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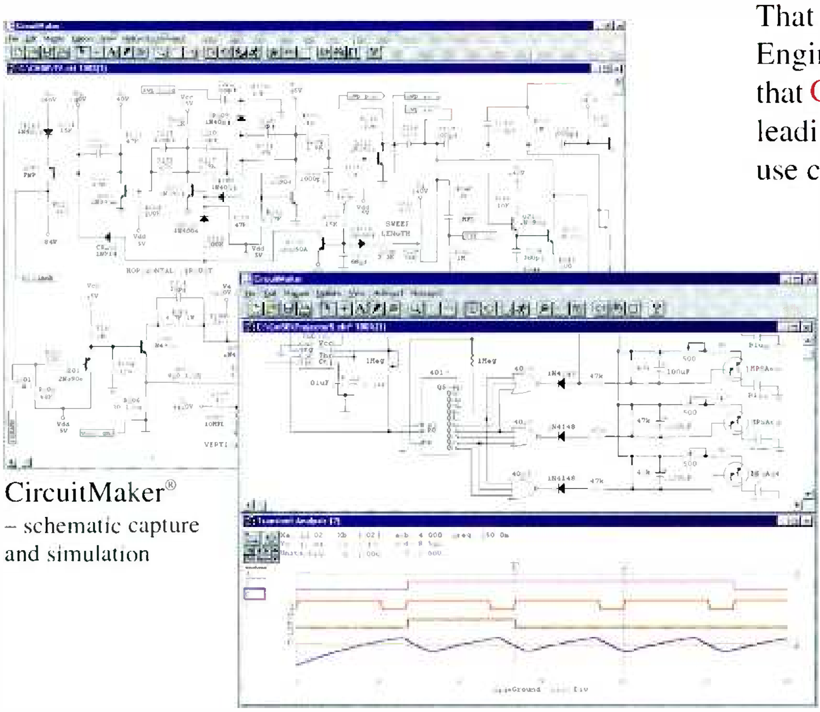

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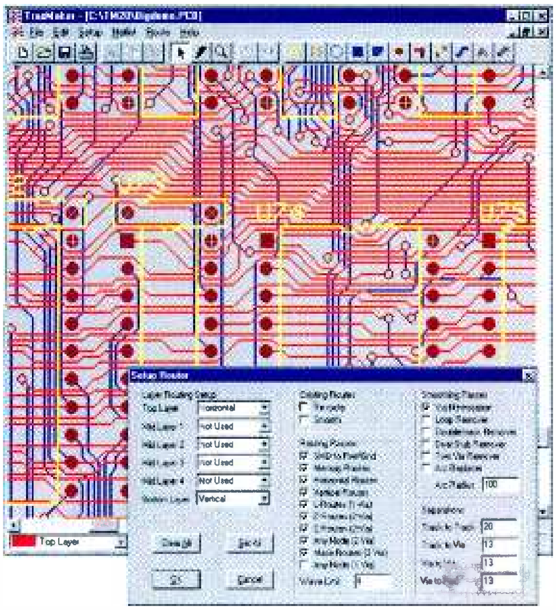

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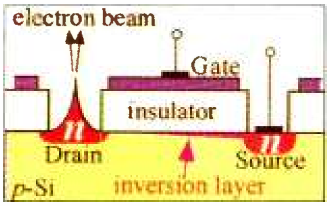

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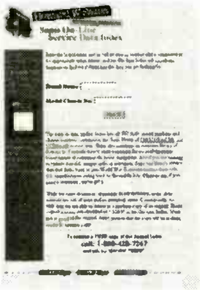

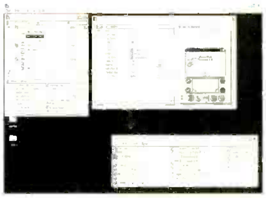

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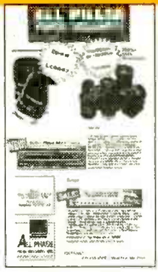

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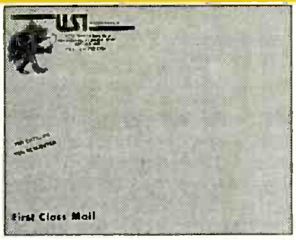

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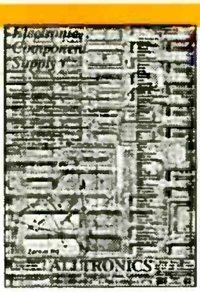

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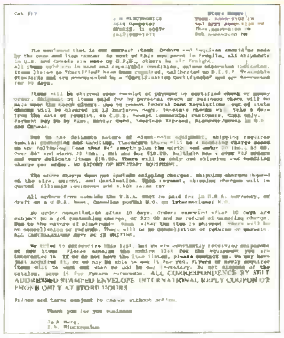

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EDITORIAL

Don't Miss Out, Part II

My Editorial on the opportunities the Internet affords electronics hobbyists, which appeared in the August, 1997 issue ("Don't Miss Out"), seems to have stirred up strong feelings among some of our readers. I have received several letters expressing an opposing view; one appeared in the November 1997 issue, and one amplifying on that writer's views appears this month (see page 8).

At the risk of appearing argumentative or sounding like an Internet evangelist, I must take issue with some of the writers' comments. One relates to the reliability of information. On the Usenet newsgroups, there is no denying that the garbage-to-signal ratio is so high as to make vast parts of it nearly unusable. However, vast parts does not mean all. In particular, the sci.electronics groups, while not moderated, are monitored by many dedicated hobbyists and professionals. The result is that any wrong information is almost always caught and quickly corrected. Even better, it seems that the "spammers" and idiots have, for the most part, decided to leave the sci.electronics groups alone.

But even if the above were not true, the real wealth of information lies in the Web sites maintained by manufacturers, distributors, retailers, publishers, dedicated hobbyists, universities, colleges, research facilities, the government, etc., etc., etc. The accuracy and reliability there is as good as can be found in any conventionally printed book, catalog, or other reference. That's because, in many cases, the material has been taken intact from original printed sources; the only changes are information updates or corrections. In fact, that is one way that the Internet is better than conventional printed media: Errors and omissions can be corrected, and updates can be provided, with speed that is simply not possible were it not for the Net.

Another question that needs addressing is why would a printed publication like **Electronics Now** be so interested in promoting the Internet. The answer is survival; not ours, but that of the electronics hobby. Since at least the 1960s, one of the greatest challenges confronting the hobbyist was the accessibility of parts, manuals, and other information.

That challenge proved too much for many. The numbers of active electronics hobbyists have been steadily declining and had fallen to alarming levels in recent years. Now, with the arrival of the Internet, the entire world of electronics has suddenly been thrown open to everyone. Need an exotic part? No sweat, even if it is only available in Australia or Europe. Need a schematic or manual? You can easily find it, or a place to get one. Need a circuit or circuit idea? There are hundreds if not thousands available. Need . . . well, you get the idea.

The Internet is a lot like a hammer, or, for that matter, any other conventional tool. If you use a hammer properly, it is invaluable; use it improperly, and it will cause lots of damage. But that doesn't mean we should avoid using hammers, does it?

Carl Laron

Carl Laron
Editor

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LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Go to the Head of the Class

Mr. Douglas "Enzo" McCallum, go to the head of the class!

In "Letters," (*Electronics Now*, November 1997), Douglas McCallum wrote about the editorial "Don't Miss Out" (*Electronics Now*, August 1997). His letter contained excellent advice for anyone seeking reliable information.

I share Mr. McCallum's concern that *Electronics Now* has placed more emphasis on the Internet than on reliable resource material (usually printed). Equally puzzling is why *Electronics Now* (a printed publication) is promoting the Internet.

The Internet has great potential as a resource tool. To date, however, the Internet is sorely lacking as a source of reliable information. As a research tool, the main value of the Internet is contact with other researchers and the exchange of data. A researcher can provide not only the data, but verify the source as well.

In this day of mass communication through Internet, CD-ROM, publications, books, etc., there is a lot of information floating around. Much of the Internet information is being passed around with no effort to sift and sort it. Good information is diluted with faulty information. No matter how good the original data may have been, it can quickly become garbage.

The Internet may *become* a valuable resource tool some day. For now, I've decided that it's more productive to do research the old-fashioned way. It's not worth sifting through Internet garbage looking for data gems.

T. LAMAR MOORE
Alexandria, VA

Your comments raise many important issues—issues that need addressing. Since space to do that adequately is not available here, please see this month's editorial on page 6—Editor.

Tomorrow's Technicians: Two Sides

I enjoyed the article "Recruiting Tomorrow's Electronics Technicians" by Joel Goldberg (*Electronics Now*, October 1997), but the focus was just on consumer service technicians. Your readers may be

(Continued on page 23)

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Decoding GPS Output

Q *This letter concerns Loran-C and GPS receivers and the NMEA 0183 data that they output. How can I interface them to a PC or Commodore computer? — G. C. B., Radford, VA*

A If your computer needs to know where it is, try the interface circuit in Fig. 1 and the IBM PC BASIC program in Listing 1. NMEA-standard navigation receivers (both Loran and GPS) output a stream of serial data at 4800 baud for use by autopilots and other navigational equipment. You can feed that data stream directly to the serial port of a computer. We tried it with a Magellan 3000 XL GPS receiver.

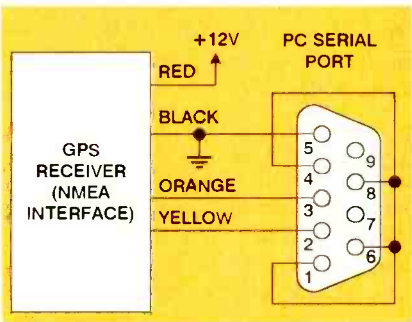


FIG. 1—USE THIS DIAGRAM TO HELP you connect a GPS receiver (NMEA interface) to your PC. The orange wire is needed only for bi-directional communication outside the NMEA standard.

As soon as the receiver locks on a set of satellites, it begins to transmit a series of messages every couple of seconds. Each message is one line of data, beginning with "$" and ending with return. The most useful message is the GLL message, shown in Fig. 2, which gives the latitude, longitude, and precise time of day.

When building the interface, check the pin numbers carefully because, of course, the plug is a mirror image of the socket. Note that pins 1, 4, 6, and 8 are tied together so the computer will start listening immediately, without waiting for any "ready" signal lines that are not used.

The NMEA data formats are described in some detail in the manual for this Magellan GPS receiver, as well as on numerous Internet sites (do a search for "NMEA" on http://www. altavista.com). The full standard can be purchased for

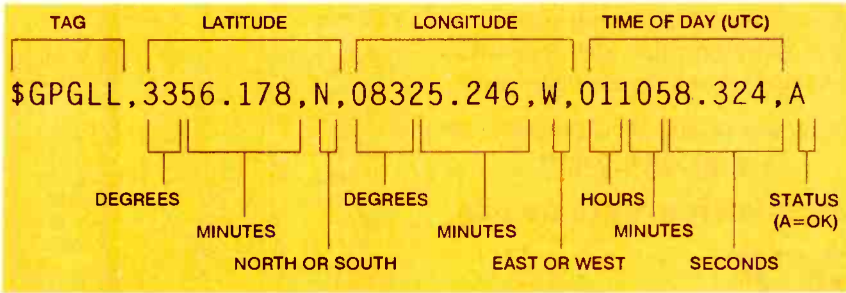


FIG. 2—HERE'S THE STRUCTURE OF AN NMEA 0183C "GLL" (geographic latitude and longitude) message. NEMA 0183A is similar, but has fewer decimal places and omits the time of day.

LISTING 1

```
100 ' Program to decode NMEA 0183C data
110 ' M. Covington 1997
120 '
130 CLOSE #1 ' just in case
140 OPEN "COM1:4800,N,8,1" AS #1
150 PRINT "Press Ctrl-Break to stop"
160 ON ERROR GOTO 200 ' ignore comm errors
170 '
180 ' Get data from GPS receiver
190 PRINT
200 PRINT "Waiting for data..."
210 PRINT
220 LINE INPUT #1, D$
230 WHILE ASC(LEFT$(D$,1)) < 33  ' trim CR and LF
240  D$ = RIGHT$(D$,LEN(D$)-1)
250 WEND
260 PRINT
270 PRINT "Received: <";D$;">"
280 '
290 ' If it's a GLL message, decode it
300 IF LEFT$(D$,6) <> "$GPGLL" GOTO 190
310 LATD = VAL(MID$(D$,8,2))  ' lat degrees
320 LATM = VAL(MID$(D$,10,6)) ' lat minutes
330 LATX$ = MID$(D$,17,1)     ' "N" or "S"
340 LOND = VAL(MID$(D$,19,3)) ' lon degrees
350 LONM = VAL(MID$(D$,22,6)) ' lon minutes
360 LONX$ = MID$(D$,29,1)     ' "W" or "E"
370 UTCH = VAL(MID$(D$,31,2)) ' time hours
380 UTCM = VAL(MID$(D$,33,2)) ' time minutes
390 UTCS = VAL(MID$(D$,35,6)) ' time seconds
400 PRINT "Latitude ", LATD; " deg.", LATM; " min.", LATX$
410 PRINT "Longitude", LOND; " deg.", LONM; " min.", LONX$
420 PRINT "Time (UTC)", UTCH; ":"; UTCM; ":"; UTCS
430 GOTO 190
```

$125 from NMEA, PO Box 3435, New Bern, NC 28564.

Ringing Transformers

Q *I have a homemade square-, sine- and triangle-wave generator and a Hitachi oscilloscope. Can you tell me how to perform ringing tests on flybacks and switch-mode transformers? — J. M., Athens, TX*

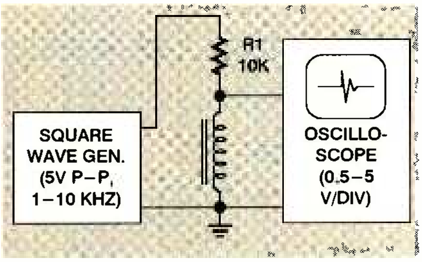


FIG. 3—USE THIS SET UP to perform a ringing test on a coil or transformer. The waveform displayed depends on the transformer's inductance and capacitance.

A Figure 3 shows a simple circuit for testing inductors and transformers of all types. Apply a square wave across a coil through a 10-kW resistor, and you'll get a distinctive ringing waveform that depends on the inductance and stray capacitance of the coil (or transformer winding). If the coil is open, you'll see the squarewave, unchanged or slightly rounded; if the coil is shorted, the scope will show a flat trace (no signal). Otherwise, the amplitude of the waveform is roughly proportional to the inductance.

In general, you'll use this tester to compare a suspect transformer to one that is known to be good. After a while you'll be able to recognize the waveforms produced by good and bad components from experience.

Clock Wanted

Q *Could you recommend a power-supply circuit that would provide DC power plus a nicely squared-up 60-Hz clock source to run a digital clock chip? — S. J., Palmerton, PA*

A The power supply is the easy part; just find out what voltages are needed by your particular chip and follow a book such as RadioShack's *Building Power Supplies* or *The ARRL Handbook for Radio Amateurs.*

To get a 60-Hz signal, use a National Semiconductor MM5369AA IC as

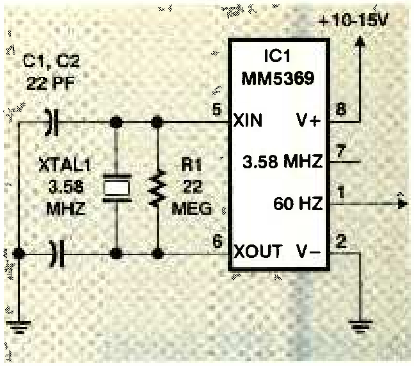


FIG. 4—THIS CIRCUIT, built around a MM5369, derives a 60-Hz signal from a common 3.58-MHz TV crystal.

shown in Fig. 4. That handy chip takes a 3.58-MHz color-TV crystal and delivers a quartz-controlled, rock-steady 60-Hz square wave.

Apple II Forever (PC XT Too?)

Q *I am trying to run down products of vintage PC- and Apple-compatible hardware manufacturers. Of particular interest is an 8MB RAM card for the Apple IIgs called the "Octo RAM." Where can I get some information? — D. J., Sturgeon Bay, WI.*

A Some parts for vintage Apple II, Macintosh, PC XT, PC AT, and PS/2 computers, among others, are available from Back Thru The Future Microcomputers, Inc., 622 Route 10 West, Unit 21, Whippany, NJ 07981. Also check the ads in *Computer Shopper* and *Nuts and Volts,* On the Internet, do a search for "Apple II" at http://www.yahoo.com and look for Apple-related newsgroups. There's a lot of information out there—all of it spread very thin across the Net!

Cable TV Amplifier

Q *I've been trying for years to get cable to my house, but being 1000 feet from the nearest trunk line has posed some technical difficulties. The local cable company wants several thousand dollars to put in an additional trunk line and other unnecessary equipment. However, all I really need is a signal amplifier powerful enough to push the signal through the 1000 feet of RG-6 that I already have. I figure I will need 60 dB of*

(Coninued on page 17)

Prototype

New MOSFETs Lead to Micro Vacuum Tubes

BY ITOH JUNJI & KANEMARU SEIGO*

Integrated-circuit technology has long since driven vacuum tubes from electronic circuits, but now that same technology is ushering in a new use for the tubes. However, unlike their older counterparts, these new vacuum tubes are constructed on the micron level (one micron is one millionth of a meter), can be integrated up to a density of $10^7/cm^2$, and operate at voltages that are about one order of magnitude lower than their predecessors. Also, the tubes no longer use thermal cathodes (filaments), but instead use ultra-miniature cold cathodes, called field emitter tips (microtips) and fabricated by IC technology, as a powerful electron source.

This new technology, called vacuum micro-electronics, is expected to produce high-performance vacuum microdevices. Of course, vacuum microelectronics are hardly likely to replace silicon ICs, but they may well bring about an epoch-making change to the cathode-ray tube (CRT), which is still used in TVs and has not changed in principle since its inception. (As most people know, the cathode-ray tube is a vacuum tube in which a beam of electrons is projected on a fluorescent screen to produce a luminous spot at a point on the screen.) Vacuum-microelectronics technology can reduce the size of CRTs to the micro level and integrate them on a glass in numbers equal to the number of pixels (the small, discrete elements that together constitute an image on a television screen). That approach creates a new flat-panel display called a field-emission display (FED), which is thinner, brighter, and consumes less power than liquid-crystal displays (LCDs).

However, to make the FED possible, it is critically important to overcome the drawbacks apparent in conventional microtips such as instability and poor uniformity in emission-current characteristics. Those drawbacks originate in the field-emission mechanism itself and are therefore very difficult to overcome.

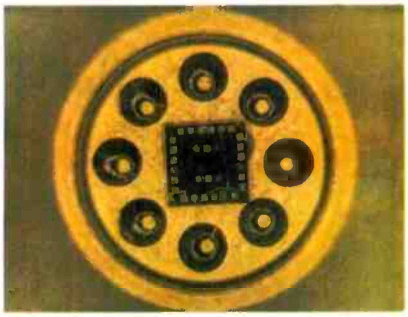


FIG. 2—TO MEASURE THE emission characteristics, the Si-MOSFET tips were mounted on a commercial TO-5 header.

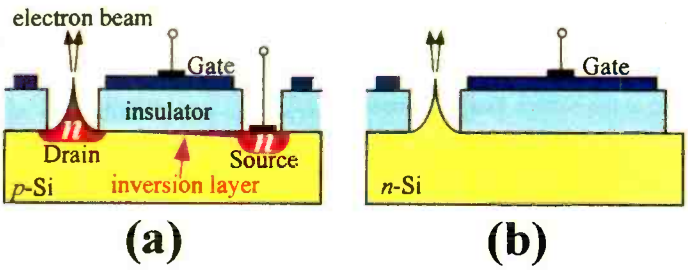
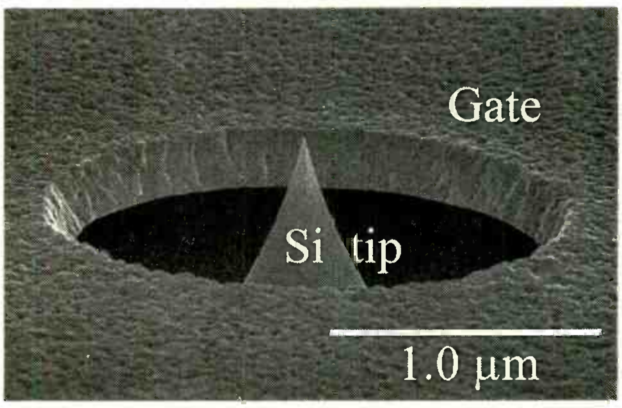


FIG. 1—THE NEWLY DEVELOPED Si-MOSFET tip is shown in A, while a conventional Si tip is shown in B.

That's where a new MOSFET could play a vital role. In 1996, researchers at Japan's Electrotechnical Laboratory (ETL), part of that country's Agency of Industrial Science and Technologies, developed a metal-oxide-semiconductor, field-effect-transistor, structured Si tip (Si-MOSFET tip). In that structure, which is shown in Fig. 1A (for contrast, a conventional Si tip is shown in Fig. 1B), a cone-shaped Si tip doped to n-type is made just on a drain of the MOS-



HERE'S A LOOK at the new Si-MOSFET gate as seen through an electron microscope.

*Courtesy LOOK JAPAN, August, 1997

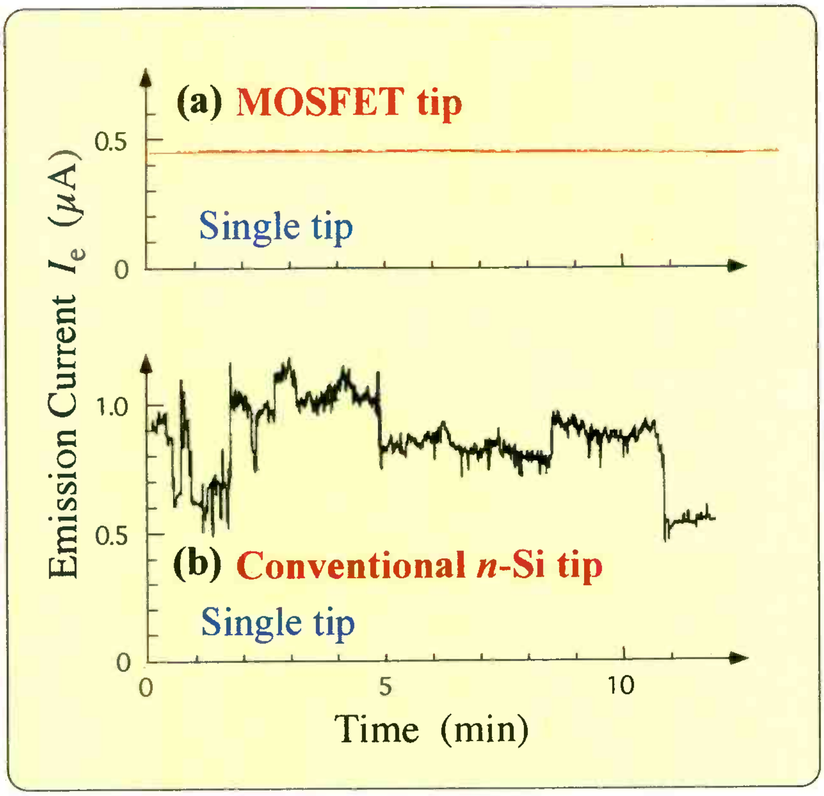


FIG. 3—THE EMISSION CURRENT of the new Si-MOSFET tip is shown at the top of this figure, while the current from a conventional Si tip is shown at the bottom. The differences in the stability are striking.

FET. The gate plays two roles at the same time: one role is that of a conventional extraction gate, the other is that of an FET-gate, controlling the drain current supplied from the source to the tip through the inversion layer (n-channel). Thus the emission current is precisely controlled by the drain current and is free from the field-emission-related drawbacks caused by structural and work-function variations.

FIG. 4—THE CATHODE LUMINESCENT PATTERN showed excellent stability.

To measure emission characteristics, the MOSFET tips were mounted on a commercially available TO-5 header (see Fig. 2), and installed in a UHV (ultra-high vacuum) chamber evacuated to a pressure of 10^{-7} Pa. A glass plate coated with (conductive and transparent) ITO film and phosphor (ZnO:Zn) was placed about 30 mm away from the tip and biased to 2 kV to observe the luminescent pattern.

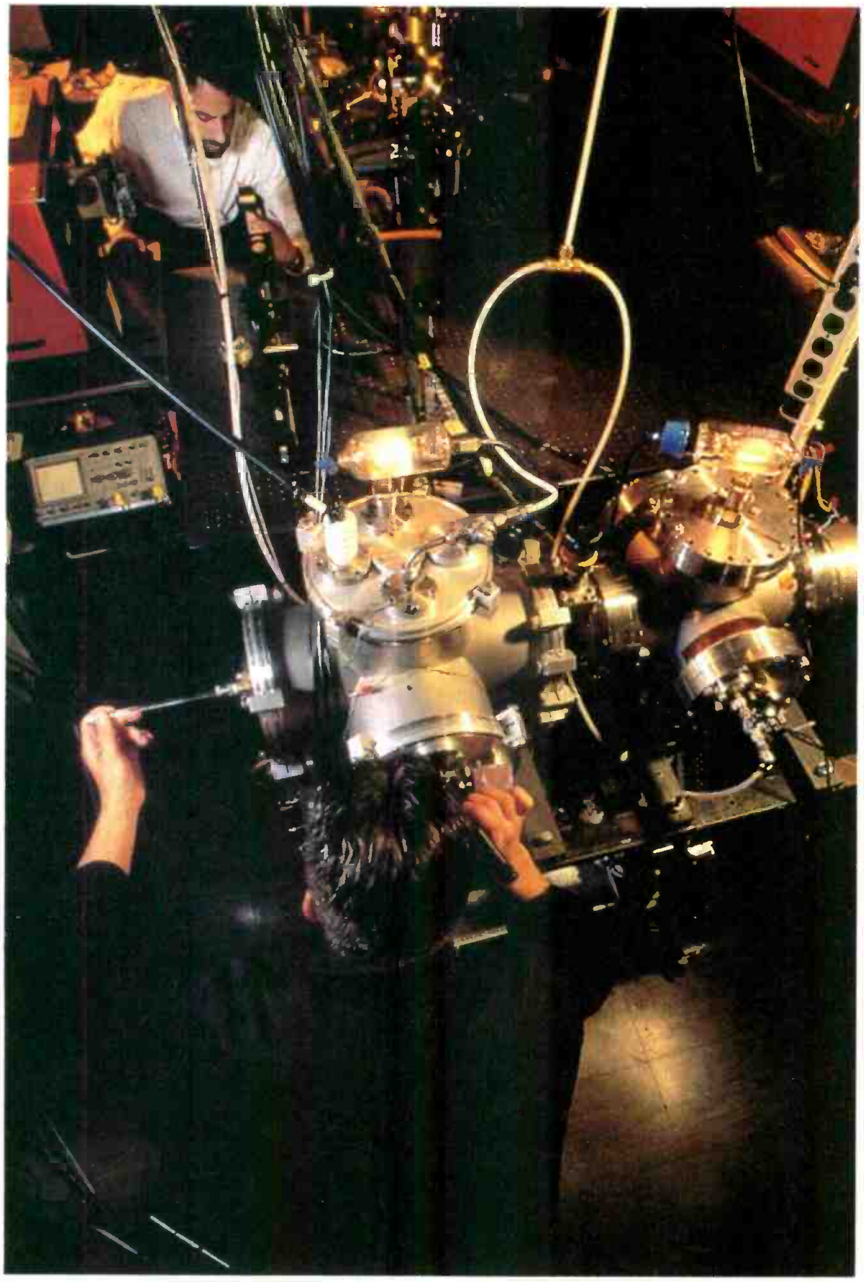
Emission-current stability of the single tip was measured using an X-T recorder. As shown in Fig. 3, the new MOSFET tip showed excellent current stability compared to that of a conventional n-type Si tip. The cathode luminescent pattern was also very stable (Fig. 4) and did not change for a long period. That effect has not been observed with any conventional microtips, making the MOSFET tip a promising cold cathode for vacuum microdevices such as the FED.

The Si-MOSFET-tip is superior to any other FET-combined tips so far proposed because of its simplicity in structure and ease of fabrication. Those advantages are born of the fact that the gate plays the roles of a conventional extraction gate and of an FET gate controlling the drain current. Based on the above principle, it is possible to extend the basic structure seen back in Fig. 1A to a multi-gate MOSFET structure, which could make low-voltage, flat-panel, field-emission displays possible, and practical. EN

"Extraordinary" Quantum Properties

An interdisciplinary team of researchers at the Georgia Institute of Technology has isolated a new series of highly stable and massive gold-cluster molecules that possess a set of "extraordinary" quantum properties. Each molecule in the new series has a compact, crystalline gold core. This pure metallic core—one-to-two billionths of a meter across—is encapsulated within a shell of tightly packed hydrocarbon chains linked to the core via sulfur atoms. The principal members of the series have core-masses of about 14-, 22-, and 28-thousand protons, which correspond to about 75, 110, and 145 gold atoms, respectively.

Gold is important technically not only for its inertness—once made, the crystals are immune to corrosion—but also for its highly stable surfaces. "The main fascination of very small metal crystals, and the foundation for their envisioned use in future electronics, arises from the fact that their construction electrons are quantized both in their number—charge quantization—and in the states they can occupy—energy quantization," stated Dr. Robert L. Whetten, Professor of Physics and Chemistry at Georgia Tech. "In crystals larger than a few nanometers, these effects can only be observed and used at very low temperatures, such as that of liquid helium, near absolute zero. The new series of nanocrystals are both sufficiently small that these effects are prominent even at ordinary tempera-



RESEARCHERS USE A HIGH-MASS SPECTROMETER to analyze a new series of highly stable gold-cluster molecules.

tures and yet are large enough to have the robust crystalline properties of the bulk metal."

Gold cluster molecules emerge spontaneously during the decomposition of certain gold-thiolate polymers (the type used in decorative gold paints and in gold anti-arthritis drugs). With sufficient control of the decomposition process, this series can be isolated without concurrent production of larger gold crystals. It is then relatively easy to separate the principal members of the series from each other to obtain the necessary homogeneity. Once purified, the molecules spontaneously assemble into crystalline thin-films, powders, or macrocrystals, while preserving the discrete properties of the individual gold nanocrystal cores.

This new gold cluster is an exciting breakthrough—the first molecule to exhibit the charge-quantization effect in a macroscopically obtained material for which every cluster behaves identically. Dr. Whetten and his collaborators have developed an electrode based on the most massive of this new series. According to Whetten, "With these properties, the molecules are very attractive building blocks for testing one type of ultra miniaturized architecture envisioned by some for 21st-century nanoelectronics."

Research in the area of nanometer-scale molecular materials is highly interdisciplinary, requiring the skills of many diverse researchers and facilities. Molecular gold materials were developed in Whetten's laboratory, guided by the theoretical predictions and modeling of Dr. Uzi Landman's Center for Computational Materials Science. The National Science Foundation, the U.S. Office of Naval Research, the Packard Foundation, and the Georgia Tech Foundation supported this research. EN

Cable-Ready Compatibility Standard

The Consumers Electronics Manufacturer's Association (CEMA) has developed standard EIA\IS-105.1, specifying the interconnection method for attaching a basic code decoder (a set-back box) to consumer electronics equipment such as TVs or VCRs. This standard describes two connection ports between the decoder and the TV: an audio/video/control port, which sends descrambled programming from the set-back box to the TV; and an IF port, which provides the scrambled signals from the TV's tuner to the box..

The interface allows a receiver to provide a descrambled picture while supporting record-while-watching, sequential recording, picture-in-picture, and other features. Equipment with this interface standard may be labeled "Cable Ready," which tells the consumer that these products can operate seamlessly with their cable systems.

This standard is the second step in a three-part process to establish a cable-ready interface, as described by the Cable Act of 1992. By the end of 1997, EIA\IS-105.2, which specifies the control protocol and commands between the two ports, is also slated for completion. The two documents, EIA\IS-105.1 and EIA\IS-105.2, describe the guidelines for proper operation of simple systems. An advanced interface to support the basic cable-ready functions plus text over video, as well as home-theater requirements, will be in the AVBus interface, another CEMA standard, which should be ready by mid-1998.

Cable operators, manufacturers, and any interested parties can order EIA\IS-105.1 by contacting Global Engineering Documents, Tel: 800-854-7179, Web: www.global.ihs.com. Further information can be found at CEMA's Web site: www.cemacity.org. EN

Cellular Phones and Mini-Screens

Motorola recently announced an agreement with Kopin Corp., Taunton, MA, to begin attaching thimble-sized screens to phones, pagers and other products. Kopin spent 12 years and $100 million dollars to develop CyberDisplay, which enables callers to see a full page of e-mail or view a Web site. The multi-million dollar agreement with Motorola, the world's largest wireless company, follows a similar deal with the wireless unit of Siemens AG of Germany that Kopin signed in June.

The device is built around a tiny LCD screen—only 0.28-inches in diameter. The screen looks like a video camera's viewfinder. Users see an image—equal to one on a much larger screen—on which there's a full-page of readable text. CyberDisplay allows phone users to talk on a phone that has the screen attached and simultaneously read an incoming fax. The tiny screen's high quality, low cost, and very low power consumption could lead to a wide variety of other applications, as well.

Analysts project strong growth in the demand for "smart phones"—wireless phones that allow people to access anything from address books to the Internet, as well as other digital data. Expected growth of "smart-phone" sales around the world is estimated to be 8.8 million units by the year 2002. Approximately 577,000 such phones were sold world-wide in 1997.

Whether CyberDisplay will fly or fail is unknown. It remains to be seen how many people will actually buy it, but research indicates that the market is there. EN

➢ Invention-Promotion Scams

Every year, Americans lose an estimated hundred-million dollars to fraudulent invention promoters who promise more than they can deliver. Many would-be entrepreneurs fall victim to scam artists, who for an upfront fee offer to guide amateur inventors through the whole process from product evaluation to patenting to marketing their brainchild. In truth, few inventions ever make it to the marketplace; and even getting a patent on a design, if an inventor manages to do so, does not guarantee commercial success.

The FTC has announced law-enforcement actions against five companies offering invention promotion services. The agency recently released a new bulletin about these costly scams: *Consumer Alert: Spotting Sweet-Sounding Promises of Fraudulent Invention Promotion Firms.* In addition, there are two other brochures on this subject: *Facts for Consumers: Invention Promotion Firms* and *FTC Briefs: So You've Got A Great Idea!* The FTC catalog of consumer and business publications, *Best Sellers*, is also available.

Copies of all these publications can be obtained free from: Federal Trade Commission, Consumer Response Center, 6th Street and Pennsylvania Avenue, NW, Washington, DC 20580, Tel: 202-326-2222 or (for the hearing impaired) 202-326-2502. The full text of these brochures as well as over 150 other publications can be found on the FTC ConsumerLine Web site: www.ftc.gov. EN

Space-Age Medicine

An experiment in advanced telemedicine (conducted jointly by NASA's Lewis Research Center in Cleveland, OH; the Ames Research Center, Moffett Field, CA; and Dr. James D. Thomas of the Cleveland Clinic Foundation) will benefit patients in remote or medically under-served areas of the country. In the experiment, a "patient" undergoing an echocardiogram at the Lewis Center was remotely diagnosed by Dr. Thomas at Ames. He viewed a real-time display of echocardiographic video images transmitted over the broadband NASA Research and Education Network (NREN). Dr. Thomas interactively guided the technician administering the procedure through a two-way voice link.

Echocardiography is a medical technique that applies the methods of ultrasound imaging to the cardiac system, providing a motion picture of the heart in action. A small, rural clinic may have access to an echocardiograph machine, but not to a specially-trained technician or to a staff cardiologist.

If the clinic were connected to a major, metropolitan medical facility through a high-speed communications network, a minimally-trained technician could carry out the procedure under the supervision and guidance of qualified echocardiography personnel. The challenge of procedures such as echocardiography is that high-resolution, moving images must be transmitted in real time. This requires a reliable broadband network and robust data compression.

NREN is NASA's cornerstone project of the interagency Next Generation Internet Initiative (NGI), supported by President Clinton and Vice President Gore. As David A. Foltz, networking project manager at Lewis, stated "This experiment was a step toward reaching the goal of the NGI. Pushing current networking technologies to the limit helps us understand how to design, build, and operate a national communications network for the future." Reaching these goals will affect health care on this planet and will pave the way for physicians here to view the heart function of an astronaut aboard the International Space Station, according to medical personnel. EN *gain to achieve that. Can you tell me where I can buy, beg, or borrow a schematic for such an amplifier? — T. B., Duluth, MN*

A The reason cable TV systems are so expensive to build is that it's absolutely necessary to keep the signals from leaking out of the cables. The reason? "Cable channels" are not broadcast TV frequencies; they are frequencies which, in the outside air, are used for other kinds of communication, such as aircraft, police, and fire department radios. If a signal leaks out, it could interfere seriously with the nearest town's emergency communications.

Your 60-dB amplifier would take a 1-microwatt input signal and put 1 watt of power into the cable—nearly all of which would leak out, because, at high frequencies, RG-6 is quite leaky. One watt is comparable to the output of a walkie-talkie. In effect, you'd be building a broadband radio transmitter that would transmit simultaneously on all frequencies from about 50 to 450 MHz.

That's why cable TV systems use hardline (which provides much better shielding) and specially designed amplifiers. That's also why the FCC pays so much attention to their signal leakage. Have you considered a full-sized or DBS satellite dish instead?

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

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

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

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

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

Copies of past articles: Copies of past issues of **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.

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

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

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

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

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

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

Nintendo Pinout

Q *I'm currently working on a project and have come to a dead end. I need to know the outputs for the 50-position card connector (cartridge port) for the Nintendo 64 gaming system. — Bill Laubscher, Jr., 5438 McDonald Road, McDonald, TN 37353.*

A As far as we know, that pinout hasn't been made public, and although there are Nintendo-"hacking" sites on the Internet, we couldn't find the connector pinout. We're publishing your address so that anyone with information to share can contact you directly. Readers?

Car Detector

Q *I need to detect automobiles passing over a loop buried in the pavement. Any ideas? — J. W., Perris, CA*

A A car-detector circuit was published in the January 1996 issue of our sister magazine, **Popular Electronics** (see pages 63-64). It's essentially a metal detector that uses a gigantic coil (50 turns on a 50-inch form). You can obtain this magazine from our Reprint Bookstore (see the "How to Find Electronics Information" box). In fact, you can probably adapt any metal detector circuit by using a big enough coil.

AM-To-Ham Radio Converter

Q *Please show a simple front-end schematic for 3500 to 3800 kHz, with a BFO, to use with a standard broadcast AM receiver. — D. H., Milan, TN*

A For the front end, use the shortwave converter circuit that appeared on page 10 in the March, 1997 installment

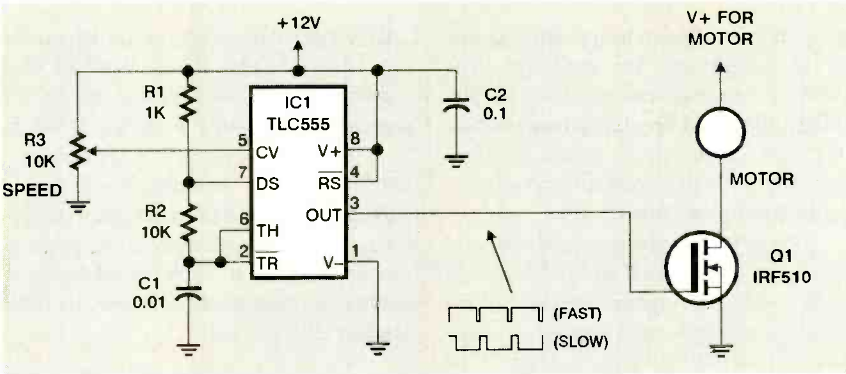


FIG. 5—IN THIS PULSE-WIDTH MODULATOR CIRCUIT, R3 is used to vary the width of the output pulses, and hence the speed of the motor.

of this column, but use a 2.5-MHz crystal and increase C5 (for a starting point, use 330 pF) until you hear signals.

The BFO is a separate circuit. You can use the oscillator shown in Fig. 6; it originally appeared in **Popular Electronics**, May 1990. Note that it does not connect directly to the radio; instead, you place the coupling wire near or around the detector diode. Once you've tuned the BFO initially, you can probably fine-tune individual stations with the radio's tuning knob without making further adjustments to the BFO.

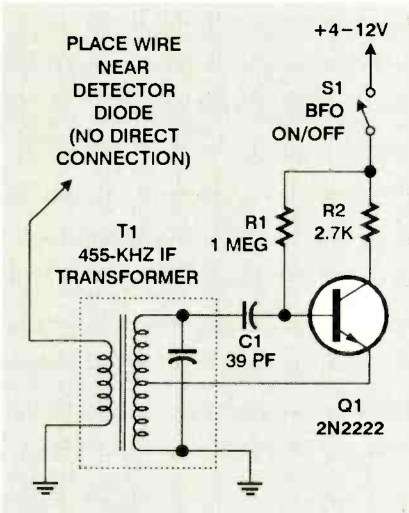


FIG. 6—YOU CAN ADD CW AND SSB reception to any radio with a 455-kHz IF using this simple BFO circuit.

Clock Conversion

Q *I would like to convert the electronic clock-timer of an oven to operate on 50-Hz power. It uses an HD 614042 IC.* —*R. N. L., Curacao, Netherlands Antilles*

A We assume you've solved all the other voltage problems, so the clock is working correctly but running at 5/6 of normal speed. We're not familiar with the HD 614042 chip, but if you can find out where it receives its 60-Hz input, perhaps you can build the oscillator in Fig. 4 and supply the 60-Hz signal from that rather than from the line.

Motor-Speed Control

Q *I would like to install an electric drive on an adult tricycle for use in a retirement community, with a solid-state "chopper" speed control. I've been advised that such a controller might be constructed using the 555 timer in PWM mode. Can you help?* —*R. L., Kissimmee, FL*

A A motor-speed control circuit that you can probably adapt for your purposes is shown in Fig. 5. In the prototype, we used an IRF510 and a small tape-recorder motor; for your big motor, you'll want to use a number of MOSFETs in parallel. The 555 operates as a pulse-width modulator (PWM), producing a squarewave that is positive for an adjustable percentage of the time. Thus, the average voltage at the motor can be varied without wasting any energy in a rheostat.

Writing to Q&A

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

EQUIPMENT REPORT

INDEPENDENCE ELECTRONICS CAPACITOR WIZARD ANALOG ESR METER

An easy-to-use tester that can spot bad capacitors, even in-circuit, that others miss.

If you've done any significant amount of electronics troubleshooting and repair, you've almost certainly come up against one of those near-impossible-to-diagnose situations that just makes you want to scream: All of the components test out good, yet the unit fails to operate properly. Only after hours—or days—of painstaking trial-and-error substitution do you finally find the culprit, a faulty electrolytic capacitor; yet when you put a standard capacitor meter on it, the darn thing still tests out as good. What gives?

More than likely, the problem lies in the capacitor's equivalent series resistance, or ESR. Quite simply, a real-world capacitor has resistive elements associated with it. Those include the DC resistance of the leads, the connections to the dielectric, and the plates. Most important, however, is the in-phase AC resistance that the dielectric material presents at a specific frequency and temperature. Note that the last resistance only exists when an AC signal is applied to the capacitor.

Why is ESR so important, and why is it ignored by many capacitor testers? In the past, when tube and other circuits with very high impedances were the norm, coupling capacitors were likely to be in the 0.05-µF range and ESR values were hardly ever a factor at audio frequencies. Back then, power supplies used electrolytics valued at maybe 40–60 µF and always had ripple at 60/120 Hz.

But today's equipment uses large-valued electrolytics with small physical volumes. In fact, modern capacitors can have values as large as a fraction of a farad, which is several orders of magnitude higher than units used twenty years ago. Such large-valued electrolytics are often found in the linear and switching power supplies of computers, VCRs, microwave ovens, computer monitors, laser printers, and TVs; in fact, in almost anything that plugs into the AC line. Sometimes even a half dozen such capacitors might be used in a particular unit.

Especially problematic are switching power supplies where the ripple components are found at frequencies ranging from 20 to 100 kHz. At those high frequencies, the ESR of the capacitors used becomes a significant consideration, and so is a new failure mode: high ESR.

What causes high ESR? As a high-value, small-volume electrolytic capacitor ages, the dielectric can begin to dry out. Once begun, that process can take years; then suddenly, the process accelerates. That happens when the ESR rises high enough to cause significant heating (just like any resistor), causing the electrolytic to dry out faster, causing the ESR to rise, causing . . . well, you get the picture. The result is that a capacitor's ESR can rise by a factor of 10 or 20 in as short a time as a month.

The problem with using a conventional capacitor meter to detect that problem is that while capacitance will also change as the dielectric deteriorates, it does not change by nearly as much as the ESR. In many cases, the reading will be within the unit's design tolerance (remember, the capacitors, and particularly electrolytics, have very wide tolerance specifications).

The Capacitor Wizard

That's where the Capacitor Wizard comes in. That in-circuit/out-of-circuit meter is an AC ohmmeter with its frequency, waveform and measurement point carefully chosen to maximize its ability to measure low values of ESR on capacitors of 1µF and up. In particular the test frequency is important. That's because, unless the frequency is high enough, the effects of the capacitor's capacitive reactance can throw off the test results. For that reason, a frequency of 100 kHz was chosen. The trade-off is that the Capacitor Wizard can not be used to test capacitors smaller than 1 µF. A 5-millivolt test voltage was chosen to allow in-circuit use, since that low voltage level won't turn on solid-state devices.

Results are shown on an analog display that is somewhat reminiscent of what you used to see on vacuum-tube testers. A logarithmic scale displays markings from zero to 30 ohms, plus infinity (which would indicate an open capacitor), with a qualitative scale (bad/compare/good) below. In addition, a beep feature, whose threshold is adjustable, sounds when a capacitor tests out as good.

The Capacitor Wizard is housed in a case that measures 7 by 4 by 1.5 inches, which to this reviewer seemed a little larger than necessary or convenient. However, as this is intended as more of a bench instrument, it might not bother you as much. In addition to the meter, the front panel features a power switch, a low-battery indicator LED, the threshold control for the aforementioned beep feature, a zero-ohms adjust control, and some general guidelines and warnings for the user. The unit comes complete with a pair of permanently wired, black test probes. Four alkaline AA batteries are required and should be good for about 60-80 hours. That is sufficient for several months to a year of use if you turn the unit off when you are done with it. There is no "sleep" function, and no visible reminder to tell you that the meter is on (unless you count the low-battery LED, and once that's lit, it is too late).

While the unit is intended for use as an in-circuit tester, it is extremely important that the circuit not be powered and that all capacitors be completely discharged first. As a reminder, a warning to that effect is placed permanently on the face of the unit. Should you choose to ignore or forget about that warning, or simply make a mistake, a file on the manufacturer's Web site (www.awiz.com) gives step-by-step instructions on how to repair your unit. Most of the likely-to-be-damaged parts are easy to find locally, or can be ordered from the manufacturer. A flat-fee ($35) repair service is also available.

One might wonder why better overvoltage protection is not provided in the first place. According to the manufacturer, any suitable protection would require an unacceptable trade-off in sensitivity, accuracy, and cost.

In any event, using the unit could not be easier. Just turn it on using the power switch, touch the probe tips together and set the meter to read zero (if necessary), then place the probes across the capacitor in question and read the result.

Final Comments

Overall, it is this reviewer's feeling that the Capacitor Wizard is a useful instrument that gets the job done, and fast. For the most part it is well engineered and easy to use.

That's not to say that everything is perfect. A power-on indicator would have been useful. Also, I found that the beep feature, while great in concept, was pitched a bit high and the volume was a bit low for me. Unfortunately, there is no way to adjust that and, though your hearing and preferences might differ, I found it nearly inaudible even a few inches away from the case.

Speaking of which, there are a few points about the case that I think could stand improvement. The four bottom rubber feet imply that lying the unit on its back is the proper position, and that's all well and good, but there are times when having the meter upright is simply more convenient. However, there is no easy way to position it that way; some type of tilt stand would have been a welcome addition. As stated previously, a smaller case size, or at least one better proportioned for portable use, would also have been appreciated, as would have been a protective holster of some type.

But, in truth, those are just quibbles. In the high-tech arena, time is money, and wasted troubleshooting hours are expensive. In some cases, just one use could justify the entire purchase price of $179.95. For more information on the Capacitor Wizard, contact the manufacturer, Independence Electronics (119 S. Main, Independence, MO. 64050; Tel: 800-833-1094 (orders) or 816-836-1094) directly, visit them on the Web at www.awiz.com, or circle 15 on the Free Information Card. EN

LETTERS

continued from page 8

interested in the explosive demand for electronics technicians in industry. Computer manufacturers, the semiconductor and auto industries, and chemical refineries want electronics technicians who specialize in robotics and instrumentation and control

In the Dallas area, semiconductor and telecommunications firms hire as many technicians from the local two-year community colleges as they can get their hands on. With a two-year degree in engineering technology, technicians can earn entry salaries as much as $25- to $30,000 per year. Experienced, competent technicians can earn $50,000, or even more.

Fortune magazine reported in its article "Technicians—The New Worker Elite" (August 22, 1994) that technicians are the key people of our new high-tech age, as all types of manufacturing companies upgrade with the latest in computer-and electronic-controls for factory automation.

GLEN W. SPIELBAUER
Dallas, TX

I have some comments on the article "Recruiting Tomorrow's Electronics Technicians" by Joel Goldberg (***Electronics Now***, October 1997). The author focuses mainly on the repair of consumer electronics products. It seems to me that Mr. Goldberg had neglected to mention (or doesn't realize) the problems involving the decrease in product value. There's a narrow margin between replacement cost versus repair cost in many consumer electronics products.

As a repair-shop owner and operator for over ten years, I have noticed that the problem is getting worse. For example, an inexpensive, off-brand VCR might carry a price tag of about $100. Now, lets say that the VCR has or develops a defective tuner/RF module. The part itself without price markup is about $50. Add a reasonable labor rate of $40 to $50 to diagnose the problem and replace the defective part, and you have matched or even exceeded the replacement cost. The same is true of any low-cost gear: A service technician can only make a minimal profit, if any, by servicing small radios, cordless telephones, and answering machines.

The author expressed much enthusiasm for recruiting young people to learn electronic servicing, but failed to mention the amount of money they might expect to earn. Although he did say "earning potential is very strong," based on the amount of units sold and the dollar amount of sales, he did not use the actual unit sales and the type of units sold as a reference. Mr. Goldberg does not mention failure statistics for various products nor the typical cost to repair them.

The article discussed industry working with educators to recruit young technicians. It is my opinion that many manufacturers are not too concerned about after-sales service. After all, every unit that gets repaired means one less unit sold. I don't know of any technicians getting rich in this line of work. Do you?

STAN BOGOVICH
Daytona, FL

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

BY SAM GOLDWASSER

Finding Information

NO MATTER HOW SKILLED YOU ARE, THERE ARE MANY TROUBLESHOOTING SITUATIONS WHERE YOU NEED MORE INFORMATION THAN IS IMMEDIATELY AT YOUR DISPOSAL.

The aim of this month's column is to help you learn where that help can be obtained.

Service Manuals

Believe it or not, service manuals are available for most consumer-electronics devices. The most obvious source is from the original manufacturer. Be aware, though, that such manuals can be quite expensive; depending on the type of equipment, service literature can range in price from $10 to $50, or more. However, once you have reached the limits of what you can do without the manual and/or schematic, that cost might be well worth it. Also keep in mind that some manuals are more useful than others. For example, not all include the schematics. So if you are hoping to repair an electronic problem, make sure the schematics are present before buying.

There's also the problem of identifying who actually made the piece of equipment in question. Only a few manufacturers actually produce the vast majority of consumer-electronics gear. For example, RadioShack, Magnavox, and Emerson do not make their own VCRs. However, house brands are nearly always the products of well-known manufacturers, and they are identical or very nearly identical to their standard models—but repackaged or at least re-labeled to reflect the store chain's name and logo. This is one reason why such lower-cost products may be a good deal (though not always).

How do you determine the actual manufacturer? For most types of consumer-electronics equipment, there is something called an "FCC ID" or "FCC number". Any type of equipment that could potentially produce RF interference or that could be affected by such interference is required to be registered with the FCC. That number can be used to identify the actual manufacturer of the equipment. A cross-reference and links that will let you use that number to find out the actual manufacturer can be found on the Internet at: http://www.repairfaq.org/REPAIR/F_FCC_ID.html.

Finding Older Manuals and Literature

Getting manuals for current or recent models may present few problems, if any but getting those manuals for older gear is quite another story. Fortunately, there are a number of places to obtain literature for older gear.

As most people interested in this area probably know, Howard Sams & Company (2647 Waterfront Parkway, East Drive, Indianapolis, IN 46214; Tel: 800-428-7267) publishes circuit diagrams and service information for just about every TV sold on this planet since the 1940s. What you might not know is that they also have a Web site at http://www.hwsams.com where you can search to determine if they have a folder for the set you are troubleshooting. In addition to their Photofacts, there are also a limited number of Computerfacts and VCRfacts available. Note that in the case of the later, the newer ones tend to have strictly mechanical information.

Sometimes Sams' Photofacts are available (for photocopy costs) from your local library, which might even subscribe to the complete series. If not, a large electronic distributor can order the needed folder for you, or you can order direct. One advantage of the Sams' information package is that it is compiled in a very consistent format so that once you are familiar with one model TV, it is easy to transfer that knowledge to any other. They provide waveforms at key locations and DC voltage measurements almost everywhere. Additional information such as IC pin to ground and coil resistances are often provided as well. In fact, they are often more complete than the manufacturer's service manuals.

In addition to Sams, there are a number of other places to get literature, manuals, and information. The following list comes from William E. Miller at Eagle Trader, and that's why he is at the top!

William E. Miller, Tel: 317-831-0896, e-mail: Eagle@trader.com, Web: http://www.trader.com/users/5010/549: "We help find, buy, promote, and sell—almost anything, almost anywhere. TV repair woes? Get the Sams Photofact TV Service Manual $7 Postpaid. Besides the used Sams TV Repair Manuals I sell, here are a few good sources you can try for various flavors of service manuals:"

A.G. Tannenbaum, P.O. Box 386, Ambler, PA 19002, Tel: 215-540-8055, Fax: 215-540-8327, e-mail: k2bn@agtannenbaum.com: Lots of parts and service data, 1920s to the present.

Michelle Troutman, e-mail: ai495@yfn.ysu.edu: She has various manuals for sale.

Marty Gasman, e-mail: mgasman@tiac.net. Web: http://www.tiac.net/users/mgasman: He has a lot of audio service manuals for sale. Check his full list at the web site.

John Gallawa, e-mail: mtek@gulf. net. Web: http://www.yup.com/microtech: They will be happy to help anyone who needs a schematic or parts breakdown for virtually any make and model (commercial or residential) microwave oven.

Inside the Cover

Even if you can't locate the service manual, another solution might be close at hand. Television sets and even old radios often have some kind of circuit diagram pasted inside the back cover. In the old days, that was a complete schematic. Now, if one exists at all, it just shows part numbers and location for key components, though that's still very useful. Some manufacturers include a complete schematic in the owner's manual, though that is the exception.

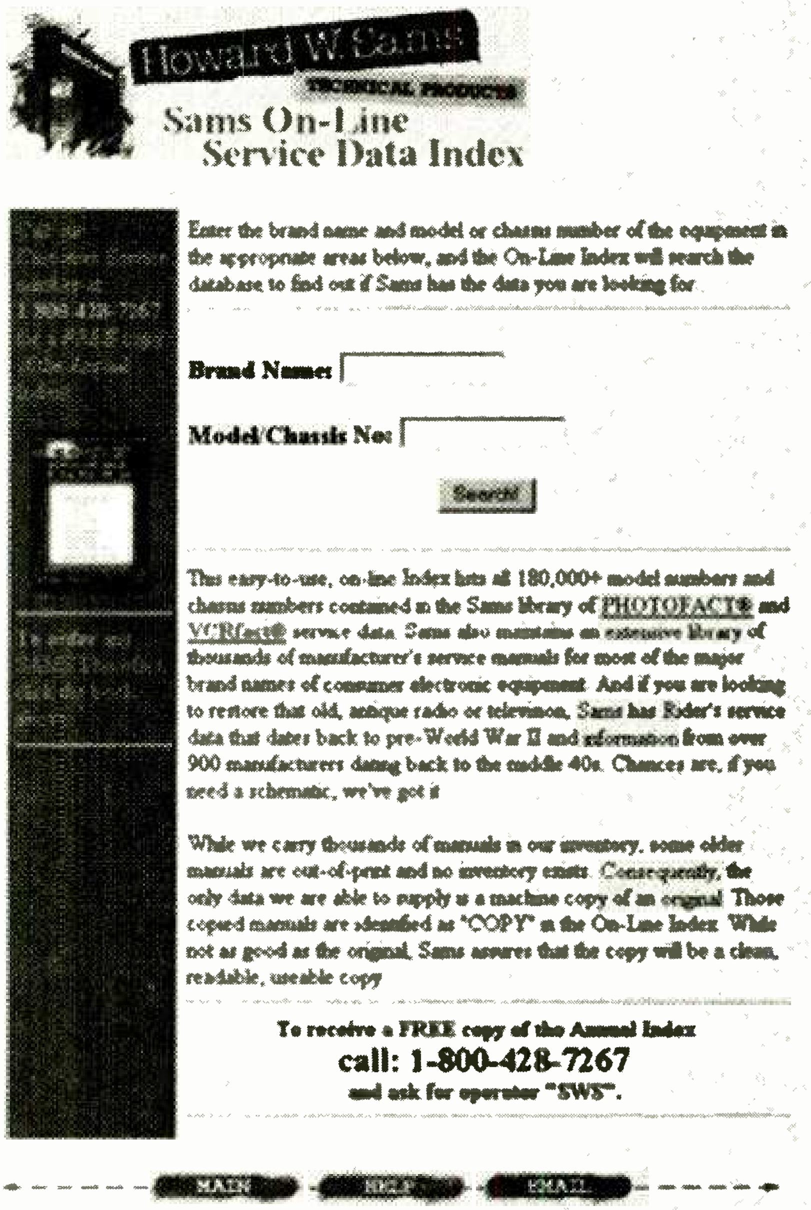
Microwave ovens almost always have a schematic diagram of the microwave power-generation circuitry pasted inside the sheet metal cover. That will include the high-voltage transformer, interlocks, rectifier, capacitor, and magnetron. Since most microwave-oven problems are in those areas, that is all you are likely to need. The controller, especially if it is an electronic unit, is often omitted or covered superficially.

Finding Components

One of the major problems in getting replacement semiconductors is finding out who makes the ones you need. Again, the Internet can be a tremendous help as most manufacturers these days have a Web presence. Some of your best bets include: http://www.design-net.com (Motorola), http://www.semiconductors.philips.com (Philips), and http://www.st.com (SGS-Thomson).

There are others, but they are smaller and harder to find. If you know the manufacturer, try contacting the local sales rep, sales office, or company-literature department. Look in the phone book or on the Web page for the phone number, then call them up and ask. It's their job to provide customer support, and if you sound like you halfway know what you're doing (saying you're a student works, too), they'll often be more than willing to send you information. (These days, it might even be a CD-ROM of their whole product line.)

If they won't help you, ask them where there is someone who can, like the nearest distributor. Larger electronics distributors often fill the same litera-



HOWARD W. SAMS' WEB SITE includes a searchable index of their available Photofact and VCRfact service-data packages.

ture-distribution role as the sales rep. Other distributors like Jameco, JDR Microdevices, and Future Active sell databooks as a catalog item. Also, a local distributor that caters to the walk-in trade will have a databook shelf and allow (or have a nominal fee for) photocopies. (Unfortunately, the big distributors are closed operations, mostly using phone salesmen and UPS for distribution. Visitors aren't always welcome.)

Another data source is a good library. Look for one at a university that has an electrical engineering program, or even a large city library. Used book stores or big unselective 'book dump' operations often will have a good stock of old databooks—ones that you can't get from the manufacturer any more. Likewise, electronics surplus stores (most big cities should still have one or two) often have older databooks.

Parts Numbers and Cross References

I have found one of the most useful single sources for information on semiconductors to be the ECG Semiconductors Master Replacement Guide, which runs about $6 from your local Philips distributor. Thomson (SK replacement line), NTE, and others have similar manuals. The ECG manual will enable you to look up U.S., foreign, and many manufacturer's "house" numbers and to identify device type, pinout, and other information.

Note that searchable cross-references are also now available on the Internet at http://www.ecgproducts.com (ECG), http://www.nteinc.com (NTE), and http://www.inland-electronics.com/skcross (SK). Mostly these just provide the appropriate replacement part number and a short one-line description (no specifications or pinouts). However, the NTE site does provide a fair, though by no means complete selection of data sheets. For those devices that don't have data sheets on line, a more comprehensive selection is available via their Fax-on-demand service (800-683-3292, or in NJ call 973-680-4897, and request Doc #1 for the semiconductor index).

I am not recommending using ECG (or other generic) replacements if the original parts are readily available. For one thing, the original part is often less expensive than the generic equivalent. Also, don't assume that the specifications of a generic replacement are identical to the original; sometimes they could even be better, but they could also be inferior. However, they should work in most applications where an original part is not available, and the cross-references can save countless hours searching through databooks or contacting manufacturers.

Identifying Transistors

U.S.-made semiconductors used to be mostly of the "nN" variety—2N with a 3 or 4 digit number following for a bipolar transistor, for example. This is called the Joint Electron Device Engineering Council (JEDEC) standard numbering. It seems to have been replaced by letter prefixes which may be manufacturer dependent, although the same part may possibly be available from multiple sources.

Look at a semiconductor in a piece of modern equipment, however, and you're likely to see semiconductors with designations that begin with a letter (A, B, C, D, F, J, and K) followed by a 3 or 4 digit number. What you are looking at is a Japanese numbered part. To confuse you further, you need to add a 2S in front of the letter to get the complete part designation (the 2S is nearly always absent from the package label). While these once might have been hard to find, with the complete number you can often find a suitable generic replacement from one of the sources mentioned earlier. Even better, many of the more common 2S parts are now available from places like MCM Electronics, Dalbani, Premium Parts, and Computer Component Source, as well as other advertisers you will find in the *Electronic Shopper* section in the back of this magazine. Incidentally, the 2SA and 2SB prefixes indicate PNP bipolars; the 2SC and 2SD prefixes indicate NPN bipolars; 2SF indicates a thyristor; and 2SJ and 2SK indicate an FET/MOSFET part. There are many other 2S prefixes, but those are by far the most common.

You'll also often see suffixes on the

THE NTE CROSS-REFERENCE and similar ones from other manufacturers can help you locate a suitable replacement device.

part number. Those usually denote package type or some special feature like an internal damper diode (D, for horizontal output deflection transistors), enhanced gain, special speed sort, etc.

House Numbers

In many pieces of consumer gear, semiconductors bear cryptic numbers such as 121-1025 or 113234. These follow no known numbering scheme and are often the only marking on that critical part you need to replace or identify.

What you are looking at is a "house-numbered" part. Are they used just to make life difficult? It certainly seems that way from the perspective of repair—give me industry-standard numbers any day. However, house numbers are a fact of life. The house number is what you need to order a replacement from the original manufacturer of the equipment. Of course, that may not always be desirable due to the possible high cost and difficulty in locating a suitable distributor that carries the manufacturer's replacement parts.

Another possibility is to use one of the cross-reference databooks mentioned earlier. That's especially true if you know or have an idea of the specifications for the part you are replacing. Note that, for the most part, you'll need to use the hard copies of these since very little in the way of data (specifications, pinouts, mechanical details, etc.) is available on line except at the NTE site, and there's not much even there. The books can run you a few dollars, but if you do repair work regularly, they are well worth it.

Internet Sources

Not too long ago, finding technical or other information on a device or product was a near-impossible task. Even finding a starting point for your search was a frustrating experience. Thanks to the Internet, however, that is rapidly changing. Many, if not most, manufacturers now have a presence on the World Wide Web, meaning that the answer to your question might be a mouse click away. And if you think most of what's there is advertising or public relations fluff, well, you are right. However, there is also an amazing amount of technical information that these companies and others are making freely available. For example, disk-drive manufacturers often have product information including detailed specifications as well as complete jumper and switch settings for all current and older hard drives.

Finding these sites is usually easier than looking in a telephone book. Most addresses are simply variations on www.*xxx*.com, where *xxx* is the company name, or a common abbreviation or acronym. For example, Hewlett Packard can be found at www.hp.com. You can also search for these companies using any of the available search engines such as Infoseek (www.infoseek.com), Excite (www.excite.com), etc.

If you'd like to check out examples of what is available, here's a couple of pages to try: For some introductory material on various aspects of consumer electronics, take a look at http://www.philipsmagnavox.com/product/pe33.html. That is the Magnavox Electronics Reference Web site. There you will find links to a number of articles on the basic principles of operation of CD players, laserdisc and optical drives, TVs, VCRs, camcorders, loudspeakers, satellite receivers, and other consumer A/V equipment.

Tandy (RadioShack) has a nice web resource and fax-back service. It is mostly for their equipment, but some of what is available applies to other brands, and there are diagrams that might be useful for other manufacturers' VCRs, TVs, camcorders, remote controls, and other devices. To check it out for yourself, go to http://support.tandy.com for the Tandy homepage and http://support.tandy. com/ video.html for their video products. In addition to Tandy products, a couple of Sony models are covered. Furthermore, since Tandy does not manufacture its own TVs, VCRs, or camcorders (they are other brands with Realistic or other RadioShack logos) your own model might actually be covered—it might just take a little searching to find it.

Searching USENET Newsgroups

It really seems sometimes that no problem is really new or unique. Therefore, there is an excellent chance that your question has come up and resulted in information being passed back and forth on sci.electronics.repair (or another appropriate newsgroup). For example, if you have had problems with a late model RCA/GE television, there have been dozens if not hundreds of postings on this subject over the last couple of years.

The question is how do you find that information. You could simply post your question, but that is not necessary and will simply add to the clutter of an already busy newsgroup. Instead, try searching Dejanews first. Dejanews is a USENET newsgroup-searching facility that has been archiving newsgroup articles since March, 1995. By going to their Web site, you can invoke a search of over 15,000 newsgroups (120 GB of data!) for any set of words, names, or e-mail addresses. Within seconds, they will provide a list of postings that satisfy your search criteria. Try using Dejanews at least once—you will be instantly hooked. The site URLs are: http://www.dejanews.com, for the Dejanews homepage and http://www. dejanews.com/home_ps.shtml, for the Dejanews Power search form. While postings typically drop off a local server in a few days, or less, Dejanews maintains them "forever" so that locating an entire thread becomes a trivial exercise in identifying a search string that will narrow down the postings to those relevant to your needs.

Posting to sci.electronics.repair

If all else fails, you can try posting your request for help to the sci.electronics.repair newsgroup. However, if you do this, be sure to read and understand the following suggestions. They will greatly increase your chances of getting a successful and useful reply, and minimize any frustrations on your part, as well as for those who read and follow that newsgroup.

Please read the on-line repair FAQs or repair guides first. Your problem may be covered. Even if an exact solution is not provided there, the additional information may allow you to ask your questions more concisely and intelligently and therefore arrive at a solution more quickly. The FAQs can be found at: http://www.repairfaq.org. First read the README and Mirrors links to identify the best way for you to access the information from your location.

Put the type of device (*i.e.*, VCR, CD player), manufacturer, and model number in the subject header, as that will get the attention of the professionals. If you do not provide that information, the first reply you will receive will be a request to provide it. Avoid that waste of Net bandwidth. For general questions, such information might be unnecessary, but it will not hurt.

As with professional repairs, provide as much relevant information as possible. Ambiguity can lead to totally bogus advice. For part identification, include both the designator (*e.g.*, R324, Q1) and type (*e.g.*, 330K, BU407D), if available.

If a little circuit diagram will help, provide it in ASCII if possible. ASCII takes up almost no space and everyone (with a fixed width font) can read it. If you have a large, scanned schematic, offer it via e-mail. Large binary files are not supposed to be posted on those newsgroups and doing so will likely get you flamed. In general, people get upset when they inadvertently download a 1 MB file they have no interest in, but may not know that until they see the description. Further, some ISPs charge for connect time and bits transferred.

You need to be patient. Not everyone sits at their computers all day. Some news servers may be days behind in their postings. If you truly get no replies of any kind (to the newsgroup or e-mail) in a few days, re-post your question with a note that it is a repeat. The net isn't perfect and due to finite disk space, many servers will miss postings or purge them after a day or less.

Don't just ask for repair tips—describe what you have done so far in terms of troubleshooting approach and tests performed, but don't fill screen upon screen with details. People don't want to read them. Include only the essentials if possible.

Don't ask for help on 25 problems in the same posting—that is taking advantage of the generosity and time of others. Dribble them out and reciprocate by replying to other people's problems as well if you can. However, don't just post to say something. If you act immature, you will end up in everyone's kill file.

Don't ask for help on problems that you could just as easily solve on your own by checking a databook you should have or a Web site that you should know about.

Don't ask for an e-mail response. First of all, it is very impolite. The sci.electronics.repair newsgroup was not created for your benefit. We do this because we like to help people, but at the same time do not want to feel like we are being taken advantage of or taken for granted. We are not your private consulting service. In addition, others will know when an adequate response to your query has been provided and will not need to waste their time repeating the same information. And, everyone will learn something in the process.

When you get a response, wait a day or two to see if there are any follow-up responses before acting on it. While there is no profit motive or other incentive for someone to intentionally deceive or mislead, mistakes happen. Usually, there is enough cross-checking by others so that any gross errors in analysis will be uncovered.

That's all we have room for this month. Until next time, you can find more information by simply visiting my sci.elecronics.repair FAQ site on the Internet at www.repairfaq.org. You can reach me directly via e-mail at sam@stdavids. picker.com. EN

BY FRANKLIN J. MILLER

Performing Our First Tests

A FEW MONTHS BACK, WE BUILT AN AUDIO OSCILLATOR. LAST TIME, WE BUILT A RESISTANCE-SUBSTITUTION BOX. THIS MONTH, WE'LL PUT THEM TO WORK TO PERFORM SOME BASIC TESTS. BEFORE WE START, THERE ARE A FEW ITEMS YOU'LL need to obtain. First off, you will need two sets of shielded leads. They should have dual banana plugs on one end and standard phono plugs on the other. You also should buy or make up a cable with dual banana plugs on one end and clip leads on the other. And phono-to-3.5-mm-monaural-plug adaptors will also be handy.

If you purchase those cables, make sure you get good quality items. There is nothing like taking the time to make a complicated test only to find one of the cables was no good. Some good advice from many years of experience is to test the cables periodically—say every three months.

You'll also need an audio voltmeter (an AC voltmeter optimized for use at audio frequencies). If you don't own or have access to an audio voltmeter, a future column will detail one you can build.

Measuring Frequency Response

For our first test, we will measure the frequency response of a power amplifier under load. Figure 1 shows the setup.

Note that the wattage of the load resistor must be equal to or greater than the power amplifier's rated output. It is always better to use higher-wattage loads if possible. It is also important that the resistor be a non-inductive type.

Before you begin, you will need some way to record the data you measure for future use. Since we will be looking at how the output level changes as output frequency changes, one of the most efficient ways of recording the information is to graph it. However, while doing research for this article I discovered that the kind of graph paper most appropriate for this type of work is nearly impossible to find; perhaps it is no longer being made as I could not get it from any of the standard sources (office supply stores, drafting stores, and catalogs).

Since I felt that it was important for record keeping, I designed two types of graph paper. The first type is Lin/Log, and it is used when the measurements are made in decibels (dB) versus frequency (the decibel is already expressed as a log function). The other is Log/Log and is used where the measurements are made in volts (or mV) versus frequency.

A sample of the Lin/Log paper is shown in Fig. 2; a sample of the Log/Log paper is shown in Fig. 3. Each includes an area in which you can detail the test itself and the setup you used (you should do your record keeping at the time of testing when all the details are fresh in your mind). The graph paper is available in pads of 25 sheets from the author as per the information in the Ordering Information box, or you can simply copy the artwork directly from this magazine and make your own graph paper; for convenience, it is shown full sized.

Now, back to our testing: Be sure that all equipment is plugged into the same AC outlet or power strip to avoid possible ground loops. If the power amplifier has a volume control, set it to maximum for this part of the test. Before you turn the power amplifier on, make sure the audio voltmeter has its range switch in the highest position and the

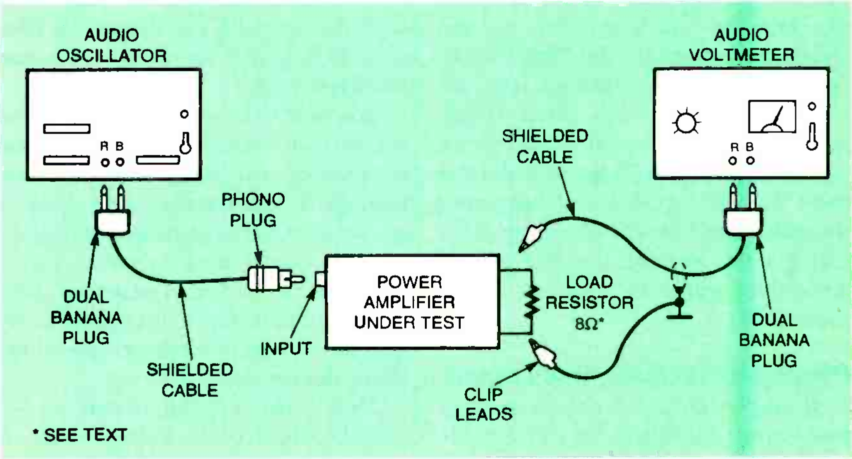


FIG. 1—TO MEASURE FREQUENCY RESPONSE VERSUS POWER, use this test arrangement. Make sure that the load resistor equals or exceeds the power rating of the amplifier being tested.

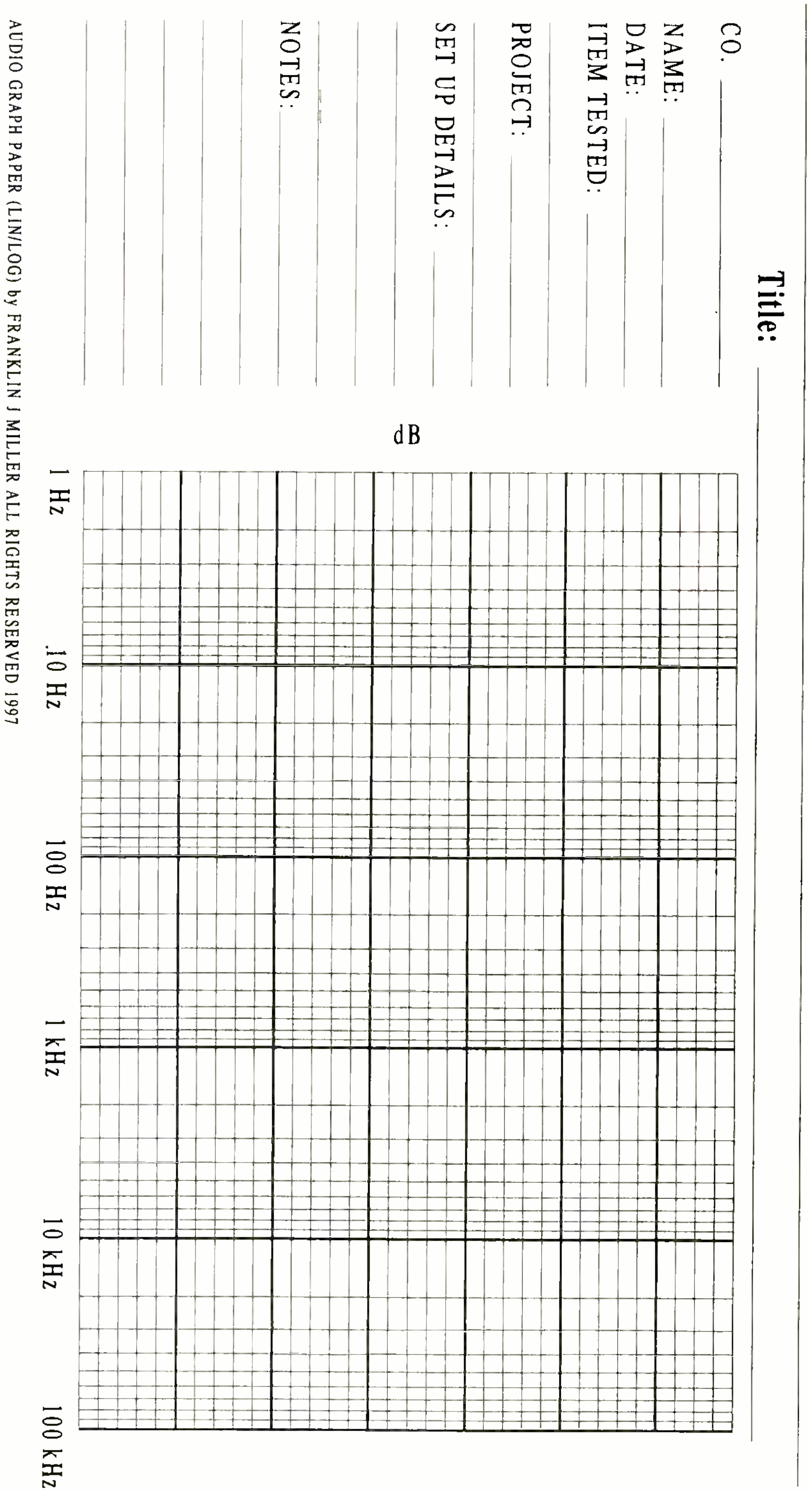


FIG. 2—LIN/LOG GRAPH PAPER is ideal for recording the measurements that are made in our first test.

audio oscillator is set for its lowest output and a frequency of 1 kHz. That is done so that you will not destroy your valuable test equipment!

While looking at the audio voltmeter's scale, increase the output of the audio oscillator from -56 dB to -10 dB. That should give you some reading on the audio voltmeter. Then reduce the setting on the audio voltmeter to a more sensitive scale. Continue doing that until the reading on the audio voltmeter is about 80% of the meter scale (which is usually the most accurate portion of the scale). Because that reading is done at 1 kHz, it becomes the reference point. Place that data on your test-data sheet. You can now make more measurements at different frequencies. Every time you change frequencies, wait several seconds for the oscillator to settle and write the data in their proper columns. Note that the lower frequencies take a longer time to settle than the higher frequencies.

The question most asked is "How many data points should I take?" The minimum would be 10 and the maximum should be no more than 100 points. About 30 data points make a really accurate and useful graph. Yes, this is a great deal of work, but it is worth the time in the end.

Determining the Input Impedance

To conduct this test, you will need an audio oscillator, an audio voltmeter, the R-Box, and cables to suit your particular equipment.

Set up equipment as shown in Fig. 4. Be sure that all of the equipment is plugged into the same AC outlet or power strip to avoid possible ground loops. If the unit you are testing has an input volume control, turn it to the maximum to avoid any false reading. Next, turn on the device under test. Then make sure that the audio voltmeter has its range switch in the highest position and turn it on. Last comes the audio oscillator. Set it so its output is in the lowest position and the frequency is at 1 kHz before turning it on.

The first step in this test is to set the audio-oscillator output voltage. If you are testing an input that is designed for microphone circuits, set the output switch to -56 dB. If the input is a line-level type (RCA or phono jack), set the audio oscillator at -10 dB. The last input type is the professional type, and its level is +4 dB. Be sure to notice if it is a balanced type. If it is, you must unbalance the input to do the

ORDERING INFORMATION

The following items are available from Franklin J. Miller, 2100 Ward Drive, Henderson, NV 89015: R-Box—A complete kit of all parts including pre-drilled aluminum case, front-panel label, all switches and colored switch buttons, all 1%, ⅛-watt resistors, printed-circuit board, and banana jacks; $70. Graph Paper—Pads of 25 sheets are available for $6.00 each; please specify Lin/Log or Log/Log. All prices include shipping inside the continental United States.

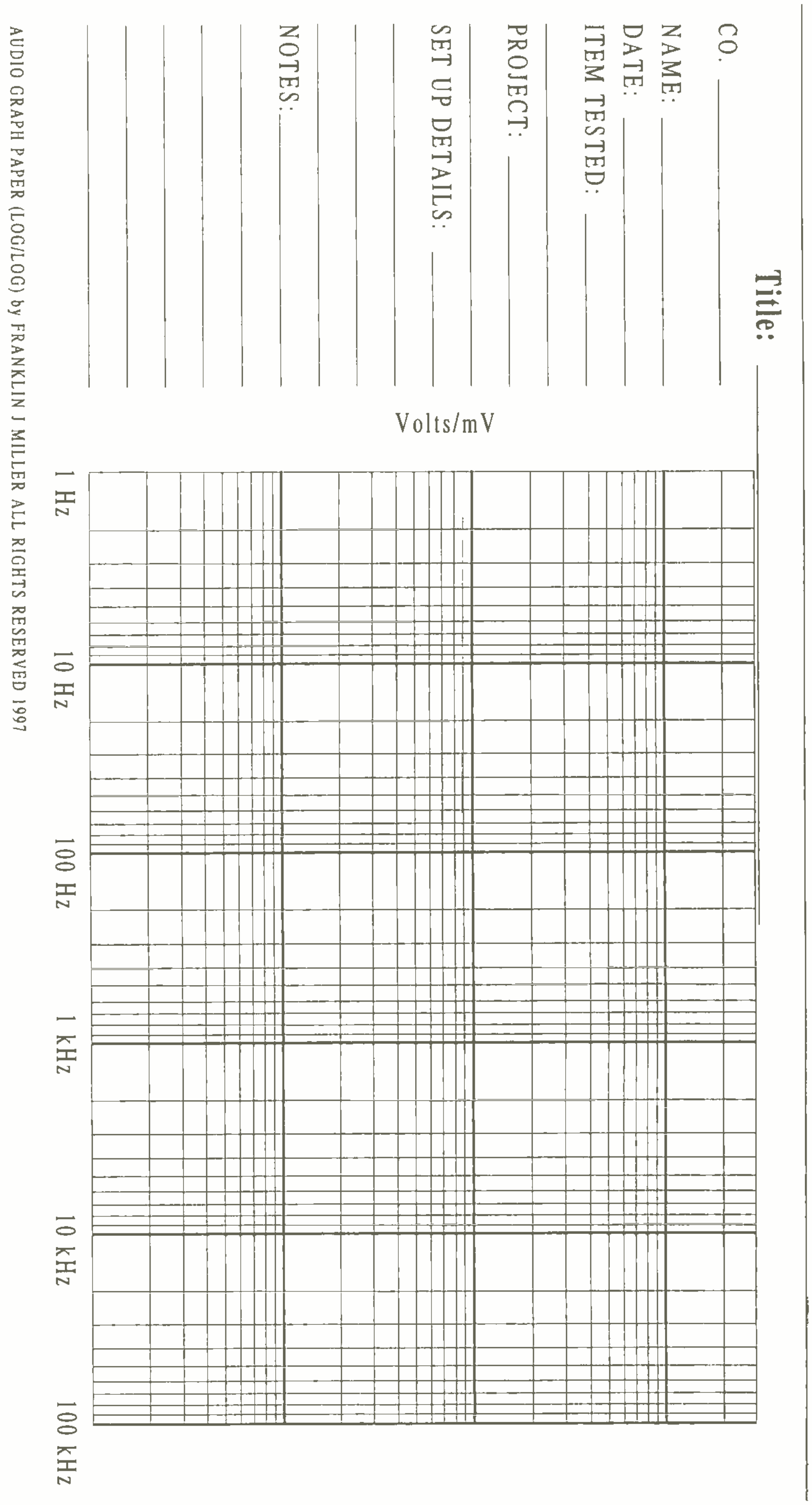


FIG. 3—LOG/LOG GRAPH PAPER is also handy for recording test data. You can purchase it or make your own using the full-size example shown here.

test. Usually an XLR 3-pin connector is used here. Pin 2 is the standard for the hot signal, and is connected to the center conductor of the cable. Next, pins 1 and 3 are tied together and then connected to the shield of the cable. Once that is done, we can begin testing.

Set the R-Box so that none of the buttons are engaged (infinite resistance), or disconnect it from the circuit completely, and read the voltage at the output of the device under test. Record that number on a piece of paper that you will save for later use. Next, set the R-Box so that the volt-

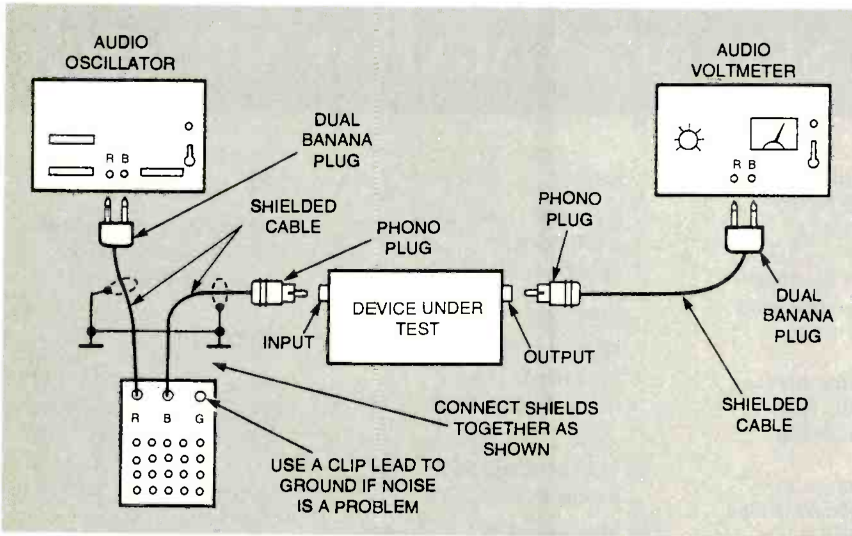


FIG. 4—DETERMINING INPUT IMPEDANCE is easy with the equipment setup shown here. For the first part of the test, disconnect the R-Box or make sure none of its switches are engaged.

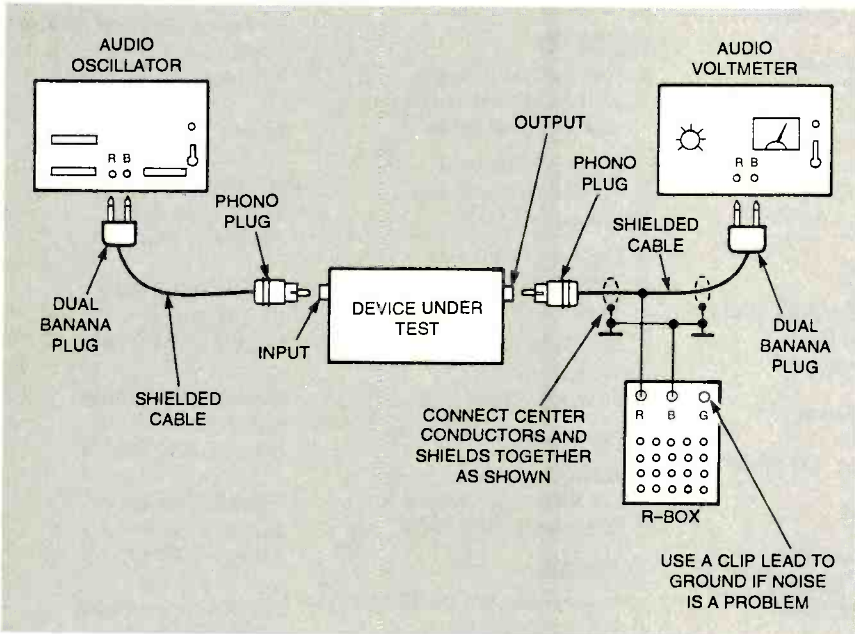


FIG. 5—TO MEASURE OUTPUT IMPEDANCE, use this test setup and follow the starting-point guidelines given in the text.

age reading is one half the first reading. This is a trial-and-error process that calls for guessing what the impedance might be. As a starting point, microphone-input circuits are generally in the 150- to 200-ohm range; line inputs in the better consumer products are generally around 10,000 ohms; and the professional inputs are either 600 or 10,000-to-15,000 ohms. Once the correct voltage reading is obtained, simply read the impedance from the front panel of the R-Box.

Determining the Output Impedance

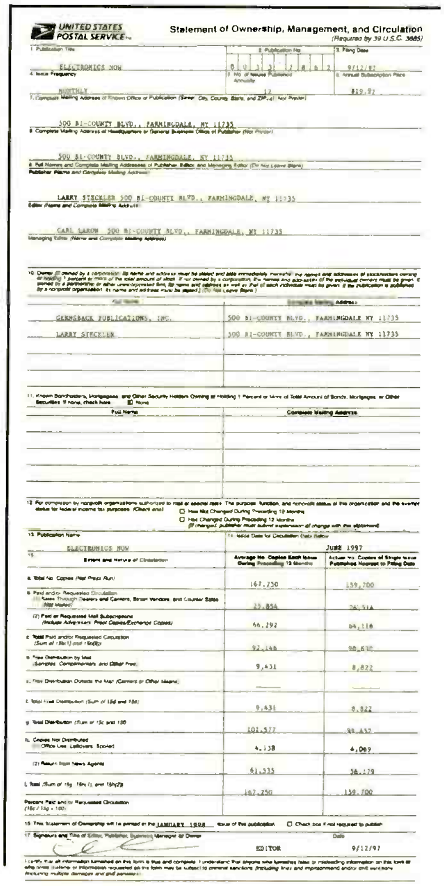
This test will tell us the output impedance of a piece of signal-processing gear in ohms. To perform it, you'll again need an audio voltmeter, audio oscillator, R-Box, and cables to suit your particular equipment.

Start by arranging your equipment as shown in Fig. 5. Be sure that all equipment is plugged into the same AC outlet or power strip to avoid ground loops. If the unit has an input volume control, turn it to the maximum to avoid any false reading. First turn the device under test on, then the audio voltmeter (make sure its range switch is in the highest position,) and finally the audio oscillator with its output in the lowest position and the frequency set at 1 kHz. All of this should sound familiar by now!

First we need to set the audio-oscillator output voltage. If you are testing an input that is designed for microphone circuits, set the output switch to -56 dB. If the input is a line-level type (RCA or phono jack) set the audio oscillator at -10 dB. As in the previous test, if it is a balanced type, then you must unbalance the input to do this test.

Next, set the R-Box so that none of the buttons are engaged (or disconnect it from the circuit), and read the voltage at the output of the device under test. Record that number for later use. Adjust the R-Box until the output voltage is half the reading you noted. This process is partly guessing what the impedance might be. Line outputs in consumer products are generally 1000 ohms or higher, and the professional outputs are 600 ohms. This should give you a starting point. Continue until you get the required voltage reading and read the corresponding impedance directly from the front panel of the R-Box.

This wraps things up for this issue. Next time we will look at assembling a capacitance box that looks a lot like the R-Box we built. We'll also look at how you can put it to work in audio testing. EN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Build the Automotive Performance Tester

You have just spent a lot of money on a performance tune-up for your car or truck. You might have just installed a set of high-performance tires, or maybe you've just switched brands of gasoline. You *think* you're accelerating faster or cornering harder than before. How can you be sure that you're getting your money's worth of improvements?

It might not be practical to take your car to a timed drag strip. Hand-timed stopwatch measurements rely on an observer watching the speedometer. Cornering tests are even more subject to error. How can you really know whether your car or truck can pull more "g"s around a curve or can accelerate faster?

BY DAN HARRISON

Measure zero-60-mph acceleration time, 'g' force, and more.

The answer to those questions is an accelerometer. With an accelerometer, you can measure cornering forces directly, and tire and brake performance by noting the maximum g force exerted during braking so you can find out at what point the tires start to lock-up. You can measure straight-line acceleration, which is a good indication of performance, but, by applying some simple physics, you also can have velocity measurements and distance-traveled measurements as well.

Measuring Zero to 60. In order to measure the time it takes to accelerate from zero to 60 mph, we need a couple of basic formulas. Measuring speed (distance × time) is simple at a constant velocity. It's when you throw acceleration in (change in speed over time) that things begin to get complicated. A typical acceleration curve for a manual-transmission automobile is shown in Fig. 1. Obviously, as the car accelerates in each gear, there is a rapid increase in the acceleration. Just before each gear shift, the amount of acceleration drops off as the accelerator pedal is released. While the clutch pedal is depressed and the transmission gear is being changed, there is a negative acceleration (slowing down) until the clutch is released and the engine can once again drive the car forward.

During a positive acceleration in a straight line, you go faster and move farther from your starting position. You can calculate both velocity and distance traveled once you know the acceleration that the vehicle is experiencing. Velocity (or speed) is found with the equation

Velocity=Acceleration × Time

Once we know the velocity, we can find out how far we've traveled with the equation

Distance=Velocity × Time

With those two formulas, it becomes much easier to calculate the classic performance standards. For the most famous one, zero-to-60-mph time, you just need to measure the vehicle's acceleration over time and calculate the velocity. When the acceleration-derived velocity equals 60 mph, count the time you've spent accelerating since you started moving, and you have your zero-to-60 mph performance measurement.

The other classic performance standard is the quarter-mile time and speed. Using the same formulas, we can both measure the quarter-mile distance and the final speed at the precise time that the quarter-mile mark has been reached.

How It Works. The Auto Performance Tester (APT) is designed around two essential components. A Motorola MC68HC705P9 microcontroller is programmed to calculate the zero-to-60 mph performance and display the results on a liquid-crystal display. An Analog Devices' ADXL05 accelerometer measures the actual acceleration forces and changes them to a variable voltage that the microcontroller can convert into a binary number using a built-in analog/digital converter circuit. The A/D converter is the main reason for choosing the P9 version of the MC68HC705. In addition, the microcontroller has a 16-bit timer that will be used as a real-time clock and sufficient digital input/output pins to control the LCD and switch inputs.

The Analog Devices' ADXL05 is a relatively new component designed primarily for automotive use. The auto industry tends to require low-cost products with a high reliability. That is the reason for choosing this particular device.

The Accelerometer. The ADXL05 is a solid-state ±5-g accelerometer that runs on a standard 5-volt supply. It has a built-in preamplifier and buffer amplifier, making the ADXL05 a complete acceleration-measure-

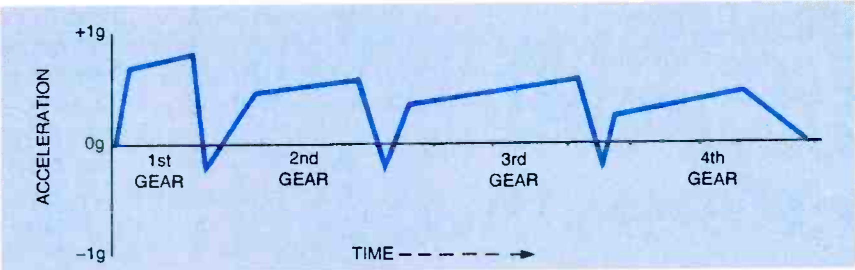


Fig. 1. When a vehicle is accelerating, there is a pattern to the amount of acceleration the vehicle experiences. As you take your foot off the gas while preparing to shift gears, the amount of acceleration drops off. While you are actually shifting gears, the vehicle starts slowing down. That causes the "negative" spikes shown here.

ment system on a chip.

When held in place in the direction of the earth's gravity, the ADXL05 will sense an acceleration of one g. That force will put 625 millivolts at the ADXL05's output pin when the circuit is properly calibrated. Because the buffer amplifier in the ADXL05 is an inverting stage, the actual voltage will be negative for a positive acceleration.

The ADXL05 is designed to be sensitive to acceleration in one axis. An ideal sensor will react to forces along or at angles to its sensitive axis but will reject signals from any force that is exactly 90° from the axis that is being measured. However, even an ideal sensor will produce an output signal if the unneeded signals are not *exactly* 90° to the sensitive axis. Any acceleration from a direction different from the sensitive axis will show up on the ADXL05's output as acceleration at a lower value. For that reason, it is important that the ADXL05 be mounted and aligned so that its axis of sensitivity is the same as the vehicle in which it is mounted.

Another common source of error in acceleration sensing is resonance of the mounting fixture. For example, the circuit board that the ADXL05 mounts to might have resonant frequencies in the same range as the signals of interest. That could cause the signals that are being measured to be larger than they really are. A common solution to that problem is to dampen the resonance by mounting the board that the ADXL05 is attached to with additional screws.

The ADXL05 is available as an evaluation-board kit. It comes complete with all parts necessary for configuring the ADXL05 accelerometer. Those parts include non-resonant surface-mount resistors and capacitors so that the circuit can be configured and customized in terms of the accelerometer's scale factor, zero-g bias level, and bandwidth with either AC or DC coupling. For those reasons, the evaluation board is an excellent choice for the APT's accelerometer sensor. The evaluation board is available through several sources including Allied Electronics; ordering information for that company is included in the Parts List.

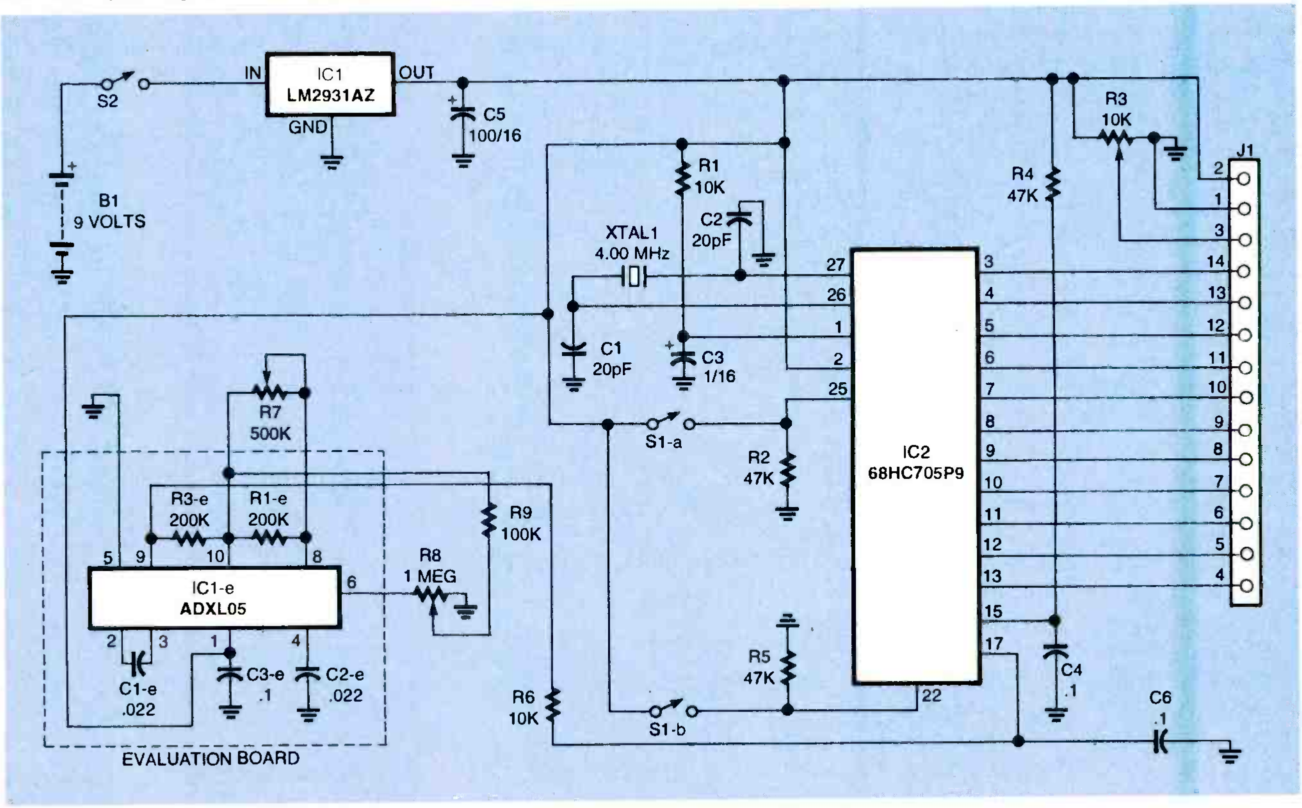


Fig. 2. The Automotive Performance Tester is built around two components—a Motorola 68HC705P9 microcontroller and an Analog Devices ADXL05 accelerometer. The ADXL05 evaluation board is used with this project. That board is sold as a kit that comes with all of the parts that are labeled "-e" within the dashed outline. Don't confuse those part designations with the part designations of the main circuit.

Circuit Description. The schematic diagram in Fig. 2 shows how simple the APT actually is. The MC68HC705 microcontroller, IC2, is the main semiconductor in the circuit. A 16-character, one-row LCD, DISP1, is connected to IC1 through J1, a 14-pin header. The LCD being used in the APT has enough on-board intelligence to accept simple commands from the microcontroller such as where to place the display cursor and what character to display at which location.

The APT is powered by B1, a 9-volt battery. The total current drain on the battery is less than 20 mA. To help keep the current consumption down, an LM2931-AZ5 voltage regulator is used for IC1. That regulator uses very little power for itself and has a very low dropout voltage. However, a standard 78L05 could be used if the LM2931 is not available. Switch S1 is a single-pole, double-throw, momentary-contact switch. That switch is a center-off type. It is used to select whether the APT will be displaying zero-to-60 time or current "g" force.

The ADXL05 evaluation board is connected to the internal A/D converter of IC2 through a simple low-pass filter made up of R6 and C6. That filter helps remove some of the random vibration noise that is present in all cars. Two panel-mount potentiometers (R7 and R8) adjust the ADXL05's gain and zero offset, respectively. Those adjustments are important for the APT to provide accurate measurements. The full-scale reading for the A/D converter is set by a reference voltage. The reference voltage in the APT is the 5-volt supply voltage filtered by R4 and C4

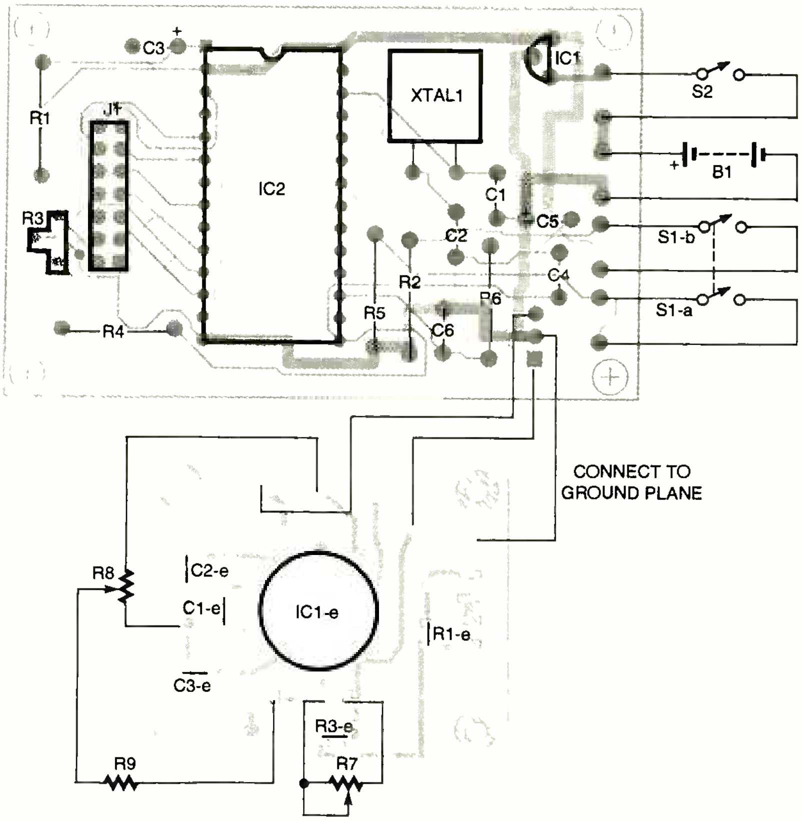


Fig. 3. If you use the foil patterns for the Automotive Performance Tester, use this parts-placement diagram when building the board. The Analog Devices ADXL05EB evaluation board is also shown. Those components that are included with the evaluation board are marked with an "-e". Not all of the parts that are included with the evaluation board will be used—only the parts shown here.

Software. All software for the APT was written in 6805 assembly language. The actual code is burned into IC2. If you wish to program your own IC, the code is available as apt.hex on the Gernsback FTP site (ftp://ftp.gernsback.com). While the actual programming code will not be discussed here, an overview of the action will help to explain how the APT works.

When power is applied to IC2, it automatically resets and begins running the initialization portion of the program. That includes setting the direction of the I/O pins, the internal timer, and the A/D converter.

Obviously, a zero-to-60-mph measurement cannot be accurately made without some sort of clock. The APT's clock is IC2's internal timer. During initialization, the timer is set to "tick" at 100 Hz. That rate will give a timing resolution of 0.01 second.

Once the sections of the APT are running, the main loop of the program is entered. A startup message is displayed on DISP1 and the system waits for S1 to be closed in one direction or the other. If S1-a is closed, then the g-Meter routine is run. If S1-b is closed, then the zero-to-60-mph routine is run instead.

When either routine is finished, the program loops back to the beginning of the main loop where it displays a startup message on DISP1. The system waits for S1 to be closed in one direction or the other. The entire loop runs continuously until the unit is turned off.

Construction. Building the APT is quite straightforward. The main PC board is double-sided. If you do not want to fabricate your own board, a pre-etched board is available from the source given in the Parts List. If you use a pre-etched board or make one from the foil patterns, the parts-placement diagram in Fig. 3 should be followed when building the APT.

Begin by assembling the accelerometer board first. The evaluation board parts-placement is shown in Fig. 3, but the part designations that end in "-e" are the components that come with the evaluation board. Any components that do not have an "-e" in their designation must come from other sources. The instructions that come with the evaluation kit, for example, will refer to R1-e as "R1." Do not confuse that R1 with the R1 that is mounted on the main printed-circuit board.

Several modifications must be followed for the evaluation board

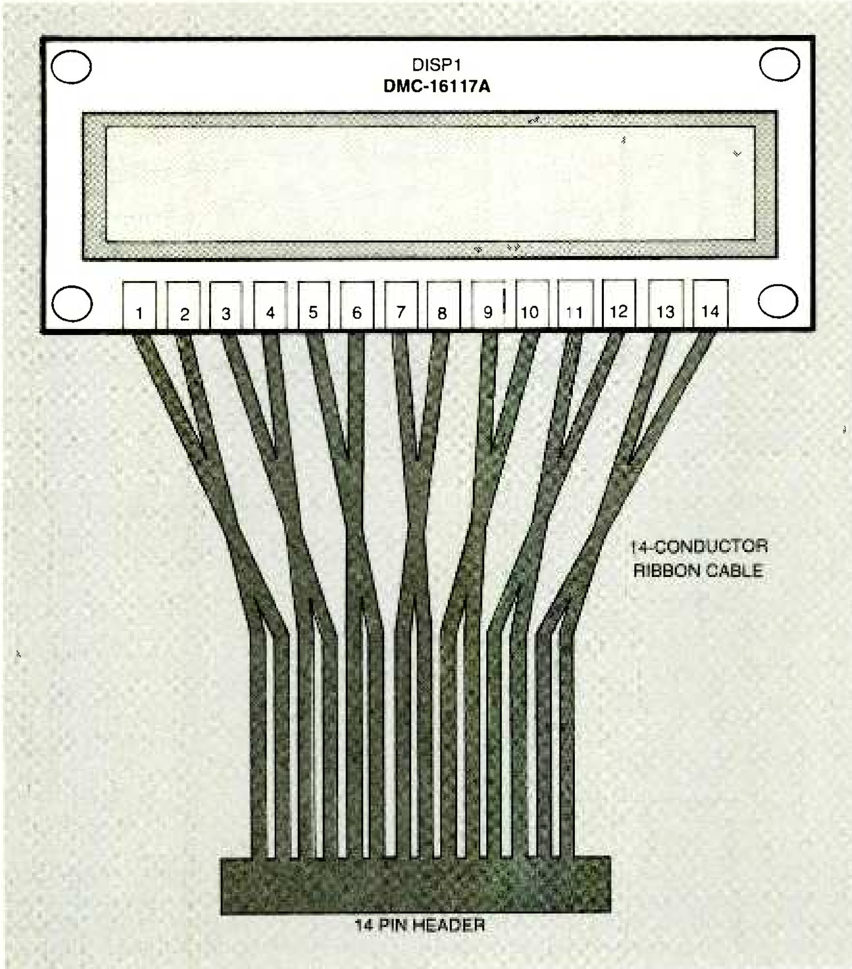


Fig. 4. The wires that connect the LCD to the 14-pin header are connected this way.

to be used in the APT. Install R1-e, R3-e, C1-e, C2-e, and C3-e only—the other surface-mount components will not be used. Calibration controls R7 and R8, along with R9, are wired to the evaluation board with suitable insulated wire, such as 30-gauge wire-wrap wire.

The ADXL05 evaluation board uses surface-mount resistors and capacitors. Those components can be difficult to install for a beginner. You should only attempt to build the evaluation board with a fine-tip 15- to 20-watt soldering iron and fine-wire solder or solder paste.

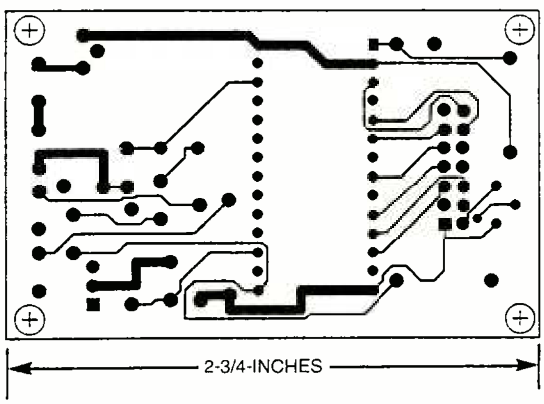
Once the evaluation board is finished, set it aside and go on to the main board itself. Assembly of that through-hole circuit will be quite easy compared to the evaluation board. If you decide to build the APT board on perfboard or some other prototyping board material, keep XTAL1 as close to IC2 as possible. Using a 28-pin socket for IC2 can be a good idea for ease of troubleshooting in case you have a problem and think that IC2 might be damaged. It will also make upgrading the APT easier in the future if you want to use a different program.

Connect two 22-gauge wires to S2 and solder it into the board as shown. When wiring S1, the "down" position should be connected as S1-a, and the "up" position will be S1-b. Solder the battery-connector leads to the board as shown. Be sure to observe the correct polarity. If you are not sure, connect a 9-volt battery and test the polarity with a voltmeter.

The LCD assembly is shown in Fig. 4. Press a 14-pin header onto a length of 14-conductor ribbon cable. Keep the marked edge of the cable and pin 1 of the header lined up. On the unconnected end of the cable, separate out the wires about 1½-inches back from the end of the cable and strip the insulation about ¼-inch from the ends. Tin all of the wires with solder, and then solder the wires to the holes in the edge-connector pads on the LCD as shown.

Connect the header on DISP1 to J1. Double-check that pin 1 on the cable and J1 are both matched properly. Don't connect the accelerometer board to the main board yet. Be sure that the power switch is in the off position and connect a fresh 9-volt battery to the battery connector. Switch the power on and DISP1 should display "Up - g's Down 0-60". If you don't get that sign-on message, turn the power off and check all of the wires and connectors carefully. Remember that the design is very simple. Most of the time the problem is a misplaced wire, bad solder joint, or other similar human error. It is very unlikely that a component is bad if you have purchased new parts and have taken the usual and proper electrostatic discharge (ESD) precautions.

When the startup message is suc-



Here is the solder side of the Automotive Performance Tester circuit board.

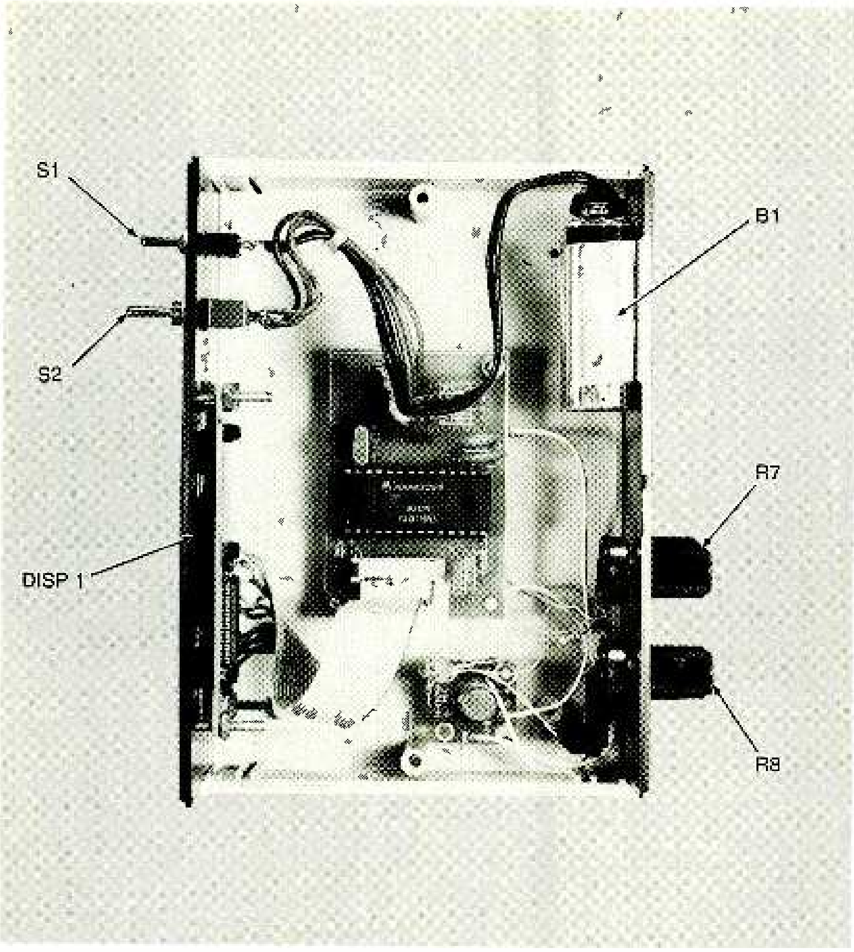
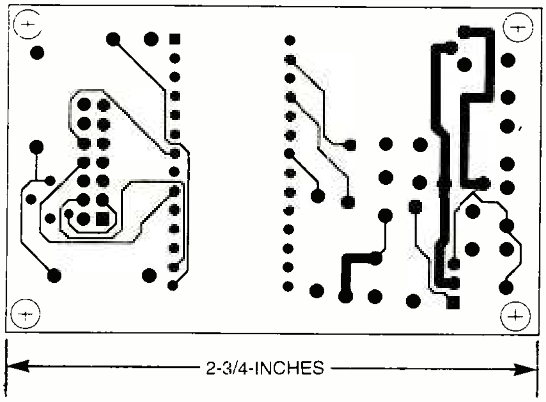


Fig. 5. Here is an inside view of the completed Automotive Performance Tester. The accelerometer board should be mounted securely so that any vibrations from the vehicle will not influence the readings taken by the APT. Mount the accelerometer so that the tab on the IC faces the front panel.

cessfully displayed, set the display contrast by turning R3. Turn off the power and disconnect the battery. The accelerometer board is then connected to the main board with three wires.

Drill and cut appropriate holes in a suitable enclosure for S1, S2, DISP1, R7, R8, and both PC boards. Mount the boards and switches in the case. A suggested mounting arrangement is shown in Fig. 5. The accelerometer board must be mounted rigidly and square with the case. The tab on the ADXL05 must point towards the front of the case. Also be sure that the accelerometer board is parallel with the mounting surface of the case. Any tilt of the accelerometer board will affect the accuracy of the APT.



Here is the component side of the Automotive Performance Tester circuit board. Be sure to solder any components that have connections on both sides of the board if you etch your own board.

Calibration. With a fresh battery installed, turn on the APT. Center both R7 (gain) and R8 (offset). Using a carpenter's level, set the case of the APT so that it is completely level. Select the g-meter function and adjust the offset until a 0.00 reading is seen on DISP1. Carefully tilt the unit exactly 90° so that the display is facing up. Do not disturb R7 or R8 while turning the unit. The reading on DISP1 should be a negative number. Adjust the gain control for a reading of –0.32. The zero offset might have changed, so recheck the level for 0.00. If it's not zero, then keep readjusting the offset and the gain until the readings are correct. You might have to repeat the procedure two or more times to get it perfect. The APT is now calibrated and ready to run.

Using the Automotive Performance Tester. It is important to mount the APT solidly in the vehicle so that it does not bounce or twist during a performance test. The errors discussed earlier will come into play if the unit moves relative to the car. The mount must be secure and should prevent the APT from shaking or swaying during driving. Suction-cup mounts sold for radar detectors will work well, but they might have to be modified slightly in order to be used with any particular enclosure housing the APT.

The APT is very good at determining the zero-to-60-mph time if certain conditions are met. First the unit must be level. That is done by using the g-meter function prior to each timed zero-60-mph run. Level the APT so that the display reads 0.00 gs. Once again, that is important because the APT will pick up some amount of gravitational acceleration in any position other than level. The gravitational acceleration component will cause erroneous zero-to-60-mph times in either the positive or the negative direction depending on whether the unit is slanted down or up. Another important fact to keep in mind is that the road or track must also be level for the same rea-

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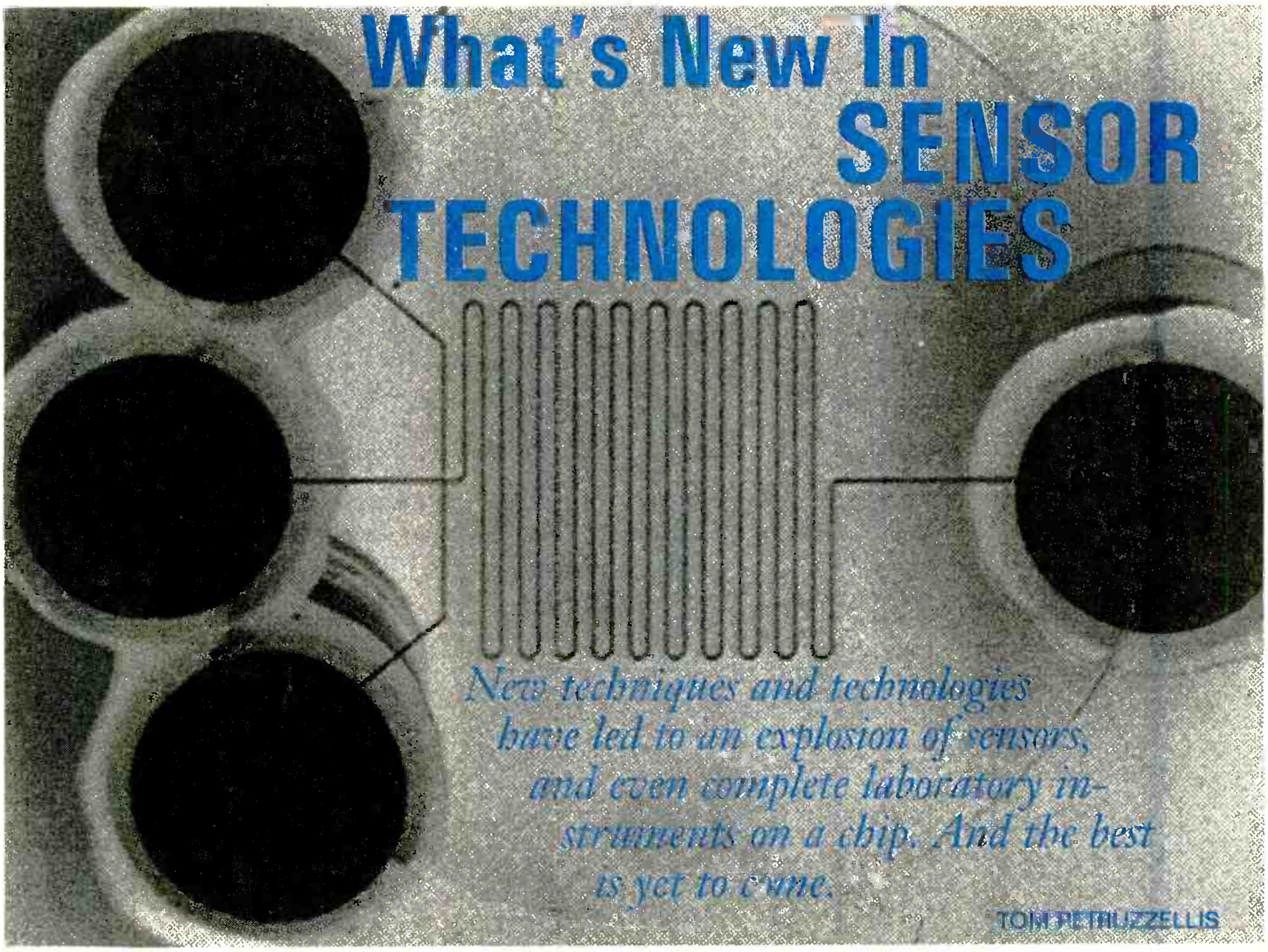


What's New In SENSOR TECHNOLOGIES

New techniques and technologies have led to an explosion of sensors, and even complete laboratory instruments on a chip. And the best is yet to come.

TOM PETRUZZELLIS

Most people might not have noticed, but a quiet revolution is taking place all around us. That revolution is in the area of sensor technology, and the result is a whole new brigade of advanced, highly-integrated smart sensors. And while that revolution might be "quiet," progress in this area is nothing short of astounding, with sensor technologies developing at such a rapid rate that new advances are taking place almost daily.

Sensors, Technology, and Us. The latest and most dramatic advances have been focused around the new micromachined thin-film sensors. Those include light sensors, pressure sensors, accelerometers, tilt sensors, resistance temperature detectors (RTDs), anemometers, and a host of gas and chemical sensor arrays.

Just how will these developments affect our professional and personal lives? Well, industrial process and control systems are already benefiting from smart-sensor technology. Advanced micro sensors have also moved into the medical field, producing many new diagnostic sensors ranging from silicon microprobes that can interface with a patient's nervous system to portable blood-chemistry analysis systems. The technology is making it possible to place complete systems on a single chip, and to place complete chemical laboratories in the palm of your hand.

Automobiles will also benefit from the new smart-sensor onslaught. Presently, there are about 20 sensors used in the average new car, and the number is growing. Many of the new micromachined automotive sensors will provide additional convenience and safety features based on new smart-sensor technology. Those could include failed-brake sensors, wheel-speed sensors, tire-pressure sensors, rate gyros for anti-skid braking, oil-degradation sensors, and new emission sensors.

The above just scratches the surface of what is now or soon will be possible. Let's look at some of the details.

Micromachining. Much of this new sensor revolution is based on the advantages of micromachining and thin-film-deposition techniques found in the semiconductor industry. Until recently, much of the work has centered on the bulk micromachining process. That technology involves using chemicals to machine pits or holes and structures into bulk silicon at the wafer level. Bulk micromachining has been well suited for pressure sensors and accelerometers.

However, a newer, and very promising technology used in advanced sensor manufacturing is the surface-micromachining process. Surface micromachining involves depositing layers onto a substrate of silicon and selectivity etching those deposited layers to form structures. Surface micromachining

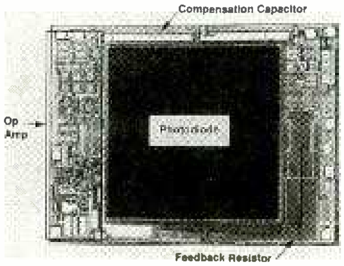


Fig. 1. The new Burr-Brown OPT 202/211 series optical detectors incorporate a large surface photodiode, an op-amp with an internal feedback resistor, and a compensation capacitor.

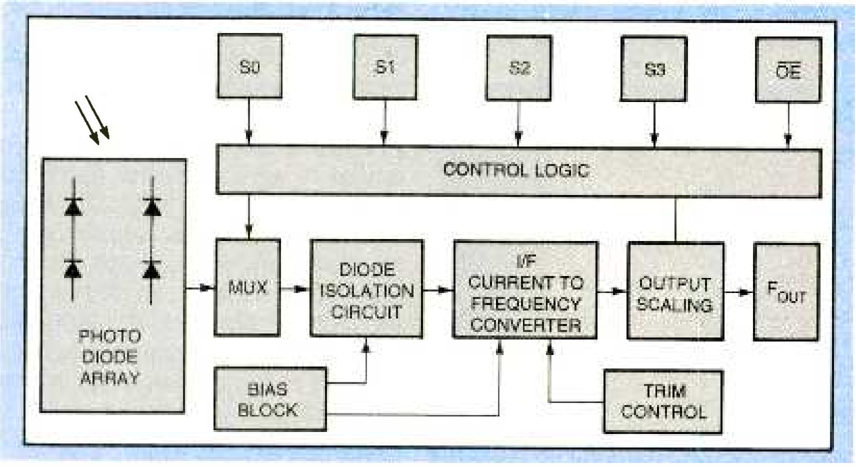


Fig. 2. The TSL-230, from Texas Instruments, can convert light intensity to a digital-compatible pulse train, providing a simple, low-cost means of getting light-intensity information into a digital system. A block diagram of that device is shown here.

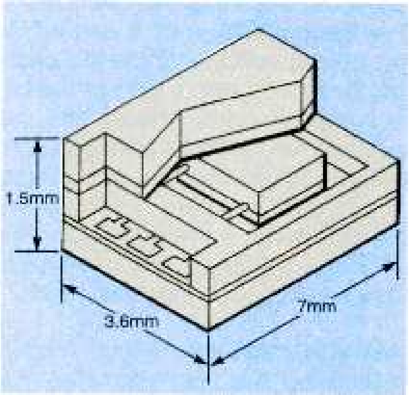


Fig. 3. In this capacitive acceleration sensor, the center layer forms a seismic mass that is suspended by two cantilever beams and located symmetrically between two plates, which act as electrodes. As the mass moves under acceleration, it changes the position between the plates and therefore causes a change in capacitance.

creates smaller, more intricate, and more precisely patterned structures since it takes advantage of photolithography used in making small ICs. Using that technology, it is possible to form tiny beams, masses, and other small structures with features as small as 1-2 micrometers.

Surface micromachining takes far less silicon real estate than the bulk micromachining process; the geometries are smaller because the etching tolerances are much tighter, and you only have etch one side of the wafer as opposed to two sides in the bulk-micromachining process. The surface-micromachining process can reduce the size on the order of $^1/_{10}$ and reduce the surface area on the order of $^1/_{100}$ as compared to bulk machining. Another great advantage to surface micromachining is that the electronic signal conditioning and the sensor can be combined on the same die or substrate; that is an important factor in keeping signal integrity and reducing noise. Surface micromachining promises to reduce costs, size, and heat generation and increase endurance and reliability.

Several major manufacturers, including Motorola, have been actively developing surface micromachined sensors. One area in which they have already gained a market presence is in consumer motion detectors. With the advantages it offers, and as other high-volume applications become practical, it is likely that surface micromachining will largely replace the bulk-machining process.

Optical Sensors. A number of new integrated thin-film sensors and arrays have already hit the marketplace. The new Burr-Brown OPT 202/211 series optical detectors incorporate a large surface photodiode, an op-amp with an internal feedback resistor, and a compensation capacitor all built into an 8-pin mini-dip package (see Fig. 1). The IC converts the photodiode's current output into a voltage while preserving a high accuracy since the detector is placed in close proximity to the op-amp electronics. Generally, the size of a photodiode and the speed of an amplifier determine the speed of an optical system. With a large photodiode and an integrated amplifier close by, good speed and accuracy are possible. Optical filters can be placed ahead of the detector to create any desired passband. Among other things, the OPT 202 can be used to create a low-cost integrated photometer that can operate from a single 9-volt battery.

A new high-accuracy, wide-dynamic-range light-to-frequency converter chip from Texas Instruments, the TSL-230, can convert light intensity to a digital-compatible pulse train, providing a simple, low-cost means of getting light-intensity information into a digital system. The highly integrated chip, a block diagram of which is shown in Fig. 2, consists of a 100-unit, multiplexed, photodiode array. The current output of the array is passed to a diode-isolation circuit that buffers the output and keeps the photodiode array's bias near zero. Next, the signal is passed to a current-to-frequency converter. The TSL-230 eliminates the need for an A/D converter, since the direct conversion to frequency is done right on the chip. The TSL-230 has two sets of digitally-programmable inputs to control sensitivity and scaling of the output. The 8-pin, 5-volt mini-dip is directly compatible with any microcontroller or computer. The applications for the light to frequency converter are enormous and include such things as water-turbulence sensing, chemical analysis, and process control. Chemical diagnostic applications range from smoke and gas detection to body-chemistry analysis. The new TSL-230 has already been put in widespread use by General Electric to measure water clarity in its new Profile series dishwashers.

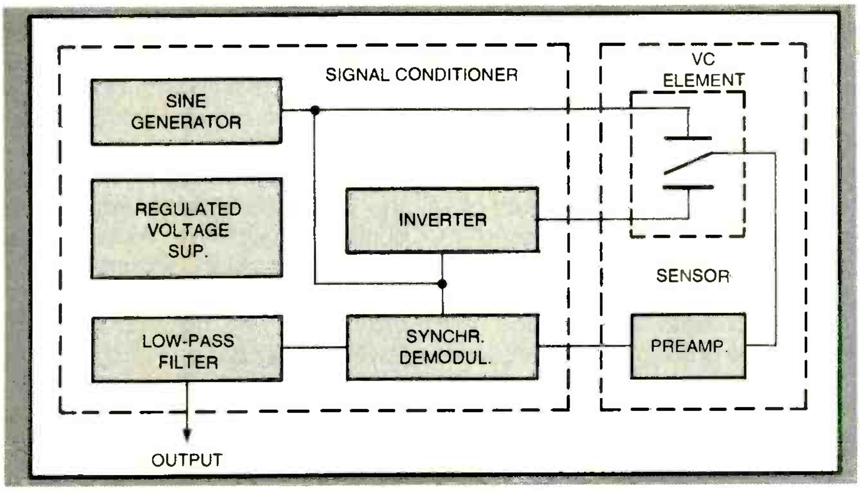


Fig. 4. The capacitive accelerometer's integrated signal-conditioning electronics output an analog signal that is proportional to the acceleration.

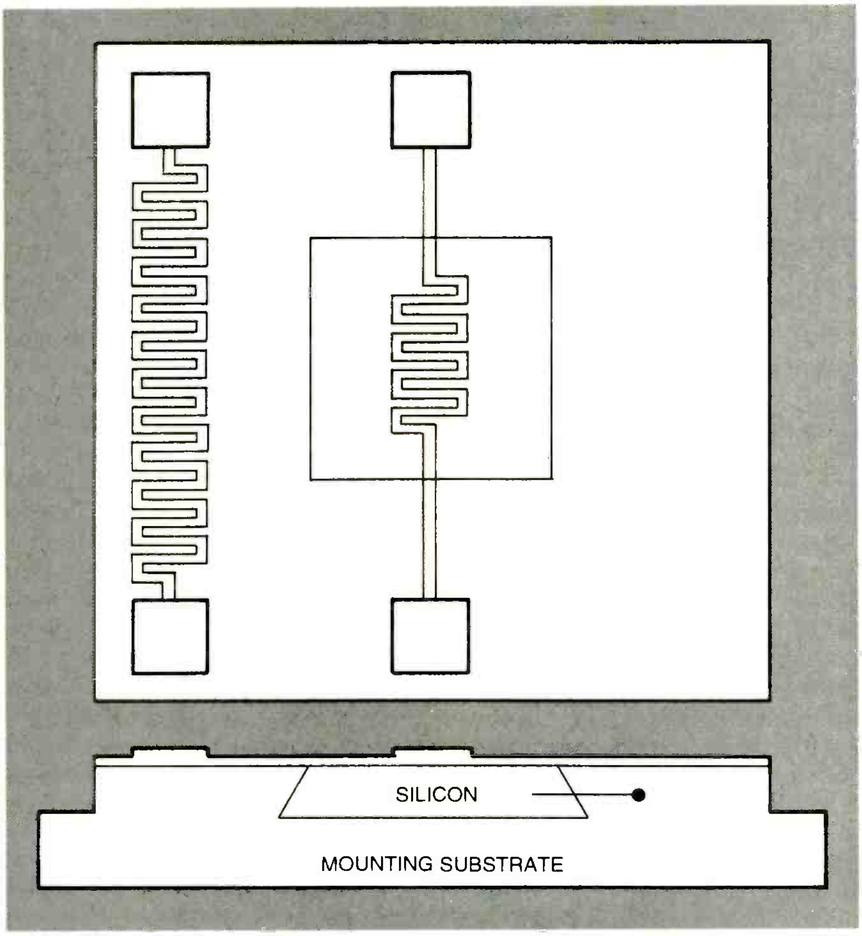


Fig. 5. In the new advanced hot-film anemometer sensor, a small platinum RTD is thermally isolated at the center of a thin membrane to keep it from affecting a larger RTD on the silicon frame.

Recent advances in chemical/optical micromachining have made it possible to fabricate optical components out of silicon to create an optical "bench" on a chip. Micro lenses, fresnel lenses, tunable filters, beam splitters, photodetectors, lasers, and LEDs can all be fabricated and combined together on a chip as needed for a particular application. Micro lenses have been built down to one-third of a millimeter or 0.013 inches across. Applications for the micro-optical "bench" include holography and interferometry. The "micro-bench" is extremely strong and rigid for its size, and because it does not have the mass

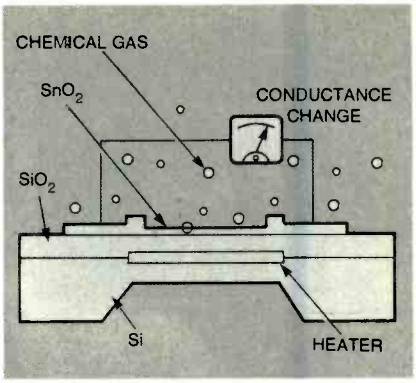


Fig. 6. Just as with its traditional counterparts, the micromachined gas sensor works by measuring changes in conductivity in a silicon-dioxide layer caused by the presence of a chemical gas.

of large optical mounts and tables, vibrations dampen out quickly.

Pressure Sensors. Motorola, a leader in semiconductor technology, has created the MPX-2000 series of pressure sensors, which use a piezo-resistive strain-gauge ion implanted on a thin silicon diaphragm. The highly integrated MPX-2000 also contains electronic signal conditioning and auto-calibration, all on the same chip. Excitation current is passed longitudinally through the piezo resistor. The pressure that stresses the diaphragm is applied at a right angle to the current flow. That stress establishes an electric field in the piezo-resistor that is sensed as an output voltage. Since the strain gauge is an internal part of the silicon diaphragm, there are no adverse temperature effects due to differences in thermal expansion, a common problem among older pressure sensors. These pressure sensors are available in three types: gauge, absolute, and differential.

Accelerometers. Silicon micromachining has also permitted the development of various types of piezoelectric and capacitive accelerometers whose performance closely matches that of more expensive servo accelerometers. Micromachined capacitive accelerometers are readily available to measure static phenomena, and are ideally suited to sensing the slow-motion movement created by building flex and bridge movements; their DC characteristic makes them highly effective inclinometers as well.

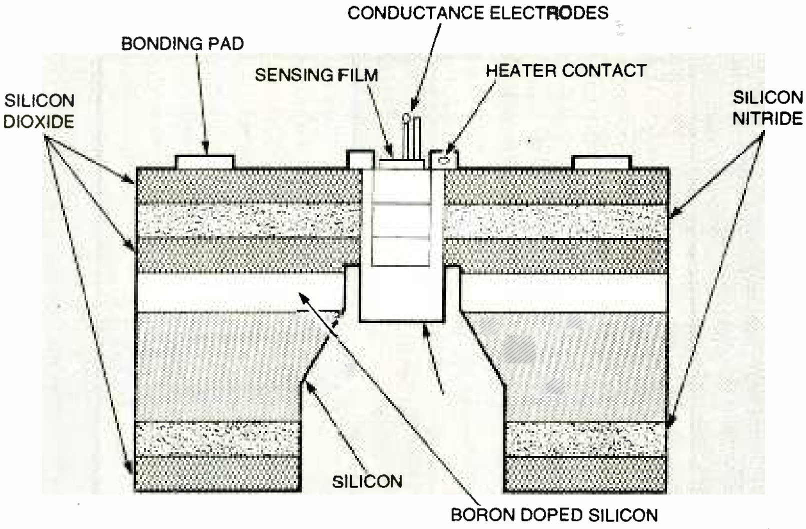


Fig. 7. A technology pioneered by University of Michigan researchers allows the creation of very thin, precise films in a small area. The highly selective deposition process allows for a wide variety of different sensitive films to be easily incorporated in a single device or in a cluster of sensors.

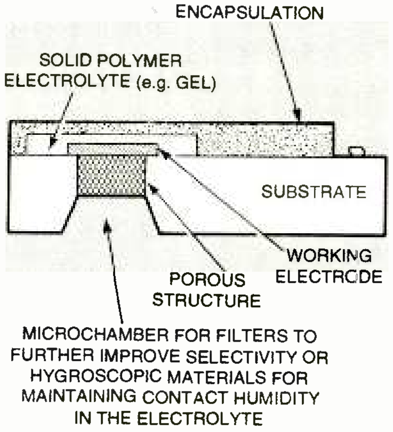


Fig. 8. This back-cell micro-electrochemical gas sensor consists of a substrate material with an opening across which a gas-permeable sensing electrode is placed. The front side of the electrode is coated with an electrolyte, and the gas diffuses from the back side.

Micromachined capacitive sensors (see Fig. 3) are built of three layers of silicon and two of glass fused together. The center layer forms the seismic mass, which is suspended by two cantilever beams. The seismic mass is located symmetrically between two plates, which act as electrodes. As the mass moves under acceleration it changes the position between the plates and therefore causes a change in capacitance. A block diagram of the integrated signal-conditioning electronics is shown in Fig. 4. The output produced by that circuitry is an analog signal that is proportional to the acceleration. Eventually, the high integration, low weight, and low cost of such micromachined accelerometers will most likely make older, bulk-machined accelerometers obsolete.

Tilt Sensors. In the past, tilt sensors were electrolytic; as such, they were slow to respond and suffered from considerable "slosh' noise" due to moving liquid. However, new, dual-axis tilt sensors from Crossbow Technologies make use of the accelerometer technology outlined in the previous section to produce a digital tilt sensor that provides excellent accuracy and frequency response, and can withstand 1000g shock forces. The new digital tilt sensor consists of two micromachined accelerometers, a temperature sensor, an A/D converter, and a microcontroller.

RTDs. Platinum thin films over micromachined silicon are now the medium of choice in the design of high-performance resistance-temperature detectors (RTDs), anemometers, and chemical gas sensors. Platinum-film micromachining has also been applied to the design of surface acoustic-wave (SAW) sensors, vibrating cantilevers, and micro actuators. Platinum wire and film have long been recognized for their near linear resistance *vs.* temperature relationship and wide temperature range. The ability to accurately measure temperature by measuring resistance is at the heart of many traditional and advanced RTDs.

Heat flow occurs whenever a difference of temperature exists between two points and continues until those two points reach thermal equilibrium *i.e.* the same temperature. If the temperature difference is held constant, the thermal transport between two points is also constant. Sensor design now becomes a matter of isolating a particular heat-flow mechanism and making the associated temperature measurements sensitive enough to observe changes in the heat flow. The thermal-transport balance equation is the focal point of some new platinum-on-silicon sensor designs.

Anemometers generally incorporate two RTDs. The temperature of one RTD is raised by resistive heating while the other RTD is held at ambient room temperature. The power needed to keep the temperature difference constant is thus a measure of heat loss due to conductive flow.

To work well, the hot RTD must be thermally isolated from the ambient RTD. That requirement has posed a number of heat-flow-control and packaging problems. For example, in the new advanced hot-film anemometer sensor, a small platinum RTD is thermally isolated at the center of a thin membrane to keep it from affecting a larger RTD on the silicon frame (see Fig. 5). That provides compensation for the temperature of the flow. The small heat capacity of the heated structure allows the sensor to respond rapidly to airflow changes. Using that same basic platinum on silicon design, it is also possible to create other types of sensors.

Gas Sensors. Some of the greatest advantages in new sensor design revolve around the sensing of gas and chemical species using thin-film micromachined technology. Traditionally, gas sensors use a heating wire that is covered with an insulating layer, which in turn is covered by a thin layer of tin dioxide. When the tin-dioxide layer is heated (by the interior wire), any reducing or oxidizing gasses present react with the absorbed oxygen on its surface and produce measurable changes in conductivity in that layer. The conductivity is monitored via a set of gold-plated electrodes. That basic technique is used for sensing hydrogen, carbon dioxide, methane, propane, and organic solvent vapors.

Figure 6 illustrates a micromachined sensor based on the same principle. It uses a micromachined membrane with a thin-film suspended heater element. The gas sensor consists of a micromachined thinned section of silicon, a heating circuit, an insulating silicon-dioxide layer, and a tin-dioxide sensing layer. The gas sensor integrates separate heating and temperature sensing elements as silicon circuits in the silicon membrane. One of the chief benefits offered here by thin-film and micromachining technology is that it allows operation at lower temperatures, hence greatly reducing power requirements. Older gas-sensor technology consumed $^1/_2$ to 1 watt of power in its heating element.

One of the most recent developments in gas sensors, pioneered by University of Michigan researchers, uses the idea of an integrated heater to perform a post process anneal on the thin film, essentially removing the film formation from the IC process itself. The integrated heater is used under the CVD-built thin film as a local heat source, which creates a small thermal mass. This process allows the creation of very thin, precise films in a small area; see Fig. 7. Heating the film to 1000°C can be accomplished in milliseconds due to the small area. The highly selective deposition process allows for a wide variety of different sensitive films to be easily incorporated in a single device or in a cluster of sensors. One of the design objectives was to create an integrated cluster of sensors that can combine temperature, gas, and humidity sensing on a credit-card-sized package that can be used by troops in the field to monitor the environment on a battlefield.

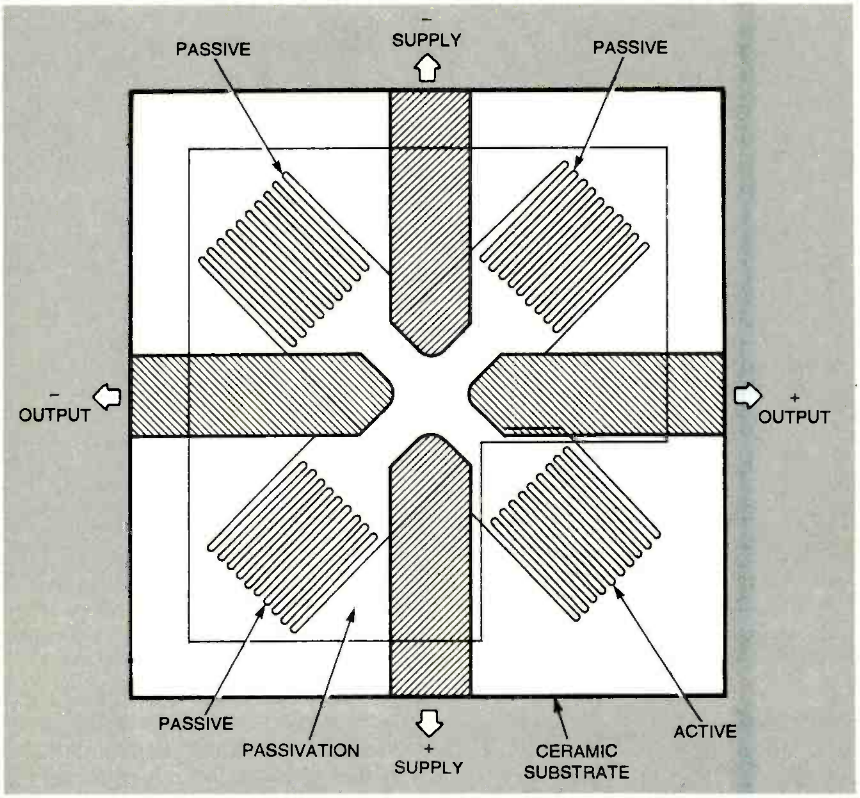


Fig. 9. In this hydrogen-palladium gas sensor, which is comprised of thick films, conductors are deposited as a serpentine pattern and connected as a Wheatstone bridge.

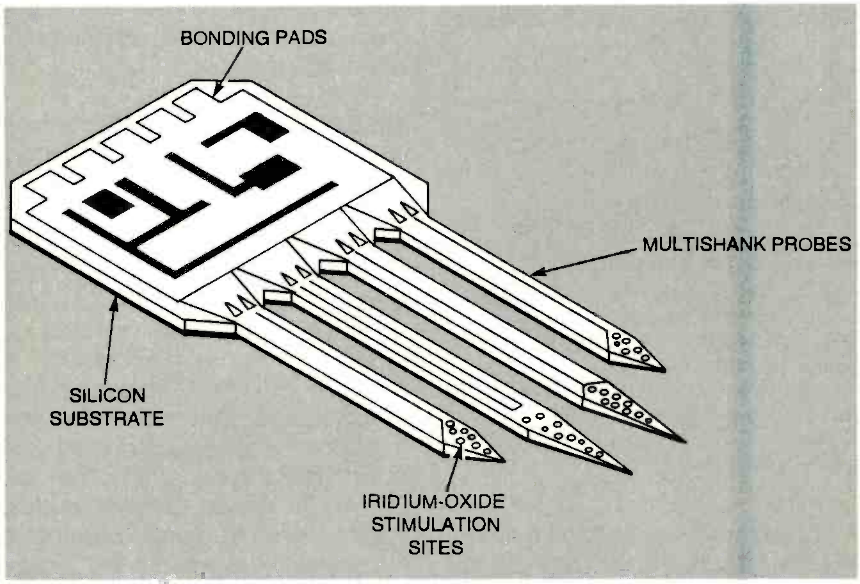


Fig. 10. This neural probe consists of bonding pads, highly integrated CMOS circuitry over a silicon substrate, and multi-shank iridium-oxide probe pins.

Teknetron has recently developed a back-cell micro-electrochemical gas sensor that consists of a substrate material with an opening across which a gas-permeable sensing electrode is placed. As shown in Fig. 8, the front side of the electrode is coated with an electrolyte, and the gas diffuses from the back side. The design is unique in that the material to be detected can diffuse directly to the electrode without having to bridge a long liquid path. The result is a linear response-time that's an order of magnitude faster than traditional electrochemical sensors. This new micro design is vastly superior to the older electrochemical gas sensors and uses a thick electrolyte layer of

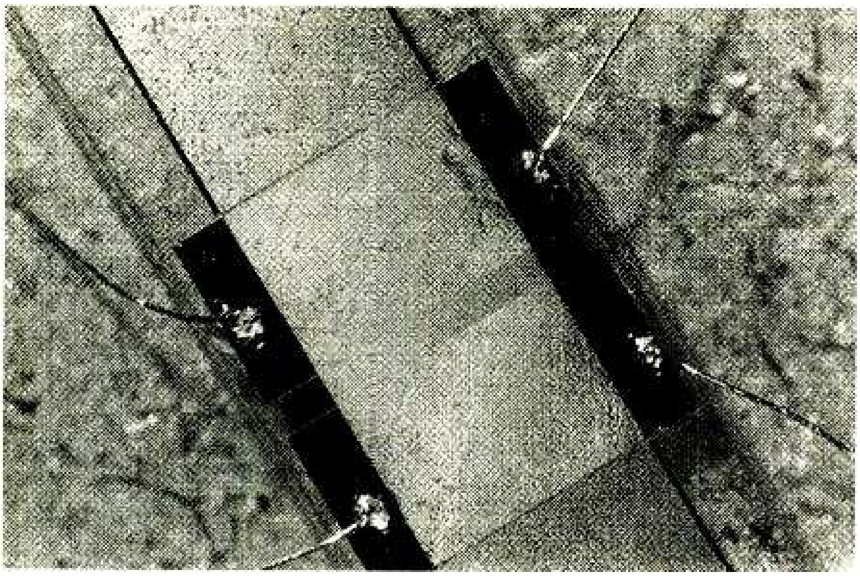


Fig. 11. A molecular-engineered, cyclodextrin-coated surface acoustic-wave micro sensor.

Nafion film, which is suitable for measuring a wide range of gasses, including oxygen, carbon dioxide, and carbon monoxide. Other new devices, which make use of calcium or yttrium-stabilized zirconium sensors, work by detecting voltage or current changes caused by gasses in contact with the solid electrolyte. Those types of sensors are used primarily in fuel-combustion control systems to determine air/fuel ratios.

A new group of low-power hydrogen sensors relies on the solubility of hydrogen palladium. Hydrogen molecules dissociate at the palladium/metal surface, and atomic hydrogen is absorbed until equilibrium is reached. That phenomena can be measured as a change in resistance in palladium. The new experimental hydrogen sensor is comprised of thick films. Conductors are deposited as a serpentine pattern and connected as a Wheatstone bridge. The thick film sensor is printed with a palladium paste on the first of four layers. The second layer is a gas-sensitive layer deposited as four identical serpentine patterns; see Fig. 9. The third layer is four individual segments that link the four sensor legs. The fourth layer consists of a twice printed passivation coating. Key features of the new hydrogen sensor are low cost, small size, and reduced power consumption. The target is to reduce power further and incorporate signal conditioning in the same package.

ChemFETs, or chemical field-effect transistors, are another new type of gas sensor. A chemically sensitive layer is placed onto the gate of an FET. Palladium, which is sensitive to hydrogen and hydrocarbons, is typically used as gate material. Thus the gates can be altered to target different gasses such as carbon monoxide and methane. ChemFETs can sense multiple species and could ultimately be produced cheaply. The limitations at present include poor selectivity and membrane adhesion. New research is also being done on ISFETs, or ion-sensitive field effect transistors. Lanmuir-Blodgett (LB) films or fatty acids that form a monolayer when spread on water are possible choices for use as ion-sensitive gate layers for these new FET gas sensors.

A research team in England has recently developed an array of 12 tin dioxide gas sensors with remarkable sensitivity. Each sensor in the array is slightly different from the other, and, using combinations of the 12, researchers have been able to train the array to distinguish between several varieties of tobacco smoke, the aromas of five types of alcohol, and a number of different blends and roasts of coffee. Classical pattern recognition, algorithms, or neural-network techniques interpret the pattern of the sensors' electrical resistance changes. This surrogate "nose" must first be trained by exposing it to specific concentration of known chemicals. The sensor responses are then stored and later compared with signals derived from sniffs or samples of unknown but related gasses.

Smart Sensors. Highly-integrated and advanced smart sensors are a hot topic in the control and process-technology arena. That interest is driven by the need to communicate information about processes or environments within a distributed control system. Integration technologies have allowed these new sensors to become microsystems in themselves, often incorporating sensor, signal-conversion microprocessor, memory, calibration, digital protocol, and communication features. The result is an advanced smart sensor with appropriate decision-making capability that can act as a stand alone sensor and communicate in a peer-to-peer relationship with other sensors in a large process or control subsystem. Smart sensors generally incorporate a ROM that stores the necessary information to allow the sensor to act as an intelligent node in the system and to identify and characterize itself over a two or three wire system.

Already there are a number of competing network protocols for smart sensors. The Lontalk system has been used in building automation systems as well as in automated toll booths. The CAN protocol developed by Bosch automotive is currently used in vehicle and industrial control applications. Honeywell is offering its SDS system. Control giant Allen-Bradley is marketing its Device Net protocol sensor technology. Dallas Semiconductor has introduced its low-cost, tiny, three-lead DS2407P two-channel addressable switch, which can be used to report temperature, vibration, and alarm activity in their MicroLan distributed network.

Medical Sensors. The medical industry has embraced advanced sensor technology and many applications are emerging. To date, the most widely used medical micro sensor has been the disposable pressure sensor. Micro pressure sensors have been used in a number of devices ranging from blood-pressure monitors, inter-uterine pressure transducers, infusion pump monitors, as well as kidney-dialysis machines.

The micro-miniaturization of chemical sensors and instruments is bringing about a revolution in instrumentation. Thin-film and micromachining technologies, along with advances in silicon semiconductor circuitry, have resulted in miniature sensing devices whose performance is equal to and in many cases better than their full size counterparts. Miniature massively-parallel sensing arrays with highly integrated electronics may eventually replace full-sized laboratory instruments.

By creating a "chemistry lab on a chip," researchers will be able to truly create hand-held devices to diagnose patients' diseases in the doctor's office. To accomplish such Herculean tasks, researchers are using every trick in the thin film and micromachining book.

I-Stat Corporation of Princeton, NJ has developed a hand-held blood-chemistry-analysis system. Conventional blood-chemistry analysis involves drawing blood, sending the samples to a lab, and waiting hours or days to get the results. The new hand-held blood-analysis instrument contains a series of cartridges. The instrument itself contains all the cartridge-interface sensing electronics, display, keyboard, and actuators necessary to operate the fluidic components. Each cartridge contains a silicon-based chemical-sensor chip, a sealed packet of calibration solution, and various fluid channels and chambers molded into the plastic cartridge. In operation, a sample of blood is introduced into a port in the cartridge and inserted into the instrument. The instrument punctures the seal of the calibration packet, causing the solution to flow over the sensor chip. Once calibration measurements are made, the blood sample flows over the chip in place of the calibration solution. The instrument then records and displays the measurements. Measurements are made in just a few minutes, making this instrument well suited for emergency situations.

The University of Michigan at Ann Arbor is focusing its efforts on the development of an implanted biomedical microprobe. The silicon microprobe is designed to interface with the body's central nervous system at a cellular level. If inserted in the brain, electrodes within the device can record electrical firing patterns of the neurons. Effectively that would allow for compensation of neural deficits and could be used to help provide control of natural or prosthetic limbs in paralyzed patients. The neural probe, shown in Fig. 10, consists of bonding pads, highly integrated CMOS circuitry over a silicon substrate, and multi-shank iridium-oxide probe pins. The microprobe device is fabricated using deep boron diffusion techniques, and is typically 15-μm thick. The active microprobe can be used for recording activity at, and stimulation of, a tissue site.

SAW Sensors. One of the most popular chemical sensing devices is the SAW, or surface acoustic-wave sensor. A SAW sensor consists of a piezoelectric film coated with a thin film that allows selective rejection or retention of a specific species for a variety of mixtures. After the thin-film material has been applied to the piezo surface, a transducer delivers a surface acoustic wave of a known frequency. The thin-film coating acts as molecular "flypaper" that increases the mass of the device if certain gasses are present. That causes the baseline frequency of the surface acoustic wave to shift to a new, lower constant level that is correlated to the presence of a selected sample.

For example, a modified SAW sensor labeled the Enviro-SAW uses a thin organic membrane for selective retention of PCBs. The front end of that system consists of a sampling device and a catalytic filter to reduce the amount of noise introduced by heavy organic compounds, such as sludges and oils. Integrated electronics for the SAW sensor and data collection are controlled by a laptop or desktop personnel computer.

The new SAW sensing devices need only $^1/_{10}$ the sample volume of a laboratory GAS chromatograph and only $^1/_{1000}$ of the amount needed for immunoassay systems. Surface acoustic wave sensors can be used for other types of applications, such as monitoring hydrogen gas levels.

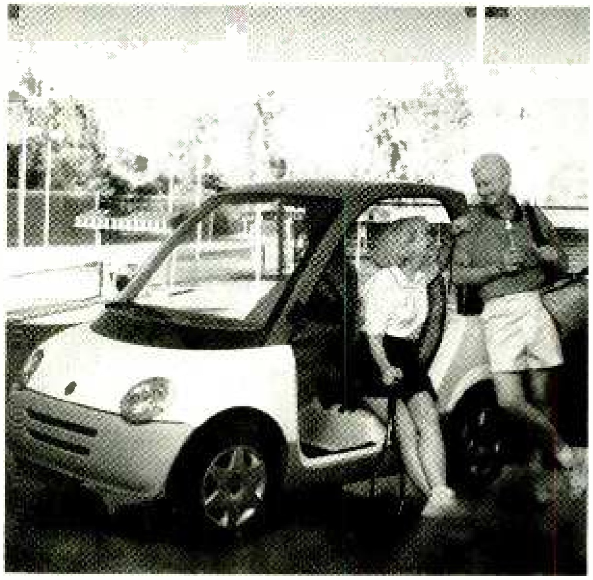
Another recently created SAW device is capable of conducting remote real-time sensing of volatile organic compounds in air, water, and possibly soils. That SAW device relies on molecular self-assembly technology, which allows toxin sensing molecules to self-assemble so that one end of the molecule covalently bonds directly to a sensing detector while the other end extends as a bucket tailored to temporarily trap specific chemicals. Changing the size and polarity of the bucket allows the micro sensors to be chemically and structurally tuned to optimize their sensitivity and selectivity to specific toxins. The buckets are constructed using molecular-engineered cyclodextrin, a component of starch that traps organic toxins but doesn't bind them. A molecular-engineered, cyclodextrin-coated surface acoustic-wave micro sensor is shown in Fig. 11.

Other Developments. A recently developed glass microchip sequentially performs chemical reactions and capillary electrophoresis. That device, shown in the photo at the beginning of this article, could provide faster, less-expensive, and more-reliable chemical analysis for environmental monitoring, medical diagnosis, and process control. That postage-stamp sized sensor uses a hair-like capillary channel etched into the glass using standard micromachining techniques. The channels are closed and formed into capillary tubes by bonding a thin plate of glass over the etched tubes. Reservoirs for buffers, reagents and waste are also bonded into the chip. That type of sensor promises to reduce the amounts of samples and reagents consumed, use less power, and perform faster—chemical separations in the sensor can be carried out in 150 ms—than before possible using standard laboratory analysis. It is also inexpensive to produce.

At Lawrence Livermore Lab, a

(Continued on page 50)

NEIGHBORHOOD ELECTRIC VEHICLES



Has Electric-Powered Transportation Finally Found a Niche?

BY BILL SIURU

The quality of the air we breathe has long been a topic of concern and debate. And while there are many sources of air pollution, one of the largest and most noticeable is the automobile. To help combat that problem, California, which has some of the most severe air-quality problems in the country, issued a mandate that required 2% of total vehicle sales by the major carmakers in 1998 to be zero-emission vehicles (ZEVs), increasing to 10% in the years following 2002. Of course, the only zero-emission vehicle currently practical is the electric vehicle, or EV.

That mandate meant that the major automakers had to produce and sell around 22,000 EVs annually. The first part was no problem. However, the second part turned out to be a very tall order. The primary drawbacks included the EV's still limited range, its ability to operate only in warm climates because of severe battery capacity degradation in cold weather, and, foremost, its very high cost.

General Motors' experience with its sleek looking, two-seat Saturn EV1 illustrates the problem of selling EVs today. GM leases rather than sells EV1s through selected Saturn dealers in Los Angeles, San Diego, Phoenix, and Tucson. From their introduction in December 1996 to mid-1997, only about 200 EV1s have been sold. Because of that, and the experience of other manufacturers, the mandate has been dropped. Reportedly, GM is now building EV1s only "to order" and is subsidizing leases to make them a bit more affordable. While other automakers are still working on EVs, these are now pretty much back-burner projects. Besides improving performance, primarily range, they are also looking for ways to decrease costs and increase value

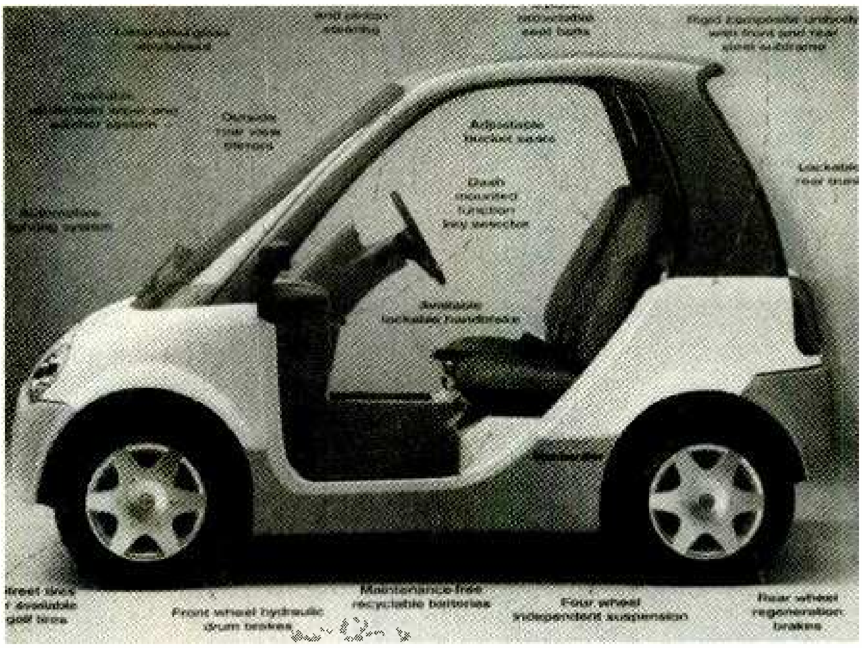
Neighborhood Electric Vehicles. Does that mean that the concept of the EV is dead? Absolutely not. New products succeed not because of government mandates or subsidies, but because someone finds a need in the marketplace and fills the need at an attractive price. For EVs, that market could be the rapidly growing population of people living in retirement and gated communities. The growth of sheltered communities ranges from 10 to 40% annually, depending on the locale, with the greatest growth of retirement communities in Arizona, California, and Florida—locations that are perfect for electric power.

Electric golf carts are already popular for transporting seniors around retirement communities. In the sunbelt, open, electric-powered vehicles are perfect as "second" cars. They could even be "only" cars for those that do not travel long distances or may no longer feel confident venturing out on the open road. Small EVs are perfect for running errands, shopping, visiting friends, etc. While many complain about the golf cart-like performance of many EVs, this performance means independence for older folks who no longer need or want a regular car.

Several manufacturers already offer electric vehicles that can also be used on the golf courses, a feature found in many of these communities. One interesting EV comes from Bombardier, known for its Ski-Doo Snowmobiles and Sea-Doo jet boats. Its Neighborhood Electric Vehicle (NEV) will carry two people at speeds of up to 25 mph. The Bombardier NEV has a composite unibody with a front and rear steel subframe. The top provides protection from sun and rain. The laminated glass windshield can be fitted with an optional windshield wiper/washer. Optional doors plus rear and side curtains provide comfort in inclement weather. Other carlike features include twin automotive headlights, adjustable bucket seats with seat belts, regenerative drum brakes, lockable trunk, rack-and-pinion steering, and radial tires. An AM/FM stereo radio is optional.

Equipped with a 4 kW (5.4 horsepower) motor, the NEV has a range of up to 30 miles between charges of its six 12-volt lead-acid batteries. It takes about 8 hours to fully charge the batteries using household current and the on-board charger. Prices start at $6,699; a version that can be used on the golf course costs $300 more. Initial sales will be in Arizona, California, and Florida.

Other neighborhood-type EVs already on the market range from single-person electric carts from EMV Carts to "ultimate" golf carts from Elmco, Inc. Costing about $3000, the plastic-bodied EMV Cart uses twin 400-watt motors driving each of the rear wheels. Car-like features include a headlight, turn signal, horn, integrated canopy, all-purpose carrying basket, pull-



The Bombardier neighborhood electric vehicle has a car-like appearance and features.


For the ultimate in luxury on the links or on the road, here's the Rolls-Royce version of Elmco's golf cart.

down windscreen, and waterproof front trunk.

While targeted at the golfer who wants a golf cart with car-like style and prestige, the Elmco EVs satisfies those with "Cadillac tastes" even when it comes to their EVs. Elmco's Cadillac Golf Cart was styled with the help of the General Motor's design staff and has a definite Cadillac look. Available in two- or four-passenger versions, this ultimate golf cart has a front trunk, windshield, wire wheels and white sidewall tires—just like full-sized Cadillacs. Elmco also offers a Rolls-Royce version. The Elmcos are priced at about $10,000, considerably less than the EV1, but then again, the Elmcos only have a top speed of about 15 mph on or off the golf course.

Letting NEVs operate on public roads does require some changes in the laws. Some states have already made the changes. Arizona has created a separate category for vehicles that operate at speeds of 35 mph or less. California and Florida allow slow-moving vehicles in specially-designated lanes on public roads. NEVs do require a driver's license and insurance.

The Sparrow and the Gizmo. Statistics show that 87% of Americans commute less than 18 miles back and forth to work daily, and usually alone. Two new EVs could find a role servicing that commuter market.

The Sparrow is a "personal transportation module" for commuters. That three-wheel, electric-powered, single-seat vehicle takes up no more space on the road or in a parking lot than a motorcycle. Because of its lightweight, extremely-strong, composite body, over half of the Sparrow's 900-pound weight comes from its eight batteries. That provides for a high power-to-weight ratio, which translates to good performance: The Sparrow can travel at 60 mph for a distance of 60 miles between battery charges. With its own 110-volt charger, it can be recharged virtually anywhere—overnight at home or during the day at work.

The Sparrow's single rear wheel is driven by the motor while the front wheels do the steering. Since the batteries' location give the vehicle a low center of gravity, the Sparrow handles almost like a slot car. Since the Sparrow can be licensed as a motorcycle in most states, it qualifies to use "carpool lanes" for a speedier commute in heavy traffic. Due to its small size, the Sparrow could quadruple the parking capacity of most parking lots. The estimated price of the Sparrow is about $12,500.

Another alternative comes from the Neighborhood Electric Vehicle Corporation in Eugene, Oregon (NEVCO). Their Gizmo NEV is a single-passenger, electric-powered vehicle designed specifically for local city and neighborhood travel, and for commuting to and from work. It is designed for a top speed of 35 mph, but, according to NEVCO, that speed is practical for travel virtually anywhere within most cities and towns.

The three-wheel, single-seat Gizmo weighs 500 pounds. Its four 12-volt lead-acid, deep-cycle batteries weigh 240 pounds. Power comes from a 3.5-horsepower DC motor. Top speed is around 30 mph, with a range between recharging of about 25 miles. A full recharge takes only 3.5 hours from a standard 110-volt AC source. Rapid recharging is accomplished by using a separate charger for each battery. The batteries are good for 300 or more full recharges. A completely new set of replacement batteries cost less than $250.

Only eight-feet long and four-foot wide, the Gizmo is easy to park and maneuver in congested traffic. Simple hand controls allow use by almost anyone.

To keep the Gizmo's light weight, the body is again made of composite materials. The body tilts forward for entry. With its side and rear curtains installed, it can provide comfortable trips in inclement weather. Battery heaters can be used while the Gizmo is parked. That prevents significant loss of charge in very cold weather. Lead acid batteries typically lose 30-40% of their charge in sub-freezing temperatures. To keep the Gizmo simple and allow coasting, regenerative braking is not used.

The Gizmo lists for under $7000. It meets existing transportation laws in most locales and can be licensed as a moped or a motorcycle with similar insurance coverage. It meets DOT safety guidelines for components and design.

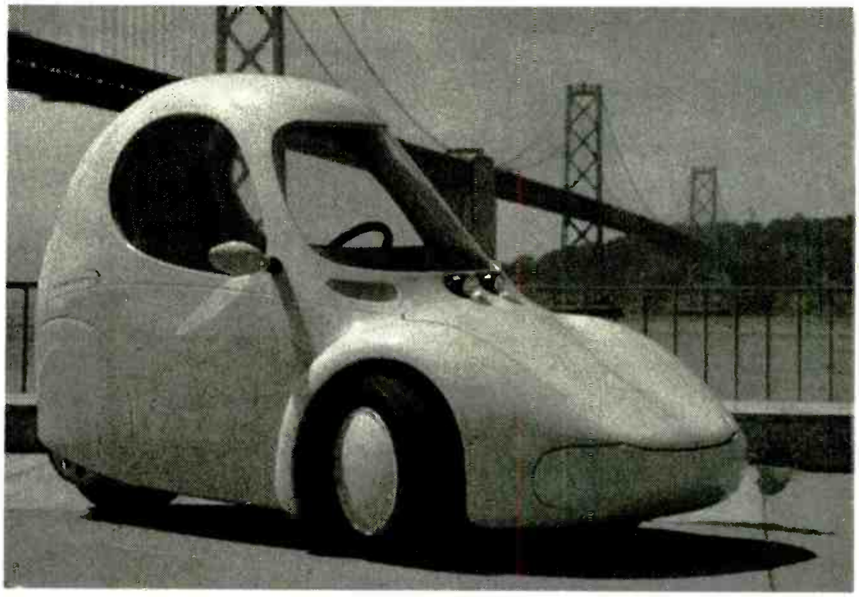
Electrically-Assisted Bikes and Scooters. Bicycles are the ultimate environmentally-friendly transportation modules. Five hundred miles of bike commuting equates to keeping over three pounds of hydrocarbons, 25 pounds of carbon monoxide, and almost two pounds of nitrogen oxide out of the atmosphere, and saves around 25 gallons of gasoline as well.

However, for many people and many situations, bicycles are not appropriate. For one thing, there is the fatigue factor. The answer for that could be the electrically-assisted bicycle. Such units are now being marketed by AeroEnvironment, APS, ZAP Power Systems, BAT International, and the Electric Bicycle Company.

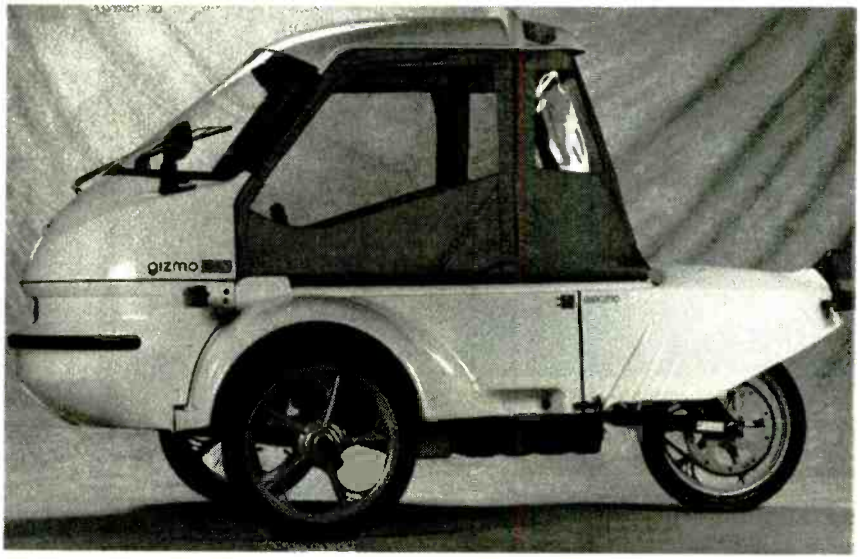
They are called "electrically-assisted" because their electric motors operate for limited periods, such as during hill climbing, for an extra burst of speed, or while resting. Typical designs use a couple of small electric motors that directly drive the rear wheel or have a small motor mounted in the rear wheel hub.

For example, ZAP Power Systems offers several Electricycles that use twin 600 watt electric motors driving the rear wheels of ordinary bicycles via friction. The installation is like the tiny gasoline engines that were attached to bicycles years ago. The ZAP system includes a 12-volt battery pack mounted under the crossbar, a controller on the handlebars, and a quick charger.

For about $500, you can order the components to convert just about any existing bicycle to electric-assist. There are also several ready-to-roll bicycles for about $1000 each. The ZAP PowerBike is an electrically-assisted mountain bike, and the ZAP ElectriCruizer is patterned after bicycles of the 1950s, including whitewall tires. The ZAP PowerTrike, an electrically-assisted three-wheeler, could be just the ticket for seniors or the disabled.



The Sparrow "personal transportation module" can use car-pool lanes in most locales.



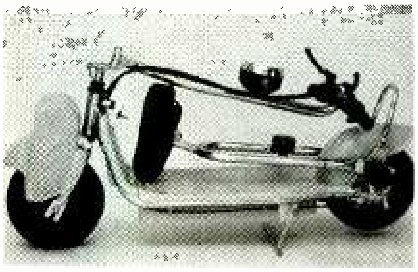
The Gizmo EV can be recharged in 3.5 hours and can attain speeds of 30 mph.

Depending on the terrain and speed, ZAP electrically-assisted bikes can travel from 8 to 20 miles without pedaling. Top speed on electric power is about 15 mph. Speeds increase to 18-20 mph if you also pedal. The bikes feature regenerative braking where energy is recouped to help recharge the battery while coasting or traveling downhill. You could also mount the bike on a stationary stand and get some exercise while charging the battery. A full charge via the quick charge takes under three hours using 110-volt household current. The other competitive electrically-assisted bikes have similar performance.

Another solution is a scooter, like the one you might have used as a kid. However, the Zapino from Zap Power Systems adds the "kick" of an electric motor for significantly greater speed and range. The Zapino is only three feet in length and weighs about 73 pounds. When the handlebar and seat are folded down, it easily fits into the trunk of a car. It even has its own easy-carrying tote bag as an option. A speedometer is also optional.

You can stand up and push yourself along, or you can give your legs a rest and sit on the folding seat as the electric motor moves you along at 14 mph. When operating on electric power, the Zapino has a range of up to 18 miles. Charging on ordinary 110/220-volt household current

The ZAP PowerBike batteries are installed under the crossbar, and twin electric motors drive the rear wheels via friction.



The Zapino powered scooter folds for easy storage and weighs under 75 pounds.

The Zap PowerBike shown here is fitted with a "police package."

with the built-in charger takes from 2 to 6 hours. The price is $1,495 and includes an electronic horn as well as front and rear lights.

Electric Bikes for the Police. Electrically-assisted bikes are not only popular with pleasure riders and commuters, but are also used by police in several communities. Bicycles are great for community policing, working with juveniles, and patrolling parks; and they are often the fastest way to travel through city traffic. When stopped in congested areas, they do not block traffic. Virtually silent, they allow the officer to retain the element of surprise.

Both ZAP Power Systems and AeroEnvironment are marketing electric-powered "police packages" for bicycles. An officer of the law can use both the electric motor and pedal power when in a hot pursuit or climbing a steep hill. Just before arriving at the crime scene, the officer could rest a few minutes—letting the motor do the work—and get ready to handle a tense situation. Police packages include flashing lights, sirens and police markings. Ω

SOURCES

AeroEnvironment, Inc.
222 East Huntington Drive
Monrovia, CA 91016
Tel: 818-357-9983

APS
9722 Sixth Street
Rancho Cucamonga, CA 91730

B.A.T. Int'l & Electric Bike Co.
3601 Empire Blvd.
Burbank, CA 91505

Bombardier Motor Corp. of America
2202 West Lone Cactus Drive, Suite 4
Phoenix, AZ 85027
Tel: 602-581-1515

Elmco, Inc.
P.O. Box 176
Cooksville, IL 61730
Tel: 309-725-3533

EMV Carts (Canada) Ltd.
64 Front St., North
Campbellford, ON
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Neighborhood Electric Vehicle Co.
PO Box 11319
Eugene, OR 97402
Tel: 541-687-5939
Web: www.nevco.com

Sparrow
11445 Commercial Parkway
Castroville, CA 95012
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Zap Power Systems, Inc.
117 Morris Street
Sebastopol, CA 95472
Tel: 707-824-4150

SENSORS

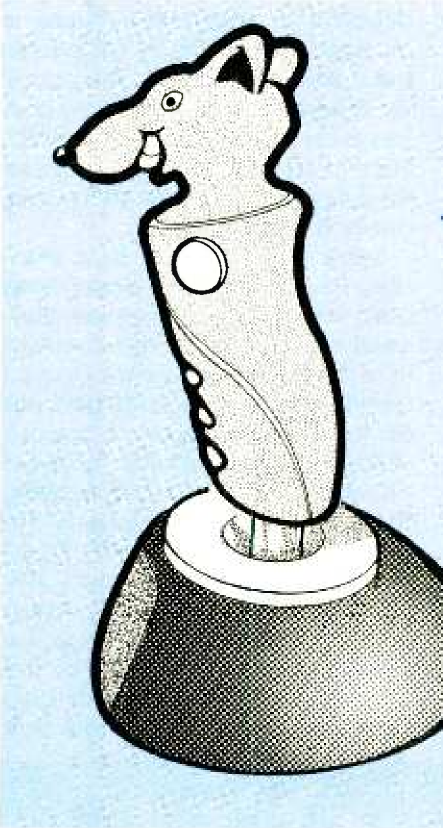
(continued from page 46)

miniaturized polymerase chain-reaction instrument, or PCR, has been created. The miniature PCR, which is actually a miniature chemical reactor, is machined from three components: a single silicon crystal, which acts as an efficient heat sink; a low-stress silicon nitride, which acts as a chemical passivation layer and a window for viewing the reaction with fluorescence detection; and doped polysilicon, which acts as a miniature heater. Among other things, that new device could be use for forensic analysis, genetic engineering, clinical diagnostics, and environmental contaminant/pathogen detection.

Advances in micromachining have created miniature gas chromatographs or GC sensors, which create the basis for an amazingly powerful handheld instrument capable of operating up to 20 times faster than its larger laboratory counterparts. In the past an immunoassay could take up to 30 minutes to perform, while the miniature micro GC can complete the exact same measurement in less than 10 minutes.

A chemist at the University of California at Berkeley has constructed a miniaturized electrophoresis gel instrument, which at 25mm by 50µm, is fifty times smaller than slab gels used in conventional instruments. This "gel on a chip," which is shown in the photograph at the beginning of this article, is the first step in building a micro chemical-analysis system where DNA could be put on a chip, amplified, loaded into a capillary array, detected, and analyzed all in one step. This is truly chemistry on a chip at the micron level.

As impressive as the advances outlined here are, smart-sensor technology is still in the embryonic stages of its development. The future for this exciting field is virtually unlimited, and could well make possible technologies and devices that heretofore have belonged only in the realm of fantasy and science fiction. Ω



Build the Joymouse

Use a joystick as a mouse with any program.

BRIAN BEARD

A computer mouse and a joystick are both pointing devices. They both have button inputs. However, a joystick is an "absolute" position device Its control stick can deflect only so far from the center position. A mouse, on the other hand, is a "relative" device—it can be lifted off the table and moved while the cursor on the computer screen stays where it is. Unless you have an Apple Macintosh, you can't use one in place of the other. Wouldn't it be nice if you could use a joystick as a mouse on an IBM or IBM-compatible computer?

The Joymouse described here is just the device to fill that need. The circuit board is small enough to be mounted inside a joystick. With the flick of a switch, the Joymouse can change from joystick to mouse and back.

What's in a Joystick? An analog joystick is a very simple device. The mechanical arrangement of a typical joystick is shown in Fig. 1A. Electrically, it has two 100,000-ohm potentiometers and two normally-open pushbuttons. The shafts of the potentiometers are mechanically connected to the stick by gimbals that isolate the left-to-right (X-axis) movement from the forward-to-backward (Y-axis) movement. The stick is usually spring loaded so that it returns to the center position whenever it is released.

Joysticks for IBM and IBM-compatible computers are designed to work with the specification for the original IBM Game-Control Adapter. That adapter has eight inputs—four digital inputs and four resistive inputs. Two inputs of each type are grouped as a pair of joysticks, called Joystick A and Joystick B. The wiring diagram and connector-pinout description for hooking up two joysticks to an IBM Game Adapter is shown in Fig. 1B.

Joysticks have a male DB15 connector that connects to the female DB15 game-port connector on the PC. If two joysticks are to be connected to the game port, a Y-shaped adapter is used to split the signals for each joystick into individual DB15 connectors that are wired as Joystick A. Joysticks that have additional features such as a throttle control, rudder control, or four buttons use the inputs of both Joystick A and Joystick B at the same time for the additional controls. Obviously, since that type of joystick appears to the game port as two joysticks, only one device can be hooked up at a time.

Examinning the wire diagram, we see that one side of each potentiometer is tied to a 5-volt power source with the wiper being connected to one of the resistive inputs. The resistive-input circuit has a capacitor connected to ground. That capacitor and the potentiometer form an RC-timer circuit. Moving the joystick changes the charging time of the capacitor. The joystick driver-software periodically grounds the resistive input, and then times how long it takes for the voltage on the capacitor to rise to a certain level. That time lapse indicates the position of the joystick handle. The circuit is very similar to an LM555-based "one-shot" timer circuit. In fact, some earlier game-port cards used that exact chip for the input circuit.

Most joysticks have trim tabs for each axis that allow the center-position resistance to be set by rotating the body of the potentiometer. The buttons on the joystick are connected to ground and the button inputs. The button inputs have resistors that apply a 5-volt signal to the input on the game card when the buttons are not pressed. Pressing a button grounds that particular input. The trigger on the joystick is normally wired as button 1. Some joysticks have an auto-fire circuit connected to the trigger. When the trigger is held down, an oscillator circuit pulses the button-1 line faster than a person possibly could.

What's in a Mouse? Mice, because of the way they are connected to computers, need to have some intelligence built into them, instead of having some interface hardware built into the computer. A single-chip microcontroller (MCU) takes the information from the mouse buttons and the x- and y-axis inputs and sends it to the computer.

A typical mouse mechanism is shown in Fig. 2A. The mechanical portion of the mouse consists of a rubber-coated steel ball and a pair of roller shafts. The two shafts are set at 90° angles to each other so that one rotates when the mouse is moved left and right. The other shaft rotates when the mouse is moved back and forth.

Each shaft has a slotted wheel attached to it. On either side of each slotted wheel are two pairs of LEDs and two pairs of photodetector. The LED and photodetector pairs are positioned on opposite sides of the wheel. That arrangement can be seen in Fig. 2B. When the mouse is moved, the rubber ball presses against the shafts connected to the slotted wheels. As the ball rolls, the wheels spin and the slots alternate blocking and passing the light from the LED to the photodetector. The output pulses from the photodetectors look like the pulse train shown in Fig. 2C.

The two LED–photodetector sets on each axis are offset so that the pulses from each photodetector are 90° out of phase. Whichever output switches first indicates the direction in which the mouse is moving. The microcontroller counts the pulses and monitors the phase to determine the distance and direction the mouse is moved. Each pulse is a "dot," and mouse resolution is often quoted in dots-per-inch (dpi).

Serial mice connect to a standard RS-232 serial port. Since those ports don't have any power connections, the mouse draws power from the RS-232 signal lines. Unused control lines on the serial port are set to either the "mark" or "space" voltage level, which are at about −12 volts and +12 volts, respectively. The mouse circuitry converts the negative voltage to +5V by a switching-converter circuit. The negative voltage is usually drawn from the TD (transmit data) line. The positive voltage is supplied by the RTS (request to send) line. That line is also used to detect if a mouse is attached to a serial port. The software toggles the RTS line from off to on and then looks for a response from the mouse on the RD (receive data) line. If a mouse is connected and working, it sends the letter M in ASCII code. If, after a few milliseconds, no "M" is received, the driver software reports that there is no mouse connected and resets RTS to the off state.

How a Mouse Communicates. Since the mouse is an input device, it doesn't make sense to send messages when there is no information to send. Messages are only sent when the mouse is moved, a button is pressed, or a button is released. The messages sent by the mouse are referred to as *packets*. There are several formats for mouse-data packets, but the Microsoft Serial Mouse format has become the de facto industry standard for

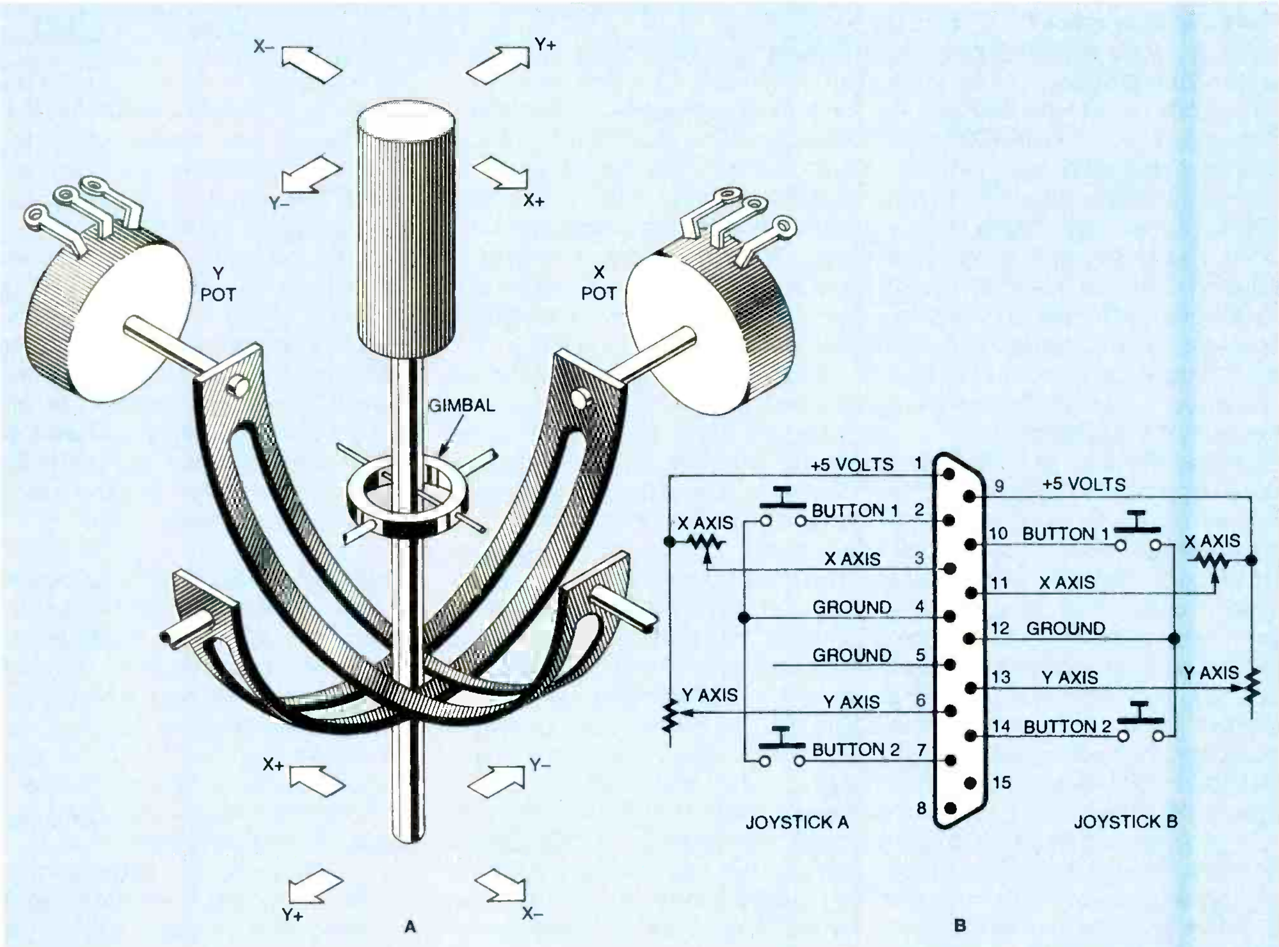


Fig. 1. In a typical analog joystick, a gimbal-mounted control moves the shafts of two potentiometers (A). The resistances of those potentiometers indicate where the stick is. The IBM Game-adapter is designed for two joysticks to be used at the same time (B).

TABLE 1
MICROSOFT MOUSE PACKET FORMAT

	D6	D5	D4	D3	D2	D1	D0
1st byte	1	LB	RB	Y7	Y6	X7	X6
2nd byte	0	X5	X4	X3	X2	X1	X0
3rd byte	0	Y5	Y4	Y3	Y2	Y1	Y0

LB is the state of the left button, 1 = pressed, 0 = released
RB is the state of the right button, 1 = pressed, 0 = released
X0–X7 is movement of the mouse in the X direction
Y0–Y7 is movement of the mouse in the Y direction

serial mice. The Microsoft format is shown in Table 1.

The Microsoft mouse format only allows for two buttons—if a three-button mouse is working in a Microsoft-compatible mode, the middle button is ignored. All moves are sent in an 8-bit two's-complement binary-numbers format. That arrangement requires seven bits plus a sign bit. Since the packet sends seven-bit bytes with the highest bit unused, the movement values are split between two bytes. The data for the X-axis movement is stored in the second byte, and the Y movement information is stored in the third byte. The first byte combines the extra bits from both the X and Y movement data with the state-of-the-mouse buttons. The mouse driver software in the computer separates out the X and Y movement data from the different bytes in the packet.

The packets are sent at 1200 baud with one stop bit and no parity. Although the Microsoft format only requires 7-bit data, most mice actually send 8-bit bytes with the most significant bit set to one. Apparently, the mouse-driver software ignores D7.

How the Joymouse Works. The Joymouse circuit, shown in Fig. 3, converts the resistive and button inputs from an analog joystick into a serial data stream that emulates a

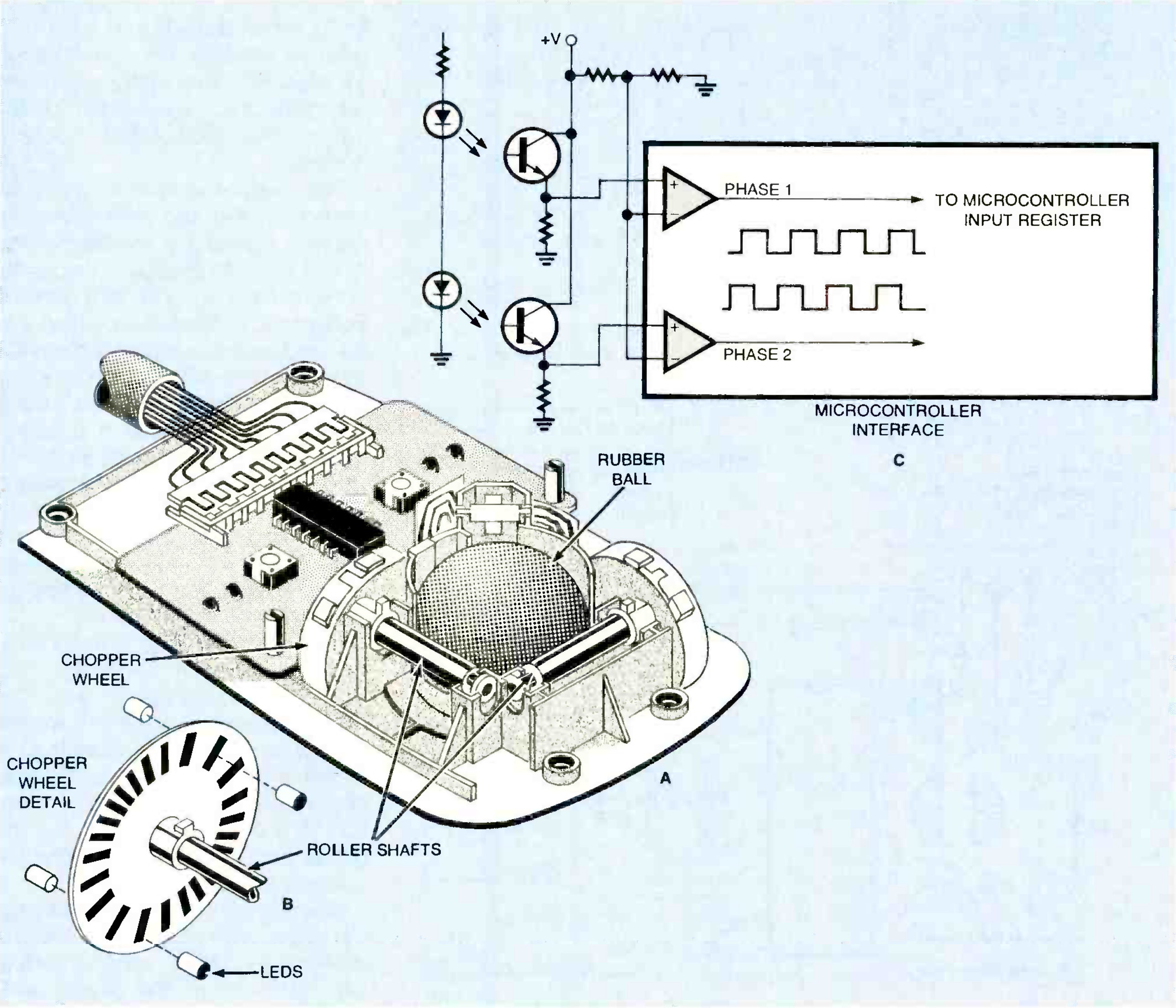


Fig. 2. In a typical mouse, a rubber ball spins the shafts of two slotted wheels (A). The slotted wheels block the light between a pair of LEDs and a pair of photodetectors (B). The photodetectors are set so that a pair of out-of-phase signals will indicate which direction the shaft is spinning (C).

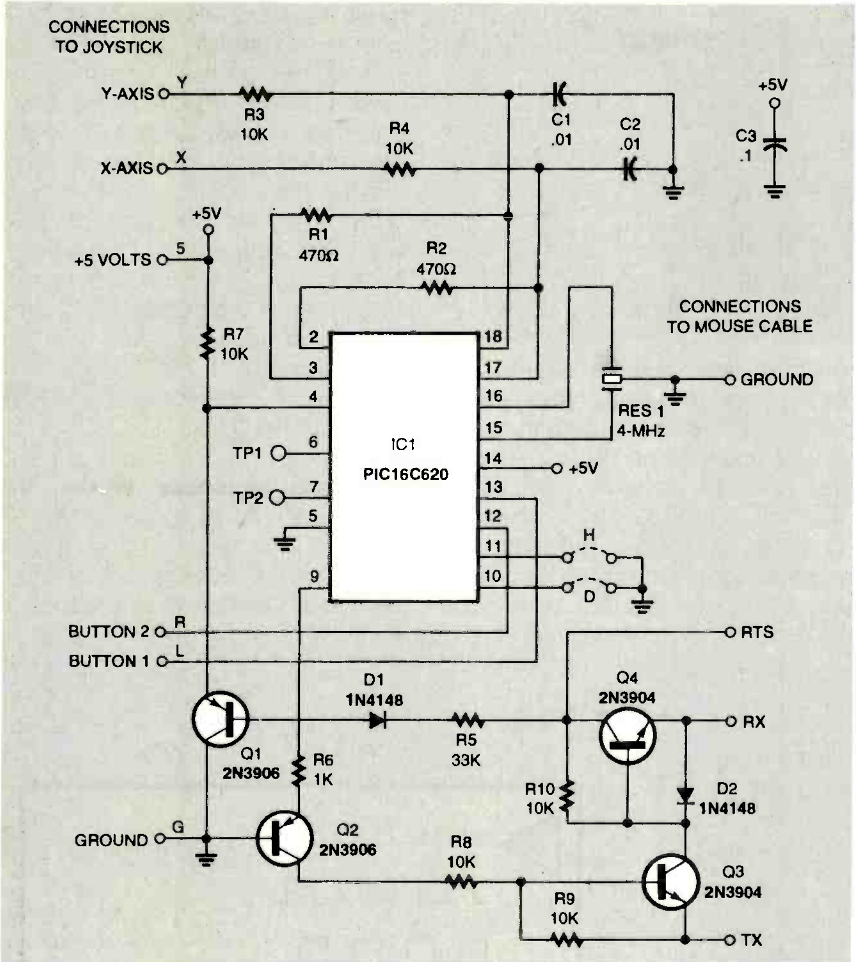


Fig. 3. The circuit for the Joymouse is quite simple. A single-chip microcontroller does all of the work. The optional jumpers labeled "H" and "D" adjust the response of the Joymouse.

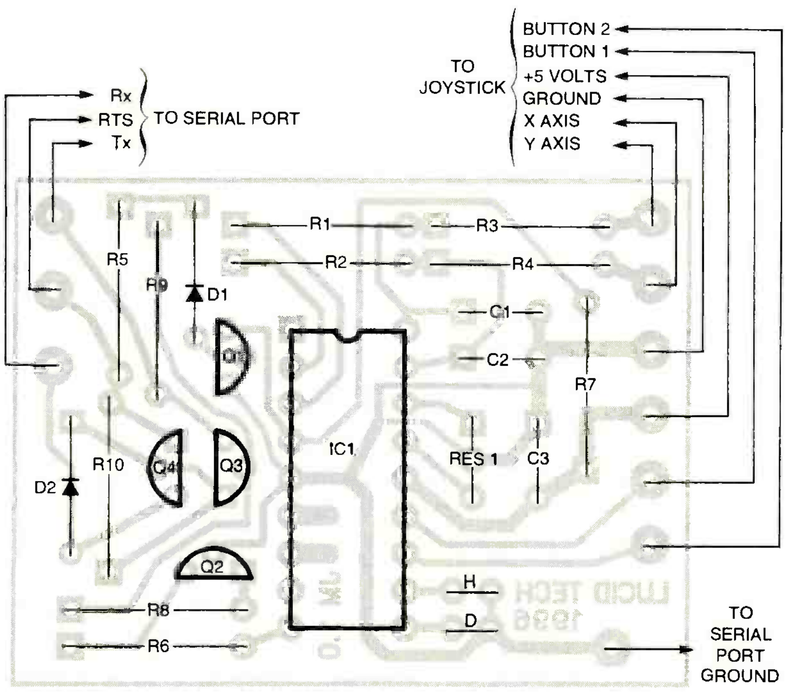


Fig. 4. If you are using either a PC board from a kit or the foil pattern shown in this article, use this parts-placement diagram to locate the components.

Microsoft serial mouse. Because the Joymouse is connected to both the serial port and the game port, the game port's 5-volt supply is used to power the Joymouse circuitry.

The heart of the Joymouse is IC1, a PIC16C620 microcontroller. That chip combines a unique set of features that make the single-chip design possible. Those features include 2 analog comparators, 13 digital input/output lines, a programmable voltage reference, a power-up reset timer, a "watchdog" reset timer, 512 bytes of EPROM, 80 bytes of RAM, and a high-performance RISC CPU.

The reset pin on IC1 is controlled by the RTS signal on the serial port. When the RTS line has a negative voltage, Q1 turns on. That grounds the reset line on IC1, resetting the MCU. When the RTS line is set to a positive voltage, no current flows through Q1. The voltage on the reset line of IC1 is pulled up by R7, letting the PIC16C620 operate normally.

The resistances from the joystick's potentiometers are converted into position signals by measuring the time it takes to charge a capacitor up to a fixed voltage. That circuit is built into IC1. When the position is to be read, an internal capacitor in IC1 that is connected to an analog-input pin is discharged. The joystick potentiometer supplies a charging voltage through a resistance. The lower the resistance is, the faster the capacitor will charge. A timing loop in the software counts how long it takes for the voltage to reach a level of 3.59 volts. At that level, an internal comparator switches.

When the software sees that the comparator has switched, the amount of time that it took for the comparator to switch indicates the position of the joystick's handle. One circuit is used for each of the joystick inputs. That method is very similar to the method used by the game port circuit to measure the position of the joystick.

Since the charging and discharging of the Joymouse circuit and the game port circuit would interfere with each other, the Joymouse is designed to disconnect the joystick from the game port when it is being used as a mouse. Those signals are

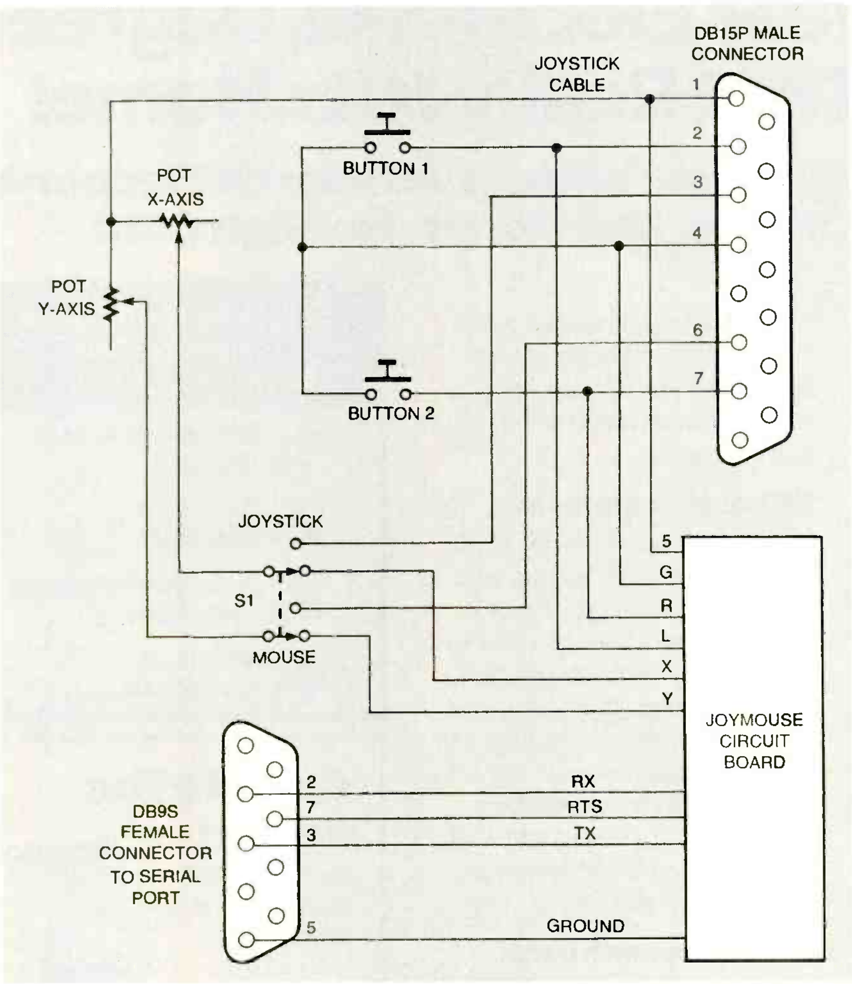


Fig. 5. This wiring diagram shows how to connect the Joymouse if you want to install the board directly into the base of a joystick. The four-wire serial cable should be the same length as the joystick's game-port cable.

switched by a double-pole double-throw switch. The joystick pushbuttons, on the other hand, are connected to resistors on the game-port card, so there is no problem connecting the Joymouse directly to those inputs.

The RS-232 cable that connects the Joymouse to the PC's serial port has four lines. The RTS and TD lines are used for the positive and negative voltages that are needed by the Joymouse. A reference voltage level is provided by SG (signal ground), and RD is the serial data that is sent by the Joymouse to the PC.

The logic for the serial data transmitter is done by the Joymouse software. The serial data stream from IC1 uses an external circuit to shift the voltage levels to the RS-232 voltage standards. When the serial data level is high, Q2 turns on. That, in turn, switches Q3 on. The negative voltage on the collector of Q3 keeps Q4 turned off. As a result, the voltage level on RD is pulled to the negative RS-232 voltage through D2. When the serial data level is low, Q2 and Q3 are turned off. That leaves Q4 turned on, pulling RD to the positive RS-232 voltage.

Software. Any device with a microcontroller inside is really defined by its software, and the Joymouse is no different. Most of the program consists of subroutines—small blocks of instructions that are called from the main program loop. Some of the subroutines in the Joymouse program include measuring the joystick resistances, creating the data packet for the serial port, sending that data, and setting up various timing delays.

In a real mouse, if there are no pulses coming from the photodetectors, the mouse is not moving. However, the Joymouse always sees a resistance for the two joystick potentiometers. How does it know

PARTS LIST FOR THE JOYMOUSE

SEMICONDUCTORS

IC1—PIC16C620P
Q1, Q2—2N3906, PNP transistor
Q3, Q4—2N3904, NPN transistor
D1, D2—1N4148 silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R2—470-ohm
R3, R4, R7-R10—10,000-ohm
R5—33,000-ohm
R6—1,000-ohm

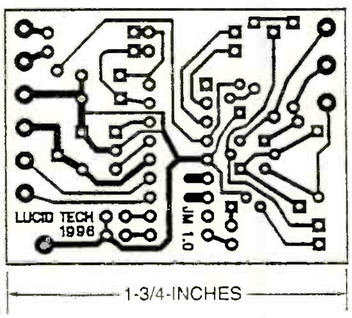
CAPACITORS

C1, C2—0.01-µF, Mylar
C3—0.1-µF, ceramic-disk

ADDITIONAL PARTS AND MATERIALS

RES1—4-MHz ceramic resonator, ECS ZTT-4.00MG (Digi-Key X902-ND or similar)
S1—double-pole, double-throw switch
PC board 18-pin IC socket, 4-conductor cable, female DB9 connector, plastic DB9 connector cover, DB15 connectors (see text), jumpers, etc.

Note: The following is available from Lucid Technologies, 12907 Crookston Lane, Unit 22, Rockville, MD 20851, Web: http://www.cs.com/lucid: Complete kit of all parts, PC board, complete printed schematics, and technical manual on disk (specify 5¼-inch or 3½-inch), $25.00; partial kit consisting of programmed IC1, complete printed schematics, and technical manual on disk (specify 5¼-inch or 3½-inch), $13.00. Please add $3.00 for shipping and handling. Maryland residents add appropriate sales tax.



Here is the foil pattern for the Joymouse. A single-sided board is easy to etch and assemble.

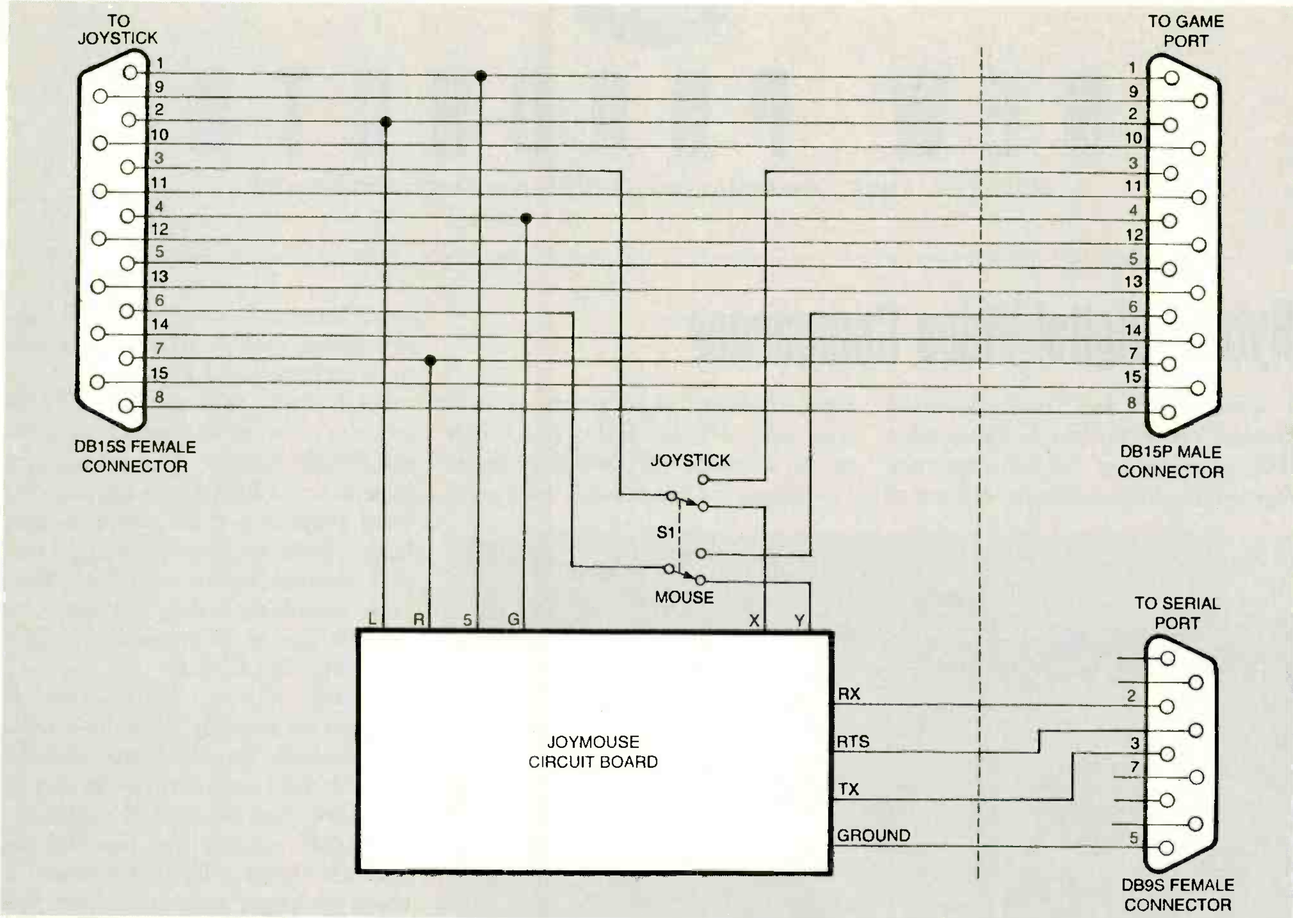


Fig. 6. The Joymouse can also be built as a stand-alone box that connects between the joystick and the computer. Switch S1 selects either joystick or mouse operation.

exactly what the center resistances are for each axis? The answer is that when RTS goes positive and the Joymouse MCU starts running its program, it assumes that the joystick is centered. The first joystick readings are used for the center position values. Since the resistances at the center might not be exactly 50,000 ohms due to component tolerances and trim tab settings, the Joymouse will keep checking the joystick readings until both values are between 38,000 ohms and 62,000 ohms.

When a joystick is released, its spring loading returns the stick to the center position. However, due to mechanical slop in the linkages, the resistances at the center are seldom identical from one reading to the next. For that reason, the software doesn't consider the center as just a pair of X and Y resistances, but as a range of values surrounding the center values measured after reset. That region is called the *deadband*. The Joymouse will only send movement data to the PC when one or both resistance values fall outside of the deadband. Moving the stick further from center is equivalent to moving a mouse faster.

The default deadband and ramp should work well with most joysticks, but they can be changed with the jumpers labeled "D" and "H" in Fig. 3. Shorting the "D" jumper will increase the width of the default deadband by 50% to compensate for unusually loose joysticks. Shorting the "H" jumper will decrease the slope of the ramp by 50% making the cursor move slower.

No special software is required on your PC to use the Joymouse. Any Microsoft mouse-compatible driver will work with the Joymouse.

Construction. Building the Joymouse is simple and straightforward. The PC board is a single-sided design that is easy to etch and drill if you want to build your own. Both a complete and partial kit is available from the source given in the Parts List.

Before you assemble the Joystick PC board, IC1 must be programmed with the Joystick software. A pre-programmed chip is available from the source given in the Parts List. If you wish to program your own chip, the software can be downloaded from the Gernsback FTP site (ftp://ftp.gernsback.com). The file name for the Joymouse software is joymouse.hex.

The parts-placement diagram for the Joymouse circuit board is shown in Fig. 4. Be sure to use a low-wattage soldering iron when assembling the board. If an iron with a high-wattage rating is used, the small pads might lift off the board if they are overheated.

It's a good idea to use pins and jumper blocks for the jumpers labeled "D" and "H." That way, the response of the Joymouse can easily be changed if you find that the default response is not to your liking. For now, do not install any jumpers in

(Continued on page 72)

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Hybrid Digital-Video Camcorder

Canon U.S.A., Inc. has introduced the Optura, the first hybrid digital-video (DV) camcorder; it combines the mini digital-video format with the features of 35mm SLR cameras. The Optura's unique recording modes and its IEEE-1394 digital connector are designed to suit a multitude of sophisticated imaging and computer-applications needs, including digital motion video, still image, and multimedia capture—all in one unit. In addition to recording full-motion video and audio digitally, the Optura captures still images that are undetectable to the human eye.

CIRCLE 20 ON FREE INFORMATION CARD

Using an exclusive "Progressive-Scan Mode," the Optura records high-resolution still images of fast-moving subjects at a rate of 30-frames-per-second (fps)—three times faster than the motor drive of a professional 35mm camera. The Progressive Scan image sensor reads each of the 360,000 effective pixels in a single scan to capture a full-frame image every $^{1}/_{60}$ of a second—vivid, high-quality still images of high-speed action that can be used for TV display, computer input, or digital photo prints. In contrast, other DV and analog camcorders use an interlace scan, which processes field images (or half the scan lines) every $^{1}/_{60}$ of a second, thereby diminishing image quality.

This camcorder uses an RGB primary-color filter, which creates more uniform colors in still images by improving the reproduction of subtle intermediate gradations. Thanks to the progressive-scan CCD and two new proprietary ICs, users can capture high-resolution still images occurring within action. These images may be displayed on a TV or computer screen, or they may be output to a printer.

In Photo mode, the Optura is transformed into a virtual digital SLR camera with five programmed auto-exposure settings that automatically determine exposure and shutter speed. Manual controls can be used by selecting "Shutter Priority" (Tv) or "Aperture Priority" (Av). Tv and Av are easily identified by icons on the programmed AE selector dial. Tv adjusts the shutter speed between $^{1}/_{8}$ of a second and $^{1}/_{2000}$ of a second, while Av allows the aperture to be set between f/1.8 and f/32.

Each digital still captured in Photo mode is recorded to tape for approximately six seconds. The microphone remains active during this time, enabling voice annotation to be added to each image. Users can also operate a 10-second self-timer before recording. Photo mode records more than 500 images on a single tape in SP mode and exceeds 800 images in LP mode.

Finally, Normal Movie mode is designed for shooting full-motion video for playback on television. Any of Optura's three recording modes may be combined on to one Mini-DV cassette.

Special features are plentiful on Canon's Optura video camcorder. It boasts the longest optical zoom lens on a DV camcorder at 14× magnification. The digital zooming feature extends the 14× optical zoom to a full 35× magnification. With the FlexiZone Auto Focus Image Control System, users are able to pinpoint the area of focus anywhere in the viewfinder, utilizing a "joystick" controller.

Measuring $5^{7}/_{16}$-inches high by $4\ ^{3}/_{16}$-inches wide by $5^{1}/_{4}$-inches deep and weighing approximately two pounds, the Optura retails for $2699. It is bundled with a battery pack, power adapter/battery charger, DC-900 DC coupler, shoulder strap, lens cap, LCD screen cover, wireless remote control, stereo and S-video cables, lithium battery, and digital video cassette.

CANON U.S.A., INC.
One Canon Plaza
Lake Success, NY 11042
Tel: 516-488-6700
Web: http://www.canondv.com

Hand-Held Frequency Counters

Offering wide input ranges, Models F-2800 and F-2850 (shown) universal frequency counters from Elenco Elec-

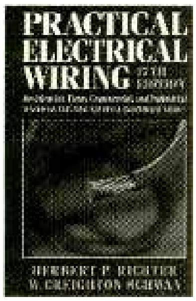
(Continued on page 64)

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Practical Electrical Wiring: 17th Edition

by Herbert F. Richter and
W. Creighton Schwan
McGraw-Hill, Inc.
1221 Avenue of the Americas
New York, NY 10020
Tel: 800-2MCGRAW
Web: www.mcgraw-hill.com
$39.95



CIRCLE 338 ON FREE INFORMATION CARD

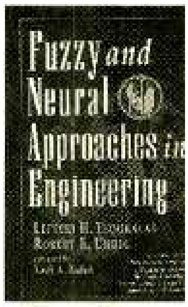
Revised and updated to include the requirements of the latest National Electrical Code, the 17th edition of *Practical Electrical Wiring* remains an authoritative guide in its field. Written in clear and simple language, it is both a comprehensive reference for the professional and an easy-to-use resource for the do-it-yourselfer. This how-to book explains step-by-step professional techniques for safe, efficient installations.

Included in this edition is a thorough discussion of the latest Code requirements and their meaning. Among the areas covered are requirements for: ground-fault circuit interrupters, grounding dryers and ranges, overcurrent protection, and classification of hazardous locations. Principles for planning, layout, and installation of the most commonly used wiring methods are clearly and completely discussed. The guide presents all the tools and materials that the electrician needs; professional "tricks of the trade;" and safety practices for virtually any home, commercial, or small industrial wiring project.

Filled with helpful examples, tables, and illustrations, *Practical Electrical Wiring* gives you recommended shortcuts, solutions to problems, and safety "musts" to help you do every job right the first time.

Fuzzy and Neural Approaches in Engineering

by Lefteri H. Tsoukalas and
Robert E. Uhrig
John Wiley and Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 800-225-5945
$79.95



CIRCLE 339 ON FREE INFORMATION CARD

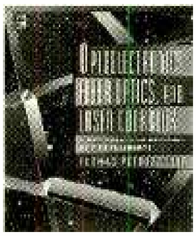
Researchers are applying neural networks and fuzzy systems in series, but the integration of those two fields into a "neurofuzzy" technology holds even greater potential benefits in reducing computing time and optimizing results. Exploring the value of relating genetic algorithms and expert systems to fuzzy and neural technologies, this book highlights an entire range of dynamic possibilities within soft computing.

This definitive text for students and practicing engineers provides an accessible introduction to this integrated technology by presenting a detailed examination of the fundamentals of neural networks and fuzzy systems. Numerous examples are specifically designed to overcome the obstacles of notation and overly mathematical presentations frequently found in other texts.

After a brief discussion of hybrid artificial-intelligence systems, the first five chapters of the book discuss fuzzy logic and its applications in detail. The next five chapters do the same for neurocomputing. Then the authors present ways in which fuzzy system and neural networks can be integrated, describing both fuzzy methods in neural networks and neural methods in fuzzy systems. The book ends with a discussion of other artificial-intelligence systems and genetic algorithms.

Optoelectronics, Fiber Optics, and Laser Cookbook

by Thomas Petruzelllis
McGraw-Hill, Inc.
1221 Avenue of the Americas
New York, NY 10020
Tel: 800-2MCGRAW
Web: www.tabelectronics.com
$29.95



CIRCLE 340 ON FREE INFORMATION CARD

Optoelectronics is one of the hottest fields in electronic technology today. A practical guide to optical circuits, this collection presents state-of-the-art experiments and projects, including fiber optics and lasers. Detailed discussions of optoelectronics explain the essentials of the field, as well as future trends, in non-technical terms.

Over 150 challenging and enjoyable projects and experiments clearly demonstrate how optical circuits work and how they can be applied. Included are home-security projects such as window- and door-leak detectors, lightning monitors, flame sensors, and power-outage and laser perimeter-alarm systems. Among the photographic projects are creating a solar photometer and building your own photo flash meter. Laser seismographs and range finders, as well as high-speed optic data links and wireless IR speaker systems, are also covered in detail.

All the projects are illustrated with circuit diagrams and schematics, and they are accompanied by parts lists. A handy appendix of suppliers tells you where to buy the parts you need. Whether you're a student, hobbyist, or technician, this book gives you the knowledge and skills needed to design and build time-saving devices using cutting-edge optical circuitry.

(Continued on page 71)

BY JEFF HOLTZMAN

Pilot Development Tools

ONE THING THAT SETS 3COM'S PALMPILOT APART FROM MOST OTHER PDAs IS THE AVAILABILITY OF HIGH-QUALITY TOOLS FOR DEVELOPING CUSTOM APPLICATIONS. IF YOU CAN WRITE CODE IN ASSEMBLER, C, C++, BASIC, FORTH, OR LISP, OR CAN handle a Visual-Basic-like forms-development environment, you can create Pilot software. All of those languages (and more, including programmable calculators and symbolic math programs) are currently available for the Pilot; they vary widely in their capabilities and degrees of fit and finish.

If you're having trouble deciding which way to go or want more detailed information, the Resources box lists the premier Web sites and newsgroups dealing with Pilot development. (If you're evaluating alternatives, the Wademan site has an excellent FAQ.) My focus here will be software development kits (SDKs) for C.

Two Types of SDK

In essence, a conduit is a DLL that hooks into the Pilot's desktop-synchronization process, providing a pipeline through which data on the Pilot and data on the desktop may be synchronized. Each of the built-in apps has its own pipeline, or conduit; third-party apps must supply their own. Developing apps that run on the Pilot itself requires one SDK; developing conduits requires another. Each SDK has its own set of APIs, and even its own hosting environment. Typically, you use MS Visual C++ 4.1 to develop conduits, and one of the following tools to develop native, Pilot-hosted apps.

A Pilot app doesn't necessarily need a conduit. By simply setting a bit in the database header of a Pilot "file," that file will automatically get backed up, *i.e.*, copied to the PC. However, such a file simply gets stashed in a backup directory. There is no opportunity for two-way record-level synchronization, like that provided by the Address Book application. In addition, to do anything to the file on the PC, there would have to be some sort of active user intervention, whereas proper conduits can be called automatically during HotSync.

C Tools

There are two choices for C programmers: GCC and CodeWarrior. GCC is a public-domain set of compilers for various languages and platforms; in a sense, it's the Linux of development tools. For more about GCC in general, see the November 1997 installment of this column.

Getting GCC up and running is tough, and the tools themselves are a bit rag-tag. I've heard that there is a CD in the works; reportedly, it will have a smart installation routine, which should greatly ease installation pain. Until that CD becomes available, I can't really recommend GCC unless you've already got experience in the GNU world. Also, Palm is supporting the GCC development effort, but, as of this writing, GCC does not support conduit development.

The canonical, officially supported development tool is called CodeWarrior; it is produced by a company called MetroWerks. MetroWerks is primarily known as a Macintosh tool supplier, although the company supports an impressively broad array of languages and platforms, including Macintosh, Win32, MagicCap, and PlayStation, in C, C++, Pascal, and Java. In addition, MetroWerks is trying to support a common development environment running on multiple platforms. I have to admit that I was less than impressed with the early versions of the Win32 host for the Pilot development system, but the latest version (release 3) has assuaged most of my doubts.

CodeWarrior for Pilot is available for both Mac and PC-hosted development; in fact, both versions come on the CD, which also includes both the Pilot and the conduit SDKs. To digress for a moment, Palm seems to have the same type of ambiguous relationship with Apple as many people these days. I've been told directly by Palm employees that the Mac is their long-term platform of choice for development. However, at the user level, Palm's support for the Mac is notably inferior to that for the PC. In fact, given the current state of affairs, I wouldn't recommend Pilots for Mac users at all. On the other hand, I have reason to believe that Palm is working hard to rectify the situation. Recent on-line want-ads, for example, have specifically targeted Mac users. I also have it on good authority that most internal development is done on Macs.

Other Choices

I'm going to talk about Code Warrior in depth. But first, here is a brief overview of several other programming tools:

There are two forms-based development tools, PilotForms and Satellite Forms, primarily used for creating data-entry applications. Typically, you design a set of input screens on a PC, then download a file that a run-time engine interprets, generating the screens and collecting user input, which is then sent back to some sort of database at the next HotSync.

There is a freeware Basic interpreter, called cBasPad, with which you can do some surprising things. The tool is being incrementally developed and released; as of this writing, it is in version 0.82. It has several rough edges, and no capability for creating run-time modules suitable for distribution. But you can do things like access the serial port, play sounds, access internal databases, display bit-mapped graphics, call assembler routines, and quite a bit more.

There is a FORTH development system that is also being incrementally developed and released. It's still in the very early stages, but shows much promise for eventually being able to develop serious applications.

Another option is CASL, a scripting language halfway between Pascal and BASIC. A run-time engine is licensable, so it is conceivable that programs could be distributed in that format.

Another GNU-related item is PILA, the Pilot Assembler. As the name suggests, it is an assembly-language tool with proper interfaces and headers for calling Palm OS routines directly. For certain kinds of system hacks, or other low-level programming, PILA is well worth checking out. However, the same caveats apply to it as to GCC.

JUMP is a Java language cross compiler that accepts Java source code and generates 68000 assembly language suitable for compilation by a GNU tool. Last I heard, JUMP had not been updated in a long time, although that may have changed by the time you read this.

There are other choices as well. For those, check the sites listed in the Resources box.

Code Warrior

Now we'll discuss MetroWerks' Code Warrior. CW actually comes in three pieces, plus documentation.

- The Constructor provides a nice GUI for creating resources (bitmaps, icons, text strings, and screen layouts).
- The misnamed IDE is a code and project manager.
- The third piece is a debugger that allows source-level debugging of apps running on the Pilot. You'll also want to keep a Windows Explorer window open during development.

I say that the IDE is misnamed because a true IDE would integrate all components, not just the code editor and project manager. For example, I think it's silly that the code editor provides syntax highlighting and the debugger does not. Despite its incomplete integration, using the various components is pretty intuitive. The whole environment has a decidedly Mac-like feel, some bugs, and some incomplete features.

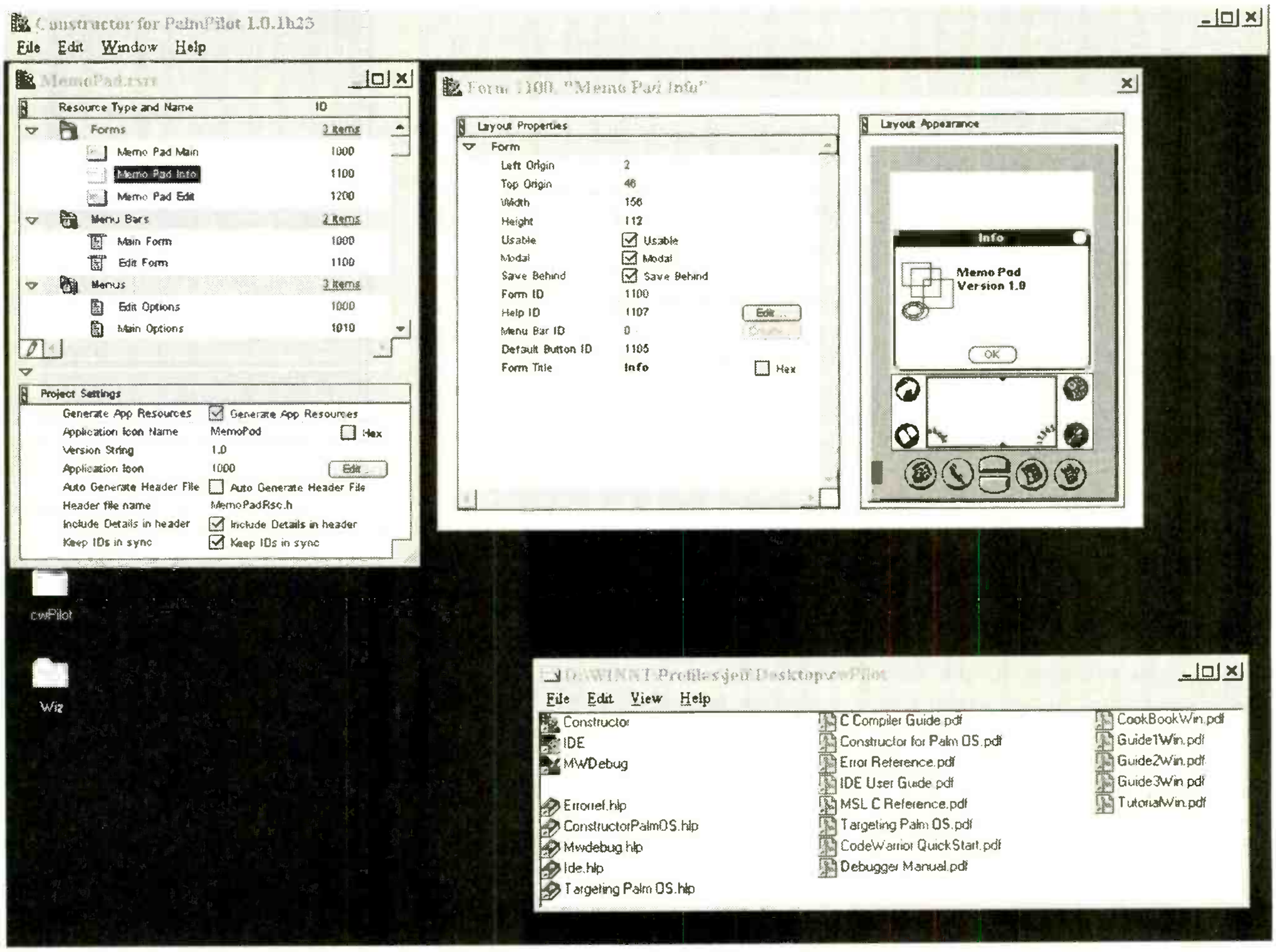


FIG. 1—METROWERKS' CODEWARRIOR PROVIDES three tools for building applications: A user-interface builder (the Constructor, shown here), a code editor and project manager (the IDE), and a source-level debugger.

Documentation is problematic. The CD comes with a slim little "getting started" booklet; everything else is packed on the CD in one of several formats. For Windows users, that primarily means WinHelp and Adobe Acrobat. Mac users have four or five formats to contend with. In addition, there are numerous "readme" files. I find it more than a little annoying to have to sort through all that garbage.

Comparable tools from Borland and Microsoft long ago surpassed that level of (dis) integration. For example, in CW, you must create menu bars and menus themselves separately, link them to one another, and then link them to a form. All the linking occurs via drag-and-drop actions, so it's not a big deal. It's just that the more modern Borland/Microsoft approach is superior.

RESOURCES

Developer Infomation:

www.wademan.com/Pilot/Program/FAQ.html
www.massena.com/darrin/pilot/index.html
www.sls.lcs.mit.edu/raylau/pilot/
www.usr.com/palm/pilotlinks.html
www.roadcoders.com/pilot/index.html
www.shoppersmart.com/jlehett/gccwin32.html
www.usr.com/palm/dresources.html

Newsgroups:

alt.comp.sys.palmtops.pilot
news.massena.com/pilot.programmer
news.massena.com/pilot.programmer.codewarrior
news.massena.com/pilot.programmer.gcc
news.massena.com/pilot.programmer.jump
news.massena.com/pilot.programmer.pila

However, the bottom line is that once it becomes clear how all the various and sundry pieces fit together, CodeWarrior for the Pilot is a pretty solid tool. For ease of access to all the tools and documentation files, I created a folder on the desktop with shortcuts to the three development tools, five WinHelp files, and eight PDF files, as shown in Fig. 1.

CW also comes with a 21-phase tutorial. The first few phases teach the basics of operating the Constructor, the IDE, and the Debugger; how to download apps for debugging; and how to create a simple Pilot application. Succeeding phases elaborate on the application. Each phase includes all the source and resource files needed to build the application at that point. After you get the hang of the build process, actually performing the tutorials may seem to have questionable value. I found myself wishing that the source code were published in the tutorial document (a PDF).

On the other hand, even though you add no code of your own, gradually building up the UI of the sample app, compiling, debugging, downloading, single-stepping, and running it are somewhat satisfying. Some of the debug problems that crop up are not covered in the tutorial, so it's not a totally brainless exercise. In sum, the tutorial provides a good overview of the UI components that can be used in Pilot apps, a basic introduction to use of the development tools, and an indirect overview of the Pilot OS's event-driven programming model. Concerning the latter, if you've done any event-driven programming in Windows, Macintosh, or elsewhere, you'll have a painless transition. It's not object-oriented; only C is supported, not C++.

When you purchase CW, you're essentially purchasing a subscription upgrade plan. The initial purchase is $369 list; that entitles you to all interim upgrades between the current version and the next major upgrade, typically four or five interim builds. Release 3 (for the PC) is the first one that won't have you pulling your hair out. MetroWerks also sells bundles that include a Pilot and a copy of CW.

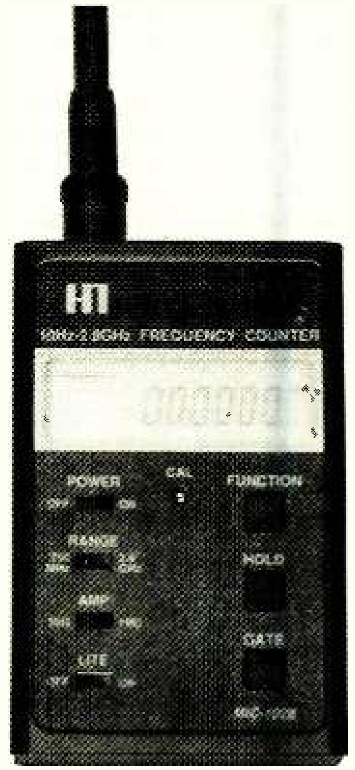
Using CW definitely keeps you aware of what's going on behind the scene to a much greater degree than comparable SDKs from other vendors. However, building screens with Constructor is infinitely better than specifying resource attributes in text files, and the source-level debugger really is quite impressive. Nonetheless, I will be keeping a close eye on the GCC development efforts. If that faction comes through with what they have been promising, CW will have serious competition.

That's all for now. Incidentally, I had hoped to get started on serial I/O programming, but space just didn't allow it. That's where we'll pick up next time. In the meantime, you can stay in touch via e-mail; my address is jkh@acm.org. EN

NEW PRODUCTS

continued from page 60

tronics are compact, handheld units. Both devices have a 250-MHz direct-count range for high resolution, a 16-segment signal-strength bargraph, and a data-hold capability, which allows readings to be frozen on the display for recording results later. A six-hour NiCd battery pack, as well as a wall-plug adapter is included with both frequency counters. Both units feature a 10-digit LCD readout (backlit on the F-2850).



CIRCLE 21 ON FREE INFORMATION CARD

The F-2800 displays frequencies from 1 MHz–2.8 GHz, while the F-2850 ranges from 10 Hz–2.8 GHz. Among the additional features of the F 2850 are auto-triggering, dual 50-ohm/megohm inputs, and time-period display.

The F-2800 measures approximately 6-inches high by 2.5-inches wide by 1.25-inches deep, and has a retail price of $149.95. The F-2850 stands 9.9-inches high, and otherwise has identical dimensions. It retails for $216.50.

Elenco Electronics
150 W. Carpenter Avenue
Wheeling, IL 60090
Tel: 847-541-3800
Fax: 847-520-0085
EN

BY DON LANCASTER

A Look at Reactance Limiting, More on Miracle Motors, Handheld Data Acquisition, and More

EVERY NOW AND THEN, SOME OLD IDEA GETS REDISCOVERED. FOR THE MOST PART, THESE SEEM "GEE WHIZ" BRILLIANT ON THE SURFACE, BUT A CLOSER LOOK USUALLY REVEALS SOME REALLY NASTY HIDDEN GOTCHAS. LET'S START THIS month with a look at one that has caused me some grief in the past.

Reactance Limiting

Say you are using the 110-volt-AC power line and need to run a much lower voltage device; what are your choices? You might use a step-down transformer, and pick up some safety isolation in the process. You could use a series resistor, albeit inefficiently, and burn your difference up as heat. Or, you could rapidly turn your input on and off, changing the duty cycle in a much more efficient and easily adjusted manner. The third choice is what Triac lamp dimmers and switch mode supplies are all about, and today that is often the most popular choice.

But we have a fourth and sneaky route. You can use the reactance of a capacitor or an inductor to provide the voltage drop for you. In theory, a "pure" capacitor or a "pure" inductor stores energy without dissipation. A reactive voltage drop sometimes can end up "lossless."

For example, in Fig. 1 we see an inductor known as a ballast being used to limit current to an older single-fluorescent-bulb desk lamp. There are three steps to the operation: Both switches are initially closed. The lamp's filaments both light, heating the emitters in the bulb. The inductor behaves as a reactance limiter to hold the filament current to a design level. After a second or two, the start button is released. That produces an open circuit across an inductor with a large stored magnetic field in it. The result is a suddenly collapsing field, which generates a rather large voltage spike of many thousands of volts, "striking" the bulb and lighting it. The lit bulb now conducts, and the reactive ballast acts as a "lossless" run-time current regulator for you.

Use of inductive-reactance limiting has worked out fairly well for a long time, though these days, switch-mode electronic ballasts are used instead. The newer electronic ballasts are smaller, lighter, and more internally efficient. Some are even dimmable. They often run the lamps at higher frequencies, for more efficient phosphor excitation and eliminating dangerous strobe effects. They are also gentler on the power line.

Given the above, couldn't we also use a capacitor as a simple and cheap reactive current limiter for AC? At first glance, the answer is yes. But, as regular readers of this column might have guessed, there are some severe problems lurking in the shadows. For one thing, doing just that has recently been outlawed.

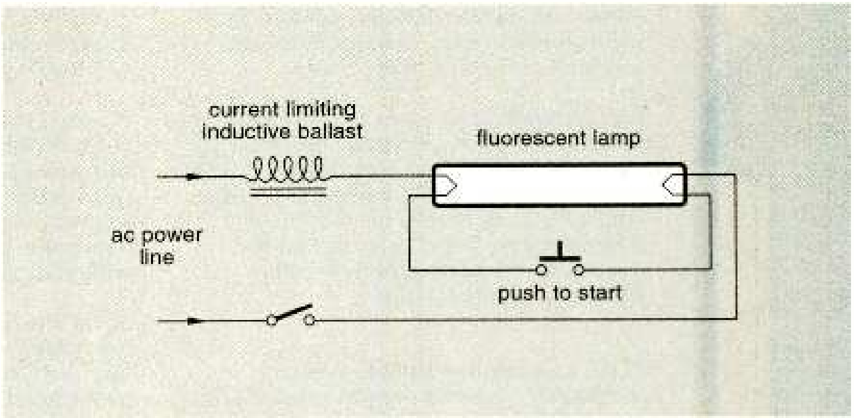


FIG. 1—FLUORESCENT LAMP BALLAST can offer you "lossless" inductive reactance current limiting.

A recently proposed line-operated generator for hydrogen and oxygen is shown in Fig. 2. Since an electrolysis cell needs only 1.5 volts for operation, the lion's share of the AC voltage drop takes place across the capacitor, and it does so simply and efficiently. What could possibly go wrong? go wrong? go wrong?

Well, for openers, there is a deadly "hot-chassis" shock hazard. If the user expects only a volt or two to be present at their cell, they are in for a rude surprise. There are two options here: Either provide for a safety isolation transformer, or else seal the entire circuit up so nothing is touchable.

Next, any poorly-chosen capacitor can and will explode! A cheap capacitor, or one with too high an ESR (equivalent series resistance), or one not properly AC-current rated, can quite easily self destruct. Electrolytics, in particular, are a big no-no here.

I suspect that battle scars still remain on Watson Hall at Lafayette College from a 1960 incident that I am familiar with. It seems that this capacitor, which was a key controlling part of a fall-weekend float competition, uh, blew up. At least that's what "some sources close to an associate of the barber of a usually reliable spokesperson" tell me. Fortunately, it was after we won.

Incidentally, this also was my first TV typewriter, having a one-character, six-foot-high display that serially spelled out "CRUSH LEHIGH." Watson Hall also used to have five floors, but that is another story.

Anyway, where were we? Oh yes; lets get back to the dangers of capacitive-reactance limiting.

The charge on a capacitor cannot suddenly change, so if you close the switch near an AC line peak, the full line voltage can appear briefly across your load! In this case, a 1.5-volt system has nearly 200 volts suddenly thrust upon it. Such an ugly transient can cause heavy damage, besides badly glitching your power line with a nasty spike.

A series posistor can help, but is not a cure. Thus, using a capacitor in series with a pilot light or LED might very much shorten the lamp's life, which is never a good idea.

Any series capacitor is largely a current regulator, so output voltage will shift badly with changing load. With no load, you end up with the full AC line voltage at your output! Because an electrolysis cell is supposed to be a constant-voltage device, that is not normally a problem. That is, until you are almost out of water.

This series capacitor is also a high-pass filter, so harmonics are emphasized. Your ninth harmonic gets relatively "amplified" by twenty decibels. Once I tried to use a series capacitor on a 400-Hz aerospace application and was amazed to observe huge seventeenth harmonic glitches. It turns out that they were highly "amplified" slot noise from the 400-Hz lab generator. Similarly, any spikes or transients get relatively "amplified" and raise havoc.

Last, and by no means least, use of reactance limiting is now illegal in Europe, and shortly will be in the United States. New stringent restrictions severely limit any harmonic or reactive energy you are allowed to take out of the commercial power line.

The maximum attainable current limiting values that you can get from either an inductor or capacitor are shown in Fig. 3. Safer and saner alternates to series capacitors are offline switch-mode-operation and the new power-factor-correction chips that are available from such sources as Maxim, Motorola, Unitrode, Burr Brown, Analog Devices, and many others. Details on new power-quality regulations appear in *Compliance Engineering* and *Power Quality* magazine.

Great New FM Service

Check http:wmbr.mit.edu/stations/locate.html for a free FM-station-online directory service. You can find out what that weak mystery station at 91.7 is with-

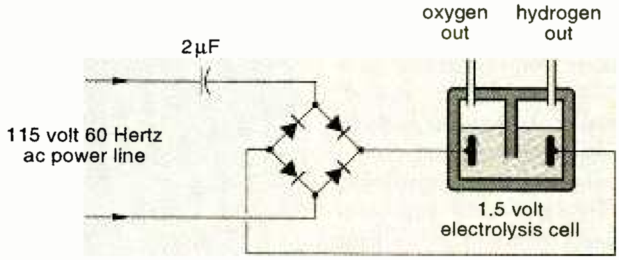


FIG. 2—BESIDES BEING ILLEGAL, what else do you see wrong with this capacitive reactance current limiter circuit?

out having to wait for call letters. You can make complete lists for every expected station in your area, local, distant, fringe, or manic.

If you are planning a trip, just enter the cities for each 30 miles into your route and extract a list of strong local stations to listen to. Better yet, print up a custom glove compartment book for every town that you are ever likely to visit.

We looked into FM DX tricks and techniques back in HACK86.PDF (available on www.tinaja.com). As a refresher, for local use, the best setup is an elevated ten element Yagi antenna and a 12-decibel line amplifier feeding a high quality receiver. Select one that lets you select a narrower mono IF bandwidth if needed.

You should note that local radio stations might have low-level spurs at wildly different frequencies. In my case, a local spur trashes Tucson's superb KXCI. Also, strong signals can cause cross modulation and may splatter stuff into unexpected places. So be sure your ultra-weak signal is not really just a nearby station in disguise.

Shades of Gray

There sure are a lot of "Webizens" questioning just how and why all of those "overunity" miracle motors are getting suppressed. A couple of older examples of that are called the Gray motor and the Adams motor, and there are a dozen or so other equally-improbable candidates.

The usual cause for suppression of a miracle motor is lab work that is so utterly and mesmerizingly awful that it is not even wrong. At that point, the developer will realize the error of his ways and will quietly move on to other things, or else, the supporters find working with a misguided and a wildly intractable "inventor" to flat out not be worth the hassle. Life is too short.

But given enough obstinance, the miracle motor eventually becomes a prime candidate for marketing as a "suppressed" pseudoscience rip-off, with the usual over-wording, murky copies, and shaky videos. And that is why miracle motors get suppressed: For the money. To date, there has never been any miracle motor that has been able to survive a diligent enough search for bad enough lab work. Miracle motors simply do not work.

There are several reasons for bad lab work. First and foremost is not understanding what true scientific experimentation, correct measurement, decent documentation, and realistic interpretation is all about. Second is confusing average and rms currents; ordinary AC meters lie like a rug! Third is failing to understand what counter emf is and how it works. Fourth is not getting an independent verification. Fifth, and the real killer, is failing to realize just how excruciatingly difficult it is to accurately measure real power, especially with strange wave-

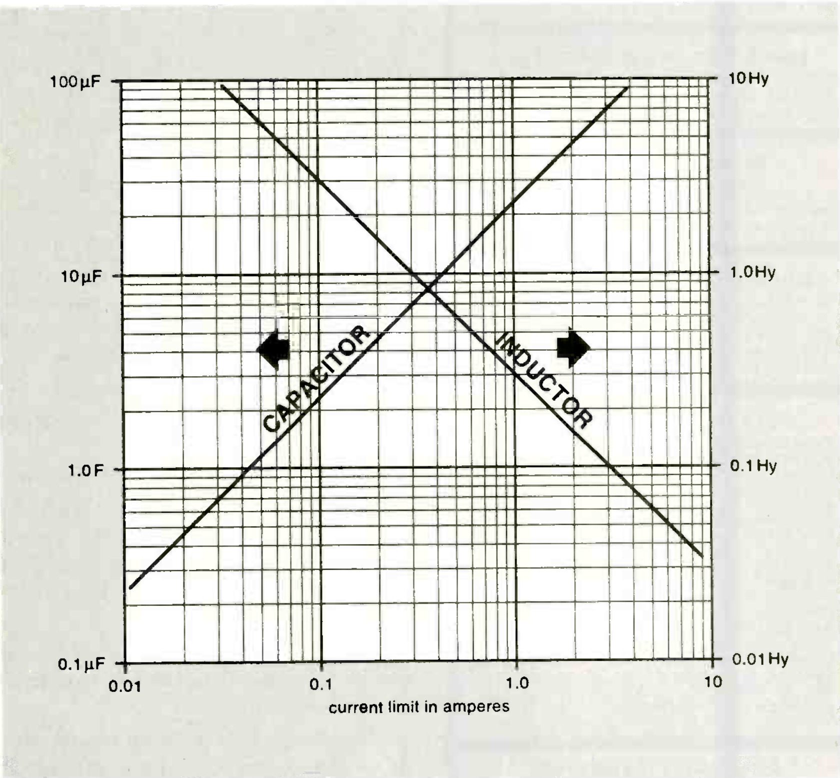


FIG. 3—MAXIMUM CURRENT LIMITING VALUES for inductors or capacitors connected to the 115-volt, 60-Hz, AC power line.

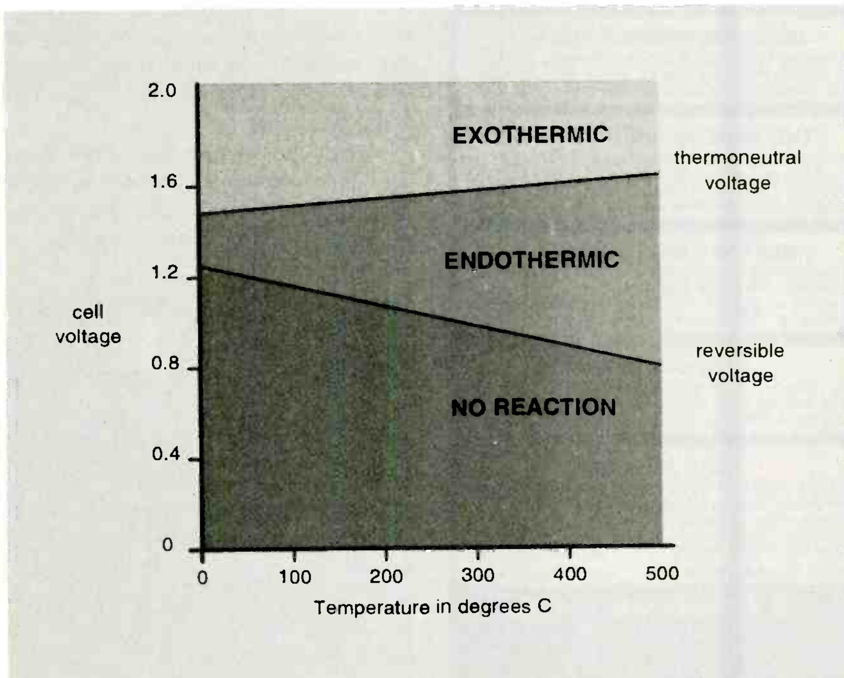


FIG. 4—NOT ALL HYDROGEN ENERGY need come from the electricity input to an electrolysis cell. Up to one sixth of the energy can sometimes come from waste heat instead. Sadly, this effect is more curious than useful.

HANDHELD-COMPUTING RESOURCES

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(206) 776-6758

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Cleveland, OH 44130
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Compsee
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Mt Gilead, NC 27306
(800) 768-5248

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Westboro, MA 01580
(508) 898-5000

Data Limited
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LaPorte, IN 46350
(800) 526-1299

Data Vision
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Ivyland, PA 18974
(800) 486-0620

Dynasys
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Westborough, MA 01581
(508) 836-8700

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Ventura, CA 93003
(805) 650-7888

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San Jose, CA 95134
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Nashua, NH 03063
(603) 881-8666

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Charlotte, NC 28227
(800) 782-4263

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(800) 347-2623

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Fairlawn, OH 44333
(330) 869-5555

Measurement & Control
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(412) 343-9666

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Dunedin, FL 34698
(813) 734-9175

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Cedar Rapids, IA 52401
(800) 553-5971

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(516) 681-5208

Portable Design
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(603) 891-0123

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Newton. MA 02158
(617) 964-3030

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Peterborough, NH 03458
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Plano. TX 75074
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(714) 365-5675

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Houston, TX 77036
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Texlon
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(210) 922-5377

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Uniform Code Council
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Dayton, OH 45458
(937) 435-3870

Warehouse Management
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Radnor, PA 19089
(610) 964-4000

Western Design Center
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Mesa, AZ 85203
(602) 962-4545

Wireless LAN Alliance
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Palo Alto, CA 94306
(415) 328-5555

forms, nonlinearities, sparking, noise, harmonics, fields, reactance, or subtle hidden effects.

Most of the casual free-energy enthusiasts often fail to pick up on a key point: The beginning electrical engineering students have spent over a century and a half perfecting bad lab work. They labor thousands of hours each day, year in and year out, creatively finding newer and better ways to trash up measurements, misinterpret results, fudge reports, or jump to wildly wrong conclusions. They are the undisputed all-time world champions at this.

You have to ask: "Why have all of these bad lab work professionals consistently failed to ever find even the faintest trace of some fumes of anything even remotely overunity, while doing so with proper training, tools, and environment?" If you want to convince me your miracle motor works, you've got to: (a) prove to me you know how to measure instantaneous real power; (b) Show me one net watt of long-term continuous overunity production; and (c) Show me acceptable and independent experimental verification.

All of that is from an engineer's point of view. A scientist would also insist on: (d) show me a peer-reviewed and refereed paper in a respected mainstream journal.

More on those miracle motors is located at www.keelynet.com and at www.eskimo.com/~billb. Lots more on motor efficiency is found at www.rmi.org and www.epri.com. Finally, more on the problems measuring real power can be found in MUSE112.PDF and more on a genuine new opportunity to legally improve AC-motor efficiency is www.tinaja.com/magsn01.html.

Handheld Data Acquisition

There are lots of small, dedicated computers being used these days to do everything from logging UPS deliveries to evaluating forest stands to entering bar codes to counting cows to warehouse-inventory applications. I thought we might gather some of the key players in this area together as our resource sidebar for this month. On one hand, all of these small handhelds do their job very well. On another, they always seem pricey and klutzily "behind the curve" compared to emerging general-purpose laptops and personal digital assistants. One major reason is high non-recurring engineering (or NRE) costs. Another is the restricted sales volume caused by fragmented niche markets.

The leading two trade journals in this area are *Automatic ID News* and *Portable Design*. Other useful magazines include *ID Systems*, *Sensors*, *Measurement and Control*, *Scan Tech News*, and *Pen Computing*. There are dozens of handheld data-computer manufacturers. Your two real biggies seem to be Data General and Fujitsu Personal Systems.

A pair of outfits having case-keyboard-LCD solutions are Two Technologies and QSI Corporation. Resellers of new and used gear are Ryzex Remarketing and Dynasys.

One fine Web site is Bar Code 1 at www.adams1.com/pub/russadam Included there are book lists and extensive web links. A second site with lots of tutorial information is www.mgfx.com. A third is Aha!'s links to mobile computing at www.ahasoft.com/complink.htm.

Key trade associations are AIM, focusing on automatic data collection and identification; WLANA, the Wireless LAN Alliance; and UCC, the Uniform Code Council. Let me know if I missed anybody important here.

Another Hydrogen Resource

One good but misleadingly titled book is *Fuel From Water*, by Michael Peavey and published by Merit Products. Lindsay Books now has it in stock at $20.

Yes, this book is clearly boom-rah boosterism that is way off scale on optimism, but it does have all of the needed numbers and solid research references you'll need to intelligently study hydrogen. There are even some accurate figures for the energy density of gasoline.

This text does point out something rather surprising: Under some rare circumstances, a hydrogen generator can

NAMES AND NUMBERS

Analog Devices
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(617) 329-4700

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

Compliance Engineering
1 Tech Drive
Andover, MA 01810
(508) 681-6600

Coriolis Books
7339 E Acoma Dr., #7
Scottsdale, AZ 85260
(602) 483-0192

Cypress Semiconductor
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San Jose, CA 95134
(800) 858-1810

Electronotes
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Ithaca, NY 14850
(607) 273-8030

Horn Speaker
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Mabank, TX 75147
(903) 848-0304

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Minneapolis, MN 55427
(800) 328-8456

Journal of Internet Law
1185 Avenue of the Americas
New York, NY 10036
(800) 638-8437

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Bradley, IL 60915
(815) 935-5353

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Sunnyvale, CA 94086
(800) 998-8800

Micro Linear
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San Jose, CA 95131
(408) 433-5200

Mobile Computing
29160 Heathercliff, #200
Malibu, CA 90265
(310) 579-3400

Motorola
5005 E McDowell Rd.
Phoenix, AZ 85008
(800) 521-6274

National Renewable Energy Lab
1617 Cole Blvd.
Golden, CO 80401
(303) 231-7681

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

Pem
PO Box 1000
Danboro, PA 18916
(800) DIAL-PEM

Power Quality
2742 Eastman Ave., #33-34
Ventura, CA 93003
(805) 650-7070

Qualcomm Inc
6455 Lusk Blvd.
San Diego, CA 92121
(619) 587-1121

Renewable & Sustainable Energy Reviews
1617 Cole Blvd.
Golden, CO 80401
(303) 384-6604

Snaptron
2468 E 9th St.
Loveland, CO 80537
(970) 663-2820

Synergetics
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Thatcher, AZ 85552
(520) 428-4073

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

Unitrode
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Merrimack, NH 03054
(603) 424-8610

return modestly more energy than is input as electricity. In a water electrolysis cell, there are two possible energy inputs, heat and electricity. Well, with optimum conditions, as much as one sixth of the energy needed to make hydrogen can come from waste heat; the details are shown in Fig. 4. At room-temperature electrolysis, you should find a threshold of 1.23 volts; below that point, no hydrogen is produced. There is also a thermoneutral voltage of 1.47 volts where all of the reaction electricity will get converted into splitting water without adding or removing heat.

Now for the neat part: Heat gets absorbed from the surroundings in an endothermic electrolysis reaction if you are between 1.23 volts and 1.47 volts. Above 1.47 volts, your reaction will become exothermic and excess heat gets dumped to the ambient environment. Your bottom line here: Burning hydrogen releases 79.3 watt-hours-per-mole of energy. But at its optimum production point, a mere 63.5 watt-hours-per-mole have to come from electricity while 13.5 watt-hours-per-mole could be extracted from the ambient heat energy. Thus, up to one sixth of the hydrogen that is produced can sometimes come from waste heat.

Sadly, this "one-sixth" gain only takes place at low currents and low production rates. You get a lot more hydrogen a lot faster with the higher-voltage, exothermic reactions. Any gain usually is swamped by resistive cell loses as well. Finally, you can bet that if the best electrolysis cell is endothermic, the best fuel cell would pretty much have to be equally exothermic.

New Tech Lit

From Texas Instruments comes two fat data books about *Data Transmission Circuits*. One is on communication controllers, the other on line circuits. From Cypress comes their *Universal Serial Bus Specification* manual and from Qualcomm, there's a brand new *Synthesizer Products* data book.

A thorough tutorial on solar cells appears in the March/June 1997 issue of *Renewable & Sustainable Energy Reviews*. Included is a detailed bibliography. Copies may be available through the National Renewable Energy Lab. The same journal also has a geothermal-energy update in it.

Bernie Hutchins' *Electronotes* has long been the finest electronic music-synthesizer newsletter. While lower profile than before, these are most definitely still being published. Back copies also remain available.

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ 85552
Tel: 520-428-4073

US email: don@tinaja.com
Web page: http://www.tinaja.com

A good Web gateway for wavelets is www.waveloe.org/wavelet/links.html.

Lots of new books this month. From Newnes, there's Stuart R. Ball's *Embedded Microprocessor Systems*. From Lindsay, his very own *Vacuum Tube Regenerative Receiver* book. From Jeff Duntemann's Coriolis Books comes great heaping bunches of new software development titles.

Are you looking for freebie samples? Available are Snap Shot dome switches from Snaptron, new flexible plastic netting from InterNet (whose company name is either a neat play on words or a really baaaad choice), and self-clinching fasteners from PEM.

Featured magazines for this month include *The Horn Speaker* on antique radio, a rather costly *Journal of Internet Law* newsletter, and *Mobile Computing* magazine.

For the insider secrets of starting up your own tech venture, pick up a copy of my *Incredible Secret Money Machine II.* Details can be found in my nearby Synergetics ad. You can preview parts of the text on my Guru's Lair site; the url for that is http://www.tinaja.com/ ismm01. html. Also there are scads of my other reprints, e-zines, and lots of carefully chosen annotated links. You'll also find full details of my new and fast InfoPack research service on the site.

Finally, a reminder that my Guru's Lair is now welcoming banner ads at a cost that can end up well under two cents per click-through.

As usual, most of the mentioned items should appear in the Names & Numbers or the Handheld-Computing Resources sidebars. Always look there before you call our US technical help line shown in the Need Help? box you'll find nearby. As always, I look forward to hearing from you. EN

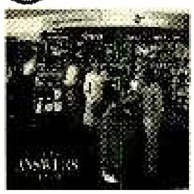
NEW LITERATURE

continued from page 61

1998 Answers Catalog

RadioShack
1500 One Tandy Center
Ft. Worth, TX 76102
Tel: 800-THE-SHACK
Web: www.radioshack.com

Free



CIRCLE 342 ON FREE INFORMATION CARD

The *1998 Answers Catalog* contains dozens of pages describing a large assortment of telephony products, such as corded and cordless phones, answering machines, caller-ID units, and cellular phones. In addition to telephones, the color-coded catalog divisions include a wide variety of products for home and office electronic needs: communications, audio, video, and computer equipment; as well as tools for the do-it-yourselfer, security devices, power controllers, adapters, clocks and weather meters, and automotive instruments. There's also electronic games and toys, and products for people with special needs.

Among the highlights of this catalog is the extensive line-up of telecommunications products and services offered by the Sprint Store at RadioShack, which will be located in more than 6,000 RadioShack stores and participating dealers nationwide. Featured among the Sprint products is the latest in wireless technology, the 100% digital Sprint PCS phone.

Readers of the catalog will find it serves as a handy reference tool for learning about electronics, with helpful how-to information on topics such as mini-satellite hookup. EN

PERFORMANCE TESTER

(continued from page 39)

sons. The unit must also be square with the vehicle. If the unit is not lined up properly, then the measured acceleration will be in error by the sine of the angle of offset.

Once the APT is installed and calibrated, you're ready for an acceleration test. Place the car on level ground and turn on the APT. Go into the g-meter function and check the level of the APT. Go to your favorite raceway, private road, or some place where you can accelerate to 60 mph from a standing start without breaking any laws or endangering others. Put the APT in the zero-to-60-mph mode and "Waiting to go" will appear on DISP1. Begin accelerating quickly. The APT is looking for a 0.2-g "kick" to signal the start of a run. When the APT detects the start condition, the display will change to "*xx* ft/sec," displaying the real time velocity of the car in ft/sec. When 88 ft/sec is reached, the APT will stop accumulating velocity and will print "*xx.xx* sec" giving you your zero-to 60-mph time.

Other uses of the APT are braking tests. You could use the g-meter function to determine the maximum braking force. Cornering forces could be read by rotating the APT 90° so that it can sense left or right forces.

Have fun, but be safe at all times. Remember that trying to read the APT while driving is dangerous. Have a friend read the unit while you are doing cornering tests. Ω

PARTS LIST FOR THE AUTOMOTIVE PERFORMANCE TESTER

SEMICONDUCTORS

IC1—LM2931AZ-5.0, voltage regulator, integrated circuit
IC2—MC68HC705P9, microcontroller, integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R6—10,000-ohm
R2, R4, R5—47,000-ohm
R3—10,000-ohm, potentiometer, printed circuit mount
R7—500,000-ohm, potentiometer, panel-mount
R8—1-megohm, potentiometer, panel-mount
R9—100,000-ohm

CAPACITORS

C1, C2—20-pF, ceramic-disc
C3—1-µF, 16-WVDC, electrolytic
C4, C6—0.1-µF, ceramic-disc
C5—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
DISP1—16-character liquid-crystal display (Digi-Key 73-1012-ND or similar)
J1—14-pin header (Mouser 512-QSD124 or similar)
S1—single-pole, double-throw, momentary-contact switch (Digi-Key CKN1007-ND or similar)
S2—Single-pole, single-throw switch (Digi-Key CKN1023-ND or similar)
XTAL1—4-MHz crystal
Analog Devices ADXL05EB evaluation kit (available through Allied Electronics, 7410 Pebble Drive, Fort Worth, TX 76118, Tel: 817-595-3500, Fax: 817-595-6444, Web: http://www.allied.avnet.com), IC socket, enclosure, PC board, ribbon cable, wire, hardware, etc.

Note: The following is available from Harrison R&D, 9802 Sagequeen, Houston, TX 77089, Tel: 281-485-7107, e-mail: dharrison@ghgcorp.com: Pre-programmed IC2, $25.00; Main circuit board, $10.00; Pre-programmed IC2 and main PC board together, $30.00; Complete source code for IC2 on 3½-inch diskette, $49.00 (Please specify either IBM or MacIntosh format). Please add $3.50 for shipping and handling to USA and Canada. Texas residents, add 6¼% sales tax.

JOYMOUSE

(continued from page 59)

those locations. When all of the components are installed, examine your work for any bad solder joints, solder bridges, or components that have accidentally been installed backwards.

You must decide how you want to mount the completed circuit. Two choices are presented here—a separate box that connects between the joystick and the computer or installing the circuit board inside the base of a joystick.

The connection diagram in Fig. 5 shows how to wire the Joymouse board if it is going to be installed inside a joystick. Since there are many different brands of joysticks compatible with the IBM PC, specific installation instructions are not possible. You must be able to find the correct signal wires that need to be spliced into the Joymouse. The main trigger button (button 1) will be the left mouse button. If there is an autofire circuit connected to the buttons, either remove the autofire circuit or connect the Joymouse button inputs to the input of the autofire circuit. The cable that connects the Joymouse to the computer's serial port should be the same length as the joystick's existing cable.

It is also important to include S1 if you want to be able to switch the Joymouse between joystick and mouse operation. One final item to remember is that if you decide to modify your joystick, you will void any existing warranty from the joystick manufacturer.

If you do not want to modify a joystick, the wiring diagram in Fig. 6 shows how to build the Joymouse into a stand-alone box that would connect between your joystick and the computer's serial and game ports. The female DB15S connector that the joystick will plug into can be mounted directly on the box. The game port and serial port connectors are best mounted on short cables. The rest of the stand-alone construction is similar to the joystick-modification method.

Testing the Joymouse. Turn your computer off, attach the joystick cable to the game port, and connect the mouse cable to the serial port used for a mouse. Adjust the trim tabs on the joystick to their center position and make sure that S1 is set to mouse operation. Turn on the computer and boot to Windows. The joystick should be centered while Windows is starting. The mouse cursor should be controlled by the joystick. Move the cursor around for

(Continued on page 104)

SUPPLEMENT TO ELECTRONICS NOW JANUARY 1998

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Stackable RS-232 Kits

Digital I/O - 12 I/O pins individually configurable for input or output. DIP switch addressable; stack up to 16 modules on same port for 192 I/O points. Turn on/off relays. Sense switch transistions, button presses, 4x4 matrix decoding using auto-debounce and repeat. **$32.00**

Analog Input - 8 input pins. 12-bit plus sign self-calibrating ADC. Returns results in 1mV steps from 0 to 4095. Software programmable alarm trip-points for each input. DIP switch addressable; stack up to 16 modules on same port for 128 single-ended or 64 differential inputs. **$49.00**

Home Automation (X-10) - Connects between a TW523 and your serial port. Receive and transmit all X-10 commands with your home-brewed programs. Full collision detection and auto re-transmission. **$38.50**

Caller ID - Decodes the caller ID data and sends it to your serial port in a pre-formatted ascii character string. Example: "12/31 08:45 850-863-5723 Weeder, Terry <CR>". Keep a log of all incoming calls. Block out unwanted callers to your BBS or other modem applications. **$34.50**

Touch-Tone Input - Decodes DTMF tones used to dial telephones and sends them to your serial port. Keep a log of all outgoing calls. Use with the Caller ID kit for a complete in/out logging system. Send commands to the Home Automation or Digital I/O kits using a remote telephone. **$33.50**

Telephone Call Restrictors

Two modes of operation; either prevent receiving or placing telephone calls (or call prefixes) which have been entered into memory, or prevent those calls (or call prefixes) which have "not" been entered.

Block out selected outgoing calls. Bypass at any time using your password. **$35.00**

Block out selected incoming calls. Calls identified using Caller ID data. **$46.00**

50 MHz Frequency Counter

Reads frequency from 1Hz to 50MHz and displays up to 7 digits on a 16 character LCD. Auto-range feature provides floating decimal point and automatic placement of suffix (Hz, KHz, or MHz). Microcontroller based provides for very small parts count, only 2" x 3" big. **$48.50**

IR Remote Control Receiver

Learns and records the data patterns emitted by standard infrared remote controls used by TVs, VCRs, Stereos, etc. Lets you control all your electronic projects with your TV remote. Seven individual I/O pins can be assigned to any button on your remote, and can be configured for either "toggle" or "momentary" action. **$32.00**

DTMF Decoder/Logger

Keep track of all numbers dialed or entered from any phone on your line. Decodes all touch-tones and displays them on a 16 character LCD. Holds the last 240 digits in a non-volatile memory which can be scrolled through. Connect directly to radio receiver's speaker terminals for off-air decoding of repeater codes, or numbers dialed on a radio program. **$54.50**

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4 Way Speaker Switch

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

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

"The Sound Bridge" FM Stereo Wireless Transmitter

HOT NEW ITEM!

The Sound Bridge is a mini FM wireless transmitter that can be used to broadcast stereo sound from any audio source like portable CD players, TVs, electronic games, CD-ROM, even computer soundcards, to your home stereo receiver! Adjustable from 89 to 95.5 MHz.

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Weller Professional Irons

Weller®

Perfect for a variety of electronic soldering work, this top quality iron features a long life, double coated tip and a quick change, plug-in heater element. Lightweight handle includes a comfortable cushioned grip. Net weight: 1/2 lb.

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#EN-372-112 (35 Watt) $38.90 (1-3) $34.95 (4-UP)

Peak Instrument Co.

"The Woofer Tester"

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

#EN-390-800 .... $249.00 EACH

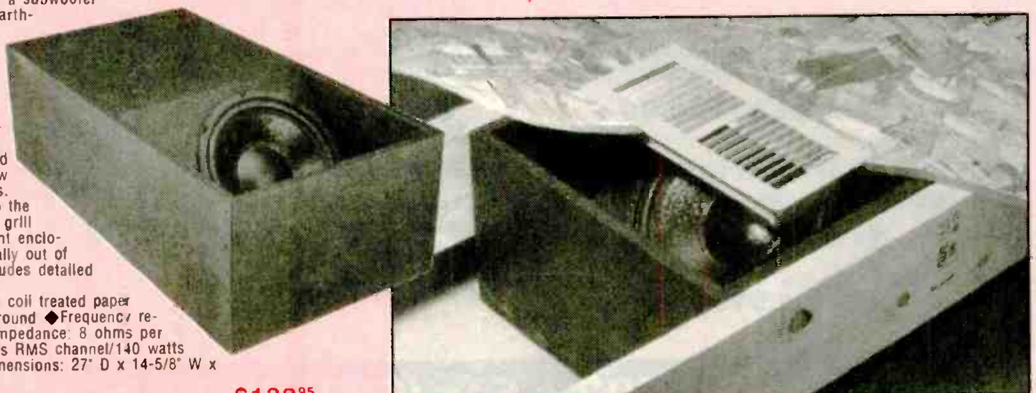
900 MHz Wireless Speaker System

- 900 MHz technology sends signal up to 180 ft., through walls, floors and ceilings.
- Ideal for use as rear surround speakers or for adding wireless sound to every room in the house!
- Full range, bass reflex design with built-in high power, low distortion amplifier.
- Weather resistant cabinet for outdoor use.
- Selectable battery (six C size for each speaker) or AC operation, adaptor included. Built-in recharging circuitry for ni-cad batteries.
- System includes: 900 MHz transmitter, wireless speaker pair, AC adaptors, and all cables necessary to hook up system.
- Limited availability. ◆ Net weight 9 lbs.
- Frequency response: 20-18KHz.

#EN-319-030 .... $169.95 EACH

Home Theatre In-Floor Subwoofer

Dayton Loudspeaker Co.®



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

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

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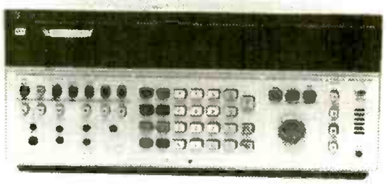

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Modulation Analyzer, frequency range 150 kHz to 1300 MHz, measures AM and FM to 1% accuracy, measures RF frequency and RF power. Completely automatic. Opt 001, HP-IB.

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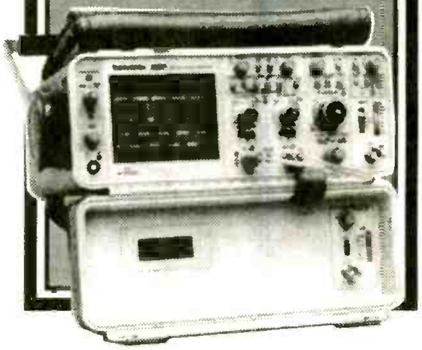

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LCR Meter, multi-function, 100 Hz to 100 kHz in 11 spot frequencies, 1 mV to 5 Vrms, 0.1%, high resolution 5.5 digit. Opt 002, 0 to ±99.9 V internal dc bias, resolution: 100 mV steps.

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Universal Time-Interval Counter, 11 digits/s freq. resolution, 20 ps single shot LSD, +100 ps accuracy achievable, frequency and period to 100 MHz, 8000 measurements possible, built-in stats functions.

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Spectrum Analyzer,10 kHz to 21 GHz, (capable of up to 325 GHz with external waveguide mixers, not supplied), nonvolatile memory storage, direct plot capability, keypad data entry.

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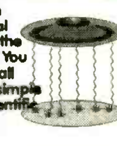

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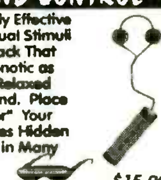

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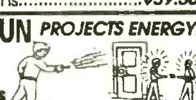

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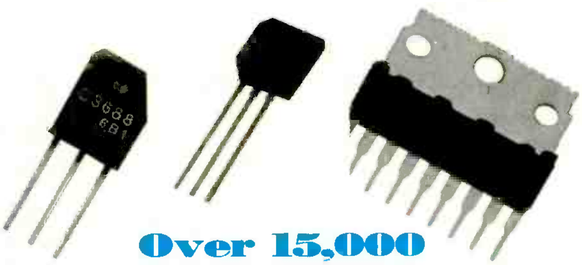

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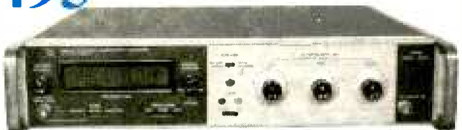

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500Khz to 1300Mhz $850

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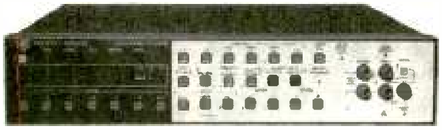
500Khz to 1500Mhz



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HP 3455A Digital Multimeter

The 3455A is a microprocessor controlled 5 1/2 or 6 1/2 digit intergrated voltmeter for bench or systems applications. The standard instrument measures dc volts, ac volts, and resistance. HPIB , auto, or manual ranging are also standard.

Hewlett Packard 5328A/031, 011

1300Mhz Universal Counter

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100ns or 10ns time intervals

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With option 011 HPIB

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60Mhz Bandwidth $1,050

2 input channels

Waveform Measurments

Full Programmability IEEE-488

5mV to 2000V

Included Accessories:

operators manual, 2 probes

Hewlett Packard 8654A Signal Generator

10 to 520Mhz

Calibrated output power

-130 to +10dBm output level

AM and FM modulation

$795

$995 Wavetek 270 Function Generator

The 270 is a compact and versatile 0.01Hz to 12Mhz programmable function generator. With a digital display the 270 can store up to 200 complete settings in memory for fast recall. Output amplitude 0.01 to 10V into 50 Ohms. This unit weights 14lbs.

Tektronix 1502/04 Cable Tester $1,295

AC or Battery Powered, With Chart Recorder

The Tek 1502 can provide 0.6 inch resoltion on short cables and up to 2000 feet of cable, but with decreasing resolution as distance increases. The unit is matched to 50 ohm cables, but may be used on others by adjusting the gain control.

Tektronix 465

100Mhz at 5mV/div

2 Channel $595

2nS/div Sweep Rate

X10 Sweep Magnification

Trigger View

Tektronix 475

200Mhz at 5mV/div

2 Channel $750

1nS/div Sweep Rate

X10 Sweep Magnification

Trigger View

Hewlett Packard 1630D *Logic Analyzer*

Timing analysis up to 100Mhz to check hardware and status signals.

State analysis at 25 Mhz to trace program and software flow.

Analog analysis at 200 megasamples/second to verify data voltage and time parameters.

Features: 43 channels, 1K memory, 3 clocks, demultiplexing, and HPIB,HPIL programmable

Including PODS $895

Hewlett Packard 141T Storage Mainframe

20Hz to 18Ghz depending on the plug-in.

6 plug-ins to chose from.

4 RF Sections and 2 IF Sections.

Absolute amplitude calibration

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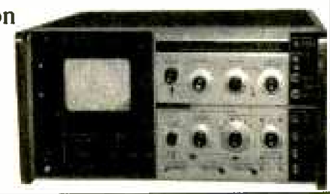
High resolution

$695 Price doesn't include new CRT



Tektronix 7603 System

- DC-75Mhz Bandwidth
- CRT Readout $595
- 6.5 inch CRT

Tektronix 7623A System

Storage Oscilloscope

- This mainframe holds 3 plug-ins
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Systems complete with 3 plug-ins: two 7A18 Amplifiers and one 7B53A timebase.

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Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

$19.00 any qty

DC Voltage (DCV)

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

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

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

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

Resistance (Ω)

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

Maximum Open Circuit Voltage: 2.8V

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

ohFE Test
Measures transistor hFE.
Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding, Calibrated in rms of a Sine Wave.

AC Voltage (ACV)

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

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

Special Offer!

The next generation of Digital Multimeters with 3-3/4 digits, 4000 count, auto-ranging and analog bargraph, 10MHz frequency counter, True RMS mode and RS-232C interface. **LIMITED TIME OFFER! You MUST enter your order by December 31st, 1997 to receive this special price!** Regular C.S.I. price $169.00. ***Plus we'll even include the optional temperature adaptor and K-type thermocouple probe! We even include the holster!***

CAT NO	DESCRIPTION	PRICE
PROTEK506	Digital Multimeter	$139.00

Developer

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

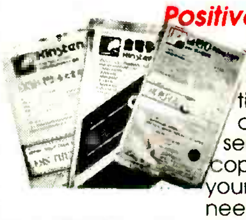
CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Chemicals/Ferric Chloride

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

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

Positive Photo Resist Pre-Sensitized Printed Circuit Boards



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

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

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

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

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

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

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

Etching Tank

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

REDUCES ETCHING TIME!

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

1/3" CCD Board Cameras

Available with **PINHOLE LENS** with **AUDIO**; **STANDARD LENS** with **AUDIO**; and **STANDARD LENS** with **INFRA-RED**. 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

Dimensions

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


WDP-2000


WDS-2005


WDI-4000

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 (no audio)	89.00	77.00
WDPH-55BW	Plastic Housing Option for B&W Board Cameras	13.00	12.00

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240x64 dot LCD with built-in controller.

AND 4021ST-EO. *Unit is EL back-lit.* $59.⁰⁰ or 2 for $109.⁰⁰ or
OPTREX. DMF5005 *(non back-lit)* $49.⁰⁰ or 2 for $89.⁰⁰
20 character x 8 line
7¼L x 2½H
The built-in controller allows you to do text and graphics.

Alphanumeric—parallel interface

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

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

Graphics and alphanumeric—serial interface

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

6" VGA LCD 640X480, Sanyo LMDK55-22 **$25⁰⁰**

LASER PRODUCTS

HeNe Laser Head (10Mw max. output) TEMOO. 15.5" long MFG: NEC **$89.⁰⁰**
Laser Power Supply (for HeNe tube) **$79.⁰⁰**

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

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

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

3 and 4mW, 1,300nm LASER DIODES, 5.6mm package, $15⁰⁰
Mitsubishi Electric part number ML701BIR-E21A, General specs are:
1. Vop=1.25, Beam Divergence 25.6° x 28.6°; 2. Tc=24°C, Iop=19 to 20mA, ITH=10.7mA; 3. Wavelength range between 1,280nm and 1,330 nm

POLYGON MOTOR UNIT & DRIVER $69⁰⁰
Ten-sided first surface mirror mounted on an armature that spins at 125 revolutions per second yielding a beam sweep rate of 1250 sweeps per second. The driver for the polygon unit requires 24 volts and plus and minus 12 volts to operate. There is also an f-theta lens in front of the polygon scanning mechanism with a three inch diameter. Great for optical experiments, etc. Very high quality units. (MFR: JAPAN ELECTRONICS)

POS & BAR CODE

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

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

POWER SUPPLYS

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

CHARGE COUPLED DEVICES

"The Spy In The Sky" $29.⁰⁰ **MATRIX TYPE**

Thomson 576X550 pixel CCD
400-1,100nm resolution and responsivity. **$500⁰⁰ Original cost device**

Sony CCD Imager - designed for black and white composite video cameras. Picture elements: 384 (H) x 491 (V) $29⁰⁰
Chip size 10.7 (H) x 9.3 (V) mm² • Unit cell size 23.0 (H) x 13.4 (V) um².
Ceramic 24 pin DIP package • Mfr: Sony, Part# 016AL

LINEAR TYPE

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

MISCELLANEOUS

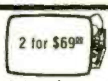
ADAPTEC 4070A (RLL) OR 4000A (MFM), SCSI Controller, your choice $25⁰⁰
IBM 370 option XT and AT emulation boards $25⁰⁰

MONITORS

Non-Enclosed TTL

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

5" COLOR MONITOR $39.⁰⁰



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

9" COLOR SVGA MONITOR $249.⁰⁰

Fully Enclosed – Tilt and swivel type.

HACKER CORNER

Encased Spread Spectrum RF Modem $199⁰⁰

The ProxLink Radio Module is a small communication device which replaces cables between RS-232 devices with wireless RF (Radio Frequency) technology. Attaching a pair of ProxLinks to any two devices with three wire asynchronous RS-232 ports allows wireless data transmittal at rates up to 19.2 Kbaud (full duplex) over a range of 500 - 800 feet. Modules use 900 MZ spread spectrum radio for communication which does not require an FCC site license. A variety of configuration information (radio channel, baud rate, serial port configuration, etc.) can be programmed into module's non-volatile memory by host PC to provide compatibility and avoid overlapping systems. Configuration changes are supported by menu driven, on-board software. Commonly used Terminal Emulation software and transfer protocols can be used for configuring modules and transferring data between computers. ProxLinks require only 6-9 VDC (350 mA), RS-232 (9 pin sub - D) interface, and small (~ 4") whip antenna for operation. Unit size is 4.0" x 6.5" x 0.75". Installation schematics and application details available.

US made Micronics 486 VLB ALL in ONE $39⁰⁰ or 2 for $69⁰⁰
motherboard, supports 3.4 or 5V CPU, at either 25 or 33 mhz basic clock. Can use AMD or Intel from 486SX25 thru 486DX4-100 to HOT new AMD 5X86-133 cpu. On board SVGA video. On board 1 meg video ram expondable to 2 meg with ATI Moch 2 chip set. On board 2 high speed seriol ports, 1 printer port, floppy and IDE hard drive controller, On boord 256K cache. Uses 72 pin simm memory. Landmark speed rating of 479 with AMD chip.

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

COLOR CCD CAMERA $149⁰⁰

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

SONY Miniature Color LCD Display (LCX005BKB) $29⁰⁰

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

CELL SITE TRANSCEIVER $49⁰⁰ 2 for $99⁰⁰

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

Encased Black & White Composite CCD Camera with Adapter

1R viewing to 1000 nm 7 ½ L x 2 ¾ W x 1 ¼ H
Comes complete with CCD camera, mounting nut on bottom of casing, 12VDC power supply. Excellent low light capability, standard RCA NTSC video out. **$89.00**
Great for: entryway security/remote monitoring, video conferencing/desktop video conferencing **2 for $159.00**
This miniature camera is perfect for multimedia computer applications as well as security and surveillance. NTSC output allows use with all popular video digitizing boards for Apple Macintosh and Microsoft video for Windows. Connects directly to any composite monitor or VCR with "video" input. Its razor-sharp wide-angle lens focuses from two inches to infinity and its state-of-the-art CCD technology accurately captures 16 level grayscale images for Quick Time movies and still pictures. Records at 30 frames per second and 260 lines resolution with excellent low light capability. Uses 12VDC (adapter supplied) and standard RCA cable.

POINT OF SALE BANK TERMINAL $39⁰⁰ or 2 for $69⁰⁰

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

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CIRCLE 275 ON FREE INFORMATION CARD

Does your Desoldering Tool really SUCK?

If not, try one of my two favorites.

I have attended many trade shows worldwide in the last few years and these are the top two Desoldering Tools that I have found. You have probably seen the testimonials on the **DEN-ON SC-7000Z** in the last several issues. If you wish to see a copy or referrals from technicians in your state, call toll free and we will fax it to you immediately.

New Features and Specifications

- Totally Self Contained diaphragm vacuum pump and AC motor (In the handle) for high vacuum suction or reversible hot air blow for SMD removal.
- 100Watt Ceramic heater with zero-crossover switching heater control circuit which prevents spikes and leakage currents.
- Unique patented long lasting filter cartridge design. Solder builds up on easily cleaned baffle, while air flows around the outside of baffle.
- Totally ESD Safe. The housing contains carbon and the tip is at ground potential for complete ESD Protection.
- Maximum vacuum of 650mmHg is attained in 100 milliseconds.
- Temperature adjustable from 300°C - 500°C (572°F - 932°F).

- **Voltage**——AC100v,120V,230V,50/60HZ
- **Power Consumption**——120W
- **Pump**——Diaphragm Type
- **Motor Output**——2W
- **Vacuum Attained**——650mmHg
- **Temperature Range**——300°C—500°C (572°F—932°F)
- **Air Flow Rate**——15 Liter/Minute (Open)
- **Heater**——100W (Ceramic)
- **Control System**——Feed Back Zero Cross-over Type
- **Net Weight**——420Grams

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EDSYN has redesigned and improved their most popular ZD500 SOLDA-PULLT Hot Tip Self-Contained Desoldering Station and renamed it the ZD500DX .

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⇒ Updated modular design for easier maintenance.
⇒ Adjustable trigger and head assembly for comfort and ease of operation.
⇒ Wide range of tips available for all applications.
⇒ Vacuum Pump starts when handle is lifted from holder, thereby placing full vacuum at the trigger switch waiting for the trigger to be depressed. This allows for increased performance over conventional competitive models.

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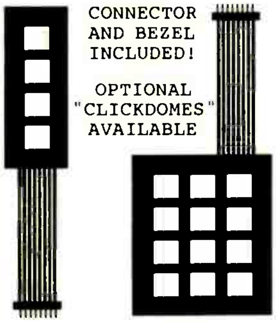

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Modern computing and standard surge suppressors...a recipe for disaster.

Almost all surge protection devices use MOV's (metal oxide varistors) as their active element. MOV's are sacrificial/wear/limited life components. Surge suppressors based on this technology are doomed to failure. These surge "suppressors" also don't suppress a thing. They divert powerline surges equally to the ground and neutral wire. When you put current on the common ground wire of interconnected equipment some of that current will flow (through the inherent ground loops) to the data lines. This is a major cause of lock-ups and misoperations that plague today's computer environments. Another fact; all modern computers use switch mode power supplies. During surges the power supply capacitors must charge to the clamping level of the MOV before the MOV turns on. A recent study has shown that it takes a 3000A surge 15 microseconds (15,000 nanoseconds) to charge the typical capacitors of these power supplies to that level. The surge is virtually over before the MOV reacts. ***(See five things you probably don't know about your surge suppressor at www.fivethings.com.)***

THE POINT: Standard surge suppressors allow too much current to hit the computer. Standard surge suppressors divert surge current to the ground wire and disrupt data transfer. Standard surge suppressors eventually fail without warning. Modern computers have logic voltage levels (the signals that transmit the data) and power supply voltages that are dramatically lower than that of their recent predecessors. Modern computers use integrated circuits with transistors of ever decreasing physical geometries. Modern computers are virtually always interconnected to other computers or peripheral equipment. The bottom line; ***modern computers are much more sensitive and susceptible to powerline anomalies.***

INTRODUCING BRICK WALL SURGE FILTERS. . .

The World's Best Surge Suppressor

Initially engineered for critical, non-fail industrial applications, this patented device protects indefinitely and sets a new standard for every measure of surge suppressor and powerline filtering performance.

A Brick Wall 1) Utilizes *NO MOV'S* or Any Other Sacrificial Components (a two pound inductor and nine capacitors are the heart of the unit) 2) Has No Joule Rating or Surge Current Limitations *3) HAS BEEN TESTED AND CERTIFIED BY UL TO THE MOST DEMANDING CLASSIFICATION OF A NEW GOVERNMENT SPECIFICATION; CLASS I, GRADE A. Which Means: UL PUT ONE THOUSAND 3OOOA, 6000V SURGES (this is the largest surge an interior environment can experience) THROUGH A UNIT (at 60 second intervals) AND DOCUMENTED NO FAILURE OR PERFORMANCE DEGRADATION OF ANY KIND WHATSOEVER.*

i.e.: A Brick Wall Will Not Fail.

We know of no cord connected, MOV based surge protection device that has, or can pass this test.

A Brick Wall possesses UL's lowest Suppressed Voltage Rating (let-through voltage) of 330V. This is the lowest rating they will grant. In that test of one thousand 6000V, 3000A surges, *UL NEVER SAW THE LET-THROUGH VOLTAGE EXCEED 290V. YOU CANNOT DO BETTER THAN THIS FOR A POINT-OF-USE SURGE PROTECTION DEVICE.* Once again, we know of no other surge protection device that could come close to this performance level.

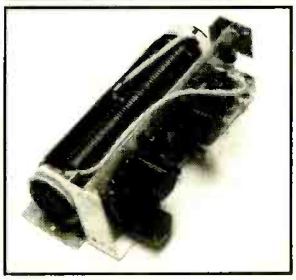
A Brick Wall is a current activated *Series Mode* device. *Since it is not wired in parallel, nor voltage activated, it does not have to wait for the capacitors of the power supply to charge before it becomes effective. YOUR EQUIPMENT IS PROTECTED INSTANTANEOUSLY (and indefinitely).*

These devices were engineered utilizing a current limiting/surge filtering technology. *THEY DO NOT DIVERT ANY SURGE CURRENT TO THE GROUND WIRE. They Will Not Cause Your Computer System To LOCK-UP, CRASH OR MISOPERATE as a consequence of surge diversion. Your current surge "suppressor" will.*

Powerline Filtering

In addition to all this, Brick Wall Surge *FILTERS are the best AC powerline filters you can buy (that we have been able to find anyway). Industrial machinery, copiers, coffee makers, laser printers, fluorescent lights, refrigerators, etc., all cause powerline noise that can cause your computer to misoperate. A Brick Wall Surge Filter will make powerline noise related problems disappear.*

You Can't Buy a Better Surge Protection/Powerline Filtering Device...Anywhere.



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EEPROM DATA MEMORY	NONE	64
PROGRAM MEMORY	768 OTP	1K FLASH
MATH REGISTERS	1	32
MAX INSTRUCTIONS / SEC	5M	20M
MAX COUNTER BITS	16	18
INPUT / OUTPUT BITS	12	15
A TO D COMPARATOR	NO	YES
HARDWARE INTERRUPTS	NONE	3

PINOUT:

RESET	1	20	VCC
PD0	2	19	PB7
PD1	3	18	PB6
XOUT	4	17	PB5
XIN	5	16	PB4
PD2/INT	6	15	PB3
PD3	7	14	PB2
PD4/TMR	8	13	PB1/AD1
PD5	9	12	PB0/AD0
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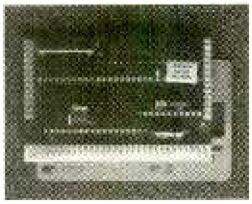

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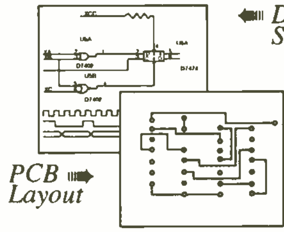

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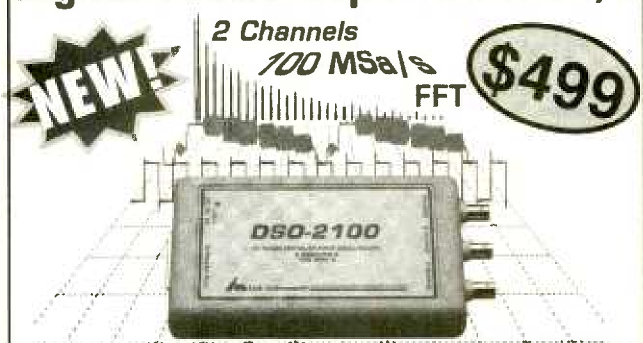
Digital Oscilloscope 100 MSa/s



- 2 Ch. Digital Oscilloscope
- 100 MSa/s max single shot rate on both channels
- 32K samples per channel
- Advanced Triggering
- Easy to use Windows and DOS software included
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- **Parallel Port** interface to Laptop or Desktop PC
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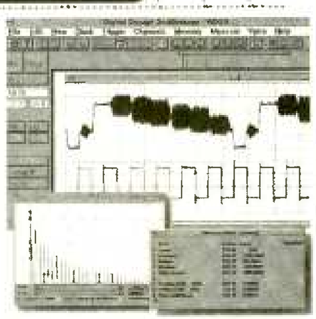

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JOYMOUSE

(continued from page 72)

a while to get used to the way the Joymouse works. The cursor will keep moving as long as the stick is displaced from center so you have to start moving the stick back to the center just before you reach your target.

Try adjusting the sensitivity of the mouse driver for cursor speeds that suit you. If you still want a slower cursor, add the "H" jumper on the Joymouse board. If the cursor slowly drifts while you have your hands off the joystick, you might need to increase the size of the deadband by adding the "D" jumper on the Joymouse board.

The two test points on the Joymouse are controlled by the Joymouse software subroutines. Test point TP1 goes high whenever the joystick resistances are being measured, and TP2 goes high whenever a mouse-data packet is being transmitted. In addition to showing that those functions are running, the test points can also be used to synchronize an oscilloscope. That will let you watch the comparator circuits and the RS-232 interface. Ω

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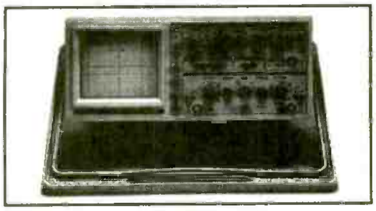

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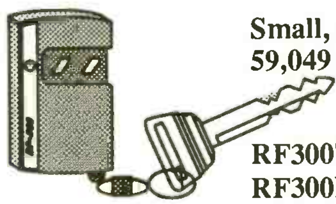

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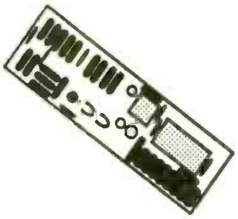

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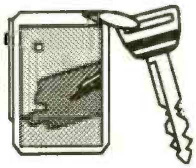

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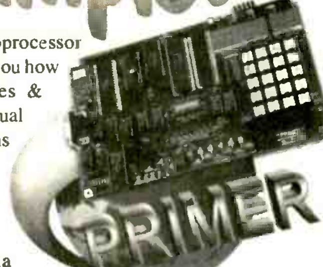
Learn by Example!



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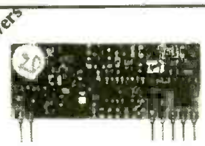

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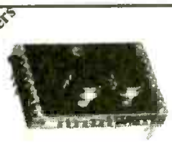
Transceivers



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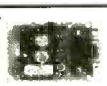

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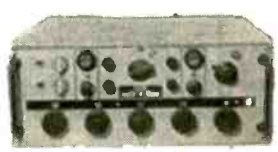

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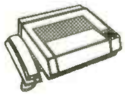

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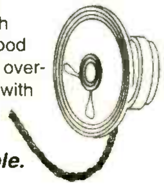

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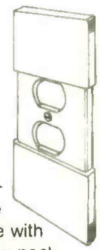

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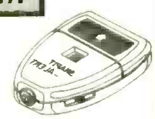

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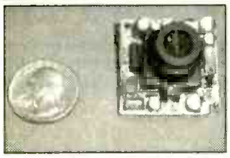

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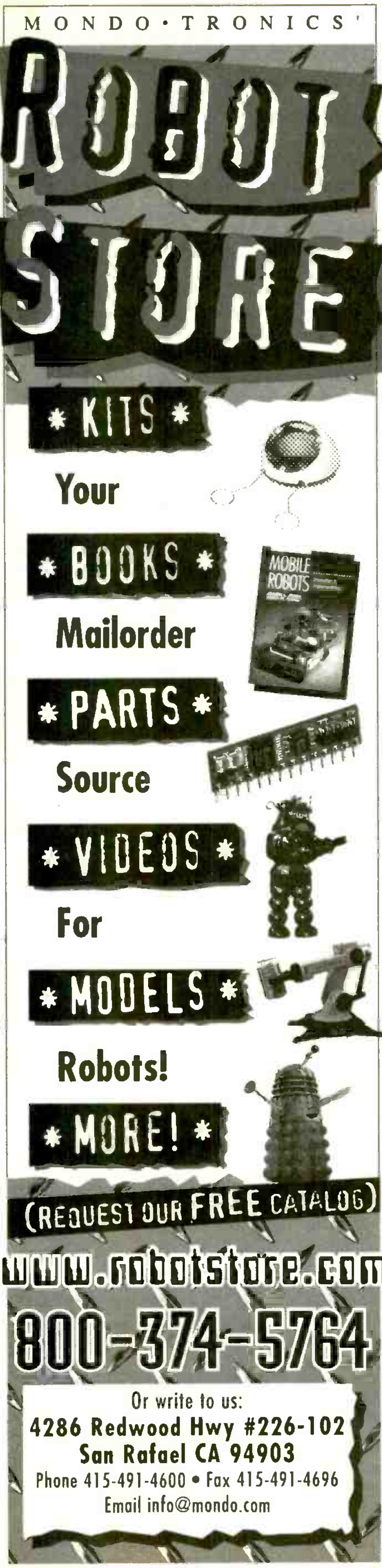

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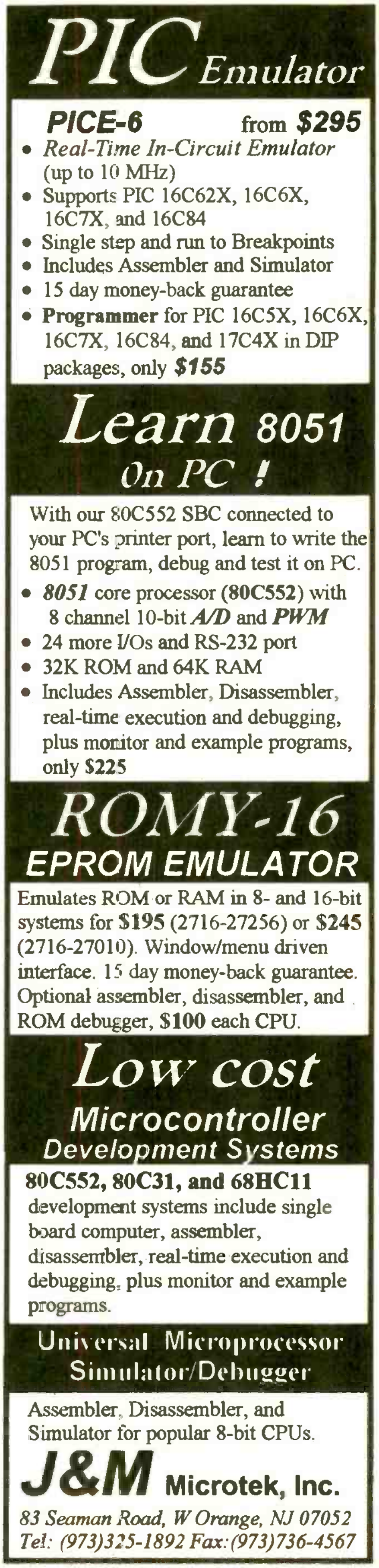

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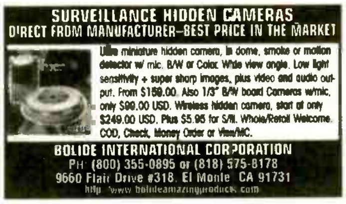

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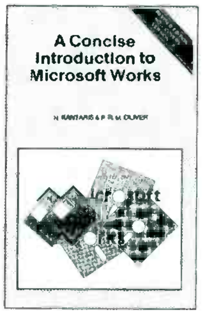

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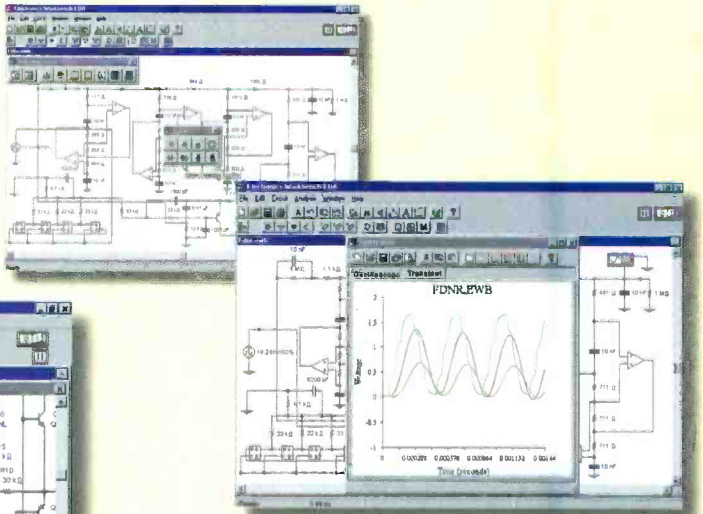

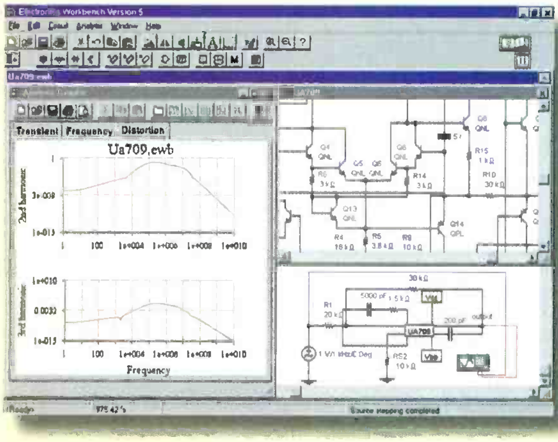

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