable for publication, we'll make it $50. If similar ideas are received, the one that gets here first is the one that gets the cash.

We'd really like to revive "Try This One," but whether we can or not is up to you. I'm sure that there are plenty of ideas out there that need to be spread around. All we need is people to share them with each other. Let's get to it, and thanks.

Carl Laron

Carl Laron
Editor

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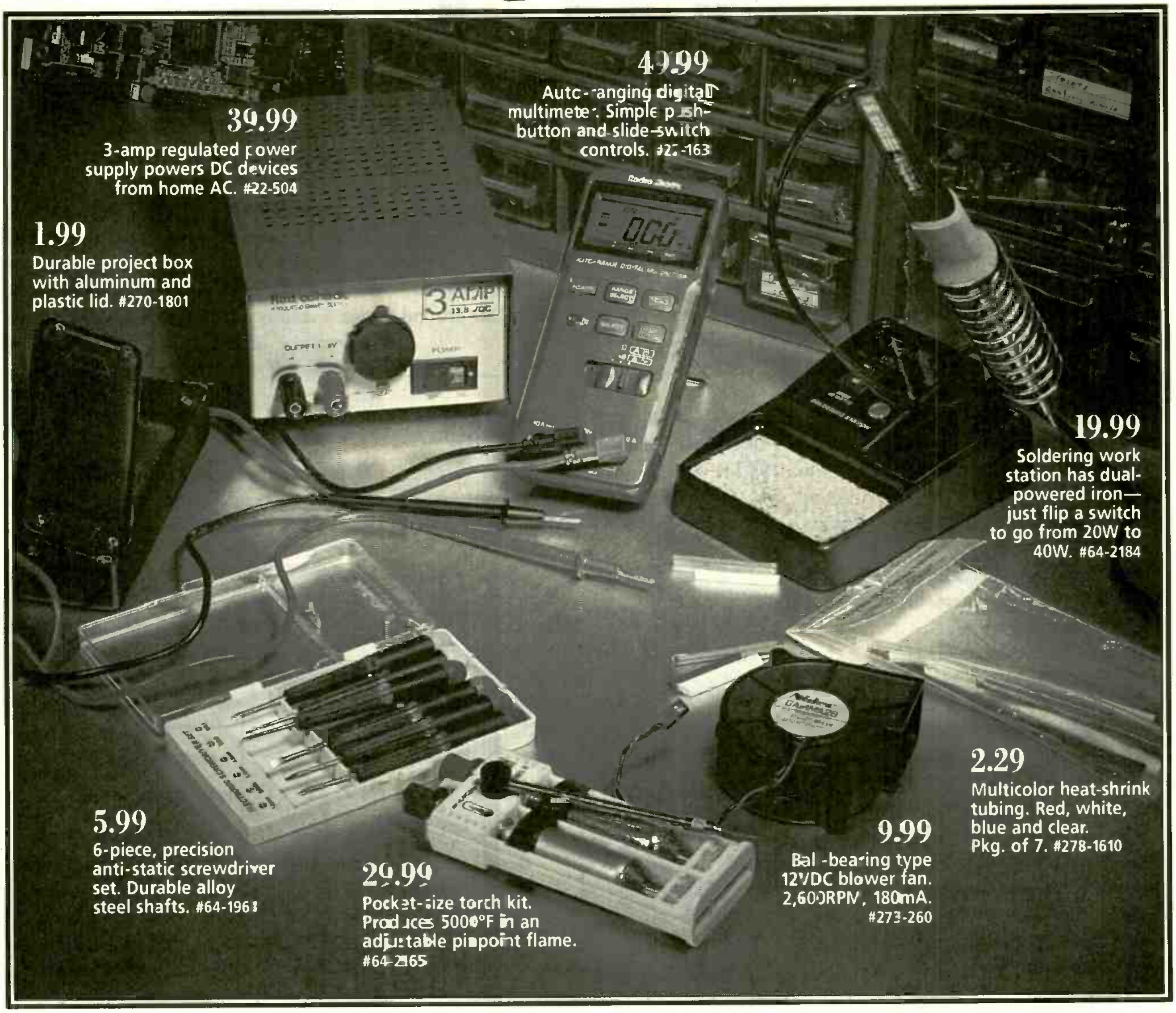

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Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

Long-Period Timer

Q *Is there any chip or simple circuit that can be used as a reliable timer for a long time delay (30 days) with good repeatability? — J. Z., Missisauga, Ont., Canada*

A Let's see, 30 days equals 2,592,000 seconds, which means you'll need to count billions of cycles if you use a crystal clock oscillator. The cheapest way is to use a microcontroller, which can count up to any number by using multiple registers. Each 8-bit register can count to 255; each time it rolls over, increment another register, and chain registers together until you can count high enough.

Off-the-shelf long-period-timer chips also exist. The 4060 includes a crystal oscillator and 14 divide-by-two stages so that it can count to 16,384; it runs on supply voltages from about 5 to 15 volts. The 74HC4060 is an equivalent device except that it requires a fixed 5-volt supply. Three of those chips in cascade, controlled by a 1.696-MHz crystal, would produce a square wave with one cycle every 30 days. Figure 1 shows a circuit using that approach. Unfortunately, we did not have a few months to spare, so we haven't tested it fully. You can get custom-made crystals from JAN Crystals, PO Box 60017, Fort Myers, FL 33906, and other suppliers.

Crystal Tester

Q *I am building a test panel and would like to include a tester to tell whether crystals are good or not. Can you help? — R. B., Langley, B.C., Canada*

A Figure 2 shows a classic Colpitts oscillator circuit that will test crystals from about 1 MHz up. The LED glows (not at full brightness) when the crystal is oscillating; for best results, use a low-current LED. You can connect a frequency counter across the LED to measure the frequency of oscillation. Note that overtone crystals will oscillate at their fundamental frequency; for example, 27-MHz CB crystals will oscillate at 9 MHz, and most scanner crystals will oscillate around 18 to 20 MHz.

Closed-Caption Decoder

Q *I've been told that the chips for decoding TV closed captions cost about $5. I know all modern TVs are required to have closed-caption built in, but in all the schematics I've looked at, the decoding is an integral part of the master processing chip. Is there a chip that can easily be added internally to older sets so that a decoder box doesn't have to be carried around and connected to different sets around the home? If so, where can I get information on the chips and associated circuitry? — J.N.B., Denver, CO*

A It isn't simple and certainly isn't a matter of a single off-the-shelf chip. You need a microprocessor that has access to

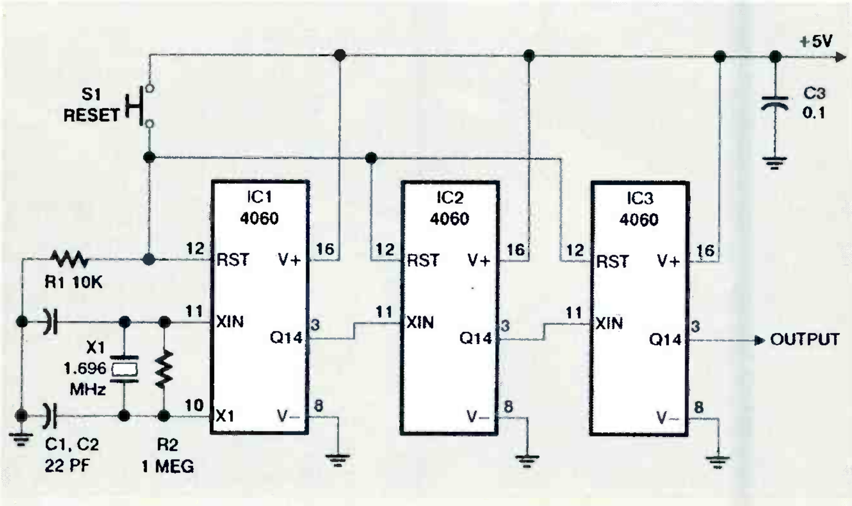

FIG. 1—THIS SUPER-SLOW OSCILLATOR produces a squarewave with a period of 30 days (one cycle per 30 days). The crystal can be ordered from the source provided in the text.

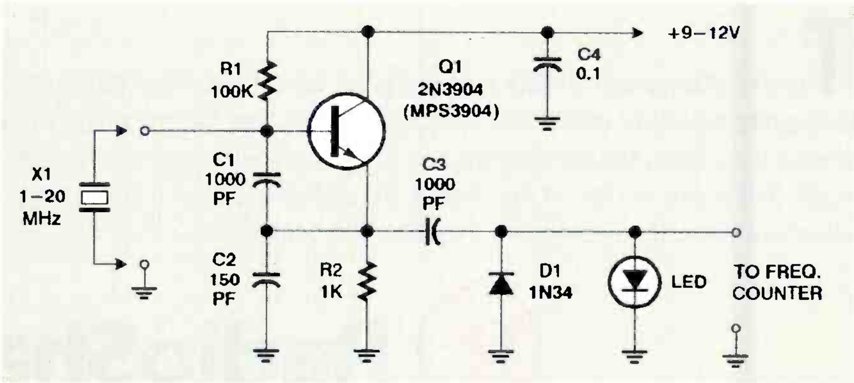

FIG. 2—THE VERNERABLE COLPITTS OSCILLATOR can be used to test crystals from 1 to 20 MHz, and even higher. If the crystal is good (oscillates), the LED will light.

the video and sync signals and the ability to generate its own video (for the lettering) in sync with what's coming in. The only reason closed-caption decoding is cheap to add to modern TV designs is that they already have such a microprocessor for other purposes, such as displaying the channel number and setup menu on the screen. So the closed-caption decoder isn't really a chip, it's some additional software in the chip that's already there.

See our December, 1994, issue, pp. 31-43, for a closed-caption decoder that sends its output to a personal computer rather than the TV screen. See also *http://www.brouhaha.com/~eric/pic/caption.html* for a circuit and the code for closed-caption decoding with a PIC microcontroller.

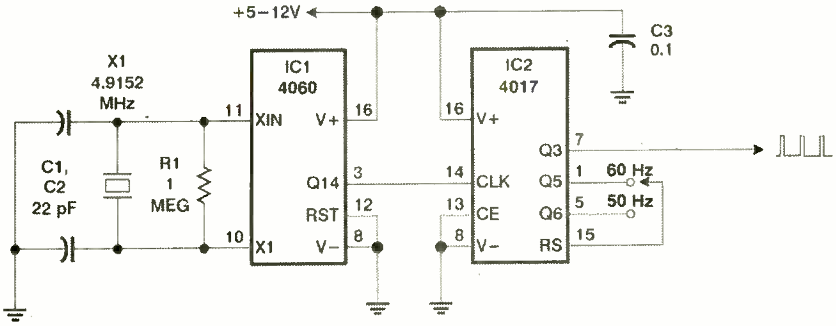

FIG. 3—THIS TWO CHIP CIRCUIT can be used to generate an accurate 50 Hz or 60 Hz clock signal using a standard microprocessor crystal.

Safe NiCd Discharge

Q *I found out by accident that letting a NiCd battery pack sit unused for a long time (several months or more) safely "conditions" the power pack to accept a full charge as if it were new. In time, the cells discharge to a very low voltage without the danger of reverse-polarizing a cell, which is what might happen during deep discharging with a load. If I used a very light load (say 1 mA), would it be possible to discharge a battery pack safely without reverse-charging any of the cells? —J. A., via e-mail*

A It's well known that if you charge a NiCd battery a lot, but never discharge it deeply, its performance will suffer. On the other hand, if you discharge the battery below about 1 volt per cell, you risk reverse-charging and ruining the cells that go dead first, since current will still be flowing through them from the other cells.

Leaving a battery pack alone is a good way to deep-discharge all the cells without reverse-charging any of them, but as you've discovered, it takes a long time. Unfortunately, we know of no shortcut. When you leave the battery unused, each cell discharges through its own internal leakage without sending any current through the other cells. If you use a load, no matter how light, the current passes through all of the cells regardless of each cell's state of charge. As you surmise, very light loads are better than heavy loads, and a 1 mA load might actually be quite safe—but full discharging would still take a couple of months.

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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. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org.

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 1993 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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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.

Erasing Videotapes

Q *The last letter I wrote to your predecessor magazine with a question was in 1948. You were most helpful. I have another question I hope you can help me with.*

Do you have any ideas on construction of a bulk eraser for video tapes? I don't want to wear out my VCR by running each tape through it just to erase. My collection of your magazines goes way back before the invention of VCRs but I can't seem to locate a project of this type. — J. L. A., Mesa, AZ

A We're glad to hear from you again and glad to be of service to you at precise 50-year intervals. We'll expect to hear from you again in 2048.

Seriously, for readers who may not know it, **Electronics Now** is one of the oldest electronics magazines in the business; it was formerly **Radio-Electronics**, and before that, **Radio Craft**. Our founder, Hugo Gernsback, was a prominent advocate of new technology, and was also a pioneer science fiction publisher.

On videotape erasing, see this column, August 1998, page 11. The key is going to be getting the tape close enough to an AC electromagnet. You might modify a video tape rewinder to spool the tape past a bulk eraser. Driving the electromagnet with a frequency higher than 60 Hz might also help. Apparently, videotape erasing is surprisingly difficult; we'd like to hear from readers who have built tape erasers that work well.

Have LCD, Want To Use It

Q *I have a back-lighted 10.5-inch-diagonal LCD screen, a Sharp LM64C35P, from a deceased notebook computer. Can I connect it to a desktop computer as a monitor? Is a pinout diagram available? — B. M., U.S. Navy*

A You can get detailed information about Sharp display panels from *http://www.sharpmeg.com* or by contacting Sharp Microelectronics, 5700 N.W. Pacific Rim Blvd. M/S 20, Carnas, Washington 98607. Interfacing the panel to a PC sounds like a challenging project; as you surmised, it doesn't take the video signal from an ordinary VGA card, but instead responds to digital commands from the computer.

MM5369 Substitute Found

In August (pp. 12-13) we lamented National Semiconductor's decision to discontinue the MM5369AA/N IC, which produces a precise 60-Hz square wave from a 3.58-MHz color TV crystal.

Figure 3 shows a substitute. Now that 4.9152-MHz microprocessor crystals are a standard item, all you have to do is divide that frequency by 16,384 (= 2^{14}) and then by 5 to get 60 Hz. That means you can build a crystal-controlled source of 60 Hz with two chips, and if you want 50 Hz all you have to do is change one connection. The output waveform does not have a 50% duty cycle, but that's no problem if what you're doing is controlling a clock. To get precise frequency control, make one of the capacitors C1 or C2 variable. You can use 74HC chips (74HC4060, 74HC4017) if the supply voltage is 5 volts.

Plated-Through Holes

In the April issue, reader E. V., of Toledo, Ohio, asked how to make plat-

ed-through holes on a two-sided printed circuit board. Several readers wrote to recommend various kinds of eyelets or rivets. Brian M. Meyers of Greensboro, NC particularly recommends eyelet kits available from T-Tech, Inc., 5591-B New Peachtree Rd., Atlanta, GA 30341, Tel: 770-455-0676, Web: http://www.ttech.com. One of their kits, the "Copperset," produces an especially faithful imitation of a plated-through hole. Eric Dod, of Sunnyvale, CA, points out that all you really need to do is put a wire through the hole and solder it on both sides.

TV Headphones Revisited

Responding to the April column, John H. Markell, of Sun City, CA, points out that the best source of headphone audio for a TV viewer is a high-fidelity VCR; it's designed to connect to audio systems and has output jacks just like an audio tape deck. If you're using the VCR as a tuner and don't need to play tapes, look for one that has been junked because of mechanical problems; you may be able to get one for the asking. Even ordinary (non-high-fidelity) VCRs usually produce better sound than TV sets.

LCD Conductive Strips

In the May issue, W. B. H., of Knoxville, TN, asked about a source of replacements for the special layered conductive rubber strips used in a digital multimeter to connect the LCD display to the circuit board. Edward Mulvaney, of Pasadena, CA, advises us that these are made by Fujipoly, 365 Carnegie Avenue, Kenilworth, NJ 07033, Web: http://www.fujipoly.com—but the ones in your multimeter are probably custom-made and the instrument manufacturer is the place to start.

Tom Pearson, of Ogallah, KS, says his Fluke multimeter has the same problem—the conductive strips lose their connection with the circuit board and/or display, and the display goes bad. But he doesn't have to replace the strips. Instead, he cleans them with a cotton swap moistened with rubbing alcohol, taking care not to get alcohol into the LCD. Thanks to everyone who wrote in!

HP Calculator = IR Remote Control?

In the June issue a reader asked if a Hewlett-Packard palmtop computer could use its infrared output device to mimic the signals from a TV remote control. Reader Greg Stanforth, of Lexington, KY, advises us that HP-48 calculators definitely can; if the palmtops use similar hardware and software, they may be able to emit remote-control signals as well. See Hewlett-Packard's FTP site, ftp://hpcvbbs.external.hp.com/dist/hp48g/comms, files ir_samp.zip and rem33bg.zip.

Darkroom Timer Found

Q *In your April issue, a reader asked for plans for a darkroom timer with red LED displays. My book, Build Your Own Home Lab, published by Howard W. Sams (Prompt Publications), contains a construction project that should meet the requirements. It has a range of 100 minutes with a one-second resolution. The instrument can function as a timer or stopclock. — Clement S. Pepper, Janesville, WI*

A Thanks for writing. Readers should be able to order your book through any bookstore (ask them to look it up in *Books In Print*) or by contacting the publisher at 800-428-7267 (800-428-SAMS).

IC Data on CD-ROM

Q *Where can I find data such as pinouts, circuit diagrams, and descriptions of CMOS, TTL, and linear ICs? Is this information published on CD-ROM? — X. Y., Trenton, NJ*

A Yes. Most IC manufacturers now publish data sheets on CD-ROM, and they give away the CDs or sell them for a small price. Among the most useful CD-ROMs are those from Texas Instruments (P.O. Box 655303, Dallas, TX 75265; Web: www.ti.com; Tel: 972-644-5580) and National Semiconductor (Technical Communications Dept., MS 16-300, PO Box 68090, Santa Clara, CA 95052-8090; Web: www.nsc.com).

Virtually all IC manufacturers also publish data sheets on the World Wide Web. You can locate any manufacturer by going to the search engine at www.yahoo.com and typing the company's name. Even better, there's a huge directory of all manufacturers' ICs, indexed by type number, at www.chipdir.com.

Writing to Q&A

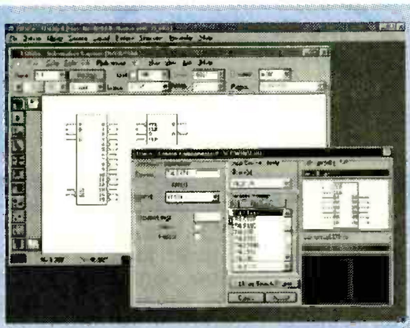
As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication) and give your full name and address (we'll only print your initials). Write to Q&A, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. **EN**

EQUIPMENT REPORT

EDWin NC CAD/CAE SOFTWARE

Design circuits from scratch to finished product on your PC with EDWin NC

CIRCLE 15 ON FREE INFORMATION CARD



The core of this magazine's coverage, and the main interest of most who read it, is electronics circuitry. Most readers have tried their hand at building at least a basic circuit, and many are accomplished builders. And even those who have never picked up a soldering iron like to look at the circuits and try to figure out how they work.

Another large segment of readers are those who like to design their own circuits. These are generally electronics professionals or advanced hobbyists with years of experimentation under their belts. This group of people is quite familiar with the tools of the trade: data books, notebook paper, pencils, erasers, breadboards, components, desoldering equipment, and so on.

The one good thing about circuit design is that it has become easier and more accessible thanks to the personal computer. The reason for that is the wide variety of Computer Aided Design/Computer Aided Engineering (CAD/CAE) software packages now available. The downside is that high-end CAD/CAE software is usually priced beyond the means of most hobbyists. However, we've found a product that is not; we'd like to tell you about it.

EDWin NC

EDWin NC, short for Electronic Design for Windows—Non Commercial, is a CAD/CAE software package that provides everything one needs to capture electronic circuits in the form of schematic diagrams and printed-circuit board layouts. The software even generates final documentation for manufacturing PC boards.

While EDWin NC from Visionics, a leading British software vendor, is far more than a hobbyist-level product, it is available to hobbyists at a hobbyist-level price. In fact, this is an engineering-level software package that normally costs thousands of dollars. But it is available to students, teachers, and amateurs for non-commercial use at just 10% its normal price—only $149.95. A $279.95 package includes EDWin NC plus EDSpice simulation software, SPICE code-development kit, and thermal-analysis software. Volume discounts are available.

EDWin NC is powerful software, but it does not require a state-of-the-art computer system. Minimum system requirements are a PC-compatible 386 or better with 8 MB of memory, 40 MB hard-disk space, an SVGA color monitor, Windows 3.1 or higher, and a mouse. Of course the faster the system, the happier you'll be with EDWin's performance.

EDWin integrates five circuit-design modules: Schematic Capture, Layout Design, Postprocessing, Simulation, and Library Editor. Users can capture circuits as schematic diagrams or as PC-board layouts. Schematic Capture and Layout Design are linked together so that changes to one affect the other, and vice versa. That way both parts of a circuit can be built simultaneously. Various tool sets are provided for each operation.

Schematic Capture involves placing parts on a snap-to page and making the appropriate circuit connections. Component outlines and pin-out data can be created by the user or pulled from the included libraries of parts. Connections between components (the netlist) are made by routing "smart" wires accordingly. Components must be laid out as devices, while other parts of a circuit are represented as symbols. For example, while +5V and GND mean something to the circuit designer or builder, they are generally not physical items placed on a circuit board. As such they do not get placed on a layout or added to a parts list.

The Layout Design module creates layouts for components consisting of silk-screens and component footprints, a netlist, and trace routing. All component and netlist information is automatically transferred from the schematic diagram to the circuit layout. Components are automatically placed with proper pin clearance and connections. Any changes made to the netlist or components on the PC-board layout are automatically transferred to the schematic. That allows board outlines from AutoCAD to be imported as .DXF files.

The Postprocessing module converts the circuit layout into data for manufacturing PC boards: artwork and documentation printouts, outputs for photo plotting, and Numerically Controlled (NC) drilling information. The Simulation module can validate circuit operation during Schematic Capture or Layout Design before actually building the circuit. The Simulation module has a Diagram Generator that graphically presents the simulated results, a Mixed Mode Simulator for AC and DC circuit analysis, an EDSpice Simulator for SPICE simulation, and a Thermal Analyzer for simulating temperature effects on a working circuit.

Even though the parts libraries bundled with EDWin NC are quite extensive, EDWin NC's Library Editor module lets users create new elements and edit elements that are already included in the bundled parts libraries. Elements can consist of device descriptions, schematic symbols, layout symbols, and so on. A library viewer lets users inspect the contents of the part libraries and make cross references between components.

Each module is activated from drop-down menus on EDWin's main screen. EDWin is packed with help files that pop up whenever a new action is initiated, so it is not difficult to learn how to use EDWin. However, as mentioned before, this is no hobbyist-level product, so there is no software wizard that will automatically design circuits. The user has to know what he's doing or else EDWin will be of little help. It definitely takes some time to become familiar with the software.

As involved as EDWin might be, such is the business of circuit design. EDWin NC is simply a product that can speed up the circuit-design process and make it far more convenient for the designer. However, when it's available at hobbyist-level prices, EDWin NC is the perfect software bundle for that budding engineer in all electronics hobbyists. The bad part is that once a hobbyist gets good enough at circuit design to make money at it, they will have to pay full price for EDWin.

For more information on EDWin NC, contact the US distributor (Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002; Tel: 800-831-4242; Web: www.jameco.com); visit the Visionics Web page (www.visionics.a.se); or circle 15 on the Free Information Card. **EN**

Prototype

Using Electronics To Beat Smugglers

Many experts believe that the collapse of the Soviet Union has made the world an even more dangerous place. That's because illicit material is being smuggled across the borders of the former Soviet Union and its former satellites on their way to rogue nations attempting to build nuclear and chemical weapons. Because of very limited funding, poorly trained inspectors, and lack of detection equipment, much of this dangerous stuff is now reaching its intended destination. Fortunately, the U.S. government is working hard to stop the flow of materials that represent a future threat to the entire world.

For instance, the U.S. Department of Energy's Pacific Northwest National Laboratory (PNNL) in Richland, WA is developing advanced electronic devices to help border inspectors uncover the smuggling of various material that are needed in the construction of weapons of mass destruction. The devices can also be used to detect more benign smuggled goods from jeans to drugs.

One of these devices is the Ultrasonic Pulse Echo Detector, a hand-held unit that contains a sensor head and a computer. With the device, an inspector can determine the contents of sealed containers, measure how full a container is, and find any cavities or hidden packages—which might hold drugs or other smuggled goods—within the container.

The sensor, which transmits ultrasonic pulses and detects any return echoes, is placed on the outside wall of the container. As sound waves are transmitted, the return echoes bouncing off the other side of the container are analyzed in terms of time of transit and amplitude decay to identify the characteristics of the contents and compare those features against information in a database library. The Ultrasonic Pulse Echo Detector was originally developed by the PNNL for inspecting chemical weapon stockpiles in Iraq after the 1991 Gulf War.

THE MATERIAL IDENTIFICATION SYSTEM is shown at the left attached to laptop computer. The engineer is holding the Ultrasonic Pulse Echo instrument.

A Metal Detector

Another device used to keep dangerous goods from reaching the wrong hands is the Material Identification System, which uses eddy currents to detect strategic metals that could be used in making nuclear weapons. Most metals, including those used for strategic purposes, are similar in appearance. Therefore, it is virtually impossible for inspectors to determine what a metal is just by looking at it.

The Material Identification System uses a hand-held probe that is connected to an ordinary laptop computer via a plug-in instrument card. When the probe is passed over the suspect metal, the instrument measures the flow of electrical, or eddy, currents through the metal. Eddy currents flow through different metals in distinctive ways. The system takes advantage of that fact and uses a computer to compare and reconcile the measured flow against an extensive U.S. Customs material database to determine whether the metal is, in fact, what it is declared or purported to be, as well as determine the most likely identity of the metal. The inspector can also search the database for additional information including the classification of the metal and applicable regulations.

As a demonstration of the device's capability, it can distinguish between nickels, dimes, and other coins. Besides detecting strategic metals for nuclear

FOR MORE INFORMATION

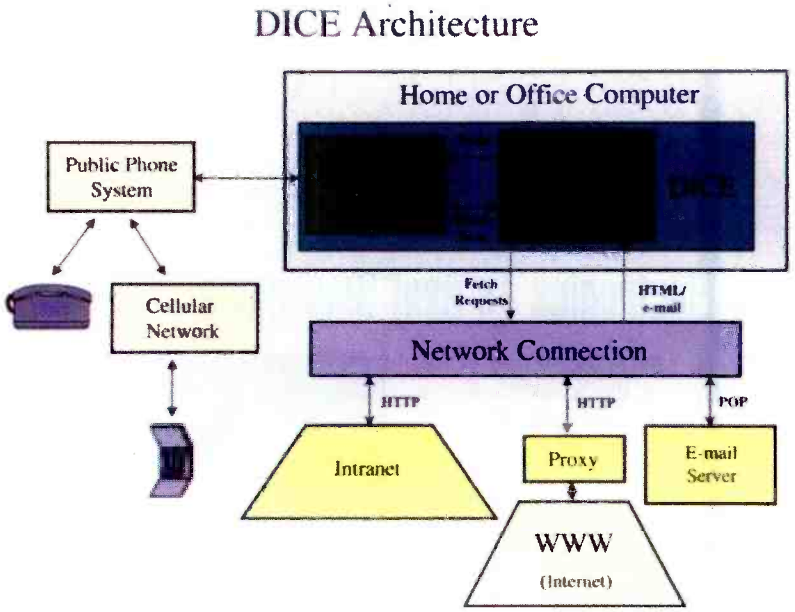
Pacific Northwest National Laboratory
PO Box 999
Richland, WA 99352

weapons, border inspectors can use the Material Identification System to determine if a shipment of metals has been labeled fraudulently to avoid a higher duty fee.

Both pieces of detection gear, which the PNNL recommends be used together for a "one-two punch" for most effective border security, are already in use. For instance, the Ultrasonic Pulse Echo device is currently being used by the U.S. Customs Service, and the U.S. On-Site Inspection Agency recently ordered 10 sets of the equipment for use at borders in the former Soviet Union and Eastern Europe. Cypress, Malta, and several other countries have also requested both units.

Use of the new devices will also be included in the curriculum of the new Hazardous Materials Management and Emergency Response (HAMMER) training facility at PNNL's Hanford, WA site. There U.S. Customs Service and PNNL will train foreign border-enforcement officials to stop smugglers. The course, which will start this fall, includes a simulated international-border crossing and is located amid the sand and sagebrush of the southeastern Washington desert. The first "students" will come from Hungary and Slovakia.—**Bill Siuru** PT

Keep In Touch—Any Time, Anywhere



USING ANY TOUCH-TONE TELEPHONE, including a cellular, the DICE system analyzes e-mail and HTML documents, and then plays them back as audio.

A prototype system developed by scientists at Siemens Corporate Research, Inc. (SCR) allows e-mail messages or World Wide Web pages to be accessed without a laptop computer. The DICE (Delivering Information in a Cellular Environment) system uses a computer algorithm to analyze e-mail and HTML documents, and then play them back as audio over any touch-tone telephone, including a cellular. DICE uses speech synthesis tools, which convert text to audio.

A unique feature of DICE—SCR has three patents pending—is that its algorithm also analyzes the format and layout elements of a document. The system communicates both the text and structure of a document. Even highly structured HTML documents can be converted to an audio format without confusing the listener.

Using the touch-tone keypad of any telephone, callers dial a service provider, either their own home or office PC. Users can access Web pages from a list of selected bookmarks, and also retrieve e-mail by simply pressing a few keys and listening. DICE also provides a fully-functional touch-tone-based browser. Over the phone, users can follow hyperlinks, use a history list, or access standard audio features such as fast forward, rewind, or pause.

A caller can surf a favorite newspaper's Web page and hear the headlines. If there is a particular article he wants to hear, the caller simply presses a button and listens; the system retrieves the new page and plays it in real time. Pressing another button instructs DICE to remember the page for later viewing on a computer.

"For many who are on the go but don't have access to a computer, DICE enables one to retrieve and answer e-mail messages away from the office, whether driving to work, on a plane, or at the poolside," says Arding Hsu, department head, Multimedia/Video Technology. Dr. Hsu explained that once having listened to the message, one can respond by keying in a number on the phone to record a voice message. "We're working on converting the verbal response back into an e-mail message at the other end, and should support this feature soon," he said.

The system was developed by SCR scientists Michael Wynblatt, Stuart Goose, and Dan Benson in cooperation with Siemens AG's Private Communication Systems. Another similar project called WIRE (Web-based Interactive Radio Environment) is under development. It will enable drivers to access e-mail and Web sites using a driver information system rather than a telephone. SCR is working with Siemens AG's Automotive Systems Group to develop a prototype system based on this technology. PT

Ultra-Small Computers?

A team of scientists from the Georgia Institute of Technology recently observed ballistic conductance—a phenomenon in which electrons pass through a conductor without heating it—at room temperature in multi-walled carbon nanotubes up to five microns long. (A micron is a millionth of a meter.)

"This is the first time that ballistic conductance has been seen at any temperature in a three-dimensional system of this scale," said Dr. Walter de Heer, a professor in Georgia Tech's School of

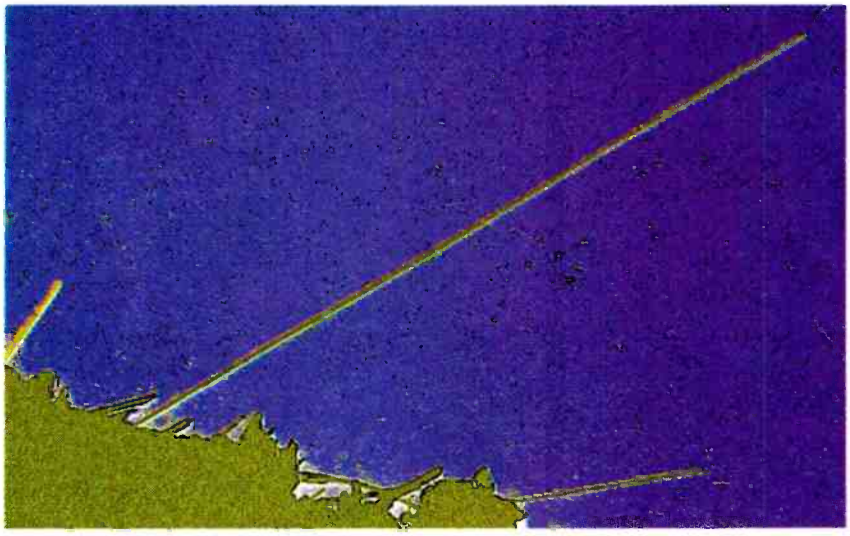


IMAGE FROM ELECTRON MICROSCOPE shows a long nanotube protruding from a bundle of nanotubes. Resistance was measured in the long tube.

Physics. "There would be interest in this for ultra-small electronics, because it shows that you can constrain current flows to narrow areas without heating up the electronics. It also introduces a new stage of electronics in which the wave nature of electrons becomes important."

Using the positioning equipment of an atomic-force microscope, researchers found that the electrical resistance of the nanotubes remained constant—regardless of their length or width. This quantum conductance is not seen in larger structures.

"In classical physics, the resistance of a metal bar is proportional to its length," said Dr. Z. L. Wang, a professor in Georgia Tech's School of Materials Science and Engineering. "If you make it twice as long, you will have twice as much resistance. But for those nanotubes, it makes no difference whether they are long or short because the resistance is independent of the length or the diameter."

In the laboratory, de Heer, Wang, and collaborators Stefan Frank and Phillipe Poncharal attached a tiny electrode to a bundle of nanotubes that had a single long tube protruding from one end. They mounted the bundle in place of the probe normally used in an atomic force microscope and connected a battery to the electrode.

They used the microscope controls to raise and lower the single protruding nanotube into and out of a pool of mercury that completed the circuit back to the battery. The resistance they measured as the nanotube was raised and lowered into the mercury remained constant, changing only when a shorter tube protruding from the bundle—which resembles a handful of straw—made contact with the liquid metal.

Researchers measured the resistance of 20 nanotubes of different lengths and diameters through as many as 1000 cycles that consisted of dipping them in and out of mercury and two other molten metals—gallium and Cerrolow-117. The tubes averaged 15 nanometers wide and four microns long, but ranged from one to five microns in length, with diameters from 1.4 nanometers to 50 nanometers. The quantum of resistance remained 12.9 kiliohms.

That's possible, explained de Heer, because the electrons act more like waves than particles in structures whose size approaches that of the wavelength of electrons. "The electrons are passing through these nanotubes as if they were light waves passing through an optical waveguide," he said. "It's more like optics than electronics."

In normal wires, the electrical energy they carry dissipates in the conductor, but in the nanotubes, energy dissipates only in the leads used to connect the tubes. Such effects had previously been seen only in structures a thousand times smaller, and finding them in the comparatively large nanotubes was quite surprising.

The absence of heating allows extremely large current densities to flow through the nanotubes. Wang and de Heer measured current densities greater than ten million amps per square centimeter—far greater than could be handled by any other conductor. Normal resistance heating would have generated temperatures of 20,000 K in the nanotubes, well beyond their combustion temperature of 700 K.

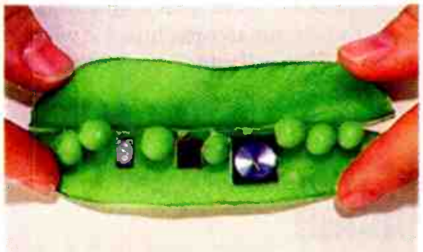
At more than five microns, however, de Heer believes electron scattering may defeat the ballistic conductance effect. "We can only guarantee that we can carry that kind of current over five microns," he said. "We don't know what will happen if you try to conduct for longer distances. This will certainly not be a way to transport current over large distances."

Electronic devices using nanotube conductors are perhaps decades away. One fundamental issue is that carbon materials are incompatible with the silicon that is the basis of current integrated circuits. Solving that challenge will require a revolution in electronic design.

"This just opens the door; it doesn't tell you how to build a better world," de Heer said. "This should be seen as the proof of principle showing that we can do ballistic conductance at room temperature." PT

Lab on a Chip

Imagine bands of tiny vehicles that cooperatively sniff out suspicious or threatening chemicals or even land mines. About 40 scientists and engineers at Sandia National Laboratories have been researching such technology. Within three years, they hope to demonstrate a device about the size of a palm-top computer that can sniff explosives and chemical warfare agents. In



THE THREE MAIN COMPONENTS OF Sandia's micro-chem lab for gas-phase detection and analysis are small enough to fit easily inside a snowpea pod.

five to ten years, devices should be able to simultaneously identify hundreds of liquids and gases.

Arrays of these chemistry labs-on-a-chip could be sent onto battlefields or mounted near factories to provide chemical reconnaissance. Potential national security applications range from detecting weapons of mass destruction to monitoring the state of the nuclear stockpile. Devices might one day become available at local stores to test water and food, to monitor the course of an illness, or to determine the safety of the environment.

"There's a huge amount of information in chemical signatures that the world is not making use of," says Sandia chemist David Rakestraw, "because it's too costly. It's also very difficult to extract out all of this information using any traditional analytical chemistry in a laboratory."

Research to create an autonomous micro-chemistry lab involves exploring science in a microdomain where properties can run counter to normal intuition. For instance, liquids experience no turbulence as they move along channels smaller than a hair. Gas detection also would work differently. First, a sample would be gathered on a microporous film, then heated to vaporize. The tiny pulse of gas would then flow into a long, coiled column for separation. From there, separated gases would flow over an array of coated acoustic-wave sensors. Different absorptions by the different coatings (signaled by a shift in frequency) would build up a fingerprint characteristic of each chemical.

Sandia researchers are also creating cooperative, distributed sensing, and behavior systems. Sensors in fixed spots or on swarms of small, smart vehicles known as robugs could communicate and map the location of suspicious chemicals. In three years, researchers hope to have an architecture for what a distributed intelligence system should look like. PT

JUDGE FULLER AND LISA SILLS LOOK AT A LAPTOP that is accessing Georgia court information on the new database she designed.

Criminal Records Online

Officials in Georgia's state, superior, and juvenile courts are using the latest in information technology to help put a lid on crime. This summer, several Georgia counties gained online access to a new management information system that enables them to systematically pool information about criminal activity and other court-related matters.

Although the Georgia Crime Information Center (GCIC) already maintains an electronic database, its information is focused on sentencing and dispositions. The new database goes beyond that, making a wealth of case-related data readily available to Georgia court officials via the Internet.

Designed by senior research scientist Lisa Sills and her team in the Information Technology and Telecommunications Laboratory at the Georgia Tech Research Institute (GTRI), the database is comprised of a TCP/IP network that can be used any place with Internet access by account holders—primarily judges and clerks. It is a highly complex project that has been in the works for two years. With the new database, officials will be able to obtain more complete information about a suspect's record. For example, the database would quickly reveal if a suspect arrested by one county is under warrant for arrest in another county, alerting intake officers not to let that person out on bail.

The database is split into two major sections: one for juvenile court and one for state and superior courts. Information can be tracked either by a case docket number or by name. Under case history, the database indicates whether a bench or jury trial was held, specific events of the trial, outcome, and any changes in original sentencing. Entries for individuals also include date of birth, gender, known aliases, and a complete record of charges.

The juvenile section tracks dates of foster care along with "interested persons," including parents, guardians, and attorneys. The database also tracks gang information, which is becoming increasingly important.

Sills explained that all the information had to be imported from existing county systems, which required an automated system to be in place first. "There are many kinds of systems out there … Integrating their data into ours is challenging."

"By bringing some standardization, we can rely better on all the data that comes in," commented Judge Hilton Fuller, a DeKalb County Superior Court judge and chairman of the Georgia Courts Automation Commission, which is funding the project. The database will also serve as a communications system, he added. "We'll be able to pass information between the courts, as well as the database. That's also an important part of this tool." PT

BY SAM GOLDWASSER
SERVICE EDITOR

Specific Problems, Interesting Signals, and More

THIS MONTH, WE WILL CONCLUDE OUR SERIES ON CD PLAYERS AND CD-ROM DRIVES WITH SOME NOTES ON SOME COMMON PROBLEMS THAT OCCUR WITH A VARIETY OF PIONEER MODELS. THEN, WE'LL TAKE A LOOK AT THE EXCITING world of the CD player "eye pattern" and other interesting signals, and then wrap things up with some other "items of interest!"

Pioneer Problems

Note that we are not singling out Pioneer for any particular reason. These or similar problems also occur with units from other makers. It is just that we are familiar with the machines from this company. So, let's get started:

Pioneer PD/M series players/changers do not recognize discs:

There are a variety of Pioneer models that use basically the same or a very similar optical deck, and thus are subject to several problems that ARE likely to occur eventually on all these units. Where a Pioneer player or changer does not recognize discs, the most common causes are:

1. Partially shorted spindle motor due to "crud" on commutator. Cleaning might be possible. The disc might spin, but at insufficient speed. Try the unit's test mode toward latter (outer) part of disc as the required rotation rate is lower and/or check voltage to motor; if you are not familiar with the test mode, we'll go over it in a moment.
2. Cracks in flex cable to optical pickup assembly. If that is the cause, replacement of flex cable will be required. That defect might also result in erratic operation while playing.
3. Collapsed rubber suspension grommets. There may be a scraping or clicking sound associated with that failure. For changers, gently lift up on the optical pickup assembly while the disc is attempting to spin to see if the disc is recognized and will play. To fix, you need to replace the deteriorated grommets.

Let's now discuss the Pioneer PD/M series test mode, which is extremely useful for narrowing down problems. Note that you might also find similar test modes on players from other companies, but details will likely differ.

- To enter the test mode, press the test button while turning power on and then hold it on for at least 1 second.
- Some models only have a set of contacts; on those, short between the contacts with a piece of wire or a paper clip.
- On players with a standby mode (not a hard on/off switch), plug the unit in while pressing the test button or shorting the contacts.

The test button or contacts are located on the main board (usually near the front right corner, and might be obscured by cables).

Once the test mode is engaged, the servos can be controlled from the front panel:

- STOP turns all servos off.
- TRACK FWD enables the focus servo (and loads disc 1 in changer).
- PLAY enables the spindle servo.
- PAUSE enables the tracking servo.
- Use manual search FWD or REV to move the optical pickup.

Note that, depending on model, the specific functions and behavior of the front panel buttons in test mode might vary slightly.

WARNING: Normal safety checks are disabled in the test mode. Thus, the laser might remain on as long as focus/tracking/spindle servos are engaged even if no disc is in place. Take care.

Power cycle (by unplugging if necessary) to return to normal mode.

Pioneer spindle motor problems:

When operating normally, here are the typical measurements for the PD/M series players: Spinup: >2.5 volts; time to lock (est.): 1-2 sec.; start of disc (500 rpm): 1.0 volt; and end of disc (200 rpm): 0.5 volts. Similar values apply to many other cheap permanent-magnet-type CD-player spindle motors.

When bad, the spindle servo drive tops out at around 0.6 V and 100 mA. The player is therefore unable to spin up to required 500 rpm to read disc directory.

While the exact cause of this problem is unclear, the theory is that a large voltage applied at startup followed by long periods of very low voltage (0.5-2 volts) operation allows conductive crud (carbon) to build up on the commutator, eventually reducing resistance to the point where the driver cannot apply enough voltage to achieve 500 rpm. The spindle-motor servo drive IC becomes quite warm when attempting to power a shorted motor. However, it does not appear to be harmed.

A short squirt of degreaser through the motor access holes and/or spinning the motor when disconnected from the player (using a 9- to 12-volt battery or power supply) will have an immediate dramatic effect, often returning operation to normal. However, just how long either of these "fixes" will last is another matter.

If the above fixes don't cure the problem, enter the test mode to play disc at outer track. If this is normal, then the spindle motor is probably bad as the rotation speed at the outer tracks is less (200 rpm) and a partially shorted motor may still run fast enough for this.

One last note before we leave the Pioneer players: The basic servo alignment procedure for Pioneer CD players is virtually identical to the general one presented last month.

Interesting CD-Player Signals

Poking around inside a working CD player makes an excellent exercise for the student. Component CD players very often have clearly marked test points for RF, focus, tracking, and audio data. With care, (basic ESD precautions, careful probing, etc.) there is little risk of damaging anything as long as you are not tempted to try your hand at tweaking any of the internal adjustments.

If you have nothing better to do and you have your CD player open, try to locate the test points for data, fine tracking, and focus. They may be labeled something like TP.DTA (or TP.RF), TP.FO, TP.TR. TP.DTA or TP.RF is the data coming off of the disc having gone through only the photodiode segment combiner and preamp (probably). Using a 10:1 probe, set your oscilloscope for a horizontal sweep of around 0.5 μs/div. Try a vertical sensitivity of 0.2-volts per division to start and adjust for a full screen display. Use internal positive triggering. While playing a disc, you should see the classic "eye" pattern used in the communication world to characterize channel quality.

The Eye Pattern

The eye pattern results from the characteristics of the run-length-limited 8-14 modulation coding used on the CD, where there are no fewer than 3 and no more than 11 clock cycles per symbol. You should be able to make out the fact that the minimum distance between channel bits is 3 with the smallest distance between bit transitions of about

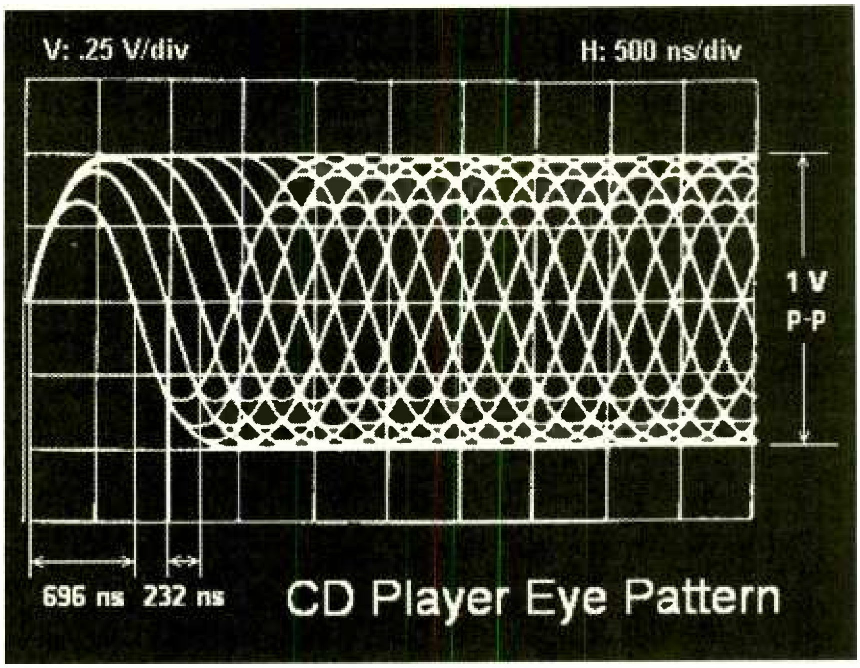


FIG. 1—HERE'S THE TYPICAL EYE PATTERN you will see while playing a musical track or reading data from a CD-ROM. If the pattern is well formed, you can be reasonably certain that the unit's optics are fine.

3×232ns (696ns). The readout clock is 1/(232 ns) or about 4.321 MHz.

A "good" eye pattern will be clean, symmetric, and stable with clear visibility in the cross-hatched areas. Its amplitude is typically in the 0.75- to 2-volt p-p range when measured at the RF test point. That waveform may be viewed using an oscilloscope of at least 5 MHz bandwidth. Some typical RF amplitude specifications are 1.3- to 1.4-volts p-p on Aiwa units, 1.2-volts p-p, on Sony full-size units, 0.85-volts p-p on Sony automotive and portable players.

Figure 1 shows the general form of the eye pattern present while playing a musical track or reading data from a CD-ROM using a typical unit. As the spindle servo adjusts motor speed, the instantaneous frequency could vary by 10 percent or more. Extensive buffering inside the player makes sure that a steady stream of data is sent to the D/A converter, and your ears!

Examining the eye pattern should be the first measurement that is performed to determine the condition of a CD player's optics and electronics. A good eye pattern eliminates most of the parts of the optical pickup from suspicion. Note that the eye pattern observed while the player is accessing the following areas of the disc may not be well formed as in Fig. 1:

- Disc directory (Table of Contents or TOC)
- Before the start of the first track (Track 1, time less than -0:01)
- Between tracks of distinct selections (where there is silence)
- After the end of the last track

(I await e-mail from anyone who can describe this waveform in detail!)

The reason why the pattern is not well formed is that there is no musical data at those locations on the disc (but probably a constant value like 0) and the TOC and/or time display is obtained from the Q bit. The Q bit is part of the Control and Display byte that is present once per frame (14 EFM coded bits out of 588 total bits per frame) as discussed earlier in this series. As a result, the funny looking eye pattern at those point has much more low frequency content and thus does not exhibit the nice cross hatched area that you see when the highly variable audio data is present.

Focus and Tracking Drive or Error Signals

TP.FO or TP.FE is the focus voice-coil error signal. Monitoring that signal with a disc in good condition will show what looks like noise—the more or less random fluctuations in the actuator current that is necessary to maintain proper focus within ± 0.5 μm of the disc surface. On a warped disc you will see the DC level of this signal varying at the disc rotation rate. On a damaged disc, you will see higher-frequency variations in the level depending on what kind of defects are present. Gently tapping the optical deck should evoke a visible effect on this signal as the servos correct for your mischief.

TP.TR or TP.TE is the fine-tracking voice-coil error signal. As with TP.FE, it will show a noise waveform with a good disc. On a disc with runout, you will see a periodic level variation at the spindle rotation frequency. Note how the DC value of that signal gradually changes as the voice-coil actuator maintains lock on the track while the track spirals outward.

Eventually, that error becomes great enough to trigger the coarse-tracking motor to jog the pickup a fraction of a mm and re-center it on the track, at which point the signal you are watching will suddenly shift its DC level.

On a disc with scratches, there will be higher frequency deviations that will be readily visible on a scope trace. Gently tap the optical deck from various points and observe the effects on this signal.

For both focus and tracking, you can actually hear the voice-coil actuators as they compensate for minute defects or just the normal data pattern. That is the "gritty" sound one hears from the CD audio or CD-ROM transport when it is operating correctly, and is an indication that the laser and focus (at least) are most likely functioning properly. If you listen carefully, you can actually hear various defects by the effect they have on that gritty sound, but there will be no corresponding effect in the audio outputs as there would be with an LP.

Focus, Tracking, and Error-Correction Performance

If you have a test CD (or you could also use a regular CD for this), put your scope on one of audio outputs. Create some "defects" by placing some thin pieces of tape or by marking with a (water-soluble) felt-tipped pen radially on the bottom surface of the disc. Play some tracks that have constant pure tones or silence. For widths less than the error correcting capability of your CD's LSI chipset, there should be no detectable signal degradation.

As an experiment, you might want to see what happens as you increase the width of your "defects." Another thing to try is to put your finger on the spindle or even gently touch the disc as it is rotating. Note that unless you really press hard, the disc will continue to play normally without any change in pitch. This is due to the servo control and extensive buffering of the data—unlike an LP turntable where the instantaneous speed is what determines pitch. Other experiments are left as exercises for the student.

Laser-Diode Fundamentals

Note: What follows here is a summary. For additional information on using laser diodes, see the document entitled: "Sam's Laser FAQ: Safety, Info, Links, Parts, Types, Drive, Construction" at my Web site (www.repairfaq.org).

Typical CD laser optics put out about 0.1 to 1 mW at the objective lens, though the diodes themselves might be capable of up to 4 or 5 mW depending on their type. The laser diodes for CD players are infrared, with a wavelength of usually around 780 nm. Visible laser diodes are also readily available from many sources. The most common wavelength for those is 670 nm—which is deep red—but 630-nm diodes are also available; the later are red/orange and appear much brighter (they are also more expensive at the present time). Inexpensive (relatively) laser pointers use visible laser diodes with power outputs up to about 5 mW. That is enough power to risk permanent retinal damage if you look into the beam, especially when it is well collimated as is required for a pointer. Needless to say, you should never look directly into any laser beam

Typical currents for laser diodes are in the 30 to 100 mA range at 1.7 to 2.5 volts. However, the power curve is extremely non-linear. There is a lasing threshold below which there will be no output. For a diode rated at a threshold of 80 mA, the maximum operating current may be as low as 85 mA. That is one reason why all actual applications of laser diodes include optical sensing (there is a built-in photodiode in the same case as the laser emitter) to regulate beam power. You can easily destroy a laser diode by exceeding the safe current even for an instant. To protect the life of the laser diode, it is critical that you do not exceed the safe current limit—even for a microsecond!—under any circumstances.

Laser diodes are also extremely sensitive to electrostatic discharge, so use appropriate precautions. Also, do not try to test them with a VOM; the test currents they put out on the low-resistance ranges could exceed the diode's safe current rating.

While only a few hundred mW at most are dissipated by a laser diode, a good heat sink is also important for the device's long life and stability. That's one of the reasons why the optical pickup is usually a metal casting. Remember that the active diode chip is only about 0.1 mm on a side. However, some optical blocks are now made of plastic, so this might not be as important as in the past.

It is possible to drive laser diodes with a DC supply and resistor, but unless you know the precise value needed, you can easily exceed the ratings. One approach that works for testing is to use a 0- to 10-VDC supply (preferably a linear supply—a switching supply might put out laser-diode destroying pulses) with, say, a 100-ohm resistor in series with the diode. Slowly bring the current up until you get a beam (use an IR detector to test for the presence of the beam). If you get the polarity backwards or are actually measuring across the internal photodiode, the voltage across the diode will go above 3 volts or will be less than 1 V. If you see that, turn power off and reverse the leads. **Note:** Some laser diodes will be destroyed by reverse voltages greater than 3 V—the device's spec sheet will list the reverse voltage rating; however, the ones I have tried out of CD players were fine to at least 5 V in the reverse direction.

Without a laser power meter, however, you will have no way of knowing when the limit on safe beam power (safe for the laser diode, that is) is reached. If you have the data sheet for your laser diode, then the best you can do is limit the current to specified maximum rating. Also, there is usually a weakly visible emission which appears red (for IR laser diodes) when the device is powered. Do not be fooled into thinking that the laser diode is weak as a result of that dim red light. The main beam is IR and invisible—and up to 10,000 times more intense than it appears.

The beam from the raw laser diode is emitted in a broad wedge, typically 10 × 30 degrees. A convex lens is needed to collimate the beam (make it parallel). For optimal results, the lens needs to be anamorphic—it has unequal horizontal and vertical focal lengths—to correct the astigmatism of the beam. The mass produced optical pickups used in CD players have that characteristic, as well as other sophisticated optics.

For an actual application, you should use the optical feedback to regulate beam power. That usually takes the form of a simple current-controlled power supply with extensive capacitive filtering and a regulated reference. It is possible to modulate the beam power by tapping into the feedback circuits—as long as you take steps to ensure that the maximum current specification will never be exceeded. Laser diodes do not behave like LEDs and cannot be pulsed for higher peak power—they turn into DEDs—Dark Emitting Diodes. Single chips for driving laser diodes in both CW and modulated modes are available from a number of manufacturers.

Laser Diode Life

For all intents and purposes, laser diodes in properly designed circuits do not degrade significantly during use or when powered on or off. However, as we saw above, it doesn't take much to blow them. I have seen CD players go more than 10,000 hours with no noticeable change in performance. That doesn't necessarily mean that the laser diode itself isn't gradually degrading in some way—just that the automatic power control is still able to compensate fully for any changes.

So, then, why do some laser diodes fail prematurely? In most cases they were either defective to begin with, their driver circuitry was inadequate, or they experienced some "event" resulting in momentary (perhaps only a few nanoseconds) overcurrent.

As noted elsewhere, a weak laser diode is well down on the list of likely causes for CD player problems.

Of course, in the grand scheme of things, even LEDs gradually lose brightness with use.

Going Further

If the solutions to your problems have not been covered in this series of Service Clinic articles (or the much more extensive FAQs at my Web site), you still have some options other than surrendering your CD player to the local service center or the dumpster.

When tackling electronic faults, a service manual with schematics will prove essential. Many manufacturers will happily supply this for a modest cost—typically $10 to $50. However, some manufacturers are not providing schematics in their manuals; only mechanical and alignment information. Confirm that a schematic (not just a block diagram) is included if you need one before purchasing the manual.

If you don't have the schematic, all is not necessarily lost. Test point locations, important signals, and power-supply voltages are often clearly labeled on the electronics board. In this case, quite a bit of troubleshooting can be done without the schematic. There is a good chance that the problem can be isolated to a particular subsystem by just following the signals using this information.

There are also a variety of books dealing with all aspects of CD player repair. While not as common as books on VCR repair, there are more of these than you might think. Your local public library may have some in the electronics section. Technical bookstores, electronics distributors, and the mail-order parts sources listed elsewhere in this article often carry a variety of these texts.

Troubleshooting and Repairing Compact Disc Players, Homer L. Davidson, TAB Books, A Division of McGraw Hill, Inc., Blue Ridge Summit, PA 17294, USA, 1989, ISBN 0-8306-9107-3 (hardcover), ISBN 0-8306-3107-0 (paperback). That text includes several complete CD-player schematic diagrams (which are quite interesting in their own right). I believe there is now a third edition of this book.

Compact Disc Troubleshooting and Repair, Neil Heller and Thomas Bentz, Howard W. Sams & Company, A Division of Macmillan, Inc., 4300 West 62nd Street Indianapolis, IN 46268, USA, 1988, ISBN 0-672-22521-2.

The Compact Disc Book - A Complete Guide to the Digital Sound of the Future, Bryan Brewer and Edd Key, Harcourt Brace Jovanovich, Publishers, Orlando, FL 32887, 1987, ISBN 0-15-620050-3 (paperback). Includes a variety of high level information but no details.

The Complete Guide to Digital Audio Tape Recorders including Troubleshooting Tips, Erik S. Schetina P.T.R., Prentice Hall, Englewood Cliffs, NJ, 07632, ISBN 0-13-213448-9. Mostly directed to digital-audio-tape recording, but also includes some information on digital sampling and CIRC coding.

DAT - The Complete Guide to Digital Audio Tape, Delton T. Horn, TAB Books, Inc., Blue Ridge Summit, PA 17294-0214, 1991, ISBN 0-8306-7670-8 (hardcover), ISBN 0-8306-3670-6 (paperback. Includes a chapter on the compact disc.

All Thumbs Guide to Compact Disc Players, Gene B. Williams, TAB Books, Inc., Blue Ridge Summit, PA 17294-0214, 1993, ISBN 0-8306-4179-3 (paperback). This one is very basic but does cover the most common problems and has illustrated instructions for hookup, cleaning the lens, cleaning and lubricating the mechanism, simple electronic problems, etc.

On the Internet, Tandy (Radio Shack) has a nice web resource and fax-back service. This is mostly for their equipment but some of it applies to other brands and there are diagrams that might be useful for other manufacturers' VCRs, TVs, CD players, camcorders, remote controls, and other devices (since Tandy does not manufacture its own equipment your model may actually be covered under one of their house brands such as Realistic or Optimus—it might just take a little searching to find it). The address is http://support.tandy.com.

Some Notes on Parts

The type of belts used in CD players for drawer loading and sometimes elsewhere is nearly always a type with a square cross section. Obtaining an exact replacement belt may be difficult and not really necessary.

Measure the old belt and select one that is as close as possible from a parts supplier like MCM Electronics. What is important here is that it be of equal or slightly greater thickness and that it has an inside circumference (this is how they are measured) so that it will be tight but not so tight as to slow the motor or cause damage to the bearings. That usually means a circumference that is about 5 to 10 percent less than the old (stretched) belt.

The question often arises: If I cannot obtain an exact replacement or if I have a CD, VCR, or other equipment carcass gathering dust, can I substitute a part that is not a precise match? Sometimes, you might want to do this simply to confirm a diagnosis and avoid the risk of ordering an expensive replacement and/or having to wait until it arrives.

Anyway, for safety-related items, the answer is generally no; an exact replacement part is needed to maintain the specifications within acceptable limits with respect to line isolation, X-ray protection, and to minimize fire hazards. The good news is that there are not that many safety-related components in CD players.

Still, although only a few manufacturers produce most of the components in CD players and CD-ROM drives, don't expect a lot of readily interchangeable parts other than the common electronic ones listed below. In their never-ending search for cost reductions and technology improvements, manufacturers are constantly tweaking their designs. More and more circuitry is finding its way into custom VLSI chips. Fortunately, those do not fail too often.

The only parts that are fairly standardized aside from the electronic components are motors. Often, if the motor is physically interchangeable, then it will work as a replacement. Electronic components and entire circuit boards (if identical models and production run) can often be substituted without difficulty, though servo alignment will probably be needed due to slight unavoidable differences between apparently identical pickups or electronic components.

For common components, whether a not-quite-identical substitute will work reliably or at all depends on many factors. Except for the optical pickup, non-custom components in CD players are fairly standard.

Here are some guidelines:

Fuses: Make sure that any substitute has the exact same current rating and at least equal voltage rating. I have often soldered a normal 3AG size fuse onto a smaller blown 20 mm long fuse as a substitute.

Resistors, capacitors, inductors, diodes, switches, potentiometers, LEDs, and other common parts: Except for those specifically marked as safety-critical, substitution is fine as long as the replacement part fits and specifications are the same. It is of course best to use the same part types as originally called for—for example, don't substitute a carbon resistor for a metal-film one. But for testing, even that is not a hard and fast rule, and a carbon resistor should work just fine.

Rectifiers: Replacements should have an equal or better PRV and I_{MAX} specifications. For power-supply rectifiers, 1N400x types can usually be used.

Transistors: Substitutes will generally work as long as their specifications meet or exceed those of the original. For testing, it is usually fine to use types that do not quite meet all of the specs as long as the BV_{CEO} and I_C specifications are not exceeded. However, performance may not be quite as good. For power types, make sure to use a heatsink.

Motors: Small PM motors may be substituted if they fit physically and their winding resistance are reasonably similar (say, within 25 percent of each other). Brushless DC spindle motors are not usually interchangeable.

Sensors: Many sensors used in CD players are sufficiently similar to permit substitution.

Power Transformers: In some cases, these may be sufficiently similar that a substitute will work. However, make sure you test for compatible output voltages to avoid damage to the regulator(s) and rest of the circuitry.

Belts: A close match should be good enough at least to confirm a problem or to use until a replacements arrives.

Mechanical Parts: Screws, flat and split washers, C- and E-clips, springs, etc. can often be salvaged from another unit.

Optical Pickups: This is discussed in the next section.

The following are usually custom parts and substitution of something from your junk box is unlikely to be successful even for testing: Microcontrollers, other custom programmed chips, display modules; and entire optical pickups, optical decks, or power supplies unless identical.

Repairing an Optical Pickup

Once you have located a problem in the optical pickup, what should you do? The quick answer is: probably nothing. In the end any such attempts may simply prove too time consuming and frustrating.

The only repair below the pickup level that I would consider as having a reasonable—though still not great—chance of success would be to swap the lens assembly including focus and tracking coils between identical pickups. The optical alignment is not supercritical at this point (however, servo alignment might be needed after this exchange).

Parts Sources

For general electronic components like resistors and capacitors, most electronics distributors will have a sufficient variety at reasonable cost. Even RadioShack can be considered in a pinch.

However, for the kinds of components used in consumer-electronics equipment—such as Japanese semiconductors, flyback transformers, or even degauss Posistors—there are a few sources you should be familiar with.

MCM Electronics (VCR parts, Japanese semiconductors, tools, test equipment, audio, and consumer-electronics replacement parts such as microwave-oven components and electric-range elements, etc.) Tel: 800-543-4330; Fax: 513-434-6959; Web: www.mcmelectronics.com/

Dalbani (excellent Japanese semiconductor source, VCR parts, other consumer electronics, Xenon flash tubes, car stereo, CATV) Tel: 800-325-2264, International Tel: 1-305-716-0947; Fax: 305-594-6588, International Fax: 1-305-716-9719; Web: http://www.dalbani.com/

Premium Parts (very complete stock of VCR parts, some tools, adapter cables, other replacement parts.) Tel: 800-558-9572; Fax: 800-887-2727.

Computer Component Source (mostly computer monitor replacement parts, but also some electronic components including semiconductors.) Tel: 800-356-1227, International Tel: 1-516-496-8780; Fax: 800-926-2062, International Fax: 1-516-496-8784.

Closing Comments

Well, that's it! If you have been following this series on CD players and CD-ROM drives, you now have all the information you should need to understand at least the basics of how this technology works and to be able to remedy the majority of common problems with CD (and other optical disc) equipment.

In case you haven't noticed, this and the other material in the "Service Clinic" column are derived from the much more extensive and detailed documents—the FAQs—at my Web site: www.repairfaq.org. So, if what you were looking for hasn't been addressed, please check there!

Also, please e-mail me with your feedback; the address, as always is sam@stdavids.picker.com. I would like to know how you liked this series; whether it was too long, too short, or just right; what you would like to see covered in the future; and anything else relevant to making "Service Clinic" a monthly column you just HAVE to read!

See you next time. EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Mind Your Ones and Sevens

It has come to our attention that there was an error in the "No Parts PIC Programmer" article in the September 1998 issue of **Electronics Now**. In the description on the operation of the hardware portion of the project in the second column on page 36, the original text read "When pin 11 of the printer port is low, D1 conducts." The pin number should have read 17 instead of 11. Since the cathode of D1 is connected to pin 17, grounding that pin would be the only way for D1 to become forward biased. Additionally, pin 11 on the printer port is for input only—it is not able to output an active voltage level.—*Editor*

More Who Are You

I'm a 53-year-old ham who enjoys your magazine **Electronics Now**. I like having some of everything in each issue and really am quite happy with it just the way it is. Keep up the good work, and I'll keep reading.

EARL KOLANDA, WA7Q1U
via e-mail

I'm an electrical engineer and co-owner of a small electronics development company, Sensor Technology Engineering, Inc. I have been reading your magazine for many years, and I have always enjoyed it.

Educationally, I have a bachelor's degree in physics and a masters degree in electrical engineering. Prior to forming my own company, I worked for one of the national laboratories. Most of my day is spent designing circuits, and electronics is my business and my livelihood.

But it's my hobby also, and one of my life's passions. As a kid, I pored over issues of **Popular Electronics** and **Radio-Electronics**. Gernsback's magazines kindled the fire of interest in electronics that led me to where I am today. I suspect one of the reasons that the U.S. has led in the development of electronics in this century has been that there are lots of guys like me out there.

The basic formula of your magazine works as well today as it did 40 years ago. I find project articles are always interesting, even though I rarely build any of them. It's fun for me just to figure out if they'll work or not. What's new articles are also good, provided they have some technical content to them. Don Lancaster's column is worth the price of the magazine all by itself.

I love the clever and elegant construction articles best. The beverage-can radon monitor comes to mind as an all-time great. The complexity of the project doesn't mean much to me, provided I can sit down and read about it and reach an understanding of how it works. I don't like construction articles where the author holds back necessary details, such as software, or uses gate arrays since it is impossible to determine what they are doing by simply reading the article. And despite what many authors suggest, most of the construction article projects can be built without their PC boards.

Some of the computer articles are interesting, but I wouldn't push aside the basic electronics in the hope that computer articles will attract more readers. There are lots of magazines about computers and very few electronic hobbyist magazines. Trying to be everything to everybody is always a losing strategy—you end up being nothing much to anyone.

It is my opinion that you should challenge your readers and push their knowledge level a bit. I think it's a mistake to underestimate the capabilities of hobbyists. I've seen some remarkable things accomplished for the sheer objective of having fun!

I appreciate your seeking the opinions of your readers concerning the contents of your magazine. However, don't doubt yourself too much—your magazine is important and has a far-reaching influence.

KEN VADNAIS
via e-mail

EN

Write To:
Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

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.

BY JEFF HOLTZMAN
COMPUTER EDITOR

Comparative Anatomy

LAST MONTH, WE BEGAN A PROJECT TO IMPLEMENT A C COMPILER FOR THE AVR LINE OF MICROCONTROLLERS. WE COULD START FROM SCRATCH, BUT THERE'S AN EASIER WAY: THE SMALL C COMPILER FIRST PUBLISHED IN *DR. DOBBS JOURNAL* almost 20 years ago. That compiler was created by James E. Hendrix; full source is available. The very first version of Small C was created on and for a Z80 microprocessor running CP/M. The final version (2.2) was created on and for an Intel CPU running DOS. Many ports of Small C exist (*e.g.*, to 8051, 6502, and more).

To implement a compiler for a given CPU or MCU, you must have a detailed understanding of the architecture of the target device. In addition, Small C initially generates code for a virtual CPU, and then translates that generic code into 8086 assembly language, after which it can be assembled, linked, and executed on the target system. To be able to change Small C's code-generation module, you must understand both the virtual CPU and the target, in this case, the AVR microcontroller family.

Thus, to initiate this project, we're going to hold a course in comparative anatomy. But you don't have to worry about the smell of formaldehyde or cutting up organic tissues. Our subject is silicon, and we'll do it on paper.

The Virtual Architecture

Internally, after parsing the input text, Small C generates pseudo-codes (p-codes), which it then translates into x86 assembly language. An external assembler translates the assembly language text into a relocatable machine-code object file. Then an external linker combines the object file(s) with the C run-time library to produce an executable file. Figure 1 illustrates the process.

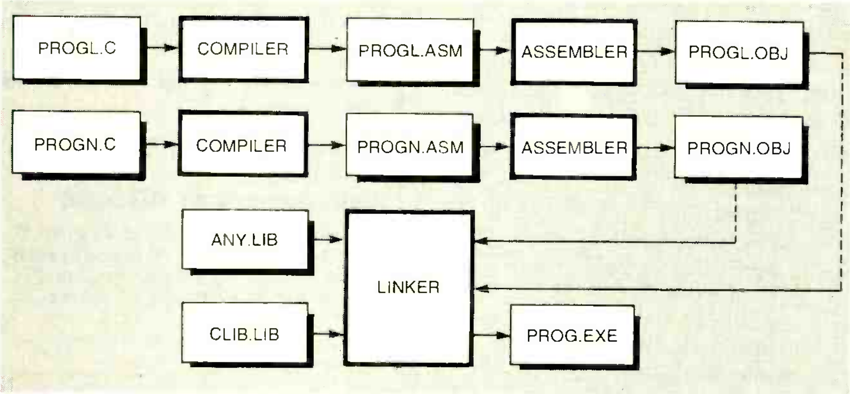


FIG. 1—THE PROGRAM CREATION PROCESS in Small C: One or more C program files is compiled, assembled, and linked with the Small C library (and optionally other libraries), and finally linked to produce an executable.

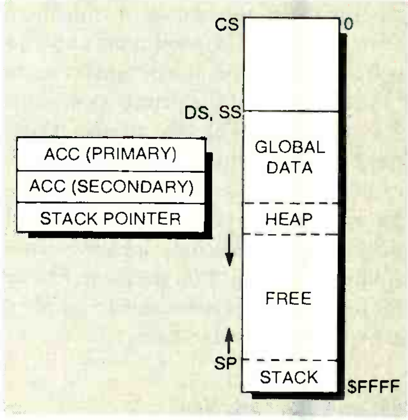


FIG. 2—SMALL C's COMPILER MODEL as implemented on an 8086 CPU. The Code Segment is fixed in size and is as large as 64K. The Data and Stack segments are equal, and also as large as 64K. The Heap grows up and the Stack grows down; woe should they ever meet!

As mentioned last time, Small C includes its own assembler, but no linker. DOS used to come with a linker, and most old 16-bit development tools did as well, but that's no longer true. I'll post a copy of a very old version of Borland/Inprise's TLINK.EXE, which is adequate for our purposes, on the Ingeneering Web site (www.ingeninc.com).

Unfortunately, in Small C the dividing line between the parsing and code-generating phases is not as clean as the diagram makes it seem. Some of the earlier phases actually emit some assembly language, and it's hard coded to the Intel CPU family. That doesn't affect us now, but it will later, when we actually start generating code. At that time we'll borrow a trick from Andy Yuen, who implemented a multitasking module for Small C. (Andy's trick involves adding additional p-codes, thereby removing the architectural dependency.)

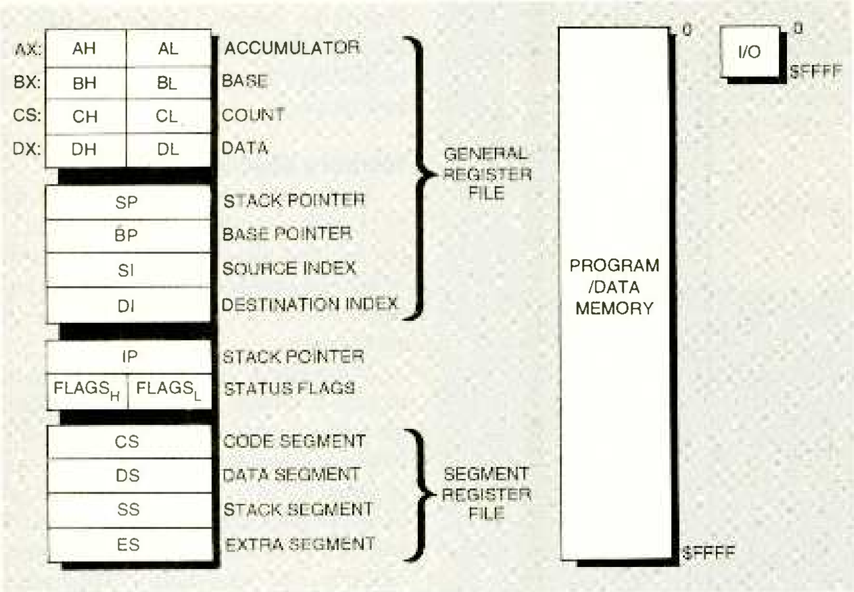


FIG. 3—THE 8086 REGISTER, memory, and I/O model: It might not look like much, but it kicked off the PC revolution.

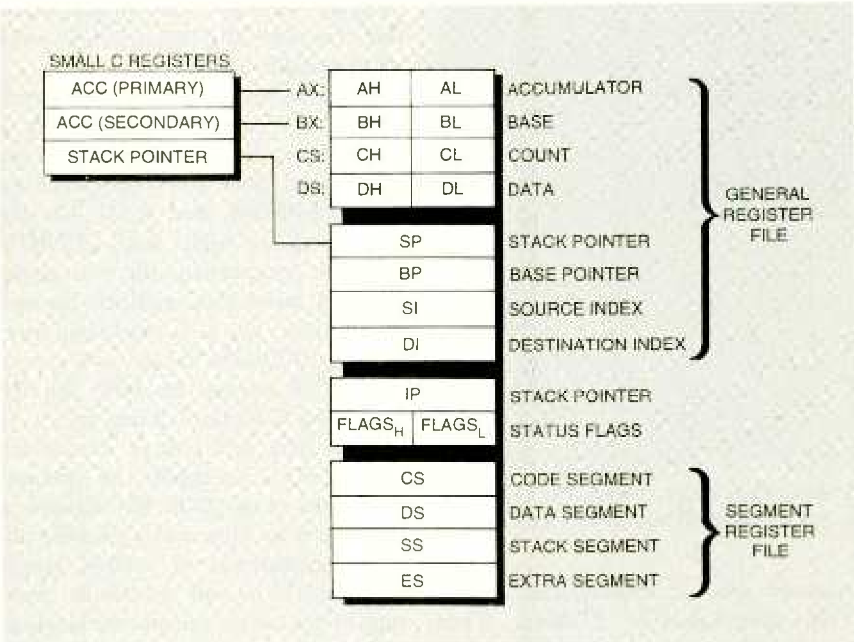


FIG. 4—SMALL C's VIRTUAL CPU maps to an 8086 as shown here.

The processor for which the p-codes are generated is the so-called virtual CPU mentioned above; its architecture appears in Fig. 2. The CPU has two accumulators (primary and secondary), a stack pointer, and a unified program and data memory store. That memory is used for program code, the stack, and the heap. The heap is where dynamically allocated memory exists. In a running program, the heap and the stack share some big chunk of memory; the heap grows upward, and the stack grows downward. A program may crash or data may be corrupted if they ever cross.

The x86 Architecture

The 8086 architecture is more complicated. As shown in Fig. 3, there are four general-purpose registers (A, B, C, and D); four memory index pointers (SP, BP, SI, and DI); the program counter; a set of flags; and four segment registers (CS, DS, SS, ES). Each general-purpose register can be addressed as a 16-bit whole (*e.g.*, AX), or in 8-bit halves, high and low (*e.g.*, AH and AL). There is also a separate 64K space for I/O, and a 20-bit (1 MB) program memory.

The segment registers require special explanation. By itself, a 16-bit register can address a maximum of 65536 bytes, or 64K of memory. To surmount that limit, all x86 CPUs allow a 20-bit address to be formed by taking the contents of a segment register, multiplying by 16, and then adding the contents of a base register. Doing so gives an effective 1-megabyte address space, even though it makes life difficult for programmers. Just about any book on 80x86 assembly language programming can spell out the details, but for our purposes, they don't matter. Small C essentially ignores segmentation, effectively limiting Small C programs to 64K of code and 64K of data/stack. Today that may not seem like much, but remember, both Small C and Small Assembler are written in Small C, proving that useful does not necessarily have to be big.

As discussed above, the Small C virtual CPU has three registers; those are mapped to x86 registers as shown in Fig. 4. The remaining x86 registers can be used by the code-generating system of Small C any way it sees fit.

The AVR Architecture

The AVR is a microcontroller, which means that in some ways it is more complex, and in others, less so, than a general-purpose microprocessor like an x86. Various members of the AVR family have different I/O functions, including serial and parallel I/O, pulse-width modulation, A/D conversion, and so on. We're going to discuss a moderately high-end device, the 8515. The low-end devices are memory-poor, and higher-end devices are still expensive and hard to obtain. The 8515 provides a pretty good balance; for detailed information, request a data book from Atmel (2325 Orchard Parkway, San Jose, CA 95131), or see the company's Web site (www.atmel.com).

The 8515 has the following built-in capabilities: 4K × 16 program (flash) memory, 512 bytes of EEPROM, 512 bytes of static RAM, 32 8-bit general purpose registers, four 8-bit ports, a serial UART, a serial programming interface, an 8-bit counter, a 16-bit counter, two PWM outputs, external and internal interrupts, a watchdog timer, and an analog comparator. The 8515 comes in 40-pin DIP and 44-pin PLCC packages, can run at 2.7± 6.0 volts DC, has fully static operation up the rated clock speed, single-cycle execution of most instructions, and lock bits for software security. Several functions are multiplexed to single pins, so you can't have all capabilities active simultaneously.

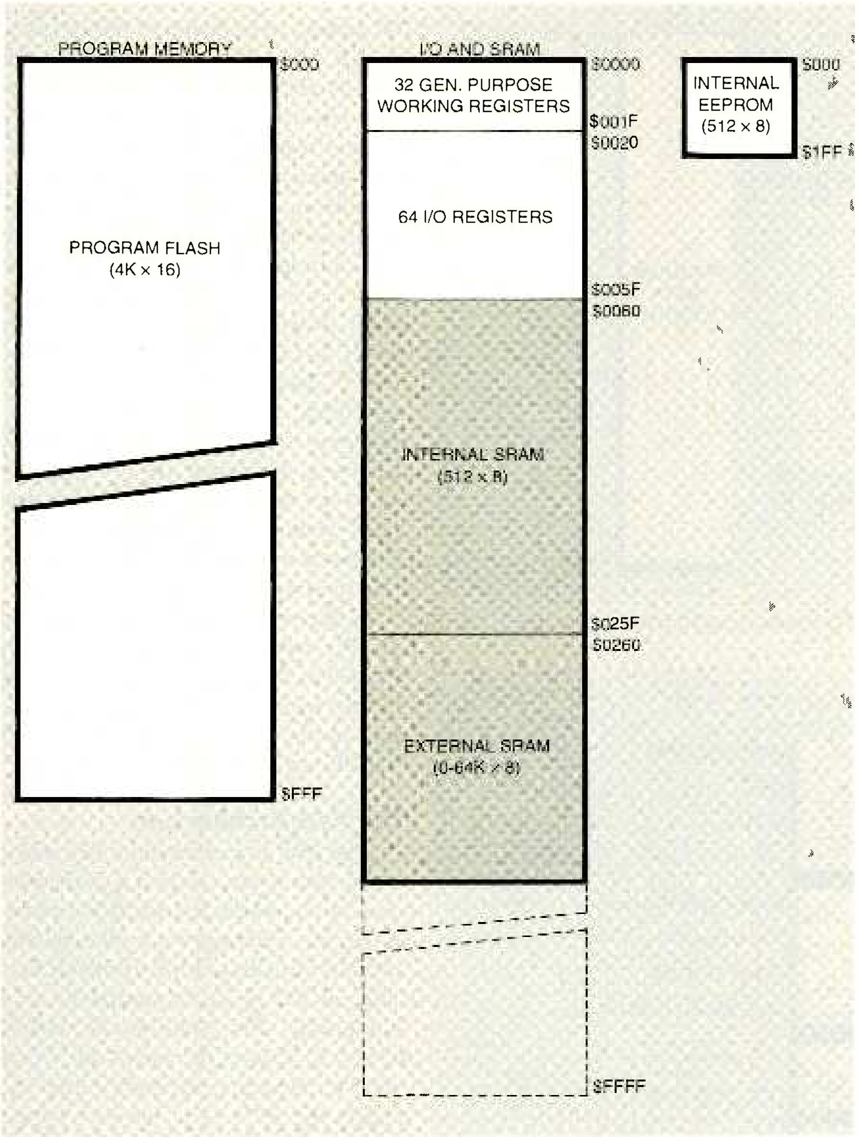


FIG. 5—ATMEL's AVR MICROCONTROLLERS have built-in Flash, SRAM, and EEPROM, as well as extensive I/O capabilities, depending on the model. Shown here is the 8515.

For example, you can use two of the 8-bit ports to implement up to 64K of external static RAM.

The 8515's memory architecture appears in Fig. 5. Note that are three separate memory spaces. The program memory space is implemented as on-chip programmable FLASH. That means you can download code and data to the program memory space, and it will remain there indefinitely. However, the program memory space is essentially ROM; you cannot write to it within a local program.

The data memory space has several unusual features. Working from top to bottom, note that the CPU's 32 general-purpose registers are addressable here. You can also address them directly (*e.g.*, R1, R2, ... R32). Following the general-purpose registers are the I/O registers. Those allow controlled access to all the I/O capabilities of the MCU, including ports, control registers, setup registers, and so on. Next comes 512 bytes worth of internal static RAM. Following that comes the optional maximum 64K of external SRAM. Third comes 512 bytes of EEPROM, which can be read and written locally.

SMALL C RESOURCES

Dr. Dobbs Journal sells a CD-ROM that contains the complete text of James Hendrix' excellent, out-of-print book on Small C, as well as the complete source to Small C 2.2, several ports, and more than a dozen additional articles of interest. See www.ddj.com, or call 800-822-1162.

You can also visit the Tech Corner of the Ingeneering Web site (www.ingeninc.com), where I'll post the Small C source and executable, a linker, and any code generated as part of this project.

Memory Madness

With all the I/O capabilities of the 8515 AVR chip, it's easy to lose sight of the fact that the chip has only 512 bytes of general-purpose RAM. The 64K segment size of the x86 chips is huge in comparison.

What that means is that we're going to have to change the way global objects are stored, and possibly alter the Small C language somewhat. The problem is that in Small C, as in most C compilers, all local variables are located on the stack, and 512 bytes is not much. The general idea is that by using static or const access specifiers, we could force the compiler to store items such as long text strings in program memory. The strings would then be read-only, but precious stack space would be spared.

Actually, it's even more complicated than that. We may also want a way of storing data in EEPROM. Thus we would need three access specifiers: for flash, EEPROM, and RAM. On the other hand, we might make EEPROM accessible programmatically, through the language, rather than implicitly, through the compiler. I've even considered making the EEPROM appear as a sort of implicit file stream, accessible through the normal C routines (fopen, etc.).

Next time we'll look at ways of enhancing raw C to handle the hardware capabilities of the AVR. We will look at issues such as: How will we handle differing capabilities of various family members? How will we handle interrupts? How can we enhance the language without destroying its essential flavor? In the meantime, stay in touch via e-mail at jeff@ingeninc.com. **EN**

Digital Multimeters

DESIGNED FOR ELECTRONIC and electrical technicians and for electricians, the 80 Series III digital multimeters (DMMs) from Fluke provide high-performance measurement accuracy. Durable, rugged, and highly portable, these units are true rms, analog/digital meters. They withstand power surges up to 8 kV and meet IEC 1010 CAT III 1000-volt safety standards.

The 80 Series III DMMs feature 11 functions for electronic and industrial applications, including high-performance DC/AC voltage and current measurement, frequency, duty cycle, resistance, conductance, continuity, diode test, and capacitance measurement. These meters offer improved resistance to EMI noise, 250 µS peak min/max, and .05% basic DC accuracy.

Included in this series are the Model 83 III, Model 85 III, Model 87 III, and Model 87/E III. The last-cited DMM is specially configured for electricians and comes with extra-long silicone-insulated test leads, customized test probes, and an SC20 industrial test clip.

All models feature a recording mode that captures the maximum, minimum, and average readings, while monitoring a signal. The meter emits a beep while recording to indicate that a new reading has been sensed and stored. Users can select response times from 100 ms to 1 second on all models. In addition, the 87 and 87/E have a 250 µs response setting for capturing fast transients, which can be used to isolate the peak of an AC signal.

Touch Hold and Relative modes are provided on all models. Touch Hold captures the measurement, beeps, and locks it on the digital display for later viewing. In this mode, readings are automatically updated with each new measurement. Relative mode remembers a reading and displays the difference between it and subsequent readings.

The 80 Series III DMMs are easy to read with an LED backlight that provides viewing under virtually any ambient conditions and an LCD with large digits and an improved viewing angle. A separate on/off control operates the backlight. Models 87 and 87/E have a 4-$^1/_2$ digit mode.

The battery access door enables the user to change batteries without breaking the calibration seal. A holster protects the meter, which measures approximately 7.3 by 3.4 by 1.2, when it is used in harsh operating conditions. List prices range from $279 for the 83 III to $369 for the 87/E III.

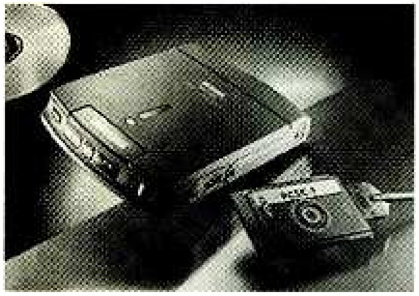
CIRCLE 20 ON FREE INFORMATION CARD

FLUKE CORPORATION
P.O. Box 9090
Everett, WA 98206-9090
Tel: 800-44-FLUKE or 425-356-5500
Fax: 800-FLUKE-FAX or 425-356-5116
e-mail: fluke@info@tc.fluke.com
Web: www.fluke.com

Portable CD-ROM Drive

MEANT FOR THE POWER USER who wants performance and portability, the CDPS-PX24 is a high-performance 24-speed SCSI CD-ROM drive. The durable, compact and lightweight CDPS-PX24 has a transfer rate of 3600 kbps and an access time of 90 ms. The included 16-bit SCSI-2 Interface Type II PC Card easily connects the CDPS-PX24 to any notebook PC, and it can be used with palmtops as well.

The drive supports CD-DA (audio), CD-ROM XA (video), enhanced CD, photo CD, and 8 cm CD. With headphone and lineout speaker jacks, it plays conventional CDs as well as CD-ROM. It is compatible with Windows 95, Windows 3.1, or DOS.



CIRCLE 21 ON FREE INFORMATION CARD

External controls and the LCD readout make the CDPS-PX24 easy to use. The drive weighs 370 grams and measures 5.2 by 8 by 1.1 inches. It operates from either six "AA" batteries or from AC power.

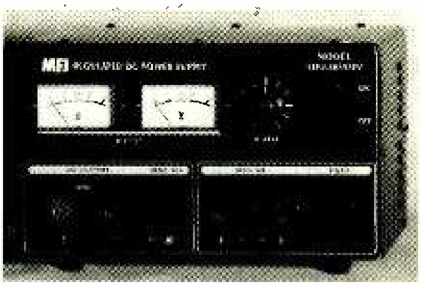
In addition to the PC card, the drive is bundled with interface cable, supporting software, 13.0-VAC adapter, and operating manual. It retails for $299.

I-O DATA DEVICE, INC.
2005 Hamilton Avenue, Suite 220
San Jose, CA 95125
Tel: 408-377-7062
Fax: 408-377-7085
e-mail: info@iodata.com

Adjustable Power Supply

THE HEAVY-DUTY MFJ-4035MV 35/30 amp adjustable regulated DC power supply features 35 amps surge and 30 amps continuous power. Voltage is front-panel adjustable from 1 to 14 VDC. Detent is set at 13.8 VDC. The front panel of the MFJ-4035MV has lighted meters—a volt-meter and an amp-meter that monitor the load continuously—an easy-to-reach on/off switch, and a fuse holder for convenient fuse replacement.

There are three different output terminals: a five-way binding post for HF/VHF radio, two pairs of quick connects for low-current accessories, and a cigarette lighter socket for mobile accessories.



CIRCLE 22 ON FREE INFORMATION CARD

The power supply has circuit protection built in that automatically shuts it down when it's drawing too much current. A quiet internal fan cools the unit, which measures $9^1/_2$ by 6 by $9^3/_4$ inches and weighs approximately 10 pounds. The MFJ-4035MV power supply retails for $149.95.

MFJ ENTERPRISES, INC.
P.O. Box 494
Mississippi State, MS 39762
Tel: 800-647-1800 or 601-323-5869
Fax: 601-323-6551
e-mail: mfj@mfjenterprises.com
Web: www.mfjenterprises.com

Tri-Band Transceiver

PRESENTED AS THE WORLD'S smallest tri-band handheld and the only one with 50-MHz coverage, the ICOM T8A weighs only 9.9 oz. and measures approximately $2^1/_4 \times 4^1/_4 \times 1^1/_8$ inches. The transceiver covers the 6-meter, 2-meter, and 440-MHz amateur bands, which include "receive" coverage of the popular aircraft-band, 150- and 450-public safety bands, and FM and TV broadcast bands.

The T8A's transmitter output power is 5 watts on all bands. Simply pressing the BAND switch selects the active band. It has a 123 memory capacity, including 10 scan edges and 1 call channel per band, arranged in 10 groups of 20 channels each. A variety of scanning methods are provided.

Tone squelch, pocket beep, and auto-squelch are standard features of the T8A, as is tone scan, which allows users to determine the subaudible tones required to access repeaters. The pocket beep feature also provides a "pager-like" function. The T8A also offers a DTMF decoder with nine DTMF memory channels.

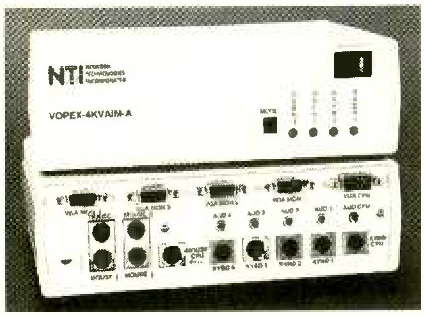
Other features include auto-power saver, electronically controlled volume, and direct keypad input. A guide function allows display of the selected mode in the T8A's display window for convenient setup. This window has an LCD backlight with a timer. Power is provided by a lightweight Ni-MH battery pack. The transceiver is water-resistant and features a die-cast aluminum chassis for durability and reliability. The T8A has a suggested list price of $392.

ICOM AMERICA
2380 116th Avenue NE
Bellevue, WA 98004
Tel: 425-454-1855
Fax: 425-454-1509
Web: www.icomamerica.com

CIRCLE 23 ON FREE INFORMATION CARD

Keyboard, Monitor, and Mouse Splitter

AUDIO CAPABILITY HAS BEEN added to the VOPEX-4KVAIM-A, a four-port keyboard, monitor, and mouse splitter. Now multiple users can connect to the same computer and use headphones to independently hear and interact with desktop presentations and electronic training software. Network managers who use these splitters to access servers from dual locations such as the office and the warehouse can bring the audio to both places.



CIRCLE 24 ON FREE INFORMATION CARD

Four keyboards, monitors, speakers, and mice are plugged directly into the VOPEX-4KVAIM-A. The computer peripherals can be placed up to 500 feet away by connecting extension cables between them and the splitter. All the VGA monitors show the same image, with guaranteed 1600 × 1200 resolution up to 250 feet. Access from the keyboards and mice is automatic upon typing or mouse movement.

Audio output devices connect to 3.5 mm stereo jacks. Three-foot cables for connecting the VOPEX-4KVAIM-A to the PS/2 or compatible are included. The splitter—housed in a 8 × 6.2 × 2.6 plastic case—is powered by 110 or 220 VAC and retails for $515.

NETWORK TECHNOLOGIES INC.
1275 Danner Drive
Aurora, OH 44202
Tel: 800-742-8324 or 330-562-7070
Fax: 330-562-1999
Web: www.networktechinc.com

Computer Monitor Tester

DESIGNED FOR USE IN BOTH the field service and shop maintenance areas, the Checker Pro is a computer color monitor pattern generator that can check out almost any monitor. Problems can be isolated by directly connecting the unit to the monitor. The unit can be AC or battery operated.

The Checker Pro makes it easy to do testing and evaluating. It is no longer necessary to swap video cards or monitors or even open the computer for a diagnosis. Technicians no longer need to tie up a computer system to test or burn in a monitor. With sweep rates from 31.5 to 64 kHz, the Checker Pro supports Mono, CGA, EGA, MAC, and VGA modes.

CIRCLE 25 ON FREE INFORMATION CARD

On the bench, the tester offers great flexibility. Technicians can quickly switch modes using the pushbuttons, add sync on green, turn off any of the colors, and turn off either horizontal or vertical sync. The Checker Pro features various test patterns for VGA monitors. Its color bar/8-step gray-scale pattern allows color balance and tracking to be quickly evaluated and or adjusted. The Checker Pro has a suggested retail price of $499.95.

COMPUTER & MONITOR MAINTENANCE, INC.
6649-N1 Peachtree Industrial Blvd.
Norcross, GA 30092
Tel: 800-466-4411 or 770-662-5633
Web: www.computermonitor.com

Virtual Scope

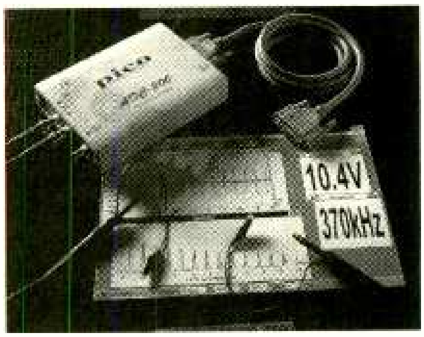
PICO TECHNOLOGY'S ADC200-100 virtual digital scope combines the functions of a 100 million samples/sec dual-channel digital oscilloscope and a 50-MHz spectrum analyzer in a PC-based virtual instrument. Performing all the operations of a standard oscilloscope and digital multimeter, the ADC200-100 uses its computer capability to annotate and save, as well as print traces in black and white or color, and to cut and paste waveforms into word-processing documents.

The PicoScope software supplied with the instrument provides simultaneous display of the oscilloscope, spectrum analyzer, and digital multimeter functions. In addition, the autoranging multimeter features simultaneous display of multiple parameters, such as true rms or DC voltage, dB gain, and frequency measurements.

Easy-to-use features include overlaying a live trace with a stored reference trace, plus on-screen help and pull-down menus. Powerful triggering modes help to capture intermittent or unusual events. The "Save On Trigger" option saves every trigger event to disk, complete with date and time stamp.

Identifying the source of noise on power lines, which is difficult with a standard oscilloscope, is simplified on the ADC200-100's spectrum analyzer. Even when there are multiple noise sources, the analyzer makes it easy to identify the signature of the noise and to determine its source. The 0–50 MHz spectrum analyzer range covers frequencies required for EMC-conducted noise testing.

With the ADC200-100, transferring the data to other applications such as spreadsheets is easy. Users can also automate data collection and analysis with the software drivers supplied.



CIRCLE 26 ON FREE INFORMATION CARD

Previously available in Europe, the ADC200-100 is now available in the U.S. for $799 from the Saelig Company.

SAELIG COMPANY
1193 Mosely Road
Victor, NY 14564
Tel: 716-425-3753
Fax: 716-425-3835
Web: www.saelig.com

EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Digital Satellite Television

by Frank Baylin
Baylin Publications
1905 Mariposa
Boulder, CO 80302
Tel: 303-449-4551
Fax: 303-939-8720
Web: www.baylin.com
$50 plus $4 S & H

CIRCLE 338 ON FREE INFORMATION CARD

In this completely rewritten version of *Ku-Band Satellite TV*, Dr. Baylin has extensively revised and expanded the material, covering all aspects of world-wide digital satellite television systems. The book starts with the basics, including concepts of communication, digital modulation methods, the effects of noise and frequency allocations, and analog video and audio methods. Video compression, the MPEG-2 standard, DVB and channel encoding techniques are then discussed.

The author covers the components of a satellite circuit—the uplink, the satellite, and the receive site; geostationary satellites; and satellite design and operation. He goes on to discuss the current state and future trends in the design of both analog and digital satellite receiver. Other topics explored in this comprehensive 488-page manual are installation methods; upgrading systems from C- to Ku-band, from single to multi-feed operation and from analog to digital reception; and methods of designing and sizing dishes.

Conventional and IF distribution systems, mobile applications for satellite television, and troubleshooting and repairing satellite receive systems are all thoroughly reviewed. This comprehensive book is profusely illustrated with over 400 photographs and diagrams.

USB Peripheral Design

by John W. Toon
Annabooks
111838 Bernardo Plaza Court, Suite 102A
San Diego, CA 92128
Tel: 800-462-1042 or 619-673-0870
Fax: 619-673-1432
e-mail: info@annabooks.com
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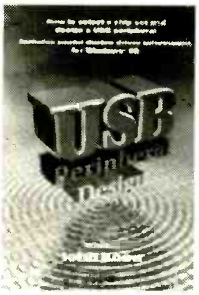


CIRCLE 339 ON FREE INFORMATION CARD

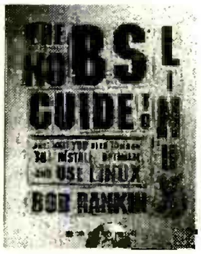
A complete overview of and practical guide for designing USB peripherals, this book answers the most common questions about the subject and refers readers to the resources needed to develop and test USB device drivers for Windows 95/98 and Windows NT 5.0. It is a complete reference manual for design, marketing, sales, and product managers and for device driver developers. Highlights of the latest USB Specification, a summary of USB features and operations, and application examples are included. Audio, video, and various device functions are defined.

It covers hardware and software components, including Windows 98, host and device side interlayer communication models, and use of generic drivers. How to design your own drivers, USB hub and device design considerations, power requirements, and numerous compatibility and testing issues are presented. The book also covers device, host, hub, and power ICs, as well as USB development tools and sources.

The appendix includes contact names and numbers for the leading suppliers of tools, hardware, and software required for USB peripheral design.

The No B.S. Guide to Linux

by Bob Rankin
No Starch Press
401 China Basin Street, Suite 108
San Francisco, CA 94107
Tel: 415-284-9900
Fax: 415-284-9955
e-mail: info@nostarch.com
Web: www.nostarch.com
$34.95

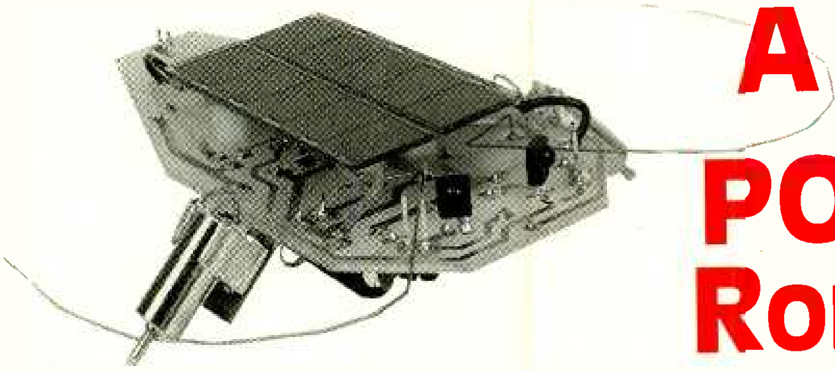


CIRCLE 340 ON FREE INFORMATION CARD

Previously those who were curious about Linux had to tackle bulky, technical books. This straightforward, easy-to-read guide tells readers just what they need to know to run and install Linux, and it is bundled with a complete copy of Linux on CD-ROM. The CD-ROM also contains the complete *Linux Encyclopedia*, as well as the Apache Web server and dozens of games, compilers, and utilities.

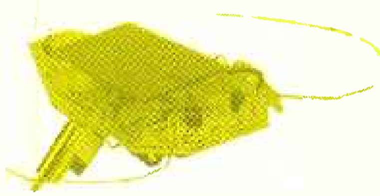
The author presents a concise treatment of installing Linux in ten easy steps; using the Bash shell; understanding the File System and navigating tree-structured directories; and listing files, creating and changing directories, and modifying command prompts. Explanations are given of running Windows programs and accessing DOS files, data manipulation—utilities for sending, searching, reporting, compression, encoding, and encryption—and configuring and using X Windows. Internet access and tools, reading and sending e-mail, using text editors, and running a Linux Web server are among the other topics discussed.

(Continued on page 59)



A SOLAR-POWERED ROBOT BUG

It creeps. It crawls.
It constantly searches for light on which to feed.
It's also as fun to watch as it is to build!



DAVID WILLIAMS

The concept of robots and robot design has captivated the mind and imagination of people since antiquity. Indeed, there have been kits, plans, and ready-assembled "mechanical servants" available for years. Robots from the ultra-simple to the extremely complex have graced the pages of many hobbyist and technical magazines, including **Electronics Now**.

The immediate image that the average person has whenever the term "robot" is mentioned usually leans toward the "mechanical man" design. Examples of that concept include Robby the Robot from the classic 1950's science-fiction film *Forbidden Planet* and the *Lost In Space* television series of the 1960's.

Robot design usually falls into one of three categories: mechanical devices that require human control for their operation, self-contained machines that follow an internal computer program, and simple "stimulus-response" units that use layers of simple electronic circuits and sensors to react to their environment.

It is that last category to which the subject of this article belongs. The *Solbot* presented here is an insect-like solar-powered robot. Although it has no computer and no provision for remote control, it has the ability to seek light and avoid obstacles.

Robot Behaviors. To mimic an insect's ability to maneuver in a real-world environment, the Solbot relies on autonomous "behaviors" that are organized into a control system. The most primitive of those behaviors is *explore*, which constantly urges the robot to move forward. However, with just that single behavior, it has no direction to its wanderings and no way to avoid being stuck. To give the robot more purpose, a second behavior, called *seek*, comes into play. That function lets the bug "see" light and move towards the strongest source. That can also be thought of as a "feeding" behavior, since the unit needs light falling on its photovoltaic cell for electrical power. To help the Solbot with the problem of being stuck, a third behavior, *avoid*, overrides the seek behavior.

That collection of three behaviors gives the control system a prioritized set of rules. The order of priority in the behaviors is designed to resolve any conflicts in the individual behaviors and coordinates a goal-oriented activity. In a sense, the system acts very much like a simple neural network.

Neurons. In living creatures, a nervous system organizes the reflexes in order to accomplish a task. The fundamental units of any nervous system are neurons. Neurons are nerve cells containing dendrites (inputs), a cell body (signal processor), and axon (output). An example of a neuron is shown in Fig. 1A. A neuron receives signals from other neurons through the dendrites. When a particular number of dendrites are stimulated in a particular way, the neuron "fires," sending an electrical impulse down the axon.

The cell body accumulates and grades all of the dendrite inputs through the surrounding membrane. Through a complex electrochemical process, each input has a "weight" associated with it. Those weights let each signal have a different influence in stimulating the neuron. In addition, some inputs can have negative weight that will inhibit the neuron from firing.

All of the inputs are combined and integrated over time. If a certain threshold potential is reached, the neuron will fire and send an impulse down the axon. The axon signal can trigger another neuron, stimulate a gland, or cause a muscle cell to contract, depending upon the neuron type.

Modeling Neurons. A block diagram of a neuron's function, and therefore the Solbot's nervous system, is shown in Fig. 1B. Two dendrites are used for the light detection and obstacle avoidance sensors. The block diagram also shows the two functions of the "cell body"—the summing of the inputs and the threshold function for the output. The diagram also includes a motor-control output to match the axon in a biological nerve cell.

With that information, we can design a circuit that carries out the functions just described.

Circuit Description. The Solbot circuit, shown in Fig. 2, is an improved variation of a circuit originally designed by David Hrynkiw of Canada. Two identical circuits are used; the description applies to both halves. The circuit uses two high-efficiency solar cells, PC1 and PC2, to convert sunlight or ambient light into a DC voltage. That voltage is accumulated by charging C3 and C4. The two capacitors are wired in parallel, which doubles the effective capacitance of the circuit. The "explore" behavior mentioned before comes from that power source. In the dark, the Solbot will remain stationary, but in the light, it has an endless will to move.

The "seek" inputs are provided by photodiodes D1 and D2. The setting of potentiometer R5 and the intensity of the light falling on each photodiode determine the relative importance of each input with respect to each other. As the voltage rises across C3 and C4, current flows through R5, D1, and D2. That, in turn, charges C1 and C2. Since the photodiodes restrict the amount of current in relation to how much light that they "see," the voltage that appears on C1 and C2 will represent the amount of light seen by the photodiodes. The setting of R5 balances the circuit so that C1 and C2 will have the same charge if the amount of light falling on D1 and D2 is the same.

Switches S1 and S2 are the "avoid" inputs. If the Solbot's "antennas" brush up against an object in its way, one of the switches closes, depending on which side of the robot the obstruction is on. When the switch closes, either C1 or C2 discharges to ground through R3 or R4, respectively. That way, Solbot will "think" that there is no light in that direction. In a sense, the "seek" behavior has been overridden by the "avoid" behavior, turning Solbot away.

The voltages that appear on C1 and C2 are fed to IC1 and IC2, respectively. Those integrated circuits

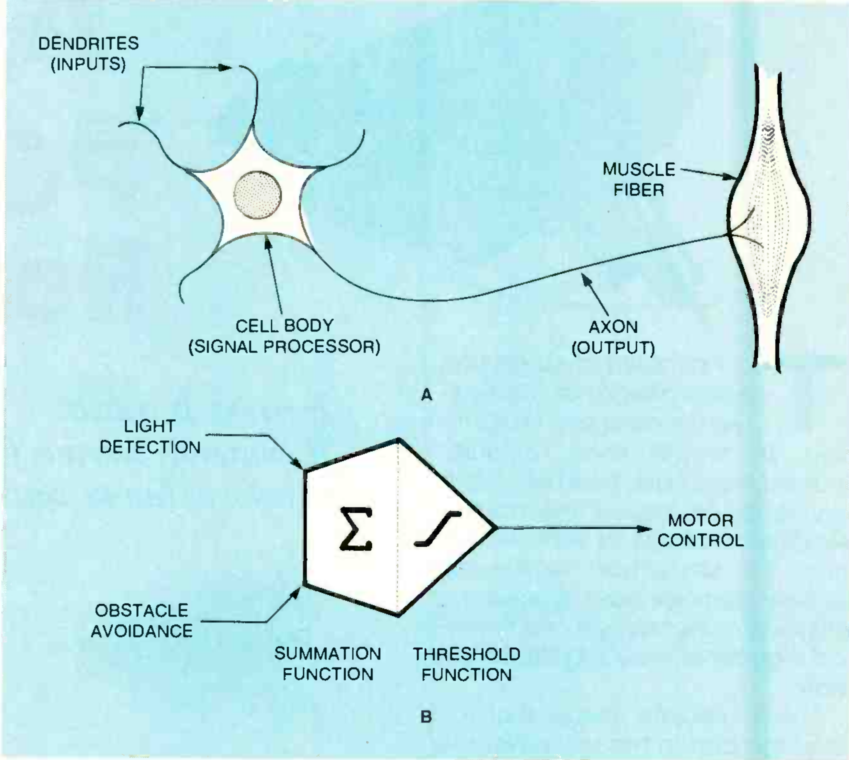


Fig. 1. In an organism (A), a nerve cell has several dendrites that serve as inputs. The cell body processes the inputs and "fires" when the right combination occurs. The output pulse travels down an axon to signal a muscle to contract. The entire process can be diagrammed schematically (B).

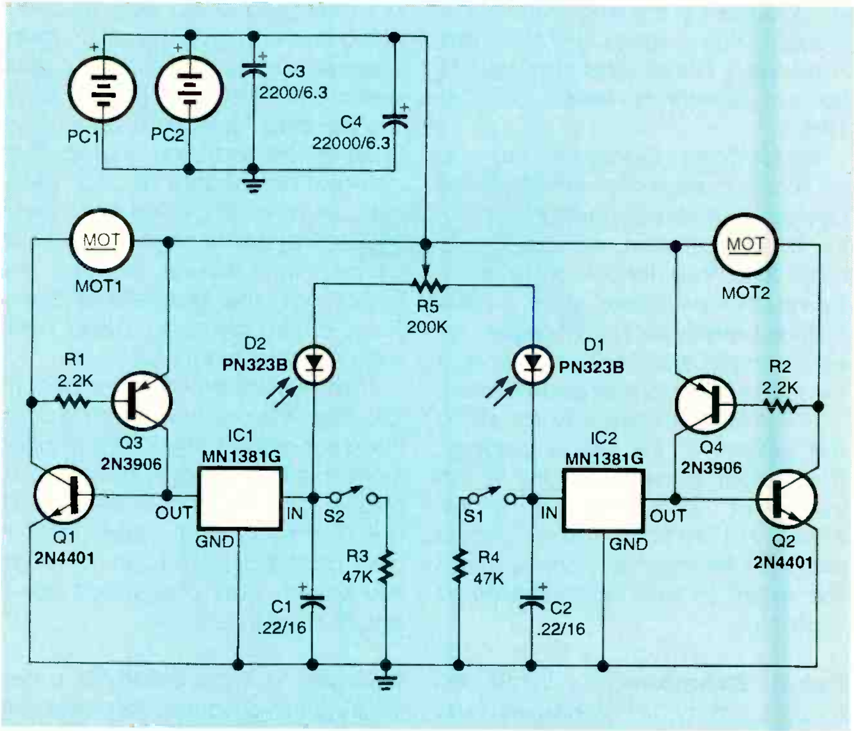


Fig. 2. The Solbot's circuit is a simple circuit that charges a pair of capacitors. When the capacitors reach a certain voltage level, the stored charge is dumped into a pair of miniature electric motors. If the ambient light is stronger on one side, the opposite circuit will charge faster, steering the robot in the direction of the light. The switches close when something is in the way: the robot will then move away from the obstruction.

were originally designed to be "power-on reset" circuits for microprocessor-based devices. Here, they are being used for threshold detection of the voltage on C1 and C2. When the input voltage on pin 2 of the MN1381s is less than 2.5 volts, the devices are "off"—their output pins are grounded. When the voltage on pin 2 rises above 2.5 volts, the device turns on, with the voltage on pin 1 equal to the input voltage on pin 2.

The output of each threshold detector goes to a motor-drive circuit. That circuit is the axon of the "electronic neuron." The drive circuits are designed to let the full charge of C3 and C4 flow through the motors. A single transistor is not sufficient, because as the voltage on C3 and C4 drops below 2.3 volts, the MN1381s will switch off and shut down the motor drive. To get around that limitation, two transistors and a resistor are used to form a circuit that acts like a silicon-controlled rectifier, or SCR. Once it is triggered, Q3 and Q4 will continue to supply current to Q1 and Q2. The circuit will stay latched on until C3 and C4 are discharged to about 0.7 volts. At that point, there is no longer a sufficient voltage drop for the silicon-based semiconductors to remain conductive.

Construction. The Solbot's circuit has no critical requirements in terms of layout; it can be hand-wired on a perfboard using standard construction techniques. However, an etched PC board will make it easier to position the motors and the antennas properly, as well as make for a neater and more professional look to the unit. If you choose to use a PC board for the Solbot, you can etch your own board using the foil pattern that has been included here. As an alternative, you can purchase a pre-etched board from the source given in the Parts List.

If you are going to use a purchased board or one made from the foil pattern, follow the parts-placement diagram shown in Fig. 3. Mount the parts to the board starting with the smallest ones. The following components should not be mounted to the board at this time: D1, D2, PC1, PC2, MOT1, MOT2, S1, and S2.

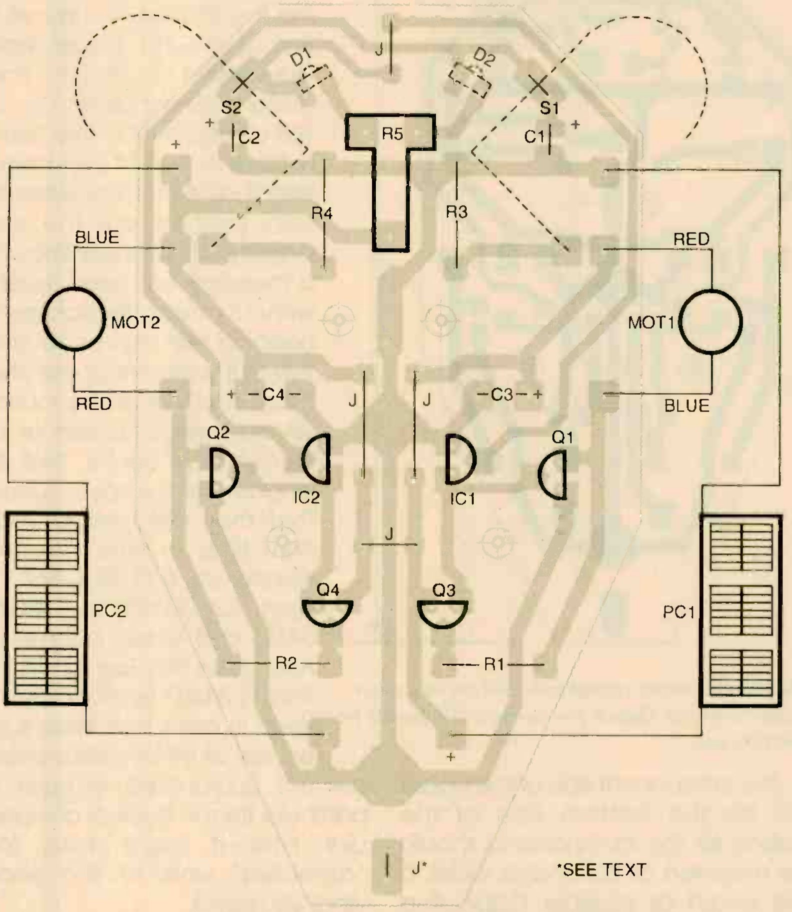


Fig. 3. Here is the parts-placement diagram for the Solbot solar-powered robot bug. All of the parts that are placed on the component side will be the unit's "underbelly." The jumper wire at the narrow end is a "skid" that holds up the robot's rear end.

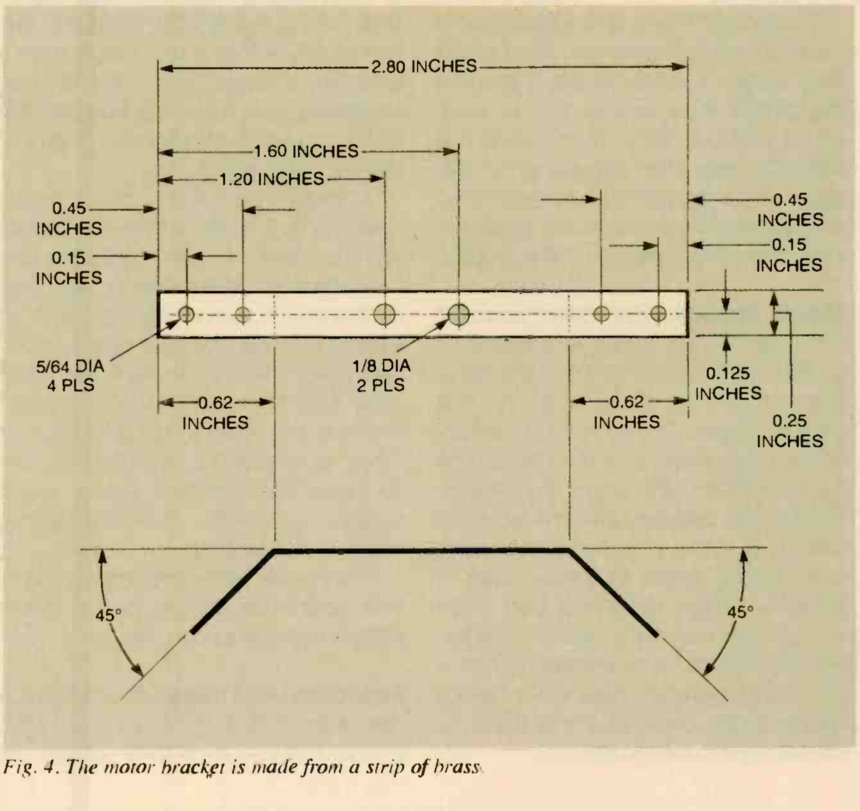
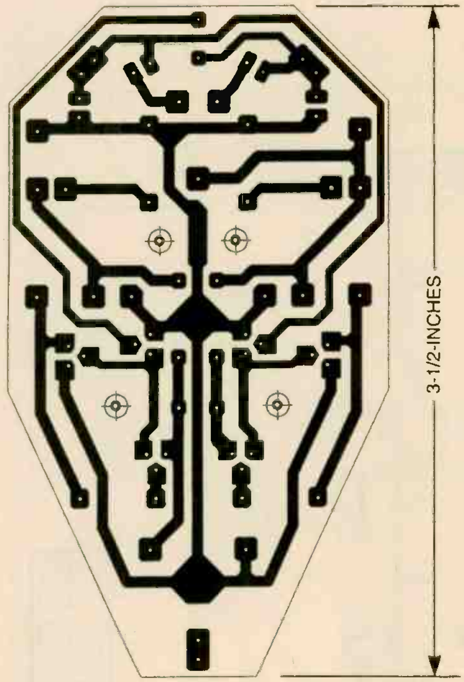


Fig. 4. The motor bracket is made from a strip of brass.



The Solbot is simple enough to be laid out on a single-sided PC board. Only a few jumpers are needed to build the unit.

The component side of the board will be the bottom side of the Solbot, so the components should be mounted as flat and as close to the board as possible. Capacitors C3 and C4 should be mounted laying sideways. If any components stick out too much, they will drag on the ground.

Note that there is a jumper wire at the narrow end of the board that doesn't seem to be a part of the circuit. That jumper wire is actually a skid-like "foot" that keeps the Solbot's belly from dragging on the ground. It is simply a U-shaped loop of solid wire that should be about ½ inch from the surface of the board.

Motor Mounts. The motor bracket is made from a ¼-inch-wide strip of brass that is available at any hobby shop. Cut the brass strip to the length shown in Fig. 4 and drill six holes. Using pliers or a vise, bend the two ends at a 45° angle. Fuse-holder clips are inserted into the holes at the ends of the strip. Bend their tabs and solder them in place. Use a larger-wattage soldering iron than you would normally use for soldering PC boards—the brass strip has a lot more thermal mass and needs much more heat to bring it up to soldering temperatures.

The fuse clips will be holding the motors that move the Solbot around. Pager motors are used in this project. Pager motors are miniature 1½- or 3-volt electric motors that normally have a weight mounted on their shaft off-center. When they spin, they vibrate the entire pager, letting the user know that a message has been received without the attention-getting beeping that can be so disruptive at the theatre or elsewhere. Those motors can be found at several surplus resellers or at a local repair center that fixes pagers. Two surplus suppliers that may carry pager motors from time to time include All Electronics (PO Box 567, Van Nuys, CA 91408, Tel: 800-826-5432) and Marlin P. Jones and Associates (PO Box 12685, Lake Park, FL 33403, Tel: 800-652-6733). Keep in mind that those suppliers, like all other surplus dealers, are not guaranteed to have any particular item in stock at any particular time—it might take some "detective" work to find exactly what you need.

The weights will not be needed for the Solbot—remove them. In their place, slip a ¼-inch length of rubber or vinyl tubing over the motor shaft. That tubing will act like a rubber tire, giving the Solbot extra traction on a smooth surface. With the motors snapped into the fuse holders, the entire assembly should look similar to the drawing in Fig. 5.

Attach the motor bracket to the component side of the PC board with a pair of nylon screws and threaded spacers, along with two additional screws and spacers as shown in Fig. 6. The four hex spacers are used later to mount the solar cells and the nylon material helps reduce the bug's weight. You will have to move C3 and C4 in order to install the barcket. Once it is in place, reposition the capacitors against the board.

The motor wires are attached to the board as shown in the parts-placement diagram, Fig. 3.

Antennas And "Eyes." On the solder side of the PC board, position D1 and D2 so that their lenses are facing towards the front of the robot. Carefully solder them to the board.

The contacts for S1 and S2 are made from a length of straight-pin header. Cut two sets of two-pin headers, mount them with the long pins sticking out the foil side of the board—the plastic molding will act like a "component body." Solder the headers in place and clip off the excess pin from the header's plastic base on the component side of the board.

PARTS LIST FOR THE SOLBOT SOLAR-POWERED ROBOT BUG

SEMICONDUCTORS

IC1, IC2—MN1381G, 2.5V Voltage Detector (Digi-Key MN1381-G-ND or similar)
Q1, Q2—2N4401 NPN transistor
Q3, Q4—2N3906 PNP transistor
D1, D2—PN323B photo-sensitive diode (Digi-Key PN323BPA-ND or similar)

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—2200-ohm
R3, R4—47,000-ohm
R5—200,000-ohm potentiometer

CAPACITORS

C1, C2—0.22-µF, 16-WVDC, electrolytic
C3, C4—2200-µF, 6.3-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

PC1, PC2—3-volt photovoltaic cells (Digi-Key P247-ND or similar)
MOT1, MOT2—Subminiature DC pager motor (see text)
S1, S2—2-pin header, straight-pin (see text)
$^1/_{64}$-inch-diameter brass wire, ¼-inch-wide brass strip, PC-mount fuse clips, wire, hardware, etc.

Note: The following items are available from LNS Technologies, PO Box 67243, Scotts Valley, CA 95067; Tel: 831-768-9155; Web: www.ccnet.com/~lnstech: Complete kit of all parts including etched and drilled PC board, solar cells, 2 pager motors, ICs, and all other components listed above, (SOLARBUG-KIT) $59.00; Miniature DC Pager Motor, (PAGER-MOTOR) $12.00 each; PC Board only, (SOLARBUG-PCB) $10.00. Please add $5.00 for shipping and handling. California residents must add 8% sales tax.
MasterCard and VISA orders are accepted. No C.O.D. orders will be accepted.

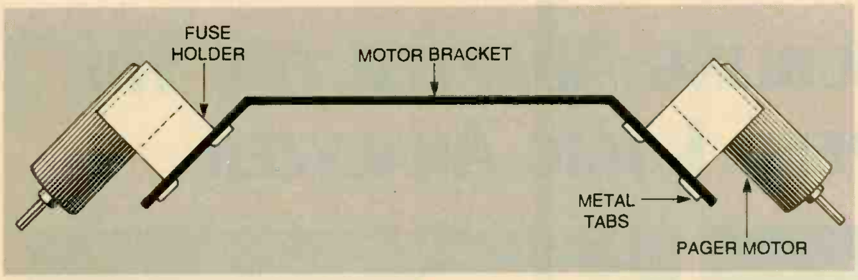


Fig. 5. The pager motors are clamped to the bracket with a pair of PC-mount fuse clips. Bend the tabs of the clips before soldering them—that will increase the strength of the unit.

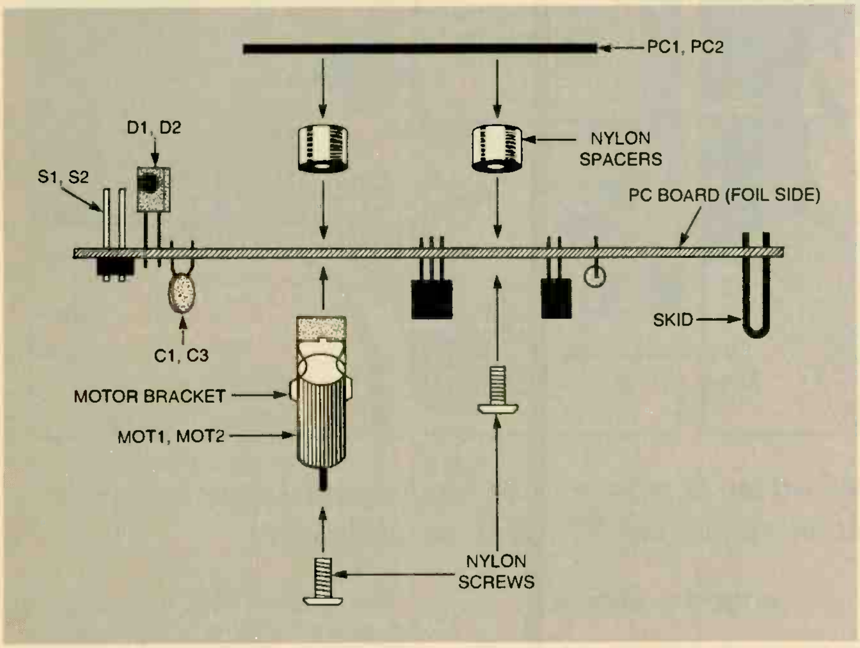


Fig. 6. Some of the Solbot's parts mount onto the foil side of the board, including its photo diode "eyes" and the "feeler" switches.

The "antennas" themselves are made from $^{1}/_{64}$-inch-diameter brass wire, which is available at the same hobby shops that carry the brass strip used for the motor mount. The diameter specified has just the right amount of spring. Cut two 6-inch lengths. Bend each piece to the approximate shape shown in Fig. 3. Start with a 90° bend about ½-inch from one end that will be soldered into the board later. Slip the wire into its hole in the PC board and make a second bend so that it passes exactly between the two header pins. The wire that extends beyond the headers is bent into a sweeping curve so that it looks like an insect's drooping "feeler" antennae.

Once the wires are shaped properly, solder them to the PC board. Make sure that they are not touching any traces on the board except where they are soldered. If needed, bend the wires so that they sit in between the header pins. If the wires are pushed to either side, they should make contact with the header pins. It is also important that the wires are below the top level of the nylon spacers that will be holding the solar cells.

The final step is to attach solar cells PC1 and PC2. Cut four 1-inch lengths of 26-gauge insulated wire and strip ¼-inch of insulation from all of the ends. It is a good idea to use different colors for the wires—two red ones and two black ones are the most logical. Solder the wires to each terminal of the solar cells; use the red wires for the positive terminals and the black wires for the negative terminals. You can use a voltmeter to identify the solar cell's polarity if you're not sure.

Glue the solar cells to the nylon spacers with epoxy or hot-melt glue. Once the adhesive is set, carefully connect the wires to the PC board, making sure that the antenna wires are free to move.

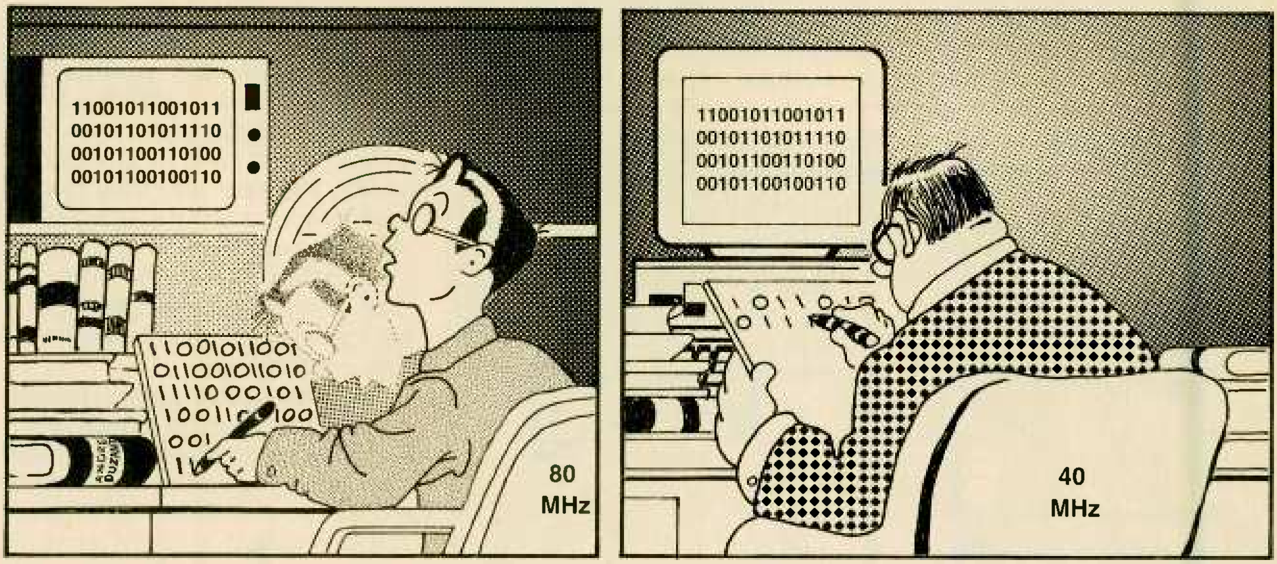
With the Solbot's construction completed, it is time to test the circuit.

Testing And Operation. Set R5 to its center position. Place the Solbot on a table or desk directly under a bright lamp. After several seconds of charging, the robot will make a quick lurch forward. It will charge for several more seconds before it will move again. Although it moves slowly back and forth in a crab-like motion, the robot will move toward the light source. Eventually, the robot will pass under the light and start to make a U-turn. Over time, in its constant attempt to reach the light, it will roam around in circles within a fairly confined area.

Test Solbot's light-seeking behavior by placing it first to the left of the light source and then to the right of the source. In each case, the robot should turn and move in the direction of the light. If Solbot tends to move in one direction only, you might need to adjust R5 to balance the sensitivity of D1 and D2. If you take the unit outdoors under the sun, it will move faster, but will head in a single direction only.

The Solbot will move tirelessly as long as there is a strong enough light source to charge the capacitors. In fact, you may have to store it in a drawer or closet to get it to stop! You might even consider building two or more Solbots and watch them "bug" each other! Ω

A SPEED-DOUBLING ADAPTER FOR THE HIGH-SPEED LOGIC ANALYZER



With this simple adapter and enhanced software, the High-Speed Logic Analyzer can read data at an astounding 80-MHz sampling rate!

ROBERT G. BROWN

The High-Speed Logic Analyzer that was featured in the March 1998 issue of **Electronics Now** was designed to be expandable. One example of that feature was the Digital-Storage-Oscilloscope module that appeared in the May 1998 issue of **Electronics Now**.

Although the Logic Analyzer can sample signals at a 40-MHz rate, many users of the device have asked if the speed of the device can be increased. For those who have a "need for speed," the Speed-Doubling Adapter presented here is just what you've been asking for. With that adapter and a simple update to one of the programmable chips within the Logic Analyzer itself, you can capture samples at an 80-MHz rate. However, as with any performance gain in a piece of equipment, there is usually a tradeoff. In this case, the number of channels available for sampling will be reduced from 16 to 8.

How it Works. As you can see from the schematic shown in Fig. 1, the Speed-Doubling Adapter is a very simple circuit. There are only two ICs: a voltage regulator and a clocked latch. The eight data inputs are connected to P1. That connector replaces the original data connector on the High-Speed Logic Analyzer. The logic signals are routed to two locations. First, they are applied directly to channels 1 through 8 on the Logic Analyzer. Second, they are also applied to the input latches on IC1. The outputs of the latches on IC1 are then connected to channels 9 through 16 on the Logic Analyzer. The 5-volt power needed by IC1 is supplied by IC2, which gets its power from the Logic Analyzer's expansion connector.

The key to sample-rate doubling is on the Logic Analyzer board itself. Although additional circuitry has to be added to the Logic Analyzer, that circuit is contained completely within one of the programmable-logic devices (PLDs) within the Logic Analyzer—the GAL22V10. For a discussion of the Logic Analyzer circuit, see the **Electronics Now** articles mentioned above.

The situation here shows one of the advantages to using programmable logic in any circuit design. Whenever the design needs to be updated or modified, it is a simple task to reprogram the PLD. The changes we will be making to the Logic Analyzer will not affect the unit's normal operation in any way.

To get a sample rate of 80 MHz from a 40-MHz sampling clock, we must be able to take a data sample on both the rising and falling edges of the clock signal. We can do that by making the clock signal that appears on the Logic Analyzer's expansion port (pin 24 on connector P3) inverted in relation to the Logic Analyzer's main internal clock. That way, IC1 will be latching data from the input signals while the Logic Analyzer is getting ready to capture the next sample. When it does, the current state will be on channels 1-8, and the "half-clock" capture being stored in IC1 will be on channels 9-16. That is why we can only sample 8 channels instead of 16. Another tradeoff for increasing the Logic Analyzer's performance is that the Logic Analyzer's trigger circuit is still running at the 40-MHz clock rate. That means that the trigger condition must occur for two data samples to be sure of a solid trigger.

Table 1 shows a new clock-selection chart for IC2 on the Logic Analyzer. The new additions are marked with an asterisk.

Building the Speed-Doubling Adapter. Although the circuit for the Speed-Doubling Adapter is very simple, it must be built on a PC board because of the high frequencies involved. You can either make your own PC board by using the foil patterns supplied here, or purchase a pre-etched board from the source given in the Parts List.

Follow the parts-placement diagram shown in Fig. 2. Start by mounting surface-mount capacitor C2 to the solder side of the board. It is located beneath IC1. If you want to use a socket for IC1, you can mount that item next. Continue construction by mounting the capacitors, IC2 and P1. Install P2 and P3 on the solder side of the board.

It is a good idea to check for proper power distribution before installing IC1. After carefully inspecting the board, plug it into the Logic Analyzer (of course the Logic Analyzer should be off when you do that). Turn on the Logic Analyzer and measure the voltage between pin 10 and pin 20 of IC1. Pin 20 should be at 5 volts. If IC2 is working correctly and supplying the proper voltage to IC1, you can turn off the Logic Analyzer, remove the Speed-Doubling Adapter, and install IC1.

You might need to update the GAL22V10 (IC2) on the Logic Analyzer board. You can check if IC2 needs to be upgraded by using the ALTADIAG program that came in the ALTALOG.ZIP archive that you obtained when building the Logic Analyzer. With the Speed-Doubling Adapter plugged into the Logic Analyzer and the Logic Analyzer connected to the PC, start the ALTADIAG program. Select low-level diagnostics by pressing F6. Once in the low-level diagnostics, select F1 in order to set the clock-select lines C0, C1, C2, C3, and C4. Enter the value 18. That selects the "self" clock as the system clock (see Table 1). Next, monitor the external clock sig-

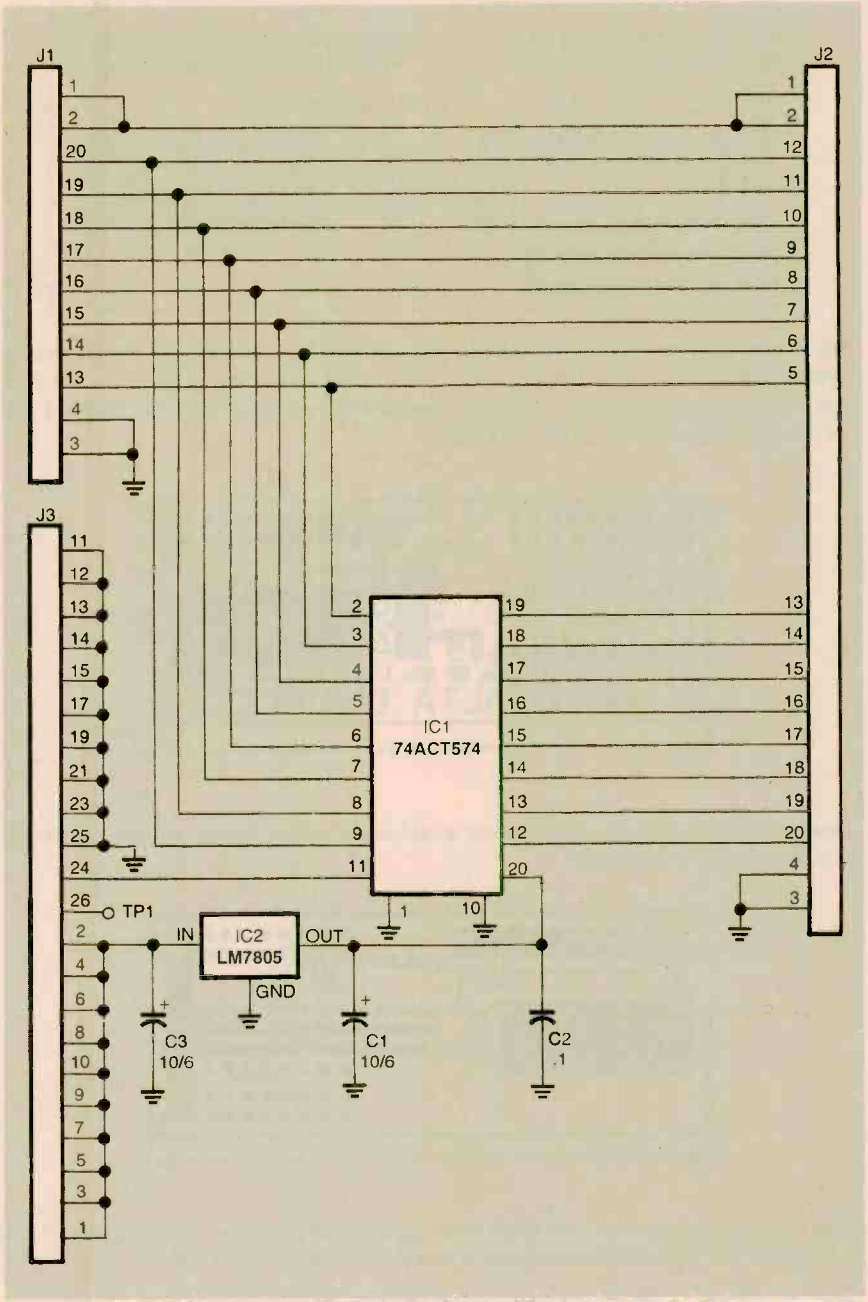


Fig. 1. The Speed-Doubling Adapter for the High-Speed Logic Analyzer uses a simple latch to capture additional samples between the normal capture cycles. The replacement PC software then combines the 16 channels of interleaved data into eight channels of high-speed data.

TABLE 1

C4	C3	C2	C1	MAINCLK	EXPCLK
0	0	0	0	40 MHz	MAINCLK
0	0	0	0	20 MHz	MAINCLK
0	0	0	1	10 MHz	MAINCLK
0	0	0	1	5 MHz	MAINCLK
0	0	1	0	2.5 MHz	MAINCLK
0	0	1	0	1.25 MHz	MAINCLK
0	0	1	1	0.625 MHz	MAINCLK
0	0	1	1	0.3125 MHz	MAINCLK
0	1	0	0	EXT clock	0
1	0	0	0	EXT clock inverted	0
*1	1	0	0	SELF clock	SELF clock
*0	1	1	1	40 MHz	INVERTED MAINCLK

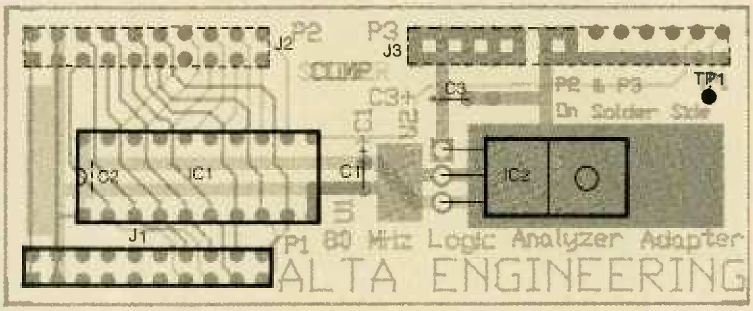
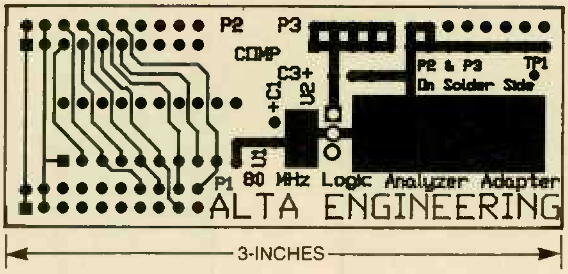
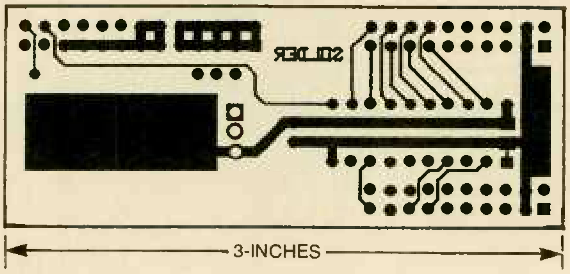


Fig. 2. Although the circuit for the Speed-Doubling Adapter is very simple, the high frequencies involved demand a PC board. This parts-placement diagram shows where to put those parts. Note that two connectors and one of the capacitors are mounted on the bottom side of the board. A simple piece of component lead can be used for TP1.



Here's the foil pattern for the component side of the Speed-Doubling Adapter. A double-sided board is needed to keep the unit small.



Here's the foil pattern for the solder side of the Speed-Doubling Adapter. If you make your own board, make sure to solder all components on both the component and foil sides.

PARTS LIST FOR THE SPEED-DOUBLING ADAPTER

SEMICONDUCTORS

IC1—74ACT574 octal D-type flip-flop, integrated circuit
IC2—LM7805 5-volt voltage regulator, integrated circuit

CAPACITORS

C1, C3—10-µF, 6-WVDC, electrolytic
C2—0.1-µF, ceramic, surface-mount

ADDITIONAL PARTS AND MATERIALS

J1—20-Pin male header, straight pins
J2 – 20-Pin female header
J3 – 26-Pin IDC female head

Note: The following items are available from: Alta Engineering, 58 Cedar Lane, New Hartford, CT 06057-2905; Tel: 860-489-8003; e-mail: alta@compuserve.com;Web: www.gutbang.com/alta; software on 3½-inch diskette, $10.00; blank PC board only, $25.00; complete kit with software, $35.00. Please include $5.00 for shipping and handling within the US; $10.00 for shipping and handling outside the US. Visa and MasterCard are accepted.

nal at pin 11 of IC1 on the Speed-Doubling Adapter board. When you select F10, the internal "self" clock should toggle between high and low. If the external clock signal that you are monitoring also toggles, you do not have to reprogram the GAL22V10. If, on the other hand, the clock signal stays low, you need to reprogram the Logic Analyzer's IC2 according to the directions in the data sheet from the chip's manufacturer. Since the GAL22V10 is reprogrammable, you can simply reprogram the existing part. The source code for the new program is in the file ALTAL80B.EQN. That code, and all of the updated files needed for using the Speed-Doubling Adapter, can be found on the Gernsback FTP site at ftp.gernsback.com/pub/EN/altal80.zip. You will need to download that archive file whether you need to update your Logic Analyzer or not—a new program for the PC will be needed to use the Logic Analyzer at 80 MHz.

Testing and Using the Speed-Doubling Adapter. As mentioned above, the new program for using the Logic Analyzer at 80 MHz is called ALTAL80.EXE. It is included in the ALTAL80.ZIP archive file. You should place ALTAL80.EXE in the same directory as the ALTALOG.EXE program since they share the same configuration file. You use the same probe assembly for both the standard Logic Analyzer and the 80-MHz adapter. The probe assembly plugs into P1 on the adapter the same way that it plugged into the Logic Analyzer. When using the Speed-Doubling Adapter, only the ground probe and the D0—D7 probes are functional. With the Speed-Doubling Adapter and the probe assembly plugged into the Logic Analyzer, turn on the unit and start the ALTAL80 program. The program works in the same way as the standard Logic Analyzer program does, except that you are limited to 8 channels at an 80 MHz sample rate.

You can test the Adapter by connecting each of the probes one at a time to TP1 on the Adapter board. Acquire data with each probe and then view the data using the timing display. The timing display should show that the signal corresponding to the probe used has a waveform that is high for 128 samples and then low for 128 samples. Once you have verified the operation of each of the eight channels, you are ready to start

(Continued on page 44)

MÖBIUS CIRCUIT

MÖBIUS CIRCUIT

Experiment with a basic IC building block—the current mirror.

SKIP CAMPISI

Take a piece of typing paper or notebook paper and cut a ½-inch-wide by 11-inch-long strip from it. Bend it in a circle as shown in Fig. 1A so that the ends overlap slightly. Tack them in place with a bit of tape. You will end up with a paper hoop that is about 3 inches in diameter and ½-inch wide.

If you cut that hoop lengthwise along its circumference and centered between its edges, you will, of course, end up with two separate hoops. Each will be about ¼-inch wide and about 3 inches in diameter.

Make another paper hoop of the same dimensions, only this time twist one of the ends by 180° as shown in Fig. 1B before tacking them together. You will end up with a hoop that has a twist in it. Now if you cut the hoop lengthwise down its center, you will *not* get two hoops! Instead, you will get *one* hoop that is about 6 inches in diameter and ¼-inch wide.

You can keep cutting that twisted hoop repeatedly, and still end up with only a single hoop that is larger and narrower with each cut. Each cut will also double the number of twists in the hoop. That type of hoop is called a *Möbius Strip*, named after the nineteenth-century German mathematician August F. Möbius, who was the first to study the strange properties of that object.

The Möbius Strip has some other unusual properties: it has only one edge and one side! You can prove that by taking a pen or pencil and drawing a line around the hoop. Continue the line until you return to your starting point, and you will see that you have covered the entire strip, including what appears to be "both" sides. In essence, you have traveled a 720° circle!

Of course, the unusual properties of the Möbius Strip are due to the "twist" (through another dimension, if you will) in the hoop. That is called a *node* or *singularity*. In the language of mathematics, it is considered a pole of high order. The branch of mathematics that deals with unusual objects such as that is called *topology*.

Another classic example of topology is the *Klein* bottle. That object has two singularities and manages to be "inside" itself! If you are interested in discovering more about those and other unusual objects, read an introductory book on topology, which should be available at your local library.

You might ask, "How does topology relate to electronics?" By examining a very basic building block of integrated-circuit design, you will see how a singularity solves many design problems. Mind you, a true "topologist" might not agree with our analogy as applied to electronics, but it does work for our purposes.

The Möbius Circuit. Looking at the circuit shown in Fig. 2A, note that Q1 has its collector shorted to its base. That is called a *diode-connected* transistor. Since Q1's collector-to-base voltage is zero, it is still in its "active" mode of operation. In addition, having Q1's and Q2's bases and emitters connected together results in their having the same base-emitter voltage.

Resistor R1 supplies a fixed-bias current to Q1, resulting in a base-emitter voltage of about 0.6 volts for a silicon transistor. That voltage biases Q2 into conduction. For the time being, we will assume that both transistors are matched exactly for both base-emitter voltage and gain, and that the current gain is extremely high.

As the base-emitter voltages for Q1 and Q2 are equal, so then are the base and emitter currents. Thus—and here is the essential point of the circuit—the *collector* currents are exactly equal in both transistors when Q2 has a load within its "compliance" range. With an extremely high gain, the base currents are negligible and the collector current of Q2 equals the current through Q1.

Using conventional current flow (flow from a positive terminal to a negative terminal) to describe the circuit response, we can state that the source current from R1 is "mirrored" by Q2. The same magnitude of current is being sinked by Q2 at its collector. Thus, the term "current mirror" is applied to that type of circuit.

The "compliance" range of Q2 mentioned before, in which its sink current is equal to the source current, can be anywhere from +V to 0.6 volts. If the voltage drops below 0.6 volts, Q2 will have a negative bias on its collector-base junction. For example, shorting Q2's collector to +V (a zero-ohm load) is viable, as is using a resistive load sufficiently high in value to drop +V to 0.6 volts at the load (or source) current set by R1.

The value of R1 is set by the same formula:

$$(+V - 0.6V)/I_{sink}$$

Of course, the transistors selected must be able to handle the desired current. The basic current mirror circuit indeed has a "singularity" all its own—the base-emitter voltage (0.6 V) that is being shared by Q1 and Q2.

With perfect components and matching, no matter what we do to the output circuit at Q2, the singularity will not change. It remains at its predictable voltage with any load.

The circuit shown in Fig. 2B shows another example. Transistors Q3 and Q4 have been added in parallel with Q2. Each of those additional transistors can now sink the same amount of current along with Q2. By connecting the collectors of Q2, Q3, and Q4 together as shown in Fig. 2C, we can now sink a current that is three times the size of the input source current. That is because the Q2-Q3-Q4 "composite" transistor now has three times the chip area of a single transistor.

Indeed, when fabricating integrated circuits, current mirrors actually use transistors with various chip areas to provide different magnitudes of current all over the IC. That is typical of "current-steering" networks. The current mirror makes an ideal current sink (with NPN units) or source (with PNP units). Either circuit is easily fabricated on a monolithic chip.

As you have seen, our "Möbius" circuit has some unusual (and desirable) qualities, although we have stretched a point in considering it with the topological analogy. Right now, it might seem to be an "ideal" circuit, allowing a large number of paralleled outputs with perfect responses. However, in the real world, that is never the case.

As we will see in the following breadboard experiments, factors such as base-emitter voltage and gain matching, temperature tracking, and output resistance affect circuit performance to various degrees. We will also present some circuit modifications to greatly improve our results.

If you want to learn more about bias voltage, bias current, and temperature effects on semiconductor junctions, or would just like to "bone-up" a bit on the background, refer to the author's article "Semiconductor Diode Guidebook" that was published in the June 1997 issue of **Popular Electronics**. That will help you understand the concepts presented here and the experiment results.

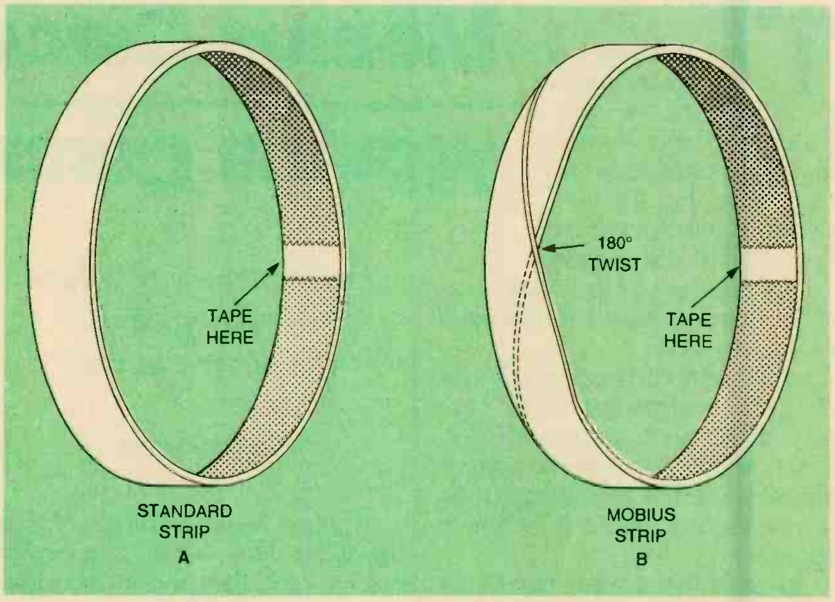


Fig. 1. Taping a strip of paper into a loop does not demonstrate anything interesting (A), but if you put a twist in it before joining the ends, you end up with a model of a Möbius loop (B). A Möbius loop has several interesting properties, including one side, one edge, and the ability to travel 720° before reaching your starting point!

Designing Current Mirrors. The best place to start our experiments is with standard discrete transistors. The only equipment needed is a small solderless breadboard, a standard 9-volt battery, a few ¼-watt resistors, and a few transistors.

If you already have a handful of general-purpose transistors, all bearing the same part number, you are ready to proceed. If not, NPN types such as a 2N3904 or 2N2222 are available in 10- or 15-piece packages at very low cost. Likewise, PNP types such as a 2N3906 or 2N2907 are similarly available. Any type will work in the circuits with which we will be experimenting.

Our first experiment will try to match up a pair of discrete transistors. With any luck, you might find a good match out of 10 pieces! However, a good match is not needed for valid results. Refer to Fig. 3A for NPN units or Fig. 3B for PNP units and set up the simple current-mirror circuit on a breadboard, using 22-gauge solid-wire jumpers where needed.

Starting with an 8200-ohm value for R1, the input reference current will be

(9.0 volts–0.6 volts)/8200 ohms

or roughly 1 mA. Connect ammeter M1 in series with R1 and apply power to the circuit. Make a note of the actual current measurement. Now change R1 to 82,000 ohms and repeat the test.

You should now see a reading of about 100 microamps; record that reading, also. Remove M1 from the circuit, making sure to re-connect R1. With Q2's collector terminal open, measure the voltage drop across the base-emitter junctions of Q1 and Q2, which will be at about 0.6 volts.

Short Q2's collector to +V (for the NPN version) or ground (for the PNP version). There should be a 10- to 20-mV increase in the base-emitter voltage drop. That is a result of the finite gain and output resistance of transistors, which in the real world have non-ideal characteristics. We will demonstrate the results of that increase shortly.

Connect M2 (again, using an ammeter) in series with Q2's collector terminal and note the output current with R1 still at 82,000 ohms. You should see a reading somewhere in the realm of 100 microamps. Now try substituting another transistor for Q2, using the same part number. Again, note the output current. After handling any of the transistors, always let the circuit temperature stabilize for correct measurements.

Add the original transistor in parallel to the current Q2 and note the output current, which should be close to the sum of your previous readings. Go back to one unit for Q2 and try substituting a few more units in the same way to see if you can find a transistor that matches Q1. If you get within 10% or 20%, you're rather lucky!

Once you find your "best match", change R1 back to 8200 ohms for a 1-mA reference current. The match between the transistors at that current level should be the same as you had at the 100-microamp level. Don't expect an exact correlation. While monitoring the output current, touch Q1 with your fingertip. The output current will "nose-dive" because of the drop in Q1's base-emitter voltage affecting Q2's bias level.

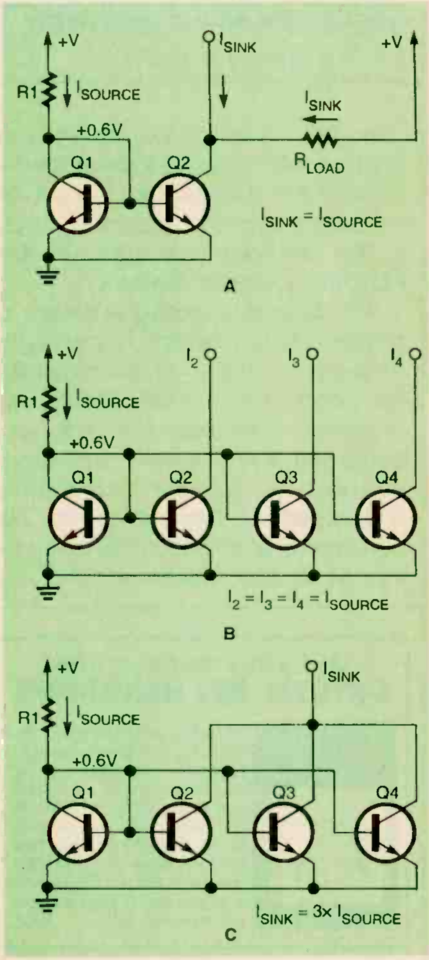


Fig. 2. Current-mirror circuits can come in several variations to meet certain needs. A basic mirror circuit **(A)** *is one where the output current will always match and follow any changes in the input current. Multiple independent outputs* **(B)** *can follow a single input, or they can be ganged together* **(C)** *for a multiplying function.*

That voltage decrease just barely changes the reference current, but drastically affects the output current! Now touch Q2 and note the opposite effect—the output current rises rapidly as Q2's effective bias point decreases, while the net base-emitter voltage remains constant, along with the reference current.

Obviously, temperature tracking between both transistors can be a huge problem using discrete units. Of course, using a common heat sink or even bonding the units together will help a great deal. However, the best solution is to use units that have been fabricated on the same substrate and mounted in the same package. We'll be discussing more on that technique later.

Using our "matched" circuit from above, we will next demonstrate the effects of finite gain and output resistance mentioned before. With the temperatures of both transistors stabilized, again measure and note that the output current is about 1 mA.

The circuit will be modified by adding R2 as shown in Fig. 3C, which shows the NPN version of the circuit. If you are working with the PNP version of the circuit, R2 is added in a similar fashion.

Use a value of 1000 ohms for R2. Note the output current. Now increase R2's value by about 2000 ohms and again note the resulting output current. Keep increasing the value of R2 and take measurements of the output current until you reach about 7500 ohms. At that point, the transistors should be near their maximum compliance voltage at that current level. You will soon see that as the value of R2 is increased, the output current decreases by 20% or so with typical transistors over the compliance range. That is caused by the limited output impedance of the circuit that is in parallel with R2. An ideal current source or sink requires infinite output impedance for true constant-current generation. That circuit typically has an output impedance in the range of 100,000 ohms or so. We really need to have an impedance value in the high-megohm range to achieve true accuracy.

As you have seen, our "Möbius Circuit" is a very simple and effective current generator. However, it leaves a lot to be desired as far as accuracy is concerned. Now we will look at some circuit improvements that will come closer to the "ideal" current mirror.

Going Further. Two of the major problems with our current-mirror circuit are temperature tracking and good matching between the transistors. Both problems obviously make output accuracy and predictability unreliable. Fortunately, several types of integrated circuits are available with matched transistors all on the same substrate.

Various degrees of matching are available from manufacturers such as Harris Semiconductor, National

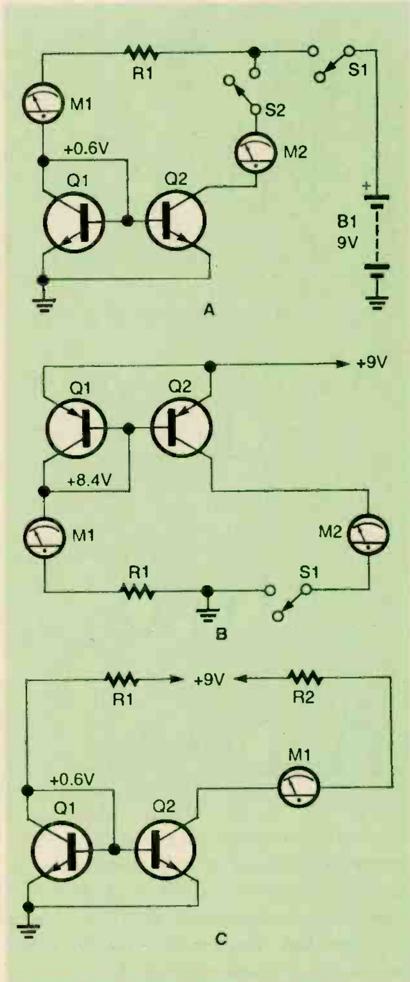


Fig. 3. In order for a current mirror to work correctly, the transistors must be "matched." A simple circuit for NPN transistors **(A)** *or PNP transistors* **(B)** *let you easily test the variations in individual transistors. Once you have a "matched" pair, the circuit in* **(C)** *will show what happens because of a transistor's "finite" gain.*

Semiconductor, and NTE. They offer multiple configurations in DIP packages, as well as dual units in TO-78 packages. Those devices, of course, have excellent temperature tracking along with the matching.

Dual transistors such as the 2N3810 (PNP) and 2N2920 (NPN) are available, and are also available from NTE. A good surplus dealer might also carry them. One surplus source for the 2N5117 dual PNP matched pair and the MAT-04, a matched NPN quad is Johnson Shop Products, P.O. Box 2843, Cupertino, CA 95015 (408-257-8614). The devices are very inexpensive. Try them in our breadboard circuit and note the vast improvement in accuracy!

Another temperature-related

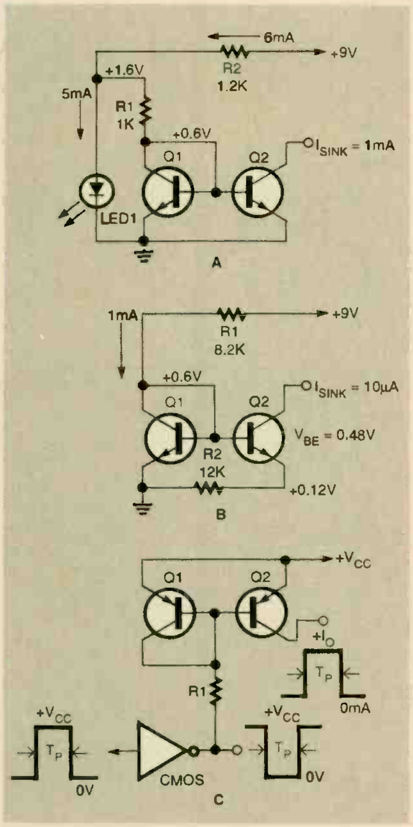


Fig. 4. Current mirrors are extremely sensitive to temperature changes in the transistors. Two different approaches are shown in (A) and (B) to compensate for temperature drift. The circuit in (C) shows how current mirrors can be "gated" on and off at extremely high speed.

problem is the drift caused by the temperature coefficient of Q1, which alters the base-emitter voltage and thus, the reference current. That can be corrected by the use of additional components as shown in Fig. 4A. A standard red LED is biased at 5 mA, resulting in a 1.6-volt drop across the diode. As Q1's base-emitter voltage is at about 0.6 volts, 1 volt appears across R1. The temperature coefficients of LED1 and Q1 are similar, and subtract out of Rl's voltage drop; thus, good compensation can be expected.

The reference current is calculated simply by dividing the value of R1 into 1 volt. An added bonus of the circuit is that much smaller values can be used for R1. That is very desirable where low values of output current are needed. Normally, the values of R1 would be quite high.

Fortunately, there is another method to provide very low currents and keep R1 to a reasonable value. The circuit shown in Fig. 4B is called a *Widlar* current mirror. Note that another resistor, R2, is in the emitter circuit of Q2.

Let's say that the reference current is set at 1 mA with R1 at 8200 ohms and that you need an output current of 10 microamps. Without R2, you would need a value of 820,000 ohms for R1 to do that. However, by including R2, we can reduce the base-emitter voltage applied to Q2.

The output current is an exponential function of the base-emitter voltage. For about every 60-mV decrease in voltage, the output current drops by one decade. If we select R2 to drop 120 mV at 10 microamps, the output current should be close to 10 microamps. Breadboard that circuit using a value of 12,000 ohms for R2.

Note that you will indeed have an output close to 10 microamps with dramatically lower resistor values. Also, check the output over its compliance range and note the improvement in accuracy. The Widlar mirror offers higher output impedance. Other circuits use another transistor to supply the base-current drive for Q1 and Q2 to reduce the output resistance and bias errors. Refer to a good college text on the subject for further information.

Our final current mirror example demonstrates the high speeds attainable with current generators. In those situations, discrete current sources or sinks have a great advantage over op-amp-based designs. The circuit in Fig. 4C shows how easy it is to "gate" a current mirror.

A standard CMOS gate of any type that is able to handle the reference current simply drives R1 directly. The rise and fall times are set by the CMOS gate. If you are interested in a high-precision gated-current source, refer to the author's article "Dual Scope Adapter" in the June 1996 issue of **Electronics Now**. That circuit uses a 2N5117 transistor that is driven by an op-amp and gated at high speed; it is used as an integrator.

As you have seen, the current mirror is an extremely versatile circuit, and just might be classified as a "Möbius" circuit. It definitely seems to have a singularity when you consider the importance of the base-emitter voltage. Why not try it in your next project design? Ω

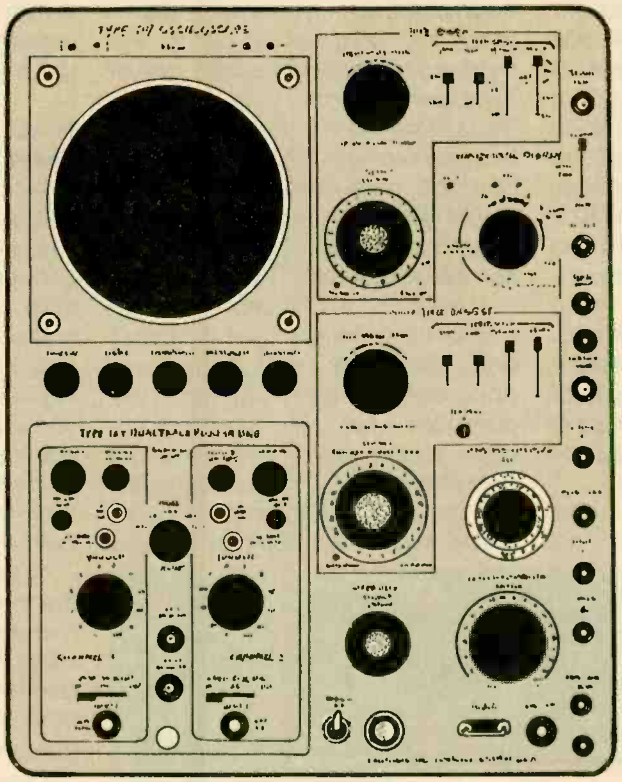
SPEED-DOUBLING ADAPTER

(continued from page 40)

using the system. If you want to run the Logic Analyzer at 40 MHz, simply remove the adapter with the power off, plug the probe assembly back in the analyzer unit and run the ALTALOG program instead.

The Speed-Doubling Adapter is another useful addition to the Logic Analyzer for those situations when you need to view a few signals with a greater time resolution than you could with the standard analyzer. If you have any questions, comments or suggestions, the author can be contacted at 860-489-8003 or by e-mail at alta@compuserve.com. Ω

FAST BUT FORGOTTEN



Despite the fact that many modern engineers have never seen one, the once popular sampling oscilloscope is still one of the fastest display devices available.

TOM NAPIER

These days about equal numbers of digital and analog oscilloscopes are being sold. One reason is that the technology of analog-to-digital conversion has advanced to the point where it is cheaper to achieve display bandwidth by sampling a signal and storing it in memory than by displaying it directly on a CRT. Besides, once a signal is in numerical form, it can be processed in many useful ways. For example, it can be averaged to remove noise or its frequency spectrum can be computed.

One problem with digital oscilloscopes is that they must be used with care because of *aliasing,* something that has no counterpart in an analog scope. If the sampling rate is set to a frequency that is close to the repetition rate of the input signal, the display will show the correct waveform. However, it will indicate a time scale that is much slower than the true one and the display may even be time reversed. If the sampling rate is close to a multiple or submultiple of the data rate, the resulting display looks like a combination of several signals and is difficult to interpret.

Can Aliasing Be An Advantage? Aliasing isn't always bad. Back in the middle 1950s a fast transistor, or a good oscilloscope for that matter, had a bandwidth of 5 MHz. (Or 5 Mc/s as it was called then.) Integrated circuits didn't exist, and if you had asked an engineer to design a fast amplifier he would have used vacuum tubes. Despite that, some people were building oscilloscopes that had an effective bandwidth of 300 MHz. They used a few diodes, a few transistors, and a trick or two.

Their secret was a sampling circuit that could measure signal amplitude in a nanosecond or two. If the input was a pulse that was repeated at regular intervals, then successive samples could be taken from different pulses. If each sample was taken from a different place on each pulse, you could build up a picture of its shape without using any really fast electronics.

Because the sampling ran just a bit slower than the repetition rate of the input, it generated an alias of the input signal. The amplitude samples, which were being taken perhaps every 10 ms, were stretched until they could be displayed on a cheap oscilloscope with a bandwidth of about 1 MHz. That technique was described in the *Proceedings of the British Institute of Electrical Engineers* in 1959.

Using A Sampling Scope. The early sampling scopes were improved upon, and in their heyday they could display signals up to 10 GHz. They remain the fastest signal-display devices available, although few modern engineers have ever seen one. I first used a sampling scope back in 1983 while developing a 1.6 gigasample-per-second analog demultiplexer for the front-end of a digital oscilloscope.

That device was built as a thick-film hybrid on a substrate that measured about 1.5 by 2.5 inches. It had a pair of 5-GHz transistors whose bases were driven in antiphase by an 800-MHz sinewave. That switched their common-emitter current, the input signal, to both collectors in turn. Two more transistor pairs demultiplexed those current pulses at 400 MHz. The result went to four four-way demultiplexers whose transistors were driven by individual base-voltage pulses. The sixteen current pulses charged capacitors that drove sixteen 100-megasample-per-second digital-to-analog converters.

The device had to be checked out by probing inside it. A sampling scope was the only thing fast enough to do the job. The design worked after a fashion, and it convinced my superiors that it was worth developing as a custom chip. That company is now one of the world's biggest manufacturers of digital oscilloscopes.

That experience with a sampling scope came in useful about three years ago when I was a member of a team designing a receiving system to demodulate and decode the signals from the EOS series of Earth resources satellites. That equipment ran at data rates up to 210 Megabits-per-second, and the circuit board that was being developed was jam-packed with 300k series ECL logic chips. It also used two flash analog-to-digital converters that were sampling the input data 420 million times per second. Each bit was shorter than the time it took a signal to travel the length of the board, so the distribution and timing of the clock and data signals was critical.

To debug another board in the system one of my colleagues had persuaded management to lease a gigasample-per-second storage scope for a monthly sum about equivalent to his salary. I didn't fancy my chances of prying the money for a second scope out of my superior—indeed he suggested that I share the first one with my colleague on a twelve-hours-on, twelve-hours-off basis. Well, I knew who would get the night shift, so I rooted around in the company's calibration lab to see what I could find.

I dug up a Tektronix sampling scope that looked as if it hadn't been used in 25 years. Since I was apparently the only engineer in the company who knew what a sampling scope was, I was granted exclusive use of it, and I continued to work more or less normal hours. I made myself two 500-ohm probes with exactly equal time delays from a couple of lengths of 50-ohm coax and two 453-ohm resistors. With this equipment, I made all the timing measurements I needed and soon got my prototype board to work.

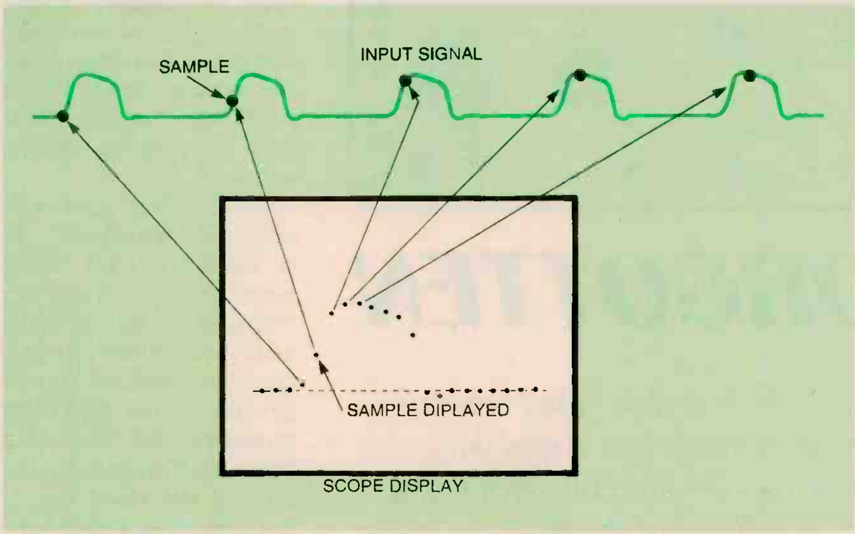


Fig. 1. Each dot on the display of a sampling scope represents the amplitude of a different input pulse at a particular instant. In practice many pulses may go by between each one that is sampled.

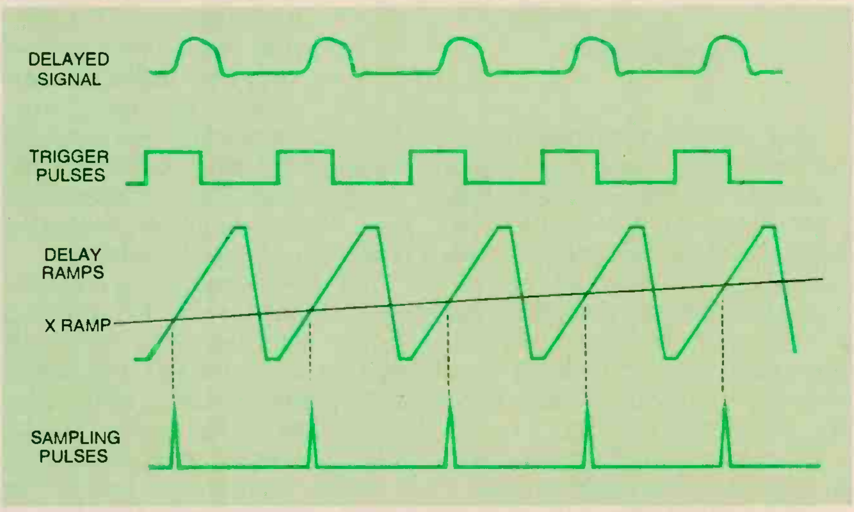


Fig. 2. A sampling pulse is generated when the ramp triggered by the undelayed input signal reaches the same voltage as the ramp that drives the X-sweep of the scope.

Is A Sampling Scope A Digital Scope? A digital oscilloscope uses one or more very fast analog-to-digital converters. Those take consecutive samples of the input signal and convert them into numbers. It stores from 1024 to a million or so of those numbers in memory, then stops. That is, a digital scope is ideal for recording events that happen just once. If you want to show a continuous signal you need to display and throw away the last set of samples, or save them in slower memory or on a disk, before you can take more.

A sampling scope doesn't digitize anything, and it can't work on a one-shot signal. It depends on the input signal repeating itself exactly, and it takes one sample from each of many input pulses. That means it has an appreciable time available to process each sample.

Each time around, the sample is taken from a slightly different place on the input waveform. The results are superimposed to build up a picture of a typical input pulse. Figure 1 shows how that works. The time resolution of the display equals the extra delay given to each sample time. For example, if pulses are sampled with delays of 1 through 50 ns, the display will show the first 50 ns of the pulse with a resolution of 1 ns. Of course, if the input signal is noisy or is not exactly repetitive, the output picture will be fuzzy.

Only the sampling and timing circuits need be fast; the processing circuit is slow and analog. That makes a sampling scope much simpler and cheaper than a digital scope. If you wanted to build your own digital scope, you'd first have to buy a fast ADC chip and a bunch of ECL memory chips. You're looking at a thousand dollars just for parts, not to mention the test gear and expertise you'd need to get it going. However, if you are familiar with ECL components and high-speed layout, it would be practical to build your own sampling front-end. That could extend the range of an oscilloscope from, say, 50 MHz to 500 MHz. The output signal can be made slow enough to drive a chart recorder or even a computer's audio digitizer card.

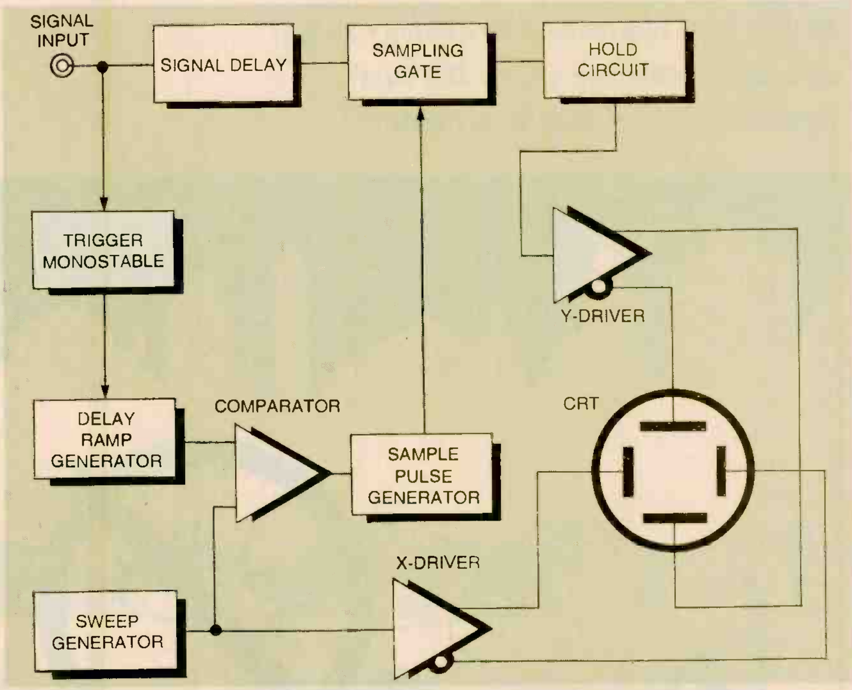


Fig. 3. Here's a block diagram of a sampling oscilloscope. Note that in a sampling scope, unlike a digital scope, only a few components have to operate at high speed.

How Does It Work? The secret of the sampling scope is that, even in the 1950s, some parts, particularly silicon diodes, were quite fast. If you applied a voltage ramp to a diode, a good device would go from non-conducting to conducting in under a nanosecond. Because of stored charge the diode might not turn off quite so fast, but it was still a lot faster than contemporary transistors. By switching one diode on and another one off almost simultaneously, you could make a switch that was only on for the few nanoseconds when both diodes were conducting.

Another important development was the ferrite material from which low-loss high-speed transformer cores could be molded. Fast pulses could be inverted using lengths of coaxial cable wrapped around ferrite rings, enabling four-diode switches to be driven in a push-pull fashion. The switching pulses had to be bigger than the signal, this reducing driver pulse feed-through.

Such a switch was connected between the input signal and a capacitor. The switch was terribly inefficient, but each time you drove the diodes you ended up with a capacitor voltage that was a function of the instantaneous input voltage at one particular moment in time.

That is a crude form of sample-and-hold circuit, and its output could be amplified with relatively slow components. Once the voltage was big enough to generate a useful deflection on a CRT, you had a dot on the display that was proportional to the input voltage sample. One input pulse produces one sample.

Now comes the clever bit. Assuming that the input signal is a repetitive pulse, you could trigger a ramp generator at the same point on each pulse. The ramp might last, say, 50 ns. After that time, you didn't worry about what happened so you could use slow components to reset it and be ready for the next cycle.

A second ramp generator was free-running and much slower; it might take 10 ms per cycle in a practical system. That ramp was subtracted from the fast ramp so that the time the sum took to reach some threshold voltage was delayed more and more the later you were on the slow ramp. With the fast comparators available today, you would apply the two ramps to the opposite inputs of a comparator, as shown in Fig. 2.

Reaching the threshold triggered the sampling circuit; thus, each new sample was taken later and later in its respective input pulse. The X input to the CRT was driven from the slow ramp so the result was a picture of the input waveform that was redrawn every 10 ms. The X scale width was the time taken by each fast ramp, 50 ns in the example above. In that case, the effective time base sweep, 50 ns, was 200,000 times faster than the actual time base sweep, 10 ms.

Commercial sampling scopes had several inputs with matched timing characteristics, and they could be triggered from the input signal or from an external source. The latter was very useful for examining the characteristics of a filter or an amplifier, since the triggering input could come from the generator that was driving the device under test.

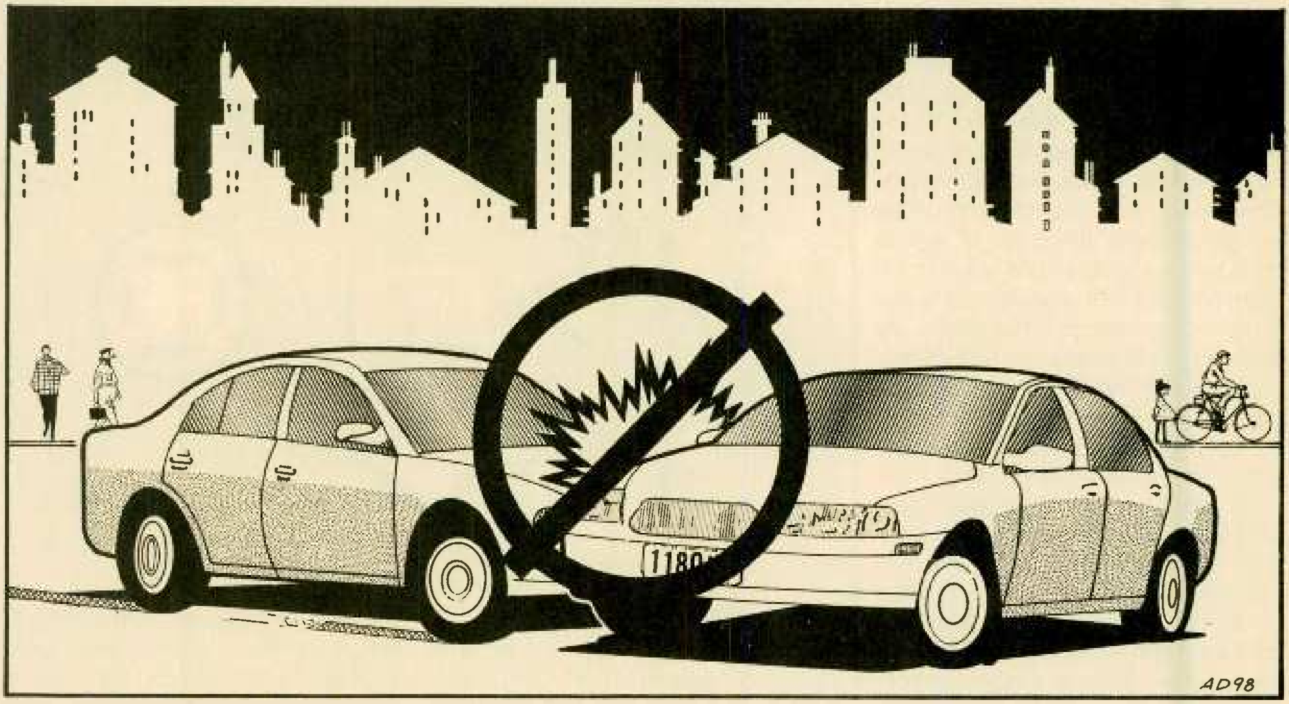
The test generator often used a now-forgotten device, the tunnel diode. That device had an N-shaped characteristic with a negative resistance region. As the current through the diode increased, the voltage across it would increase to perhaps 100 mV and then suddenly jump to 800 mV. The jump had a rise time as short as 100 ps.

With a tuned circuit and the correct bias current, a tunnel diode would oscillate at VHF frequencies. If you varied either the capacitor or the inductor, you got a micropower FM transmitter. One curious feature of the tunnel diode was that it was a majority-carrier, device, and its characteristics were almost independent of temperature. Transistors stop working if you make them too cold, but a tunnel-diode oscillator will carry on working even in liquid helium at 4 degrees absolute (K). I once used that feature to transmit measurements from inside a cryostat.

If you needed a bigger signal than the half-volt or so from a tunnel diode, you used an avalanche transistor. That is an ordinary transistor with a high-value collector resistor. With its base held at zero volts, the device could sustain some three times its normal breakdown voltage on its collector. When trig-

(Continued on page 60)

Here's how electronics technology might someday eliminate one of the most common types of traffic accident.



NO MORE ACCIDENTS

BILL SIURU

You're about to make a left turn across a busy intersection. Suddenly, an icon depicting a vehicle starts flashing on the Heads-Up Display (HUD) projected onto your windshield. By warning you that there isn't sufficient spacing between you and an on-coming vehicle, you possibly avoid a serious crash. That is just one of the capabilities of the Intersection Collision Avoidance (ICA) Threat Detection System being developed by the Calspan Corporation and Battelle Memorial Institute in a five-year long Intersection Collision Avoidance Using IVHS Countermeasures Program. The research is sponsored by the National Highway Traffic Safety Administration's (NHTSA) Office of Collision Avoidance Research.

According to the NHTSA, intersection collisions are second only to rear-end crashes in their frequency of occurrence. Collisions at intersections account for about a quarter of all police-reported crashes. This translates to 1.7 million crashes each year.

Initially, the researchers determined under what circumstances, and why, intersection crashes occur. Calspan researchers reconstructed over 200 intersection collisions. As shown in Table 1, they found a number of different causes for those collisions. They also were able to determine that those accidents generally could be classified as one of four types: violation of traffic-control devices (traffic light, stop sign, etc.), 43.9%; inadequate gap in crossing traffic, 30.2%; oncoming traffic left turn across path, 23.8%; and early entry into intersection, 2.1%.

Once the researchers had a better understanding of how and why intersection collisions happen, they were ready to develop countermeasures that could potentially reduce the number and severity of these collisions. While not all causes can be eliminated with advanced electronics technology, several of the major ones—faulty perception, driver inattention, impaired or obstructed vision, and violation of a traffic signal—could be addressed by countermeasure technologies. These are now being incorporated into an Intersection Collision Avoidance testbed vehicle, which is shown in Fig. 1.

Avoiding Accidents. According to the researchers, the optimum countermeasure method is to install intersection collision-avoidance equipment such as transponders on vehicles so they could actively interact with one another to avoid collisions. That would be somewhat like the Traffic Alert Collision-Avoidance System (TCAS) already used in aircraft. In that system, a TCAS-equipped aircraft detects the presence of other aircraft fitted with TCAS transponders.

But because equipping every vehicle with interactive countermeasure equipment is unlikely, at least in the foreseeable future, vehicles would also have to rely on passive detection techniques. That could include front-mounted radar used with collision-avoidance algorithms. With those sophisticated mathematical algorithms, an onboard computer can determine if the vehicle is on a collision course with another vehicle.

The algorithms for the ICA Threat Detection System—developed by Calspan researchers—use information from several sources. Those include a vehicle front-mounted radar, the Differential Global Positioning System (DGPS), the Geographic Information System (GIS), an electronic compass, a radio communications system, and accelerometers.

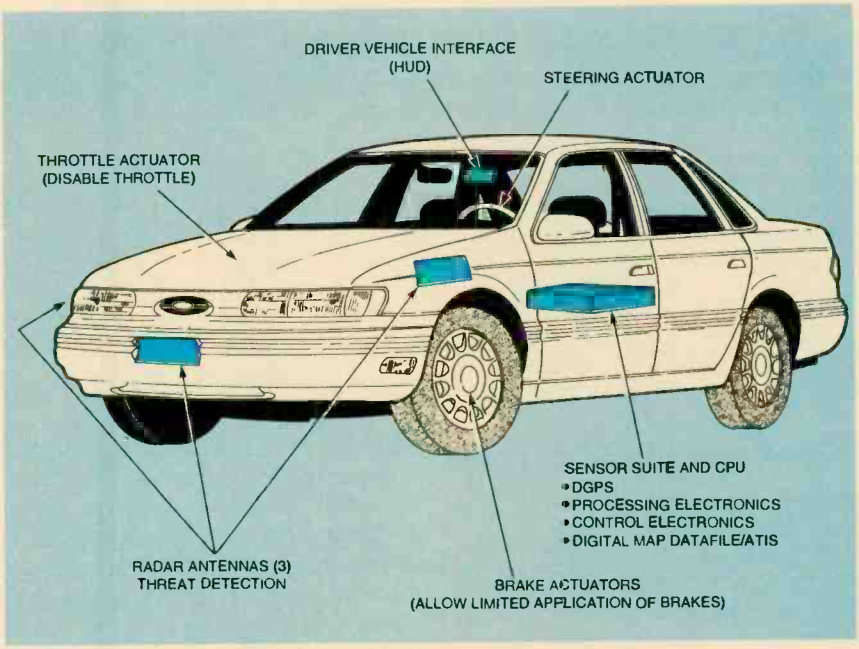


Fig. 1. This drawing of the ICA testbed vehicle shows the various on-board components of the system.

How it Works. A block diagram of the system is shown in Fig. 2. Two key ingredients of the Calspan Threat Detection System are DGPS and the GIS digital map database. DGPS and an electronic compass are used to precisely and continuously pinpoint the vehicle's current position and heading. DGPS—with an accuracy of about 3 feet, compared to about 300 feet for ordinary GPS,—provides the required level of precision for intersection-collision avoidance.

The GIS digital map database contains information about the intersection. That includes the road the vehicle is traveling on, the location of the particular intersection, and what traffic control devices (TCD) like traffic signals or stop signs are at the intersection. The current distance from the vehicle to the intersection is determined using

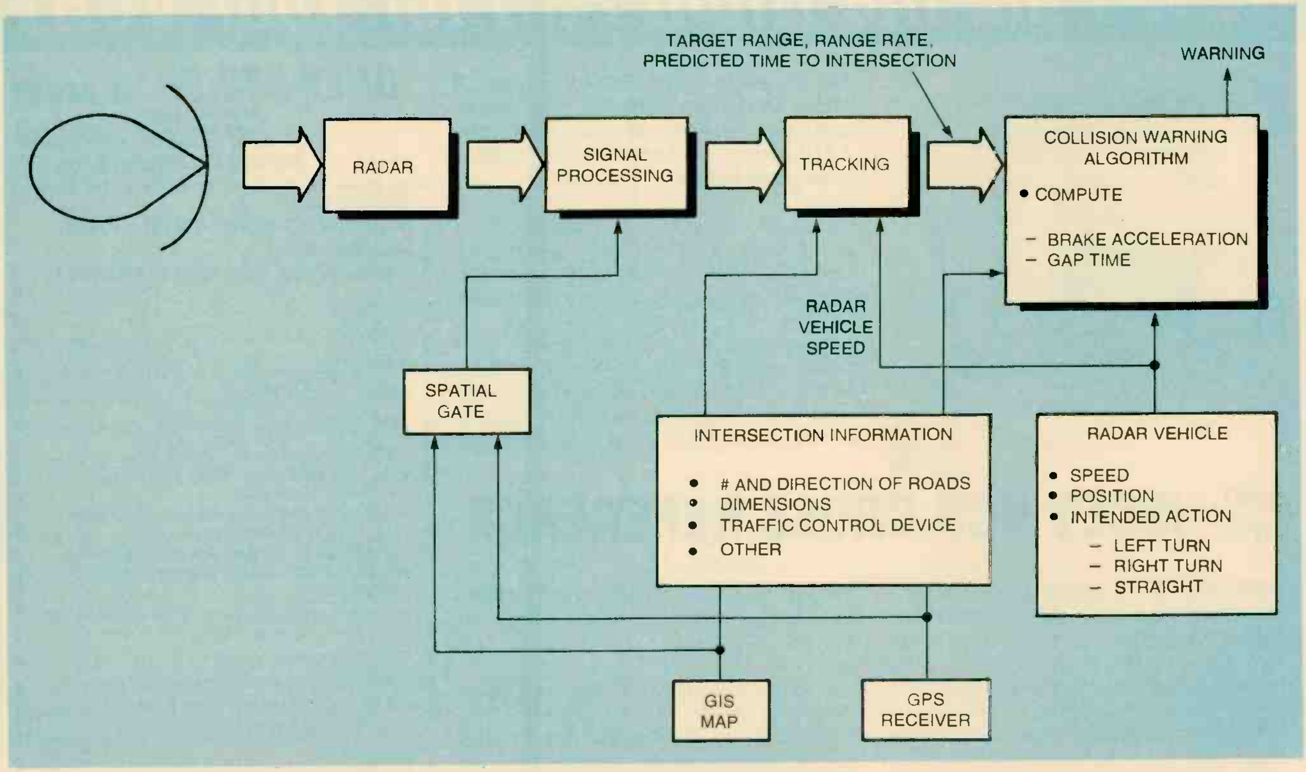


Fig. 2. A block diagram of the Calspan Threat Detection System. As is shown here, DGPS and the GIS digital map database play a large role in this passive collision-avoidance system.

TABLE 1—CAUSES OF INTERSECTION COLLISIONS

Reason	Percentage Of Total Intersection Crashes
Faulty Perception	33.88%
Driver Inattention	28.66%
Vision Impaired/Obstructed	11.13%
Deliberate Violation of Signal	9.01%
Attempt to Beat Other Vehicle	5.08%
Driving Under the Influence	4.57%
Deliberate Violation of Sign	3.38%
Vehicle Defect	2.09%
Attempt to Beat Traffic Control	0.90%
Hit and Run	0.31%
Other	0.99%

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position information from DGPS. The current status—red, green or yellow—of any traffic lights can be sent to the vehicle by the radio communication system.

Sensors on the vehicle itself provide information on its speed and intended action at the intersection—left turn, right turn, or straight-ahead. Information about the configuration of the intersection, such as number and approach angles of intersecting streets, can be used by the threat-detection system to prioritize scanning directions towards areas that represent the greatest risk.

Information from all the sources is fed to an on-board computer, which determines if the vehicle is on a collision course with another vehicle or if the vehicle's travel rate indicates that it is about to run a red light or stop sign. If a dangerous situation exists, the Driver Warning System alerts the driver. This can include a flashing icon on the HUD. Icons that show the type of intersection hazard can include those depicting a traffic signal, direction of another approaching vehicle, or an insufficient gap in on-coming traffic to make a safe left turn across the intersection.

Another warning could be provided by automatically pulsing the brakes and disabling the throttle. Since driver inattention is a major contributing factor in intersection collisions, brake pulsing should usually be sufficient to get the driver's attention. Brake pulsing also slows the vehicle and is thus the proper vehicle response in this situation. If the driver fails to make the appropriate avoidance maneuver, the system could automatically take over and initiate full braking.

The next step is testing of the ICA testbed vehicle. The program will be completed in the fall of 1999. Then, hopefully, we will start seeing the technology appearing on new cars and trucks. Ω

BY DON LANCASTER

Pseudoscience Today, Theater Lighting Controls, and more

IN MY OPINION, FINDING A SOURCE OF "UNLIMITED FREE ENERGY" WOULD BE ONE OF THE MOST HEINOUS POSSIBLE CRIMES AGAINST HUMANITY. THE UNAVOIDABLE CONSEQUENCES OF SUCH A DISCOVERY WOULD INCLUDE TURNING THE PLANET into a cinder.

Even so, great heaping piles of free energy enthusiasts can be located on the Web in such fantasy forums as Bill Beaty's odd www.eskimo.com/~bilb/freenrgl/fnrg or else Jerry Decker's www.escribe.com/science/keely Fortunately, almost all of free energy pseudoscience boils down to labwork so mesmerizingly awful that it is not even wrong. To me, it sure is challenging fun to find out exactly where and precisely how they have screwed up.

The outcome is never in doubt because accurately measuring real nonlinear power or doing small DT calorimetry can both be exceptionally difficult tasks. Worse, the results of those measurements will almost always be deceptively high when carelessly done. Everybody always fouls these up—at least on their first few hundred tries.

I've recently posted some essential tools that might let you intelligently evaluate pseudoscience on your own. Find those at www.tinaja.com/glib/bashpseu.pdf These key tools include finding out what is really happening, doing an objective meta study, using a binary consequence tree, slicing up with Ockham's razor, applying my highly devastating "looks like a duck, quacks like a duck" filters, avoiding negatives, and tracking the cash flow. Those tools separate useful adjuncts for porcine whole body cleanliness from the total hogwash.

Free Energy "Ludicrosities"

Here is my take on all the ongoing pseudoscience scam du jours:

The Adams Motor: To me, this one looks and acts exactly like a plain old switched reluctance motor. Except for having woefully inefficient flux paths, this is simply one continuously driven variant of the stepper motor. Independent tests give efficiencies in the 10 to 30 percent range. The extreme difficulty of measuring the rms power of pulse waveforms appears to be the basis for the overunity claims.

But: New "real" switched reluctance motors are poised to revolutionize air conditioning and electric autos.

Brown's Gas: A stoichiometric mix of two parts of hydrogen and one part of oxygen by volume provides many highly unexpected properties, none of which include proponent's claims of overunity, long-term monatomics, or radioactive neutralization. To date, zero believable differences between Brown's Gas and plain old stoke gas have ever been convincingly shown.

But: Rather exciting "real" hydrogen stuff is coming down over nanotube storage and metalloradicals.

The Neuman Motor: After a careful and long-term review, I do not see much here. Clear-cut and unarguable results seem conspicuously lacking. Recent web measurements on those large, high-voltage DC machines show efficiencies of 20 percent, but even these are suspiciously high, owing to a questionable power measurement. Uh, if a motor sparks, it is inefficient.

But: Exotic pulse energy recycling might improve battery life.

The Water-Powered Car: These seem to reside somewhere between wishful thinking and outright criminal fraud. "Molecular resonance" of water takes place at frequencies far higher than claimed and provides zero overunity options. If you don't believe that, ask any radio astronomer. There's very strong evidence that any strange waveforms or high voltages during electrolysis can only reduce your conversion efficiency. Another name for a system where a car engine drives some alternator that generates hydrogen that runs the engine is a dynamic brake. Switching it in would cause the auto to stop in much less than its usual coasting distance.

But: A modest hydrogen injection might improve the performance numbers of an otherwise stock gasoline engine.

The Magic Lamp: Take a 32-volt light bulb and a 110-volt bulb. Connect them to dimmers and adjust for equal

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high brightness. Use a cheap enough meter, and you'll measure one third the current and one third the voltage on the 32-volt bulb and then jump to the wildly wrong conclusion that the 32-volt bulb is more efficient and uses less power (even though it is no cooler than the other bulb). Careful analysis quickly leads to classic E.E. student lab blunder #01-A—confusing average and rms on low duty-cycle waveforms.

But: A lot of high-efficiency lamps are now under study, but those are based on studiously avoiding any incandescence at all.

The Hydrosonic Pump: This is simply a blocked cavitating pump applied to generate heat. (Just what they warned me to avoid at all costs in fire school.) In other words, a high-wear pump with one-sixth the efficiency of a heat pump and six times the costs of a resistor, rerunning that classic "mechanical equivalent of heat" experiment and ignoring the fact that all mechanical energy is much "more valuable" than heat energy. This one comes out of the woodwork each decade.

But: A sonoluminescence is now associated with cavitation that leads to several really exciting new wonderments.

The Tesla Turbine: This involves bladeless discs that control shear forces in viscous liquids to convert moving fluid into rotary motion. Viscous liquids are inherently lossy, and thus demand a thermodynamic inefficiency. Your conversion clearly is a non-adiabatic process; one that always throws off unwanted heat. Thus, a Tesla turbine simply has to be inefficient to work at all.

But: When used backwards, Tesla turbines are quite useful for such essential tasks as pumping live fish or transporting frozen chickens.

The Switch Flippers: There are folks out there who claim that no current flows if you connect an open circuit wire to a battery. Instead, mysterious "superluminal" communications and an "etheretic energy transfer" takes place if you flip switches fast enough on long enough wires. Sorry, but a transient current always results the instant you connect any wire to any battery, open circuited or otherwise. The Maxwell field equations and the characteristic impedance of the line sets the initial current. The ultimate current is determined only after slower-than-light reflections from the load take place. This flipping concept is flat out wrong; too much of electronics simply would not work were it true.

But: There's all sorts of astounding real electronics uses for fast switch flips.

Homopolar Machines: The homopolar generator is the only known machine that can generate true DC. Because of special relativity, it turns out that it does not matter in the least whether the magnets move or not. There is no way to

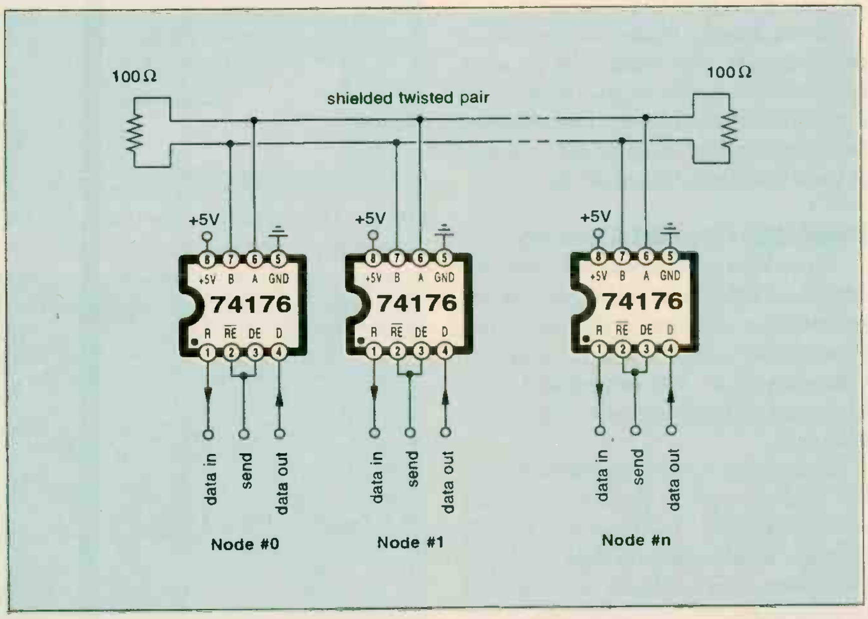


FIG. 1—THE RS485 SERIAL COMM STANDARD is widely used for computer networking. The older RS422 differs in that the left driver is permanently enabled, while all other nodes must act as receivers.

decide if a uniform magnetic field is rotating or stationary. Your homopolar output depends only on your relative stator and rotor speeds and the magnetic field strength. What the magnets are up to simply does not matter. Which can lead to severe misinterpretations and subtleties over what's really happening, especially in the way of counter EMFs and the reaction torques.

But: Homopolar machines are one possible solution to electric autos, as well as other "Uh compared to what?" needs.

Zero-Point Energy: If something is sitting still and you know where it is, you have got more information than when something is sitting still and you do not know where it is, which is what zero-point energy is all about. It's simply a way to get all the special relativity statistical math to balance out. Here's the kicker: If all of the gross zero-point energy in a volume the size of the earth were somehow 100 percent recovered, it would equal the chemical energy in one gallon of gasoline.

But: An exciting new field of Bose-Einstein Condensates is now opening up, revealing a previously unknown state of matter.

You'll find plenty of ongoing and lively Web discussions on all these topics. Start with www.dejanews.com to pick up as much detail as you can stand, both pro and con. On second thought, let's capitalize that: *Con*.

A wondrously bizarre assortment of pseudoscience files shows up at www.keelynet.com Links to others at www.tinaja.com/scweb01.html More objective "real engineering" analysis can be found at www.tinaja.com/pseudo01.html

Stage and Concert Lighting

Have you ever wondered how the dozens of lights and related effects are controlled at a theater, a club, or a rock concert? Obviously running a separately controlled power line to each and every lamp is ridiculously expensive and fraught with peril.

It turns out there is a fairly unknown but widely applied lighting standard called DMX512. It allows up to 512 lights (or combinations of lights and special effects commands) to be controlled by one cable.

Before we can look into DMX512, though, we'll first have to find out a little about...

EIA RS422/RS485

These are serial asynchronous data-communication standards. Note that RS422 has largely been replaced by the RS485, which we will mainly focus on here.

See Fig. 1. The key element in a RS485 circuit is a twisted pair transmission line. A digital logic one exists when "B" line of the pair is positive (between 2.5 and 5 volts) and the "A" line of the pair is near ground. A digital logic zero exists when the "B" line of the pair is near ground and the "A" line of the pair is positive (between 2.5 and 5 volts).

A driver circuit converts an input one or zero into the differential pair. A receiver circuit can sense that differential voltage and convert it on back to a local output one or zero. A transceiver is simply a chip that holds one or more receivers and one or more drivers. There can be dozens and sometimes hundreds of drivers and receivers in any combination, but only one driver can be active at one time. That can be handled by having a master driver that is in control of your system, or else by using some sort of collision detection.

Because of those balanced signals and the differential receivers, noise immunity can be quite good—all but incredibly bad common mode signals are ignored. Lines can sometimes be nearly a mile long.

Note that there must be one and only one terminating resistor at the "start" of the transmission line and one and only one terminating resistor at the "end" of the line. The line must go from device to device in the daisy chain manner shown in Fig. 1. Use of stubs or multiple paths is a no-no. Only one message can route over the RS422 or RS485 line pair at a time.

The RS485 standard is used for many computer-networking systems. When you use classic RS422 communications, only a single, permanently enabled driver is used. That driver chip must go at one end of the comm line, replacing the termination. A single RS422 line pair thus will be unidirectional only. It may have one transmitter driving any reasonable number of receivers.

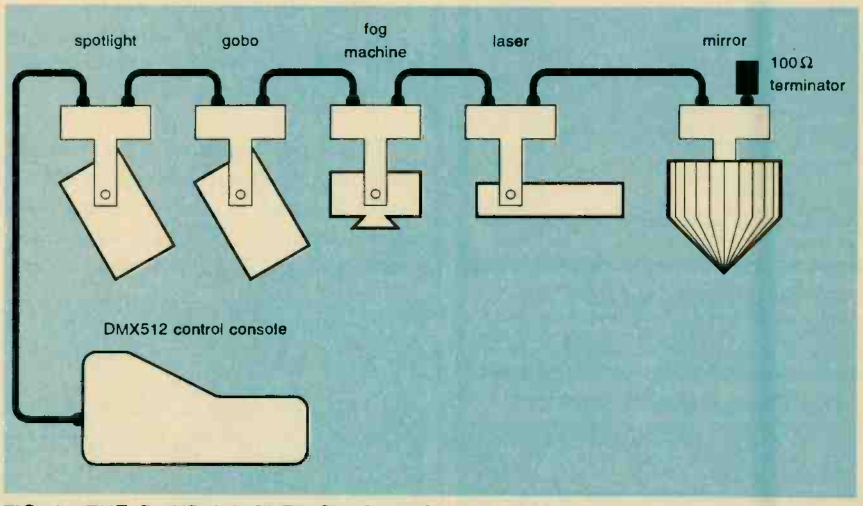


FIG. 2—THE DMX512 LIGHTING CONTROL STANDARD lets a single console and a daisy-chained wire pair control spotlights, fog machines, lasers, mirrors, or animation.

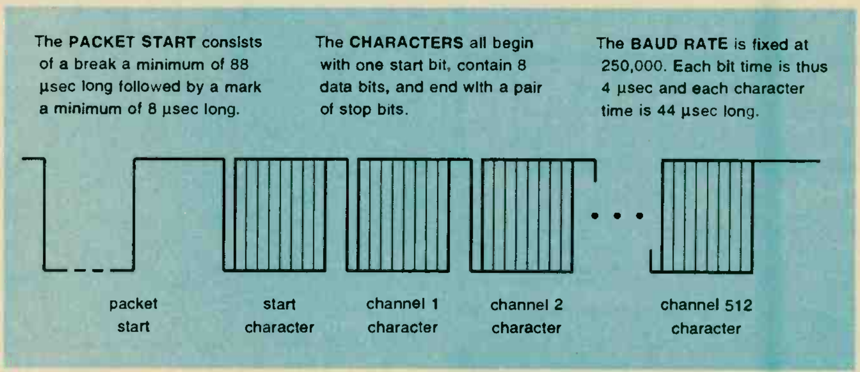


FIG. 3—DMX512 COMMUNICATIONS waveforms. Up to 512 8-bit channel commands can be sent to various devices along a chain up to 4000 feet long. Each device responds to its own channels in a selected proportional or on-off manner.

NAMES AND NUMBERS

Apex Microtechnology
5980 N Shannon Rd.
Tucson, AZ 85741
(520) 690-8600

Bumpon/3M
3M Center, Bldg. 220-7W-03
St. Paul, MN 55144
(800) 362-3550

Dallas Semiconductor
4401 Beltwood Pkwy. S
Dallas, TX 75244
(972) 371-4000

Electronic Expediters
14828 Calvert St.
Van Nuys, CA 91411
(818) 781-1910

International Journal of Hydrogen Energy
PO Box 248266
Coral Gables, FL 33124
(305) 284-4666

Lakeview Research
2209 Winnebago St.
Madison, WI 53704
(608) 241-5824

Linear Technology
1630 McCarthy Blvd.
Milpitas, CA 95035
(408) 432-1900

Loctite
1001 Trout Brook Cross
Rocky Hill, CT 06067
(860) 571-5100

Micrel Semiconductor
1849 Fortune Drive
San Jose, CA 95131
(408) 944-0800

Pacific NW National Laboratory
Box 999
Richland, WA 99352
(509) 372-4270

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

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

Peter Zelchenko
1757 W Augusta Blvd. #3
Chicago, IL 60622
(312) 733-2473

Additional details are in the EIA standards themselves or in a great tutorial found at www.bb-elec.com/bb-elec/literature/485appnote.pdf

The latest replacement for either standard is RS644, which is called low voltage differential signaling. New chips here are the 65LVDS31 driver and a 65LVDS32 receiver from the folks at Texas Instruments.

DMX512

A theater lighting-control system using the DMX512 standard is shown in Fig. 2. It uses an RS422 or newer standard twisted pair to get from a control console up to whatever lights and devices need to be controlled.

The serial code is shown in Fig. 3. Its packet consists of a header and up to 512 data blocks. Each data block is called a channel and holds an eight-bit word. These words might be sensed as eight individual on-off controls, might set a brightness to one of 256 levels, or might be set to a linearized but lesser number of levels. Channels could be paired for 16-bit resolution. Several channels might be used for one device: perhaps one to set your level, one to set the color, and two to set the position. Non-lighting effects such as smoke generators, spinning mirrors, animation, and certain laser effects could also be controlled.

Your baud rate is 250,000 bits-per-second. When the full 512 words are used, updates take place at a maximum rate of around 44 per second.

Each channel byte uses one start bit, eight data bits, and two stop bits similar to classic UART serial communications. Those 11 bits make each channel byte 44 microseconds long.

The packet starts with a logic zero that is at least 88 microseconds long. That is followed by a MAB, or *M*ake *A*fter *B*reak that is 8 microseconds or longer. A start character follows that and forms an optional enable.

Up to 512 bytes of channel data follow. Each byte can represent any 8-bit value from 0 to 255. The use of these values depends on the device being addressed. Each device is set to respond only to its intended channels.

Suitable shielded twisted-pair cables include Belden 9841 and 9842, and Alpha 5274. Normal terminating resistance is 110 ohms.

The system uses 5 pin XLR connectors, with male connectors on the cables or terminators and female on the devices.

Concert Lighting: Techniques, Art & Business, James Moody, *Focal Press*, 1997.
Concert Sound and Lighting Systems, John Vasey, *Butterworth-Heinemann*, 1994
Control Systems for Live Entertainment, John Huntington, *Butterworth-Heinemann*, 1994.
Discovering Stage Lighting, Francis Reid, *Focal Press*, 1993.
Effects for the Theatre. Graham Walne, Drama Publishers, 1995.
Handbook of Scenery, Properties and Lighting, Harvey Sweet, *Allyn & Bacon*, 1995.
Light on the Subject: Stage Lighting for Directors, David Hays, *Limelight Editions*, 1989.
Lighting and Sound (Phaidon Theater Manual), Neil Fraser, *Phaidon Press*, 1995.
Lighting and the Design Idea, Linda Essig, *Hbj College & School Div*, 1996
Lighting the Stage: A Designer's Experiences, Francis Reid *Focal Press*, July 1995
Painting with Light, John Alton, *University of California Press*, April 1995.
Projection for Performing Arts, Graham Walne, *Focal Press*, 1995.
Recommended Practice for DMX512, Adam Benette, *USITT*, 1993.
Scene Design and Stage Lighting, Oren Parker, *Holt, Reinhart & Winston*, 1996
Stage Lighting Design: The Art, Craft, & Life, Richard Pilbrow, *Drama Publishers*, 1997.
Stage Lighting Handbook, Francis Reid, *A & C Black*, 1996.
Stage Lighting in the Boondocks, James Miller, *Meriwether Publishing*, 1987.
Stage Lighting Revealed: Design & Execution, G. Cunningham, *Betterway Pubs*, 1993.
Stage Lighting Step by Step, Graham Walters, *Betterway Publications*, 1997.
Theater Backstage from A to Z, Warren Lounsbury, *University of Washington Press*, 1989.
Theater Lighting from A to Z, Norman Boulanger, *University of Washington Press*, 1992.
Theater Technology. George Izenour, *Yale University Press*, 1997.

FIG. 4—SELECTED THEATER and concert lighting books. More details on many of these titles are found at www.tinaja.com/amlink01.html

The pinouts for the connectors are: pin 1—shield and common; pin 2—dimmer complement; pin 3—dimmer true; pin 4—optional complement; and pin 5—optional true.

DMX RESOURCES

AMX
11995 Forestgate Dr.
Dallas, TX 75243
(800) 222-0193

Angstrom
837 N Cahuenga Blvd.
Hollywood, CA 90038
(800) 422-5744

Artistic License
Livingstone Ct., Peel Rd.
Harrow, Middlesex HA37QT
England

Electronic Theater Controls
630 9th Ave., Ste. 1001
New York, NY 10036
(212) 397-8080

ESTA
875 Sixty Ave., Ste. 2302
New York, NY 10001
(212) 244-1505

Doug Fleenor Design
396 Corbett Canyon Rd.
Arroyo Grande, CA 93420
(805) 481-9599

International Laser Display Assn.
4301 32nd St. W, Ste. B-23
Bradenton, FL 34205
(941) 758-6881

Mole-Richardson
937 N Sycamore Ave.
Hollywood, CA 90038
(323) 851-0111

PLASA
38 Leonards
Eastbourne, E Sussex BN21 3UH
UK

Production Arts Lighting
636 Eleventh Ave.
New York, NY 10036
(212) 489-0312

Pyrotechnics Guild International
Bill Sprague
93 Poquanticut Ave.
N Easton, MA 02356

USITT
6443 Ridings Rd.
Syracuse, NY 13206
(800) 93USITT

Note that there is zero error correction here and that the optional return channel has nonstandard uses. Thus, DMX512 should definitely not be used for pyrotechnics or anywhere public safety is a concern.

Although a variety of commercial controllers are readily available, you can easily build your own DMX512 controller as a mid-range PIC project. Additional PIC support appears at my www.tinaja.com/picup01.html

I've gathered a few of the DMX512 standards, suppliers, and info sources together in the resource sidebar. A useful site is www.dmx512.com An amazing number of nice international-lighting links appear at www.ozemail.com.au/~bhill/links.html

Apparently the "must have" book is Adam Bennette's *Recommended Practice for DMX512*. It and the standard itself can be obtained from USITT, short for the US Institute of Theater Technology. Useful newsgroups include: alt.stagecraft, comp.arch.embedded, net.theatre.stagecraft, rec.arts.theater.stagecraft, and sci.engr. lighting

My choices of popular and more general books on concert and theater lighting are shown in Fig. 4. More details on many of these titles are at www.tinaja.com/amlink01.html

New Tech Lit

From Apex comes their new data book on power integrated circuits. And from Micrel, there's a data booklet on their new QwikRadio single-chip UHF modem data receivers. Only three external parts are needed here!

A new free data book and CD ROM is available from Dallas Semiconductor. Dallas seems to be the first one to tame the data monster by providing only the first page of each data sheet in the printed catalog. You go to the CD or their site at www.dalsemi.com when you need more detail.

Free Filter Design Software for Windows CD is now being promoted by Linear Technology.

Electronic Expediters has some 33 million integrated circuits and semis in stock. Check www.expediters.com But a much better source for instant ordering of single quantity samples is www.questlink.com

Serial Port Complete is a new Jan Axelson book on RS232 and RS484 links and networks. PCs, Basic Stamps, and other popular micros are well covered. A companion software disk is included. Jan also wrote the great *Parallel Port Complete* text. The publisher is Lakeview Research More at www.tinaja.com/amlink01.html

Volume One: The Instant Book is a bound tutorial by Peter Zelchenko on Book-on-demand publishing. Contact him at www.volumeone.net For more on BOD, other service bureaus, and related topics, check the details at www.tinaja.com/bod01.html

The latest release of the *Inventor Assistance Source Directory* is newly available from the Fed's Inventions & Innovation program. The publisher is Pacific Northwest National Lab. But remember that calling yourself an "inventor" is often monumentally stupid. Find out why at www.tinaja.com/patnt01.html

The superb *International Journal of Hydrogen Energy* is one definitive but extremely expensive ($1476) publication. Chances are you could access copies through a larger library. Additional magazines on hydrogen, books, links, and resources are found through my www.tinaja.com/h2gas01.html

Free samples of new light-curing adhesives are available through Loctite. They also publish a new product selector guide. Free samples of Bumpon stick-on feet are available from 3M.

For those fundamentals of active-filter design, check my *Active Filter Cookbook*. Available by itself or in my *Lancaster Classics Library*. See my nearby Synergetics ad or visit my www.tinaja.com/synlib01

I've finally managed to provide a powerful online site search for my www.tinaja.com Web site. Yeah, this now includes full text searching for all the tutorial Acrobat PDF files. As well as the usual HTML and text. A bunch of earlier columns have newly been uploaded.

Instant answers and cost-effective technical solutions can be found at www.tinaja.com/info01.html, while lots of great test equipment bargains (especially superb Tek 2213 scopes and fantastic buys on premium logic data analyzers) are found by clicking www.tinaja.com/barg01.html

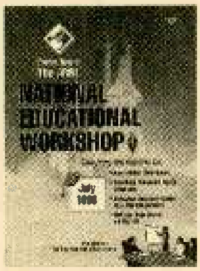
As usual, most of the mentioned items are in our "Names and Numbers" or "DMX Resources" sidebars. Always look here first before calling our free US technical helpline. EN

NEW LITERATURE

continued from page 30

Proceedings of The ARRL National Educational Workshop

The American Radio Relay League
224 Main Street
Newington, CT 06111
Tel: 800-243-7767
Fax: 860-594-0303
e-mail: jwolfgang@arrl.org
Web: www.arrl.com
$12



CIRCLE 341 ON FREE INFORMATION CARD

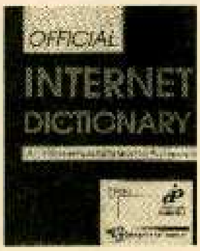
Designed for educators who teach amateur radio and written by experts in the field, the articles in this volume discuss such subjects as getting new hams on the air, recruiting hams, teaching amateur-radio courses, and bringing amateur radio into the regular classroom.

There are case studies of programs in schools around the country, stories of teaching radio for scout badges, and discussions of integrating science and ham radio. Other topics include ham radio and the Internet, Morse Code, technical careers, youth clubs, books on ham radio, and teaching amateur radio to people with disabilities. In the over 40 articles in these proceedings, there is something of interest for educators, hobbyists, and anyone who wants to encourage the growth of ham radio enthusiasts.

Official Internet Dictionary: A Comprehensive Reference for Professionals

Edited by Russ Bahorsky
Government Institutes
4 Research Place, Suite 200
Rockville, MD 20850
Tel: 301-921-2355
Fax: 301-921-0373
Web: www.govinst.com
$49 plus $6 S & H in U.S.

While there is no shortage of information available on the Internet, managing that information is becoming overwhelming. This new reference book provides advanced, professional, and new Internet users with an authoritative and



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practical source of information on the World Wide Web, electronic mailing lists, e-mail, and a wide variety of other Internet resources. Endorsed by the Association of Internet Professionals and the Webmaster's Guild, the dictionary defines the language of the Internet and its most important functions for marketers, network administrators, programmers, and other professionals.

In addition to providing a thorough glossary of terms pertaining to networking, Internet programming basics, electronic commerce, Internet applications from web browsers to mail-user agents, and the issues shaping the future of the Internet, the dictionary also includes several essential resources for Internet users. They include a file name extension finder, guide to advanced search tools, command guides to the most widely used electronic-mailing-list programs, a quick- reference index of the language of Internet shorthand, and an error-message analysis chart for effective troubleshooting.

Guide To Emergency Survival Communications: How To Build and Power Your System

by Dave Ingram
Universal Electronics, Inc.
4555 Groves Road, Suite 12
Columbus, OH 43232-4135
Tel: 614-866-4605
Fax: 614-866-1201
$20

CIRCLE 343 ON FREE INFORMATION CARD

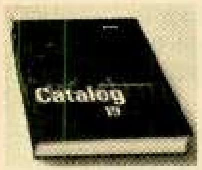
This is the first complete, up-to-date book dealing with survival communications—the ability to receive accurate and timely information in time of crisis. Covering the subject in depth, this guide discusses the many types of communication systems that are available and where they can be found: shortwave, amateur radio, citizen's band, federal services, weather services, overseas news services, plus many more important sources of vital information and programming.

Ways of finding and choosing the proper equipment and building a communication system are discussed in detail. Using simple radio equipment to keep in touch with friends, without needing to take a radio license test of any sort, is explained

Information is provided to help readers build and set up systems using various types of emergency power sources, including inexpensive solar-power systems, small generator systems, and backup emergency battery systems that start to work when the power grid goes down. This guide also covers building inexpensive satellite radio systems that can be powered by alternate power sources, such as solar and wind power.

1998 Test & Measurement Catalog

Hewlett-Packard Company
Test & Measurement Organization
P.O. Box 50637
Palo Alto, CA 94303-9512
Tel: 800-452-4844, ext. 5766
Web: www.hp.com/go/tmc98
Free



CIRCLE 344 ON FREE INFORMATION CARD

This 640-page hard-cover catalog includes descriptions of more than 1400 Hewlett-Packard test and measurement products, systems, and services. It provides a convenient resource for researching, planning, budgeting, and purchasing a broad range of test products and services.

Featured in this catalog is the HP Infinium digital oscilloscope, a state-of-the-art digital instrument with the look and feel of an analog scope. It offers a Windows-95 based GUI and built-in measurement assistance and set-up guide. These capabilities help users make complex measurements easily and quickly.

Many other advances in measurement and test technology are contained in this edition. Among the new products included are the HP E2310A Logic Dart Advanced Logic Probe, the HP Advanced Design System, the HP 81200 330/660

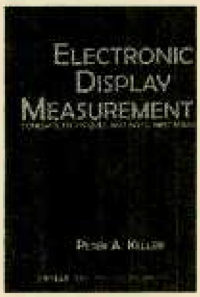
MHz Data Generator/Analyzer, the HP E8400A VXI Mainframe and low-cost, plug-in modules, and the HP AccuSite CDMA PCS base-station test set.

Along with descriptions and technical specifications of standard products and systems, the catalog also includes product-comparison charts, tutorial material, an indexed list of application notes, and descriptions of other available literature such as newsletters and specialty catalogs.

Extensive bibliographies are provided for the readers who wish to delve more deeply into any topic. Equations in the body of the text are kept to a minimum, but a full set is provided in an appendix. Other appendices contain the CIE Standard Observer tables and provide information on international and national standards organizations, national standards laboratories, equipment suppliers, and calibration services. EN

Electronic Display Measurement: Concepts, Techniques, and Instrumentation

by Peter A. Keller
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158
Tel: 800-225-5945
Web: www.wiley.com
$69.95



CIRCLE 345 ON FREE INFORMATION CARD

Written in a conversational style, this volume is the first complete reference manual in its field. A practical and up-to-date guide to the most reliable techniques, methods and instruments available for measuring electronic displays, it is an invaluable tool for designers, engineers, and manufacturers of display systems.

This book describes practical techniques and instrumentation used for display measurement and the common pitfalls that result in errors. The author presents each major topic from a basic to a working level in a self-contained chapter so that all the relevant information is easily accessible without cross-referencing. This easy-to-understand manual helps readers gauge the dependability, accuracy, and competitiveness of any electronic display. It explains how to measure luminance, resolution, contrast, quality, color, uniformity, registration, and more.

FAST BUT FORGOTTEN

(continued from page 47)

base, many transistors, even quite slow ones, will turn on in a nanosecond, generating a negative going edge perhaps 30 volts high.

If you connected a delay line to the collector, you could generate 5 ns pulses that no other contemporary device could match. Early sampling scopes used avalanche transistors to generate the short pulses that turned on their sampling diodes.

Practical sampling scopes had built-in signal delay lines. It takes a finite time to trigger the fast ramp. Without a signal delay, the front edge of a pulse would always be out of sight whenever internal triggering was used. That delay line was often made from rigid coax that zigzagged down the inside of one side of the scope. The cheaper sampling scopes had effective rise times in the half-nanosecond region, but some worked down to some tens of picoseconds and allowed you to examine microwave signals.

The sampling scope had its disadvantages. Its behavior was critically dependent on the repetition rate of the input signal. If it was too slow, then so was the update rate of the display and it would flicker. If it was too fast, then the trigger circuit had to ignore most of the input pulses. It often took some skill to come up with a stable display.

Figure 3 shows the block diagram of a sampling scope. The input has a 50-ohm impedance, so unless the circuit under test is designed to drive 50 ohms, you need attenuating probes to avoid loading the circuit. Typically the input can handle signals within the range +1 to -1 volts. The trigger circuit is connected directly to the input but hardly loads it at all; the real input load is the signal delay line. The sampling unit and a 50-ohm termination resistor are connected to the end of this cable. The sampler is a simple diode bridge that is turned on and off again by a very short pulse. It is transformer-coupled to the diodes, which are hot-carrier diodes that turn on and off with minimal delay. Once the input is sampled, the result is stored in a capacitor. That drives a conventional sample-and-hold circuit that retains each input sample as long as it is needed for the display.

Each time it is triggered, the ramp circuit generates a pulse with a sloping front edge. This slope is adjustable and acts as the time base for the sampler. That is, a 50 ns slope results in a display whose width corresponds to 50 ns at the input. The length of the pulse can be adjusted to set the time between sampled inputs to a convenient value.

That pulse drives one input of a comparator. The other input is driven by the slow ramp, which forms the X input to the display. When the two ramps are equal, the comparator fires the sampling pulse to measure the input amplitude. This drives the Y input to the display and makes a dot on the screen. The successive dots outline the shape of the input signal.

Building Your Own Scope. Designing and building conventional oscilloscopes was something of a hobby of mine when I was a physics student. By the time I was professionally involved in electronics, analog scopes had reached the 300-MHz bandwidth of the early sampling scopes and the latter were relegated to specialist uses.

From time to time, I contemplated building my own sampling scope. Recently I took another stab at it. After breadboarding the timing circuit I concluded that, although it was a feasible project, I could not justify further effort. High-speed electronics is pretty tricky and success depends on many tiny details. While I didn't doubt that I could get something running, I thought I was unlikely to end up with a design that the average home-brewer could put together. However, constructing a sampling scope could be an interesting project for the advanced amateur. Ω

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- Network Tool Set 55625 without the Multi-Network Cable Tester.

Order No. 55600 $99.00

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- Serial & Parallel Loopback Connectors
- DIP IC Puller
- PLCC IC Puller
- Grounding Wrist Strap
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DMM-20 ($74.95): AC/DC (V, A), Freq, cont., Capac, Induct., Ω, hFE, diode, duty cycle
DMM-122 ($59.95): DC/AC(V,A), Ω, hFE, diode, capacitance, freq, logic, continuity
DMM-123 ($44.95): DMM + capacitance, DC/AC(V,A), Ω, hFE, diode, continuity
DMM-10 ($19.95): 3½ digit, DC/AC V, Ω, hFE, diode, signal output(+3V,-0.5Vsq.,50%duty)

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CAP-15 (*$49.95*): 3½ digit, 0.1pF-20mF, 9 Ranges, 0.1pF resolution, zero adjustment.
LCR-24 (*$119.95*): 0.1µH-200H, 0.1pF-2000µF, 0.01Ω-20MΩ, diode test. *New Model*
LCR-131D (*$219.95*): autorange, 0.1µH-10kH, 0.1pF-10mF, 1mΩ-10MΩ, Q Factor, serial/parallel, 120Hz/1kHz testing mode.
FC-1200 (*$129.95*): 1.25GHz Handheld, 8 digits display, 10ppm accurary, sensitivity 5mV (130-350MHz), 30mV (440MHz)

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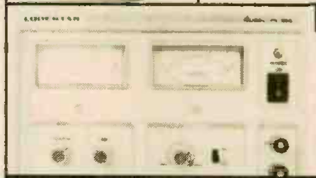

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Triple Output (Analog displays)
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PS-8103 ($489.95) 30V/5A/30V/5A

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- Const. volt, current mode
- 4 analog or 2 digital display

PC-3030 ($499.95)
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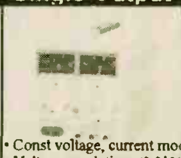
Single Output



- Const voltage, current mod
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- Current regulation ≤0.2%

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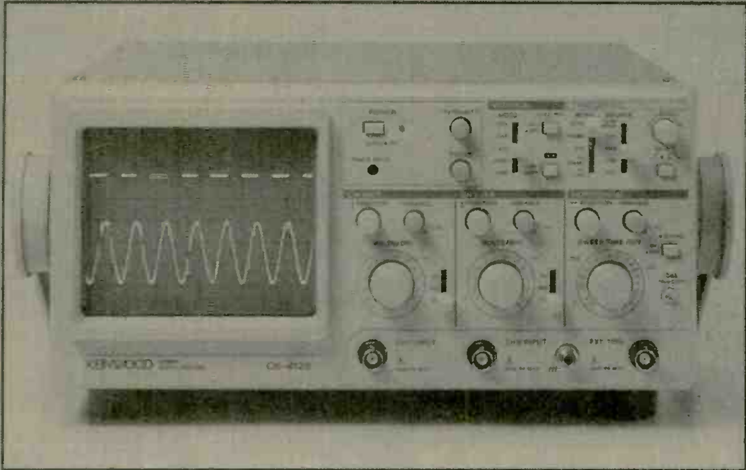

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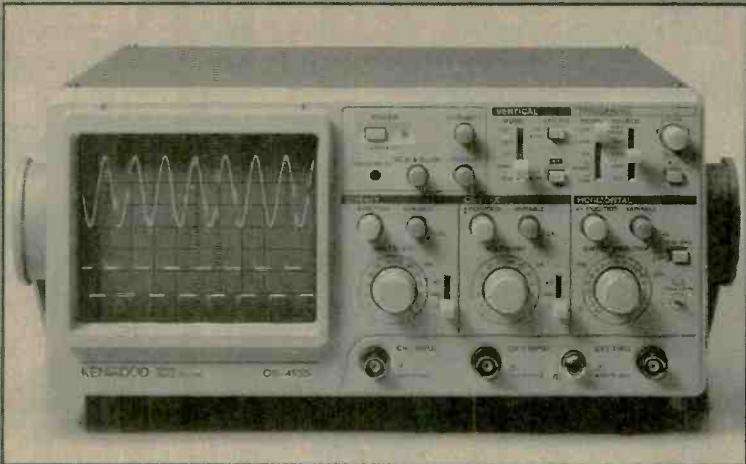

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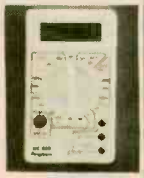

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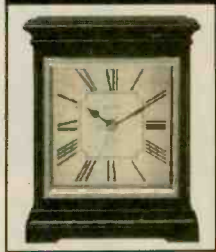

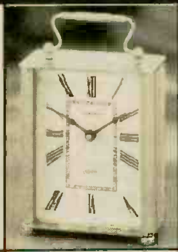

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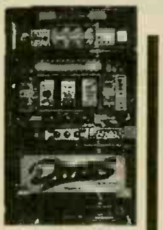

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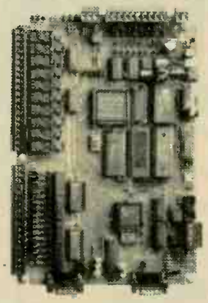

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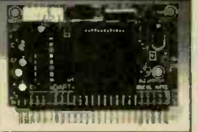

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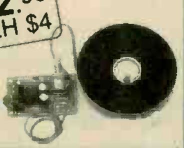

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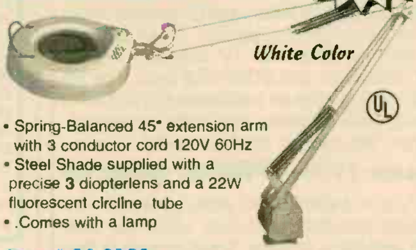

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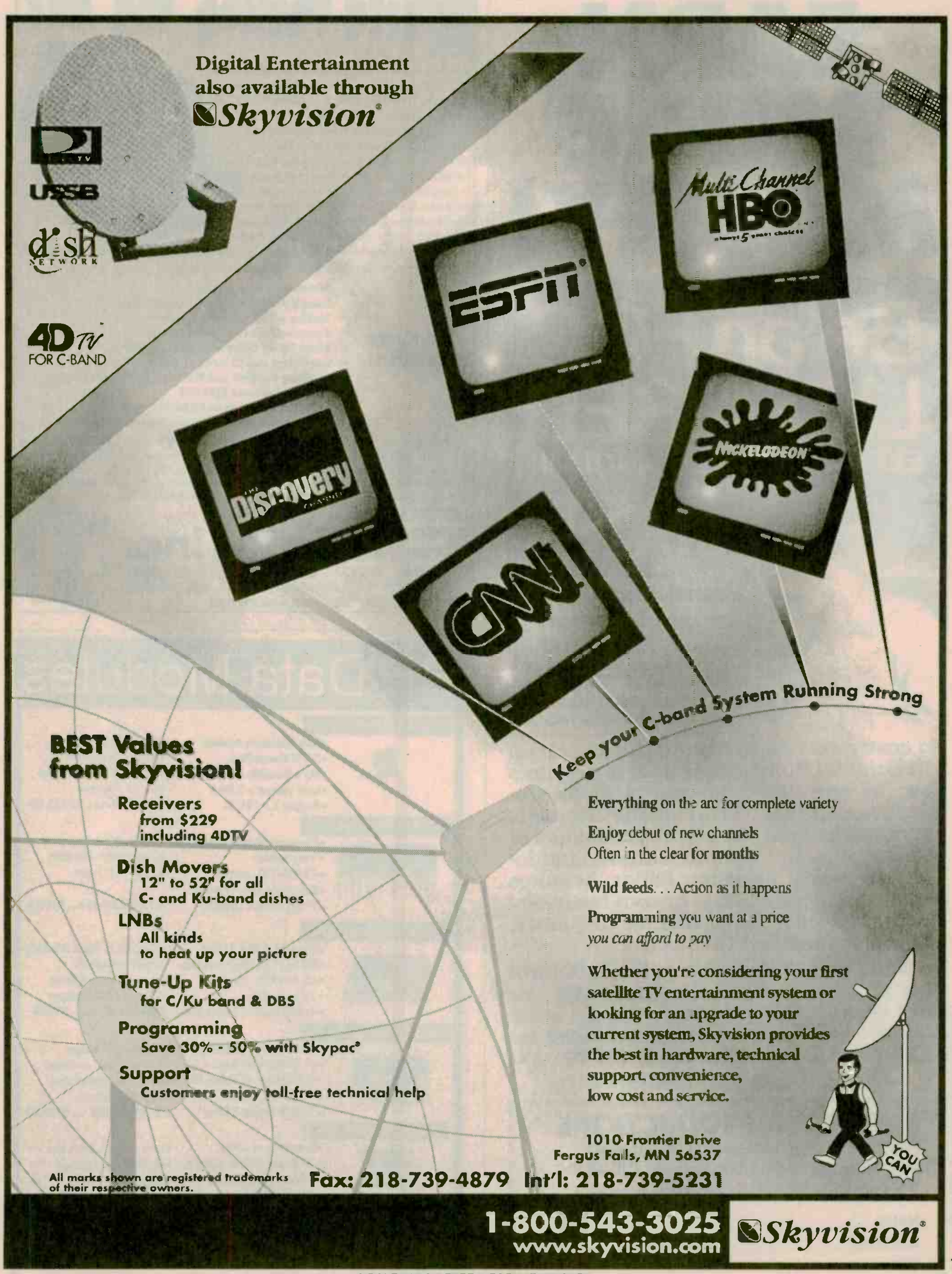

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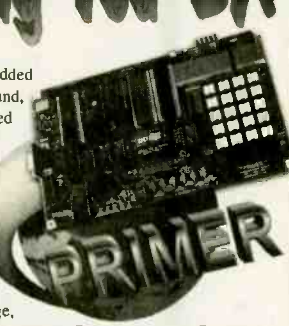

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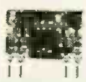
AM Transmitter



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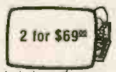

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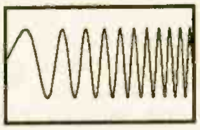
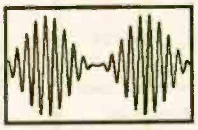
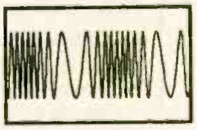


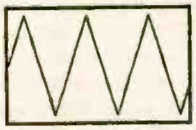
DC to 20 MHz linear and log sweeps



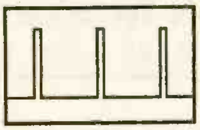
Int/Ext AM, SSB, Dualtone Gen.



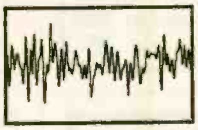
Int/Ext FM, PM, BPSK, Burst



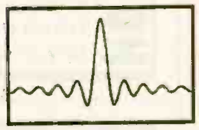
Ramps, Triangles, Exponentials



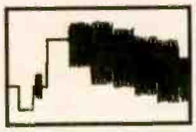
Pulse Generator



Noise



Arbitrary Waveforms



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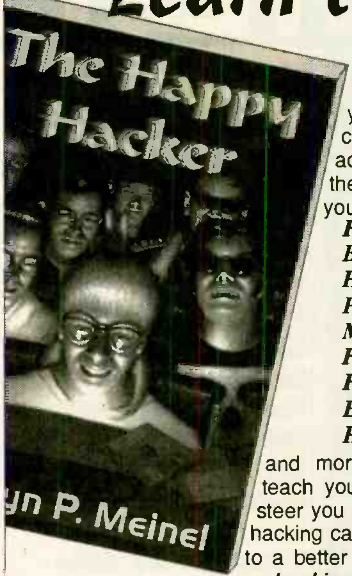

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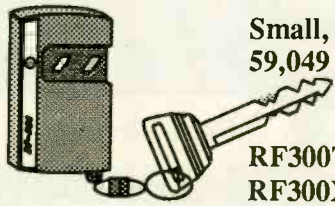
Miniature Transmitters and Receivers



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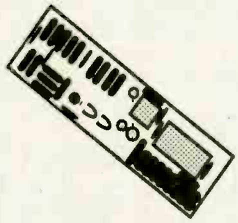

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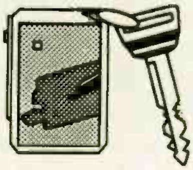

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Set Code, 60' Range, 1–7/8"x2–3/8"x7/16" (T), 2"x2–3/4"x9/16" (R)
Receiver Input: 5 vdc Output: Gated TTL Momentary Line

	Qty	1	5	10
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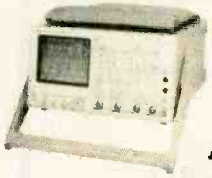

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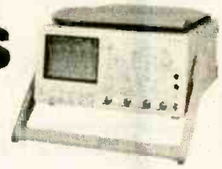

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Super Pro FM Stereo Radio Transmitter

A truly professional frequency synthesized FM Stereo transmitter station in one easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set frequency easily with the Up/Down freq buttons and the big LED digital display. Plus there's input low pass filtering that gives great sound no matter what the source (no more squeals or swishing sounds from cheap CD player inputs!) Peak limiters for maximum 'punch' in your audio - without over modulation, LED bargraph meters for easy setting of audio levels and a built-in mixer with mike and line level inputs. Churches, drive-ins, schools and colleges find the FM-100 to be the answer to their transmitting needs, you will too. No one offers all these features at this price! Kit includes cabinet, whip antenna and 120 VAC supply.

We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

FM-100, Professional FM Stereo Transmitter Kit..............$299.95
FM-100WT, Fully Wired High Power FM Transmitter..........$429.95

AM Band Radio Transmitter

Ramsey AM radio transmitters operate in the standard AM broadcast band and are easily set to any clear channel in your area. Our AM-25, 'pro' version, fully synthesized transmitter features easy frequency setting DIP switches for stable, no-drift frequency control, while being jumper setable for higher power output where regulations allow. The entry-level AM-1 uses a tunable transmit oscillator and runs the maximum 100 milliwatts of power. No FCC license is required, expected range is up to 1/4 mile depending upon antenna and conditions. Transmitters accept standard line-level inputs from tape decks, CD players or mike mixers, and run on 12 volts DC. The Pro AM-25 comes complete with AC power adapter, matching case set and bottom loaded wire antenna. Our entry-level AM-1 has an available matching case and knob set for a finished, professional look.

AM-25, Professional AM Transmitter Kit..............................$129.95
AM-1, Entry level AM Radio Transmitter Kit............................$29.95
CAM, Matching Case Set for AM-1.......................................$14.95

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CCDPH-2, Color CCD Camera, wide-angle lens.........$149.95
IR-1, IR Illuminator Kit for B&W cameras....................$24.95
IB-1, Interface Board Kit..$24.95

FM Stereo Radio Transmitters

Microprocessor controlled for easy frequency programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole Island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized FM Stereo Transmitter Kit........$129.95

A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit.............$34.95
CFM, Matching Case and Antenna Set.....................$14.95
AC12-5, 12 Volt DC Wall Plug Adapter.......................$9.95

RF Power Booster

Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat, professionally finished look, add the optional matching case set.

LPA-1, Power Booster Amplifier Kit..............................$39.95
CLPA, Matching Case Set for LPA-1 Kit......................$14.95
LPA-1WT, Fully Wired LPA-1 with Case.....................$99.95

Treasure Finder Kit

Search for buried treasure at the beach, backyard or park. This professional quality kit can detect metal at a depth of up to 6 inches. Easy to use, just listen for the change in tone as you 'sweep' the unit across the surface - the larger the tone change - the larger the object. Has built-in speaker or earphone connection, runs on standard 9 volt battery. Complete kit includes handsome case, rugged PVC handle assembly that 'breaks down' for easy transportation and shielded Faraday search coil. Easy one evening assembly. This nifty kit will literally pay for itself! That guy in the picture looks like he found something - what do you think it is - gold, silver, Rogaine, Viagra? You'll have fun with this kit.

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BNO-1, Binoculars and case..$24.95
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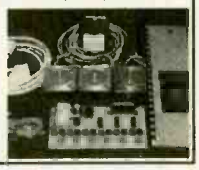

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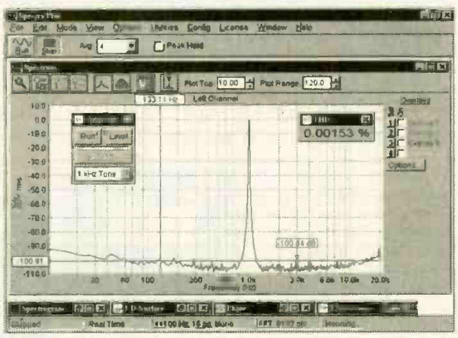

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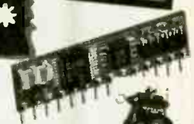

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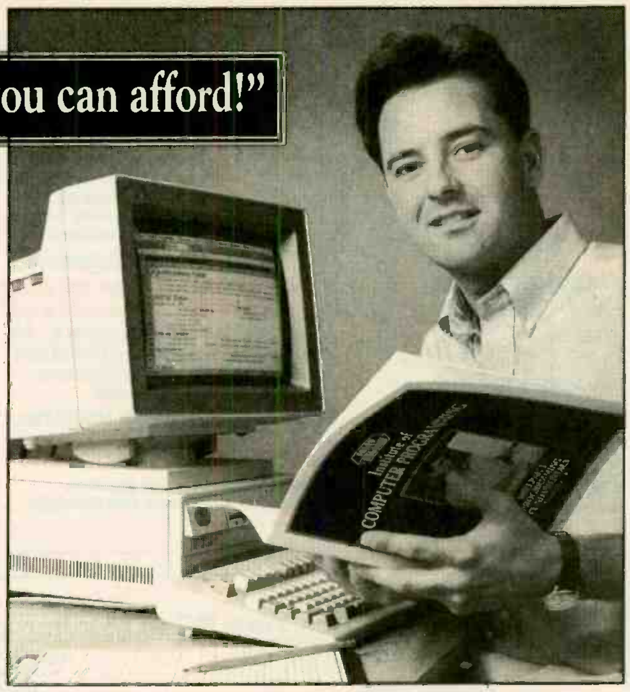

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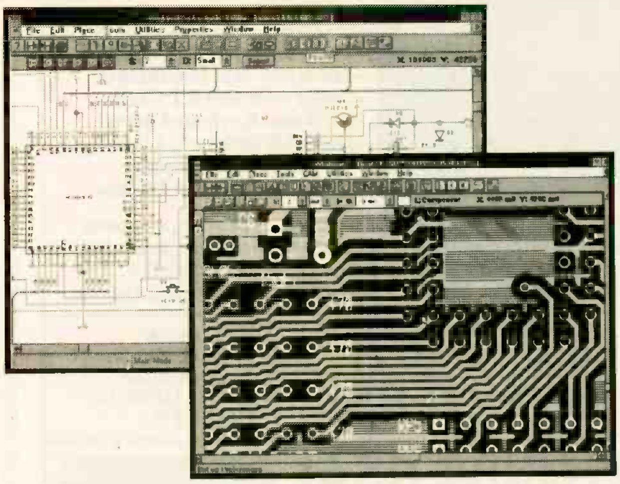

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HARDWARE INTERRUPTS	NONE	3

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PD1	3	18	PB6
XOUT	4	17	PB5
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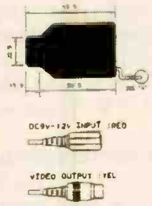
Scanning System:	2 : 1 interlaced
Sync System:	Internal sync
Sync Pulse:	15.734KHz+1%(H)/15.625KHz +1%(H) 59.94Hz +1%(V)/ 50Hz +1%(V) Sub-Carrier 3.57 MHz +30ppm
Resolution:	400 TV lines (H)
S/N Ratio:	More than 46dB (typ)
Gamma Characteristics:	0.45
Min. Illumination:	1 LUX (F1.2 10 IRE)
Video Out:	Composite video signal : 1.0Vp-p
White Balance:	Auto white balance
Electronic Shutter:	1/60 - 1/100,000 SEC(N) 1/50 - 1/100,000 SEC (P)
Power Supply:	DC 12V + 10%
Power Consumption:	240mA (typ)
Lens:	4mm (78 or 92 degree) F : 2.0
Ambient Operating Temp:	-5 deg. C +40 Deg. C
Ambient Storage Temp:	-10 Deg. C+50 Deg. C RH 95% MAX
Dimension:	2 1/8" (L) x 1 1/4" (D)
Weight:	3 oz.



CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-5407S	Color Water Tight Bullet Camera	$299.00	$269.00

(water tight for outdoor use, not suitable for sustained underwater use)

CCD Bullet Cameras

new!

Available with standard or pinhole lens. Virtually indestructible bullet shaped casing. This sleek B&W camera can be mounted on walls or ceilings along narrow corridors or virtually any location for virtually any surveillance application. 0.5 lux minimum illumination with 380 lines of resolution. Even includes a built-in electronic iris for automatic light compensation.

Features

- Extremely low power consumption
- No blooming, no burning
- 0.5 LUX minimum illumination
- CCD area image sensor for long camera life
- Ultra small size allows for simple application and installation
- Built-in electronic auto iris for automatic light compensation
- Ultra compact camera

Specifications

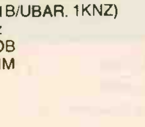


Image Pick-Up Device:	1/3" CCD area sensor
No. of Pixels:	EIA = 512(H) x 492(V)
Pixel Pitch:	EIA = 9.6uM(H) x 7.5uM
Scanning System:	EIA=525 lines, 60 field/sec
Sync System:	Internal sync
H. Resolution:	430 TU line
V. Resolution:	400 TU line
Usable Illumination:	0.5 Lux F1.6
S/N Ratio:	More than 48dB
Gamma Characteristic:	0.45
Video Output:	1.0 - 1.1 up-p 75 Ohm
Electronic Shutter Time:	EIA=1/60 - 1/50,000 sec
Lens F No. Focal Length:	STD : 1.6 Open / 4.3mm(78 deg) Pinhole: 4.3 fixed/ 2.8mm(91.4 deg)
Power Consumption:	DC 9V (8-10V), 110mA
Operational Temp.:	-10 deg - +50 deg C RH95% max
Storage Temp:	-20 deg - +60 deg C RH95% max
Dimensions:	STD : 22mm(W) x 22mm(H) x 38mm(D) Pinhole: 22mm(W) x 22mm(H) x 30mm(D)
Weight:	35g max

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDB-07S	Standard Lens Version	$144.00	$129.00
WDB-07P	Pinhole Lens Version	144.00	129.00
WDP-07S/water	Standard Lens Weather Proof	169.00	152.00

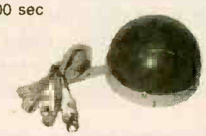
CCD Dome Camera with Audio

B&W DOME camera with integrated microphone. Ideal security system application. 12 VDC operation.

new!

Specifications

Image Device:	1/3" interline transfer CCD
Picture Elements:	EIA=542(H)x492(V)
Scanning System:	2:1 Interlace
Synchronization System:	Internal
Horizontal Resolution:	380 TV Lines
Sensitivity:	Under 0.3 LUX
Electronic Iris (linear):	EIA = 1/60~1/100,000 sec
Video Output:	1.0vp-p, 75 ohm
S/N Ratio:	More than 50dB
Power Supply:	12V DC (±20%)
Gamma:	r=1
Power Consumption:	110 mA max
Operating Temp.:	-10°C ~ +50° C
Operating Humidity:	RH 95% Max
Weight:	100g
Applied Lens:	3.6mm -92°, 4.3mm -78°
AI/EE/Flicker Less/Mirror Image:	Jump soldering selection
Audio Pick-up Sensitivity:	-60dB (0dB=1V/ubar)
Audio Frequency Range:	20 Hz ~ 20 kHz
Audio S/N Ratio:	More than 40dB
Audio Output Level:	1Vp-p/600 ohm
Dimensions:	87 x 55.5mm



CAT NO	DESCRIPTION	PRICE EACH 1	5
WDDB-6500	B&W Dome Camera	$144.00	$129.00

1/3" CCD Board Cameras

Available with **PINHOLE LENS** with **AUDIO**; **STANDARD LENS** with **AUDIO**; and **STANDARD LENS** with **INFRA-RED and AUDIO**. These are the world's smallest commercially available CCD board cameras!

World's Smallest B&W Board Cameras

Specifications

Image Pick-Up Device	1/3" CCD area Sensor
Picture Elements	EIA=512(H) x 492(V)
Pixel Pitch	EIA=9.6UM (H) x 7.5UM (V)
Scanning System	2 : 1 Interlace
Scanning Frequency	EIA=525 lines, 60 field/sec (II) 15.750 KHz x 60 HK
Resolution	430 Lines
Minimum Illumination	0.03 LUX
S/N Ratio	45DB
Lens Mounting	4.3mm standard, 5mm pinhole
Video Output	1.0 VP-P/750OHM composite signal
Power Requirement	8-12 VDC (9VDC standard)
Power Consumption	100mA
Operating Temperature	-20C -+ 70 C RH 95% Max
Storage Temperature	-40C -= 85 C RH 95% Max
Audio Pick-Up Sensitivity	-60 DB (0DB = 1B/UBAR. 1KNZ)
Audio Frequency Range	20 Hz to 20KHz
Audio S/N Ratio	More than 35DB
Audio Output Level	1VP-P/600 OHM

WDP-2000

WDS-2005

WDI-4000

Dimensions

WDP-2000	30mm (H) x 30mm (W)
WDS-2005	30mm (H) x 30mm (W)
WDI-4000	44mm (H) x 30mm (W)

CAT NO	DESCRIPTION	PRICE EACH 1	5
WDP-2000	1/3" B&W Pinhole Lens with Audio	$89.00	$77.00
WDS-2005	1/3" B&W Standard Lens with Audio	89.00	77.00
WDI-4000	1/3" B&W Infra-RED with Audio	89.00	77.00
WDPH-55BW	Plastic Housing Option for B&W Board Cameras (WDP-2000 & WDS-2005 ONLY)	13.00	12.00

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SINCE 1971
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602-464-5824(FAX)

ESD Safe Soldering Stations

Standard Tip

- *Auto-Temp 136ESD & Auto-Temp 137ESD*
- *Meets applicable military standards*
- *ESD safe featuring ceramic heating element and state of the art P.T.C. sensor to ensure accurate temperature performance*

Features

Fine Tune Temperature from 150° C (300° F) through 450° C (850° F) without unnecessary tip or heating element changes. **Precision "Tip Temperature" accuracy is mastered to within ±3° C** (6° F) using state of the art circuit technology and a built-in P.T.C. sensor located at the top of each ceramic heater shaft for fail safe accuracy. **Fast Heat Up & Recovery.** A long life Japanese made ceramic heating element facilitates fast heat up, fast recovery and exacting temperature control with minimal overshoot. Heat-up time to working temperature is attained in about 45 seconds. **Spike Free Circuit.** "Zero voltage" switching and fully grounded design meets military application standards for protection of electrosensitive devices against line transience and voltage spikes. Tip leakage is less than 0.4 mv or 0.5 ohm resistance. **External Calibration Port.** A calibration port is located on the face of the unit thus temperature adjustments are quick and convenient. **Lightweight Soldering Iron.** Ergonomic mini handle that stays "cool". Handle assembly cord is made from silicone rubber that won't be damaged when coming into contact with high temperature irons. **Isolated Power Unit.** The power unit is isolated from the AC line by a high quality transformer and only 24 Vac voltage is used to drive the heating element. **ESD Safe.** Exceeds all soldering equipment military specifications regarding electro static sensitive devices for critical applications. **Lock-Out Feature:** Constructed with a lock-out feature to allow supervisors only to set and lock specific soldering temperatures. Accomplished via a special sized allen head screw located on the front panel. **Superior High Insulation** ceramic heater provides insulation rated over 100Mohms at 750° F. **Optional SMD Tip Series** for re-work applications. **Range of Interchangeable Tips Available** for maximum system flexibility.

XYTRONICS

136ESD

137ESD w/ Digital R/O

SEE *www.cir.com* FOR OUR SELECTION OF REPLACEMENT TIPS, REPLACEMENT IRONS AND SMD TIPS.

CAT NO	DESCRIPTION	PRICE EACH 1	5
136ESD	Electronic Temp Controlled ESD Safe Soldering Station	$99.00	$88.00
137ESD	Electronic Temp Controlled ESD Safe Soldering Station w/ Digital Readout	129.00	114.00

CIRCLE 332 ON FREE INFORMATION CARD

USE ELECTRONICS NOW CLASSIFIEDS

READ BY ELECTRONIC BUYERS AND SELLERS AND TRADERS

INSTRUCTIONS FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or PRINT your classified ad copy CLEARLY (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $2.50 per word. Minimum charge is $37.50 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues.**Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface,** add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $4.00 per word.

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. ELECTRONICS NOW is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in ELECTRONICS NOW is limited to electronics items only. All ads are subject to the publishers' approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
ELECTRONICS NOW 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 -- Antique Electronics	270 -- Computer Equipment Wanted	450 -- Ham Gear Wanted	630 -- Repairs-Services
130 -- Audio-Video Lasers	300 -- Computer Hardware	480 -- Miscellaneous Electronics For Sale	660 -- Satellite Equipment
160 -- Business Opportunities	330 -- Computer Software	510 -- Miscellaneous Electronics Wanted	690 -- Security
190 -- Cable TV	360 -- Education	540 -- Music & Accessories	710 -- Telephone
210 -- CB-Scanners	390 -- FAX	570 -- Plans-Kits-Schematics	720 -- Test Equipment
240 -- Components	420 -- Ham Gear For Sale	600 -- Publications	730 -- Wanted

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category #________ **Special Category $30.00 Additional** ________________

1 - $37.50	2 - $37.50	3 - $37.50	4 - $37.50
5 - $37.50	6 - $37.50	7 - $37.50	8 - $37.50
9 - $37.50	10 - $37.50	11 - $37.50	12 - $37.50
13 - $37.50	14 - $37.50	15 - $37.50	16 - $40.00
17 - $42.50	18 - $45.00	19 - $ 47.50	20 - $50.00
21 - $52.50	22 - $55.00	23 - $57.50	24 - $60.00
25 - $ 62.50	26 - $65.00	27 - $67.50	28 - $70.00

29 - $72.50	30 - $75.00	31 - $77.50	32 - $80.00
33 - $82.50	34 - $85.00	35 - $87.50	36 - $90.00
37 - $92.50	38 - $95.00	39 - $97.50	40- $100.00

Total words ________ $2.50 per word = $______

Bold Face ________ $0.40 per word = $______

Special Heading ________ $30.00 = $______

Other ________ = $______

Total classified ad payment $________ **enclosed** **TOTAL COST OF AD $** ________

[ ] Check [ ] Mastercard [ ] Visa [ ] Discover Card # _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Expiration Date _ _/_ _

Signature____________________________

Name ________________________ Phone ________________________

Address________________________ City State Zip ________________________

CIRCLE 333 ON FREE INFORMATION CARD

CLASSIFIED

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$400 WEEKLY ASSEMBLING Electronic circuit boards/products from home. For free information send SASE: Home Assembly-EN Box 216 New Britain, CT 06050-0216.

CABLE TV

CONFUSED?? Descramblers. Will explain all your options, all makes and models avl. Dealers are welcome. Open 6 days 9AM till 7PM EST, Toll Free# (888)238-0967. **ROYAL ENGINEERING INC.** Universal Box is here now.

CABLE TV Descramblers. One piece units. Scientific Atlanta, Jerrold, Pioneer, and others. Lowest prices around. **Precision Electronics** Houston, TX. Anytime. 1-888-691-4610.

WHOLESALE and volume pricing. **Boss** units and **Seemores** compatible with all systems. C.O.D. Call and compare prices 1-888-762-2253.

Bewildered about descramblers? Call for fast friendly explanation on your cable needs. Same day shipping or shipping is free. Tech. support with all orders. Call Toll free 1-888-221-8365. Global Electronics M-Sat. 9am-8pm.

CABLE TV Signal Eliminator - Powerful, user tunable filter for removing severe interference OR unwanted channels! Eight models, for channels (2-3) (4-6)(7-13)(14-17)(18-22)(23-29)(30-36)(95-99). Each $30, add $4 for S/H. Quantity discounts. Money back guarantee. Visa, Mastercard or check. COD $5 extra. Visit starcircuits.com. **Star Circuits**, PO Box 94917, Las Vegas, NV 89193. 1-800-433-6319.

Free Cable Descrambler Plans. For Details Write: Sierra Publishing, 909 E. Yorba Linda Blvd., Suite H-181, Dept ENU, Placentia, CA 92870.

CUBE for Jerrold Model CFT-2200, 2014, 2024, 2254, Pioneer 6300-6310, Auto-Multimode, Zenith ST-1600 $175.00. Lowest price call 800-822--8530.

CABLE TV EQUIPMENT & ACCESSORIES. Wholesalers Welcome! 30 Day Moneyback Guarantee! Free Catalog! **PROFORMANCE ELECTRONICS, INC. 1-800-815-1512.**

Descramble cable with simple circuit added to RadioShack RF Modulator and using VCR as tuner. Instructions $10.00. **TELCOM** Box 832E11 Brusly, LA 70719

Cable boxes all models, all channels, lowest prices in the United States. Open seven days a week till midnite, Pacific time. Call (877)789-7337 toll-free.

Cable Descramblers, including activators for all Jerrold Dp5-CFT 22xx's and SP's, AUTO **MULTIMUDE**, and FIBER **OPTICS**. Descrambles everything **PERMANENTLY**, guaranteed. Lowest single or lot prices. Also, ZENITH, **SCIENTIFIC ATLANTA**, and **PIONEER**. Se habla en espanol. Call 888-684-9277.

Wholesale unmod 10 lot only VIP $50, Pio 5130 $50, Zenith 1000 $15, Jerrold DPV5 $28, DR23 W/R P,IN 8^{00} SA 8570 $75, Call **APEX** 1-800-500-9825.

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Learn electronics. Home study. Outstanding careers. Free literature. **P.C.D.I.**, Atlanta, Georgia. Call 800-362-7070. Dept. ELM342.

PLANS-KITS-SCHEMATICS

ELECTRONIC PROJECT KITS: 49 McMichael St, Kingston, ON., K7M 1M8. $3.00 catalog. www.qkits.com. **QUALITY KITS.**

CATALOG: Broadcasting/micro transmitters, amplifiers, antennas. **Start your own radio station books.** Audio, TV, Ham, CB, Surveillance, Science projects and more. **www.panaxis.com PAN-COM Int'l,** PO Box 130-11, Paradise, CA 95967.

Laser experimenter's catalog, circuit boards, controller chips, hard to get parts, plans, $2.00 **MCS Research** 15611 Colorado Blvd. Brighton, CO 80601.

AWESOME KITS: Voice Changers, Levitators, Lasers, Gas Sensors and more! Catalog $1.00. **LNS Technologies,** PO Box 67243, Scotts Valley, CA 95067 www.ccnet.com/~LNSTECH.

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FREE CATALOG - Satellite TV/GPS-DIY. Technical Books, Installation Videos, Computer Analysis Software www.baylin.com 800-843-2425.

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DSS Hacking: How to construct and program smart cards, with pic16C84, PCB layout, Complete DSS system schematics, $16.95. Software $25. **CABLETRONICS** Box 30502R, Bethesda, MD 20824

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WANTED: USED TEST EQUIPMENT. TURN IDLE OR EXCESS EQUIPMENT INTO CASH. AST GLOBAL ELECTRONICS: Voice: 888-216-7159, Fax: 814-398-1176, e-mail: sales@astglobal.com

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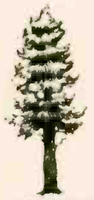

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One match can burn 3,000,000 trees.

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249 XELTEK SUPERPRO L	199 EPROM 16G TO 1 MEG
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ADVERTISING INDEX

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500 Bi-County Blvd.
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Fax 1-(516) 293-3115

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publisher (ext. 201)
e-mail advertising@gernsback.com

Adria Coren
vice-president (ext. 208)

Ken Coren
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Christina Estrada
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