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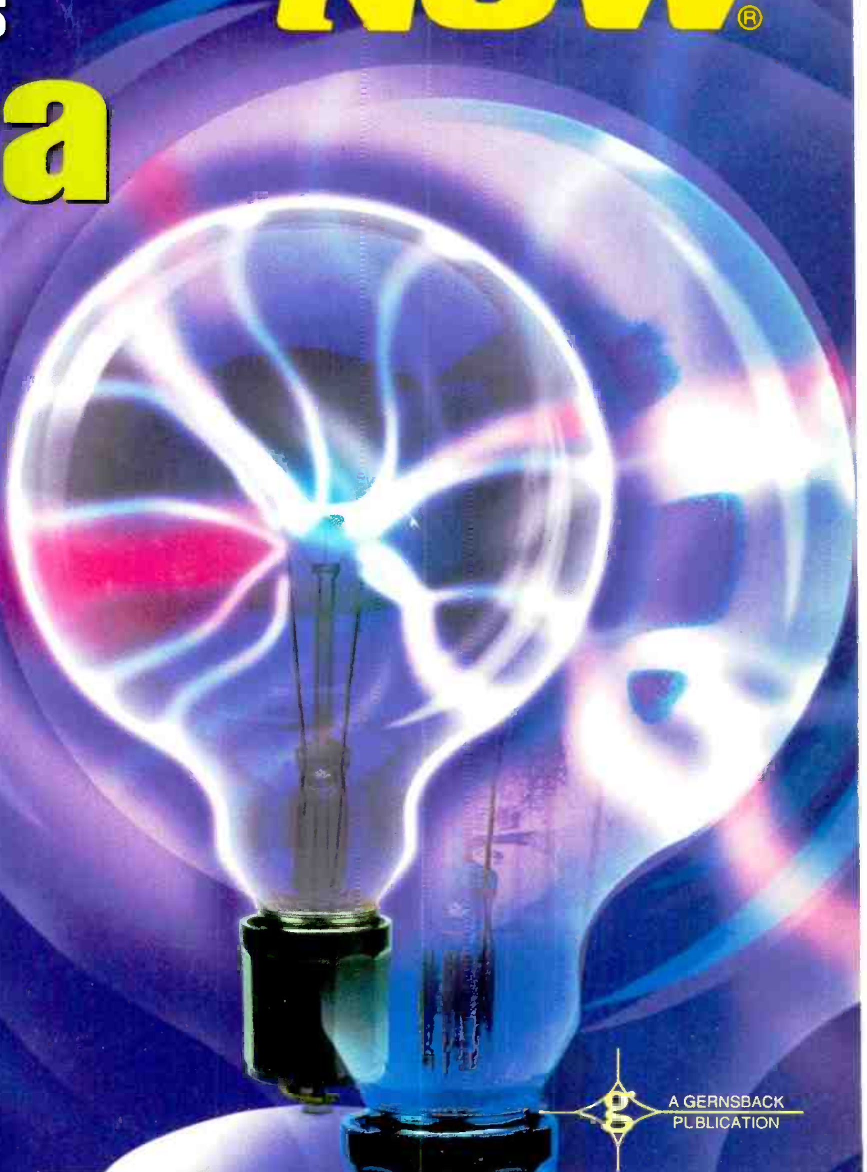

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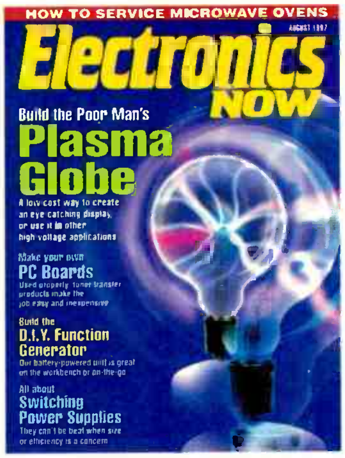

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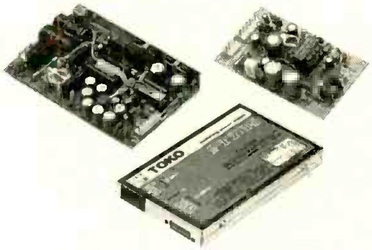

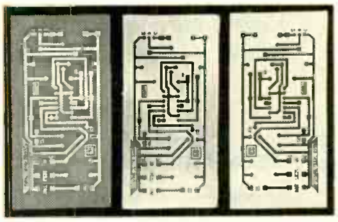

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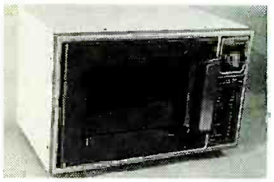

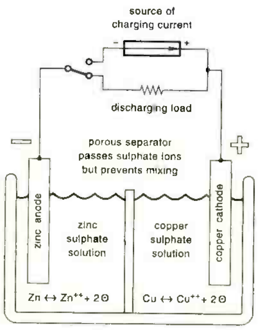

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EDITORIAL

Don't Miss Out

Most of you are familiar, no doubt, with the Free Information card that's included with every issue of this magazine. And if you've used it, you have probably noticed that there's usually a question or two on it to help us learn more about our readers' interests and activities.

Recently, we asked "Do you use the Internet?" While a little over half who answered said that they did, nearly 49% said they did not. That result both surprised and disappointed me. If you are an electronics hobbyist and are serious about what you do, by missing out on the Internet, you are missing out on a golden opportunity.

Once, every city of any size had its own "Radio Row" where you could go to find just about any component you might need for just about any project. Unfortunately, those Radio Rows pretty much disappeared decades ago. The result is that it has become increasingly difficult for hobbyists to find the parts that they needed. But, thanks to the Internet, there's now a "cyber" Radio Row. Parts distributors ranging from the behemoth catalog houses to small mom-and-pop operations can be found on the Web, and most offer on-line catalogs and ordering. If a part exists, you are almost sure to be able to track down a source for it on the Internet.

But even more important are the information resources. Regardless of your area of interest, you are sure to find Web pages, mailing lists, and other resources to learn more about it. Service Editor Sam Goldwasser's sci.electronics.repair FAQ Web page (http://www.paranoia.com~filipg/REPAIR/) is just one example of the kind of resources that can be found.

And almost every component manufacturer has a site on the Web. There you can find product information, data sheets, application notes, and much more.

Finally, let's not forget our fellow hobbyists. Do you have a question that you just can't get answered? Why not ask it on the appropriate sci.electronics newsgroup? If there's an answer out there, someone is almost sure to help. There's also the discussion forums on our own www.gernsback.com site, where you can interact with your fellow **Electronics Now** and **Popular Electronics** readers.

Yes, I know that Internet access can be costly, but it can also be surprisingly affordable—as little as $5 a month for limited access through several major providers, or even free through one of the many regional "freenets" or through many local public libraries. If you already own a computer—and most of you do—missing out on one of the greatest opportunities ever made available to our hobbyist community would be a shame.

Carl Laron
Editor

Where do more people go for electronics accessories?

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WHAT'S NEWS

A REVIEW OF THE LATEST HAPPENINGS IN ELECTRONICS

Chip-Mounted Biology Lab

Biomedical researchers at the University of Michigan (Ann Arbor) have developed a microchip that can analyze DNA immediately using just a small blood sample. The device might one day replace many of the expensive, less reliable, time-consuming, and anxiety-generating medical, diagnostic, and genetic testing procedures used today. For instance, a doctor could quickly scan a pregnant woman's DNA to determine on the spot if her baby was healthy, or determine if a patient's illness could be treated by antibiotics.

Current DNA testing requires a complete molecular biology lab and a minimum of ten individual procedures that must be performed by highly skilled technicians. David Burke, assistant professor of human genetics at UM, explains, "Our goal is to automate the process by, in essence, shrinking the lab to fit on one silicon microchip."

In the research program supported by the National Institutes of Health, Burke and his colleagues micro-fabricated components and integrated them into a DNA-analyzing chip just three centimeters (about one inch) long and one-half centimeter wide. A thermocapillary pump mixes drops of pure DNA with an enzyme solution and drives the DNA through five different components on the microchip.

Conventional techniques are used to fabricate the device, so it should be easy to produce in large quantities, according to Carlos Mastrangelo, assistant professor of electrical engineering and computer science. Before mass-production can become a reality, however, significant technical problems related to handling such small amounts of liquid, and interactions between liquids and solids in the chip must be solved. Once those issues have been resolved, the "biology lab on a microchip" could open up the technology of DNA analysis to wider applications in population-based genetic studies, forensics testing, water analysis, agriculture, and biology, according to Mark Burns, associate professor of chemical engineering.

Striving for Internet Affordability

CEMA, the Consumer Electronics Manufacturers Association (Arlington, VA), has become an active member of the Internet Access Coalition—a group that includes industry powerhouses such as AOL, Apple, Compaq, CompuServe, Digital Equipment Corp., IBM, Intel, Microsoft, Netscape, Novell, Oracle, and Sun Microsystems—in its fight against attempts by some telephone companies to impose "access charges" against Internet access providers. Both groups are concerned that additional charges would be passed on to consumers, ultimately inhibiting Internet use.

"We cannot allow local telephone companies, which already gain substantial revenues from PC modem connections, to impose further financial burdens on U.S. consumers," said Gary Shapiro, CEMA president. "In this exciting age, when our members are producing Internet-accessible TVs, phones, pagers, and computers, we must . . . ensure that all consumers can enjoy affordable access to the wonders of the Net."

In a tentative decision made late last year, the Federal Communications Commission decided not to allow phone companies to assess new charges. The FCC is seeking public comment on that tentative ruling, and also on the need for local telephone companies to provide alternatives to voice telephone switches for handling data traffic. The Internet Access Coalition supports the creation of competition to encourage the deployment of new digital technologies such as ADSL (Asymmetric Digital Subscriber Line) and HDSL (High-bit-rate Digital Subscriber Line) that can provide consumers with high-speed Internet access while eliminating any potential burden on local voice telephone networks.

Meanwhile, in early May the FCC made the Internet more affordable to educational institutions by approving a plan that gives schools and libraries discounts on Internet access that range from 20% to 90%. A maximum of $2.25 billion per year will be made available. The funds, which will be raised by charging fees to telecommunications companies, will be distributed according to the relative wealth of the school districts that apply. Private schools are also eligible under the plan. Application forms will be available in the fall, and the program is scheduled to begin in January 1998.

"For any school that has or hasn't started to put themselves onto the information superhighway, this should prove a serious incentive to get on it or increase the degree to which you make technology an integral part of every student's education," said FCC education task force director Jamie Rubin.

NEC-Compliance Software

A team of researchers at Georgia Tech's School of Electrical and Computer Engineering, headed by Dr. A.P. Sakis Meliopoulos, has created a software package that eliminates the guesswork when determining whether electrical designs comply with the equipment-grounding requirements of the National Electrical Code. Developed in cooperation with the National Electrical Manufacturers Association (NEMA), the software updates the information on grounding developed by Eustes Soares, which has been used as a primary design guide for years.

Validated by full-scale testing, the Steel Conduit Analysis (SCA) software enables electrical engineers, system designers, electricians, and inspectors to confirm design parameters of grounding systems that use steel electrical conduit. It facilitates the comparison of EMT, IMC, galvanized rigid conduit, and conductors stipulated in NEC Table 250-95 to determine the optimum combination for the desired run.

The program's graphical user interface allows analysis of a single steel-conduit system, or steady-state analysis of an electrical-power system, with or without steel conduit. The power system might include three-phase elements as well as non-symmetrical three-phase elements or single-phase elements. The software can be used to validate old electrical-system runs, accurately calculate new system designs, evaluate different system set-ups for code compliance, calculate ground/fault design with greater precision, and lower cost without sacrificing safety. The software, which costs $150, is available from Georgia Tech Research Corporation (Office of Technology Licensing CRB Building, 400 Tenth Street, Atlanta, GA 30332-0415; Tel: 404-894-6287).

Fingerprint-Verification Software

An automatic fingerprint-verification system developed by PrintScan International Inc. is being used by the Erie County Holding Center in Buffalo, New York as part of a new way to process prisoners and prevent unauthorized discharges.

"With today's overcrowded detention facilities, the wrong person can be discharged occasionally because of a common last name or a physical resemblance to the person who's *supposed* to be leaving the center," said Thomas F. Higgins, Sheriff of Erie County. "Or the papers could get mixed up. It's happened four or five times in the last several years."

Overworked staff in over-crowded prison facilities can't give every released prisoner the careful scrutiny that might be required to spot an impostor. Sheriff Higgins expects the Jail Management System to reduce incorrect discharges to zero.

PrintScan software, installed on a PC at the end of the processing line for incoming and outgoing inmates, reduces each prisoner's fingerprint to an algorithm, capturing an average of 15 to 18 points (or "minutiae"), which are encoded in a database. The PrintScan system uses "coincident sequencing"—a process of capturing and comparing fingerprint minutiae that is the only one recognized by law-enforcement agencies worldwide as proof positive of a person's identity. A fingerprint scanner is used to capture an encoded record of each inmate's finger when he is processed upon entering the holding center.

Upon discharge, the prisoner places the same finger on the scanner, where its image is compared to the stored print—or, more accurately, the stored algorithm is compared to the new algorithm presented by the live fingerprint. The process takes a fraction of a second.

The software differs from other programs that rely on the SAFIS (state automated fingerprint identification system) database in terms of accuracy and efficiency. With SAFIS-based systems, Higgins explained, "when you submit a fingerprint for a match, you might get 40 similar patterns out of a huge database containing millions of prints. Then you have to sit down and manually compare each one until you believe that a match exists. PrintScan completely eliminates this tedious process and its inherent subjectivity."

Low-Cost Thermally Conductive Substrate

The manufacture of many new electronic devices demands materials with high thermal conductivity and good dielectric properties—traits that appeared to be mutually exclusive due to the specific nature of existing materials. Aluminum Nitride Composites (ANC), developed by Advanced Refractory Technologies, Inc. (ART) of Buffalo, New York, address the electronic/electrical industry's need for one material that possesses both good thermal conductivity and a low dielectric constant. ANCs provide the thermal conductivity benefits of aluminum nitride (AIN) with the low dielectric constants of polymers.

By prefabricating a network of AIN, the company was able to create a high-performance composite that incorporates both AIN and a polymer. The technology differs from traditional AIN fabrication in that the AIN is fabricated into a porous preform into which a polymer is infiltrated, thereby creating a dense structure with higher thermal conductivity than that attainable via traditional methods. And, also unlike traditional AIN, ANC does not require exotic fabrication facilities or methodologies, allowing it to be relatively low-cost.

"We expect that ART's ANC will be of interest for applications wherever the unique combination of good thermal conductivity and thermal properties is required," said ART's director of technical marketing, Donald J. Bray. That includes electronic substrates and packaging, other microelectronic applications, insulators for electrical switches and other components, high-performance gaskets, and radar windows.

The properties of ANC include moderately high thermal conductivity (2545 W/mK), low dielectric constant (5–7), a CTE approaching that of silicon (4.3 10^{-6}°C), and good electrical resistivity (1014 ohm-cm). A unique benefit is the ability to tailor the ANC for a specific application by choosing a particular polymer that, in combination with the AIN perform, provides the desired properties.

12-inch Silicon Wafers Sought

Sematech, the consortium of American semiconductor manufacturers, Austin, Tex., is sponsoring an international group to design silicon slices or wafers that are 12 inches in diameter. These wafers are expected to permit more economical manufacture of ever larger, next-generation chips. The largest wafers now being produced have diameters of 8 inches.

The new group is called the 300 Millimeter (12 inch) Initiative because of the diameter of the new wafer. It will consist of manufacturers from the United States, Asia, and Europe. The joint research on larger diameter wafers is motivated by the increasing cost of manufacturing very large-scale integrated circuits. Most ICs are now made on 6-inch wafers, but the most advanced manufacturers use 8-inch wafers.

Intel Corp. developed 6-inch wafers, but Micron Technology Inc. and IBM pioneered in 8-inch wafers. However, the cost of developing the larger wafers is now prohibitive for even the largest IC manufacturer working alone. The objective of the research is to grow even larger diameter silicon boules with a minimum number of defects so that irregularities in the wafers will not be a cause for device rejection.

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

More About Hard Drives...

In the April 1997 installment of Q&A, a reader asked how to install a Miniscribe 8051A hard disk, with 16-bit IDE interface, in an 8-bit 8088-based PC clone. We said it couldn't be done. Reader Kinge Okauchi writes to tell us that JDR Microdevices sells a special IDE adapter for just that purpose. You can reach JDR at 1850 South 10th St., San Jose, CA 95112, or http://www.jdr.com.

...and Frequency Displays

The March installment of Q&A dealt with how to add a frequency display to an old-style analog radio receiver. Reader David McKnight points out that the 1997 *ARRL Handbook for Radio Amateurs* gives plans for just such a device. A PC-board template is available from the ARRL; programmed microcontrollers and complete kits are available from Radio Adventures Corp., RD #4 Box 240, Summit Drive, Franklin, PA 16323.

Spelling Words With LEDs

Q *I am a radio amateur and would like to put a display in the back window of my car to display my call sign, and also words such as "Hello," by lighting up different LEDs in a matrix. Would you be so kind as to show me a circuit design? — J. R., East London, South Africa*

A The challenge is, of course, that some of the LEDs are part of more than one message and need to be lit by more than one switch, but the outputs of the three switches must remain isolated from each other for the sake of the other LEDs. What you need is called a diode matrix, and Fig. 1 shows the basic idea. The diodes act like anti-backflow valves and enable both switches to light LED2 while keeping LED1 and LED3 independent of each other.

Figure 2 shows how to lay out the circuit as a matrix and put in diodes for the connections you want to make. If an LED is fed by only one switch, you can replace its diode with a direct connection. Picking out which LEDs to light with each switch is, of course, entirely up to you.

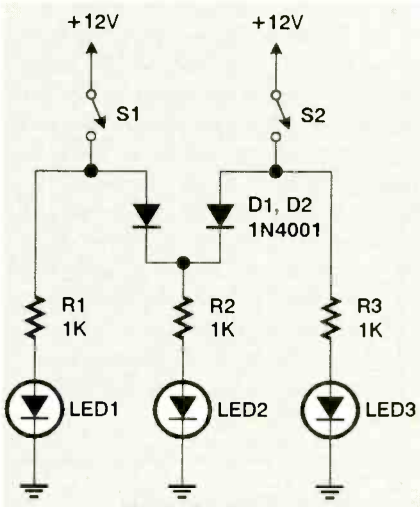

FIG. 1—THANKS TO DIODES D1 and D2, both switches can turn on LED2, but LED1 and LED3 are not linked

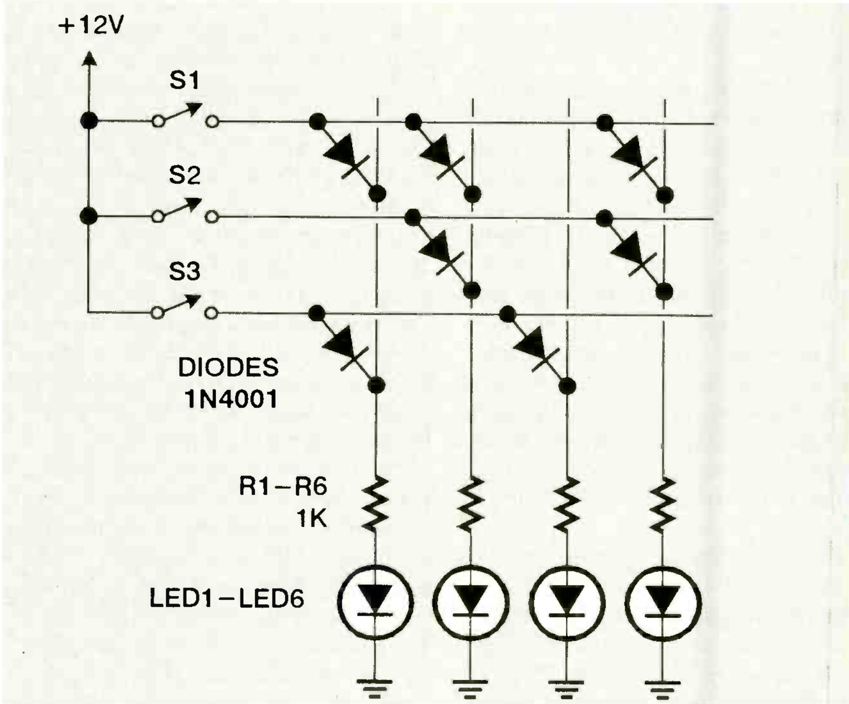

FIG. 2—A DIODE MATRIX MAKES IT EASY to see which switches go to each LED. If an LED is fed from only one switch, its diode can be replaced by a direct connection.

The Case Of The Conductive Rubber

Q *I have worked on numerous electronic devices that incorporate an LCD display. Frequently the LCD simply lies on top of the printed circuit board. Interconnecting the two is a rubbery material, which I assume is conductive. Why doesn't it short out adjacent contacts? — R. N. S., Royal Canadian Mounted Police, Regina, Sask., Canada*

A We're always glad to help the Mounties solve a mystery. All the clues you will need are in Fig. 3. As shown there, conductive and nonconductive layers of silicone rubber are laminated together vertically; as a result, the rubber pads conduct only up and down, not sideways.

VCR Plus

Q *I would like to set up my VCR Plus compatible recorder to record shows that are not listed in my TV Guide. Is there a way for me to figure out the string of numbers (Plus-Codes) to identify them? — B. K. A., Lompoc, CA*

A As far as we know, the VCR Plus code system has not been made public. Readers?

Constant-Speed Motor Control

Q *A number of years ago (like 20), I found a circuit in a magazine and built a "constant" speed control for my wife's sewing machine. A few weeks later, our house was robbed; they took the sewing machine and the obviously well-built speed controller. My wife has revived her sewing enthusiasm and I'd like to build another controller. Can you supply a circuit? — W. B., Apple Valley, CA*

A We don't recall the circuit, but we can make an educated guess. The 20-year-old sewing machine probably has a "universal" motor, which means it will operate on AC and DC over a wide range of voltages. Its built-in speed control is a rheostat (variable resistor).

As you know, putting a resistor in series with a motor is not a very good way to slow it down. The reason? When the motor hits a heavy load, it slows down and draws more current. That increases the voltage drop through the resistor, slowing down the motor even further. Because of the resistor, the motor won't maintain a constant speed under load.

A much better way to control the motor is to supply a constant voltage. If you want low speed, give it (say) 80 volts AC instead of 120 volts, but keep the voltage constant regardless of load current.

One simple way to do this is to use a Variac rather than a rheostat. That will give you an adjustable voltage with reasonably good regulation. Depending on the kind of motor, a light dimmer might even work. When experimenting with these circuits, make sure the motor doesn't overheat, and don't let it remain in a stalled condition—consuming power without turning—for any length of time.

Smarter Fuel Gauge

Q *am trying to build a fuel gauge linearizer for my car. The current gauge is linear with the depth of gas in the tank, but since the fuel tank is not rectangular (as is the case with most cars), it is obviously not linear with the number of gallons in the tank. The set-up in my car is particularly bad—the gauge stays between Full and ¾ for a long time and then quickly drops to Empty.*

The fuel sensor is a variable resistance ranging 0-ohms empty to 90-ohms full. My only idea is to convert the resistance into a voltage, scale that voltage with some op-amp circuit, and then convert it back to a resistance. How can I do that? — J. R., College Station, TX

A This sounds like a complicated analog computing problem—or a simple digital one. Use a microcontroller with an analog-to-digital input, or measure the resistance by measuring the time taken to charge a capacitor. Then compute what the fuel gauge ought to read, and make it do so by adjusting the duty cycle of a switching transistor. Figure 4 shows the general idea; you'll also need to provide a crystal, a 5-volt power supply, and a couple of capacitors depending on the particular microcontroller you choose to use. The advantage of this approach is that you can implement any function whatsoever, no matter how nonlinear. For more on fuel-gauge circuits, look back at the June 1997 installment of this column.

Duty-Cycle Meter

Q *I am planning to build a simple, inexpensive dwell (duty-cycle) meter to check the computer-controlled fuel system of my car, but I do not have a schematic. Can you help? — S. V., Hillside, IL*

A A duty cycle meter tells you what percentage of the time a pulsating DC voltage is "on" and what percentage of the time it is "off." It's especially useful for checking motor-control circuits. You can find complete plans for one in the article "Build a Duty-Cycle Monitor" in the May 1997 issue of our sister magazine, **Popular Electronics**.

Automotive Scope

Q *Is there any way I could use my oscilloscope as an auto-engine analyzer with a simple add-on device? — C. K. S., Waymart, PA*

Q *I want to use my scope to view automotive ignition systems like the diagnostic scopes. Is there an interface I could build to see the trace? — P. P., Cape Coral, FL*

A An automotive oscilloscope is like any other scope except that it has a special capacitive voltage-divider probe that clamps around a spark-plug wire. So if you can get hold of that probe, you're in business.

An alternative would be to salvage the inductive pickup from a timing light. (If you have a timing light, rig it so you can disconnect the pickup from it and connect it to the oscilloscope.) You won't see the same waveform as on a standard automotive scope, but you'll be able to tell whether all the spark plugs are behaving alike, and that's the important thing.

Incidentally, do not connect the oscilloscope directly to the spark plugs; the high voltage would damage it.

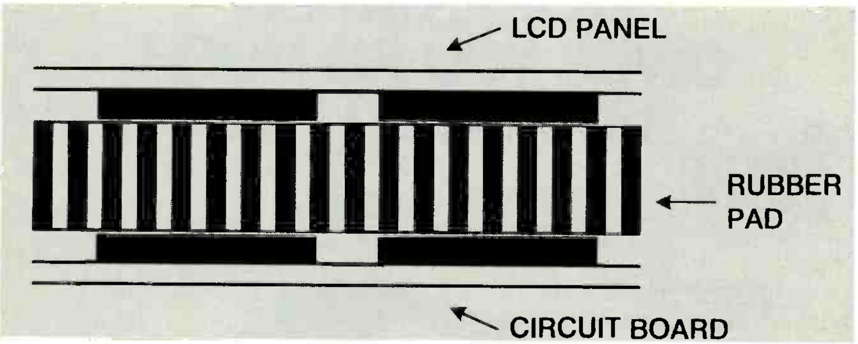

FIG. 3—THE LCD AND ITS CIRCUIT BOARD are joined together by a pad made up of tiny strips of conductive and non-conductive rubber. Because of that construction, adjacent contacts do not short.

How To Build It

Q *I am a freshman studying electrical engineering. A while back I found a project I wanted to build from a schematic, but I'm not quite sure how. I have a general purpose PC board with 25 × 15 holes on it. I can place the parts in the holes and solder them in position, but how do I connect them together? Do I have to use wire, and, if so, what kind? Is there a much better way that I am unaware of? — D. K., Northfield, VT*

A That's a good basic question, and maybe we should devote an article to it sometime. There are many ways to build a circuit, and, as Kipling put it,

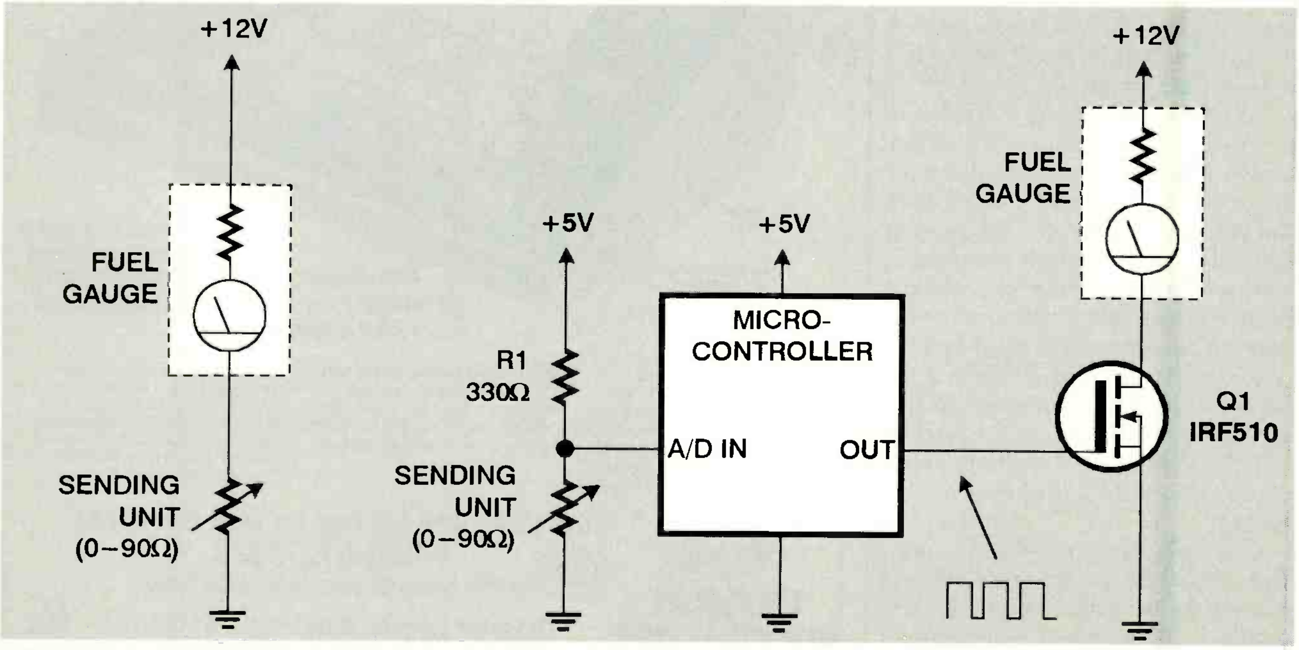

FIG. 4—HERE'S HOW TO USE A MICROCONTROLLER to make a car's fuel gauge linear. You'll also need to add a crystal and power supply for the microcontroller.

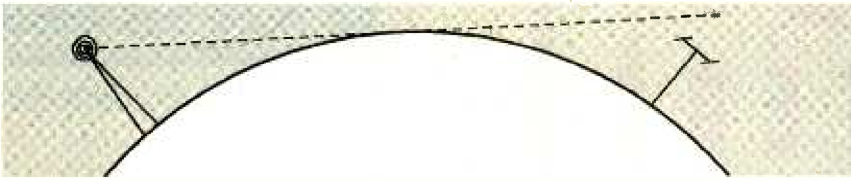

FIG. 5—REGARDLESS OF MANUFACTURER OR DEALER claims to the contrary, unless both the transmitting and receiving antennas are located quite high, reliable terrestrial reception is limited to 60 miles or less because of the curvature of the Earth.

"every single one of them is right"—at least most of the time.

It sounds like you have a "pad-per-hole" PC board with a separate piece of copper for each hole. To make connections, you'll need to use wire. Magnet wire (28 gauge) or Kynar-covered wire-wrap wire is handy for that; wrap the wire around the pins of the components before you solder them in place. With wire-wrap wire, you'll need to strip the insulation from the ends; magnet wire has an enamel insulation that melts when you solder.

A more convenient technique is to get a PC board that has some of the holes already connected together in rows. Then you can arrange your components to make the desired connections, adding pieces of No. 22 wire as needed.

Still more techniques for building circuits are described in the *ARRL Handbook for Radio Amateurs.* Most circuits work fine no matter how you build them. But if a circuit involves frequencies above 1 MHz or signal levels below 0.1 volt, you'll need to build it compactly, isolate inputs from outputs, and follow any other layout instructions provided by the circuit designer.

TV Reception Problem

Q *I'm 17 years old and have been an avid electronics hobbyist since I was 11. I have a problem with poor reception of TV channels 39 and 50. I think the TV signal in my room isn't too strong because on our other set, these channels work fine. Do you have a schematic for something I can build to improve the picture on these channels? — B. B., Ridgewood, NY*

A UHF amplifiers aren't easy to build because at those frequencies, even half an inch of wire has enough inductance and capacitance to affect the operation of the circuit. Before adding an amplifier, try making a better indoor antenna. Sometimes all sorts of random wire shapes will work well in a particular situation. Even before doing that, you might try swapping the locations of the two TVs to see if one of them is more sensitive than the other.

Receive It All?

Q *As a follow-up to your March 1997 "Q&A" question "Amplify it all?", I want to build a preamp for VHF channels 2-13 to receive stations 130 miles away. My TV antenna is supposed to receive up to 160 miles, but can't because it isn't amplified. What kind of circuit should I use? I have a lot of transistors. — V. S., Landis, Sask., Canada*

A How tall is your antenna? The reason we ask is that the curvature of the earth limits how far away you can receive VHF signals, which travel in straight lines (see Fig. 5). If the station's antenna is 1000 feet high and yours is 200 feet high, the maximum range is about 60 miles. To communicate across a 130-mile distance, you'd need antennas half a mile high at both transmitter and receiver.

Reliable 130-mile TV reception is only possible when the transmitter and receiver happen to be on mountaintops. Otherwise, if the signal isn't reaching your location, no amount of amplification will help. If you do want to experiment with amplifiers, we suggest using commercially available ones; they're cheap, and VHF amplifiers are tricky to build.

Writing to Q&A

As always, we welcome your questions; write to: Q &A, **Electronics Now**, 500 Bi-County Blvd. Farmingdale, NY 11735. The most interesting ones are answered in print, usually within nine months. 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

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF
ELECTRONICS NOW MAGAZINE

Index Request

I would like to buy copies of the Annual Indexes for *Electronics Now* and *Radio-Electronics* covering the 1980s (or earlier) through 1996. I know I can purchase print copies from the publisher, but I want them as ASCII text files. Perhaps another *Electronics Now* reader would be able to create ASCII files by scanning and converting (via OCR) the text images into pure ASCII. If so, I can be reached via e-mail at john.augustine@gmiibbs.com or via standard mail at the address below.

JOHN AUGUSTINE
3129 Earl Street
Laureldale, PA 19605

Boundary Scan Notes

I read the article, "Boundary Scan Testing" (*Electronics Now*, June 1997), in which the process presented was described as a new test method.

I was a test equipment designer at IBM until I retired in 1982. My last design was for the test of LSSD chips. What IBM called LSSD (Logic Sensitive Scan Design) is exactly the same as the Boundary Scan testing.

The first LSSD chips were probably built in 1980. At that time, they were tested with regular testers, which were not effective. All signals necessary to send and receive the serial patterns were considered as test patterns. The LSSD testers were able to take care of all signal progression.

R. SABATTERIE
Brunoy, France

Web Wonder

I would like to congratulate you on the recent additions to your Web site on the Internet (www.gernsback.com). In particular, the new discussion forums give your readers a direct way to interact with each other, as well as a great way to get article updates and corrections faster than before. Also, the searchable article index is really helpful in tracking down when and where a particular article appeared, and it will be even better when it extends back further than a year or so. I hope that will happen in the near future.

I do have one request, however. As of now, there are no projects or articles on line. If you could find a way to add them, it would make a good and interesting site into a wonderful one. How about it?

A. EASTON
Via the Internet

Plans call for us to be extending the index on a regular basis, eventually going back as far as ten years.

*Regarding your request, I have some good news for you! While we will not be adding articles on our own site, there will soon be a brand new on-line magazine called **Poptronix**. Located at www.poptronix.com, it will feature the complete text and artwork of selected articles from both **Electronics Now** and our sister magazine, **Popular Electronics**, as well as such features as new product and book reviews, an on-line store, and much more.*

To make things as accessible as possible to visitors to the site, the articles will be presented in a variety of formats, including .pdf, which is ideal for creating hard copies. The site is still under construction, but should be on line and working shortly. Check it out—I think you'll like what you find.—Editor EN

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

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

Budget Project and Computer Books

☐ **BP317–Practical Electronic Timing $6.95.** Time measurement projects are among the most constructed gadgets by hobbyists. This book provides the theory and backs it with a wide range of practical construction projects. Each project has how-it-works theory and how to check it for correct operation.

☐ **BP415–Using Netscape on the Internet** BRAND NEW **$7.95.** Get with the Internet and with surfing, or browsing, the World Wide Web, and with the Netscape Navigator in particular. The book explains: The Internet and how the World Wide Web fits into the general scenario; how do you go about getting an Internet connection of your own; how to download and install the various versions of Netscape browsing software that are available; and how to use Netscape Navigator to surf the Web, and to find and maintain lists of usful sites. There's a heck of a lot more, too!

☐ **BP325–A Concise User's Guide to Windows 3.1 $7.95.** Now you can manage Microsoft's Windows with confidence. Understand what hardware specification you need to run Windows 3.1 successfully, and how to install, customize, fine-tune and optimize your system. Then you'll get into understanding the Program Manager, File Manager and Print Manager. Next follows tips on the word processor, plus how to use Paintbrush. There's more on the Cardfile database with its auto-dial feature, Windows Calendar, Terminal, Notepad, etc.

☐ **BP327–DOS: One Step at a Time $5.95.** Although you spend most of your time working with a word processor, spreadsheet or database, and are probably quite happy using its file management facilities, there will be times when you absolutely need to use DOS to carry out 'housekeeping' functions. The book starts with an overview of DOS, and later chapters cover the commands for handling disks, directories and files.

☐ **PCP119–Electronic Music and Midi Projects $14.95.** Save cash by building the MIDI gadgets you need. Want a MIDI THRU box, program change pedal, Metronome, analog echo unit, MIDI patchbay or switcher? Over 16 practical and very useful music and MIDI projects—all in this book! The projects are explained in detail with full instructions on assembly.

☐ **PCP120—Multimedia on the PC! $14.95.** What is Multimedia? What can it do for you? It can do lots of nice things! This 184-page book helps you create your own multimedia presentation. Multimedia applications by people like you can revolutionize educational and business applications as well bring more fun, fun, fun into your leisure computer activities.

☐ **BP404–How To Create Pages for the Web Using HTML $6.95.** BRAND NEW

Companies around the world, as well as PC users, are fast becoming aware of the World Wide Web as a means of publishing information over the Internet. HTML is the language used to create documents for Web browsers such as Mosaic, Net-scape and the Internet Explorer. These programs recognize this language as the method used to format the text, insert images, create hypertext and fill-in forms. HTML is easy to learn and use. This book explains the main features of the language and suggests some principles of style and design. Within a few hours, you can create a personal Home Page, research paper, company profile, questionnaire, etc., for world-wide publication on the Web.

☐ **BP377—Practical Electronic Control Projects $6.95.** Electronic control theory is presented in simple, non-mathematical terms and is illustrated by many practical projects suitable for the student or hobbyist to build. Discover how to use sensors as an input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors. Also the text reveals how to use control circuits to link input to output including signal processing, control loops, and feedback. Computer-based control is explained by practical examples.

☐ **BP411—A Practical Introduction to Surface Mount Devices $5.95.** This book takes you from the simplest possible starting point to a high level of competence in working with Surface Mount Devices (SMD's). Surface mount hobby-type construction is ideal for constructing small projects. Subjects such as PCB design, chip control, soldering techniques and specialist tools for SMD are fully explained. Some useful constructional projects are included.

☐ **BP136—25 Simple Indoor and Window Aerials $5.50.** Many people live in flats and apartments where outdoor antennas are prohibited. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out under a rug in a room can produce acceptable results. However, with experimentation and some tips, you may well be able to improve further your radio's reception. Included are 25 indoor and window antennas that are proven performers. Much information is also given on shortwave bands, antenna directivity, time zones, dimensions, etc. A must book for all amateur radio enthusiasts.

☐ **BP336—A Concise User's Guide to Lotus 1-2-3 Release 3.4 $7.25.** Discover how to use a three-dimensional Lotus spreadsheet in the shortest and most effective way. The book explains how: to generate and manipulate 3-dimensional worksheets and how to link different files together; to generate and add graphs to a worksheet, edit them, and then preview and print the worksheet; to use the SmartIcons and become more productive with your time; to use the WYSIWYG add-in to produce top quality screen and printed displays; and much more.

☐ **BP379—30 Simple IC Terminal Block Projects $6.50.** Here are 30 easy-to-build IC projects almost anyone can build. Requiring an IC and a few additional components, the book's 'black-box' building technique enables and encourages the constructor to progress to more advanced projects. Some of which are: timer projects, op-amp projects, counter projects, NAND-gate projects, and more.

☐ **BP401—Transistor Data Tables $6.95.** The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

☐ **BP403—The Internet and World Wide Web Explained $6.95.** You've heard about the Information Superhighway. Sort of makes you feel timid about getting on the Web. Put your fears aside! This book eliminates the mystery and presents clear, concise information to build your confidence. The jargon used is explained in simple English. Once the tech-talk is understood, and with an hour or two of Web time under your belt, your friends will call you an Internet guru!

☐ **BP92—Electronics Simplified: Crystal Set Construction $2.69.** This book is written for those who wish to participate in electronics more through practical construction than by theoretical study. It is designed for all ages upwards from the day when one can read intelligently and handle simple tools. The crystal set projects are designed to use modern inexpensive components and home-wound coils. A book highly recommended for all newcomers.

☐ **ETT1—Wireless & Electrical Cyclopedia $5.75.** Step back to the 1920's with this reprinted catalog from the Electro Importing Company. Antiquity displayed on every page with items priced as low as 3 cents. Product descriptions include: Radio components, kits, motors and dynamos, Leyden jars, hot-wire meters, carbon mikes and more. The perfect gift for a radio antique collector.

ELECTRONIC TECHNOLOGY TODAY INC.
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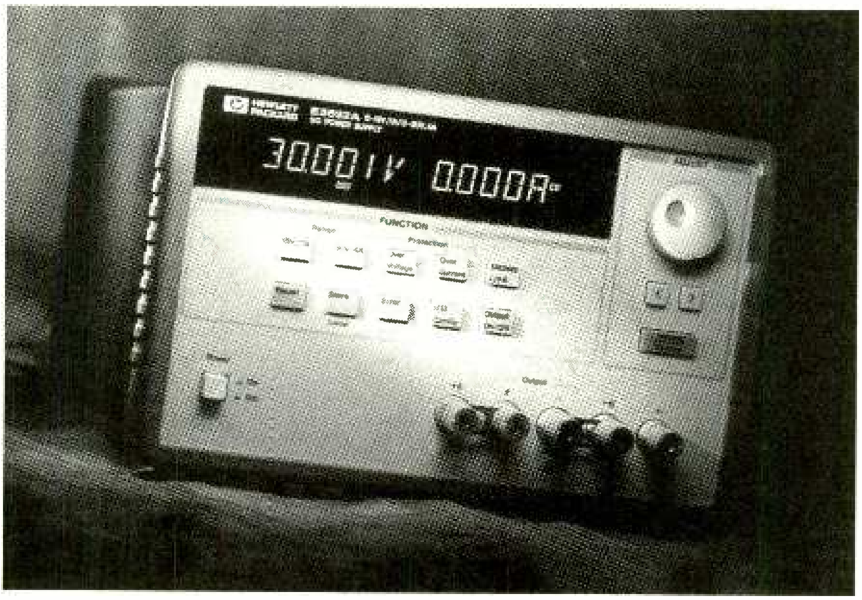
NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Lab Power Supply

Hewlett-Packard's Model HP E3632A benchtop power supply with 120-watt power output is designed for research-and-development and manufacturing-test environments. The single-output lab power supply features GPIB programmability; linear, regulated power with dual ranges (0 to 15 volts, 7 amps and 0 to 30 volts, 4 amps); and low noise.


CIRCLE 20 ON FREE INFORMATION CARD

With its high accuracy and resolution, the HP E3632A can be used as a benchtop power supply and to test components and power-up assemblies. Engineers can program the unit with a personal computer or controller via RS-232 or GPIB interfaces. For increased versatility, the unit's dual-range, high-power output is adaptable to the needs of specific applications. The power supply offers a front-panel-mounted control knob and two digital meters (voltmeter/ammeter) for convenience and ease of use.

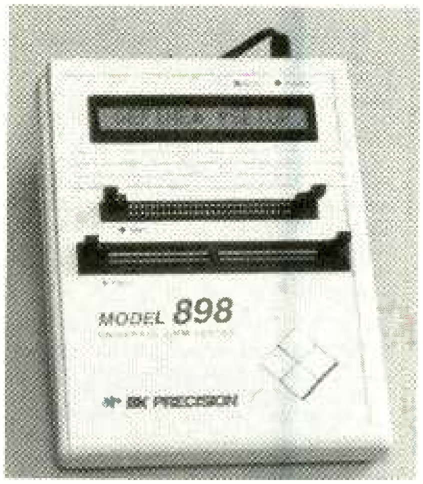
The HP E3632A costs $995.

HEWLETT-PACKARD COMPANY
Test and Measurement Organization
P.O. Box 50637
Palo Alto, CA 94303-9512
Tel: 1-800-452-4844, ext. 5146
Web: http://www.hp.com/info/HPE3632A

72-Pin SIMM Tester

B+K Precision's Model 898 is a portable unit that tests the most common types of SIMMs ranging from 8 bits to 36 bits. Optional adapters allow the testing of DRAM chips as well. The SIMM tester uses up to 10 protocols to ensure complete testing of the chip. The full complement of tests can be executed automatically, or the user can select individual tests for execution.

The Model 898 features heavy-duty 72- and 30-pin sockets, six error-detection and -identification categories, 10 selectable test protocols, and automatic identification of general parameters and the speed of the SIMM under test. It has a large LCD readout, a built-in microcontroller, and an RS-232 interface for data output to a printer or PC.



CIRCLE 21 ON FREE INFORMATION CARD

The Model 898 has a suggested price of $995.

B+K PRECISION
6470 West Cortland Street
Chicago, IL 60707-4098
Tel: 1-800-462-9832
Fax: 773-794-9740

Amplifier Relay Buffer

Designed to protect expensive radios from keying line voltage or current-related damage, Ameritron's ARB-700 interface box replaces conventional reed-relay buffer systems. The completely solid-state interface has no moving parts to wear out, and has no mechanical contacts to affect amplifier switching times or produce unwanted noise.

The ARB-700 fully protects trans-

CIRCLE 22 ON FREE INFORMATION CARD

ceivers that use conventional amplifier control lines that pull low. It also works with transceivers designed to supply a positive output voltage to activate external amplifiers. The ARB-700 can be used with any amplifier relay voltage up to 200-volts positive, while handling amplifier relay control currents up to 200 mA. It requires the radio to sink only 2 mA of current, and limits voltage applied to the transceiver to values as low as three volts.

The ARB-700 costs $29.95.

AMERITRON
116 Willow Road
Starkville, MS 29749
Tel: 601-232-8211
Fax: 601-323-6551
Web: http://www.ameritron.com

"Heads-Up" Digital VOM

Triplett's VisualEYEzer digital VOM features a "heads-up" display that is intended to improve user convenience and safety. The VOM keeps the display always in sight, and both hands free to probe.

CIRCLE 23 ON FREE INFORMATION CARD

The two-piece system consists of a headset and a belt pack, connected by a 48-inch cable. The lightweight headset, which is fastened via Velcro to an adjustable, padded headband, projects the digital display into the user's right eye. The viewing lens is a transparent, semi-silvered mirror that allows the viewer's vision to be unobstructed while projecting the red, 4000-count display and annunciators over the scene being observed. The VisualEYEzer's display emits light instead of reflecting it like an LCD does, making the display very readable in reduced lighting.

The belt pack resembles a typical fanny-pack. Made of rigid black plastic with an adjustable web belt, its sloped top panel displays the pack's only controls—an on/off slide switch and contrast- and loudness-up and -down pushbuttons.

The traditional range and function control switches and buttons are replaced by two multifunction pushbuttons located on the fused test probes.

The fused test probes extend through the front end of the belt pack and feature push-button switches positioned to be easily accessible by the user's forefingers. The buttons allow the user to change the VOM's ranges and functions without having to look at the belt pack; the LED annunciators in the display change as the different functions are selected. The functions are arranged in sequence, and selected by continually pressing the black button until the desired function is selected. Pressing the red button sets the VisualEYEzer to manual range.

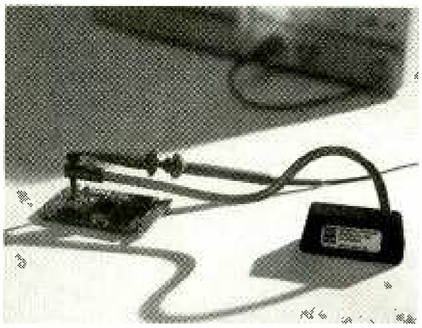
Each probe also contains a 1-amp/250-volt fuse in its tip. If a fuse is blown due to user error or circuit malfunction, damaging signals are prevented from going any further than the probes.

The VisualEYEzer digital VOM has a suggested U.S. list price of $369.

TRIPLETT CORPORATION
One Triplett Drive
Bluffton, OH 45817
Tel: 1-800-874-7538
Fax: 419-358-7956
Web: http://www.triplett.com

SMD Probe

The Quick Probe from AG Devices is an inexpensive tool used for fast and easy connection of test instruments to surface-mount components. The device consists of a weighted, non-skid base that holds a flexible shaft and a precision connection point for attaching a test instrument.



CIRCLE 24 ON FREE INFORMATION CARD

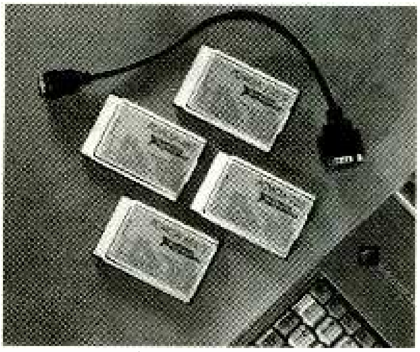
Offering a versatile alternative to traditional test methodology, the Quick Probe quickly connects a test instrument, such as an oscilloscope, to multiple types of surface-mount components. It can be used on most types of surface-mount packages, and multiple types of test points can be contacted with only a single tool. No special tooling is required, and the need for soldering test leads to components is eliminated.

The Quick Probe has a list price of $49.

AG DEVICES OF COLORADO, INC.
1804 2475 Road
Cedaridge, CO 81413
Tel: 970-856-4308
Fax: 970-856-4309

Notebook PC Serial Interfaces

Two PC cards from National Instruments give notebook PCs control of serial devices for portable or remote operations. The one-port PCMCIA-232 and two-port PCMCIA-485 are asynchronous serial interfaces that are compatible with Windows 95 Plug and Play for easier installation and maintenance. Application software packages such as LabVIEW, LabWindows/CVI, ComponentWorks, and Measure, as well as development environments such as Visual C++, can access the cards using standard serial I/O functions. The PCMCIA-232 and PCMCIA-485 deliver the additional low-cost serial ports commonly needed in laboratory applications to communicate with devices such as scales and meters. They also raise the serial transmission rate from the standard of approximately 38 kilobits per second (kbits/s) to more than 115 kbits/s.



CIRCLE 25 ON FREE INFORMATION CARD

The PCMCIA-232 and PCMCIA-485 connect to RS-232 and RS-485 devices, respectively. They include an enhanced COM driver for Windows 95 that transmits data at rates up to 115.2 kbits/s and provides a function to support the two-wire transceiver control mode of the PCMCIA-485. Both use 16550-compatible UARTs for full compatibility with PC COM ports. The PC operating system performs all board configurations—no jumpers or DIP switches are required. Because the interfaces are designed for asynchronous communication, users can connect with most serial devices simply by sending strings to and from the COM port.

The one- and two-port versions of PCMCIA-232 cost $195 and $295, respectively; the one- and two-port versions of PCMCIA-485 cost $245 and $345, respectively.

NATIONAL INSTRUMENTS
6504 Bridge Point Parkway
Austin, TX 78730-5039
Tel: 1-800-433-3488 or 512-794-0100
Fax: 512-794-8411
E-mail: info@natinst.com
Web: http://www.natinst.com

Roller-Inductor Antenna Tuner

MFJ's 300-watt AirCore roller-inductor antenna tuner provides continuous 6- through 160-meter coverage. A three-digit turns counter and spinner knob gives users exact inductance control. And the MFJ-969 has absolute minimum SWR, something that a tapped inductor just can't do. The roller inductor has an air core that can't burn up and features ultra-high-Q, low loss, high efficiency, and high power handling.

CIRCLE 26 ON FREE INFORMATION CARD

The exclusive Self-Resonance Killer keeps potentially damaging self-resonances away from the operating frequency. A large, self-cleaning, wiping contact gives excellent low-resistance connection without contact arcing or burning. A solid ¼-inch brass shaft with self-aligning bearings provides smooth, non-binding operation.

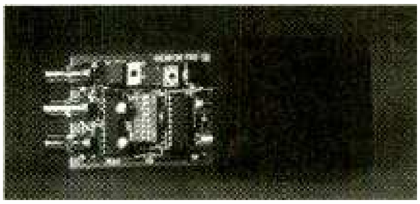
You can match any antenna—dipole, vertical, inverted vee, random wire, beam, mobile whip, and more—with the MFJ-969. You can use coaxial cable or balanced feedlines. The MFJ-969 features a lighted cross-needle SWR/wattmeter, QRM-Free PreTune, an eight-position ceramic antenna switch, built-in 50-ohm dummy load, and a heavy-duty 4:1 balun. QRM-Free PreTune lets you pre-tune your MFJ-969 into a built-in dummy load, which makes your actual antenna tuning faster and easier, without causing QRM.

The AirCore roller-inductor antenna tuner costs $179.95.

MFJ ENTERPRISES, INC.
300 Industrial Park Road
Mississippi State, MS 39762
Tel: 1-800-647-1800 or 601-323-5869
Web: http://www.mfjenterprises.com

Pint-Sized Video Sequencer

According to NetMedia, its V4x1 is the world's smallest video sequencer. Measuring in at 3.8 by 2.2 by 0.9 inches, the device contains a microprocessor-controlled video-switching system that can precisely sequence up to four color or black-and-white video cameras to a single video output. Small enough to easily hide or mount almost anywhere, it can be used for commercial, residential, and specialty security and monitoring purposes. Both the rate of sequencing (one to 225 seconds) and the number of video sources are switch selectable.



CIRCLE 27 ON FREE INFORMATION CARD

The V4x1 comes with a 110-volt transformer, or can run on a 12-volt DC power source, including batteries or solar cells. That allows it to be used where there are no standard electrical power sources, such as in motor homes and buses.

The V4x1 has a suggested retail price of $199.

NETMEDIA, INC.
10904 N. Stallard Place
Tucson, AZ 85737-9527
Tel: 1-888-RUN-TABS (520-544-4567 in Arizona)
Fax: 520-544-0800
E-mail: sales@homeautomation.com
Web: http://www.homeautomation.com

Automatic Tuner Extender

The MFJ-914 AutoTunerExtender increases your automatic tuner's matching range, allowing it to match nearly any antenna automatically. The heavy-duty, wide-range impedance-transforming device has been designed for the flat- test frequency response and the lowest loss.

The MFJ-914 will transform your antenna impedance up or down by as much as ten times, putting almost any antenna into the matching range of your automatic tuner. It lets you extend your power range by transforming your antenna impedance so that your tuner can be used in a higher power low-Q mode. The device can also extend manual antenna tuners.

CIRCLE 28 ON FREE INFORMATION CARD

The AutoTunerExtender can be used with any transceiver from 160 through 10 meters at up to 300 watts. It connects between the transmitter and the antenna with supplied SO-239 connectors, allowing you to bypass your transmitter's auto tuner and then adjust the knobs on the MFJ-914. An Off/Dummy Load setting on the unit helps protect the transceiver by connecting it to an external dummy load and providing ground to your antenna when not in use.

The MFJ-914 AutoTunerExtender costs $59.95.

MFJ ENTERPRISES, INC.
P. O. Box 494
Mississippi State, MS 39762
Tel: 1-800-647-1800 or 601-323-5869
Fax: 602-323-6551

Cordless Stereophone System

The Koss JR/900 stereophone system operates on a 900-MHz radio-frequency band—the highest power band for cordless stereophones available on the consumer market. The system, which consists of a battery-operated stereophone, the RF transmitter, and an AC adapter, allows the listener to move freely from room to room, and even outdoors, without experiencing signal break up. The signal can be transmitted through walls, ceilings, and floors, with a range of 150 feet in any direction. The JR/900 uses built-in NiCd batteries that provide 5 to 10 hours of use between rechargings. A battery recharge circuit built into the transmitter is activated when the stereophones are hung from the transmitter.

At the heart of the system, the transmitter provides five stereo transmit channels for freedom from interference; the listener can switch between channels to find the cleanest, clearest reception. Five-channel capability also makes the JR/900 well suited for commercial applications in multi-screen movie theaters, multicultural events, museums, and education programs. By hooking up additional transmitters to separate audio sources, the listener can tune into those different sources simply by pressing the channel-select control on the stereophone ear cup. A microchip in the stereophone circuit automatically locks the transmitter signal onto the selected channel to prevent drift between audio sources.

CIRCLE 29 ON FREE INFORMATION CARD

The stereophones provide exceptional sound reproduction and extended frequency response of 20–20,000 Hz to deliver deep bass and treble clarity. Circumaural leatherette ear cushions enclose the ear for maximum isolation. The adjustable, padded headband is comfortable for long listening sessions. A dual volume control on the stereophone ear cup provides convenient level and balance adjustment for a customized sound.

The JR/900 cordless stereophone system has a suggested retail price of $399.99.

KOSS CORPORATION
4129 North Port Washington Ave.
Milwaukee, WI 53212
Tel: 414-964-5000

EN

BY JEFF HOLTZMAN

Hacking the Pilot

US ROBOTICS (USR) IS KNOWN TO MOST AS A MANUFACTURER OF MODEMS. SEVERAL YEARS AGO, USR PURCHASED A THEN-UNKNOWN COMPANY CALLED PALM COMPUTING. PALM'S CLAIM TO FAME IS DEVELOPMENT OF THE FIRST WIDELY successful PDA (personal digital assistant), the Pilot. (USR was itself gobbled earlier this year by network pioneer 3Com.)

For those unfamiliar with it, Pilot is about the size and shape of the average scientific calculator. However, it does not rely on three or four dozen dedicated keys for input; rather, it is a stylus-based device that depends on manual input from the user via handwriting recognition or an on-screen keyboard. The screen is touch sensitive, so you can use some apps, such as the built-in calculator, with your fingers.

Pilot is not based on any version of DOS, Windows, or Windows CE. It runs its own proprietary operating system and applications. However, there are several ways of getting data from Pilot apps into standard PC apps. Internally, it runs a Motorola 68000-family CPU, and the official development software (from MetroWerks) runs only on a Macintosh. However, several Intel-based software solutions are available and more are on the way.

Who buys Pilots? A few months ago, I would have suggested trendy execs and other yuppie types. But since purchasing one of my own, I have come to a quite different conclusion.

Hardware Basics

The original product is called the Pilot 1000; with a memory upgrade, it's sold as the Pilot 5000. The latest version is called the Palm Pilot. The Palm Pilot includes version 2.0 of the OS, upgraded apps, and a backlight for the LCD display. You can upgrade earlier Pilots to the current OS and app level, but you cannot add backlighting. The backlight is worth having.

The base model includes 512K of memory; an upgrade to 1 MB is available. The memory upgrade card includes the system software on ROM, which is how older models get the software upgrade. The memory cards have a proprietary form factor, but they use standard memory chips. Information is available on the Web on how to perform the upgrade yourself at considerable savings over the $129 list price of the USR upgrade. Just don't expect warranty service if you do it yourself.

However you get it, the memory upgrade is worthwhile for another reason: it doubles the data-bus width, which essentially doubles CPU-memory bandwidth. A free benchmark program is available, so you can perform before and after comparisons.

The Pilot runs on two AAA batteries, which last 10-20 hours. There is no input for a charger or AC adapter. The Pilot has a single 10-pin I/O port that is basically a serial interface with two extra pins—one for input and one for output. Pilot comes with a "cradle" that is basically just a simple interface between the card-edge contacts on the unit itself, and a standard nine-pin cable that attaches to a serial port. Information on the port's pin-out appears in Table 1.

The cradle has a single button, used to initiate a "hot-sync" program that synchronizes data between the Pilot and a PC application. The Pilot itself has a power button, four reassignable buttons for launching apps, two buttons for scrolling the display, and a well-recessed reset switch on the back of the unit.

The display measures 6cm wide by 8cm high. The upper 6 × 6 square is where the LCD pixels (160 × 160) appear. The bottom 6 × 2 rectangle is where you enter data. The rectangle also contains several pseudo-dedicated "buttons" (really part of the overall touch-sensitive screen) for launching a calculator, a cross-application find

RESOURCES

Palm Pilot ($299), Palm Pilot Pro ($399, includes built-in memory upgrade), memory upgrade ($129), clip-on modem ($129)
US Robotics
1565 Charleston Road
Mountain View, CA 94043
Tel: 800-881-7256
Internet: www.usr.com/palm

Code Warrior for Pilot ($299)
Metrowerks, Inc.
2201 Donley Drive
Suite 310
Austin, TX 78758
Tel: 800-377-5416
Internet: www.metrowerks.com

Parallel Port Complete ($39.95)
By Jan Axelson
ISBN: 0-9650819-1-5
Lakeview Research
2209 Winnebago St.
Madison, WI, 53704
Internet: www.lvr.com

TABLE 1—PILOT PORT PINOUT

DB9F	Signal	Pilot Cradle	Signal
1	CD		
2	RXD	6	TXD
3	TXD	8	RXD
4	DTR		
5	GND	1	GND
6	DSR		
7	RTS	5	CTS
8	CTS	7	RTS
9	RI		
Shield	10 pF to gnd.		
		2	NC
		3	Input
		4	HotSync switch
		9	HotSync switch +
		10	Output

TABLE 2—WEB SITES FOR PILOT INFORMATION

URL	Description
http://www.usr.com/palm/	US Robotics' official home page for Pilot, lots of links to other sites
http://www.massena.com/darrin/pilot/luiz/hardware.htm	Detailed hardware information
http://pilot.cc-inc.com/stinger/stingersoft.cfm	Downloads, news, net info
http://www.massena.com/darrin/pilot/index.html	Extensive software development information
http://www.inforamp.net/~adam/pilot/	Misc. downloads
http://www.nicholson.com/rhn/pilot.html	Tiny basic
http://home1.pacific.net.sg/~kokmun/basic.htm	Tiny basic apps
http://the-tech.mit.edu/Pilot/	News
http://www.metrowerks.com/products/cw/pilot/	Code Warrior for Pilot (MetroWerks)
http://web2.airmail.net/srsimmon/pilot/hardware/	Hardware info (memory upgrades)
http://www.mot.com/SPS/ADC/pps/prod/3XX/mc68328.html	Motorola CPU info

utility, an application launcher, and a menu actuator.

The inner 3.7 cm of the lower rectangle is for handwriting recognition. Pilot uses a technology known as Graffiti, which requires you to enter stylized characters; you cannot just enter your normal sloppy handwriting. You can start using Graffiti right away, because most characters are very similar to normal letters. There are differences, but picking them up occurs rapidly. If you forget a stroke sequence, on-line help showing all characters is available.

I found that within two hours I could write correctly formed sentences at a reasonable rate; speed and accuracy increase with usage. With just a little practice, it is possible to take notes in real time. That was a critical factor for me; without it, I wouldn't be discussing the Pilot here, and I would have left it in the "toys for yuppies" category.

Built-In Software

Pilot includes the following applications: scheduler with daily, weekly, and monthly views; address book; to-do list manager; text editor; calculator; cross-application search utility; desktop synchronization utility; a game to help teach Graffiti strokes; security manager; and memory display/manager. There is also a "program manager" that allows you to switch among applications. There is no opening or closing of either apps or files. Whenever you switch out of something, its state is saved, and when you return, that state is restored.

Also, there is a small but growing collection of shareware, freeware, and commercial applications, games, and utilities. Table 2 describes several Web sites, and Table 3 describes several utilities that I have found useful, interesting, or both.

Prove It's Not A Toy

I bought my Pilot to solve three problems:

1) I am often in an odd place when an idea strikes, and seldom do I have pencil and paper. Now I have a convenient, unobtrusive solution.

2) I don't have lots of appointments, but the ones I do have are extremely critical. In addition, I need a (strong, repetitive) nudge to make sure all my business paperwork gets filed with the government on time.

3) I'm usually involved in several projects at once, and tracking and prioritizing associated tasks, as well as personal ones, is a battle I've been fighting for years.

In just a few weeks, problems one and two have been solved, and things are looking good for number three as well. And I'm not having to drastically alter anything I do, nor make allowances for technical lapses on the product side. There are definitely things I wish were different, but straight out of the box, Pilot is useful.

One of my first tasks was to run through every nook and cranny of the Pilot to see how it operated and what goodies might turn up. In so doing, I used Pilot's memo application to take notes. Table 4 summarizes my findings. (If there seem to be lots of cons, that should not detract from my overall highly favorable impression of the device.)

Weren't You Just Saying . . .

You may recall a rant here recently about how a low-end or used laptop would provide much better overall value than one of the new miniature machines. Wasn't I saying the virtue of extreme portability was overrated? Am I not contradicting myself?

No (well, maybe just a little). I looked closely at the Win CE and proprietary machines like Psion and Sharp Zaurus. I would still rather have an old sub-notebook than one of those, because you can't type on them. Pilot doesn't fit either category. I view it as an electronic replacement for a daily planner plus journal plus address book.

Opportunities

USR hasn't released much technical

TABLE 3—USEFUL PILOT UTILITIES

Program	Description
PilotMark	Memory bandwidth benchmark and comparison info
CASL	Pilot development environment
FontDisp	Displays all built-in fonts
PilHack	Dump memory in hex and ascii
HexCalc	Hexadecimal calculator
Hourz	Shareware ($20) app for tracking billable hours
Invaders	Space Invaders port for Pilot
CBasPad	Tiny Basic

TABLE 4—PILOT PROS AND CONS

Pros	Cons
Evenness of backlight	Incomplete backlight covering only the upper 6 × 6, not the pen-input area, so it's hard to use in the dark
Consistent use of categorization	Weak calculator (but PD hex calculator available)
Autosave	No built-in programmability
Nice drag and drop in calendar and memo list	Significant glare; angle must be adjusted carefully
Simplicity of operation	Poor recognition of some punctuation and commands.
Space efficiency of add-on utils	Weak text editor (No hanging indents, no outline mode, no hyperlinking)
Ease of learning	Soft case
Ease of use	No built-in telecommunications
	Dedicated use of lower rectangle for input
	No charger input, especially via cradle
	No documented "hacker" inputs
	4K limit on memos
	Even though has 'title bar' have to drop down to Graffiti area to activate menus
	No repeating to-do's (repeating dates fill calendar w/junk)
	No drawing application
	No spreadsheet application
	Program manager is weak
	Desktop manager awkward, weak

detail, but information is nonetheless available. For example, a guy in Japan has figured out how to use a miniature Apple Newton keyboard with the Pilot. Others are figuring out how to access the input and output bits in the I/O connector. The memory and address buses are available via the memory expansion card, so there are opportunities there as well. Seems to me an IR interface for cable-free file transfer and printing would be useful. And there are probably lots of vertical-market opportunities, such as point-of-presence status indicators in medical and manufacturing environments.

The broadest opportunities are probably in software. The canonical method is to code in C on a Mac using MetroWerks' Code Warrior development system. Some people have put together a package for creating Pilot apps on a PC using the public-domain GNU C compiler and some other tools. Someone else has created a Pilot emulator that runs on a PC and executes ("interprets") actual Pilot binaries. And still another person has created a version of Tiny Basic that executes on the Pilot, providing (mostly) textual I/O, Peek and Poke statements, and access to the serial port. There is also a growing body of public-domain TB programs.

Another option is a p-code type environment called CASL, which gives you a high-level, sort-of-object-oriented, sort-of-Basic-like environment for building GUI apps. Also, USR states that a Microsoft Visual C++ based development environment, which originally was due around the end of 1996, will be available soon.

Bottom Line

Is Pilot a fun and cool gadget? Definitely. Is it helping me do my job more effectively or efficiently? Definitely. That's a win-win situation.

Bookshelf

If you want to learn about PC-based parallel ports, then you need a copy of Jan Axelson's *Parallel Port Complete*. Jan covers different port types (standard, PS/2, EPP, ECP), provides many examples of input and output interface circuits, and sample code mostly in Visual Basic. She does touch briefly on doing port I/O using other products such as Turbo Pascal, Delphi, and assembly language. The book includes timing diagrams, information on current draw, cable specs, port detection, device drivers, and more. Good stuff.

That's all for now. Until next time, you can stay in touch via e-mail at jkh@acm.org. EN

EQUIPMENT REPORTS

RadioShack AC Circuit Breaker Identifier

Quickly discover which outlets, switches, and light fixtures are protected by which circuit breakers.

CIRCLE 15 ON FREE INFORMATION CARD

There are always a few tasks around the house that most homeowners do not get around to until it suddenly becomes urgent. In many cases, one of those tasks is making a record of which outlets, switches, and light fixtures are controlled by which circuit breakers (or fuses).

Unfortunately, when trouble strikes, or when it is time to do some maintenance or upgrades on your home's electrical system, that means going through a trial-and-error process, switching off several circuit breakers until you find the correct one. Generally, no harm is done. However, a running air conditioner could pop its own circuit breaker when the latter is switched off, then on. Or some alarm clocks and microwaves might have to be reset, and some VCRs might have to be reprogrammed. And we don't even want to think about what could happen to a computer that happened to be running while all this was going on.

There is a better way. The RadioShack AC Circuit Breaker Identifier lets you easily and safely locate the circuit breaker (or fuse) that powers an AC outlet or light fixture. You can also use it to help you find the specific wall or dimmer switch that supplies power to an AC fixture.

Using the Identifier

To use the Identifier, simply plug its transmitter into a standard AC outlet that has power supplied to it. To connect the transmitter to a light fixture, turn off power to the fixture and remove the light bulb; remove only one light bulb from fixtures with two or more bulbs. Screw a light-socket plug adapter (available at many hardware stores) into the open socket, plug the transmitter into the adapter, and then turn the power on to the fixture.

If power is indeed present, the indicator on the front of the transmitter lights up. Next, take the unit's receiver, switch it on, and position the tapered end of the receiver next to the transmitter. Note that the receiver beeps repeatedly (about six times per second) and the receiver's LED indicator flashes brightly each time it beeps.

Now it's time to put the unit to work. Bring the receiver down to the circuit breaker (or fuse) panel. If you have multiple breaker panels, place the tapered end of the receiver next to each in turn (it is not necessary to open the panel's door). When you find the correct one—the one that controls the outlet or socket into which you plugged the transmitter—the receiver will beep repeatedly and its indicator will flash brightly. The sensitivity control should be at maximum for this check.

Once you've found the correct panel, you can use the Identifier to determine which circuit breaker within the panel controls the outlet of interest. Reduce the receiver's sensitivity to minimum. Then move the receiver up and down over the row (or rows) of circuit breakers. When you move the receiver over the circuit breaker that powers the correct AC outlet, the receiver should respond as before. If the receiver does not respond with the sensitivity at minimum, increase the sensitivity slightly and try again. Repeat until the receiver responds. Then record the location of the circuit breaker and turn it off. The receiver should stop responding.

You can also use the Identifier to determine which wall switch supplies power to an AC outlet or fixture. Before you use the Identifier with a dimmer switch, make sure to turn the dimmer switch to its brightest position. Plug the Identifier's transmitter into the outlet or fixture as before, then turn on the receiver and set it to its highest sensitivity.

Turn on the wall switch, then hold the front of the receiver next to the switch. If the wall switch indeed supplies power to the AC outlet or fixture, the receiver will respond. If not, locate another wall switch and repeat the test.

At only $29.99, the AC Circuit Breaker Identifier (61-2722) will find many applications in your home, the homes of neighbors, the office, and shop. It was even successfully used by this reviewer to quickly unsnarl a rat's nest of power cables used by a rock band. One important feature is that only one person is required to use the Identifier, no matter how big the house.

For more information on the Identifier, circle 15 on the Free Information Card, contact RadioShack (One Tandy Center, Ft. Worth, TX 76102) directly, or visit your local RadioShack store. EN

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NEW LITERATURE

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Digital Satellite TV

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Boulder, CO 80302
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CIRCLE 338 ON FREE INFORMATION CARD

This book is a completely re-written (right down to the title) version of the popular *Ku-Band Satellite TV*. The scope of the original was expanded to cover all aspects of worldwide digital satellite television systems.

The book begins with a look at the basics of satellite-TV systems, including the fundamental concepts of communications, digital modulation methods, the effects of noise, and frequency allocations. Following a brief study of analog video and audio methods, there is a chapter dedicated to the study of video compression, the MPEG-2 standard, DVB, and channel-encoding techniques.

The next four chapters cover the components of a satellite circuit—the uplink, the satellite, and the receive site. Included are in-depth descriptions of the launching, operation, and maintenance of satellites; the design and operation of each component at the receive site; and the differences between analog and digital components.

The book provides full coverage of the practical aspects of digital satellite TV, with an overview of selecting equipment, accessories, and encryption and scrambling methods. A comprehensive look at installation methods includes a discussion of upgrades—from C- to Ku-band, from single- to multi-feed operation, and from analog to digital reception. The book also covers conventional and IF distribution systems, mobile applications for satellite television, and Internet operation and access. A complete guide to troubleshooting and repairing satellite systems is also presented.

Digital Literacy

by Paul Gilster
John Wiley & Sons, Inc.
605 Third Avenue
New York, NY 10158-0012
Tel: 1-800-225-5945
Web: http://www/wiley.com
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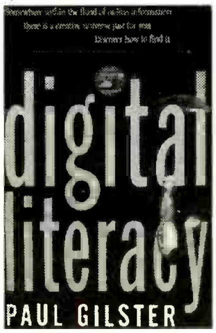

CIRCLE 339 ON FREE INFORMATION CARD

The Internet is the fastest growing form of popular media—but using it requires an entirely new mind-set. Without those new thinking skills, which the author of this book calls "digital literacy," the benefits of the Internet might be diminished or lost.

This book shows readers how to meet the intellectual demands of the electronic age by mastering the Internet. It doesn't explain how to navigate the Net; instead, it teaches the basic thinking skills and core areas of competence needed to thrive in an interactive environment.

The book explains how to evaluate sources of information found in news groups, bulletin boards, and other online sources. It demonstrates how to focus search strategies and how to use hypertext and hypermedia to literally chart your own path through vast pools of information. The book discusses the type of questions you should ask when viewing a Web site, and teaches methods for separating form from content. It shows you how to integrate the Net's massive flow of information into something that has meaning in your everyday business and personal life. Finally, it provides a glimpse of the future of digital literacy.

The Enhanced CD Fact Book Version 2.0

by Josh Warner
Apple Media Program
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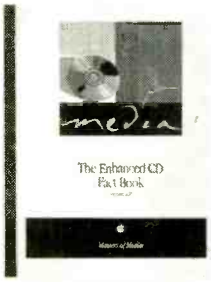

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The increasingly popular enhanced CD is a type of compact disc that contains interactive content as well as music. Users can play the disc on audio-CD or CD-ROM players. This book offers developers and consumers a source of definitive information on the enhanced CD format.

The book, which can be downloaded for free from AMP's Web site, explains different methods for creating enhanced CDs. It charts the evolution of the format and lists resources available to interactive music developers. The book includes interviews with top-selling artists Paul Simon, Bonnie Raitt, Billy Joel, and No Doubt; record producers Phil Ramone and Don Was; and many other music and multimedia industry executives and artists.

DSO Applications in High Speed Electronics

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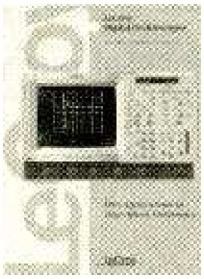

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design and test engineers in fields where high-speed electronic signals are important, such as communications, microprocessor-based systems, automotive electronics, and aeronautics. Topics include the effect of oscilloscope bandwidth on fast transients, glitches, and signal edges; sample-rate considerations; and how to achieve high effective bandwidth in a digital scope. Most important, the application note gives examples of how to efficiently solve typical measurement problems including making measurements in the presence of noise, interchannel-timing measurements between two signals, effects of crosstalk, debugging signal dropouts (such as microprocessor crashes), timing problems due to clock skew, and metastability. The note concludes with a discussion of probes and probing technique.

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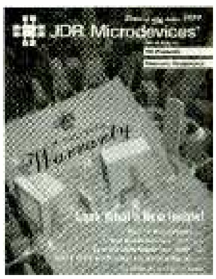

CIRCLE 342 ON FREE INFORMATION CARD

This 115-page, full-color catalog is full of products for computer and electronics hobbyists and professionals. Product categories include motherboards, floppy and hard drives, programmers, prototyping gear, printers, software, PC cables, ICs, fax/modems, industrial components, diagnostics, input devices, discrete components, accessories, test equipment, tools, kits, and connectors. New to this catalog (#59) are motherboards with the Pentium Pro processor, preconfigured network servers, educational robotic kits, and ATX motherboards and cases. "Special Value" items include the Snappy Version 2 video grabber, Casio color digital cameras, low-cost Ethernet network cards and 3Com Ethernet cards, color-coded patch cables, and a 16-bit sound card with enhanced I/O. "Derek's High Tech Corners" appear throughout the catalog, offering technical pointers and informed opinions on a wide range of electronic and computer topics.

Master Catalog 1997

from Jensen Tools Inc.
7815 South 46th Street
Phoenix, AZ 85044-5399
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Aimed at technicians and engineers throughout the United States and around the world, the Jensen Master Catalog is a comprehensive offering of products for the electronics industry. Among the new items featured are a pair of tool kits—one for electronics equipment service and the other with inch and metric tools for servicing domestic and foreign equipment. A wide range of test instruments is also offered, including the new SIMMCheckII advanced memory-module tester, an infrared temperature-measuring device, and an instrument for measuring loop current in telephone systems. The Jensen line of hand tools, selected and designed to meet the special needs of the electronics industry, has been expanded with the addition of a 35-piece super adapter set and many new tools with ergonomic designs.

Best of the New Ham Companion

edited by Steve Ford, WB8IMY
The American Radio Relay League
225 Main Street
Newington, CT 06111-1494
Tel: 860-594-0200
E-mail: ead@arrl.org
Web: http://www.arrl.org/
$12

This book presents a truly "new" take on ham radio—it's a compilation of articles

CIRCLE 344 ON FREE INFORMATION CARD

from *QST* magazine's "New Ham Companion" section, written from the perspective of the amateur-radio newcomer. The articles are all brief, easy-to-read, and informative. Together, they contain the key information needed to get started in ham radio and to operate a ham radio station like a pro. Selected articles from *QST*'s "The Doctor is IN" section are also included. They present straightforward and entertaining answers to common ham questions, and include important tips and pointers for experienced hams and beginners alike.

The book covers all aspects of getting on the air. It describes operating practices, explains the theory of—and presents plans for building—simple antennas, offers plans for building useful station accessories, and shows how to operate 2-meter repeaters. Other topics include SWL, digital modes, and linking up with ham satellites.

Starting & Running a Successful Newsletter or Magazine

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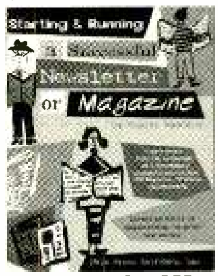


CIRCLE 345 ON FREE INFORMATION CARD

Last year, close to 1000 new magazines hit the newsstands, but less than half of them made it to the second issue. E-zines and newsletters don't fare much better—most e-zines fold before they break even.

This book, written by the co-founder of *PC World*, *PC Magazine*, and *Macworld*, shows publishing entrepreneurs how to turn their dream publications into successful business ventures. Drawing on dozens of real-life examples, the book shows new publishers how to avoid cost-

continued on page 70

BY SAM GOLDWASSER

Servicing Microwave Ovens

CAN YOU REMEMBER BACK TO WHEN YOU ACTUALLY HAD TO USE THE REAL OVEN TO DEFROST A TV DINNER, OR WHEN THE TERM "NUKE" WAS NOT USED FOR ANYTHING OTHER THAN BOMBS AND POWER REACTORS? WHILE THOSE DAYS MIGHT seem prehistoric, they only predate VCRs and PCs, not dinosaurs.

Unlike most consumer electronics products, the microwave oven has not changed much in the last 20 years; touch pads have pretty much replaced mechanical timers, but that's about it. And since microwave cooking is microwave cooking, an old but working microwave oven will heat foods just as well as a brand new one.

It is important to note that microwave ovens are extremely reliable devices. There is a good chance that a unit will operate for ten years or more without requiring repairs of any kind—and at performance levels that are virtually the same as the day it was first taken out of the box. But that is not to say that they never fail.

In this month's column and the one that follows, we are going to look at the things that do go wrong with microwave ovens and point you toward the kinds of safe repairs you can make. Specific manufacturers and models will not be covered. Instead, the most common problems and their most likely causes are described. In many cases, you will be able to take it from there, do what is required, and save an oven that would otherwise have gone to the junk heap.

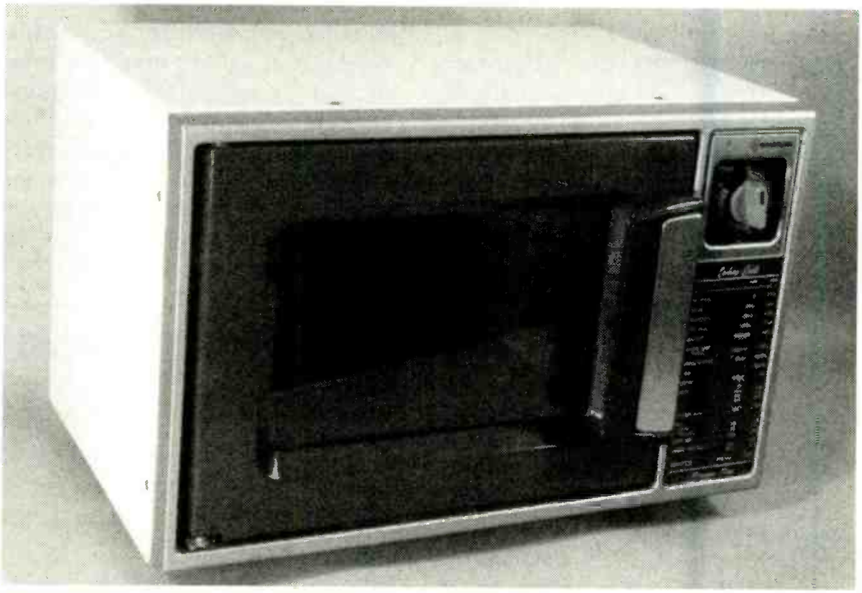
Before we get started, I would like to be sure that you know that there are two really good on-line microwave-oven-repair databases on the Internet. One is mine, located at http://www.paranoia.com~filipg/REPAIR/. The material to be presented over the next two months is actually a brief summary of what could be found there. For those looking for more information, my database is an excellent place to start. You might find the description of how a microwave oven works a particularly useful introduction to microwave repair.

A second site worth noting is at http://www.yup.com/microtech. This site also includes a "Tech Tips Database" with hundreds of solutions to common problems. Even if your exact oven is not listed, looking for one with similar symptoms may point you in the right direction. Also, there are links to other interesting microwave-oven sites. So if you have Internet access, be sure to note both of those Web addresses.

Repair or Replace

With new small- to medium-size microwave ovens selling for $60 to $125, it doesn't make a lot of sense to spend $60 or more to have one repaired. Even full-size ovens with full-featured touch pads can be found for $200 to $300. So you should seriously consider replacement before making a large investment in saving an older oven.

However, if you can handle the repair yourself, the equation changes dramatically, assuming your time is free. The educational aspects might also be appealing as you will learn a lot in the



MICROWAVE OVENS ARE GENERALLY so reliable that even a ten-year-old unit with a mechanical timer can work as well as the day it first came out of the box.

process. In addition, many problems can be solved quickly and inexpensively.

Safety Guidelines

Microwave ovens are one of the most dangerous consumer appliances to service. Very high voltages at potentially very high currents—a decidedly perilous combination—are present when the oven is operating. Those dangers do not go away even when the oven is unplugged, as there is an energy storage device—a high-voltage capacitor—that can retain a dangerous charge for a long time. **If you have the slightest doubt about your knowledge and ability to deal with those hazards, replace the oven or have it serviced by a professional.**

Careless troubleshooting can not only fry you with high voltages at high currents, but can microwave irradiate you as well. When you remove the metal cover of a microwave oven, you expose dangerous—potentially lethal—circuitry. You may also be exposed to harmful levels of microwave emissions if you run the oven with the cover off and the waveguide to the oven chamber has been damaged or misaligned.

As mentioned, there is a high-voltage capacitor in the microwave-generator circuit. Always ensure that it has been completely discharged before even thinking about touching or probing anything in the high-voltage power circuits. Remember, that capacitor can store dangerous amounts of power even after the oven has been turned off and unplugged from the wall outlet.

To further prevent the possibility of electric shock, do not operate the oven with the cover off if at all possible. If you must do so, follow this list of guidelines:

- Don't work alone—in the event of an emergency, another person's presence may be essential.
- Always keep one hand in your pocket when anywhere around a powered line-connected or high-voltage system.
- Wear rubber-soled shoes or sneakers.
- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or could get caught in moving mechanical parts.
- Set up your work area away from possible grounds that you might accidentally contact.
- Know your equipment—microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment.
- If circuit boards need to be removed from their mountings, place insulating material between the boards and anything that they might short to. Hold them in place with string or electrical tape. Prop them up with insulated sticks made of plastic or wood.
- If you need to probe, solder, or otherwise touch circuits with the power off, discharge large power-supply capacitors with a resistor (see below).
- Don't attempt repair work when you are tired. Not only are you likely to be careless, but your primary diagnostic tool—deductive reasoning—will not be operating at full capacity.
- Finally, never assume anything without checking it out yourself first. Don't take any shortcuts.

Discharging the HV Capacitors

The high-voltage capacitor must be discharged **EVERY TIME** after the oven is turned off, even if it appears to be dead. A number of faults can leave the capacitor with an even greater charge than would normally be present in a properly operating oven. Use a 25,000- to 100,000-ohm resistor with one end securely connected to the chassis—a clip-lead is convenient for that. Touch each of the capacitor terminals with the non-grounded end of the resistor for several seconds. Then, to be doubly sure, short across the capacitor terminals with the blade of a well-insulated screwdriver. I also recommend leaving a clip lead in place, shorting across the capacitor terminals as added insurance while working. At most, you will blow a fuse if you forget to remove it before powering up the microwave oven.

The Simplest Problems

Next, we will cover a variety of common problems and nearly all possible causes. To aid in your troubleshooting, I have listed the causes in their approximate order of likelihood, but you'll of course need to do a little bit of diagnostic work on your own to determine the actual trouble spot in the specific oven you are troubleshooting. Note that while we are covering a large variety of problems, we cannot cover everything that might go wrong.

Symptom: Totally dead oven.
Cause:
(1) No power to AC outlet (household fuse or circuit breaker open because of overload caused by fault in microwave oven or other electrical device connected to the same fused circuit.
(2) Blown main household fuse. Likely due to problem elsewhere in your home.
(3) Open thermal protector or thermal fuse inside microwave oven.
(4) Defective controller or its power supply.
(5) Clock needs to be set before other functions will operate (on some models only).

Symptom: No response to touch pad.
Cause:
(1) Door is not closed (some models).
(2) You waited too long (open and close door to wake the oven up).
(3) Controller is confused (pull plug for a minute or two to reset—when you reinsert it you will probably have to reset the clock as well).
(4) Defective interlock switches.
(5) Faulty controller or its power supply.
(6) Touch pad or controller board has been contaminated by over-enthusiastic cleaning.
(7) Defective or damaged touch pad.

Symptom: Oven works but display blank.
Cause:
(1) Defective controller or its power supply.
(2) Broken display panel.
(3) Oven needs to be reset (pull plug for a minute or two to reset).

Symptom: Incorrect controller operation.
Cause:
(1) Previous or multi-part cook cycle not completed.
(2) Controller is confused (pull plug for a minute or two to reset).
(3) Defective controller or its power supply.
(4) Touch pad or controller board has been contaminated by over-enthusiastic cleaning.
(5) Defective or damaged touch pad.

Symptom: Erratic behavior.
Cause:
(1) Previous or multi-part cook cycle not completed.
(2) Bad connections in controller or in microwave generator.
(3) Faulty relay.
(4) Defective controller or its power supply.
(5) Bad contacts or connections on mechanical timers.

continued on page 70

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BUILD THE POOR-MAN'S PLASMA GLOBE

This plasma globe uses an ordinary, decorative light bulb—and the power supply is great for other high-voltage experiments!

ROBERT IANNINI AND MARC SPIWAK

Man has been fascinated by high-voltage electricity ever since our distant ancestors became smart enough to realize that lightning was dangerous. However, it was thousands of years until man discovered that lightning was electrical in nature, and later was able to produce the effect on his own. Today, experimenting with high voltage is one of the most popular activities among electronics hobbyists. It's fascinating to create your own miniature lighting, plasma-globe storms, and other high-voltage effects.

The plasma-globe display described here is based on a solid-state power supply that produces a low-power, high-voltage, high-frequency electrical discharge. The main step-up transformer is simply a TV-flyback transformer with a new primary winding. To prevent overheating, the reworked transformer is submerged in mineral oil. The plasma globe itself is an ordinary 100-watt clear-globe light bulb.

Many other high-voltage experiments with bizarre effects can be conducted using the power supply. It is powered from a 12-volt DC supply, so you don't need to get involved with AC-line current. This is one of those projects that will make you feel just a bit like a mad scientist.

The Circuit. Figure 1 is a schematic of the high-voltage power supply. It is simply a step-up transformer driven by an AC signal. Input power is supplied to the circuit through 10-amp fuse F1 and switch S1. The circuit requires an input of 12- to 14-volts DC at 5 to 7 amperes. Since the power input is DC instead of AC, the transformer's input signal is generated by IC1, a Silicon General SG3525A pulse-width-modulator circuit. That component has two outputs that are 180° out of phase. The amount of time that both outputs are off (the "dead" time) is set by R1.

The output frequency of IC1 is made variable by potentiometer R3, with R2 setting the upper limit. That way, the operating frequency can be tuned to the frequency needed by T1 and any particular load connected to it. If you are thinking of connecting a voltage multiplier to the output as an experiment, varying the frequency will run the circuit out of resonance. That will give you a variable high-voltage DC supply.

The outputs from IC1 are amplified by Q1 and Q2, a pair of MOSFET transistors in a push-pull configuration. Since the transistors are driving a highly inductive load (the step-up transformer), L1 and C1 decouple the transistors from IC1, keeping the RF energy generated by the transistors away from the IC. Any parasitic oscillation that appears at the gates of Q1 and Q2 is eliminated by R4 and R5.

The step-up transformer, T1, is a standard TV flyback transformer to which a new primary winding is added during construction. The secondary winding is part of the original transformer. A snubber network consisting of R6 and C3 controls any energy caused by the transformer's leakage inductance. Otherwise, high-voltage spikes would quickly break down the transistors. The center tap of T1's primary is RF-grounded by C4 and C5, bypassing any high frequencies that appear at that point. The high-voltage output of the power supply is the result of T1's secondary coil resonating at around 50 to 70 kHz.

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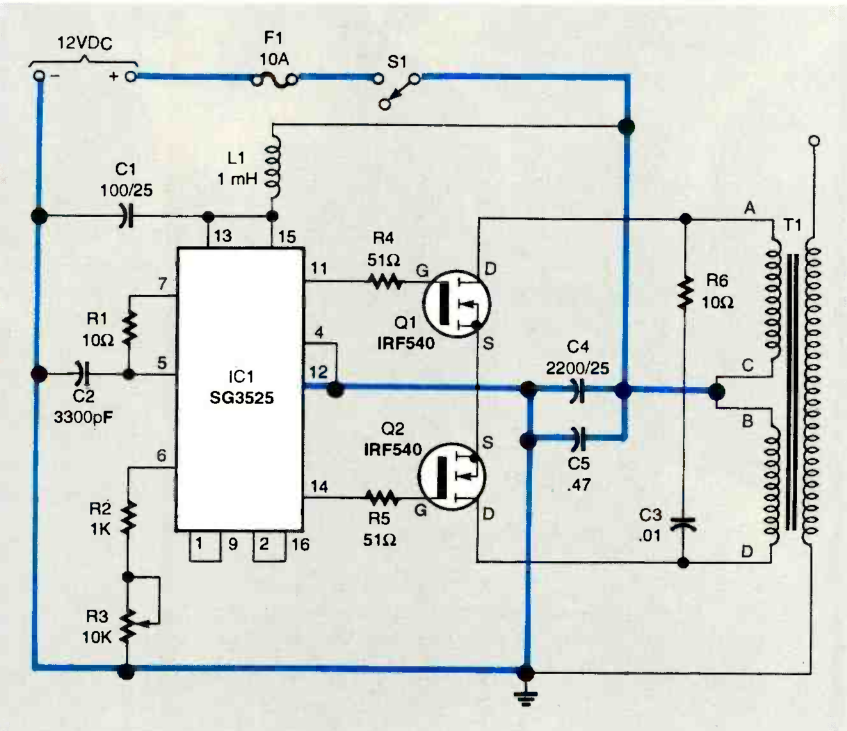

Fig. 1. The Poor Man's Plasma Globe is built around a high-voltage power supply. Transformer T1 is a modified television flyback transformer. Colored connections must carry a current up to 7 amps.

Construction. The Plasma Globe is one of those projects in which the vast majority of your time will be spent more in mechanical construction than in actual electronic assembly. If you do not have access to the necessary tools to make the base, individual components and a kit of all parts is available from the source given in the Parts List. While the parts themselves are not exotic, you might find yourself spending a lot of time and effort shopping at many different stores for the various items needed. Some of the more unusual items required include a TV flyback transformer, PVC drain-pipe parts for the tank, and mineral oil to fill it.

There is no PC board for the Plasma Globe because many of the traces wouldn't be able to handle the current. Instead, a 2-inch square piece of perforated construction board and point-to-point wiring is used. The parts-placement diagram in Fig. 2 is just one suggested layout design that you can follow if you choose. Parts placement is not exactly critical, except for Q1 and Q2 if you either buy a pre-drilled base from the source given in the Parts List or make one from the plans in this article. Holes in the base are used to mount the transistors. That way, the base can be used as a heatsink for the transistors. Bolting the transistors to the base is also a simple way to mount the circuit board to the unit. If you're not using an aluminum base, or choose another method of mounting the circuit board to the base, you'll need to come up with some sort of heatsink arrangement for the transistors. If you are using one of those bases, make sure that the holes on the transistor tabs line up with the holes drilled on the base before you solder anything to the transistor leads.

Wire-wrap connections can be used for the connections that are not drawn in color—those connections must be made with 20-gauge wire. However, instead of using wire wrap, it might be easier to simply bend the component leads over and solder them to one another wherever they are supposed to interconnect. Be sure to insulate any connections that cross.

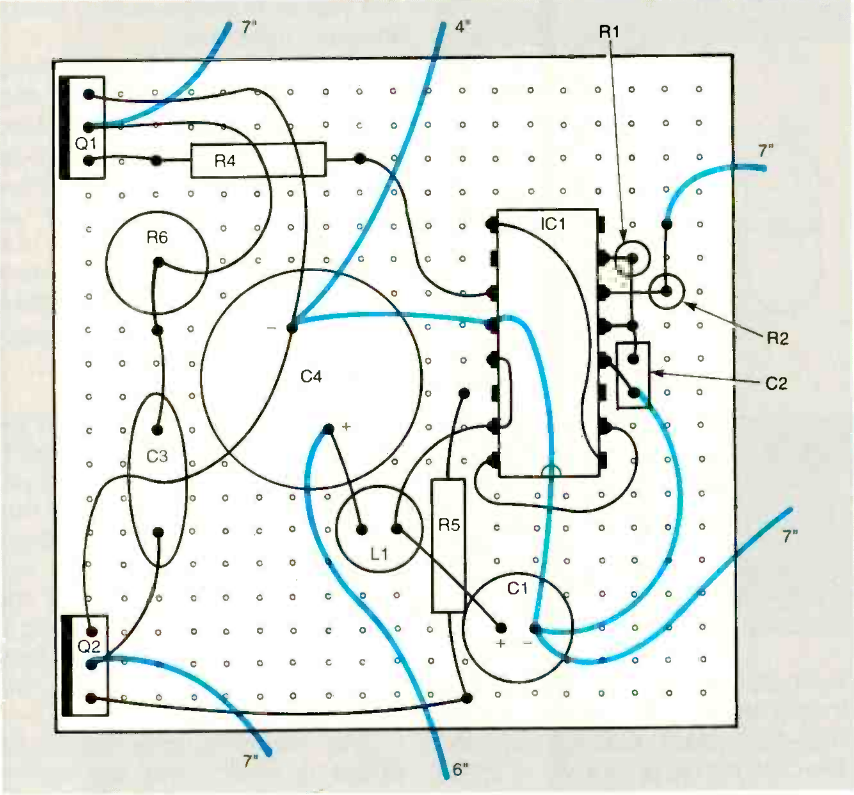

Fig. 2. The circuit is built on a 2-inch square piece of perforated construction board. The colored wires are 20 gauge in order to carry the heavy currents involved.

Six 20-gauge wire leads must be soldered to the finished board. Figure 2 indicates their positions and lengths. You'll trim them down to fit when it comes time for the final wiring.

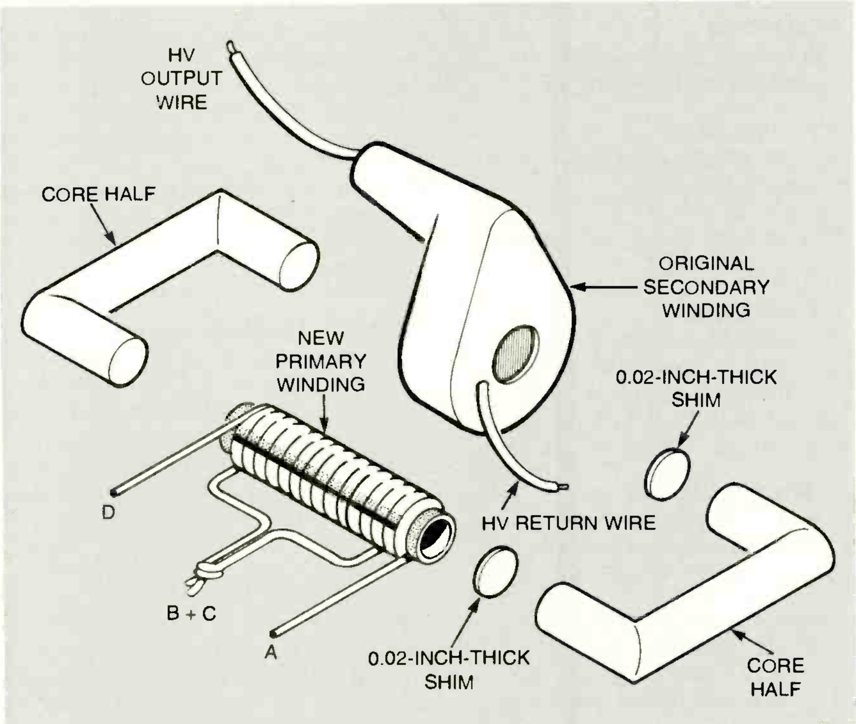

Fig. 3. It's easy to modify the flyback transformer. Parallel-wind 15 turns of 18-gauge magnet wire onto a $1^1/_6$-inch-long bobbin and wrap the winding with electrical tape. Don't forget the 0.02-inch thick shims between the core halves when reassembling. Use a nylon wire tie to hold the modified transformer together.

Flyback Transformer. Any black-and-white flyback transformer will do for the Plasma Globe. The easiest and cheapest way to get a transformer is to find one surplus. A specific part number is not important—black-and-white flyback transformers are somewhat generic in design. A suitable flyback is available from the source given in the Parts List if you have difficulty finding one or are not interested in buying a complete kit.

The modifications to the flyback transformer are detailed in Fig. 3. There is usually some sort of circuit board that has several pins in it. Those pins are connected to the transformer's primary windings. The primary windings are usually made from enameled magnet wire. There will also be a heavier, insulated wire. That wire is the ground connection of the high-voltage secondary winding. Since a new primary will be wound onto the flyback, any connections to the original primary can be discarded. However, the ground connection for the secondary winding is needed, so it is important to identify that wire first.

Unscrew the two nuts that hold the circuit board in place and remove the base. Clip off the wires from the circuit board. Verify which wire is the secondary return wire by measuring the resistance to the secondary high-voltage wire that sticks out of the top of the transformer. There will be a low resistance between the two wires. Clip off the wires from the old primary as close to the body of the transformer as possible.

The metal bracket that holds the transformer core together is now removed. The core halves are brittle, so be careful when doing the following steps. One end of the bracket passes through the body of the transformer and the other is more or less free—a bit of glue holds it in place. Bend the glued side of the bracket away from the core halves so that you can twist it back and forth. Wiggle it until it slides out of the transistor body; you might even have to "unscrew" it. Once the bracket is freed up enough, the bottom core half should slide out of the core. The

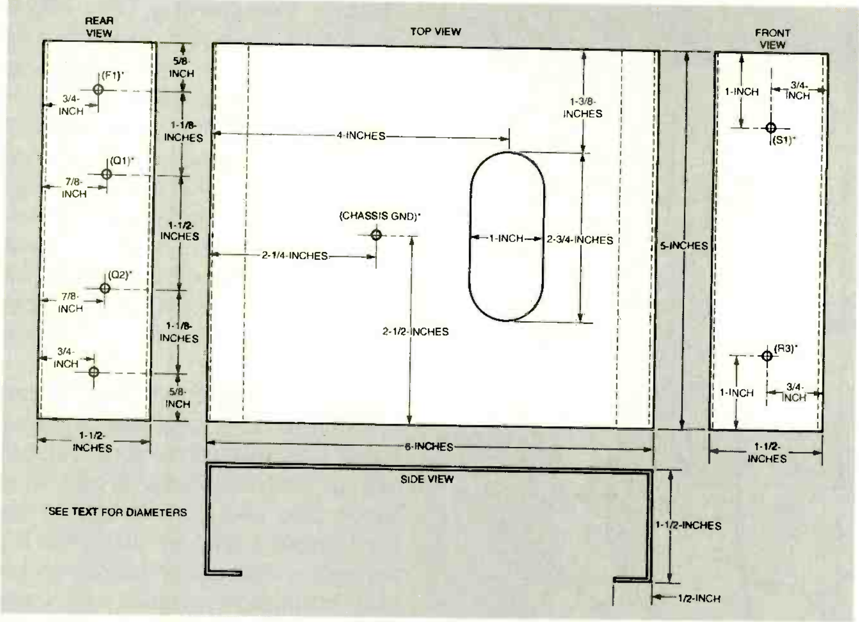

Fig. 4. You can make your own aluminum chassis by following this plan.

metal bracket and any spacers that might be located between the core halves are no longer needed, so they may be discarded. Set the transformer winding and the core halves aside for the moment in a safe place.

The new primary will be wound onto a bobbin. The bobbin can be a piece of rolled-up cardboard or plastic, plastic tubing, or any similar arrangement. The bobbin should be about $1^1/_4$ inches in length with an outside diameter of $^5/_8$ inch and an inside diameter of $^1/_2$ inch. Take two lengths of 18-gauge magnet wire and mark the ends of one wire "A" and "C." Mark the ends of the other wire "B" and "D."

Holding the "A" side of the first wire and the "B" side of the second wire together, parallel wind 15 turns onto the bobbin. That type of winding is called a *bifilar* winding—the first wire (winding A–C in Fig. 1) will be loops 1, 3, 5, etc. and the second wire (winding B–D) will be loops 2, 4, 6, etc. There will be 30 loops of wire on the bobbin—15 for each winding. Wrap the bobbin with electrical tape to hold the windings in place. Leave about 5 inches of wire for the leads. Scrape the enamel coating from the ends of the wires and tin the ends. Connect wires "B" and "C" together.

New shims for the core halves are made from a non-conductive material that is 0.02-inches thick. A business card is usually about 0.012-inches thick, so two layers of business-card stock placed between the core halves on each side of the transformer should do the trick. Check the shim thickness with a caliper if you can, as the thickness is somewhat critical. An alternative is to purchase some sheet plastic of the proper thickness from a hobby shop or craft store.

The transformer core halves, shims, primary winding, and secondary winding are reassembled as shown in Fig. 3. A nylon wire tie can be used to hold the modified transformer together. Do not use the original metal bracket as it only helps to overheat the transformer in its modified form. You can extend the ground return and output leads later on if necessary.

Mounting Base. If you bought the complete kit, then you already have a ready-to-use chassis. If you want to make your own, you can follow the dimensions given in Fig. 4 and make one out of sheet aluminum. The cutout on top of the base can be made by punching 1-inch holes spaced $1^3/_4$-inches center-to-center. Cut and file the remaining material.

The following holes should be drilled to match the size of the hardware you're using. Drill a hole for the chassis ground in the position indicated. That hole should be a clearance diameter for a 6-32 machine screw. Drill holes for poten-

PARTS LIST FOR THE POOR MAN'S PLASMA GLOBE

RESISTORS

(All resistors are $^1/_4$-watt, 5% units unless otherwise indicated.)
R1—10-ohms
R2—1000-ohms
R3—10,000-ohms, potentiometer, panel-mount
R4, R5—51-ohms
R6—10-ohms, 3-watt, non-inductive (not wire-wound)

CAPACITORS

C1—100-µF, 25-WVDC, electrolytic
C2—3300-pF, 50-WVDC, polyester
C3—0.01-µF, ceramic-disc
C4—2200-µF, 25-WVDC, electrolytic
C5—0.47-µF, 250-WVDC, polyester

SEMICONDUCTORS

IC1—SG3525A pulse-width modulator, integrated circuit (Silicon General)
Q1, Q2—IRF540 MOSFET transistor

ADDITIONAL PARTS AND MATERIALS

S1—SPST 7-amp switch
T1—Television flyback transformer (see text)
L1—1-mH choke coil
F1—10-amp fuse
Fuse holder, 6-32 × $^3/_8$ nylon screws and nuts, 6-32 × $^1/_2$ inch screws and nuts, #6 solder lugs, mica insulators for Q1 and Q2, wire strain relief, perforated construction board, 20-gauge wire, 18-gauge wire, 6 feet of 18-gauge magnet wire, metal chassis, 3-inch flat PVC end cap, 3-inch PVC top cap (3-inch curved PVC or soft plastic), 6-inch length of 3-inch diameter PVC tube, mineral oil, hardware, etc.

Note: The following items are available from Information Unlimited, PO Box 716, Amherst, NH 03031, Tel: 800-221-1705, 603-673-4730, Fax: 603-672-5406, web: http://www.amazing1.com: Complete kit of all parts including flyback, PVC parts, hardware, and pre-formed, pre-drilled aluminum base (TCL5-K), $49.50; Flyback transformer (TCL/SUPPLY), $14.50; Modified flyback (TCLFLY10), $24.50; 12-volt, 7-amp DC power supply, $39.50; Complete kit plus power supply (COMBOTCL), $79.50. Please add $5 shipping and handling on orders up to $25, $7.50 on orders up to $50, and $10 on orders up to $100. NH residents must add appropriate sales tax.

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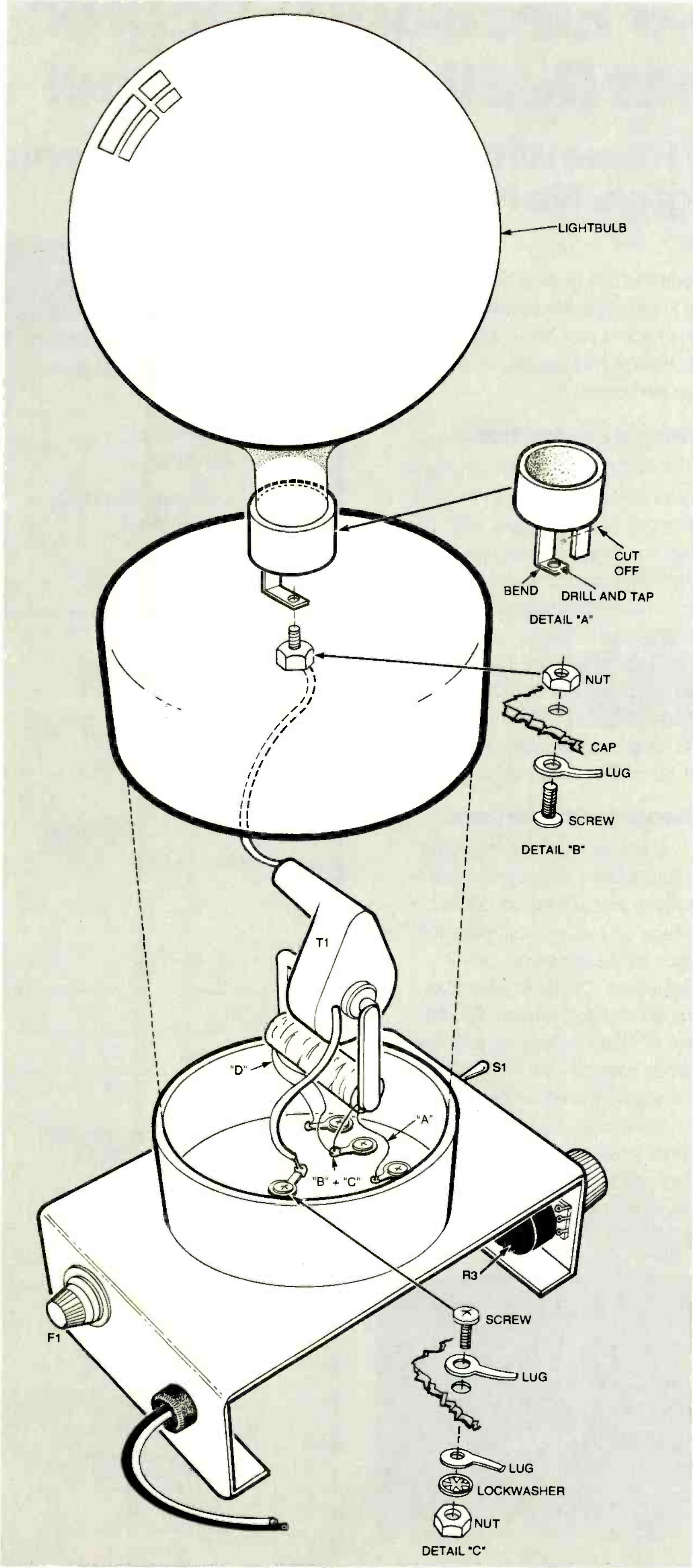


tiometer R3 and switch S1 on the front side and holes for the fuse holder and power-wire bushing on the rear side. Holes for the mounting tabs of Q1 and Q2 are drilled to the same center-to-center spacing as the transistors. They should be centered side-to-side within the rear panel and 1 inch from the top. If you followed the parts layout in Fig. 2, the holes will be $1^1/_2$ inches apart. The holes for Q1 and Q2 must be de-burred to prevent the transistors from shorting through the mica insulators.

Mount a 3-inch flat-bottom PVC cap onto the top of the base. The cap should be centered on the chassis-ground hole and the elongated slot in the top of the base. Glue or double-sided tape can hold it in place for now. Using the chassis-ground hole in the base as a guide, drill the same size hole through the PVC cap. Using detail "C" in Fig. 5 as a guide, place a 6–32 screw with a solder lug on each side through the ground hole and PVC cap and tighten in place with a nut. Drill three additional holes in the PVC cap for the transformer-wire lugs. Those holes should be equally spaced within the elongated slot in the base. Each hole receives a screw and pair of lugs in the same way the chassis-mounting screw was installed. Bend the lugs on each side of all four screws up at a right angle and seal the holes over the screw heads and nuts on both sides with epoxy or hot-melt glue. Do not get glue on the parts of the lugs where you will apply solder.

Main Assembly. Mount the circuit board to the underside of the chassis as shown in Fig. 6. The mounting screws for Q1 and Q2 hold the board in place. Be sure to use nylon screws, and put mica insulators between the transistor tabs and the chassis before mounting. Place some double-sided tape under the board to prevent any accidental shorts to the chassis. Use Fig. 6 as a guide when making the final wire

Fig. 5. Solder the transformer primary leads and ground lead to the top lugs as shown. The transformer ground lead can be lengthened if necessary. The light bulb is attached to the output by modifying a plug-in socket as shown in detail "A." The center prong is bent 90 degrees and has a hole drilled through it.

connections on the underside of the chassis. Use 18-gauge wire for the power-input leads. Those wires are indicated in color.

Turn the assembly upright and solder the transformer primary leads to the top lugs as shown in Fig. 5. The transformer ground lead is connected to the chassis-ground lug. It can be lengthened with 18-gauge wire if necessary. Insulate the splice with heat-shrink tubing. Re-check all soldering and wiring, and check the transistor tabs with an ohmmeter to make sure that they are not shorted to the chassis. Do not cement the PVC pipe to the PVC cap just yet, because once you do so, the transformer can't be accessed without a hacksaw if testing shows that there is a problem.

If you want to run it for more than just a few seconds at a time, the transformer must be submerged in mineral oil both for its cooling and insulating effects.

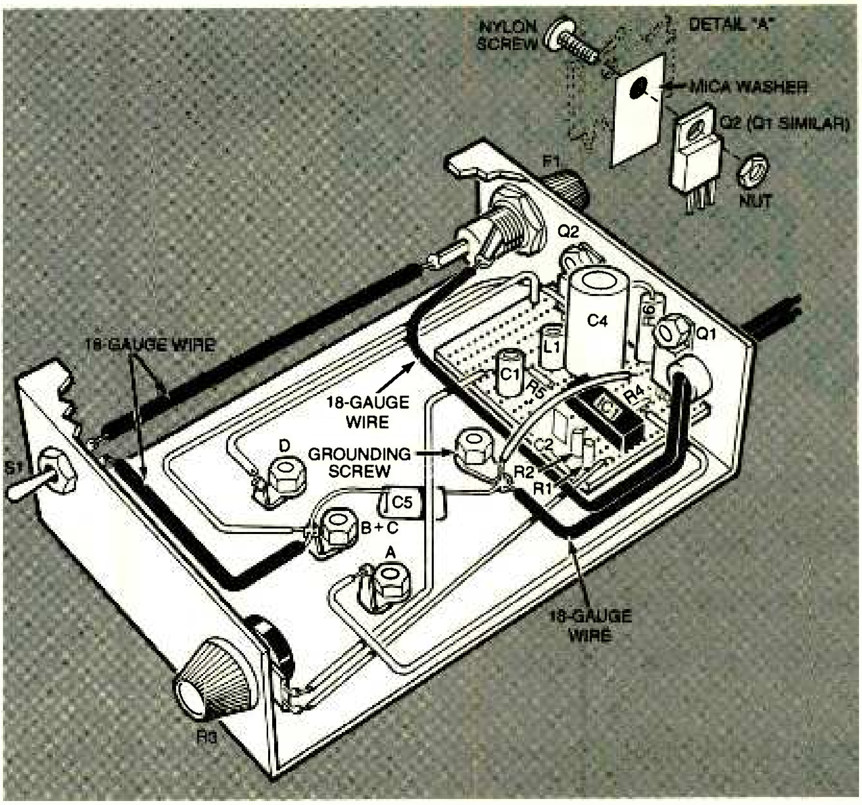


Fig. 6. The circuit board mounts to the underside of the chassis with nylon screws. Use mica insulators between the transistor tabs and the chassis. Put double-sided tape under the board to prevent shorting to the chassis. Use 18-gauge wire where indicated to carry the heavy currents.

Testing and Final Assembly. Since the circuit draws 5 to 7 amps when tuned to the resonant frequency of T1, a 12- to 14-volt DC power supply with a current capacity of at least 7 amps is needed for the Plasma Globe. That's quite a bit of current, so an ordinary power supply just won't do. A car battery will work, but that's hardly convenient. You can build a power supply, but you'll need a very large transformer, an exotic high-current regulator, and some beefy capacitors—an expensive proposition and a full-blown project by itself. It's much cheaper and easier to buy a ready-made power supply. A fixed 12-volt, 7-amp bench-top supply is available from the source given in the Parts List. Such a power supply can be useful on a test bench for years to come, which might make such a purchase a wise investment. Another alternative is a 10-amp car-battery charger, which is also useful off the test bench.

Turn potentiometer R3 fully counterclockwise and make sure that switch S1 is in the off position. Connect one end of a test lead to the chassis ground and place the other end about an inch from the bare-output wire of T1. It is very important to keep your body away from the output. Any discharge sparks can hurt, maim, or even kill. Connect the 12-volt power supply with an ammeter in series and turn on switch S1. The standby current should be about 1 amp. Slowly turn R3 clockwise and note that the current rises to about 2 amps with some corona visible at the output. At that current level, the circuit can be used continuously without risk of overheating the transformer. Continue turning R3 clockwise and note a sharp jump in current to around 7 amps. The output terminal's high-voltage discharge will come to life. Do not run it for more than a few seconds at that level or the transformer will likely overheat.

If everything is working, you're ready to seal the PVC enclosure tube. Slide the tube down over the transformer into the base cap to make sure everything fits properly. If the output lead is too short to reach the top of the tube, lengthen it with 18-gauge wire and insulate the splice with heat-shrink tubing. Remove the PVC tube, apply PCV plumbing cement to the bottom of the tube, and slide it back into the base cap. In a few seconds, a liquid-tight seal that will never come apart will form. The tube can then be filled with mineral oil to the top of the transformer.

Drill a small hole in the center of the top cap. Install a screw, solder lug, and nut as shown in detail "B" in Fig. 5. The arrangement is similar to the connections at the bottom to the tube. The high-voltage wire from T1 is soldered to the lug. The top cap does not have to be cemented onto the tube as long as the Plasma Globe is always kept in an upright position.

At The Top. The plasma globe itself is simply a decorative 100-watt clear-globe light bulb attached to the output. Those types of bulbs are usually found in specialty lighting stores. Detail "A" in Fig. 5 shows one way to connect a light-bulb socket to the output. Use a socket that plugs right into an AC outlet. Bend the prong that goes to the center contact of the bulb. The other prong is cut off flush with the bottom of the socket. The center prong is

Continued on page 47

ALL ABOUT SWITCHING POWER SUPPLIES

While more complex than their linear counterparts, where efficiency and size are concerns, switching supplies are hard to beat.

STEPHEN J. BIGELOW

Power supplies are used to convert an AC-line voltage into some fixed or variable value of DC voltage and current. The energy that the power supply delivers can then be used to drive an electrical load such as a radio, television, computer, or other circuit.

Most of us are quite familiar with the conventional linear-regulated (or "linear") supplies that are most often used for that task. While those are relatively simple and inexpensive, they are only up to 50% efficient, and can become quite large and run quite hot.

For some applications, there is a better alternative—switch-regulated (or "switching") power supplies. Those supplies use a clever technique to "chop" unregulated DC at a very high rate, then reconstruct the DC signal for use by the outside world. That high-frequency switching technique causes very little temperature rise in the supply so it can run much cooler. Also, smaller components can be used in building a switching supply, so the supply can be manufactured in a smaller package. However, the key advantage to those supplies is high efficiency—switching supplies can reach an efficiency of 85%.

In this article, we will examine switching power supplies in depth. We will look at some of the circuit variations and explain their theory of operation. We'll also look at some typical applications, the advantages and disadvantages of both switching and linear supplies, and even some basic repair and calibration issues.

Let's start our discussion by looking at Fig. 1. That illustration shows a block diagram for a simple switching power-supply circuit, and highlights each major segment for closer inspection. The first section we'll look at are the rectifiers.

Rectifiers. One of the key steps in converting an AC signal into DC is rectification. In rectification, a network of semiconductor diodes works to pass only one polarity of AC to the rest of the circuit. The single-polarity alternating signal is called "pulsating DC."

The first rectifier normally found in the switching supply is the input rectifier. It directly performs the initial conversion of AC line voltage into pulsating DC. A bridge rectifier, such as the one shown in Fig. 2A, is almost always used as the primary rectifier network since the design develops its own ground reference and isolates the rest of the supply from the AC line.

Use caution when working with the input rectifier circuit. The 120-volts AC at the input of the rectifier can easily develop up to 160-volts DC across the input filter. Those voltages can be dangerous and must always be treated with respect.

The second rectifier in a switching supply is the output rectifier. A variety of rectifier circuits could be used here. The simplest, but least effective rectifier is the half-wave rectifier shown in Fig. 2B. More often, the full-wave rectifier of Fig. 2C is used as the output rectifier; that's because it strikes an acceptable compromise between simplicity and effectiveness.

The chief drawback of the full-wave rectifier is that it requires a center tap in the secondary winding of the transformer to serve as the ground reference. Because of that, the bridge rectifier shown in Fig. 2D is also commonly used; a bridge rectifier requires more diodes, but eliminates the need for a secondary center tap at the transformer.

There are two important factors to keep in mind when working with rectifier diodes in a power-supply application—Peak Inverse Voltage (PIV) and Forward Current (I_F). The PIV refers to the maximum voltage that the diode can stand in the reverse-biased (or off) state. A good rule of thumb is for the PIV to be at least twice the peak voltage applied to the network, plus a 50%

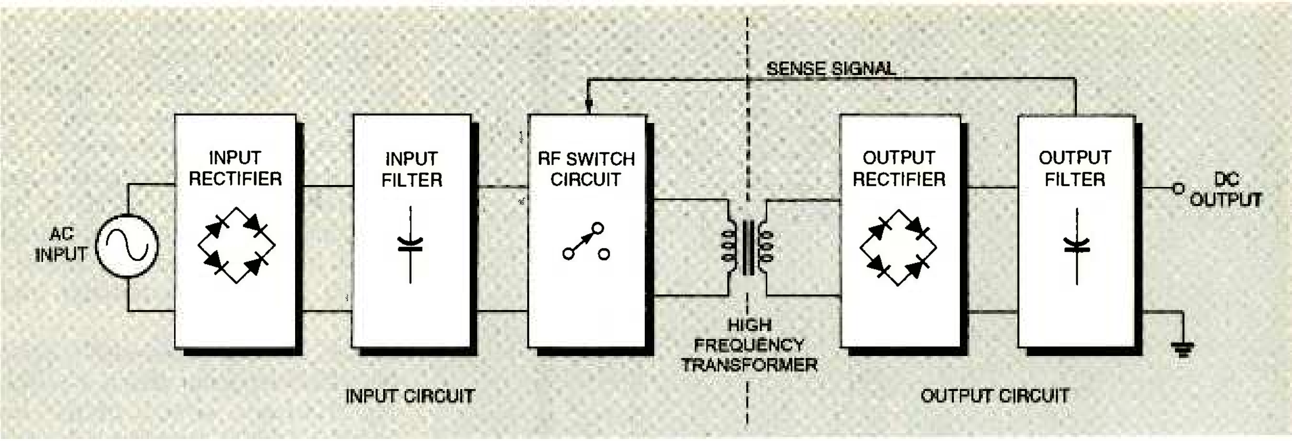


Fig. 1. This block diagram of a simple switching power supply highlights the major sections of the circuit.

safety margin. For example, if the input rectifier diode will be exposed to an AC line voltage of 115 V_{rms}, the peak voltage is $V_{rms} \times 1.414$ ($115\ V_{rms} \times 1.414 = 162\ V_{PK}$). The minimum PIV for those diodes should then be ($162\ V_{PK} \times 2$) + ($162\ V_{PK} \times 0.5$), or 405 V_{PIV}. Higher PIV ratings are acceptable. Common rectifier diode PIVs are 50, 100, 200, 400, 600, and 1000 volts.

Forward current is the maximum amount of current that the diode can pass in the forward-biased (or on) state. It should exceed the maximum expected current by at least a 50% safety margin. As an example, if 1 amp is expected to flow in the input rectifier, the rectifier diodes should have an I_F rating of (1 amp) + (1 amp $\times$ 0.5), or 1.5 amps.

Filters. Filters are used extensively in switching power supplies to smooth out the pulsating DC from the rectifiers to form a steady DC signal. As with linear supplies, capacitors are usually used as filters in switching supplies.

Capacitors are energy-storage devices that will charge up to the peak level of pulsating DC, then discharge slightly between pulses to sustain current to the load. Figure 3 shows the effects of filtering on a pulsating-DC signal—a larger current drain will discharge filter capacitors more deeply than a small current load. That charge and discharge signal across the filter is called ripple.

Turning back to our block diagram, the input filter operates at the frequency of the line voltage (50 to 60 Hz), so a fairly large value of capacitance is usually needed—a value between 1000 and 2200 mF is typically used. Additional capacitors can be added in parallel to increase the total amount of filter capacitance and allow more energy storage. That means that there will be less discharge between pulses—therefore, ripple will be lower. Use extreme caution when dealing with values of capacitance above 5000 mF. Those can store enough energy to become a shock hazard.

Since the capacitors used in the output filter will be operating at the frequency of the RF switching circuit (20 kHz or more; more on that later), much smaller values can be used there. Effective filtering of the high-frequency AC can be accomplished using values up to 470 mF.

When selecting capacitors for use here (or in any application), the working-voltage rating (WVDC) must be considered. Here, the working voltage should be more than 50% above the peak voltage of the pulsating DC.

As an example, if the output filter is being fed by pulsating 24 VDC from the output rectifier, the peak voltage from those pulses is approximately 24 V $\times$ 1.414, or 34 V_{PK}. After adding a 50% safety margin, the working voltage would be (34 V_{PK}) + (34 $V_{PK} \times 0.5$), or 51 WVDC.

High-Frequency Transformer. A transformer is used to convert high-voltage, chopped DC into a lower voltage secondary AC signal. Figure 4 shows a generic transformer that interfaces the input and output sides of a typical switching power supply. The transformer used in the switching supply must operate at the frequency of the switching circuit (20 kHz or higher). A conventional 60-Hz power transformer will not work at high frequencies. What is needed instead is a small, light, transformer designed for optimum magnetic coupling at the switching frequency. Turns of wire wrapped around a toroidal coil are often used.

Even though the size and shape of the switching supply transformer may be different than that of 60-Hz transformers, the principle of "magnetic coupling" remains the same. That is, the high-voltage pulsing applied to the transformer's primary windings will generate a strong magnetic field that will alternate as the DC pulses on and off. The core of the transformer carries that field to the secondary windings where an alternating signal is generated. That principle is also known as "transformer coupling."

RF Regulator/Switching Network. The heart of every switching power supply is the RF regulator, also known as the switching regulator. It is that critical circuit that rapidly chops the filtered DC from the input filter at 20 kHz or higher. That circuit is also responsible for providing the regulation necessary to keep the DC output constant.

Although there are several variations of switching circuits, the Pulse-Width-Modulation (PWM) technique is by far the most popular. Figure 5 is a block diagram of a basic PWM switching circuit.

That circuit operates as a

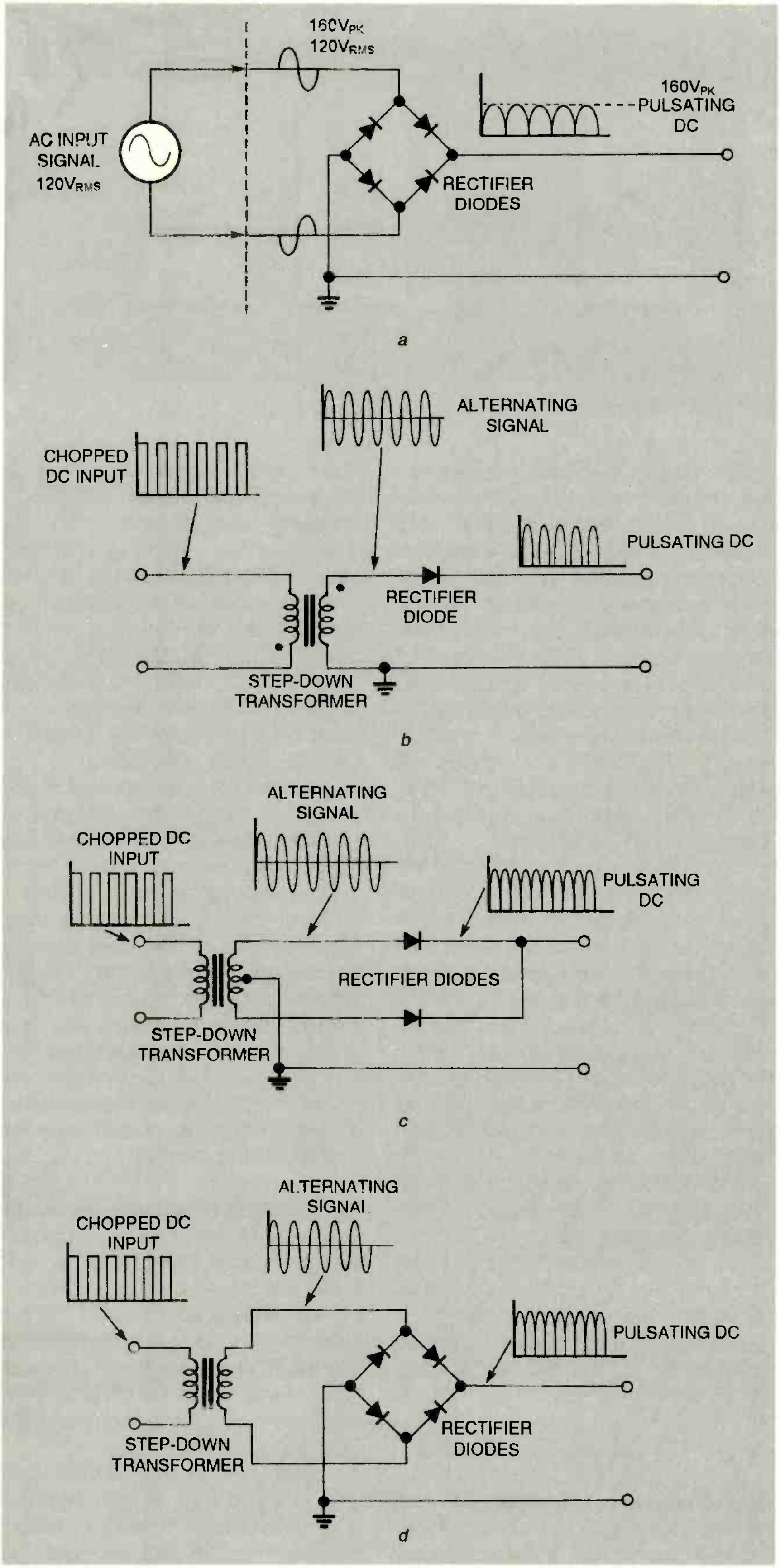


Fig. 2. A switching supply contains both an input and output rectifier. The input rectifier is usually a bridge type as shown in A. The output rectifier could be a half-wave (B), full-wave (C), or bridge (D) type.

"closed-loop" control network. The final DC output voltage is constantly sampled and checked against a factory-set reference voltage. That sample creates an error signal in an error amplifier. The error signal is used to control the pulse width of the switching signals out of the pulse-width modulating circuit, which is usually a variable pulse-width oscillator.

The varying pulse-width signal from that oscillator drives a switching transistor, which chops the unregulated DC from the input filter at a high frequency. A high-frequency step-down transformer reduces the high-voltage pulses into a low-voltage alternating signal. The "new" AC signal is then re-rectified and re-filtered in the output circuits to form the final DC output voltage. The output is sampled again and used to adjust the error signal accordingly. That "closed loop" control will continue as long as the supply is turned on.

It is the constant checking and adjustment of the closed-loop system that allows the switching supply to maintain its constant output voltage. As load conditions change, the DC output voltage will tend to vary. Those variations will be sensed by the switching circuit and compensated for automatically.

Now that we've seen how a basic switching regulator works, it is time to look at some variations and applications.

The Hybrid Switching Regulator. It is not always necessary to use a high-frequency transformer in switching designs. The transformer is used only to convert high-voltage pulses to a low-voltage signal. If the unregulated DC into the switching circuit is already at a useful voltage, then transformation is unnecessary. As an alternative, a standard 60-Hz power transformer can be used to step down the AC line voltage before the input rectifier, as shown in Fig. 6. Notice the striking similarity between the input portion of Fig. 6 and a normal linear DC supply. That type of hybrid circuit combines the simplicity of linear supplies with the efficiency of switching circuits.

A working 5-volt DC, 500-mA

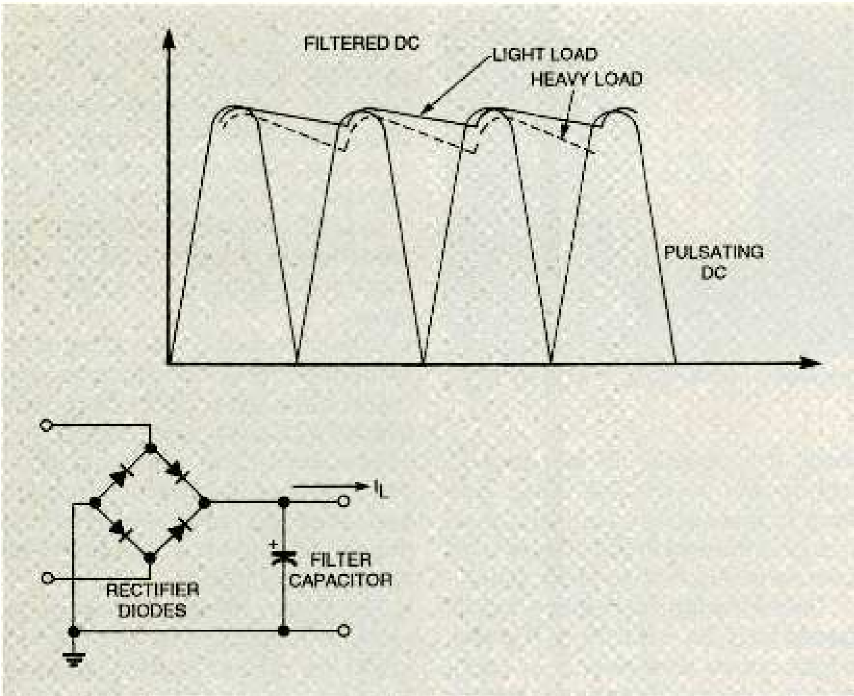


Fig. 3. The effects of filtering on a pulsating-DC signal: A larger current drain will discharge filter capacitors more deeply than a small current load, and the charge and discharge signal seen across the filter is called ripple.

power supply based on that concept is shown in Fig. 7. In it, a National Semiconductor LM341 linear voltage regulator is made to oscillate, and performs the actual conditioning of the DC output signal. Oscillation frequency in the circuit is governed by the ratio of R2 and R3, with feedback being delivered by inductor L1. The actual switching of the unregulated DC is performed by Q1.

The Flyback Switcher. The flyback switching configuration, shown in Fig. 8, is generally found in switching supplies up to about 100 watts. As can be seen in the diagram, very few components are needed to form that type of circuit, which makes it an economical arrangement for low-power supplies.

The high-frequency transformer is critical in this application, since it not only steps down voltage, but provides isolation and current limiting from the AC line. The primary and secondary windings are wound in opposing directions so that when the pulse control circuit turns on the transistor, current flows through the transformer, but the output rectifier does not conduct. When the transistor turns off, primary voltage reverses and has a "flyback" effect that allows current to flow through the output rectifier to the output filter. The pulse width controls the energy stored in the transformer—thus controlling (or regulating) the ultimate DC output voltage.

Flyback switching is limited to about 100 watts due to the current requirements of the transformer and the limitations of peak current in the switching transistor. For applications above 100 watts, the forward switching circuit, which is discussed next, is often used.

The Forward Switcher. A forward switching circuit like the one shown in Fig. 9 is most effective in 80- to 200-watt supplies. The circuit represents a serious improvement in ripple suppression as it uses a bridge rectifier, which by nature of its design, provides much less ripple than the half-wave rectifier used in the flyback switcher. To reduce ripple further, an inductor (or "choke") could be added in series with the filter capacitor. Then, when the switching transistor is on and the output rectifier is conducting, the choke will establish a potential across itself. When the switching transistor turns off and current stops in the output rectifier, the polarity of the choke's potential will reverse and provide some extra current to help sustain the load, further reducing ripple.

A slightly different pulse-control circuit is used with the forward switcher. That is necessary since the variations in the output current require changes in pulse-timing parameters to provide optimum performance. Like the flyback switcher, however, the pulse-control circuit still controls the energy delivered to the transformer, which translates into control of the DC output voltage.

Push-Pull Switcher. Above 200 watts, a more sophisticated approach is needed. A push-pull switching circuit is a high-capacity design that can be used in switching supplies up to 600 watts. In that type of switching arrangement, shown in Fig. 10, two independent pulse-width modulation circuits are used to drive each side of the switching-transistor network, which allows high currents to be developed in the supply.

Ripple in the push-pull circuit can be significantly reduced by carefully balancing the timing of each PWM circuit. Done properly, that allows the outputs of push-pull circuits to have the lowest ripple content of any switching supply.

Notice that the output rectifier and the output filter of that circuit are essentially the same as the forward switcher. Two sensing signals are taken from the DC output to serve as sample voltages in each pulse-width modulator.

Switching-Supply Disadvantages. While switching supplies offer many advantages, they are far from ideal and present many problems of their own. For example, switching power supplies are highly efficient because the high-energy, short-duration DC pulses (chopped DC) created by the high-frequency switching cause very little power dissipation—and therefore very little power wasted—in the switching transistor. That, in turn, reduces the power loss in the system. Less power dissipation also means that less

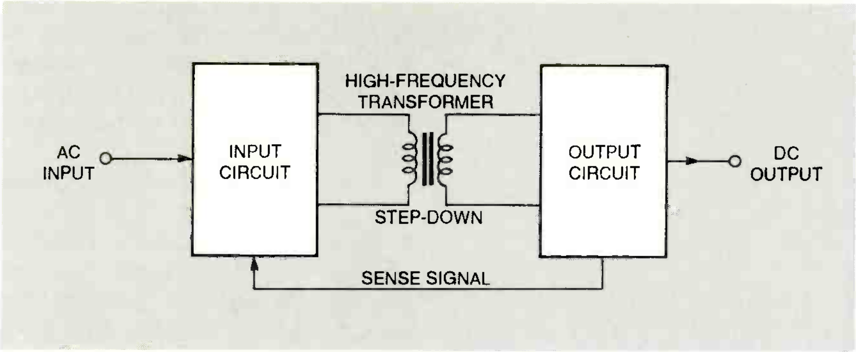


Fig. 4. As shown here, a high-frequency transformer is used to couple the switching supply's input and output circuits.

heat is generated in the power supply, which can extend the working life of the semiconductor components.

However, in order to achieve that advantage, DC is usually chopped at frequencies of 20 to 30 kHz, and switchers are currently being built to operate at up to 500 kHz; units that switch at up to 1 MHz will be available in the near future. But, each of those operating frequencies fall well within the RF (radio-frequency) spectrum. As a result, it is possible for any and all conductors in the switching portions of the supply to act as antennas and transmit those frequencies over remarkably long distances.

Under the right conditions, the RF generated by switching supplies might cause interference to other nearby pieces of electronic equipment. Even the very circuits that the supply is meant to drive might be susceptible to the disturbances that RF can cause. With that potential for noise production, it is important to know that there are several types of circuits where switching supplies probably should not be used: Extremely sensitive radio receivers and electronic instruments that must accurately measure small signals are just a few examples of that.

In spite of those difficulties, there are a variety of techniques that are used to combat the effects of noise:

- Careful shielding and grounding of the switching components and outer case can go a long way toward reducing transmitted RF.
- Interconnecting cables used in the vicinity of the supply should be well shielded, and the shielding should be common-grounded to the supply circuit.
- Electronic filtering components such as capacitors and inductors could be added to the design of the supply to suppress many of the RF emissions.
- Changing the physical orientation and position of components in the supply, as well as the location of the supply itself can alter (and

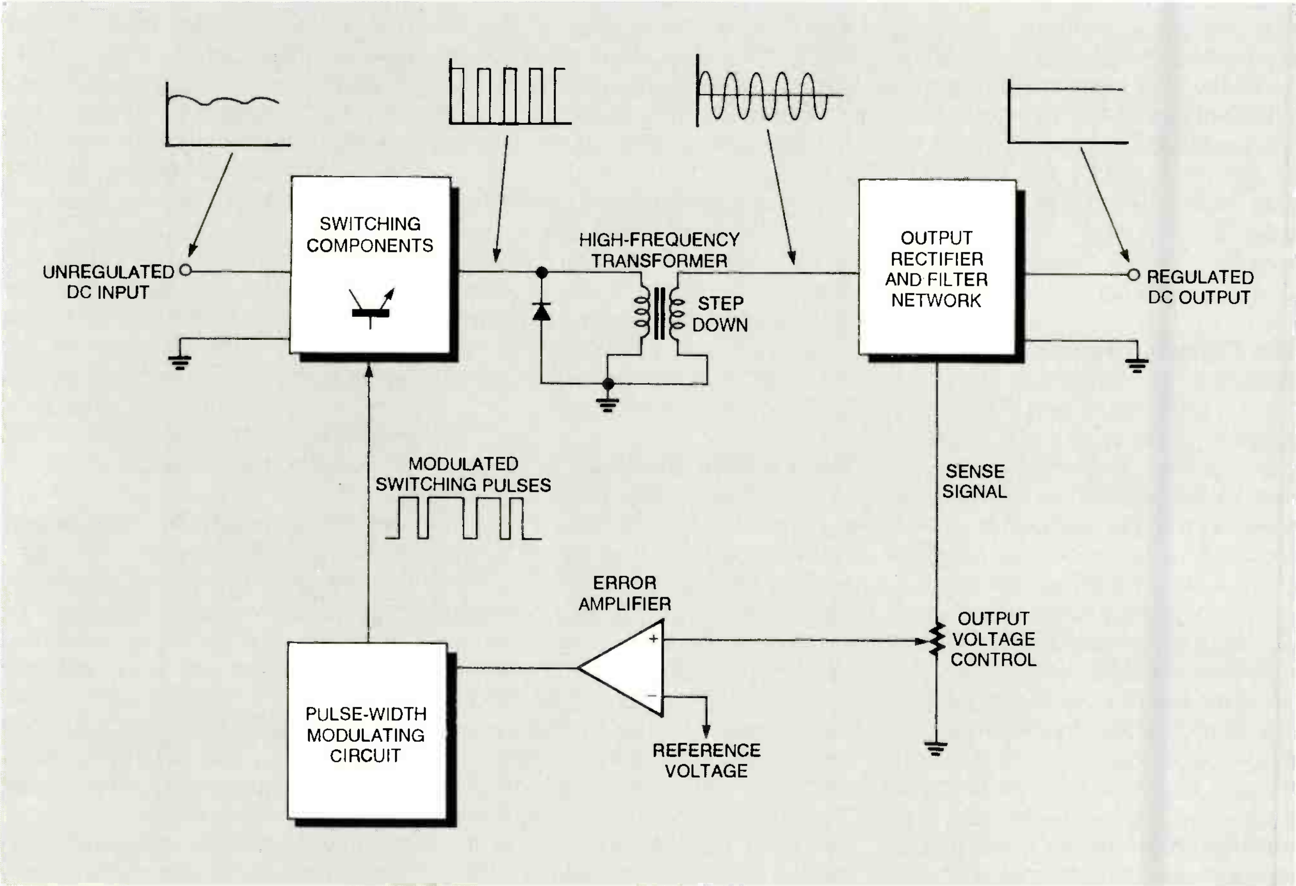


Fig. 5. The switching network used in a switching supply is shown here in block-diagram form. That circuit operates as a "closed-loop" control network.

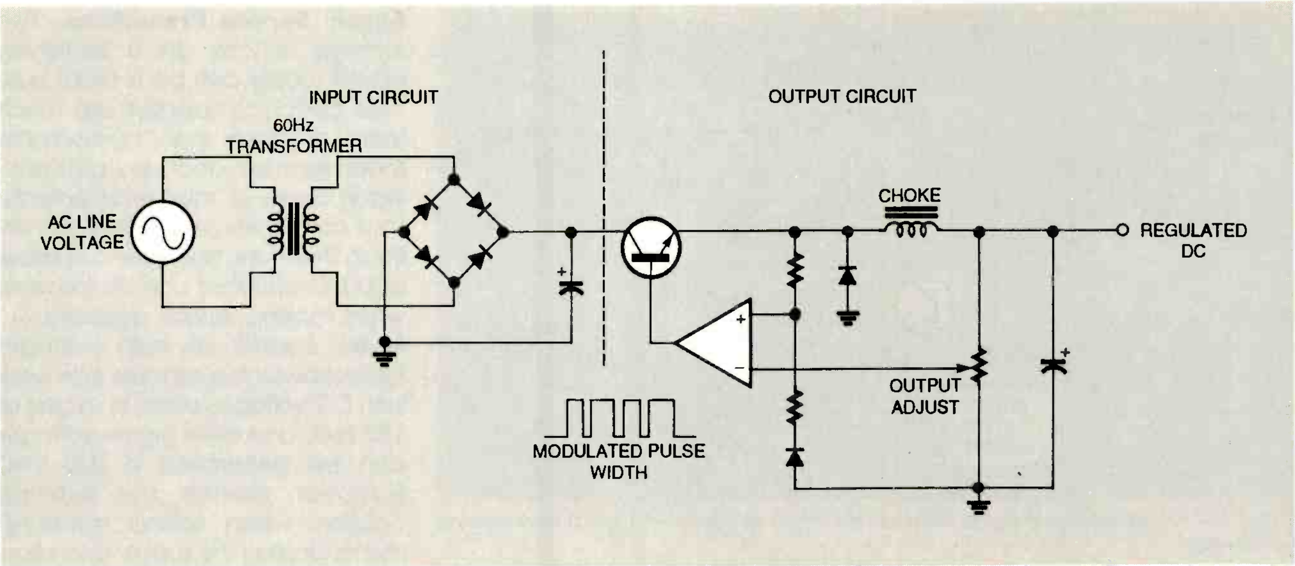


Fig. 6. In the hybrid switching supply, a standard power transformer is used to step down the AC line voltage before the input rectifier. This design combines the simplicity of a linear supply with the efficiency of a switching supply. It also eliminates the need for the high-frequency transformer.

sometimes reduce) the effects of RF outside of the supply.

When working with new switching power-supply designs, be prepared to experiment with different layouts and techniques to optimize performance. Often, noise and grounding problems may have to be solved by trial and error. Switching supplies must be designed to conform to FCC Class B requirements, as well as the European standard VDE 0871 for Class B RF products.

A switching power supply's ability to continually adjust the output voltage is not quite as good as that of its linear counterparts. That is because it takes a certain amount of time to correct the width of each pulse. If the demands of the load change, it could require several pulse cycles to fully compensate for the change. A linear regulator, on the other hand, is able to compensate for continuous load changes almost instantly.

As an example, consider a switching power supply providing an output of 5 volts at 1 amp. If the load should change suddenly and draw 2 amps, the output voltage from the supply will tend to drop. Of course, the sense signal will feedback to the PWM circuit, which will adjust the pulse width and provide additional energy to the transformer to restore the original output voltage, but it can take up to ten times longer to correct for those changes than with a linear regulator.

That phenomenon also makes it more difficult to provide the rated output voltage at full load current, so switching-supply load regulation can be as low as 1%. While that seems fairly poor, especially when you consider that a well-designed linear supply can achieve better than 0.1% load regulation, it is still fine for most applications.

Ripple voltage is an undesirable signal that rides on the DC output signal. Its magnitude is greater in the output of a switching supply than a linear supply, sometimes exceeding 10 mV peak-to-peak. A

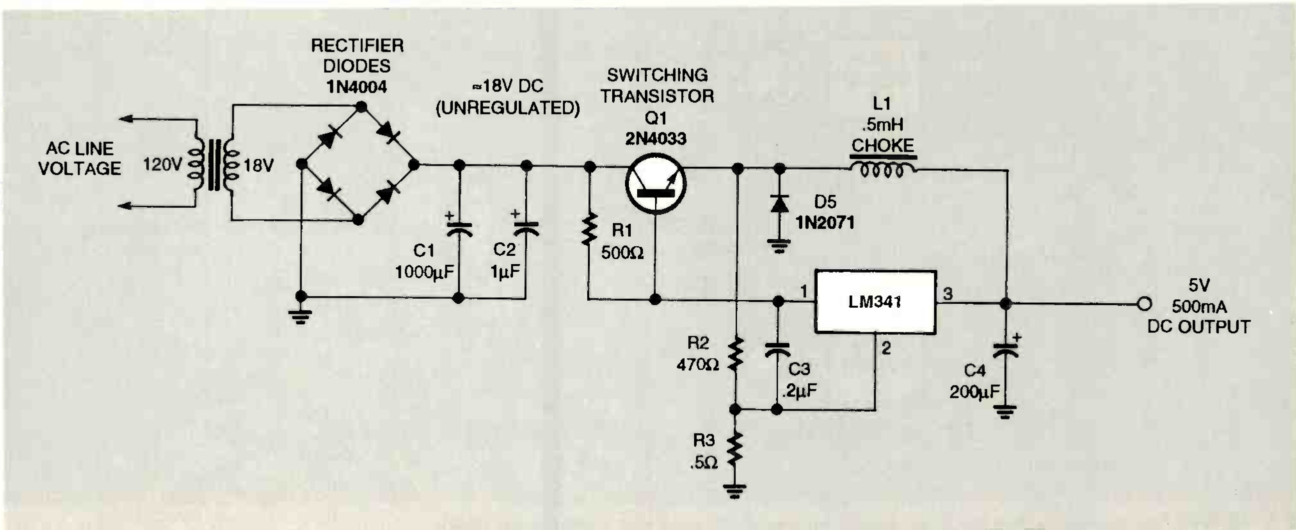


Fig. 7. The complete schematic for a practical 5 VDC, 500-mA hybrid supply is shown here.

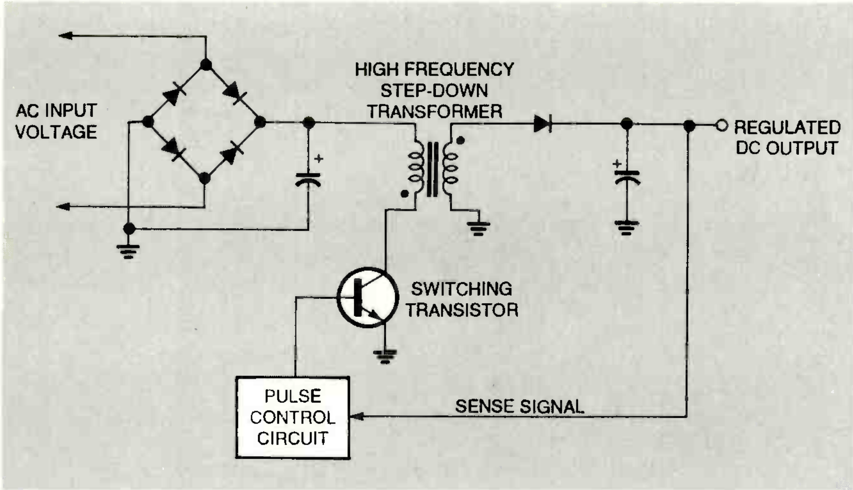


Fig. 8. For low-voltage supplies up to 100 watts, the flyback switcher shown here is an economical arrangement.

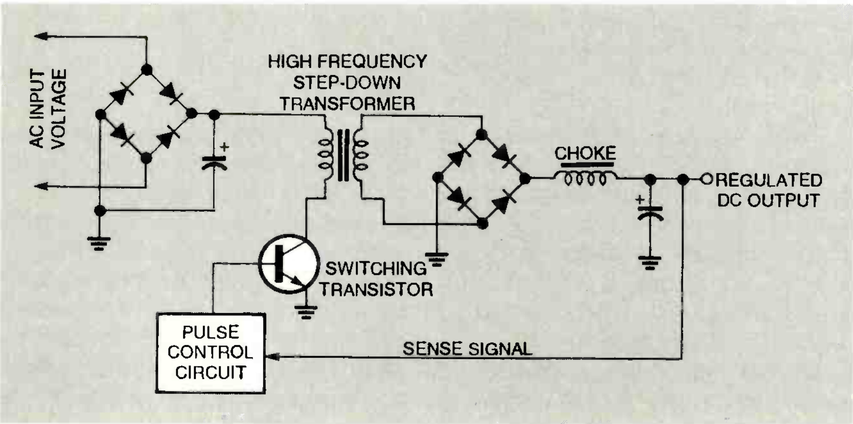


Fig. 9. The forward switcher shown here provides improved ripple suppression. It is practical for supplies delivering between 80 and 200 watts.

comparable linear supply can usually keep ripple to less than 1 mV peak-to-peak.

To make it easier to compare the advantages and disadvantages of linear and switching supplies, Table 1 compares the key parameters of each.

Supply Service Precautions. Performing service on a switching power supply can be a tricky business. Switching supplies are much more complex than comparable linear supplies, and very demanding in terms of their requirements. That can make any service job difficult. There are, however, a number of basic rules that can be followed when making service decisions.

- Be careful of high voltage! Typical switching supplies can work with DC voltages easily in excess of 150 volts, and even higher voltages can be generated in 220 VAC European models. Use extreme caution when taking measurements. Unplug the supply and allow all filter capacitors to discharge fully before doing any work on the circuit.
- Watch out for the shielding. Shielding and grounding techniques are carefully employed to suppress RF signals within the supply. Replace and re-solder any shielding, and re-secure all grounds before operating the serviced supply. Otherwise, the supply may cause unpredictable RF interference to other equipment.
- Use only exact replacement parts. A switching supply is a fairly intricate assembly of components, each chosen to provide a certain effect in the circuit. Replacing components with values other than the original value can seriously impair the supply's performance. For example, replacing a timing com-

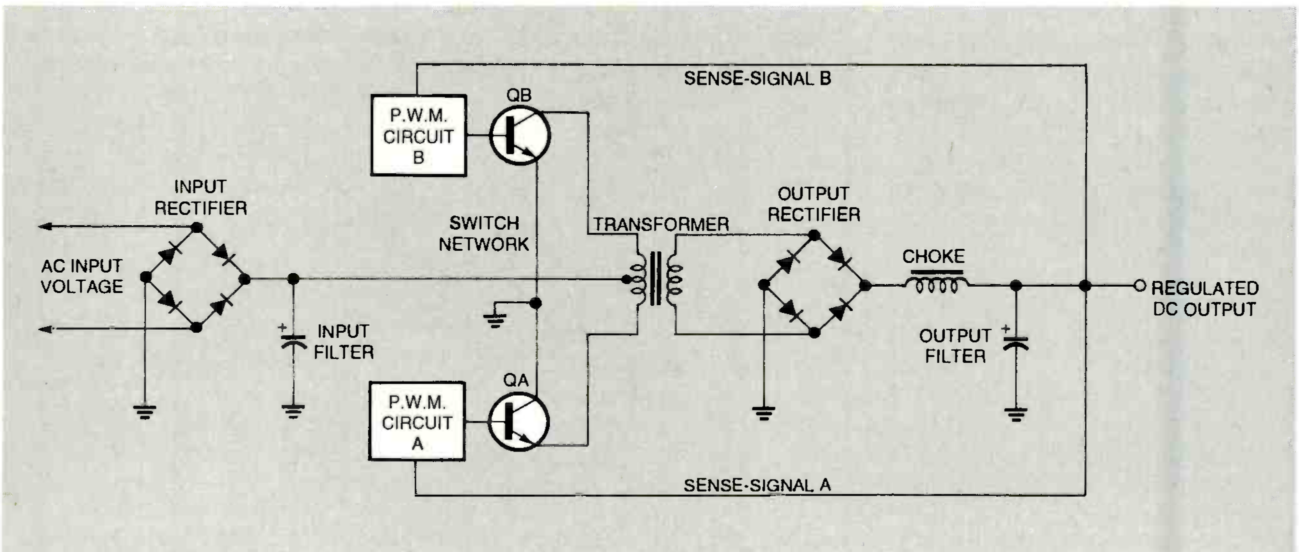


Fig. 10. While more complex than the other designs presented, the push-pull configuration shown here can be used in supplies up to 600 watts.

TABLE 1—COMPARISON OF LINEAR AND SWITCHING POWER SUPPLIES

Parameter	Switching Supply	Linear Supplty
Efficiency	60 to 80%	30 to 50%
RF Noise	Can be a problem unless shielded	Usually negligible
Transformers	Smaller, lighter, high-frequency magnetics	Requires bulky 60-Hz magnetics
Ripple	10 to 40 mV pk-pk	1 to 5 mV pk-pk
Regulation	0.3 to 1% (V_{FL})	0.05 to 0.1% (V_{FL})
Power/Weight Ratio	30 Watts/lb. (avg.)	15 Watts/lb. (avg.)
Temperature Rise	20 to 40 deg. C above ambient	50 to 100 deg. C above ambient
Reliability	Cooler operation improves the reliability	Runs much hotter and can degrade reliability

ponent in the PWM circuit with a component of a different value can effect the switching frequency, which, in turn, may render any RF suppression techniques (which have been optimized for the original frequency) ineffective. Also, use only the same type of parts. If a tantalum capacitor must be replaced, it should be replaced with a tantalum capacitor of the same value. The same is true for all other components.

• Leave calibration adjustments alone. Some versions of switching supplies may contain one or more adjustments to alter such things as current output, voltage reference, or some aspect of the switching circuit. Unless the tools and instruments are available to perform a proper service alignment, it is usually best to leave those adjustments alone. Otherwise, an improper adjustment can degrade the supply just as much as the use of an improper component.

Conclusion. The switching power supply, like all other power supplies, must convert an AC line voltage into some value of DC voltage and current that is used to power an electrical load. A switching supply accomplishes that by chopping a high-voltage, unregulated DC signal at very high frequencies (radio frequencies), transforming the chopped DC into a lower-voltage AC signal, then re-rectifying and re-filtering the AC signal into the desired DC voltage.

The primary advantage of the switching technique is efficiency. Much less power is wasted in a switching supply than in a linear supply, so more output power can usually be developed for the same amount of input power. Another advantage is compactness. Even though more components are needed to make a switching supply, they can be much smaller. That results in a smaller overall assembly.

There are some disadvantages encountered in switching supplies. RF noise is the most serious of those. The high-frequency signals generated by the switching network can cause serious interference in other circuits. A variety of noise-suppression techniques are used to keep the RF under control. Regulation and ripple are not as good as in a comparable linear supply, but a switching supply will still work well in many applications.

As switching frequencies rise and RF suppression techniques become more effective, switching power supplies will become the preferred supply for high-power applications where efficiency and size are critical. Ω

PLASMA GLOBE

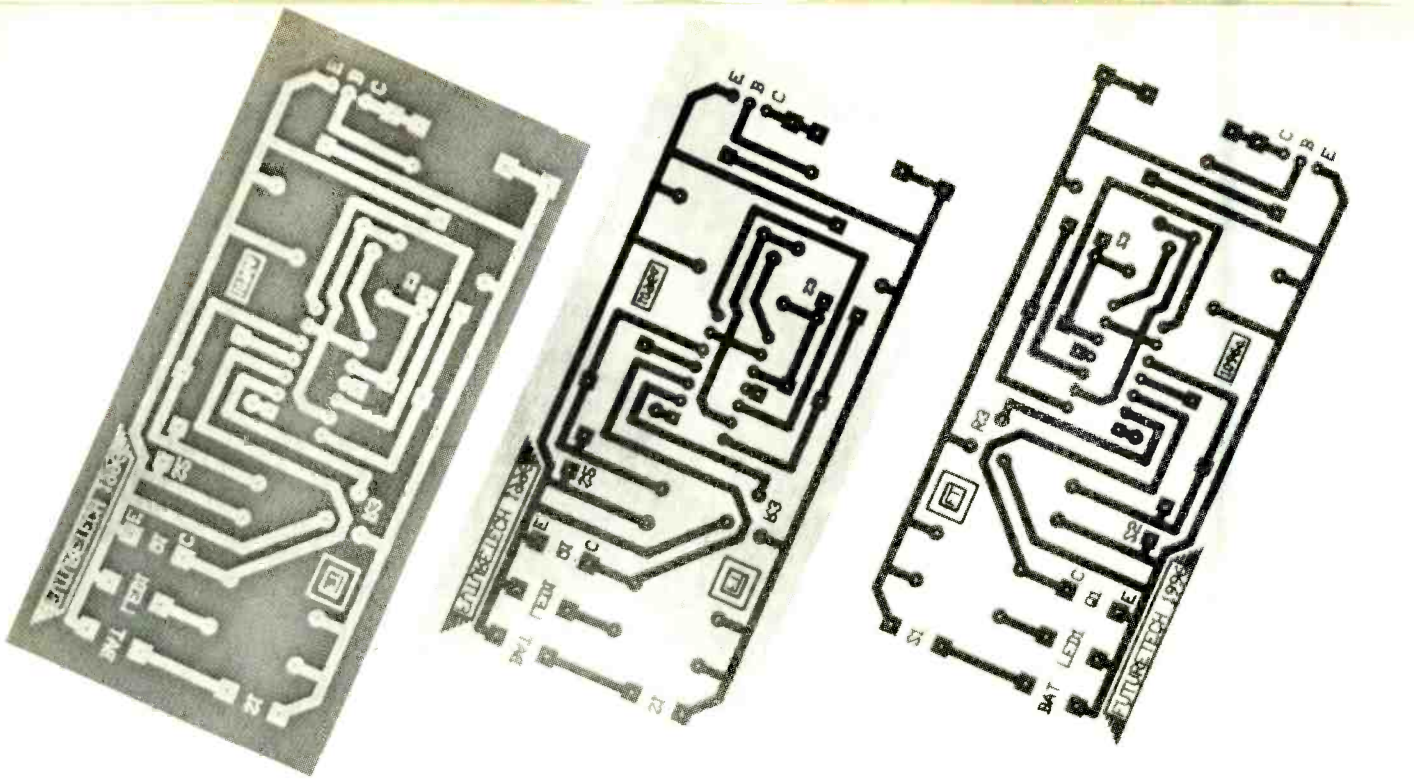
(Continued from page 39)

bent 90 degrees. Drill and tap a hole through the bent prong so that it can be attached to the small screw in the top cap. Whenever possible, use clear burned-out light bulbs—they work just as well as good ones.

Here is a standard television-flyback transformer. Modifying it by adding a new primary winding is the heart of the Poor Man's Plasma Globe.

Many interesting experiments can be carried out with the Poor Man's Plasma Globe. You can test different incandescent light bulbs for various effects, try lighting up fluorescent tubes, or even connect a mini-Jacob's Ladder to the output. If you try the Jacob's Ladder, don't expect much in the way of dramatics. You need a lot more than 7 amps to climb a big ladder.

The one important thing to remember with any high-voltage experiment is safety! Nikola Tesla would routinely adjust his high-voltage equipment with one hand in his pocket in order to prevent any accidental shock from zapping his heart. His death at the ripe old age of 86 is testimony to the fact that one can never be too cautious around electricity—high-voltage or otherwise. Ω



Make Your Own PC Boards *Using Toner-Transfer Products*

Once you've learned how, there's no easier way to make PC boards, especially if you need more than one.

LARRY BALL

What's the easiest way to make ten or twenty identical printed circuit boards? Well, while there's many different techniques you could use, in my experience toner-transfer products are your best bet!

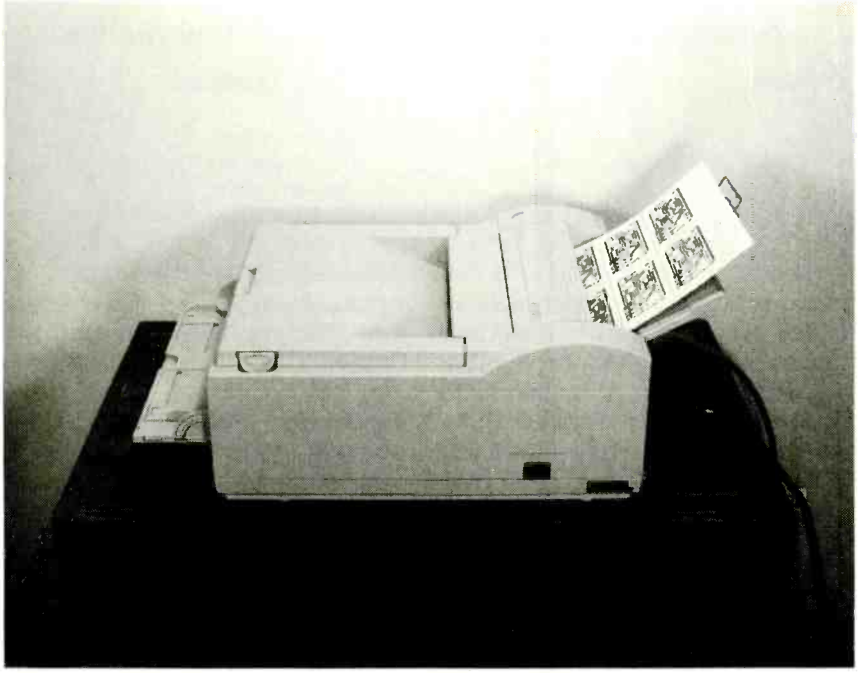
Now, perhaps you've heard that they don't work very well, or that they're a hassle to use. Well, the truth is that toner-transfer products (which we'll refer to as TTPs) require time and effort to learn to use properly, but once that effort is expended, they'll save you an enormous amount of work, time, and money.

For the balance of this article, we'll show you how to use TTPs, and help you decide which TTP is best for your needs. We'll look at DynaArt's Toner Transfer System, Techniks' Press-n-Peel (both blue and wet versions), and Meadowlake's TEC-200 Image Film; explore the similarities and differences of those products; and most importantly, compare the results you can obtain with each. We'll also cover tips to save you money when using TTPs, and help you get better results.

TTPs fall into two broad categories: transparencies and coated papers. Transparencies are ironed on and carefully peeled off, while coated papers are ironed on and soaked to remove the TTP. However, aside from that difference, the steps and procedures followed when using all TTPs, which are described below, are pretty similar. The PCB artwork is usually created using a computer program. The artwork is transferred to the TTP with a laser printer (although it can be transferred using a copying machine, as in the case of magazine artwork). The artwork is then ironed onto an extremely clean printed-circuit board (PCB), the TTP is removed and the PCB (which now has the artwork on it) is etched to remove unwanted copper. Let's take a closer look at how each step is done.

Creating the Artwork. Unless you're using artwork from a magazine article or the like, you'll have to create your own using a PCB drawing program. If you are already familiar with those programs, you know what's involved and how easy it can be. Unfortunately, space prevents us from going into those programs in any great detail. However, the good news is that the January 1996 issue of **Electronics Now** features an excellent article on the subject. It is a great introduction to the topic and features discussions of some of the most popular packages on the market.

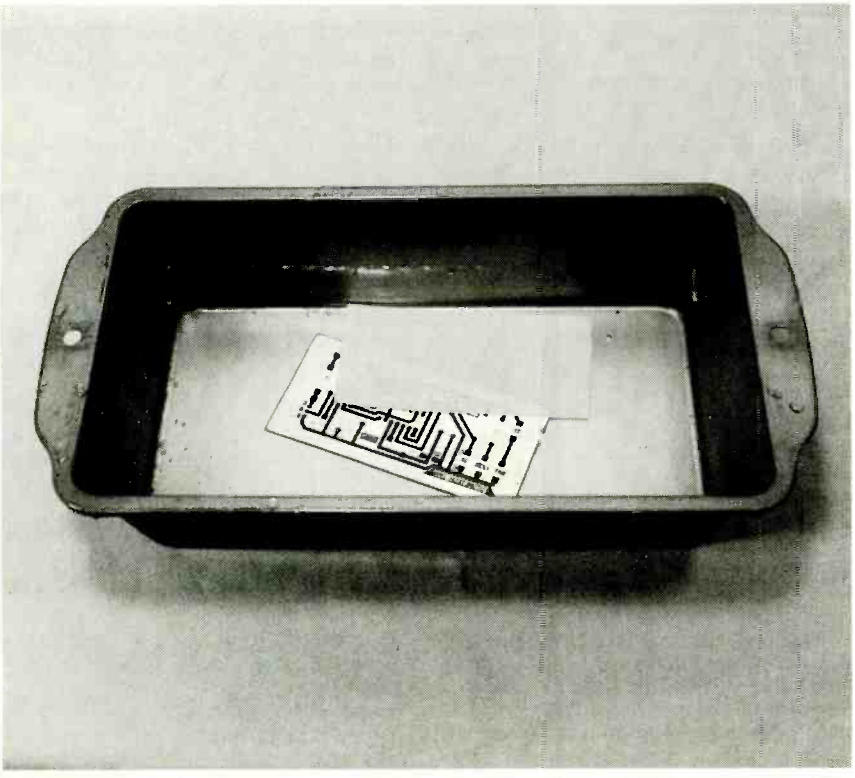
Transferring the Artwork to the TTP. Once the artwork has been created, it must be transferred to the TTP. Whether you're using a laser printer or copying machine, be sure to print your artwork on ordinary



After you create the PC-board pattern using any PCB drawing program, it is output on a standard laser printer. Use the printer's darkest setting and select the straightest possible paper path. Place multiple images on a single sheet to conserve the toner-transfer media.

paper to check its orientation and quality. It's better to waste a sheet of copy paper than a sheet of TTP.

Large copying machines work better than small ones. For example, DynaArt recommends Xerox 10xx, 50xx series, and Kodak three-digit model-number machines. Since the toner will become the actual etch resist, all copying machines and laser printers should be set to their darkest settings.



After ironing, paper-based TTPs are soaked in water to remove the paper from the PCB. Be patient as peeling the paper before it has soaked off could produce poor results.

Avoid getting fingerprints or dust on the TTP since they degrade its performance.

Once the artwork is transferred, the TTP can be carefully stored for later use.

Preparing the PCB. A properly prepared PCB can make the difference between a good toner transfer, or a frustrating, wasted effort. After you de-burr the board's edges, it has to be thoroughly cleaned. There are expensive chemicals that will do the job, such as London Chemical's Loncoterge, but the usual solution is to scrub the board with an abrasive cleaner (like Comet) until it's completely spotless, turns a hot pink color, and water forms sheets on it. Never forget that the end product of the transfer is directly related to how clean the board is!

Next, to improve adhesion, rough up the surface with Scotch-Brite, steel wool, or 400-to 600- grit wet/dry sandpaper. In my experience, regardless of which TTP is used, 400-grit sandpaper seems to work best.

Once that is done, rinse the board with rubbing alcohol and dry it with a paper towel or blow dryer. Allowing it to air dry usually results in tarnish on the PCB.

Transferring the Artwork to the PCB. TTP manufacturers suggest several methods of transferring the artwork from the TTP to the PCB. The most common method is to place the PCB on a flat, heat-resistant surface, with the TTP on top of it, and the iron on top of the TTP; and then to apply moderate pressure for a specified time at a specified temperature. The times and temperatures specified by the manufacturers are provided in Table 1.

There's an alternate method that is useful for large PCBs and/or paper-based TTPs: Place several pieces of thin cloth on a flat surface, the TTP on the cloth, the PCB on the TTP, and the iron on top of this stack. Slightly more time is needed when using this "upside-down" method.

Still another method for small boards is recommended by the makers of TEC-200. They suggest heating the PCB itself, and then placing the TTP on top of the heated board and using a small rubber print roller to apply the TTP.

Since different toners melt at different temperatures, you'll have to experiment to find the time and temperature that works best with your toner and system. Generally, it's okay to use more time (up to several minutes more). The times, temperatures, and techniques that have worked well for the author are given in Table 2.

What about motion? Well, when heating the PCB and TTP with the iron, Techniks suggests that you concentrate on getting one corner to adhere, and then apply the heat using a circular motion, especially towards the outer edges. Usually, just moving the iron every 30 seconds will provide even heat and pressure.

Once the artwork is ironed on, transparency-based TTPs are cooled and then carefully peeled backwards 180 degrees. Paper-based TTPs are carefully placed in water to soak the TTP. The TTP will peel off on its own in a few minutes (avoid the temptation to help it!). In either case, the PCB will usually need to have the transferred artwork touched up with an etch-resist pen. Inspect the PCB with a magnifier to see if you've missed any tiny holes or cracks in the traces. If you consistently get more than a couple of "drop outs" in your traces, you'll need to adjust your time, temperature, pressure, PCB cleanliness, or technique.

The PCB is now ready to etch, and should be etched immediately for best results. Waiting will allow the PCB to tarnish, and may result in a poorer final product.

Product Comparisons. An article like this one would be incomplete without some more in-depth discussion of the various products and the results obtained with each, as well as some product-specific hints and techniques that the author has found helpful. For these comparisons, note that all printing was done with a new OKIDATA OL600e laser printer using an OEM toner-and-drum cartridge. The printer was set on its darkest setting. The manual paper feed and auxiliary paper exit were used to provide a paper path with the least number of bends. Toner was transferred to over 60 identically cleaned PCBs, and over 20 were etched. Sizes varied from 4 by 5 inches to 1½ by 2 inches. The benchmark was 2 by 4 inches. As expected, it was found that TTPs are easier to use with smaller PCBs.

TABLE—1
MANUFACTURER'S RECOMMENDED TIMES AND TEMPERATURES

Product	Time	Temperature
TEC-200	not specified	265-295 degrees F; "wool" setting
DynaArt	2-3 minutes	300-350 degrees F (possibly more); "cotton" setting
Techniks PNP (Wet and Blue)	45-100 seconds	200-225 degrees F or higher; "steam" setting

Techniks' PNP WET. In the author's opinion, PNP WET is the most forgiving TTP tested. It works well over a wider range of temper-

TTP TIPS

If the artwork doesn't transfer completely, the most likely causes are: not enough time, PCB not clean enough, temperature too low, or uneven heat and/or pressure.

If the edges of your artwork appear "squashed" on the PCB, you probably used too much pressure.

Don't leave the iron in one place more than 30 seconds even when transferring the TTP to a PCB smaller than the iron. It needs to be moved to provide even heat and pressure.

When ironing a transparency, you can usually tell when it's ready by looking for the pattern to become more apparent.

All copying machines and laser printers should be set on their darkest settings!

Whether you're using a laser printer or a copying machine, be sure to print your PCB on ordinary paper first to check its orientation and quality.

Allow your iron to heat up for several minutes to give a consistent temperature.

Here's a method that is useful for large PCBs and/or paper-based TTPs. Place four pieces of thin cloth on a flat surface, the TTP on the cloth, the PCB on the TTP, and the iron on top of this stack. Slightly more time is needed to use that "upside-down" method.

When printing on TTPs with a copier or a printer, use the paper path with the least number of bends.

Paper-based TTPs can be sprayed with lacquer after printing, and then soaked to obtain a see-through sheet of artwork useful for making faceplates and decals.

DynaArt suggests replacing your drum with an "acrylic" high-capacity drum and your toner with high-density "graphics" toner. They sell those products, as well as a "super fuser" to replace the iron in the toner-transfer process.

To save money on their TTP, DynaArt also suggests cutting it into pieces slightly larger than your PCB artwork, and taping the pieces on a sheet of copy paper (with a paper-type tape, and on the leading edge only), and then sending the copy paper/TTP combination through the printer. If your printer won't pass two sheets of paper taped together, you'll need to cut an appropriate hole in the copy paper.

Another idea for getting the most out of your TTPs is to put multiple images on a single page.

When drawing your PCB artwork, remember that larger traces and pads are more forgiving in the toner transfer process.

Etching your PCBs in a heated bubbling tank will save you an enormous amount of work; the December 1989 issue of **Radio Electronics** has an excellent article on one you could build yourself.

Gaps in traces on finished PCBs may be repaired with a Circuit Works conductive pen.

Techniks (PNP WET/BLUE) recommends that the image transfer sheet be cut leaving at least ¼-inch around the circuit pattern.

Leave no more than a ½-inch border of clear film around the pattern, when using TEC-200 Image Film, to avoid distortion in the transferred artwork.

TEC-200 Image Film could be used to create a mirror image of your artwork, when used in a copier. For best results, a clean white sheet of paper should be placed on top of the film being copied. The film used to make the intermediate copy can then be cleaned with an organic solvent and reused.

NAMES AND ADDRESSES

Product	Price and Suppliers
DynaArt Toner Transfer System (paper-based product)	5 sheets/$15.00 DynaArt Designs 3535 Stillmeadow Lane Lancaster, CA 93536 Tel: 805 943-4746
Techniks Inc. Press and Peel (BLUE is transparency based) (WET is paper-based product)	20 sheets/$30.00 Techniks Inc. P.O. Box 463 Ringoes, NJ 08551 Tel: 908 788-8249
TEC-200 (transparency-based product)	5 sheets/$3.95 DC Electronics P.O. Box 3203 Scottsdale, AZ 85271 Tel: 800 467-7736
Loncoterge (copper cleaner) Part #CU3-1QT	$17.75/quart Kepro Circuit-Systems 630 Axminister Drive Fenton, Missouri 63026 Tel: 800 325-3878

Note: Single sheet quantities of toner-transfer products are available from Futuretech (P.O. Box 6291, Gulf Breeze FL 32561, Tel: 904 932-9682): DynaArt Designs $3.50/sheet, Techniks Press and Peel (both WET and BLUE) $2.00/sheet, Meadowlake TEC-200 $1.15/sheet. Sample pack of one each of all four toner transfer products $8.50/pack. Add $3.00 for shipping and handling. Florida residents add 7% sales tax.

atures, times, and pressures. It usually applies cleanly with very few "drop outs." The end result (etched PCB) is among the best tested. This TTP works well when applied using the "upside-down" method with four thin sheets of cloth placed underneath it.

Techniks' PNP BLUE. PNP BLUE is different than other TTPs in that it transfers a coating in addition to the toner. The coating/toner combination sticks extremely well to the PCB and provides extra protection during etching.

On the down side, you have to be very careful to use a light pressure and correct temperature, or you'll lose fine detail in your traces. Furthermore, the coating is so thick that you have to be more careful while touching up any "drop outs" as the etch-resist pen must fill in both the "drop out" and the transition between the thickness of the coating and the PCB. Fortunately, this technique usually requires very little touching up.

The durability of the extra coating makes it one of the most reliable TTPs tested. To get the best results, this product should be applied using the right-side-up method with a thin sheet of cloth between it and the iron.

Meadowlake's TEC-200. With TEC-200, it is easy to consistently get clean, sharp transfers. However, the clean, sharp image can be deceiving. When using TEC-200, you'll need to strike a balance between a higher temperature (which will give the best adhesion), and a lower temperature (which will give you the darkest, most solid traces). Also, avoid excessive pressure, which will make the traces squash internally and become "see-through." "See-through" traces will result in tiny holes in your etched PCB's.

Once you've found the proper temperature and pressure, this product will give you easy, consistent results. It's best applied using the right-side-up method with one thin sheet of cloth between it and the iron.

DynaArt's Toner Transfer System. DynaArt's Toner Transfer System can give you sharp PCB images with few "drop outs," but it won't tolerate inconsistent or sloppy application techniques. To get consistent results, your time, temperature, and pressure must be very consistent. It also requires more pressure than other TTPs. Unless you're transferring your artwork to a PCB larger than your iron, the right-side-up method is best for this product.

Conclusion. The good news is that all the TTPs tested will do the job. The bad news is that even with the ones that are easiest to use, you'll need to do some trial and error experimentation to get the correct combination of time, temperature, and pressure for your printer's toner, and to get a feel for using the product. Even then, one or two small "drop outs" per PCB are to be expected.

TTPs require effort on the part of the user. But once you learn the best methods, TTPs will save you loads of time, money, and effort. To help reduce the learning curve a bit, many of the points addressed in this article, as well as a few additional ones, are summarized in the box titled "TTP Tips." Ω

TABLE 2—AUTHOR'S SETTINGS

Product	Time	Conditions
TEC-200	3½ minutes	250 degrees "permanent-press" setting light pressure
DynaArt	4½ minutes	410 degrees "linen-high" setting heavy pressure
Techniks PNP WET	4 minutes	310 degrees "wool-cotton" setting upside down method
Techniks PNP BLUE	3 minutes	275 degrees "wool" setting light pressure

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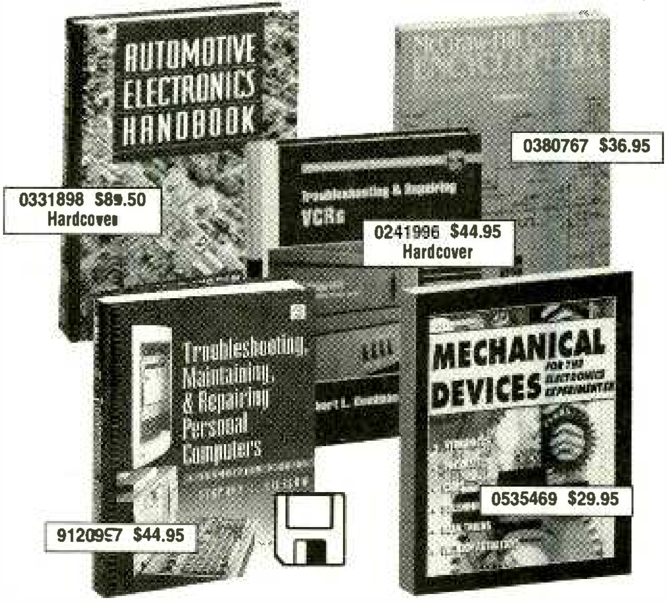

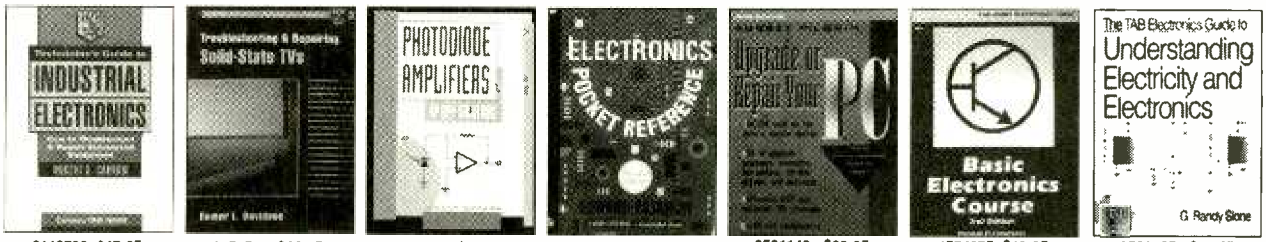

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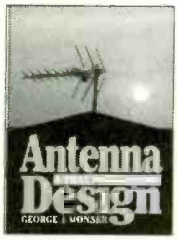

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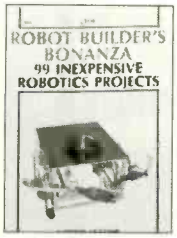

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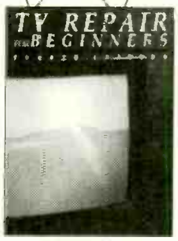

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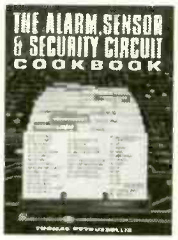

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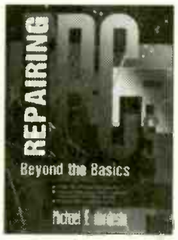

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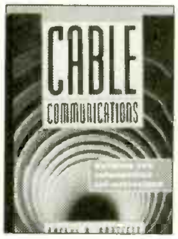

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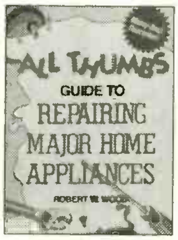

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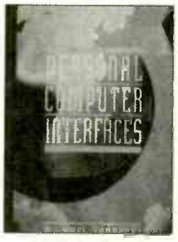

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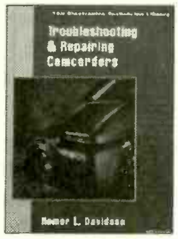

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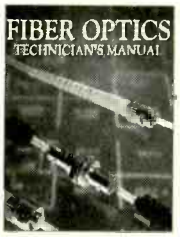

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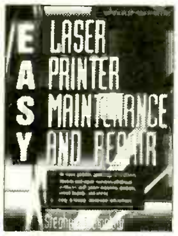

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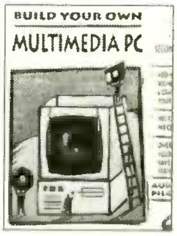

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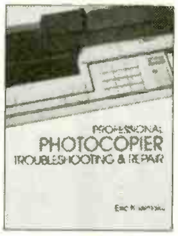

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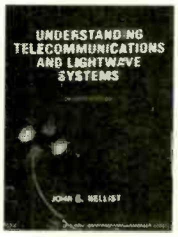

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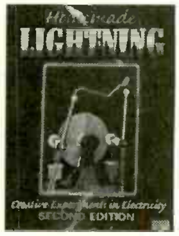

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FUNCTION GENERATOR

Here's a handy way to bring your test bench out into the field: a function generator that is small, lightweight, and battery-powered!

By now, most hobbyists are familiar with—and have possibly even tried—one or more of those multi-waveform function-generator chips. A few extremely versatile examples are the ICL8038, the XR-2206, and the MAX038 monolithic generators. All of those devices provide sine-, square-, and triangle-wave outputs with assorted other features.

However, in spite of their sophistication, those chips do have their shortcomings. It is, after all, difficult to pack all of the required circuitry onto one substrate. The first thing you will notice is that the minimum required power supply is 10 volts at moderate current levels. This means that at a bare minimum, two 9-volt batteries driving ±5-volt regulators would be needed. However, the current demands would preclude the use of batteries. A line-operated power supply would be more reasonable, eliminating the possibility of a portable unit.

The waveforms generated by the chips are largely quite good for a single-frequency design. Unfortunately, most variable-frequency designs result in a squarewave whose duty cycle doesn't remain constant as the frequency is varied. That, in turn, causes non-symmetrical triangle waves, which results in sinewave distortion to various degrees.

Trimming the sinewave output into a smooth shape can also be rather trying. The most common drawback is what can be described as a "blurb" at the maximum excursions. That defect is difficult to get rid of. It occurs because the maximum amplitude of the triangle wave must be held constant over the entire frequency range for the sine-shaping circuit to work properly. That is extremely difficult to do in any design due to propagation delays in the circuitry.

Those problems have been eliminated in the Do-It-Yourself Function Generator presented here. It is designed to operate on one standard 9-volt battery with a low current draw, making it easily portable. Unusual techniques have been used to provide squarewaves, triangle waves, and smooth sinewaves over a frequency range of 10 Hz to 100 kHz at a nearly constant duty cycle. For true portability, a built-in analog frequency display meter has been included for accurate frequency setting.

As with any complex design, some compromises have been made to achieve optimum performance. The unit provides very good waveforms throughout its frequency range. It has been intentionally limited to 100 kHz for negligible propagation-delay problems. The output swing is limited to ±1.5 volts in order to work within the constraints of the 5-volt power supply voltage.

The "Classic" Function Generator. In order to obtain a good understanding of how a typical function generator works, we will discuss the "classic" function generator shown in Fig. 1. With only three op-amps in its circuit, that basic design is capable of only low frequencies. It does illustrate, however, the feedback principles involved in all generator designs.

A *hysteresis amplifier* is a standard op-amp using positive feedback (through R_a) to achieve a voltage-comparator-like response. A feature of hysteresis amplifiers is that there are two reference levels. When the output changes state, the reference level is switched from one to the other. For example, let's say that the two reference levels are set at 2 volts and 4 volts. If the output switches high when the input rises above 4 volts, the input would have to drop below 2 volts for the output to switch back to the low state. Thus, its output has only two stable levels—positive-maximum voltage, and negative-maximum voltage, which are both near the supply-rail voltages. Hysteresis is provided via the voltage divider composed of R_a and R_b.

The integrator is also a standard op-amp with a capacitor (C_T) providing negative feedback. If a constant voltage is applied to input resistor R_T, a constant current charges the capacitor causing the output voltage to ramp up or down.

For a starting point, assume that the hysteresis amplifier's output is at a negative voltage. The integrator op-amp will try to make its inverting input equal to the ground reference on its non-inverting input. The voltage applied across C_T will charge it at a linear rate, so the integrator's output voltage will ramp up positively. Voltage divider R_a-R_b holds the hysteresis amplifier's non-inverting input below ground until the integrator's output voltage becomes positive enough to pull the input above ground.

At that point, the hysteresis amplifier's output shifts to a positive voltage. The integrator's non-inverting input is now too high, so C_T begins to discharge at the same linear rate at which it was charged. The integrator's output voltage ramps down. The hysteresis amplifier's input is held above ground by R_a and R_b until the integrator's output voltage becomes negative enough to pull the input below ground, starting the cycle again.

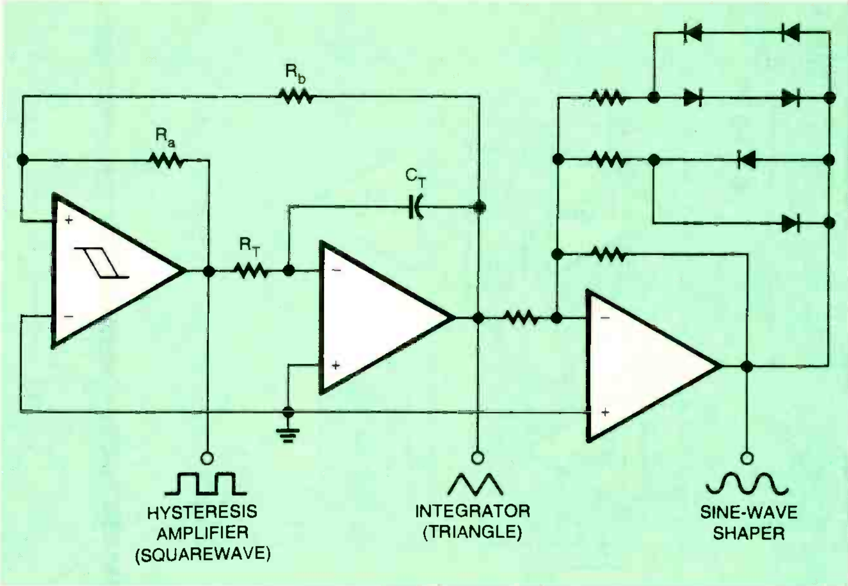

Fig. 1. A classic function generator provides sinewave, squarewave, and triangle-wave signals.

As you can see, the hysteresis amplifier's output is a squarewave and the integrator output is a triangle wave. If the ground references are exactly halfway between the supply voltages, symmetrical waveforms are obtained.

The sinewave-shaping circuit is a standard op-amp with a special negative-feedback circuit called a *piece-wise linear function fitter.* It is built with diodes and resistors. The values of the function-fitter components are selected by trial-and-error to approximate a sinewave by using the breakpoints provided by the diodes at different voltage levels.

Surprisingly good results are achieved using that method. However, it is sensitive to temperature variations, input-voltage variations, and exhibits the "blurbs" mentioned before. Analog multipliers

PARTS LIST FOR THE DO-IT-YOURSELF FUNCTION GENERATOR

SEMICONDUCTORS

IC1, IC7—LM3080 transconductance amplifier, integrated circuit
IC2—TLC555 CMOS timer, integrated circuit
IC3—TLE2071 JFET op-amp, integrated circuit
IC4—79L05 -5-volt voltage regulator, integrated circuit
IC5—LM2917 frequency/voltage converter, integrated circuit
IC6—TLE2074 quad JFET op-amp, integrated circuit
LED1—Red light-emitting diode, low-power
D1–D3—1N4148 silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R23—5600-ohms
R2, R22—10,000-ohm potentiometer, panel-mount
R3, R15—3300-ohms
R4—6200-ohms
R5—500-ohm potentiometer
R6, R11, R19–R21, R26—10,000-ohms
R7, R9, R24—4700-ohms
R8, R13—1000-ohm potentiometer
R10—2700-ohms
R12, R25—22,000-ohms
R14—10,000-ohm potentiometer
R16, R17—2000-ohms
R18—1000-ohms
R27—25,000-ohm potentiometer

CAPACITORS

C1, C4, C16, C19, C20, C21—1-µF, 16-WVDC, tantalum
C2, C15—0.001-µF, ceramic-disc
C3, C18—0.1-µF, ceramic-disc
C5—0.01-µF, ceramic-disc
C6—910-pF, Mylar, see text
C7—0.01-µF, Mylar
C8—0.1-µF, Mylar
C9—1-µF, Mylar
C10, C22—5–50-pF, variable
C11—180-pF, polystyrene
C12—0.0022-µF, Mylar
C13—0.022-µF, Mylar
C14—0.22-µF, Mylar
C17—10-µF, 16-WVDC, electrolytic
C23—20-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

S1—Rotary switch, 2-pole, 4-position, non-shorting
S2—Rotary switch, 1-pole, 4-position, non-shorting
S3—Toggle switch, single-pole, double-throw
J1—BNC connector, panel-mount, female
B1—9-volt battery
M1—100-µA panel meter, analog
Battery holder, 9-volt battery connector, enclosure, P.C. board, panel knobs, wire, hardware, etc.

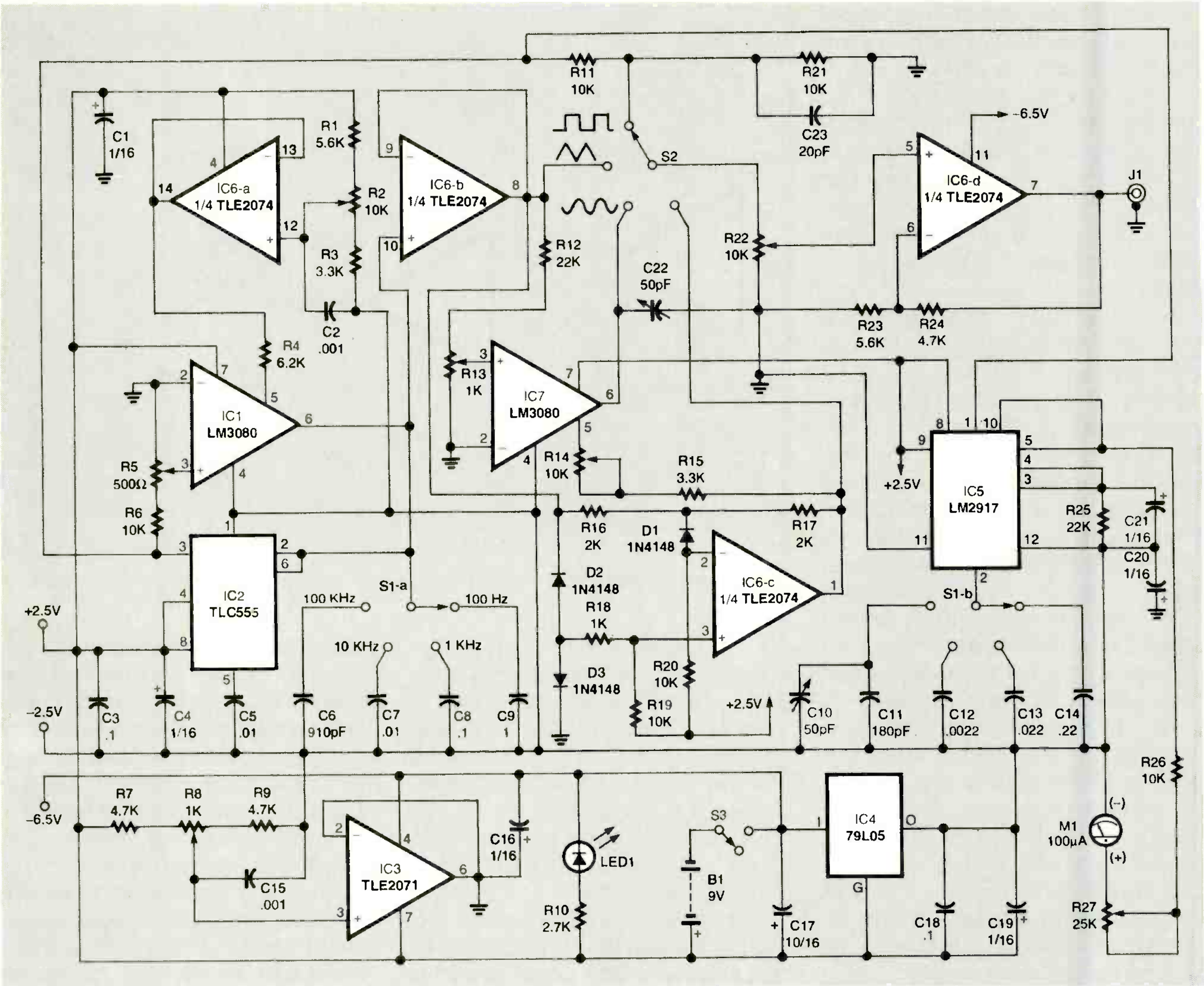

Fig. 2. Although the Do-It-Yourself Function Generator is an extremely complex circuit, it draws much less current than an all-in-one function-generator chip. That feature alone makes the Function Generator handy as a portable battery-powered unit.

have been used with much success, along with various other ingenious circuits. Further information on those alternative approaches can be found in the "Think Tank" columns in the November 1991 and June 1996 issues of our sister magazine, **Popular Electronics**.

Now that we understand the basics of function generator design, we can examine our Do-It-Yourself Function Generator in detail.

About The Circuit. Unfortunately, to successfully design a function generator circuit that will operate at low supply voltages over a relatively large frequency range, the monolithic waveform generators are out of the picture altogether. Even a quick glance at Fig. 2 will give you an appreciation of how much circuitry has been packed into the all-in-one chips.

High speed, low voltage ICs have been chosen in order to keep current drain to a minimum for extended battery life. A standard 9-volt alkaline battery feeds IC4, a 79LO5 negative 5-volt regulator, in an unusual power-supply configuration. The supply provides ±2.5 volts to the main circuit and –6.5 volts to IC3, a TLE2071 JFET op-amp, and IC6, a TLE2074 quad JFET op-amp.

Those op-amps were selected for their ±2.25- to ±19-volt supply range, a 40-volt-per-microsecond slew rate, and a 10-MHz unity-gain bandwidth. There are currently no appropriate substitutes available for IC3 or IC6.

The ground reference for the ±2.5-volt supply is provided by IC3, a TLE2071 JFET op-amp. The reference level is adjusted by R8. Setting the ground reference level gives us the ability to make the output waveforms symmetrical. The negative common-mode input-voltage range for IC3 (and IC6) is limited to signals greater than 4 volts above the negative supply rail. Therefore, the negative supply voltage must be –6.5 volts for proper operation.

The integrator portion of the Function Generator is built around IC1, a LM3080 transconductance amplifier, which is configured as a current pump. The constant positive or negative current needed for triangle-wave generation is sent through S1-a to C6 through C9, producing the triangle wave. Variable frequency control is provided by R2

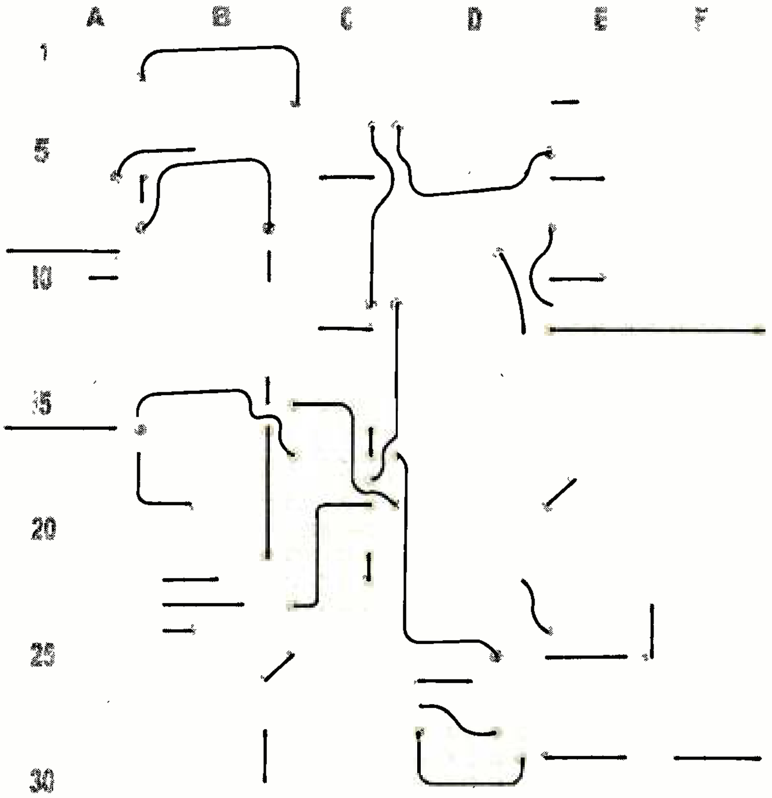

Fig. 3. If you want to use the same perfboard suggested in the text, this guide shows you where to install jumper wires. Don't forget to drill the additional holes for the ground connection.

and IC6-a, which varies the transconductance of IC1. The output current is a function of both the transconductance and input voltage.

The hysteresis amplifier is composed of IC2, a TLC555 CMOS timer, which has all of the components built into it for very fast switching. As the triangle wave swings between IC2's threshold voltages, which are $^1/_3$ and $^2/_3$ of its supply voltage of 5 volts, IC2's output provides the squarewave input for IC1. The frequency range is set by R5, limiting the input voltage to about ±50 millivolts.

The full-scale frequency range is selected by S1-a in four steps: 100 Hz, 1 kHz, 10 kHz, and 100 kHz. The frequency of each range is set with R2. That allows the division of each range by about 10, yielding a linear output frequency change of 10% to 100% of full scale on each range setting. Typical output voltages for the squarewave are ±2.5 volts, and ±830 millivolts for the triangle wave. The triangle wave provides the input for the sinewave-shaper portion of the circuit.

The sinewave-shaper network is formed by IC7 and IC6-c. The triangle wave input is buffered by IC6-b. Another transconductance amplifier is used for IC7, which is configured as a variable-gain circuit. The gain of IC7 is controlled by IC6-c.

Because IC6-c is configured as a negative absolute-value circuit that receives its input from IC6-b, its output is double the input frequency. With a triangle wave at ±830 millivolts on the input, the negative-absolute output is between zero and -830 millivolts. The current generated through R14/R15 is applied to IC7's bias input at pin 5. It varies at a ratio of 1.85 to 1. The bias current linearly controls the transconductance, and thus the gain of IC7.

The positive peak-output voltage from IC6-c (zero volts) produces a gain that is 1.85 times higher in IC7 than at the negative peak-output voltage. The positive peak occurs at the input's zero-crossings. The negative peak (-830 millivolts) occurs when the input is at its maximum. At that point, the gain applied to the input will vary from a maximum of 1.85 at zero volts to a minimum of 1.00 at ±830 millivolts. The frequency-doubled output of IC6-c allows both the positive- and negative-input excursions to be shaped equally.

A gain change from 1.85 to 1 applied to the triangle-wave input produces an extremely good sinewave approximation. The waveform generated is actually parabolic in shape, and about ±830 millivolts in amplitude when loaded by R22. If you compare the parabolic waveform to a true sinewave, you will note that the zero-crossings are slightly steeper than the sine, and that the peaks are slightly rounder.

The result is a low percentage of harmonic distortion—comparable to the monolithic generator chips. To see the distortion on an oscilloscope, the display will have to be one half cycle of the waveform and as large as possible on the screen. Above about 10 kHz, propagation delay will become noticeable as a very small "glitch" at the peaks of the sinewave; however, performance is not compromised.

The various waveforms are buffered and amplified by IC6-d. Any particular waveform is selected by S2. The output voltage, controlled by R22, can be varied from zero to ±1.5 volts. The output available at J1 is stable under loads of up to 100 pF. Standard coax up to 36 inches in length can be used. Output current capability of ±30 milliamps or more is typical.

The overall range of the output frequency is selected by S1-a and S1-b, which are ganged together. The display is a 100-microamp analog panel meter. The display is read directly as a percentage of full scale. A reading of 45 microamps with S1 set to the 10-kHz range would indicate 45% of 10 kHz, or4.5 kHz.

Meter M1 is driven by IC5, an LM2917—a frequency-to-voltage converter. The display is calibrated by R27. Selecting C12–C14 in exact decade multiples will assure accuracy at the lower ranges. The 100-kHz range is calibrated separately by C10. An accuracy of ±1% is typical with the unit.

Construction Tips. Circuit-board fabrication and layout techniques are not critical to the design. The author elected to use perfboard. One important consideration to keep in mind, however, is that the lead lengths should be kept as short as possible. One way to do that is to place the passive components as close as possible to their respective ICs in order to prevent any cross coupling of signals.

A suggested perfboard layout is shown in Figs. 3, 4, and 5. That layout is based on a general-purpose board available from RadioShack. The catalog number for the board is 276-168. The board measures $2\frac{3}{4}$ inches by $3\frac{3}{4}$ inches and has foil pads and power busses, making point-to-point wiring a simple job.

Before installing any components or wires, a series of small holes will have to be drilled in the board in order to mount some of the components to the ground distribution trace. That trace is a U-shaped foil pattern that surrounds the main pattern in the center of the board. Drill 11 holes—4 for the jumper wires, 5 for the components, and 2 for the panel controls. The locations for the holes can be seen in Figs. 3 and 4. Use a .040-inch diameter drill. Drill the holes in the approximate positions shown so that a component lead can be soldered to the U-shaped ground trace when inserted through the hole.

Following the locations shown in Fig. 3, install jumper wires on the board. For short jumpers that only connect holes that are next to each other, scrap component leads may be used. A better choice might be insulated wire-wrap wire. Using that type of wire would prevent any accidental shorts that would make troubleshooting much more difficult. For the longer wire runs, follow the routing that is indicated in Fig. 3. That will let the wires lay in between the components.

Next, install the components in the locations shown in Fig. 4. Some of the components will have to be mounted vertically in order to fit in the space allowed. If a component has a lot of exposed lead, such as R4 and R15, slide some insulated sleeving over the leads. That will help prevent accidental shorts. Small-diameter plastic tubing or insulation stripped from an 18-gauge wire will work well to insulate the exposed component leads.

Although it is not necessary, using sockets for the ICs makes repairing the unit much easier if needed. Also note that the capacitors associated with S1 (C6–C14) are mounted on the board instead of the switch. That makes wiring the switch much easier.

It might be difficult to find a suitable source for C6—a 910-pF value is not one that is in great demand. An acceptable substitute would be to assemble one by placing a 0.01-µF capacitor in series with a 0.001-µF unit. Those two values in series result in a combined value of 909 pF—obviously not exact, but, at only 2 pF off, the error is under 0.25%. That is certainly close enough to not affect circuit operation at all.

For best sine shape, the forward conduction voltages of D1–D3 should be matched. A simple way to do that is to measure the conduction of a small group of diodes using the diode-test function on a DMM. Select three diodes that measure within about 1% of each other. The actual value is not important—only that the three values are as close to each other as possible. The values of R16 to R17 and R19 to R20 should also be as close to each other as possible. The value of R18 should be 50% of R17. If you do not want to match resistor values, you may use 1% units for those resistors.

As there are many panel controls involved, lay out the front panel of the enclosure carefully. The photograph of the author's unit at the beginning of this article only shows one possible arrangement. About two dozen connections will be made between the board and panel components, so good initial positioning will allow those connections to remain as short as possible.

It is important to connect R21 and C23 between the grounded side of R22 and the fast rise-time squarewave output at S2. Those

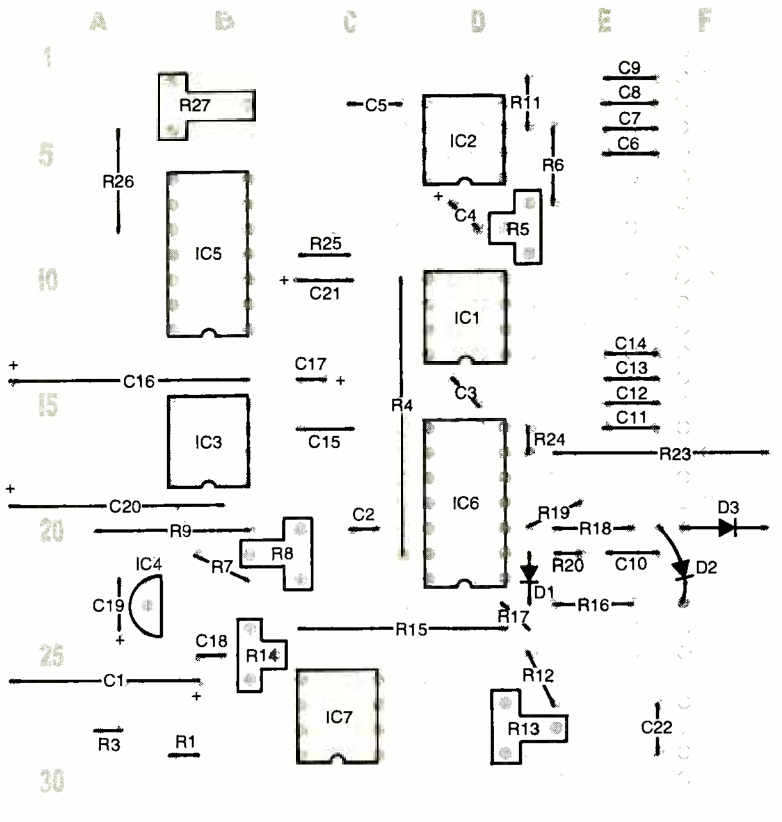

Fig. 4. After the jumper wires are soldered in place, the components are installed in these locations. Several components need to be connected to the ground trace, so drill additional holes for those connections before installing the parts.

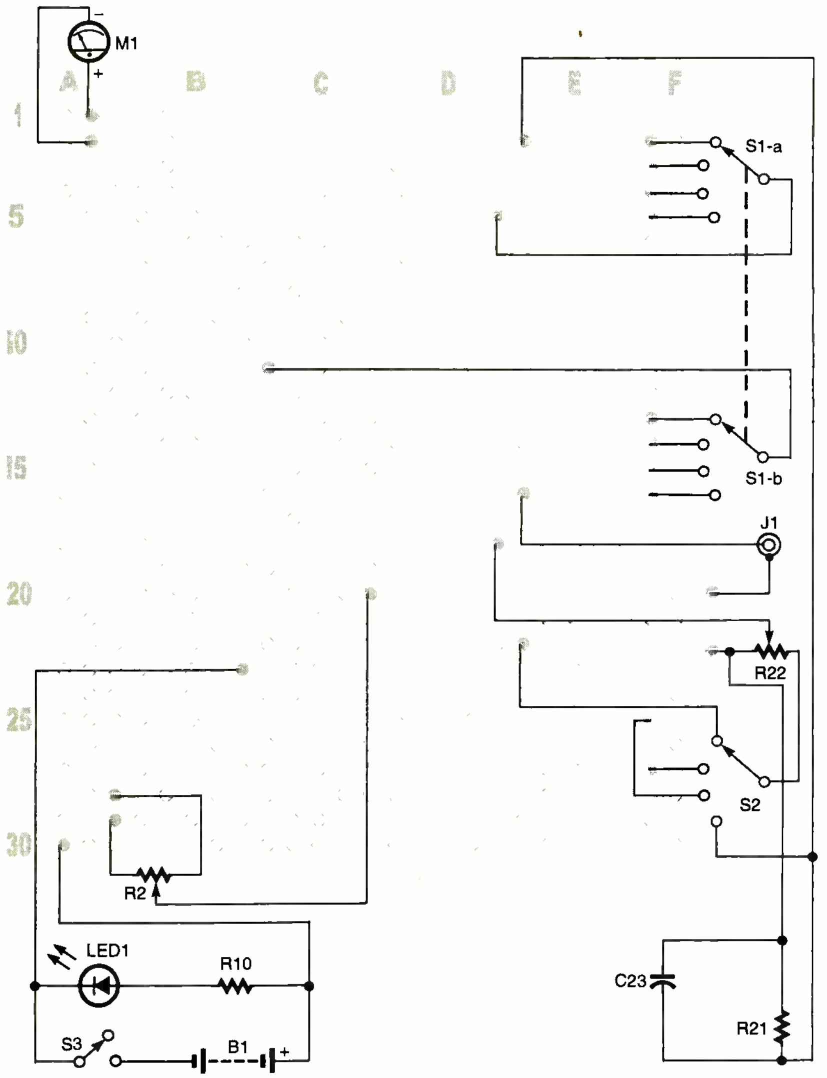

Fig. 5. Once the perfboard is wired and populated, the panel controls are wired up by following this connection diagram. Check the circuit against the schematic diagram before applying power. Extra care now will avoid burned-out components later!

components terminate the squarewave lead. That connection will eliminate any "ringing" of the squarewave throughout the rest of the circuit. The squarewave output lead itself should also be kept away from any other leads.

Any suitable plastic enclosure that can hold all the components and has room for the panel controls and displays can be used. A simple tilt stand was fabricated from heavy-gauge coat-hanger wire ($^1/_8$-inch diameter) and held in place with $^1/_8$-inch cable clamps on the bottom cover.

Double-check all of your wiring on the board, paying particular attention to component polarities, and install the board on spacers in the enclosure. Connect all of the panel components. When satisfied, install the ICs in their sockets and install the battery in its holder.

Set-Up And Calibration. Connect an oscilloscope (set up for direct DC coupling) to J1 with a standard 50-ohm BNC-cable assembly. The cable should not be longer than three feet.

Set the Function Generator up as follows:

All trimpots to mid-rotation
S1 for 1.0 kHz
R2 full clockwise
S2 to squarewave output
R22 to mid-rotation

Turn on the power and set the oscilloscope to display a couple of cycles. Adjust R22 to display the squarewave at 2.0 volts peak-to-peak. If a squarewave output cannot be seen and all of the wiring is correct, replace IC1. Although rated to provide at least a ±1.5-volt output swing with a 5-volt supply, some substandard LM3080 units may not be able to even achieve the ±830 millivolts necessary to trigger the TLC555 timer.

Select the "CAL" position on S2. A frequency-doubled triangle wave should be displayed. Rotate R8 back and forth and note the waveform changes. Set R8 so that all of the negative maximum excursions are exactly equal in voltage. That setting gives the best overall symmetry.

Select the squarewave output with S2 and adjust R5 for an oscilloscope display reading of 1000 Hz, or a 1-millisecond time period. Adjust R27 for a full-scale display of 100% on M1, the frequency-display meter.

Select the sinewave output with S2. Adjust R13 for a smooth sine shape, and set R14 for a ±1.0-volt signal on the oscilloscope display. Both R13 and R14 tend to interact to some extent, so a little trial and error might be necessary to achieve the correct results.

Set S1 to 100 kHz full-scale, leaving R2 at full clockwise. Adjust C22 for the best sine shape. Select the squarewave output with S2, and adjust R2 for an oscilloscope display reading of 100 kHz, or a time period of 10-microseconds. Adjust C10 for a display of 100% on M1. This completes the calibration of your D.I.Y. Function Generator.

Going Further. The monolithic function generator chips offer a couple of other features not discussed yet, such as swept frequency and variable-duty-cycle functions. Those features are definitely feasible on the Function Generator.

Since IC1 is essentially a current-controlled oscillator, the frequency can be changed by switching the connection between R4 and pin 5 of IC1 to another source. By varying that control current in a linear or logarithmic fashion, the oscillator will sweep its frequency over quite a large range.

The current needed by the oscillator is about 45 microamps for 10%

of full scale on each range and about 450 microamps for 100% of full scale. If a current that sweeps from 450 nanoamps to 450 microamperes is input to pin 5 of IC1, with S1 set at 100 kHz we can sweep from 100 Hz to 100 kHz. The ratio of the sweep range would be 1000 to 1!

The usable linear range of control current for IC1 is between about 100 nanoamps and 1 milliamp. The absolute maximum value is 2 milliamps before damage occurs. Quite a wide range of sweep frequencies is possible. Of course, for other ranges, different values for C6–C9 may be chosen to suit. The reference for the current input is the –2.5-volt rail for proper operation, as pin 5 is actually one diode drop (0.7 volts) above that supply rail.

The generation of sawtooth or rectangular waveforms is easily accomplished with the circuit, simply by varying the duty cycle of the oscillator. As the input voltage to pin 3 of IC1 is typically about ±50 millivolts, a shift in the ground reference voltage applied to pin 2 over a similar voltage will vary the duty cycle from 0% to 100%.

It is a simple matter to switch out the ground connection on pin 2. Apply a variable voltage from an external source that is capable of ±50 millivolts. That source has to be referenced to the zero-volt circuit ground for proper operation. That technique will have little, if any, effect on output frequency.

As you can see, a lot of performance has been squeezed from a 9-volt battery-powered instrument. It is very simple to operate, yet provides accurate and predictable results. Three separate waveforms are available for any test we wish to perform, with all controls easily accessible. The unit can also be modified for many different features, which are limited only by your imagination. Ω

BY DON LANCASTER

Understanding Source Impedance, Electrochemistry Basics, The Energy Density of Gasoline, and More

AN INDEPENDENT RESEARCHER HAS SENT ME A PAIR OF NEW ENERGY CELLS TO EVALUATE. HE GENUINELY FELT THAT THOSE DEVICES REVEALED HIS NEW BATTERY BREAKTHROUGH. THE CELLS EASILY PRODUCED ONE NET WATT OF power. On examination, the electrochemical devices appeared to be solidly based on traditional chemistry and physics. The volume and weight energy densities didn't look that bad either. The lab work certainly appeared to be credible and competent.

On the other hand, I felt that the researcher was not nearly as far along as he felt he was. In my opinion, the internal cell resistance appeared way too high, perhaps by two orders of magnitude or more, for any marketable technology. His ultimate energy density claims were based upon yet unproven developments. The stability, reaction separation, and longevity did not seem well established. Far more attention needed to be directed towards studying what others are doing in the field, especially on a somewhat similar emerging battery technology. Unfortunately, not all research is yet on the Net. For serious big-bucks development on major products, you still have to aggressively seek out the industry-insider trade journals or the scholarly publications, as well as using the tech libraries and conferences.

Be sure to use the premium search services such as Inspec, Compendex, or MathSci found on Dialog. But don't forget that patent searches are at best a minor and a uselessly mind-rotting sideshow—one focusing on losers and failures.

More on doing personal research can be found in PRIMREST.PDF and RESBN60.PDF on www.tinaja.com. More on patents can be found in WHEN2PAT.PDF on the same Web site.

One good thing came about from examining these cells. It suggested some very interesting column topics.

Understanding Source Impedance

Almost any energy supply consists of one or more voltage sources, perhaps with a current source or two, and an unavoidable collection of resistors. However, a math trick called Thevenin's Theorem tells us that we can always reduce the source to an equivalent single voltage in series with a single resistor.

Thevenin's theorem is very handy in simplifying circuit analysis. Should AC sources also get involved, you're also likely to need to deal with capacitors and inductors. In that case, Thevenin tells us we can use a single voltage source with a series RLC impedance.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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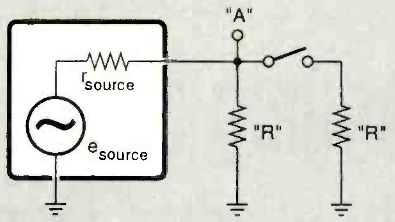
For instance, in a real capacitor, the Thevenin resistance equals the ESR, which is short for Effective Series Resistance. The ESR gets very important in capacitors used in switch-mode power supplies. At higher currents, that ESR causes internal heating and limits rates of charge and discharge; it also totally trashes efficiency.

All those highly touted supercaps from a decade back never made it out of the gate because their ESR was often ridiculously high for most applications. Some new supercaps, based on carbon aerogels, seem to be solving the high internal-resistance problem. Polystor is one source for those. Anyway, even using dozens of Farads of supercaps, you'll still have trivial total energy storage compared to, say, an AA cell, and absurdly bad voltage regulation to boot.

In a battery, the Thevenin resistor is called the internal resistance. The internal resistance causes heating on charge and discharge, and a possible explosion on a dead short. The internal resistance determines your charge-discharge efficiency. It also limits the maximum deliverable current. Internal resistance is usually nonlinear, changing somewhat with load current, moderately with time, and dramatically with state of charge or remaining cell life.

Just how do you measure a cell's internal resistance? The usual stunt to measure source impedance on plain old electronics is to hang a variable load resistor on your source, and then adjust that load until your terminal voltage drops to one half of its open-circuit value. At that point, the load resistor matches your internal one, and your Thevenin source voltage ought to be exactly double the output voltage.

That obvious "load to half voltage"



1 - Use identical load resistors "R" of "reasonable" value and power.

2 - With a rms digital voltmeter, measure voltage "A". First with the switch open and then with the switch closed.

3 - Calculate...

$$\alpha = \frac{\text{point "A" voltage with switch closed}}{\text{point "A" voltage with switch open}}$$

4 - Then find...

$$r_{source} = R\,\frac{(1-\alpha)}{(2\alpha-1)}$$

Examples: If $\alpha = 1$, you have a pure voltage source with $r_{source} = 0$

If $\alpha = 0.5$, you have a pure current source with $r_{source} = \infty$

If $\alpha = 0.9$ and $R = 560\Omega$, then $r_{source} = 70\,\Omega$

FIG. 1–ALMOST ANY ENERGY SOURCE can be replaced for analysis with its Thevenin equivalent of a single voltage source in series with a single internal resistance or impedance. Here is the "two resistor method" I often use to find the equivalent Thevenin values.

route may not perform so well with batteries because extreme currents might be involved. Instead, you can try my alternate method, which is shown in Fig. 1.

In it, you connect a "reasonable" load resistor and then measure its terminal voltage. You'll then double the load by placing an identical resistor in parallel. Then you re-measure your terminal voltage. From the ratio of those two voltages and the math in Fig. 1, you can calculate a realistic value of internal cell resistance.

An accurate digital voltmeter will be needed any time the cell internal resistance is very low. Make sure, of course, that your resistors can handle the power.

A cell's internal resistance consists of two components: Those are the true value caused by the ohmic conductance of the electrolyte, minus a time varying offsetting value of back-emf from chemical cell depolarization.

Measuring the higher-frequency AC impedance of a cell gets ugly in a hurry. Highly specialized and quite costly instruments are required. The process is called EIS, which is an acronym that means Electrochemical Impedance Spectroscopy. Gamry is a product and information source for that.

An aside: Just as there is a Thevenin equivalent where you can simplify a circuit to a single load and a single series resistance, there is also a Norton equivalent where you can replace a circuit with a single current source and a single internal loading resistor to ground. This is an example of duality and can give you another powerful analysis tool. More details on Thevenin and Norton equivalents can be found in any old circuit theory book.

However, note that neither Thevenin nor Norton can tell you what is actually going on inside of the source. They simply could not care less. A supply having real current sources and real internal resistors to ground will run much hotter and be ridiculously less efficient than a box with real voltage sources and series resistors only. Voltage sources are most efficient when open circuited. Current sources work best when short circuited.

Electrochemistry Fundamentals

Electrochemistry is that branch of science that handles the conversions of chemical and electrical energy. Your usual electrochemistry starting point is a chapter in any college-level physical chemistry textbook. Important uses of electrochemistry include batteries, fuel cells, hydrogen production, photosynthesis, corrosion prevention, metal refining, catalysts, electroplating, electroforming, water purification, and electrolysis.

The key to electrochemistry is redox, or reduction and oxidation. Certain chemical reactions remove electrons in an oxidation process. An oxidation normally takes place at the anode, or most negative terminal of a cell. Other reactions add electrons in a process called reduction. Reduction normally will happen at the cathode, or most positive terminal. These are typically called half cell reactions and must be paired.

Many reactions are reversible. Adding external electrons may cause them to proceed in one direction, but forcibly removing electrons causes them to go in the other.

One classic electrochemical cell is shown in Fig. 2. It is called a zinc-copper galvanic cell. Multiple cells in series formed a popular early battery. As shown in the figure, there is an external or conductive current path through an electric circuit and an internal or ionic current path that can travel through an electrolyte.

An electrolyte is any solution in which ions, or charged atom(s) that have too few or too many electrons, can freely pass. The conduction of an electrolyte depends upon how many ions are present. Most electrolytes are liquids.

Anyway, turning back to our cell, we basically have got a bucket of glop—two glops, actually, for there is a porous separator in the middle of the cell. That separator might be some unfired ceramic or anything else that could pass ions freely while preventing the two solutions from mixing. Other approaches to separation are actual distance, special geometries, or the use of selective current densities, but their objectives are the same: you always have to keep your anode reaction at the anode and the cathode reaction at the cathode. Otherwise, your cell shorts out.

The glop starts out as a sulphuric-acid and water solution. But zinc in acid readily becomes an ionic zinc-sulphate solution on the left. Copper in acid readily forms an ionic copper-sulphate solution on the right. Your left glop is a zinc anode in a zinc-sulfate solution. The right glop will be a copper cathode in a copper-sulphate solution.

Not all elements are equally likely to ionize. Thus, the favored zinc goes into solution, giving up electrons to the anode in its oxidation reaction. The zinc anode gets smaller as more and more of it reacts into the ionic zinc-sulphate solution.

The electrons go out through your

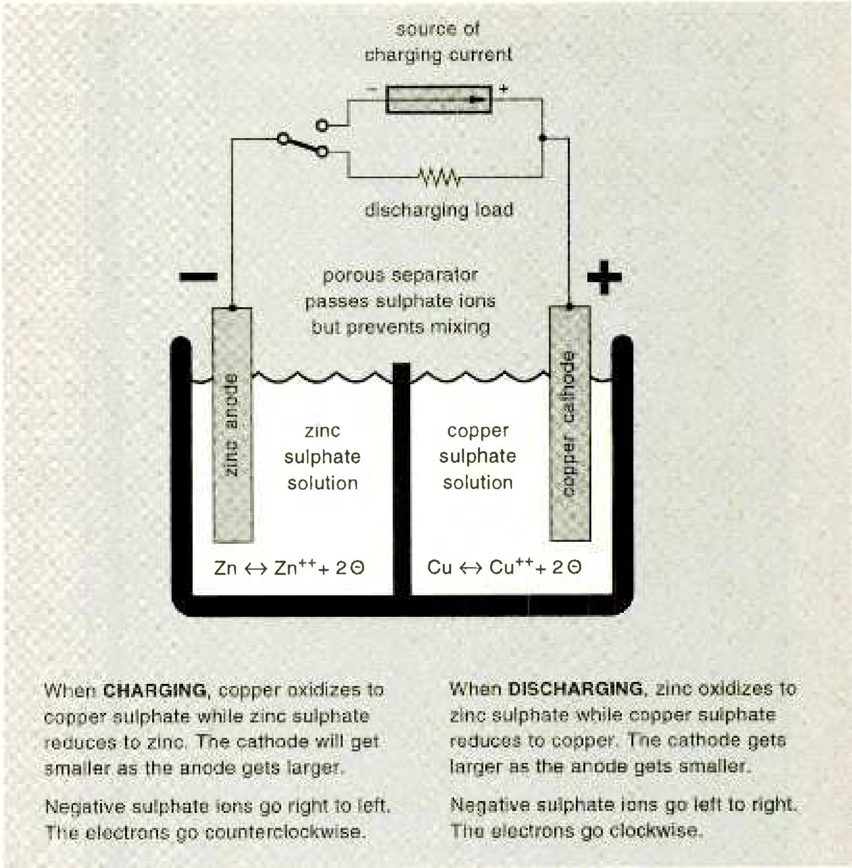


FIG. 2—A COPPER–ZINC ELECTROCHEMICAL CELL. When discharging, the zinc oxidizes into a zinc-sulphate electrolyte, while copper reduces out of the copper-sulphate electrolyte. Sulphate ions pass through the porous separator while the electrons pass through an external electrical load.

external electric circuit and return to your copper cathode. Those electrons should combine with the copper ions and reduce elemental copper out onto the cathode. The copper cathode thus gets larger as more and more ions are converted by the incoming electrons.

Meanwhile, negative sulphate ions are traveling from left to right, thus driving the external electron flow. As more and more electrical energy is removed, the remaining chemical energy will deplete (conservation of energy and all). When all of the zinc is gone, the process stops.

That process is reversible. If you apply external electric energy from a current source (such as any current-limited generator or another battery), you can force the electrons to go in the other direction. In which case, the copper goes into ionic solution and thus releases electrons while the zinc goes out of solution by consuming electrons. This time around, the zinc is getting bigger and the copper smaller.

How does that big old minus sign end up on an anode? In any vacuum tube, the electrons all go from the cathode to the anode. In a discharging electrochemical cell, the negative ions also all travel from the cathode to the anode. But since the anode is the electron source for the rest of your electrical circuit, the cell's anode ends up as the most negative terminal in your system.

While cell is discharging, the electron flow in Fig. 2 is clockwise, while the standard conventional current is counterclockwise. Note that the arrow on the charging-current source points in the conventional-current (or hole-travel) direction. The electrons actually go the other way.

Where does the cell voltage come from? Once again, zinc has a greater tendency to ionize than does copper. Those tendencies form what is known as the electrode potential series (or electromotive series) of Fig. 3 and are usually compared against a neutral or hydrogen electrode.

From that figure, we see that zinc has a tendency to reduce that is -0.76 volts less than neutral. Copper really does like to reduce, so its reduction ionization tendency is positive by 0.34 volts.

ELECTRODE POTENTIAL SERIES

ELEMENT	REACTION	VOLTAGE
Lithium	$Li \leftrightarrow Li^+$	-3.00
Rubidium	$Rb \leftrightarrow Rb^+$	-2.93
Potassium	$K \leftrightarrow K^+$	-2.92
Barium	$Ba \leftrightarrow Ba^{++}$	-2.90
Strontium	$Sr \leftrightarrow Sr^{++}$	-2.90
Calcium	$Ca \leftrightarrow Ca^{++}$	-2.87
Sodium	$Na \leftrightarrow Na^+$	-2.72
Magnesium	$Mg \leftrightarrow Mg^{++}$	-2.37
Aluminum	$Al \leftrightarrow Al^{+++}$	-1.67
Manganese	$Mn \leftrightarrow Mn^{++}$	-1.10
Zinc	$Zn \leftrightarrow Zn^{++}$	-0.76
Chrominium	$Cr \leftrightarrow Cr^{+++}$	-0.70
Iron	$Fe \leftrightarrow Fe^{++}$	-0.44
Cadmium	$Cd \leftrightarrow Cd^{++}$	-0.40
Indium	$In \leftrightarrow In^{+++}$	-0.34
Thallium	$Tl \leftrightarrow Tl^+$	-0.34
Cobalt	$Co \leftrightarrow Co^{++}$	-0.28
Nickel	$Ni \leftrightarrow Ni^{++}$	-0.25
Tin	$Sn \leftrightarrow Sn^{++}$	-0.14
Lead	$Pb \leftrightarrow Pb^{++}$	-0.13
Hydrogen	$Pt/H_2 \leftrightarrow H^+$	0.00
Antimony	$Sb \leftrightarrow Sb^{+++}$	+0.15
Bismuth	$Bi \leftrightarrow Bi^{+++}$	+0.20
Arsenic	$As \leftrightarrow As^{+++}$	+0.20
Copper	$Cu \leftrightarrow Cu^{++}$	+0.34
Oxygen	$Pt/OH^- \leftrightarrow O_2$	+0.40
Silver	$Ag \leftrightarrow Ag^+$	+0.80
Mercury	$Hg \leftrightarrow Hg_2^{++}$	+0.80
Palladium	$Pd \leftrightarrow Pd^{++}$	+0.83
Gold	$Au \leftrightarrow Au^+$	+1.70

FIG. 3—ELECTRODE POTENTIAL SERIES determines the output voltage of an electrochemical cell. Output voltage is the sum of the anode and cathode potentials. On a zinc-copper cell, 0.34 - (-0.76) = 1.10 volts.

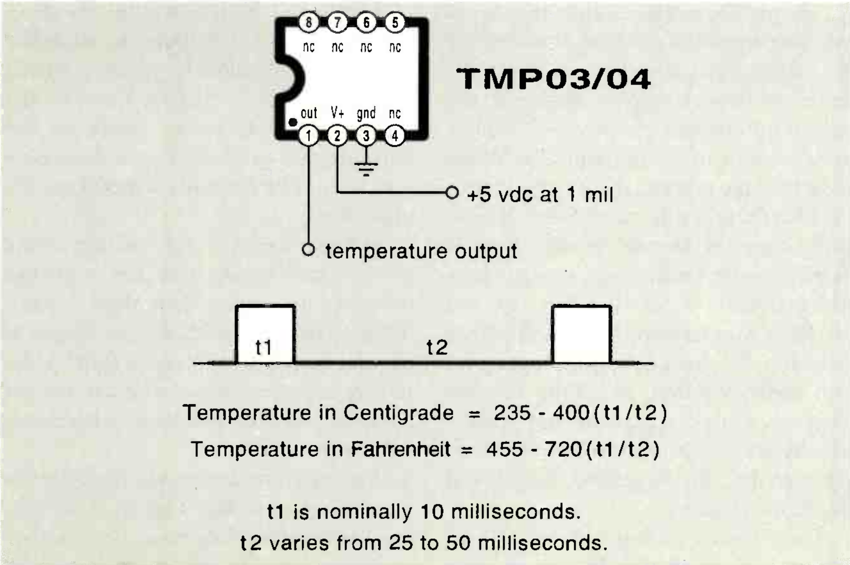


FIG. 4—ANALOG DEVICES' TMP03/04 temperature sensor features a digital output.

Together those add to 1.10 volts, which is the theoretical open-circuit voltage of a zinc-copper cell.

Terminal electrode potentials are related to the oxidation potentials and reduction potentials of the involved reactants. If you are interested in more on this, see any physical chemistry book for all the gory details.

Battery making is not a new or exotic field. For example, you can make an electrochemical cell by placing a nail and a copper wire into a lemon, and a lot of electrochemistry was done over a century ago, so there is a rich body of literature to tap. Chances are your "new" idea has been thoroughly plowed. On the other hand, there are some really big bucks waiting for the first practical solar cell replacement that mimics photosynthesis, or for improved laptop computer or cellular phone replacement batteries.

Before you start experimenting, it is important to note that there are all sorts of hazardous materials involved with all electrochemical lab work. Those materials include such things as cyanide and hydrogen.

A good set of electrochemical web links is at www.electrochem.org/ecs/intpgs.html Also check www.cmt.anl.gov/estir/info.html, and the book list at www.cmt.anl. gov/estir//books.htm The Amazon Books folks at www.amazon.com list 600+ electrochemistry books. Among the Usenet newsgroups of interest are sci.chem.electrochem and sci.chem.electrochem.battery I have provided a few other places to go for useful help on electrochemistry in this month's resource sidebar.

Energy Density of Gasoline

The "cubic goodness" of any new battery technology is measured by its energy density, which is specified using a pair of numbers. One tells you the weight of the cell for the punch delivered, and is usually specified in watt-hours per kilogram (Wh/kg). The second tells you how much room the cell takes up for the punch delivered and is usually specified in watt-hours per liter (Wh/l).

For instance, the energy density of a lead-acid battery is often specified as 25 Wh/kg and 60 Wh/l. Lithium batteries can provide 400 Wh/kg and up to 1000 Wh/l. Interestingly, from light lithium up to heavy lead the ratio of volume density to the weight density always seems to stay roughly between two and

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three. That holds true regardless of the battery technology.

The obvious question for electric cars is "How does the battery energy density compare to gasoline?" However, I've been unable to find any published source for the energy density of gasoline. There's a free Incredible Secret Money Machine II in it for you if you can lead me to one.

Anyway, let's work around that for now. We'll start by fishing out the good old *Handbook of Chemistry and Physics* from CRC Publishing. That rather massive volume tells us that gasoline can deliver just under 21,000 BTUs per pound. From a MSDS sheet, we find that the specific gravity of gasoline is 0.71. A kilogram is 2.2 pounds, so we get 46,200 BTUs per kilogram. Since a liter of water weighs one kilogram, we get around 32,802 BTUs per liter when we adjust for gasoline's lower specific gravity.

Now, a kilowatt hour equals 3413 BTUs, so we will get 13.54 kilowatt hours per kilogram, which is equal to 13,540 watt hours per kilogram, and again adjusting for specific gravity, about 9613 Wh/l. On a weight basis, gasoline is thus 542 times better than lead acid, and 34 times better than lithium. On a volume basis, gasoline is 160 times better than lead acid and around 9.6 times better than lithium.

That suggests that a 20-gallon tank of gasoline weighing 116 pounds might get replaced by a mere 69,736 pounds of lead acid batteries. Yes, you will have to adjust for delivered efficiencies and such, but no matter how much you fudge those numbers, we clearly are not there yet with today's battery technology—not by a country mile.

From the foregoing, it is difficult not to conclude that hybrid vehicles make an awful lot of sense, while the pure electrics remain monumentally stupid. You can find lots more on hybrid vehicles from

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Amory Lovins at his Rocky Mountain Institute at www.rmi.org, as well as in *Home Power* magazine. Two good battery texts include the *Handbook of Batteries & Fuel Cells* from McGraw Hill and the *Battery Reference Book* sold by Butterworth-Heinemann. Additional resources on batteries appear in RESBN58.PDF on my www.tinaja.com

Ulrich's Move Over

I have long been a fan of *Ulrich's Periodicals Dictionary*. Back in hard copy, this has been by far your most important technical tool, anytime ever. Ulrich's tells you about all the trade journals, user magazines, and scholarly pubs available everywhere in the world—around 85,000 of them.

Needless to say, these trade journals are essential for electronics. But I have yet to find Ulrich's on the web. I strongly feel that their "must subscribe" policy on their CD ROMs is outrageously snotty.

The long time number two in this field was the *International Standard Periodicals Dictionary* from Oxbridge. But these people are now freely online, complete with search capability, at their Web site, www.mediafinder.com Because of that, they are now ridiculously cheaper, faster, and better than Ulrich's.

Not all is perfect, however. For example, such industry trader journals as *ITS World* or *EDM Today* are not yet listed. But because you can instantly list yourself online, I would expect most periodicals to shortly appear. Their direct contact service also does not seem to work. Out of the two dozen media-kit requests I placed, I have yet to receive a single one.

Speaking of which, let's repeat the usual scam: The way to get a review copy of most ad-supported magazines is to contact their ad department and request a media kit. That sometimes gets you a free subscription as well. I call this the SCAR technique, short for sample copy and ad rates. More on all this in my Incredible Secret Money Machine II and in my Resource Bin reprints.

Integrated Thermometers

Semiconductor sensors have now gone way beyond simple temperature measurement. They now include such features as built-in set points, a full thermostatic action, deadbands, and elaborate digital communications, sometimes over a single wire. Two leading sources here include Dallas and Analog Devices.

I've been meaning to do a roundup on these, but let's instead look at two examples. Figure 4 shows us the Analog Devices TMP03 and TMP04 sensors, which can directly measure temperature and output it as a digital data stream to a microcontroller. Their temperature output is a duty-cycle modulated waveform from 20 to 50 hertz. Your high time is fixed at 10 milliseconds. The low output time is proportional to the temperature. A fairly simple duty cycle calculation as shown gives you the temperature in Fahrenheit or Centigrade.

The operating range is -40 to +100 degrees centigrade. Typical accuracy is half a degree. Response time varies with the package—25 seconds in free air for their T0-92 "transistor" pack and 50 seconds for the eight pin SO-8 minidip. Operating current is just under one milliamp at five volts.

The TMP03 is an open collector, while the TMP04 gives a TTL/CMOS compatible output. Either interfaces beautifully with the Basic Stamp from Parallax or any PIC. More details on these are found on the PIC Library Shelf on www.tinaja.com

New Tech Lit

There's lots new on the GPS front. For example, the new *Global Positioning Products Handbook* from Plessey, a single chip GPS-receiver front-end by California Eastern Labs, and scads of products and information from Navtech GPS Supply.

From National Semiconductor comes a free Transmission-Line Rapidesigner slide chart. From the MedianiX folks, there are data sheets on the unique MED25101 Digital Karaoke Audio Processor and a MED25005 Surround-Sound Chip.

Clement Engineering has a low cost telemetry circuit for use with balloons and such. Bio-potential skin electrodes are being sold by In Vivo Metric.

New trade journals for this month include *Intele-Card News* on phone cards and *Applied Microwave & Wireless* on high-frequency communications. *The Last Straw* is a newsletter on straw-bale home construction! Check out their "Role in the Hay" classifieds.

The newest of Levitrons now "levit" higher, and up to 24-hours and longer! Contact Mike Sherlock at his Unlimited Fun Options for details.

To pick up all the fundamentals of digital integrated circuits, check my *TTL Cookbook* and *CMOS Cookbook*. The latter is now freshly republished by Butterworth-Heinemann and should be in stock in all major bookstores. Autographed copies are available per my nearby Synergetics ad.

I've just added an "automatic newsgroup finder" as a NEWSLIST.HTML on my www.tinaja.com You also can find bunches of reprints there, surplus bargains, a consultant's network, and annotated hot links to lots of unusual and useful Web locations. Most of the mentioned items appear in the "Names & Numbers" or "Electrochemistry Resources sidebars. Be certain to check there first before calling our US tech helpline. EN

SERVICE CLINIC

continued from page 29

(6) Power surge at start of cook cycle confusing controller.
(7) Microwave leakage into electronics bay.

Symptom: Malfunctioning touch-pad keys.
Cause:
(1) Touch pad or controller board contaminated by cleaning.
(2) Defective or damaged touch pad.
(3) Controller is confused (pull plug for a minute or two to reset).
(4) Faulty controller.

Symptom: Oven does not start.
Cause:
(1) Defective start button.
(2) Faulty interlock switches.
(3) Door is not securely closed.
(4) Faulty controller.
(5) You waited too long. Open and close door to wake oven up.

Symptom: No heat—everything else seems normal.
Cause:
(1) Blown fuse in high-voltage (HV) transformer primary circuit or HV fuse (if used).
(2) Bad connections (particularly to magnetron filament).
(3) Open thermal protector or thermal fuse.
(4) Open HV capacitor, HV diode, HV transformer, or magnetron filament.
(5) Shorted HV diode, HV capacitor (will blow a fuse), or magnetron.

Symptom: Fuse blows when closing or opening door.
Cause:
(1) Defective interlock switches.
(2) Misaligned door.

Symptom: Loud hum and/or burning smell.
Cause:
(1) Shorted HV diode, magnetron.
(2) Burned, carbonized food residue in oven chamber.
(3) Shorted winding in HV transformer.
(4) Frayed insulation on HV wiring.

Symptom: Arcing in or above oven chamber.
Cause:
(1) Burned, carbonized food deposits.
(2) Exposed sharp metal edges.

Symptom: Fuse blows when cook cycle starts.
Cause:
(1) Defective interlock switches or mis aligned door.
(2) Shorted HV capacitor, HV diode.
(3) Shorted magnetron (probably won't blow main fuse, but will blow HV fuse when one is used).
(4) Defective Triac.
(5) Old age or power surges.
(6) Defective HV transformer.
(7) Short in wiring.

Symptom: Fuse blows when turning off.
Cause:
(1) Defective Triac (doesn't turn off properly).
(2) Defective relay.
(3) Shorting wires.

Symptom: Always cooks on high setting.
Cause:
(1) Faulty relay or Triac.
(2) Faulty controller.

Symptom: Cooking starts as soon as door closed.
Cause:
(1) Shorted relay or Triac.

Symptom: Heats, but power seems low.
(1) Low line voltage.
(2) Magnetron with low emission.
(3) Faulty controller or set for wrong mode.
(4) Stirrer (or turntable) not working.
(5) Intermittent connections to mag netron filament or elsewhere.

Symptom: Heats, but shuts off randomly.
Cause:
(1) Overheating caused by blocked air vents or inoperative cooling fan.
(2) Overheating caused by bad magnetron.
(3) Bad connections in controller or in microwave generator.
(4) Faulty interlock switch or marginal door alignment.
(5) Faulty controller.
(6) Overheating caused by extremely high line voltage.

Symptom: Buzzing noise when heating.
(1) Fan blades hitting support or shroud.
(2) Vibrating sheet metal.
(3) Vibrating transformer laminations.
(4) Turntable or stirrer hitting some debris.

Symptom: Light does not work.
Cause:
(1) Burned-out bulb.
(2) Bad connections.

Symptom: Fans or turntable not working.
Cause:
(1) Gummed-up lubrication or bad motor bearings.
(2) Loose or broken belt.
(3) Bad motor.
(4) Bad thermostat.
(5) Bad connections.

Winding It Up

There you have it, team. The symptoms that are most common, together with what most often causes them. If you do decide to get under the hood of your microwave, make sure you do not forget the safety considerations we outlined in the beginning—the life you save may be your own!

Next time, we will take another look at microwave ovens and touch on some of the more interesting things that go wrong, and what you can do about them. In the meantime, if you have any questions about how you can service some particular piece of electronics equipment, visit the sci.electronics.repair FAQ homepage, which is located at http://www.paranoi.com/~filipg/REPAIR/. If you have comments or questionson what we've discussed here, you can e-mail them directly to me at sam@stdavids.picker.com. EN

NEW LITERATURE

continued from page 27

ly mistakes and maximize their chances of success. It focuses on the day-to-day business of publishing—managing subscriptions, selling advertising, and fending off competitors while keeping up a regular production schedule.

The book offers advice on raising start-up money, finding the best readers and turning them into loyal customers, and using ancillary products to boost your bottom line. In addition, developing a circulation strategy and using the most efficient marketing channels, attracting top-notch talent, and finding a publishing home on the Internet is discussed. Also included is a valuable list of resources for publishers, including professional associations, reference books, courses, and Web sites. EN

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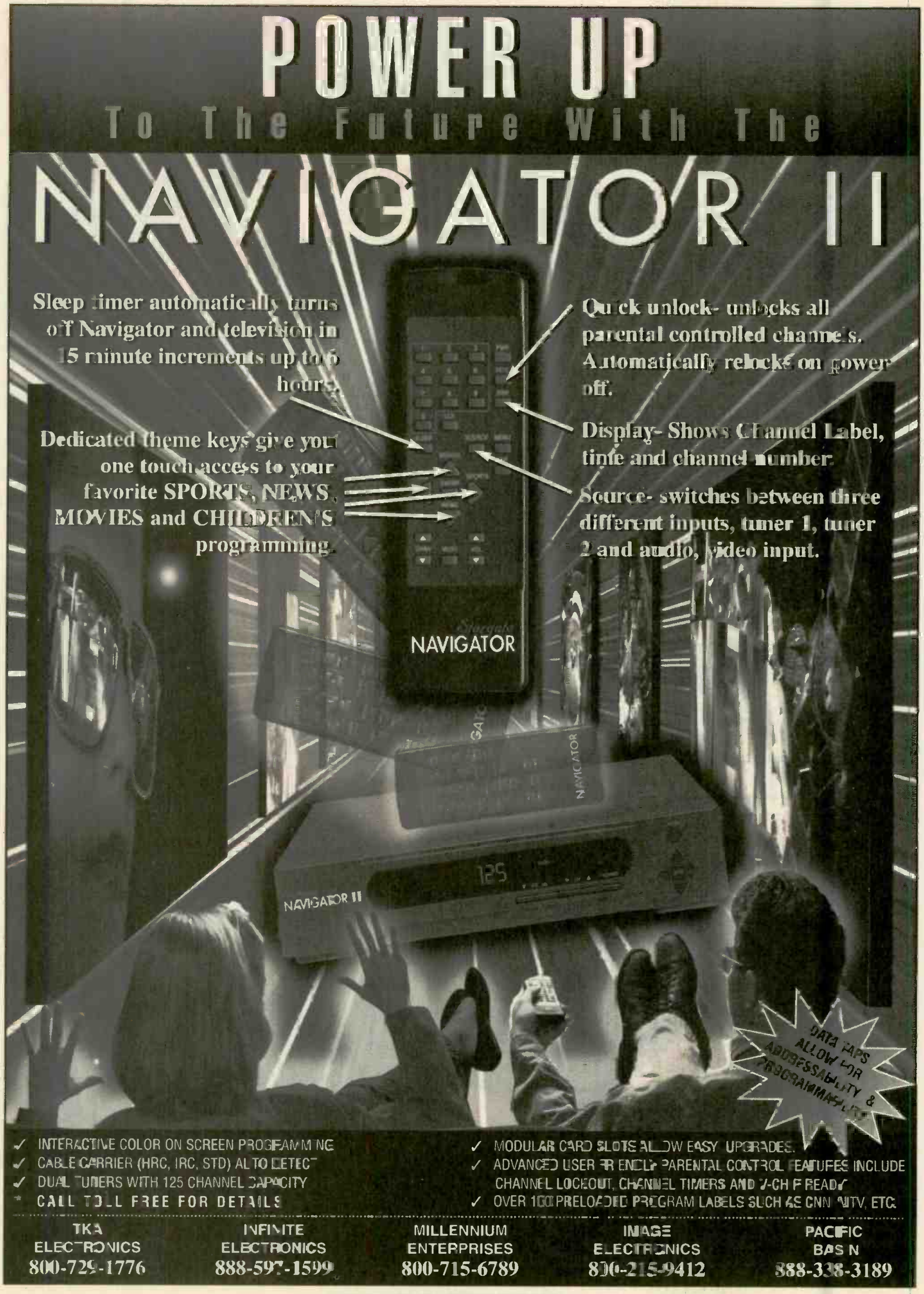

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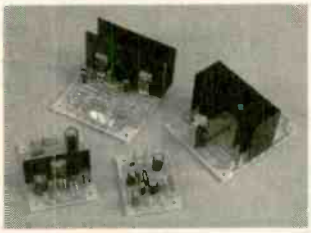

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- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

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

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

Features

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

Specifications - PM-128/PM-129

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

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

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

Features

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

Specifications - PM-328

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

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

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CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

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

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CAT NO	DESCRIPTION	PRICE EACH 1	10	25
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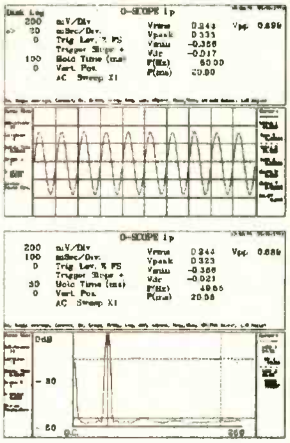

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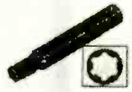

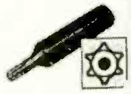

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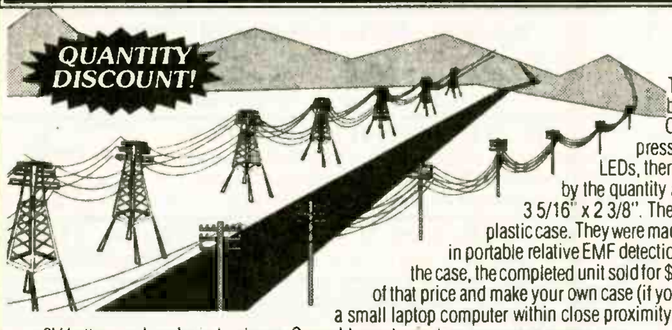
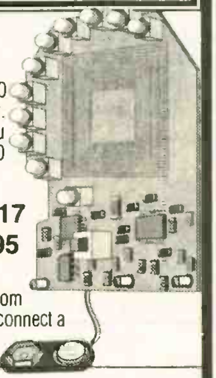


ELECTROMAGNETIC FIELD (EMF) DETECTOR

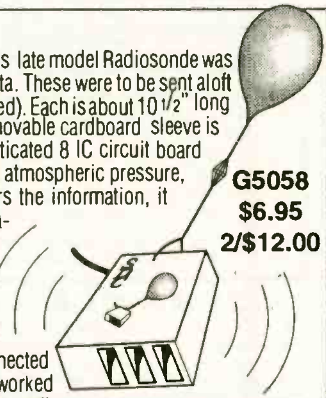


This is a complete EMF detector utilizing 3 SMD ICs and 10 bright LEDs that indicate relative strength of EMF energy. Operates on one 9V battery (not included). As soon as you press the on/off button, the unit runs a "self-test" by lighting all 10 LEDs, then it resets itself and indicates the relative EMF strength by the quantity and color of LEDs that light. Size of unit is about 3 5/16" x 2 3/8". These are brand new and prime, but without the outer plastic case. They were made in 1995 and feature some of the latest technology in portable relative EMF detection. We suspect that when the board was installed in the case, the completed unit sold for $80-$100 retail, but now you can buy it for a fraction of that price and make your own case (if you wish). We were amazed by the EMF energy emitted even from a small laptop computer within close proximity. We have no data or schematics, but all you need to do is connect a 9V battery and you're in business. Super blowout price!

G8317 $8.95

5 for $40.00 • 10 for $75.00 • 100 for $600.00

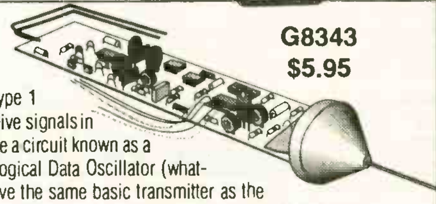
Radiosonde (Type 1)



This is a rare return of an old favorite. This late model Radiosonde was made for tracking all types of weather data. These were to be sent aloft attached to a weather balloon (not included). Each is about 10 1/2" long x 3 3/8" thick x 8" wide. Inside of the removable cardboard sleeve is a styrofoam chamber housing a sophisticated 8 IC circuit board which has sensors attached to measure atmospheric pressure, temperature and humidity. As it gathers the information, it transmits the data at about 1.677 gigahertz (GHZ). These are prime, brand new units that were waiting shipment from the manufacturer (Space Data Corporation) to the government when the contract was cancelled. These are complete except for the battery. We connected two 9V batteries in series and the unit worked perfectly from them. Sorry, no schematic available. The main board contains the following ICs: 7555, CD4051, CD4520, LM324, 4151, TLC27L (2 pcs.) and a 78M15C voltage regulator. It also has the precision T05 case pressure sensor, hygristor sensor holder (with the hygristor (humidity) sensor plate in a sealed container ready to insert into the holder), thermistor for temperature measurements and nose cone transmitter antenna assembly. Great for experimentation, building your own weather equipment, studying high frequency transmission, as a source for useful parts or just great for a conversation piece. These cost the government a bundle to have made but we are selling them at a giveaway price. Hurry, get your Radiosonde today!

G5058 $6.95 2/$12.00

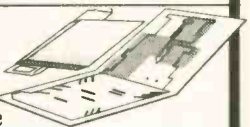
Transponder (Type 2) Radiosonde



G8343 $5.95

These are similar to the type 1 radiosondes, but these receive signals in the 403MHz range and have a circuit known as a commutator and Meteorological Data Oscillator (whatever that means). They have the same basic transmitter as the units described at left. They were made to measure temperature and humidity but we aren't sure about pressure. These have the following parts: a 4016 IC, a 4022 IC, a 78M15 regulator IC, 2 ICM 7555 ICs (or equivalent), an RCA 3404 IC and a large quantity of resistors, capacitors, several coils and transistors. Size about a foot from end to end, and 2 3/8" wide. Has 2 wire antennas for the receiver and a brass nose cone transmitter antenna. We don't have the spec or schematics, but these are new functional units. Sorry, no humidity sensor, thermister or battery included. Comes in a styrofoam box. NOTE: These were meant to be mounted in an outer chamber and sleeve (sold below).

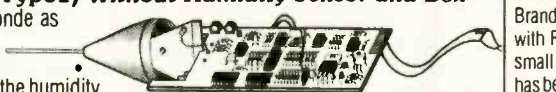
Transponder Chamber and Sleeve



This is optional as it is not part of the electronic circuit. It consists of a very large punch out corrugated plastic chamber which has certain surfaces colored black (we assume it has something to do with the temperature measurement function) You also get the outer cardboard sleeve. You will need to assemble the chamber and sleeve yourself (just punch out and fold up), and insert the styrofoam box (from the G8343 above) into it. Brand new; shipped folded in half.

G8344 $4.00

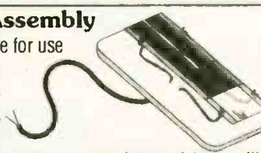
Radiosonde(Type1) *Without Humidity Sensor and Box*



Complete radiosonde as described above except these do not have the humidity sensor assembly and the styrofoam container box. These are new units that have the transmitter nose cone, pressure sensor and temperature sensor attached. Simply apply battery power and these will start transmitting data, however they do not have the humidity sensor assembly with humidity sensor plate. Brand new, but no other info.

G5578 $4.95

Radiosonde Humidity Sensor Assembly



Brand new humidity sensor plate and holder made for use with Radiosondes. The humidity sensor plate is a small 2 1/2" x 11/16" x 1/16" plastic plate on which has been deposited a surface material which causes the resistance of the sensor to go up as the humidity rises. Very sensitive - you can just breathe on it from a foot away and the resistance will go way up momentarily. Approximate resistance measured in Arizona on the day this was written was about 11,280 ohms. Control music by breathing, measure the humidity in your house or operate a relay by breathing are just a few of the possibilities - use your imagination! Brand new made by Victory Engineering. The sensor plate comes in a sealed plastic container and has not been opened. Complete assembly with 1 ft. long 2 wire cable.

G5069 complete assembly $1.89
G5070 replacement sensor plate only $1.25

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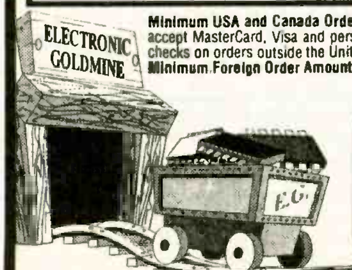
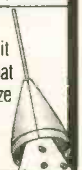


ELECTRONIC GOLDMINE
PO Box 5408
Scottsdale, AZ 85261

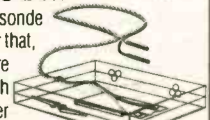
Transmitter Nosecone



These are brand new transmitter nose cone assemblies for the Radiosonde circuit board. They contain 1 transistor and an adjustable cap. They have only 3 wires that need to be connected to main board to provide transmission at over 1 GHZ. Size about 4" from circuit board base to tip of brass antenna. Brass cone is about 1 5/8" Dia. at base. Prime - but no specs or schematic.

G5190 $1.00

Radiosonde Tiny Thermister in Plastic Box



These were made to be used with the transponder radiosonde (G8343). They feature a tiny wire (almost invisible) thermister that, at about 75°F has almost 10K of resistance. As the temperature increases, the resistance goes down. These are brand new with color coded leads that plug into wires on the transponder radiosonde.

G8411 $1.00

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240x64 dot LCD with built-in controller.

AND 4021ST-EO. *Unit is EL back-lit.* $69.00 or 2 for $129.00 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.

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

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

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

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

LASER PRODUCTS

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

Laser Power Supply (for HeNe tube) **$89.00**

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

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

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

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

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

NETWORK

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

POS & BAR CODE

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

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

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SWITCHING POWER SUPPLYS $12.00 or 2 for $20.00 115/230 Volts

73 WATT (2) 4 pin power connectors attached • Dim: 8.5" L x 4.5" W x 2" H
Output: +5V @ 2-9.75, A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A

68 WATT Dim: 5.5" L x 3.2" W x 1.7" H • Output: 5V @ 4 A, 12V @ 4A

60 WATT Dim: 8¾ x 4¼ x 3 • Output:5V @ 6A + 12V @ 1A - 5V @ 1A - 12V @ 1A

CHARGE COUPLED DEVICES

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

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

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

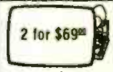
LINEAR TYPE

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

MONITORS

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

5" COLOR MONITOR $39.00
• Flat Faceplate • 320 x 200 Dot Resolution • CGA & Hercules Compatible
• 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq.
• Open Frame Construction • Standard Interface Connector • Degaussing Coil included • Mfr. Samtron



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

MISCELLANEOUS

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

IBM 370 option XT and AT emulation boards $25.00

HACKER CORNER

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

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

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

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

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

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

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

.6" COMPOSITE MINIATURE COLOR DISPLAY $99.00
Fully encased. Dim: 1.3" x 1.2" x [illegible] Volts DC power. NTSC signal. 250 H x 300 V resolution. Focus adjustable eyepiece. Applications include camcorder viewfinder, helmet mounted display, etc... Original cost over $600.00

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CAT # SK-58 — **$14.95 pair**

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CAT# SK-58A $17.95 per set

SMALL NEODYMIUM RARE EARTH MAGNETS

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

$1.00 each — **CAT# MAG-30**

160 pcs. - $100.00

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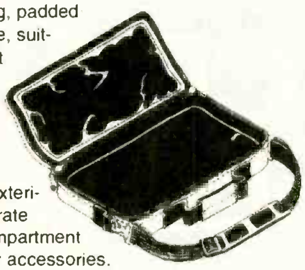
Compact, TTL compatible, optically isolated solid state relay for loads up to 5 amps @ 240 vac. 0.8" x 0.82" x 0.56" high epoxy block with a 1.4" long metal mounting flange. 1.19" mounting centers. 0.062" dia. x 0.175" high pins. Can be pc mounted or pins can be wrapped and soldered. UL and CSA listed.
Input: 4 - 8 vdc - Load: 5 amps @ 240 vac

$6.00 each — **CAT# SSRLY-2405**

10 for $55.00

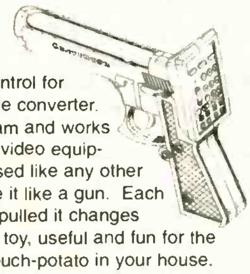
NOTEBOOK COMPUTER CARRYING CASE



Great looking, padded carrying case, suitable for most notebook computers or similar equipment. Black leatherette exterior with separate zippered compartment for papers or accessories. Detachable nylon web shoulder strap. Interior space is 13.5" X 9" X 2.5"

CAT # CSE-12 — **$9.75 each**

Shoot That TV, VCR Etc.! COLT 45 - STYLE Universal Infrared Remote



The Gunvertor ™ is a full-featured, programmable infrared remote control for TV, VCR and Cable converter. It is easy to program and works with most popular video equipment. It can be used like any other IR remote. Or, fire it like a gun. Each time the trigger is pulled it changes channels. A great toy, useful and fun for the channel-surfing couch-potato in your house. Includes instructions. (4 AA batteries not included).

CAT# GNV-1 — **$9.95 each**

470 UF, 450 VOLT SNAP-IN CAPACITOR

Nichicon LGQ2W471MHSC
1.375" diameter x 2" high.
0.4" lead spacing.

$4.50 each — **CAT# EC-4745**

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Rubycon # 1A2304A
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CAT# PPC-410

$2.00 each

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S.P.S.T. on-off keyswitch. Key removable in both positions. High-quality keyswitch with 7 tumbler-lock. 0.85" dia. chrome bezel. 0.75" diameter threaded bushing flatted on two sides. Includes brass nut and removable 1.08" dia. escutcheon. Fits panels up to 0.8" thick. Extends 1.75" below mounting surface. Includes 2 keys with black plastic protective handles. Each lock keyed differently. Each lock and key has ID number. Solder or 0.25" qc terminals.

CAT # KSW-15 — **$4.75 each**

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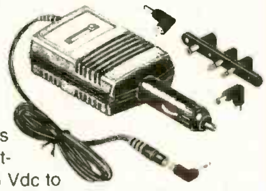

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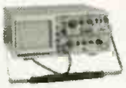
Model 2190A

- 1mV/division sensitivity
- Sweeps to 5ns/division
- Dual time base
- Signal delay line
- 15KV accelerating voltage

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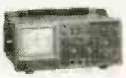
Model 2160A

- 1mV/division sensitivity
- Sweeps to 5ns/division
- Dual time base
- Signal delay line
- V mode displays two signals unrelated in frequency.
- Component tester

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40MHz DUAL-TRACE
Model 1541C

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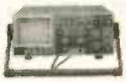
- Z-axis input
- Single Sweep
- V mode displays two signals unrelated in frequency
- Component tester

60MHz, CURSORS & READOUTS, DUAL TIME BASE
Model 2260

- Cursors and readouts
- 1mV/div sensitivity
- 23 calibrated ranges - main time base
- 19 calibrated ranges - delayed time base
- Signal delay time
- V mode - displays 2 signals unrelated in frequency.
- Component tester
- Z-axis input
- Single sweep

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Special $389.95
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S-1340 $475
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DS-303 $1095
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S-1330 $439
- 25MHz Analog
- Delayed Sweep

S-1325 $325
- 25MHz Analog

OSCILLOSCOPE SELECTION CHART

ANALOG

Model	Bandwidth MHz	Sensitivity (max)	No. of Channels	Sweep Rate Max ns/div	Delayed Sweep	Video Sync	Component Tester	Beam Find	Time Base
S-1360	60	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1345	40	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1340	40	1mV/div	2	10ns/div	No	Yes	No	No	1
S-1330	25	1mV/div	2	10ns/div	Yes	Yes	Yes	Yes	2
S-1325	25	1mV/div	2	10ns/div	No	Yes	No	No	1

DIGITAL STORAGE

Model	Bandwidth MHz	Analog Sen (max)	No. of Channels	Sampling Rate	Memory Channel	Internally Backed Up	Pretrigger %	Output
DS-303	30	1mV/div	2	20MS/S	2K	Yes	0, 25, 50, 75	RS232
DS-603	60	1mV/div	2	20MS/S	2K	Yes	0, 25, 50, 75	RS232

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V-525 - 10MHz w/ Cursors
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V-552 - 50MHz Was $1195,
NOW **$850** Save $345

V-555 - 50MHz w/ Cursors
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Was $1815, NOW **$1395** Save $420

V-1065A - 100MHz w/ Cursors
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V-1560 - 100MHz Was $1790,
NOW **$1490** Save $300

V-1565 - 100MHz w/ Cursors
Was $1960, NOW **$1595** Save $365

V-252 - 20MHz $419

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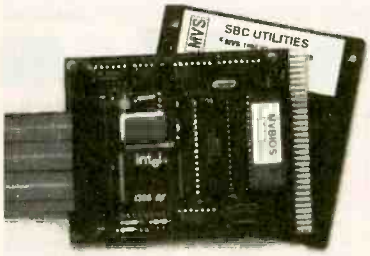
- BATT. BACK. RTC
- IRQ0-15 (8259 X2)
- 8237 DMA 8253 TMR
- BUILT-IN LED DISP
- UP TO 8 MEG ROM
- CMOS NVRAM



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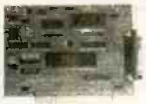

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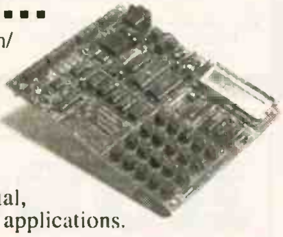

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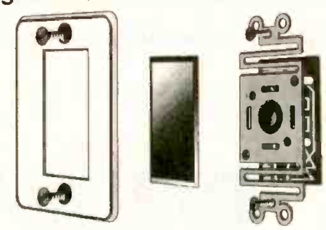

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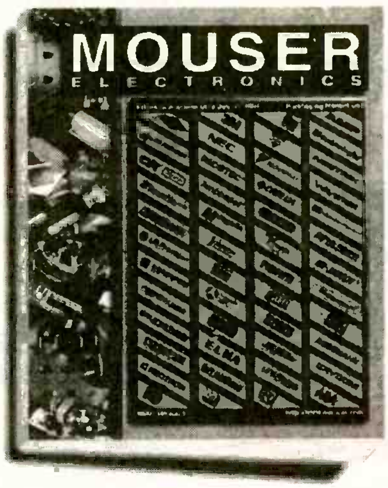

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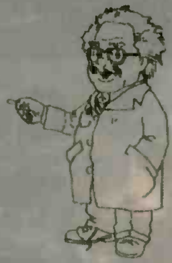

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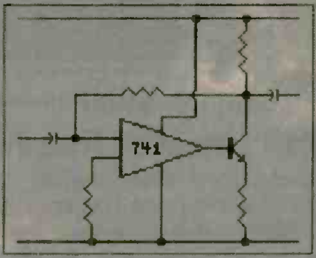

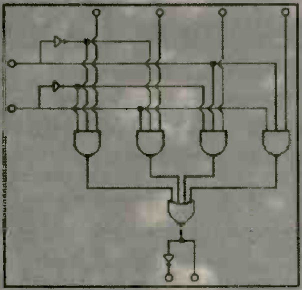

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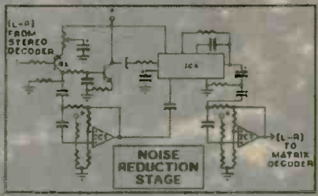

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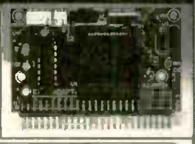

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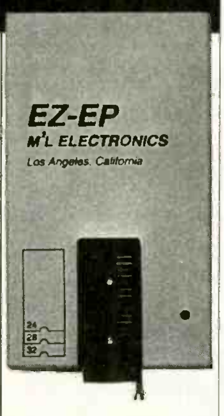

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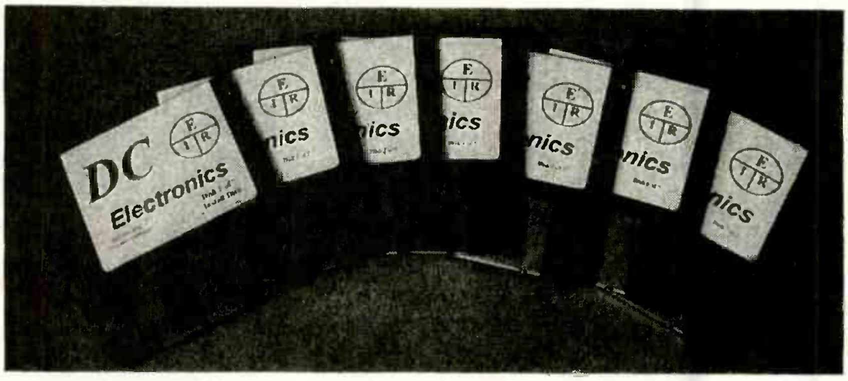

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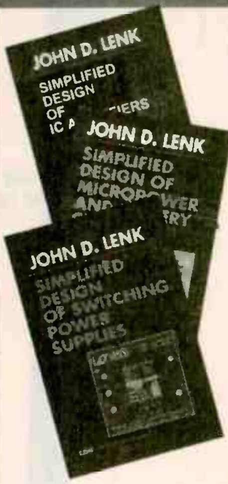

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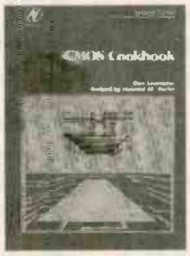

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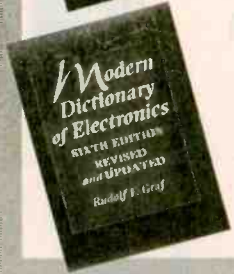

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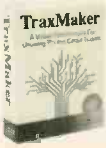

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136266	Digital-Analog lab	$329.95

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Will not crack or split when drilled or punched. PCB mounting slots on all four sides and the lid has a lip for precision fit (adds 0.4" height). Complete with four screws and lid. All sizes below are for interior dimensions. • Black ABS plastic

Part No.	Size (L x W x D)	1-9	10-49	50-99
18921	3.1" x 2.0" x 0.9"	$2.25	$1.95	$1.59
18913	4.9" x 2.5" x 1.5" ...	2.49	2.25	1.79
18892	6.0" x 3.5" x 1.9" ...	2.95	2.69	2.39
18905	7.5" x 4.3" x 2.3" ...	3.49	2.95	2.49

Jameco E(E)PROM Programmer

- Programs 16Kbits to 512Kbits EPROMs
- Programs EPROMs, EEPROMs
- Programming speeds/algorithms: normal, intelligent, and quick pulse

Part No.	Description	1-4	5-9
101400	1 socket 16Kbits-512Kbits E(E)PROM prog.......	$129.95	$116.95

7 Watt Mono Amplifier Kit

22 pc. Kit

- Music output power: 7W/4Ω
- RMS output: 3.5W/4Ω & 2W/8Ω
- Harmonic distortion: 0.05% (1W/1kHz)
- Frequency response: 20 to 20kHz (-3dB)
- Short circuit/overload protection
- Requires speakers and power supply: 15VDC (8 to 18VDC @ 0.5A)
- Board size: 2.2"L x 1.4"W • Weight: 0.3 lbs.

Part No.	Description	1-4	5-9
127255	7W mono amp. kit	$12.95	$11.49

Electronic Temperature Controlled Soldering Station

- Analog readout
- Tip temperature electronically controlled to ±6°F of idling
- Transformer isolates line transients and spikes • ESD safe
- Heater power: 60W • UL approved
- Size: 5.1"W x 8.0"D x 4.0"H
- Weight: 4.6 lbs.

ESD Safe! SPECIAL

Part No.	Product No.	Price
138923	XY960AESD ...... Special	$159.95

Benchtop PC Board Solder Station

- Holds PC boards up to 13" wide
- Can be adjusted by using press release and sliding support arm to hold desired size board
- Right hand soldering iron holder
- Size: 19.5"W x 8.8"D x 8.8"H

Part No.	Description	Price
133065	PC board solder station......	$29.95

Jameco 66 Piece Tool Kit

A comprehensive set of tools for field technicians, engineers and lab personnel. Aluminum case features removable pallets, surface-type locks, a black plastic handle, side buckles and strap.

- Size: 18.0"L x 14.0"W x 6.0"H • Wt: 18.2 lbs.

Part No.	Description	1-4	5-9
105646	66 piece tool kit ...	$179.95	$161.95

Jameco Modular Crimping Tool Set

- 8" metal modular crimping tool crimps 4P, 6P and 8P plugs
- Includes: 40 ea. 4P4C modular plugs (616), 30 ea. 6P6C modular plugs (623), 20 ea. 8P8C modular plugs (641) • Weight: 2.1 lbs.

Part No.	Description	1-4	5-9
73496	Crimping tool set...	$79.95	$71.95

Jameco 54 Watt Switching Power Supply

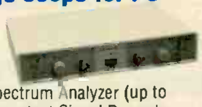
- Input: 110/220VAC @ 47/63Hz
- Overcurrent protection: 110-130% automatic current limiting
- Minimum load: all outputs at 10% of rated load
- Data sheet included
- Size: 6.3"L x 3.9"W x 1.5"H
- Weight: 1.2 lbs. • One-year warranty

Output:
+ 5VDC @ 5.0A,
+12VDC @ 1.0A,
- 5VDC @ 1.0A,
-12VDC @ 1.0A

Part No.	Product No.	1-9	10-24
17056	FCS604A	$44.95	$39.95

Velleman 32MHz Digital Storage Scope for PC

MS DOS programs include: Oscilloscope with True RMS readout, FFT Spectrum Analyzer (up to 16MHz), and Transient Signal Recorder.



- System requirements: 386 or better, IBM or compatible PC with 460KB memory, VGA display card, and mouse
- Requires 12VDC transformer P/N 129331
- Size: 8.8"W x 6.9"D x 1.8"H
- Weight: 2.8 lbs. • One-year warranty

Part No.	Description	1-4	5-9
139678	Storage scope....	$299.95	$269.95

12-Bit Motor Control / Data Acquisition Board

- A 3 wire UART port (Rx, Tx and GND) configurable to any standard baud rate in the 300-115200 range (N,8,1)
- Three 12-bit ports (PA/PB & PC) configurable pin for pin as inputs or outputs
- Three stepper motor ports
- Manual included • One-year warranty
- Size: 6.0"L x 2.6"W • Weight: 0.2 lbs.

Part No.	Description	Price
140484	Data acquisition board......	$149.95

Multi Stepper Motor Control Board

SPECIAL

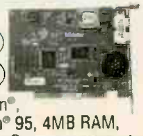
- Controls 4 stepper motors independently
- Communication with PC via RS232 at 300 to 115200 baud
- 8 TTL compatible I/O lines • Size: 8.0"L x 5.1"W x 1.3"H
- Weight: 0.6 lbs. • Six-month warranty

Shown w/ motors – not included

Part No.	Description	Price
140492	Control board..... Special	$339.95

U.S. Robotics 14.4 kbps Data/Fax Internal Modem

- Supports 14.4 down to 300 bps of data
- Compatible with ITU-T standard
- System requirements: 486 or Pentium®, Windows® 3.xx to Win® 95, 4MB RAM, 2MB hard disk space • One-year warranty



Part No.	Description	1-4	5-9
139871	14.4 int. modem....	$49.95	$44.95

Jameco Electronic Component Cabinet Kits

Kits include the most popular components with extra space for your customized expansion. Each kit includes a 20 drawer component cabinet.

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Part No.	Description	Price
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84961	420 pc. 74LS series IC kit..........	119.95
84970	300 pc. CD4000 series IC kit	84.95
84988	385 pc. Linear series IC kit	159.95
108329	540 pc. 1/8 watt Resistor kit........	29.95
81832	540 pc. 1/4 watt Resistor kit.........	28.95
107879	540 pc. 1/2 watt Resistor kit.........	31.95
108433	2200 pc. Electr. Hardware kit.......	39.95
81867	110 pc. Radial Capacitor kit..........	34.95
81859	320 pc. Ceramic Capacitor kit.......	29.95
81883	160 pc. Mylar Capacitor kit..........	34.95
81841	129 pc. Tantalum Capac. kit	49.95
82587	270 pc. Diode kit.........................	39.95
82595	180 pc. Transistor kit...................	49.95

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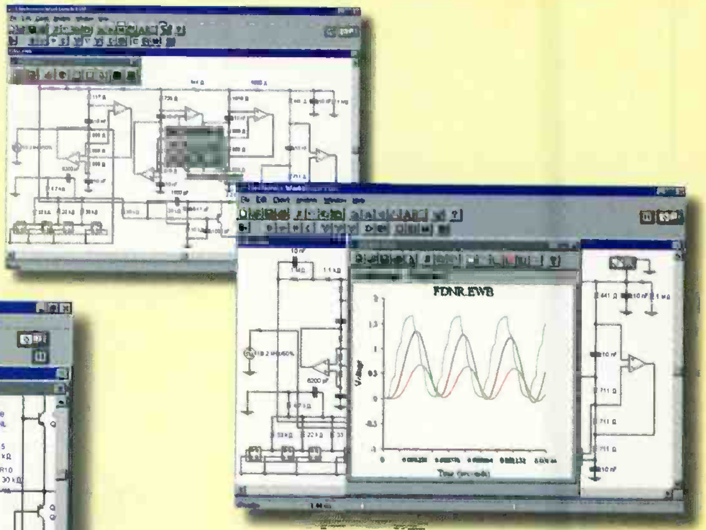

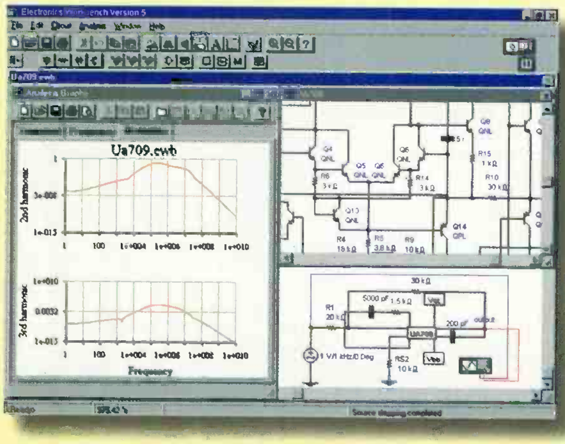

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DIGITAL ENGINE	NATIVE, 32-BIT
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PRO SCHEMATIC EDITOR	YES
HIERARCHICAL CIRCUITS	YES
VIRTUAL INSTRUMENTS	YES
ON-SCREEN GRAPHS	YES
ANALOG COMPONENTS	OVER 100
DIGITAL COMPONENTS	OVER 200
DEVICE MODELS	OVER 4,000
MONEY-BACK GUARANTEE	30-DAY
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TRANSIENT	YES
FOURIER	YES
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DISTORTION	YES

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