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POSTMASTER: Please send address changes to ELECTRONICS NOW, Subscription Dept., Box 55115, Boulder, CO 80328-5115.

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Microfilm & Microfiche editions are available. Contact reprint bookstore for details.

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EDITORIAL

Here We Go Again!

This month's editorial is going to bore some of you and annoy others. That's fine, because it is aimed at everyone else. The topic is the Internet.

If you are already on the Internet, you don't need to read what follows as it will just bore you and there are plenty of other interesting things to discover in this month's issue.

If you've made your mind up that the Internet is the biggest waste of time ever invented, inherently evil, or just not for you, you don't need to read what follows. While I can be persuasive, I can't change a closed mind.

OK, now that they are gone, we can talk freely. The first thing you might be wondering about is why am I so high on the Internet. I guess the reason is that I have come to depend on it in ways I could not have imagined just a few short years ago.

The last time I talked about the Internet, I dealt with how it can help electronics hobbyists get more out of their pursuits. This time, I want to deal with how it has impacted me personally.

You want examples? Here goes: In addition to my duties here at **Electronics Now**, my wife and I own a small collectibles business. We do a lot of traveling in connection with that, and I almost always make our hotel reservations online. One huge advantage is that we get an instant confirmation, including quoted rates, that we can print out and take with us. Having that in hand helps make sure that the check-in procedure goes smoothly. If a flight is involved, we also can check airline schedules and fares and even make the reservations online.

We've also established our own Web site. It is small and nothing fancy, but it gets the job done and has more than paid for itself.

Well, you might say, that's fine for you, but I don't have my own business so what's in it for me? Okay, here's more: An elderly member of my family needed help with her tax returns last year. The problem was she did not have the forms, and we discovered the situation too late to get them by mail. Up to the Internet we went. In minutes we had found the forms we needed (both state and federal), downloaded them in Acrobat format (so that they retained their original formatting), and printed them out—complete with the instruction booklets.

We have begun to do some preliminary research into purchasing a new car (both of ours have pretty high mileage at this point). There are sites on the Internet that provide complete details on just about every car sold today, including available options and packages. They don't only tell you what's available and how it is sold, but they also provide both sticker and invoice pricing so you are better equipped when you face off with the salesman. Some will even give you the book value of your current car (after asking you about mileage, equipment, and condition) if you are looking to trade it in.

I could go on and on, and I have, but you get the idea. The Internet is about information for your hobby, your business, and your personal life. If you think there is nothing on the Internet for "you," it is likely you've never been there or just haven't looked very hard.

Carl Laron

Carl Laron
Editor

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

Swim-Race Starting Signal

Q *I would like to build (cheaply) a pulse-tone starting signal and strobe light for starting swim races. It also should be suitable for use with a PA system. It should produce a $^1/_4$-second pulse of tone and be ready to fire again immediately in case of a false start. The rules also require a strobe flash simultaneous with the tone. — L. T., Greenville, SC*

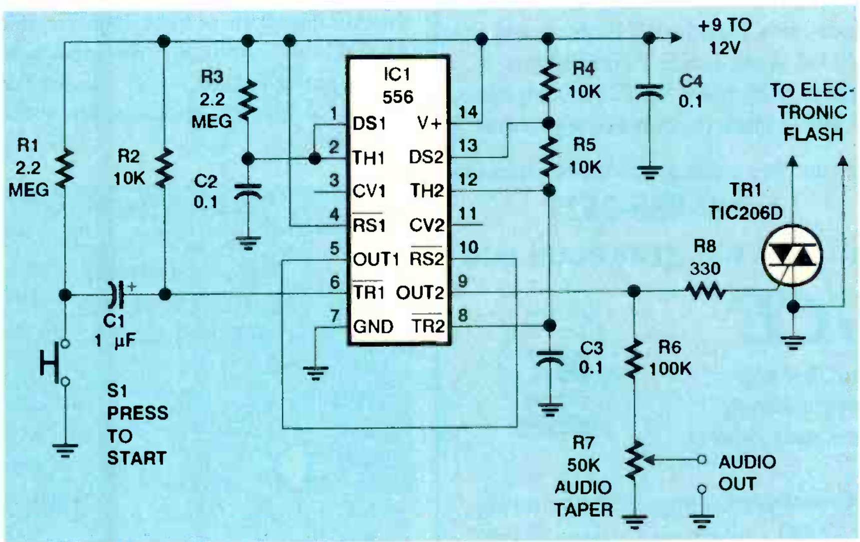


FIG. 1—THIS CIRCUIT PRODUCES an audio beep and a flash of light to signal the start of a race. It can be used with any photographic flash unit.

A Figure 1 shows a circuit you can try. It uses a 556 dual timer IC. First, R1, R2, and C1 ensure that the 556 receives only a narrow starting pulse no matter how long you hold the button down. After being pressed, the button is inactivated for about two seconds while C1 recharges, thus ensuring that an unsteady hand on the button will not produce multiple signals.

The first timer in the 556 then stretches the pulse to exactly $^1/_4$ second (well, ours measured 248 milliseconds; yours will differ depending on the exact values of R3 and C2). The $^1/_4$-second pulse activates the second timer, which is a 500-Hz audio oscillator. The audio can be fed into line-level and microphone-level inputs on your PA system; R7 controls the loudness. If the PA system you want to use this circuit with only has one microphone input available, try the hookup in Fig. 2.

The pulse also triggers Triac TR1, which fires an ordinary photographic flash. You can use any electronic flash unit, even the cheapest you can find at a flea market, since auto exposure and other fancy features aren't needed; in fact, if your flash has auto exposure, you should set it to manual in order to get the brightest possible flash. Be careful when making connections, since some cheap battery-operated flashes place as much as 300 volts across their terminals. You'll be using the flash terminals that normally connect to the switch inside the camera shutter mechanism; you can get suitable connectors at camera stores. If you want to build your own xenon flash, see the May 1996 installment of this column.

The Triac specified here, a TIC206D, is a 400-volt sensitive-gate unit; suitable substitutes include the 2N6073A, ECG5608, and NTE5608. Other Triacs may fail to trigger in this circuit.

How soon you can give another signal after a false start depends on the flash recycling time, typically 10 seconds with fresh batteries. The ready light on the flash unit will tell you when it's ready. Keep a spare set of batteries on hand for the flash so that you can replace them in the middle of a swim meet if needed.

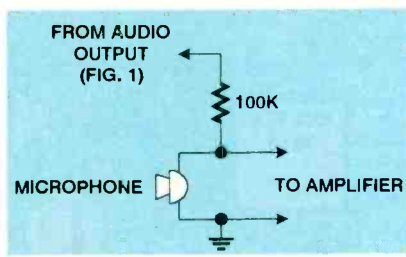


FIG. 2—IF YOUR PA SYSTEM only has a single microphone input, you can use this hookup to couple the audio from the circuit in Fig. 1 to it.

Musical ICs

Q *I am interested in purchasing some musical integrated circuits for a project but can't find the manufacturers of the chips. Can you help? — V. S., Elgin, IL*

A You're probably thinking of the melody generator ICs made by Holtek (1342 Ridder Park Drive, San Jose, CA 95131; Web: www.holtek.com) and distributed by Tech America (P.O. Box 1981, Fort Worth, TX 76101-1981; Tel: 800-877-0072; Web: www.techamerica.com) and Digi-Key (701 Brooks Ave. South, Thief River Falls, MN 56701; Tel: 800-DIGI-KEY; Web: www.digikey.com). Figure 3 shows one of the many circuits you can use. Tunes available range from "Happy Birthday" to "Music Box Dancer." According to Digi-Key, Holtek has not licensed the rights to the music; if a song is copyrighted and you want to use it commercially, you have to contact the copyright holder or appropriate agent yourself.

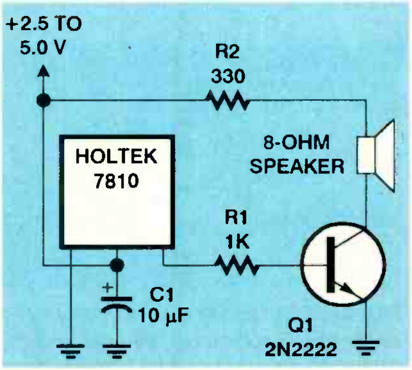


FIG. 3—HOLTEK ELECTRONICS makes a line of melody playing ICs. Here's how they are typically connected.

Holtek also makes numerous other chips such as remote-control circuits, speech synthesizers, and sound generators for use in toys. They're worth getting acquainted with.

Build an Isolation Transformer?

Q *I am looking for plans for building a variable isolation transformer that can handle up to 10 amps. — M. B., Montegut, LA*

A There's not much to build, since a variable isolation transformer consists of one or at most two components (plus any switches and circuit breakers you might add), and you might as well buy it ready-made. Figure 4 shows what's involved.

This is an extremely useful instrument to have on your workbench. The isolation transformer makes it safe to use modern, grounded test equipment when working on circuits not isolated from the AC line, such as light dimmers, old AC-DC tube radios, and the input side of any power supply. It also reduces the hazard of electric shock under some conditions.

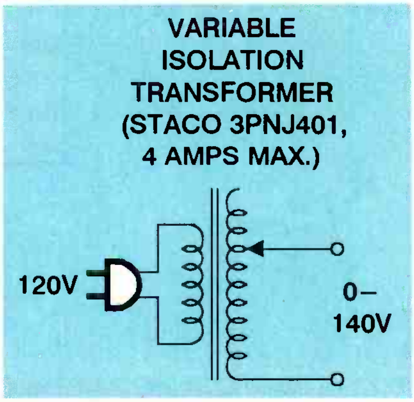


FIG. 4—ISOLATION TRANSFORMERS make it possible to safely work on a wide variety of line-powered equipment. Here are two typical circuits.

The ability to vary the line voltage comes in handy for testing intermittent malfunctions that depend on low line voltage or on overheating (which increases when the voltage is higher than normal). It also lets you apply voltage slowly to old equipment that contains electrolytic capacitors, making it possible to recondition the capacitors rather than blowing them up. Variable autotransformers are often called Variacs, a name that is actually a trademark of General Radio.

Especially because you require 10-amp capacity, these transformers are *very* expensive and you can save a lot by watching surplus sales, auctions, and hamfests, and by settling for a lower amperage (2 amps is sufficient for most equipment). Unless you get an unusual bargain, you're looking at a $200 to $500 project. Surplus transformers are available from Surplus Sales of Nebraska (1502 Jones St., Omaha, NE 68102) and C and H Sales Co. (2176 E. Colorado Blvd., Pasadena, CA 91107). Power transformers can be purchased new from Allied Electronics (7410 Pebble Drive, Ft. Worth, TX 76118), and many other industrial-electronics distributors.

CD-Changer Problem Solved

Q *In your October column, a reader was looking for a way to control his 28 Sony 200-disc CD changers to run an automated radio station.*

I have designed controllers for both Pioneer and Sony CD mega-changers as well as other related devices. My units connect to your PC's serial port and convert simple ASCII commands into the control language that the CD changers need.

Please refer your reader to my Web site, www.wintektx.com, as it is very unlikely that Sony will be responsive to his requests for data. — Alan Freeman, Wintek Software, P.O. Box 330655, Ft. Worth, TX 76163

A Thanks for writing! More people need to be in the business you're in—bridging the gaps between pieces of digital equipment from different manufacturers. It's an area full of opportunities for people with ingenuity and knowledge.

Bulk Video Eraser Plans

Q *In response to the reader whose letter in the August column asked for a good degausser for erasing magnetic media:*

A good-quality degausser that can be used for extended periods of time to erase magnetic tapes and disks and demagnetize tools and ball and roller bearings can easily be constructed from two microwave-oven power transformers.

The core consists of two metal sections, a straight part and a part shaped like the letter E. Grind through the two welds that hold the straight section of the core to the open end of the "E." Then remove the windings and magnetic shunts leaving only the "E" portion of the core. Discard the secondary windings and place both primary windings on the same "E." (If your two transformers are not identical, you will probably be able to fit both windings on one "E" but not the other.) Tie the coils down to prevent movement, then varnish them to stick them down tight. Connect the two coils in series. With the "E" open the inductance will be lower, which is why you need two coils in series to prevent excessive heating.

The alternating magnetic field comes out the ends of the "E." The electromagnet can

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www. motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online. Extensive information about how to repair consumer electronic devices and computers can be found at www.repairfaq.org.

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

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

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

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1994 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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

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

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

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

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

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

be mounted in a nonmagnetic box with the ends of the "E" flush with one side. Mine will erase diskettes on one pass and demagnetizes almost anything I have used it on. Heating has never been a problem for me, but if it needs to be on for a long time you can add a muffin fan and some vents. — Lloyd Hartenberger, Chester, IL

A Thanks very much for sharing this. Several other readers wrote to express dissatisfaction with RadioShack's bulk videotape eraser, which cannot be operated more than about one minute without overheating.

In general, adapting transformers or motors is a good way to build AC electromagnets. We have not actually built the device you describe, but your design seems sound. Put a fuse or, better yet, a light bulb in series with it when first powering it up, since if one of the windings is wired backward, the inductance will be too low and the device will draw excessive current. Make sure the windings are in series and are wound in the same direction.

To demagnetize anything—be it a tape or a piece of metal—first apply power to the electromagnet, then bring the object up to the electromagnet and move it away again before removing power. When the coil is powered off, there is a magnetic pulse that can magnetize (rather than demagnetize) objects in the immediate vicinity.

Laptop Schematic Needed

Q *I'm trying to fix a Toshiba T3100SX laptop computer and can't get a circuit diagram from anywhere; I've checked with many possible sources, including Sams. Can you help? — J. M. L., Sept-Iles, Quebec, Canada*

A Unfortunately, manufacturers of computers don't normally publish schematics, and the entire motherboard is generally treated as one (expensive) replaceable part. The few times I've fixed laptops, I've done it by educated guesswork, checking failure-prone components such as connectors and fuses without analyzing the whole circuit.

You can get some computer schematics, mainly for 1980s models, from Howard W. Sams (2647 Waterfront Parkway, Indianapolis, IN 46214; Tel: 800-428-7267; Web: www.hwsams.com), and some others, including IBM PS/2s and LaserJet printers, from Eagan (contacted through Sams). They aren't cheap; it takes a lot of work to analyze an undocumented circuit and publish the results.

However, as you discovered, neither of these companies covers laptops. However, spare parts and some service assistance for Toshiba laptops is available from Xyratex (formerly Matrix Components), 13581 Pond Springs Road, Austin, TX 78729; Tel: 512-258-7590; Web: www.matrixintl.com; and several other suppliers that you can locate by going to www.yahoo.com and searching for "Toshiba laptop parts." These companies often do "exchange repairs," where you send in a defective motherboard or disk drive and get a repaired one in return.

Lost Sansui?

Q *Answering my question in the August issue, you described a Sansui QRX-5500 as a QRX-3300 and gave the wrong address for Sansui. What is the right address? — R. S. N., Marathon, FL*

A Sorry—it looked like 3300 in your handwritten letter. In any case, Sansui service manuals are hard to find, and the Sansui office in Carson, California, has apparently closed. Sansui TV and VCR

(continued on page 11)

BY JEFF HOLTZMAN
COMPUTER EDITOR

Portable Embedded C

IT SEEMS THAT WHENEVER THE C PROGRAMMING LANGUAGE BUMPS UP AGAINST THE WORLD OF EMBEDDED SYSTEMS, SOMETHING GROTESQUE USUALLY EMERGES. ALL SORTS OF NONSTANDARD LANGUAGE EXTENSIONS APPEAR, WHICH HAS several effects.

First, any hope of portability is shot. This means that once you choose a hardware platform and write your code, you're pretty much locked in to that platform. If you want to switch to a different microcontroller family, you can pretty much count on rewriting most of your code from scratch.

Second, dialectical profusion occurs. From a software engineering point of view, knowledge reuse is important. Proliferating dialects degrade the knowledge base. You end up having to clutter your mind with numerous low-level product nuances—make that incompatibilities.

What if you could reduce those effects? What if you could have a standard language that covered most of what people do in embedded systems? What if you could increase your code reuse factor from maybe 20% to 80% or even more? And what if you could do it all in a widely used language?

Suppose you took Standard C, as defined by ANSI and ISO standards, and added to and subtracted from it to achieve an embedded-systems control language. Well, you might ask, hasn't that been already done lots of times? Doesn't that just add to the growing family of dialects that are already out there?

Well, suppose we alter the paradigm a little. Most C implementations adapted for embedded use take the core language, then add all sorts of proprietary extensions to handle specific capabilities of the specific target platform. You can't *not* do that; those specific capabilities are what lead you to choose that platform in the first place.

But suppose we alter the strategy. Suppose we abstract certain common features out in a platform-independent way. Then we use language itself to mask the differences. But how can you do that with such a wide variety of different controller architectures? And how can you do it and still remain true to the Standard C?

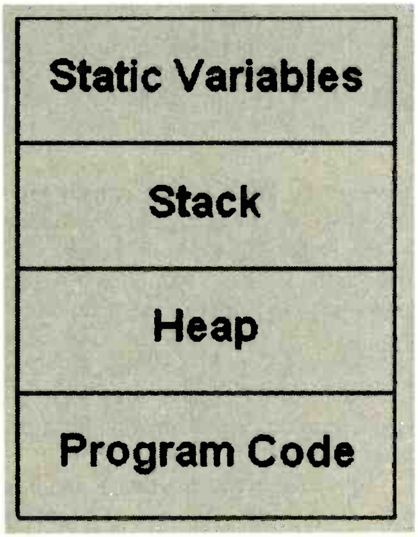


FIG. 1—THE STANDARD C MEMORY MODEL does not distinguish among the different types of memory. It is essentially one contiguous memory space.

Strictly speaking, you can't. You end up creating yet another dialect. But there's no getting around that. I contend that it's possible to create a dialect that remains true to the spirit of C, but is optimized for use with embedded systems, yet is not tied to any one microcontroller device or architecture. The following is a start on my design for such a language.

Modeling Memory

Standard C has a very weak model of the actual hardware that it runs on. Basically, it acknowledges the existence of memory—and that's it. It doesn't even distinguish among different types of memory. Figure 1 depicts that model. Basically there is a memory space with four areas: program code, heap, stack, and static variables. These four memory areas could be a single contiguous chunk of RAM or four physically separate address spaces. C doesn't care. Typical non-embedded systems use that type of layout in RAM, where the size of the static and code chunks are fixed when the program is compiled, and the size of the stack and the heap can vary at run-time. The heap grows up and the stack grows down. Of course, careful design and testing are required to ensure that they never overlap.

But in embedded systems programming, we do care about those kinds of things, and more. For example, most embedded systems put a premium on RAM. Program code must execute from some sort of read-only memory, and RAM must be allocated very carefully.

Another weakness of the model in Fig. 1 is its ignorance of any other facet of the underlying architecture. Don't get me wrong; that's also a strength—it is what has given C its extraordinary longevity and portability. However, I contend that

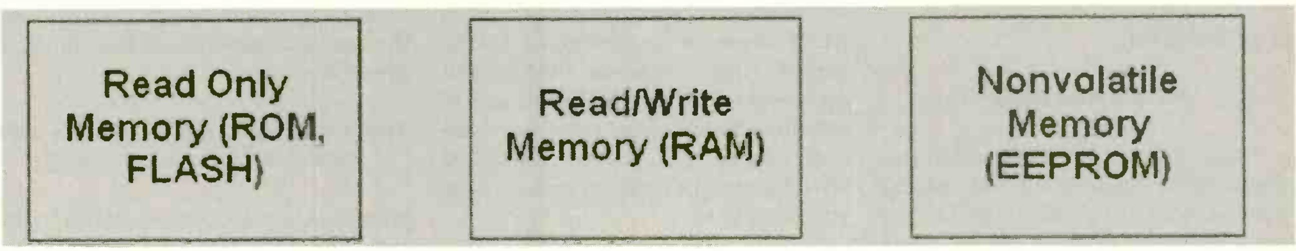


FIG. 2—IN THE PORTABLE EMBEDDED C MEMORY MODEL, the three different types of memory are explicitly acknowledged.

we can make the model a little more robust without giving up anything in the way of portability. Figure 2 shows the first step. (Flash is listed as read-only memory because from the point of view of a program executing in flash, it is read-only.)

The point here is to acknowledge explicitly the existence of these types of memory and provide language-level support for them. Doing so has a subtle but liberating effect. It allows you to declare variables and constants that exist in various types of memory, and let the compiler handle the details invisibly and automatically.

For example, C has the concept of type qualifier, which in Standard C contains only the keywords const and volatile. The compiler will (or should) prevent any attempt to alter an object declared const. In addition, it's a sign to downstream processes that such an object could be placed in ROM. However, it's not explicit, and it carries two interpretations, which are really independent. So let's add three type qualifier keywords: ram, rom, nvram; and give them the same scope of usage as the other members of type quali-

TABLE 1—PORTABLE EMBEDDED C PRAGMAS

Key	Parameter(s)	Type	Example
Family	s	string	"AVR" "8051"
Device	s	string	"8515"
MemoryModel	s	enum	tiny, small, compact, medium, large, huge
MemorySize	ram=i, rom=j, nvram=k	long, long, long	
Stack	i, j	long, long	size, initial value
Heap	i, j	long, long	size, initial value
Clock	l	long	frequency in Hz
Precision	l	enum	8, 16, 32

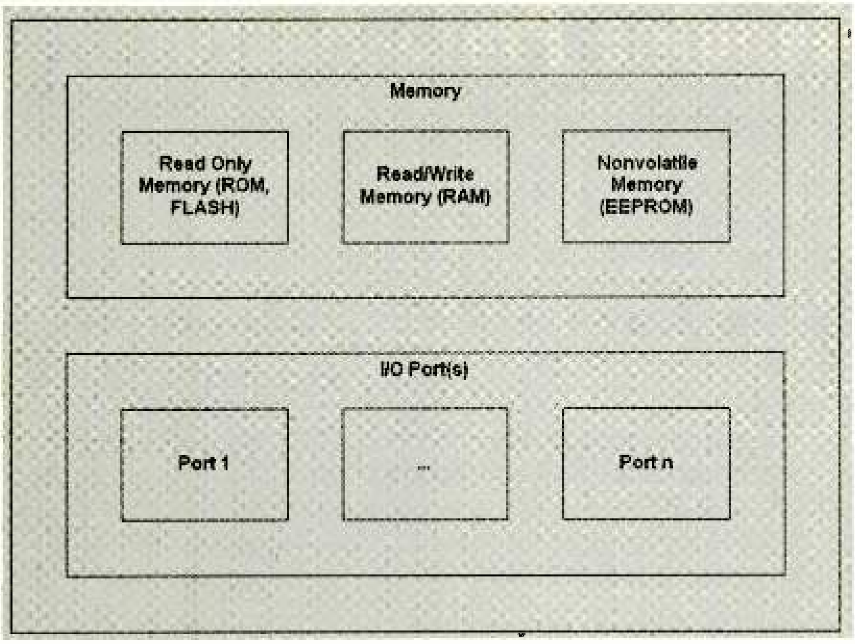


FIG. 3—HERE'S HOW THE PORTABLE EMBEDDED C memory model looks after we add I/O ports to it.

fier. With these keywords, we can thus specify where any given constant or variable is to be located. For example, we could define average as an integer that is stored in RAM:

```
int ram average;
```

or in EEPROM:

```
int nvram average;
```

From a language standpoint, this cleans up the messy process of reading from and writing to EEPROM. Let the compiler handle the dirty details; let the programmer concentrate on solving his application problem. At the application level, reading and writing a chunk of nonvolatile storage is the point; the mechanics of doing so on different processors is not.

However, there are processor-specific things we need to be able to handle in a processor-independent way. For example, most processors have what is called an interrupt vector table. This is a table of addresses, one each for each interrupt supported by the device.

From a C language point of view, an interrupt vector table is nothing but a table of pointers to functions. The catch is that we need to be able to specify the exact location in memory where the table is located (as well as the type of memory). Often the table begins at location zero—but not always. So we will allow each of our three type qualifiers to take an optional bracketed parameter, which specifies the starting address of the object, like so:

```
int rom[0] IntVecTab[24];
```

By itself, that's pretty useless, because an uninitialized interrupt vector table in ROM must be preinitialized to the desired values, otherwise they'll never get there. So let's assume that we want to initialize the first three vectors to functions named f1, f2, and f3. Standard C provides a simple means of initializing an array, as follows:

```
int rom[0] IntVecTab[24] =
    {&f1, &f2, &f3};
```

That syntax tells the compiler to put the addresses of f1, f2, and f3 into the first three locations of IntVecTab.

Syntactically, the two preceding examples are incorrect. The table is not an array of integers, as declared. It's really an array of function pointers. The syntax is messy and is left as an exercise for interested readers.

Now we can declare any type of variable or constant at a specific location in a specific type of memory. What happens if we declare a "variable" in ROM? There are several possibilities. Internally, the compiler could implement it as a constant and provide a warning or error message on any attempt to write to it. Or the compiler could simply not allow it at all.

Similarly, from where does code execute? Abstractly, it could execute from any of the three types of memory. However, a specific platform may limit it to only one or two. Our embedded C language must therefore provide a means of specifying where executable code is to be located. With the ram, rom, and nvram keywords, the problem is already solved. We just specify the type of memory as part of the function declaration or definition. For example,

```
ram int f(int i);
```

specifies a function f, which takes an integer and returns an integer, and resides in RAM.

It would be nice not to have to specify the storage type for every single function, so let's create a preprocessor directive to set a default. There are two ways to proceed. We could create a whole new directive, or use the #pragma directive, which is intended to handle platform specifics. Using #pragma increases portability, but clutters up the syntax. A related issue is whether to create three directives (one for each type of memory), or one directive with parameters. I really dislike cluttered syntax, but I have made a commitment to minimizing changes to the language. So let's use #pragma and parameters. The complete syntax is:

```
#pragma SegmentDefault [code | data
    | variable] [ram | rom | nvram]
```

where code refers to executable code, data refers to constant data, and variable refers to read/write program variables. Correct syntactic usage selects one keyword from each group.

While we're on the subject, we will need #pragmas to specify numerous other items, including controller family, specific device, quantities of available memory, initial positions of stack and heap, clock speed, memory model, default math precision (8, 16, or 32 bits), and likely more. Table 1 lists all currently defined #pragmas.

I/O Ports

Most microcontrollers have I/O ports, which may be attached to either internal or external peripherals, such as A/D converters, timers, pulse-width modulation outputs, and so forth. Can we model all those peripherals? No—at least not yet. But we can model the ports, and provide

(continued on page 20)

Q & A

continued from page 5

parts and manuals are now distributed by Orion, 3471 N. Union Dr., Olney, IL 62450; Tel: 800-289-0980; but they don't cover stereos. Some Sansui manuals are available from A. G. Tannenbaum (P.O. Box 386, Ambler, PA 19002; Tel: 215-540-8055; Web: www.agtannenbaum.com). He lists the manual you want for $17, and we have forwarded your letter to him.

Writing to Q&A

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

Prototype

These Batteries Are Included

While small batteries, called microbatteries, are not new in electrical engineering, a new version, developed by engineers at Brigham Young University (BYU), is unprecedented in size and power—they are as thin as a human hair, yet 100 times more powerful than any existing miniature battery.

This advance could open the door for many others. For example, by incorporating microbatteries directly into the tiny appliances and sensors they build, designers could greatly simplify circuitry in complex systems.

The BYU batteries can also be engineered to be self-recharging using solar cells or by exposing them to radio-frequency energy. That ability could enable a variety of invaluable medical instruments, ranging from the design of rechargeable heart pacemakers that eliminate battery-replacing surgeries to sensors used to regulate the flow of insulin in diabetic patients or to monitor the vital signs of trauma victims. Commercial uses range from self-powered "smart" cards to tiny transmitters on box labels for computerized inventory control.

RESEARCHER LINTON SALMON is shown here with a wafer containing 1200 microbatteries.

Medical Applications

"I'm personally convinced that microbatteries have tremendous potential for a large number of autonomous sensor applications, including those in the medical field," says lead researcher Linton Salmon, BYU associate dean of engineering and technology.

Such miniature devices are called micro-electromechanical systems, or MEMS. Over the past twenty years MEMS mechanical systems no larger than a dot have been fabricated for use as pressure sensors, accelerometers, chemical sensors, digital optical components, micromotors, and linear resonators.

Although many MEMS applications are still in the developmental stage, the technology is emerging with explosive growth. MEMS design and manufacturing has the potential of a greater than $8-billion market share by the year 2000, and partially accounts for projections of 10 to 20 percent annual growth in the integrated circuit industry, according to a recent issue of *Aerospace America*.

Although the fabrication techniques for these micro-devices are based primarily on silicon IC processes, many MEMS products have the same problem: they are powered by inconvenient, bulky batteries, or are connected to a remote power source by wires, defeating the purpose of a miniature instrument. Because of a divergence in research interest, reductions in the size of batteries have not followed the miniaturization of electronic devices. This BYU research has the potential to bring this anomaly into balance.

"If you need to implant a sensor into a person's body, you don't want wires dangling out of the body," says Salmon. "Microbatteries are the answer. They remove the need for connecting wires to power sources or to central control stations. Connections can now be made without wires, similar to radio frequency signals used in cellular phones."

The seed for the research germinated a few years ago while Salmon was employed by the United States government. "When I was supervising MEMS research for the National Science Foundation in the early 1990s, I noticed that fellow engineers were developing tiny, intricate systems that could be very useful except for one problem," says Salmon. "Many of these miniature systems were powered by a D-cell battery. There's no point in building a MEMS product if there is no energy source correspondingly small enough to power it."

When Salmon returned to BYU, he and his colleagues, including John Harb, associate professor of chemical engineering, embarked on research to see if they could fill that niche.

"The microbatteries we have fabricated to date have energy densities of 250mC/cm^2 with a maximum power output of approximately 20mW/cm^2," Salmon says. "We measure the energy and power densities in terms of area instead of mass because our microbatteries are so thin—less than 100 microns."

Building a Microbattery

In order to build so small a battery capable of these power improvements, the BYU team had to revolutionize the battery-manufacturing process. Previously, microbatteries were assembled piece-by-piece. "We build batteries using the same processes employed to build computer chips—intricate patterning with extremely small dimensions and extremely pure materials," says Salmon. "We hope to achieve the same kind of performance advances in the micropower field that have occurred in the computer industry."

A single microbattery measures one-tenth of a millimeter. The researchers expect most applications to use the batteries in series or parallel configurations. Even so, they are still small enough to package on microchips, ceramics, and plastics.

What's Next?

The BYU team plans to commercialize the technology through Bipolar Technologies, an Orem, Utah company that has applied for patents on the microbattery. Lengthy Food and Drug Administration approval processes for any new medical device probably means the microbatteries will emerge first in non-medical applications.

"Initially we plan to target markets that can use remote or autonomous sensors, such as the automotive industry," says Bipolar founder Rodney LaFollette. "Vehicles now have and will continue to have an increasing number of sensors to monitor conditions like tire wear and engine wear—sensors to map the entire state of the vehicle."—by **Douglas Page** PT

R2-D2 and C3PO—21st Century Surgeons?

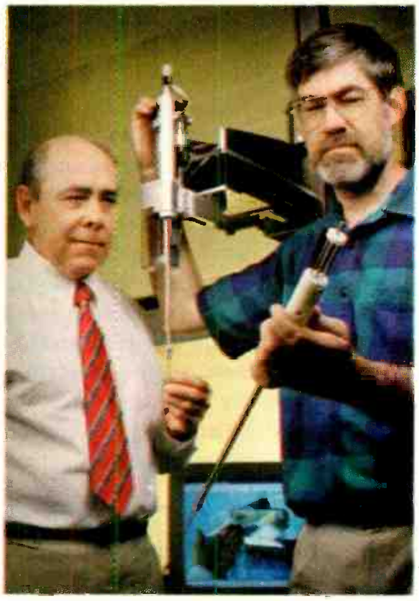
Picture the operating room of the future: Before the first incision, the surgeon uses a customized computer-generated model to make a diagnosis, evaluate treatment options, and rehearse a personalized surgical plan. As surgery starts, a computer displays the surgical plan overlaid on the patient. Robotic devices augment the surgeon's eye-hand coordination during the procedure.

Recently, the National Science Foundation (NSF) began a $12.9-million, five-year cooperative agreement with Johns Hopkins University to establish an Engineering Research Center (ERC) in Computer-Integrated Surgical Systems and Technology at the Baltimore campuses. This will be the nation's first research center to create computer-linked surgical systems and medical robots. Combining information technology and surgical expertise could dramatically change medical care.

Russell H. Taylor, a computer scientist at the university, will be the director of the center. James H. Anderson, a professor of radiology at the Johns Hopkins School of Medicine, will serve as deputy director. Takeo Kanade, director of Carnegie Mellon University's robotics institute, and Eric L. Grimson, a professor in the Electrical Engineering and Computer Science Dept. at MIT, will be associate directors.

In addition to those already mentioned, other research participants are the Hopkins' Applied Physics Laboratory, Brigham and Women's Hospital, and Shadyside Hospital. Over the first five years, the universities and hospitals involved will contribute another $8.1 million. Almost $9 million—including $1.75 million for the first year alone—is anticipated from industry donors. NSF funding is renewable for an additional five years. The program is expected to be financially self-sustainable after ten years.

Participants and consultants will include experts in computers, engineering, and physicians specializing in radiology, neurosurgery, urology, orthopedics, and opthamology. The Carnegie Mellon team will focus on computer vision, sensors, and robotic devices for computer-assisted surgery. MIT will contribute computer models to plan and guide the surgery.



RUSSELL H. TAYLOR (RIGHT) OF JOHNS HOPKINS UNIVERSITY, director of the ERC, and James H. Anderson, a professor of radiology at the Johns Hopkins School of Medicine, are seen here working with robotic equipment, including a needle injector. (Photo by Keith Weller)

Engineering Research Centers focus interdisciplinary teams of faculty and students on research to produce next-generation technology and education. Through close collaboration with industry and other practitioners, they speed technology transfer. Dr. Lynne Preston, ERC program leader of the NSF, states, "This ERC is an excellent example of how a team of researchers, medical practitioners, and their industrial partners, need a center to achieve their ambitious goals. Their vision of combining capability in robotics, computer modeling and imaging, and human-computer interfaces with surgery is nearly impossible in the traditional, disciplinary construct of a university. The center format enables collaboration across these disciplinary perspectives and sets ambitious technological goals in partnership with both industry and surgeons. Our review panels found this ERC to be very exciting and were optimistic about its potential to have a positive impact on health care." PT

Robot Contest

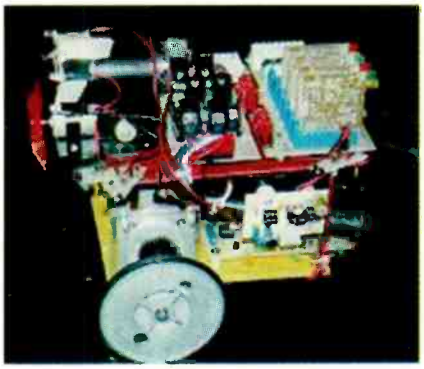
The Trinity College Fire-Fighting Home Robot Contest will be held on the college campus in Hartford, CT on Sunday, April 18, 1999. Open to entrants of any age, ability, or experience, this is the largest, public, true robotic competition of its kind held in the U.S.

Last April, people came from all over the U.S. (all 50 states), Canada, South America, and Europe (14 countries) to compete, participate, watch, and learn—from as far away as Switzerland and Argentina. Participants ranged from college professors and engineers to elementary-school students.

The goal of the 1999 contest is the same—to build a robot that can find and extinguish a fire in a house. The challenge is to build a computerized (not radio-controlled) robotic device that can move through a model of a single floor of a house, detect fire (a lit candle), and then extinguish it. Robots that accomplish the task in the shortest time win.

The 1999 rules are very much like last year's rules, with some slight changes. This international event will culminate months of work and effort by robotists of all ages. There will be two divisions again this year: a Junior division for High School students and younger, and a Senior division for everyone else. A cash prize of $1000 will be awarded to the winner in each division, with additional prizes to other winners. Other events scheduled on the contest weekend include robotics seminars and expositions.

Trinity College is also helping to set up regional contests around North America. Check the contest's Web page (www.trincoll.edu/~robot) to see if there is a site near you. Video tapes of the 1998 contest are available for $25 each (including shipping). Copies of the updated 1999 rules are available for $3. Send check or money order, payable to Trinity College, to Jake Mendelssohn, 190 Mohegan Drive, W. Hartford, CT 06117, or download the information from the Contest Web page listed above. PT



ONE OF THE "CONTESTANTS" from the 1998 Trinity College Home Robot Contest. (Photo by Jose Ordinas)

Unbreakable Code?

Scientists at the Department of Energy's Los Alamos National Laboratory have achieved a breakthrough in transmitting secure communications to and from satellites. Based on randomly generated characteristics of individual photons, the encryption scheme could keep financial transactions or military communications safe from hackers and could reveal when there are eavesdropping attempts.

For years, Los Alamos researchers have been transmitting photon-based "quantum cryptographic keys" for encoding messages over optical fibers. However, their latest achievement published in *Physical Review Letters* (PRL), was to transmit a quantum key through the air over a distance of about 1 km.

"This is an important result for our quantum key distribution system," said lead author William Butler, "because it's the lowest few kilometers of the atmosphere that will cause an optical beam to deviate the most. We've shown we can operate this system in the lowest portion of the atmospheric boundary layer, where turbulence is at its worst." If the optical signal emerges mostly intact after passing through the boundary layer, the rest of the travel to a satellite orbiting 300 km or so overhead will have a negligible effect on the signal.

The PRL paper (co-authored by Richard Hughes, Paul Kwiat, Steve Lamoreaux, George Morgan, Glen Peterson, Chuck Gabe, and Beth Nordholt) describes nighttime transmission and detection of the individual photons used to build the quantum cryptographic key. The researchers are now conducting their demonstration in daylight, immensely more difficult, but initial results have been positive.

Existing encryption schemes to protect financial transactions, national-security information, and other significant communications suffer two weaknesses: the numerical-based keys are potentially vulnerable, and they can be intercepted. Quantum cryptographic keys, by contrast, are generated as needed between the sender and receiver, creating a random string of numbers known only by them. Any attempts to intercept the shared communication or eavesdrop can be detected because of the message's quantum-based nature.

Once the sender and the receiver share a unique key, they can code, transmit, and decode messages securely.

The Los Alamos demonstration consists of a laser that can emit extremely short pulses; an attenuator that damps each pulse to a single photon, on average; and a system that randomly assigns one of two polarization states to the photon. The two polarization states represent "1" and "0" in a binary number sequence. Polarization describes a preferred direction of oscillation for the electromagnetic wave of a photon. Devices known as polarizers will transmit only specific polarization states.

The receiver includes a telescope and optics that randomly direct the photons collected along one of two paths, each configured to look for a specific polarization state.

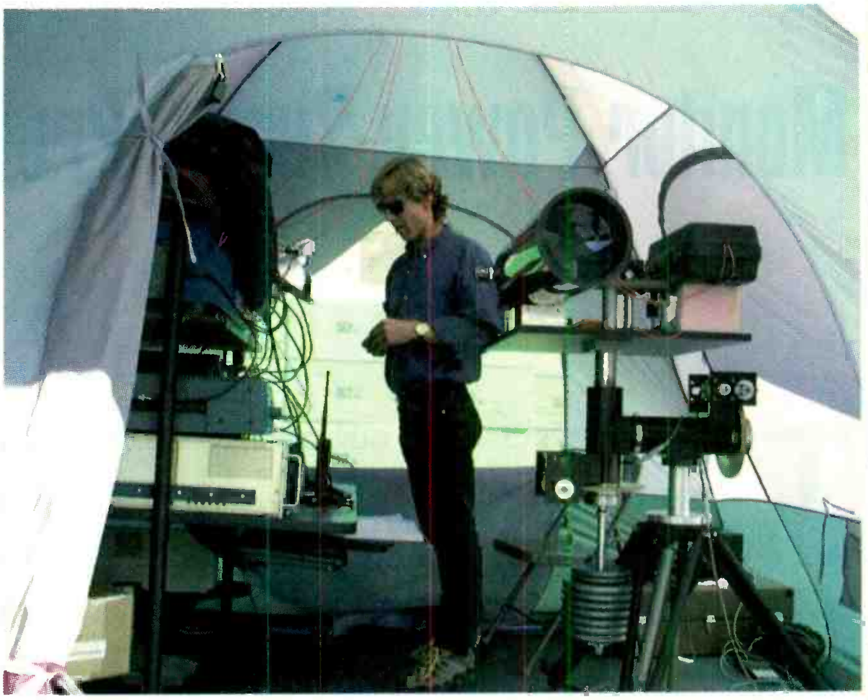
The quantum key is generated when the sender, conventionally dubbed "Alice," generates a series of individual photons, shot out at a rate of a million per second, and randomly changes the polarization to create a sequence of zeroes and ones. She has told the recipient, dubbed "Bob," which polarization state represents a one and which a zero; this information can be shared with the world at large without threatening the encryption scheme.

Bob captures as many of the incoming photons as possible, given the difficulty of plucking specific individual photons out of a sea of background photons. The Los Alamos group has shown that with precision timing and properly chosen filters a sufficiently high number of photons can be detected to make the quantum encryption scheme work.

Bob's receiver randomly switches between his chosen polarization values for zero and one. He doesn't, however, try to measure Alice's original polarization states; instead, he looks for related polarization states. This ensures that when Bob is looking for a zero, he will never see a photon if Alice transmitted a one. Yet, a fraction of the time that he is looking for a zero and Alice transmits a zero, he will record a photon and know their two values were in agreement.

In less than a second, Alice can transmit a sequence of many thousands of photons. Bob will detect and agree with the value of some random fraction of these, about a quarter of the original photon stream on average. Bob then indicates the positions in the sequence where his value agreed with Alice's. This positional information, in which only Bob and Alice know the values for each point in agreement, allows them to form their secret quantum key. If anyone intercepts the photon stream, the act will reveal itself by raising the error rate above a threshold value or eliminating the photon stream altogether.

The researchers say the quantum key distribution system could provide secure uplink and downlink satellite communications, and connect cities anywhere in the world via satellite. PT



USING THE SETUP SHOWN HERE, Los Alamos researchers have successfully transmitted a quantum key through the air over a distance of about 1 km. That achievement could lead to ways to transmit sensitive data using a virtually unbreakable encryption code.

Quantum Computer Calculations

Scientists have manipulated the atomic spin of molecules to demonstrate that reliable calculations can be made by a quantum computer. A report was published in a recent issue of *Physical Review Letters* (PRL) on the first experimental use of quantum error correction and on a demonstration of a three-bit quantum computing system.

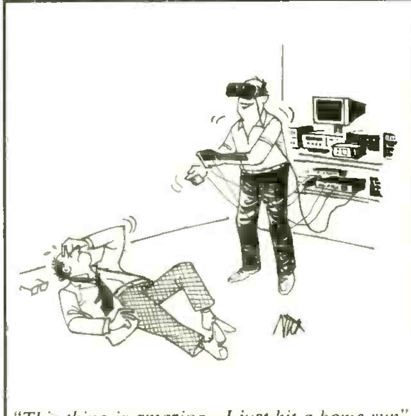
Working with David Cory at MIT, Los Alamos National Laboratory physicists Raymond Laflamme, Wojciech Zurek, and Emanuel Knill are using nuclear magnetic resonance (NMR) to test their theories. "We have demonstrated for the first time that our quantum error correction works as expected. It is also the first time anyone has manipulated three bits in a quantum mechanical way," said Laflamme. "This is the most interesting proof to date that quantum computing is not just a crazy idea."

Unlike today's "classical" computers that make calculations with a binary system of zeroes and ones from digital switches, first-generation quantum computers are assembled from molecular switches called qubits. A qubit can represent one, zero, or potentially any state in between. A functional quantum computer will manipulate atoms to perform many calculations at once by taking advantage of quantum mechanics, which allows qubits to represent many states simultaneously.

"Suddenly you have information encoded on single atoms, and you can do things that you never thought you would be able to do before," said Laflamme. Until recently, the main problem for quantum computing was believed to be an inability to correct errors. Two years ago, the Los Alamos team developed a scheme that uses repetitive processing to reduce the probability of errors. For the general error type, every encoded qubit is checked for errors, corrected, then multiplied five times. Those five qubits also get checked for errors, then corrected and multiplied, etc. Knowing how many steps a particular calculation takes, the theorists can determine the number of checks needed to ensure the calculation's accuracy.

Now the physicists have adopted NMR techniques for experimenting with qubits. NMR allows scientists to manipulate the atomic spins of nuclei by applying an electromagnetic pulse to molecules diluted in a liquid. The signal is amplified by the molecules acting in parallel. Because the researchers knew the most common errors in NMR were of a specific type, they could test quantum error correction ideas using only a three-qubit system.

Functional quantum computers that exceed current machines are years away. However, these experiments show the hurdles to overcome are merely mechanical—the difficulty of manipulating individual atoms. PT



"This thing is amazing—I just hit a home run"

SAM GOLDWASSER
SERVICE EDITOR

Monitor Power-Supply Problems

THIS MONTH WE'LL BEGIN OUR DISCUSSION OF ACTUAL MONITOR FAILURES BY DEALING WITH PROBLEMS WITH THE LOW-VOLTAGE POWER SUPPLY. UNFORTUNATELY, THERE ARE SO MANY VARIATIONS IN MONITOR DESIGNS AND POTENTIAL problems that this series can touch on only a small fraction of the possibilities. However, the most common ones are still going to be shorted/blown parts and bad connections.

With a half-dozen or more separate voltages required by the typical SVGA monitor, a dead monitor is only one of the possible symptoms of a low-voltage power-supply problem. If one of these voltages is missing or incorrect, a number of systems can be affected—and in unexpected ways.

The Series Light Bulb Trick

Before we get into the gory details of monitor troubleshooting, here is possibly the single most-useful and inexpensive gadget you can use when servicing power electronics. This is one of several of my "Incredibly Handy Widgets(tm)!"

When powering up a TV or monitor that has had work done on any power circuits, it is desirable to minimize the chance of blowing your newly installed (and likely expensive) parts should there still be a fault. There are two ways of doing this—use a Variac to bring up the AC line voltage gradually or use a series current limiter. One device that is great as a series current limiter is a common incandescent light bulb—they are readily available and inexpensive, and also provide a nice visual indication. If you go that route, here is what you'll see and what it means:

• Full brightness: a short circuit or extremely heavy load—a fault probably is still present.

• Initially bright, then fading to a reduced brightness: this is what is expected if operation is normal—the brightness drops as the filter capacitors charge.

• Pulsating: the power supply is trying to come up but shutting down due to an overcurrent or overvoltage condition. It is also possible that the wattage of the light bulb may be too low for the equipment.

Note: for a TV or monitor, unplug the internal degauss coil as it represents a heavy initial load that could prevent the unit from starting up with the light bulb in the circuit.

The following are suggested starting wattages for the bulbs: 40 watts for a VCR or laptop-computer switching power supplies; 100 watts for small (*i.e.*, B/W or 13-inch color) monitors or TVs; and 150 to 200 watts for large color monitors or projection TVs. You may need to go to a higher wattage with some equipment, but don't be tempted to remove it entirely until you are absolutely sure that the fault is no longer present.

Unfortunately, some monitors simply will not power up at all with any useful-sized series load (in terms of wattage). The microcontroller apparently senses the drop in voltage and shuts down. However, these seem to be the exceptions.

Power-Supply Fundamentals

Monitors require a variety of voltages (at various power levels) to function. The function of the low-voltage power supply is to take the AC line input of either 115 VAC, 60 Hz (220 to 240 VAC, 50 Hz or other AC power in Europe and elsewhere) and produce some or all of those DC voltages.

• In all cases, the B+ (B+ refers to the main DC voltage that powers the horizontal deflection system of most monitors) to the horizontal output transistor or (HOT) is obtained directly from the low-voltage power supply.

• With small video monitors that operate at a fixed scan rate (*e.g.*, TV monitors), many or most of the low voltages may be derived from secondary windings on the flyback (LOPT) transformer.

• The typical SVGA autoscan monitor will use one or more switchmode power supplies (SMPSs) to provide most or all of the low voltages—the flyback isn't used for this purpose.

• There are also various (and sometimes convoluted) designs using combinations of any or all of the above.

Figure 1 shows the complete schematic for the switchmode power supply (SMPS) from a small "I guarantee you never heard of the brand name" SVGA color monitor. The AC line-input and degauss components are at the upper left; the SMPS chopper, its controller, and feedback optoisolator are in the lower left/middle; and the secondaries—some with additional regulation components—occupy the entire right side of the diagram. Even for relatively basic application such as this, the circuitry is quite complex. There are more than a half-dozen separate outputs regulated in at least three different ways!

For large high-performance autoscan monitors, it becomes even worse as highly-stable voltages need to be programmed based on a wide range of scan rates. Several common design approaches are used to generate the required variable regulated B+ voltage:

1. A separate programmable SMPS generates the B+. This is done by selecting its reference voltage or the fraction of the output voltage that is fed back to the regulator.

2. A voltage from the main SMPS is fed through an additional series switchmode or linear regulator that drops it down to the required value.

3. One of several fixed post-regulators is selected based on scan rate.

Technique 2 is used by the power supply in Figure 1. The circuitry is located in the upper right-hand corner of the schematic.

Power-Supply Components

All monitor low-voltage power supplies will have:

1. A power switch, relay, or triac to enable main power.

2. Various line-filter, RFI, and surge-suppression components (coupled inductors, LCL filter networks, MOVs, *etc.*).

3. A set of rectifiers—usually in a bridge or doubler configuration—to turn the AC into DC.

4. One or more large filter capacitors to smoothe the unregulated DC (usually 150 to 160 or 300 to 320 VDC depending on design).

5. A discrete, hybrid, IC, or switchmode regulator to provide B+ to the horizontal deflection.

6. Some means of generating the various other DC voltages required by the monitor's analog and logic circuitry.

7. Zero or more voltage dividers and/or regulators to produce additional voltages directly from the line power.

8. A degauss-control circuit. Monitors having manual degauss buttons will include additional circuitry.

9. A startup circuit for booting the horizontal deflection if various voltages to run the monitor are derived from the flyback. This may run off a non-isolated voltage or the standby power supply, or it may be derived from the video input (mostly small video monitors, not autoscan types). However, the SMPS itself will have a startup circuit!

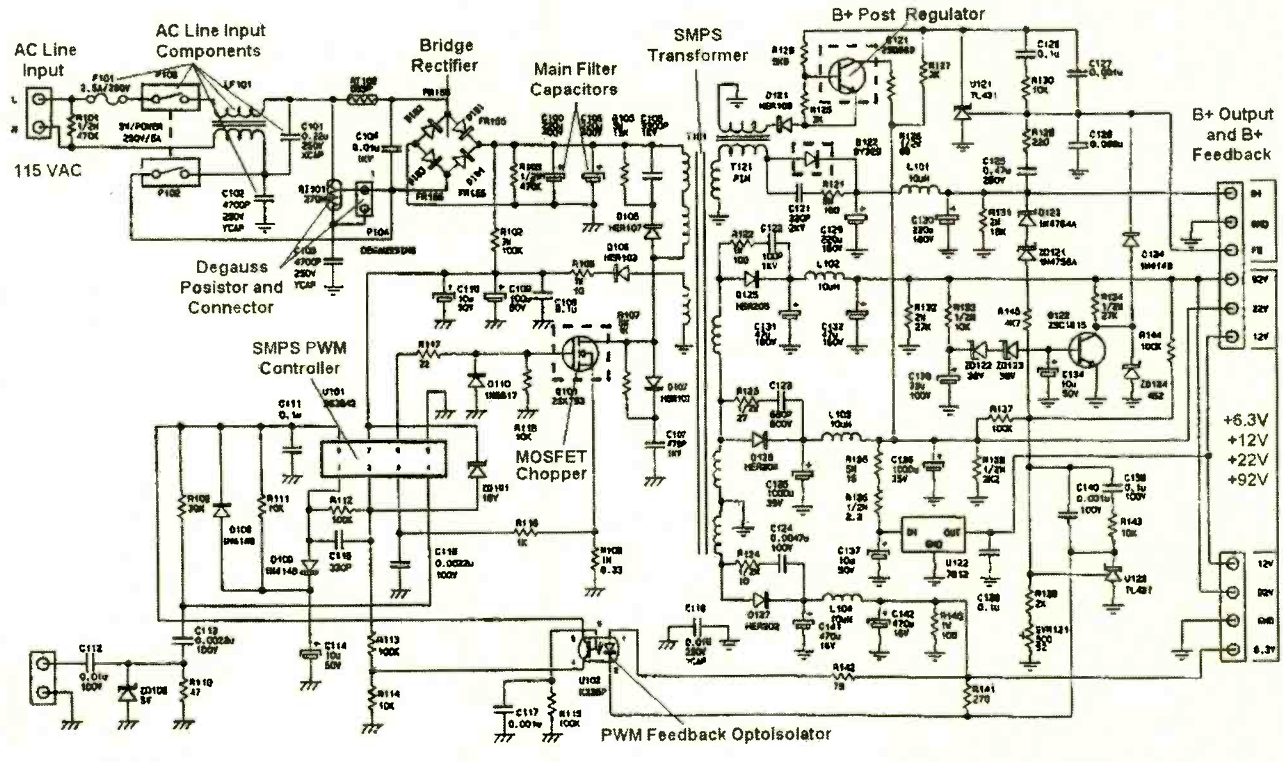
10. A standby power supply if the monitor doesn't use a latching power switch.

Items 1 to 6 might be part of a separate low-voltage power supply module or located on the main board.

Power-Supply Symptoms

Low-voltage power-supply problems can manifest themselves in an almost unlimited number of possibilities, but the following probably cover the most likely:

- Monitor is as dead as a concrete block—no picture or raster, no LEDs lit, no sounds of life (like degauss) of any kind. Most likely causes: No power at AC outlet or outlet strip, bad or loose line cord, bad power switch, blown fuse due to internal short or overload.
- No picture but unusual sounds like a whine, periodic clicks, tweets, or flubs, and/or possibly flickering or flashing front-panel LEDs. Most likely causes: Excessive load or short on output of power supply (shutdown or cycling due to overcurrent) or loss of horizontal drive (cycling from overvoltage due to lack of load).
- Unusual aromas, smoke, or six-foot flames coming from inside the case. Most likely causes: Failed parts in low-voltage power-supply, deflection, or high-voltage sections. Actually, while burning smells and even smoke aren't that unusual when parts overheat as a result of a short circuit, actual fire is quite unlikely due to regulatory design requirements for mate-



Typical Switchmode Power Supply for Small SVGA Color Monitor

FIG. 1—HERE'S THE SCHEMATIC of a typical switchmode power supply found in small SVGA computer monitors.

rials and protection devices UNLESS safety systems have been tampered with or the monitor has been operated in an environment where there is lots of flammable dust.

• Jittering, vibrating, or unstable picture. Most likely causes: External magnetic interference or power-line noise, hum in various power-supply voltages resulting from dried-up main-filter capacitor(s) or other capacitors, resistors out of tolerance—all affecting power supply regulation.

• Loss of video, deflection, geometry or size problems, or some or all adjustments have no effect. Most likely causes: Failure of one or more power-supply voltages, selection circuitry not selecting properly (autoscan monitors), bad connections.

• Monitor doesn't power up immediately. Most likely causes: Dried up electrolytic capacitors in power supply or bad connections.

• Interaction of adjustments (for example, turning up the brightness results in a loss of sync or a wavy raster). Most likely causes: Poor power-supply regulation due to bad capacitor, resistor, regulator, or other component, or bad connections.

Note that the underlying cause of any of the above might not be in the low-voltage power supply itself, but might actually be elsewhere—a shorted horizontal output transistor or deflection yoke, for example. This results in either the power-supply shutting down, becoming extremely unhappy, blowing a fuse, or just plain dying. Thus, we cannot really limit our investigation to only the power supply! In fact, with so many interconnected systems in a monitor, particularly a high-performance SVGA model—it can require the services of a master sleuth to identify the perpetrator! Therefore, before you break out the socket wrenches and DMM (or 10 pound hammer!)—or call Scotland Yard—double check that:

• Your AC outlet is live, the power cord is intact (not chewed by the dog), the plug is firmly seated, and the monitor is switched on.

• You have a valid video signal, the video cables are securely attached to the proper connectors, and/or there are no bent pins.

• The monitor isn't being commanded to go into a power-savings mode because your computer thinks it is smarter than you!

• You have the front-panel switches and controls set properly and the video-source selection is correct. Reset it to factory defaults.

If possible, try the monitor with another known-good video input that is compatible with its scan rates and signal levels, or substitute a known-good monitor for the suspect unit. In other words, try to rule out external problems and "cockpit error."

Monitor Power-Supply Problems

WARNING: You should always use an isolation transformer when working on a monitor, but this is especially important—for your safety—when dealing with the non-isolated line-operated power-supply section. Read and follow the safety guidelines presented last month and at my Web site. If there is anything you are unsure of, or if you are not familiar with the hazards and procedures required when dealing with potentially lethal voltages, stay out and get a professional's help!

The following can cause symptoms of a dead or mostly dead monitor:

1. Shorted horizontal-output transistor (HOT). This will usually blow a fuse or fusable resistor as well if fed directly from the AC line. However, when fed by a SMPS, the result may just be a soft audible whine or periodic tweet or flub, possibly accompanied by flashing front-panel LEDs. Here, the failure is not in the power supply itself but may result in damage to it or other components, especially if it continues to run in this state.

2. Shorted output rectifier diodes can load down the outputs to the point of shutting down or resulting in the same audible symptoms as item 1 above.

3. The flyback transformer can have shorted windings or shorts in the focus/screen divider network which load down the output. Those (and particularly shorts in the primary) could cause the horizontal-output transistor to fail as well. That is a common problem with older Macintosh computers and video terminals. Some secondary faults might not be instantly destructive, but result in little or no high voltage and eventual overheating.

4. Some load, or even the CRT, could be shorted leading to similar behavior or blowing fuses or fusable resistors, which then result in no power to that circuitry.

5. A failure in horizontal-drive chain; that includes the horizontal oscillator, driver, or driver transformer. Without drive, there will be no deflection and that will either result in no high voltage directly (when it is derived from the horizontal deflection) or cause it to be shut down to prevent CRT screen burn (from a stationary spot or line). When powered by an SMPS, there may be an audible ticking from the SMPS cycling on overvoltage due to lack of a load.

6. Failure of an SMPS to start. There can be any number of causes, though dried-up electrolytic capacitors and open high-value startup resistors are high on the list if the chopper transistor is not blown.

7. Cold solder joints or other bad connections; monitors tend to have these as a result of temperature cycling and—with all too many—poor manufacturing-quality control. It is possible that no parts have been damaged—at least not yet. Resoldering may be all that is needed.

Troubleshooting The Switchmode Power Supply

If the SMPS is a separate module, it may be possible to unplug its output connector and test it for proper operation independently of the monitor circuitry. However, a minimum load might be needed—at least on the output that is used for regulation feedback—and there could be other interlocks that will complicate your testing.

The most common failures in a monitor SMPS are:

• Main chopper transistor; in a monitor, this is often an expensive power MOSFET.

• Other shorted semiconductors, particularly high-speed rectifiers on the secondary side of the high-frequency transformer.

• Dried-up electrolytic capacitors leading to startup and regulation problems.

• Open high-value startup resistors resulting in no initial drive to chopper.

• Bad connections.

Detailed troubleshooting instructions are beyond the scope of this series of "Service Clinic" columns on monitor repair. However, we will have a complete series on the SMPS in the future, including those found in monitors and PCs.

Common Problems

Here are just a few of the common problems that you might come across:

Power button on monitor is flaky: If the on/off (or other button) on the monitor itself behaves erratically, then the most likely cause is the obvious—the button or switch is dirty or worn.

Believe it or not, that isn't as unusual as you might think. On a momentary pushbutton, if you can get at it, some contact cleaner could help. Replacement with a common pushbutton or toggle-type switch (as appropriate) might be much easier than attempting to locate the original part!

Dead monitor: That means there is absolutely no evidence of anything happening when the power switch is activated. The most likely causes are:

- Outlet isn't live, or the power cord is loose or defective. Try something else in the outlet, and inspect/replace the power cord.
- Bad power switch. With plug pulled, check for continuity in the on or pressed position.
- Blown fuse or fusable resistor (probably from shorted parts in power supply or elsewhere like the HOT).
- Bad power supply (not starting up or just dead), bad connections. However, degauss would likely still operate in this case.

Monitor blows fuse: If the fuse really blows absolutely instantly with no indication that the circuits are functioning (*e.g.*, no static on the screen), then this points to a dead short somewhere quite near the AC power input. The most common places would be:

- Degauss Posistor.
- Shorted parts in the AC-input line-filter capacitors and MOVs.
- Diode(s) in main bridge.
- Main filter capacitor(s).
- SMPS chopper (usually a MOSFET) if there is a line-operated SMPS or HOT (if there is a deflection derived power supply).

You should be able to eliminate those one by one using a multimeter to check for short circuits/low resistance. For everything but the HOT or chopper, replacing the bad parts should be all that is needed—those rarely fail due to OTHER parts going bad.

However, if the HOT or chopper tests bad, it is possible (though not always the case) that something downstream is causing an excessive load that caused the part to fail. Therefore, don't put the cover back on just yet!

Instead, install a new transistor and power the monitor using your series light bulb. If the bulb flashes once and then settles down to a low brightness level, the monitor might be fine. Even a pulsating light bulb might just mean that the light bulb is too small for the monitor power requirements. It might be safe to try a higher wattage bulb.

However, if the bulb glows at close to full brightness, there is probably still some fault elsewhere. Don't be tempted to remove the light bulb just yet. There is still something wrong. Continue to search for shorted parts.

Fuse replaced (doesn't blow) but monitor is still nearly dead: There might be a click indicating that the power relay is engaging (there could be bad contacts, though this isn't that likely) and the degauss is probably working now. Since the fuse doesn't blow now (you did replace it with one of the same ratings, right?), you need to check for:

- Other blown fuses. Occasionally there is more than one in a monitor.
- Open fusable resistors. Those are usually low values (a few ohms or less) and are in big rectangular ceramic power-resistor cases or smaller blue or gray-colored cylindrical power resistors. They are supposed to protect expensive parts like the HOT, but often blow at the same time, or the expensive HOT or SMPS chopper sacrifices itself to save the 25-cent resistor. Anyway, if any of these test open, they will need to be replaced with flameproof resistors of the same ratings. However, you can substitute an ordinary resistor for testing purposes ONLY as long as you don't leave the monitor unattended.

If you find one bad part, still check everything else, as more than one part may fail; and just replacing one might cause it to fail again. There may also be bad connections that are the cause of the original failure. So, always inspect for those.

Power-on "tick-tick-tick" or "click-click-click" but no other action: A variety of problems can result in this or similar behavior. Possibilities include:

- Lack of horizontal drive. The main regulator is cycling on overvoltage due to very little load.
- Excessive load or faulty power-supply cycling on its overcurrent protection circuit. The sound in this case may be more like a "tweet-tweet-tweet" or "flub-flub-flub," however—see below.
- HV shutdown, or some other system detecting an out-of-regulation condition. However, in this case, there should be some indication (like a momentary high-pitched deflection whine, static on the screen, *etc.*) that the deflection and HV is attempting to come up.
- A dried-up main filter capacitor or other filter capacitor in the low-voltage power supply that is producing an out-of-regulation condition.
- A problem with the microcontroller, relay or its driver, or standby power supply.

Dead monitor with audible whine, periodic tweet or flub, and low-low voltage: A monitor that appears to be dead except for an audible whine or a once-a-second or so tweet or flub coming from the SMPS usually indicates an overload fault in the power supply itself or a short in one of its load circuits. The power (or other) LED may be weak or flashing as well. Here is a summary of the possible causes:

- Shorted rectifiers or capacitors on secondary side of SMPS.
- Other problems in the power supply or its controller, like bad capacitors.
- Shorted HOT.
- Flyback with shorted turns or a breakdown in the focus/screen divider network.
- A short or excessive load on the secondary supplies fed from the flyback.
- Short in horizontal yoke windings.
- Bad solder connections.

Note that a whine may be perfectly normal for your monitor if there is no video input—confirm that there is a signal that is compatible with the monitor's scan rate(s) and type of sync (*e.g.*, separate, composite, or sync-on-green). Assuming you know that the input is valid, that may indicate an overloaded low-voltage switching power supply. The whine is caused by the switching power supply's chopper frequency dropping down due to the overload. The periodic tweet or flub is caused by the SMPS attempting to come up, sensing the excessive load, and restarting.

Test the B+ input to the flyback. If it is near zero, test the HOT for shorts and replace but continue testing with a series light bulb and/or Variac. There may be something causing the HOT to go bad, like a shorted flyback or bad damper diode or snubber capacitor.

If the voltage is not zero but is low (*e.g.*, it should be 120 volts but is only 60 volts) or fluctuating in time with the tweet or flub, there may be a problem with the SMPS itself, the flyback, the deflection yoke, an excessive load somewhere else, or improper drive to the HOT.

Reduced width picture and/or hum bars in picture: The most likely cause is a dried-up main filter capacitor. Once the effective capacitance drops low enough, 120-Hz (or 100-Hz in countries with 50-Hz power) ripple will make its way into the regulated DC supply (assuming full-wave rectification).

Another likely cause of similar symptoms is a defective low-voltage regulator allowing excessive ripple. The regulator IC could be bad or the filter capacitor following the IC could be dried up.

Wiggling or jiggling picture: Depending on the frequency of the instability relative to the scan rate in use, the symptoms might be that the entire picture is vibrating, that ripples are moving up or down the screen, or something else. There may also be variations in brightness—hum bars—in the picture.

First, eliminate the possibility of external magnetic interference, power-line noise, or a video-card/computer problem. Try the monitor in another location and on another computer if possible. Or, try another similar monitor in its place.

Once these causes have been ruled out, the most likely ones are:

- Dried-up electrolytic capacitors in the power supply.
- A resistor or other component has changed value in the B+ (or other) regulator. For example, one very common monitor—the Gateway CS1572FS—uses a 91K, 1-watt resistor (R331) to set its 180-volt B+ output. Invariably with use and age, that device's resistance increases in value, leading to a vibrating raster and eventual failure of other parts.
- Bad connections.

Monitor doesn't power up immediately: The monitor might do nothing, cycle on and off for a while, power up and then shut down in an endless cycle—or at least for a while. Then it comes on and operates normally until it is turned off. A couple of possibilities here:

1. The main filter capacitor or other filter capacitors in the low-voltage power supply is dried up, and this can cause all kinds of regulation problems. Other regulating components might be marginal. That might be allowing excessive voltage to reach the output of the power supply, and then the X-ray protection circuitry shuts things down.

2. Bad connections might be preventing the power supply from operating normally until the main board or components heat up a bit.

Adjustment or picture interactions: This describes problems such as turning up the brightness causes a loss of sync; adjusting height also affects width or produces a wavy raster; or a bright picture or opening a bright window results in a significant change in picture size, wiggly edges, or in the monitor shutting down!

Those might be caused by poor regulation in one or more low-voltage power supplies or an interaction between the high-voltage and low-voltage power supplies, which in turn could be caused by a dried-up capacitor if the unit is relatively old, bad connections, or another faulty component. Measure the B+ to the horizontal deflection (to the flyback, not the horizontal output transistor). If it is changing with the problem, then a regulation problem is confirmed. If that voltage is solid, you will need to check the others to see which one is actually changing.

Wrap Up

That's it for now. Next month we'll explore the exciting world of deflection system failures! Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail only at sam@stdavids.picker.com, please) of all types and will reply promptly to requests for information. See you next time! EN

COMPTER CONNECTIONS

continued from page 8

language-level support for them. Figure 3 adds ports to the model.

However, there are three operations we need to perform on I/O ports: reading, writing, and configuring. In addition, there are lots of variations in how ports work. For example, various ports provide various types of inputs, including one or more of latched, buffered, sample-and-hold, and direct signal-level. How can we distinguish among them?

I decided not to, even though modeling them was great fun, and allowed me to introduce a C++ like struct or class object, encapsulating both data and methods. I decided not to because the more I thought about it, the more things I thought it would be nice to have. Increasing features increases the raw footprint of what is required to support the base language, hence occupied storage in the target system. It was also taking me far from my goal of minimizing differences between this language and Standard C.

The simplest, and most elegant, is just to make port another type qualifier, with syntax identical to ram, rom, and nvram. Thus:

```
int port[0] p;
```

declares a port p at I/O address 0, and

```
int port[0x20] p[10];
```

declares an array of 10 ports beginning at address 32 (decimal). Reading from a port is nothing but an assignment statement

```
i = p;
i = p[0];
```

Likewise, writing to a port is also an assignment statement:

```
p = i;
p[0x17] = 2;
```

As applied to a port, the address operator (&) would return the address of the port, just as you would expect, *e.g.*,

```
a = &p;
```

If "p" refers to I/O port 17h, then "a" contains 0x17 after the previous statement executes. It might be nice to allow "p" to be an lvalue, so that you could change the port to which a variable referred to at runtime, like this:

```
&p = 22;
```

Hmm, have to think about that one.

The Grand Finale

Obviously, that's not the end of the story. However we're out of space, and time. While I've had a lot of fun bringing you "Computer Connections" over the last many years, all good things must end eventually, and that time is here. "Computer Connections" will go on, however, just with someone else at the helm.

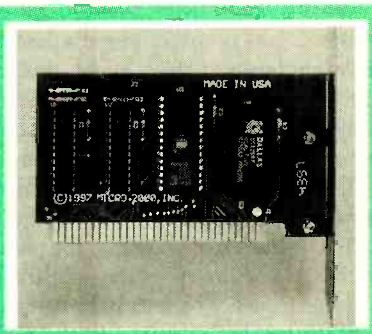
I'll be going on as well. For those who want to learn more about Portable Embedded C, visit the Ingeneering Web site (www.ingeninc.com). There you will find the first implementation of this language, specifically for the Atmel AVR. It's not Small C (or Tiny C or Godzilla C), but highly ANSI/ISO-compliant Portable Embedded C.

And for those who just want to say hello, or discuss any of the many topics we've covered over the years, you can reach me at jeff@ingeninc.com. EN

EQUIPMENT REPORT

MICRO 2000 CENTURION YEAR-2000 SOLUTION FOR THE PC

Here's an inexpensive way to protect your PC hardware from a Y2K meltdown



CIRCLE 15 ON FREE INFORMATION CARD

Unless you've been in hibernation, you've likely heard of the "year 2000" or "Y2K" problem. In a nutshell, it is that most software running on mainframe computers was written decades ago, is poorly documented, and suffers from a fatal flaw. That flaw is keeping within certain bit constraints inherent to the software code, dates were recorded using only two digits for the year. Back when most of this software was written, the thought that a lot of this stuff would still be vital, let alone even still in use, was just not conceived of or seriously considered.

Now, however, that oversight is causing governments and corporations major headaches. That is because experts believe that, when faced with a year value of 00, computers will take that to mean 1900, not 2000. If that is correct, all sorts of problems are likely to crop up in the computer systems that run banks, stock exchanges, power systems, the air-traffic control system, etc.

Now, if that nightmare was not enough, here's another one to consider: Did you know that many modern personal computers are vulnerable to the same glitch. That's because, believe it or not, some PC BIOSes are not Y2K-compliant, and neither are some real-time clocks, or RTCs. The BIOS usually checks the RTC for the time during bootup, and if either one has a problem there could be trouble in store for the computer, or more specifically, its owner. Even some flash BIOSes are affected—some have multiple layers, with basic date information hard-coded into a non-flashable layer.

Here's a typical scenario of what will happen to a non-Y2K-compliant PC when the year 2000 strikes: First the clock reverts to the year 1900. Then the BIOS checks the clock and suspects it to be wrong, so it sets the year back to some date, though probably not the right one. The least of the problems are that file date codes will be set improperly, and the worst of it could be accounting and billing departments gone haywire. Some software will crash, as will entire systems.

Micro 2000 Centurion

Fortunately there is an easy—and free—way to determine if your PC will suffer, and an inexpensive way to fix troubled PCs. Micro 2000, Inc. (1100 East Broadway, Suite 301, Glendale, California 91205; Tel: 800-864-8008; Web: www.micro2000.com) has free software available from its Web site that runs extensive tests on your computer to determine if there are any problems associated with the date. It basically sets and resets the clock numerous times and checks to see if everything remains operational.

If there is a problem, Micro 2000's Centurion, available for only $59.95, can fix it. The Centurion squeezes in between a computer's BIOS and RTC, and maintains an accurate date with seamless operation. Its on-board clock and internal lithium battery will keep the date and time accurately for up to 30 years, and up to 10 years with no external power, so it's always ready to update the system calendar when needed. A replacement BIOS must be matched to a motherboard, but the Centurion, which needs only an 8-bit ISA or EISA bus slot, will work with any IBM-compatible motherboard.

Usually you don't have to configure the Centurion, though sometimes three jumpers must be set for the primary or alternate I/O address and one of four possible ROM addresses. The Centurion automatically assumes that the PC's date is correct when the card is first installed. Afterwards, when the BIOS requests the time, it comes from Centurion's RTC and not the system's. Whenever the BIOS is instructed to change the time, the Centurion's time is updated and both RTCs are synchronized as much as possible. Once installed, operation is transparent to the user.

The Centurion was tested in an old 486 that indicated problems when tested with Micro 2000's free software. Sure enough, the same system passed the Y2K test with Centurion on board. Of course, only the actual turn of the century and extensive user intervention will reveal the real extent of the matter. Old software that might be affected will still have to be updated for Y2K-compliancy, but at least your hardware won't be at fault with the Centurion installed.

While the best solution might be to obtain a certified Y2K-compliant machine (less of a hardship than ever thanks to the bargain prices now available on even cutting-edge systems), there are many reasons why that might not be possible. Fortunately, there is a low price alternative that will help keep your older machine viable for as long as you'll need it. At the very least, you owe it to yourself to download Micro 2000's free software before the year is up to see if your PC is affected.

For more information on the Micro 2000 Centurion, contact the manufacturer directly or circle 15 on the Free Information Card. EN

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Lights Out

Technology may have overcome bureaucracy for once. I thought my fellow readers might enjoy this discovery.

I have a fairly private back yard with a hot tub on the deck; and I enjoy relaxing in the tub, especially on a cold winter night, just watching the moon and stars. However, there is a very bright street light on the edge of my property, which illuminates the back yard with the orange glare typical of sodium vapor lamps. I pay the power company $7 per month to operate this light for security. Since I pay for the light, I thought it would be nice to be able to turn it off occasionally. I called the power company and asked them if they would install a switch on the telephone pole. That was like running into a brick wall! We can't do that; it's against company policy, *etc., etc.*

I considered installing my own light switch, but there were some tough obstacles. It was probably illegal to modify their equipment; they might discover the switch; I didn't have a tall ladder; and finally there was a high-voltage power line running close to the light fixture.

One night I was sitting in my hot tub staring at the darn light when a solution hit me. As luck would have it, the photoelectric sensor on top of the light fixture is visible from my back yard. I mounted a 4 mW laser-diode pointer in a ball joint on a stand and simply pointed it at the photo sensor. The street light immediately went out, thinking it was daylight! Now I can turn it off from my deck any time by remote control and haven't modified their equipment. (I don't know the full implications of this discovery, but there are very few street lights in my city that can't be turned off from the right vantage point.)

Keep up the good work with **Electronics Now**! There are still lots of us out here who like to design and build our own electronics.

NAME WITHHELD
Kingsport, TN

One Chip for Six

In his article, "A Microcontroller-Based Precision Pulse Generator," (**Electronics Now**, December 1998), Tom Napier shows a circuit for a precision pulse generator using six ICs, based upon a PIC16C55 chip. Readers might be interested in knowing that they can use a slightly more expensive second generation 28-pin Microchip controller, such as a PIC16C63, to perform essentially the same task with only one chip.

By correctly programming the PWM circuit on the chip, you can get precision pulses as short as 50 ns at a 5 MHz (200 ns) repetition rate all the way up to about 200 µs at a 1200 Hz (800 µs) repetition rate. These pulses are generated purely in hardware and need no software intervention, once the CPU registers are set. There are also two separate PWM channels available. If slower pulses are desired, they can be generated in software.

Anyone wanting additional details can e-mail me at: oricom@sni.net
DAN MICHAELS
via e-mail

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.

Current Mirrors

Readers of Skip Campisi's article, "Möbius Circuit" (**Electronics Now**, November 1998), might like to know that they can make very fine NPN current mirrors with the 3046 and 3086 series of five-transistor arrays. These parts, which come in a 14-pin DIP package, make the matching and temperature tracking of individual transistors unnecessary.

They are also handy for making your own fast op-amps. Digi-Key (Tel: 800-344-4539) sells them as their part numbers LM3046N-ND or LM3086N-ND for under $1.50. Unfortunately, there seems to be no equivalent PNP part, except some that use very slow lateral transistors.

TOM NAPIER

Manual Wanted

HELP! I'm in need of the user manual, specifically the schematic page for the Realistic 42-210A Magnetic Phono Preamp. If anyone can help, please mail me a copy. I hope someone out there has one available.

KEN SIMMONS
29101 38th Avenue So.
Auburn, WA 98001

EN

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Video-Signal Generator

DESIGNED FOR SERVICING high-end computer monitors and performing color alignments from a new PC-based system format, the CM2250-PC "PRO" Computer Monitor Analyzer is a multi-featured "Plug & Play" video-signal generator. Its ease of use and flexibility of operation make it ideal for testing and aligning high-end displays.

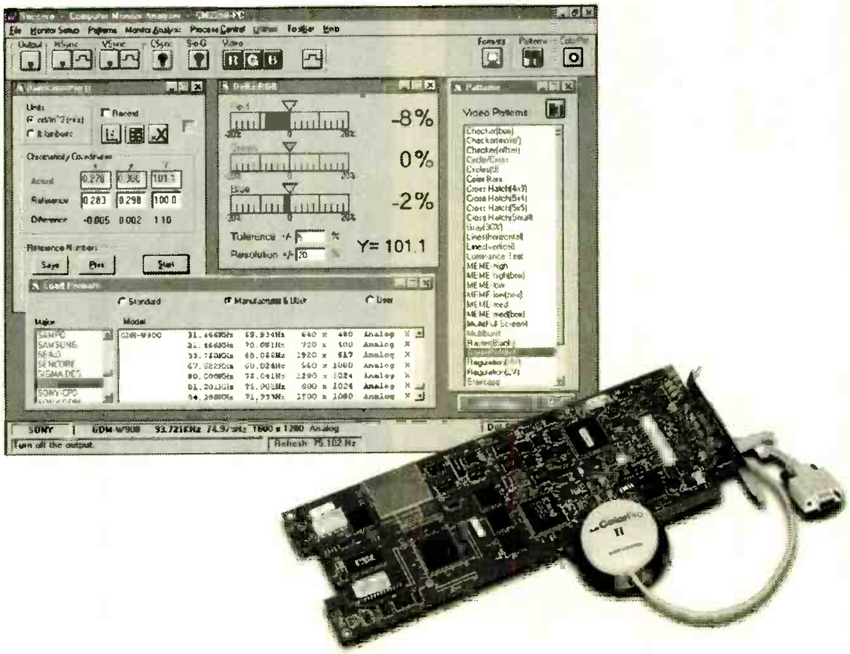
The CM2250-PC "PRO" simplifies the setup for troubleshooting monitors. Technicians simply select the make and model of the monitor, and the CM2250-PC "PRO" automatically configures to its setup. The ability to store over 2000 monitor setups is integrated into the CM2250-PC "PRO." Users can access the appropriate setups through either a convenient charting system or by scrolling through the monitors on the screen and pressing <ENTER>. There is no need to refer to service literature nor does the technician have to lose valuable time entering parameters.

Its exclusive "Process Generator" enables testers to use one system to control the testing and alignment process. The CM2250-PC "PRO" will change the video patterns and signal parameters, wait for the user to make a test or adjustment, and then go through the next step—all automatically. Other features of the computer- monitor analyzer are color-output analysis with the CP288 Auto "ColorPro II" and video generation (to 250 MHz) for complete monitor color analysis.

The CM2250-PC "PRO" has a list price of $6995.

SENCORE, INC.

3200 Sencore Drive
Sioux Falls, SD 57107
Tel: 800-SENCORE or 605-339-0100
Fax: 605-339-0317
Web: www.sencore.com



CIRCLE 20 ON FREE INFORMATION CARD

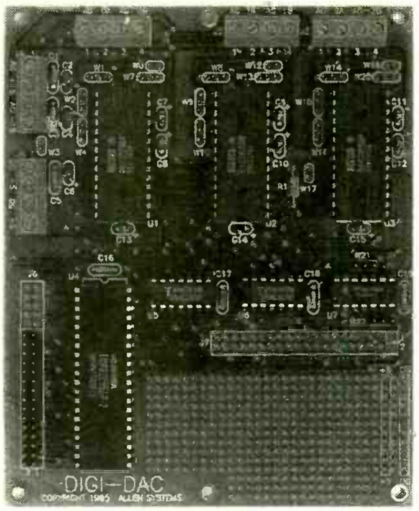
Single-Board Computer

IDEALLY SUITED FOR LABORATORY use the MICRO LAB-51 is an 8051-based single-board computer that has a small footprint of 4.5 by 4 inches. It works well in both educational and product development settings. In an academic environment, instructors can demonstrate real-world applications and students can implement projects. In the development lab, design engineers can easily create and test prototypes of their 8051-based products.

In its standard configuration, the board has a full-featured BASIC interpreter that supports floating-point math and most BASIC commands. An advanced version, which comes with system-monitor debugger software and an optional 8051 cross assembler, is also available. Suitable for 8051-based product development, that configuration enables the engineer to write assembly-language code and then run it in real time under monitor control.

The MICRO LAB-51 uses the 89S8252 microcontroller, which is 8051-compatible and runs at up to 24 MHz. A feature of the 89S8252 is that its 8 kilobytes of flash memory can be programmed serially, facilitating software upgrades even after the board has been placed into an application. In addition to the 89S8252, there are two 28-pin memory sockets. The first supports 32K of RAM, while the second supports 28K of EEPROM, EPROM, or battery-backed RAM.

Other board features include RS-232 serial-port buffering (RS-485 is optional), a processor supervisory circuit with a manual reset switch, and an ample prototyping area that measures 3.5 by 1.5 inches. Data, address, and control lines are conveniently brought out on connectors next to the prototype area, making it a snap to add custom-user circuitry. The MICRO LAB-51 comes either fully assembled and tested or in kit form. The kits sells for $99, and the assembled and tested unit sells for $139.



CIRCLE 21 ON FREE INFORMATION CARD

ALLEN SYSTEMS
2345 Brandon Road
Columbus, OH 43221
Tel: 614-488-7122

Data-Acquisition DMM

WITH THIS NEW DATA-ACQUISITION digital multimeter, you will be acquiring, analyzing, saving, or transmitting data in no time flat. The DM9100 comes complete with everything you need to have it up and running in minutes.

The meter, which meets CE requirements, performs true rms AC-, decibel-, capacitance-, and inductance-measurement, as well as temperature measurement in Celsius or Fahrenheit. Among its features are dual display, RS-232C-interface, 10-location memory, time/mode with alarm, average and relative mode, automatic power-off and "keep-on" mode, data-hold and run mode, and minimum/maximum readings.

Measuring 7.8 × 3.5 × 1.5 inches and weighing approximately 1 pound, the DM9100 also offers a pulse-signal injection function, a logic-probe function, a continuity and diode test, a back light, and a clock and stopwatch. Designed for safety, the instrument has warning signals and overload protection built in.

The DM9100 has a list price of $209.95. Just supply your own computer and the meter, along with its software and the RS-232C-interface, will do the rest.

A. W. SPERRY INSTRUMENTS, INC.
245 Marcus Blvd.
Hauppauge, NY 11788
Tel: 800-645-5398 or 516-231-7050
Fax: 516-434-3128
e-mail: cat@awsperry.com

CIRCLE 22 ON FREE INFORMATION CARD

EPROM Eraser

THE ULTRALITE MODEL UV EPROM eraser is an industrial-grade model suitable for production as well as engineering applications. It accommodates PC boards and up to 50 erasable devices. The unit's two 8-watt UV bulbs, which have a 7700-hour life span, will erase a full tray of devices in 15-20 minutes.

The Ultralite features a slide-out tray (9 by 6 by 3/4 inches) and a convenient automatic shut-off timer. A safety switch turns off the UV light when the tray is open. It has a list price of $299.

CIRCLE 23 ON FREE INFORMATION CARD

LOGICAL DEVICES, INC.
1221 S. Clarkson Ave., Suite 200
Denver, CO 80210
Tel: *303-722-6868*
e-mail: logdev@logicaldevices.com
Web: www.logicaldevices.com

Portable Soldering Iron

DESIGNED TO MAKE FIELD REpairs virtually anywhere, the Antex MLXS-12 Repair Kit features a 25-watt portable soldering iron that clips to the terminals of any automotive-type 12-volt battery. The soldering iron uses heavy-duty alligator clips and comes with a 15-foot power cord to reach the part that needs soldering.

Heating up to 800°F in under two minutes, this portable iron lets users make field repairs without the use of butane torches and hazardous flames. The tool is designed with the heating element under the tip for optimum thermal efficiency.

Packaged in a handy vinyl pouch, the Antex MLXS-12 Repair Kit is priced at $39.95 and comes with a standard tip and an emergency supply of solder. It easily fits into a tool box, under a seat, or in the glove compartment. Literature is available upon request.

CIRCLE 24 ON FREE INFORMATION CARD

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Fax: 781-631-8887
e-mail: mmn@mmnewman.com
Web: www.mmnewman.com

EN

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

PCI Hardware and Software: Architecture & Design, Fourth Edition

by Edward Solari and George Willse
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An essential guidebook for engineers using PCI in their designs, the book is thoroughly illustrated with detailed schematics and drawings. This edition, which presents detailed information about the new PCI2.2 specification, covers handling of Posted Memory Writes and new Power Management Event commands, as well as timing requirements to support Hot-Plug and Power Management capabilities. Information on the Retry Timer and Maximum Retry Time (MRT) has also been included.

Providing a complete PCI overview, the almost 900-page book discusses the relationship of PCI to the ISA bus and to Plug-and-Play architecture. Including all electrical, mechanical, and system-level aspects of PCI architecture, this edition discusses topics such as functional interaction between PCI resources, signal-line definition, detailed bus-cycle operation, cache support on PCI, master and target termination, bus ownership, parity and bus errors, reset, and power and signal-line initialization. Also covered is signaling timing and electrical requirements; connector, platform, and add-in card design; latency and performance; mechanical specifications; system resources; PCI configuration address space; system BIOS; PCI system BIOS interface; and PCI-device configuration.

The eleven appendices offer information on new capabilities, Vital Product Data (VPD), PCI class code-register encoding, user-definable configuration items, VGA palette snooping, PCI and ISA aliasing, electrical specification notes, and common problems to avoid.

1999 Catalog

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This new catalog from DC Electronics offers a wide range of products and kits for the electronics hobbyist. Among the offerings are high-performance audio kits, batteries, breadboards, cabinets, capacitors, crystal radio parts, diodes, rectifiers, heatsinks, LEDs, printed-circuit kits and supplies, replacement semiconductors, Basic Stamps and microcontrollers, surface-mount components, transistors, and tools, and more. Among the new offerings are a line of microcontroller-based PLL FM transmitters (for both the FM band and 49 MHz), a switchbox project, tiny CCD cameras, and RF transistors.

In addition, the catalog offers tips on reading resistor and capacitor values, designing bridging circuits, and a guide to data resources. DC Electronics' Web site, listed above, provides updates, new products, and links to major semiconductor manufacturers, where data sheets can be found.

The Design of CMOS Radio-Frequency Integrated Circuits

by Thomas H. Lee
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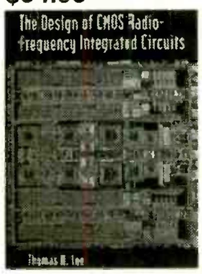

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Comprehensive and insightful, this book details how to design gigahertz-speed radio-frequency ICs in CMOS technology. An ideal textbook for graduate students or anyone taking graduate courses in RF electronics, as well as a useful reference for engineers, it contains over 350 circuit diagrams and illustrations plus numerous homework problems.

Starting with a history of radio, the author provides a solid foundation on this subject. He also presents the differences between the discrete era and the IC age. Among the topic reviewed are passive RLC networks, characteristics of IC components, and transistor models. Techniques of designing high-frequency tuned and broadband amplifiers are covered, with an emphasis on approximate methods that provide important design insight as a complement to simulation results.

Key RF building blocks, such as low-noise amplifiers (LNAs), mixers, power amplifiers, high-spectral-purity oscillators, and frequency synthesizers, are studied in detail. The book closes with an examination of transceiver architectures.

North American Repeater Atlas, 1998/99 Edition

by Bob Martin, N7JXN
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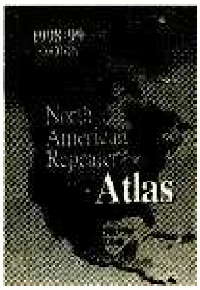

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This book is what every ham needs—whether on a business trip, touring the country in a RV, or traveling in unfamiliar territory. Written for the ham on the go who wants to keep in touch with nearby repeaters, the completely revised Atlas is a handy and useful reference.

It contains over 175 pages of repeater maps—for all 50 states, every Canadian province, and for all of Mexico, Central America, and the Caribbean. In addition, there are street maps showing repeater frequencies for most U.S. metropolitan areas. The book start with maps of U.S. 10- and 6-meter repeaters. Geographical maps also include facts about the area being shown. Repeater information—including frequency, sub-audible tone (if necessary), and indications of which repeaters have autopatch capability—is provided. The Atlas includes repeater listings for 10 meters, 6 meters, 2 meters, 222 MHz, 440 MHz, 900 MHz, and 1.2 GHz.

Other features of the Atlas are the inclusion of information for contacting Frequency Coordinators, as well as guidelines for repeater use.

License Your Invention

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Brilliant inventions are much more common than brilliant inventions that make money. The difference is in knowing how to get an idea to the right market and not get ripped off in the process. The author, an attorney and intellectual-property expert, tells inventors everything they need to know to enter into a solid licensing agreement.

Detailed instructions are given on how to work with manufacturers, marketers, and distributors who handle the details of merchandising an invention. The book shows step by step how to draft a license that will be fair to all parties. It addresses issues like ownership; applicable patent, copyright and trademark laws; license scope; dispute resolution; and finances.

Readers learn about the licensing process—they learn how to determine ownership rights, to find potential licensors, to understand and negotiate fair terms for a licensing deal, to draft a comprehensive licensing agreement, and to review and negotiate changes to a licensor's proposed agreement. In addition, the book helps inventors determine ownership rights and explains how to show the invention to others without getting ripped off. Sample tear-out agreements for anyone patenting an invention in the U.S. are provided, and all the necessary licensing forms are on the included disk.

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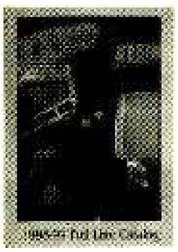
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Designed as a one-stop shop for all Sencore's offerings, this 69-page catalog contains solutions to modern servicing challenges. It features over ten new products and 29 other products. There are numerous color photos, and specifications, and accessories clearly listed.

Eight service areas are covered, including Instruments for Computer Monitor Servicing, TV Analyzing, and VCR/Camcorder Analyzing and General Analyzing; Service Center Management Software; TV-RF Distribution Analyzers; Tech Training; and Tech Disc Multimedia Services. Also in the catalog are Value-Added Business Building Resources that help service centers improve their offerings within their business.

Morse Code: Breaking the Barrier

by Dave Finley, N1IRZ
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In 1936, Ludwig Koch, a German psychologist, published the results of extensive research on Morse Code proficiency and showed how he trained students to copy at 12 words per minute in as little as 13.5 hours. That is by far the fastest Morse training program ever published, but it didn't become widely known.

According to author Dave Finley, "Very simply, Koch's technique was ahead of the technology of his time. For most people, the kind of practice you need wasn't available until microprocessors came along." In this book, Finley shows how, using a computer or a microprocessor-based pocket code-trainer (MFJ-418), today's hams and would-be hams can use Koch's technique to build high-speed code proficiency quickly and efficiently. Besides its speed, Koch's method has another advantage: it gives students frequent positive reinforcement, which means that people see results and stick with their training. EN

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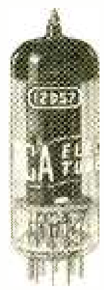
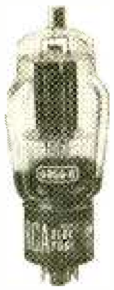
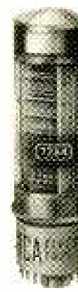
THE REAL McTUBE



FRED NACHBAUR

Give your music a real "retro" sound with this vacuum-tube based preamplifier.

With the phenomenon of the "retro" movement in music electronics, there has been renewed interest in the vacuum tube. Several manufacturers are again building tube amplifiers and other devices, with claims of "vintage sound" and "warm-tube distortion."

But are vacuum-tube-based amplifiers really "better" then solid-state units? That is an argument that might never be resolved; the "sound" of a particular piece of equipment is as much the listener's perception as the specifications of the amplifier circuit.

The only sure-fire way to find out if tube-based gear is right for you is to try one out. With the Real McTube device presented here, you can experiment with these interesting devices by building a tube preamplifier and distortion unit. The overall cost of the project will depend on how many parts you already have in your junk box, but it shouldn't be over about $50 if you shop carefully. The only part you might have trouble finding is the vacuum tube itself (along with the 9-pin miniature tube socket to go with it). Although vacuum tubes are again being manufactured in quantity (mainly in Russia), they haven't quite made it back onto the shelves of most electronics shops. If you are stuck, one source might be a musical-instrument-repair shop that specializes in vacuum-tube gear. There are also a number of companies that sell these mail order, and a number have a presence on the Internet. Some of these are STF Electronics, 171 Springlake Dr, Spartanburg, SC 29302, Tel: 864-573-6677; SND Tube Sales, 5389 Ville Rosa La, Hazelwook, MO, Tel: 314-770-0119; Tube World, Inc., 2717 Superior Av, Sheboygan, WI 53081.

The Tube Sound. So what is it about tubes that make them sound different from solid-state devices like transistors? There is really nothing mystical about it; in reality, their unique sound derives more from their shortcomings than from anything else. Being hot, bulky and expensive, manufacturers couldn't afford to make amplifiers with massive gain, which would have let them use large amounts of negative feedback to linearize the amplifier's response and reduce distortion. The exception was for applications such as studio monitors and similar high-end equipment. You only have to listen to such tube classics as Dave Brubeck's "Take Five" or Heart's "Dreamboat Annie" albums to hear for yourself that tube equipment can be made to sound as good as top-end solid-state gear.

For musical-instrument amplifiers, however, the inherent non-linearity and high degree of even-harmonic distortion of a "raw" tube amplifier with little or no negative feedback adds to the charm of its sound. "Warm" and "gutsy" are but two of the many adjectives used to describe the sound of a vacuum-tube amplifier.

That even-harmonic distortion is especially noticeable when a tube is overdriven. Unlike a transistor, which remains reasonably linear until it reaches cutoff (no current through the device) or saturation (maximum current through the device), a tube will exhibit a softer, more gradual bottoming-out at either extreme. That form of distortion is especially pronounced at the saturation end, that is, as the voltage across the tube approaches zero. There is no sharp saturation "knee", and any attempt to define the point at which a tube reaches saturation is strictly arbitrary.

There are wide variances in those characteristics between tubes of a given family, and even between individual tubes of a given type. Additionally, a tube's characteristics change as the tube ages. That can be a real nightmare if you're trying to design a consistent and predictable piece of gear using tubes. However, those factors all add up to the mystique of the vacuum tube for musicians and experimenters. I've heard of musicians who treasure old, worn-out, gassy 12AX7 amplifier tubes because of the particularly dirty distortion that they're capable of.

The 12AX7 is one of those "classic" tubes that was used in virtually all vintage tube gear, mainly because of its relatively high gain and reasonable linearity. As tubes go, it is relatively quiet—notwithstanding the high degree of thermal noise inherent in all vacuum tubes. The 12AX7 (and its European equivalent the ECC83) is at least mechanically constructed to minimize "microphonics," noise caused by mechanical vibration of its internal elements.

The 12AX7 is but one of a whole family of dual-triodes tubes. Other devices in the family are the 12AT7, 12AU7, 12AY7, 12AZ7, and numerous European types. The filament (heater) requirements are all the same—either 12.6 volts at 150 mA as suggested by the first two digits of the type numbers or 6.3 volts at 300 mA depending on how the two filaments are connected. Another boon is that the pinouts for all of those types of tubes are identical. The connections are (going clockwise from pin 1): Plate, Grid, Cathode (triode 1), Filament, Filament, Plate, Grid Cathode (triode 2), and Filament Center. The Real McTube will work with any of the tubes in that family, giving you the opportunity to experiment with different types to get the exact sound you're looking for.

Basic Tube Theory. Unlike transistors, tubes require at least two power supplies. Before the advent of universal home power, tube-based electronic gear was operated on batteries. One battery (called the "A" battery) was needed for the low-voltage, relatively high-current supply to heat the tube's filament. Another battery (the "B" battery) was the high-voltage, low-current battery used to power the tube's plate circuit. That labeling convention has persisted to this day; if you ever wondered why you hear of devices connected to "B+", now you know. In the

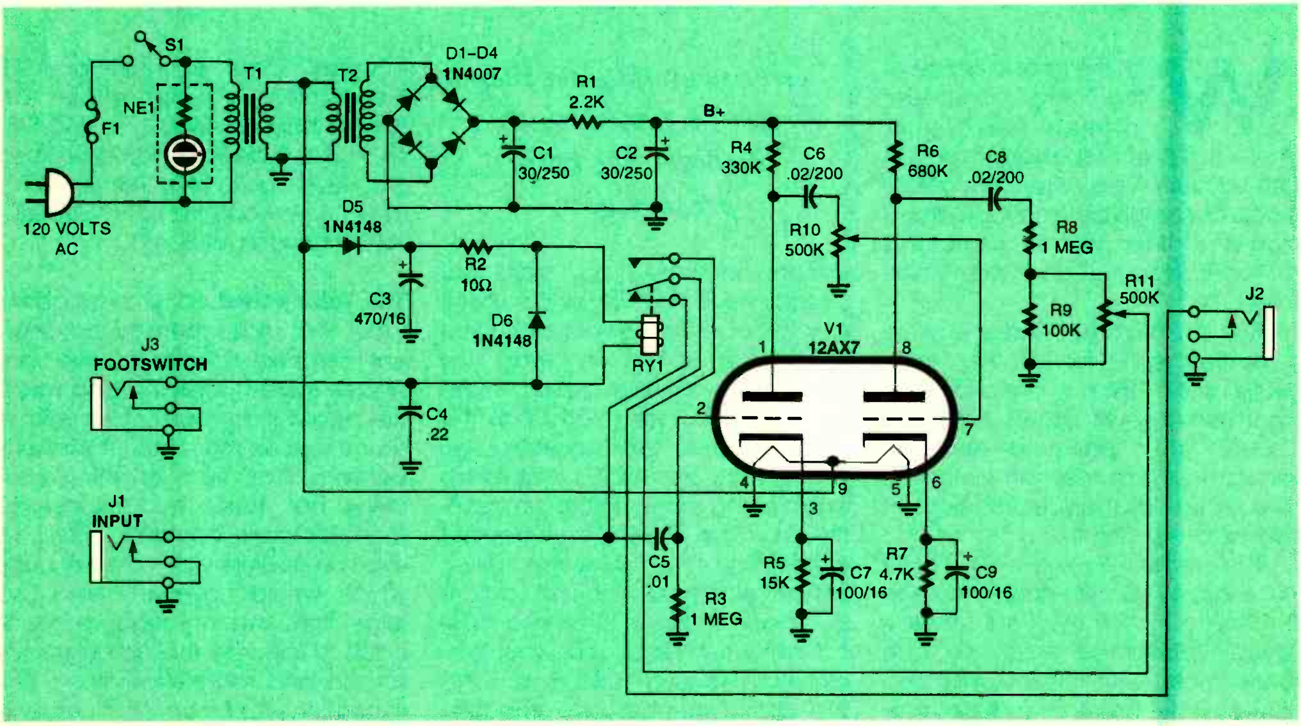


Fig. 1. The Real McTube is simply a two-stage, non-inverting preamplifier. Using a vacuum tube for the active element can create many interesting sounds—something musicians are always looking for!

early days, there was even a "C" battery. It was used to provide the negative-grid bias for some circuits. That need didn't continue for very long except in special radio applications because the negative-grid bias can usually be obtained by using a cathode resistor; that trick is used in the Real McTube.

Tubes are roughly analogous to field-effect transistors (FETs) in that they are *voltage amplifiers*; bipolar transistors amplify current. The tube's cathode is like the FET's source, the grid is the gate, and the plate is the drain. Like FETs, tubes have a near-infinite input impedance, and a high output impedance. The most widely-used tube configuration—the common-cathode arrangement—is quite similar to the common-source FET-amplifier configuration. But the similarity ends at that point.

Physically, a tube operates by heating the cathode, one of the electrodes inside the evacuated glass envelope. That causes electrons in the cathode to attain enough velocity to leave the surface, forming a "space charge" around the cathode. The positively-charged plate (also called the *anode*) surrounds the cathode with the cathode being at the center. The plate attracts the space charge, causing an electron current to flow through the space between the cathode and plate. If the plate is negatively charged, the space charge is repelled and no current flows; that is how the vacuum diode works.

In what's called a *vacuum triode*, there is another electrode called the *grid* that is placed between the cathode and the plate. It usually consists of a spiral screen of fine wire. The grid is normally biased negatively so that it does not act as a secondary plate and draw current. Small changes in voltage on the grid cause significantly greater changes in electron current through the tube from cathode to plate, resulting in amplification.

As the vacuum tube was developed, additional grids were added to form first the *tetrode*, then the *pentode*. The culmination of multigrid mania was the *heptode*, which is a five-grid device that was once used extensively as the oscillator/mixer in home radio receivers.

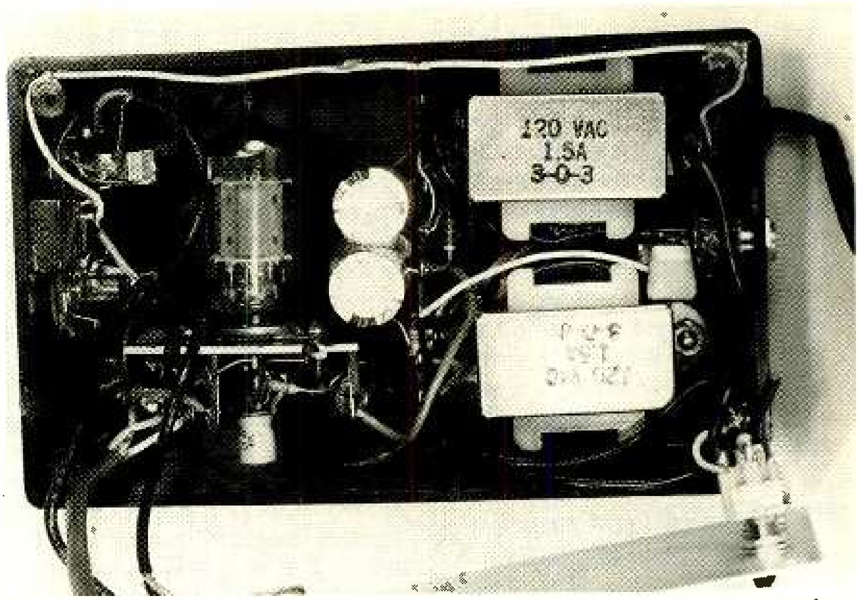


Fig. 2. Here is the author's prototype for the Real McTube. While a smaller case makes for a portable unit, assembly can be difficult.

When dealing with vacuum tubes, it makes sense to consider current flowing from the negative terminal to the positive terminal of the "B" supply because that's what physically happens. That is called the *electron-current* convention, and was taught in most technologist courses up until a couple of decades ago. The problem with that convention is that the algebraic signs end up backwards in circuit design and analysis. Engineering courses thankfully used the opposite convention, called conventional-current flow, in which current is assumed to flow from positive to negative. That has the advantage in semiconductor circuits of making the arrows in diode and transistor symbols point in the right direction. When dealing with tubes, however, which convention you use is strictly a matter of personal preference.

Finally, it should be pointed out that unlike transistors, tubes come in only one polarity because we only have one type of charge carrier—electrons. Unlike solid-state technology, no one has yet to figure out how to make holes in a vacuum. I suppose it's theoretically possible to make tubes out of antimatter in order to get "PNP" tubes, but storage and interfacing could be a bit of a headache. Such devices will probably remain in the realm of science fiction.

How It Works. The Real McTube is a simple circuit; it can be seen in Fig. 1. Line current is applied through F1 and S1 to the primary of T1. A neon bulb with an integral resistor, NE1, indicates whenever the Real McTube is turned on. The secondary of T1 provides the 6.3 volts needed to power the tube's heater filament. The tube filaments are connected in series with a center tap. Since we are supplying 6.3 volts, power is connected to the center tap; the other sides of the filaments are grounded. The tube is set up that way in order to use either a 6.3-volt or a 12.6-volt "A battery". With a 6.3-volt source, the filaments are effectively wired in parallel. If T1 were a 12.6-volt transformer, the two end terminals of the heaters would be used, leaving the center tap unconnected; that would put the heaters in a series circuit.

The output of T1 also provides voltage to bypass relay RY1. Diode D5 half-wave rectifies the voltage, and C3 filters and smoothes the pulsating DC in order to prevent noise and relay chattering. Resistor R2 limits the current draw by RY1 and provides a small voltage drop for the relay. Diode D6 absorbs any voltage spikes that are generated when RY1 turns off. Capacitor C4 helps to eliminate any transients that might cause audible clicks when RY1 changes state.

Jack J3 is wired in such a way that when nothing is plugged into it, RY1 is engaged whenever the unit is turned on. That way, the input signal from J1 is routed through the pre-amp circuit to J2. If the unit is turned off, the relay disengages and the signal is routed straight through. A simple single-pole, single-throw footswitch is plugged into J3; it lets the Real McTube be used or bypassed as needed without having to disconnect or move any wires. The footswitch is simply wired to short the contacts of J3 in order to operate RY1.

PARTS LIST FOR THE REAL MCTUBE

SEMICONDUCTORS

D1–D4—1N4007 silicon diode
D5, D6—1N4148 silicon diode

RESISTORS

(All resistors are ¼-watt, 5% metal-film units unless otherwise indicated.)
R1—2200-ohm
R2—10-ohm
R3, R8—1-megohm
R4—330,000-ohm, ½-watt
R5—15,000-ohm
R6—680,000-ohm
R7—4700-ohm
R9—100,000-ohm
R10, R11—500,000-ohm panel-mount potentiometers, audio taper

CAPACITORS

C1, C2—30-µF, 250-WVDC, electrolytic
C3—470-µF, 16-WVDC, electrolytic
C4—0.22-µF, ceramic-disc
C5—0.01-µF, 100-WVDC, ceramic-disc
C6, C8—0.02-µF, 200-WVDC, Mylar
C7, C9—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

F1—0.25A, 125-volt AC fuse, slow-blow
J1, J3—¼-inch mono switching jack
J2—¼-inch mono jack
NE1—Neon indicator, 125-volt AC, with built-in resistor
RY1—Single-pole, double-throw relay, 6-volt DC coil
S1—Single-pole, single-throw switch, 125-volt AC contacts
T1, T2—6.3-volt, 1.5-amp filament transformer
V1—12AX7 dual-triode vacuum tube
Power cord and plug, strain relief, enclosure, 9-pin miniature chassis-mount tube socket, SPST footswitch, mounting bracket for tube socket, knobs, hardware, terminal strips, wire, shielded cable, etc.

The output from T1 is coupled into an identical transformer, T2, that is wired "backwards." That steps the voltage back up to about 110 VAC for the plate supply, or "B battery." That arrangement has the advantage of providing line isolation for the Real McTube, reducing the chance of short circuits or shocks of damaging any equipment that is plugged into the Real McTube—including the operator!

Diodes D1–D4 form a full-wave bridge rectifier for the B+ voltage. Capacitor C1 filters the resulting pulsating DC, and the network composed of R1 and C2 adds another pole of low-pass filtration to reduce ripple. The end result is about 140 volts DC under load to power the plate circuits of the Real McTube.

An audio signal from J1 is coupled to the grid of the first stage through C5. Input resistor R3 serves a dual function. Primarily, it acts as a "grid leak" to prevent any electrons that accumulate on the grid from piling up on C5; the resulting negative voltage would eventually cause the tube to approach cut-off. Secondly, it serves to bias the grid at very near ground potential.

The plate-load resistor is R4. The varying plate current flowing through R4 causes a voltage drop that is proportional to the change in current. Therefore, R4 plays a major part in defining the voltage gain of the amplifier stage.

The plate current also flows through cathode resistor R5, causing a smaller voltage drop across it. The result is that the cathode is positive with respect to ground. Since the grid is at (or close to) ground potential, it follows that the grid will be negative with respect to the cathode. That is how we get the necessary negative-grid bias without having to resort to a third power supply—the "C" battery. Capacitor C7 "shorts out" any AC signal component, eliminating the negative feedback that would otherwise result. That has two major effects: first, it maximizes the voltage gain, making it easier to achieve overdrive; and secondly, it eliminates any reduction in non-linearity distortion that would defeat the purpose behind the Real McTube—getting "that tube sound."

The signal output at the plate of the first stage is coupled into a similar stage by capacitor C6 and gain control R10. The component values in the two stages were chosen more or less experimentally to suit the author's personal tastes.

The output of the second stage is routed through an attenuator consisting of R8, R9, and output control R11. The accumulated gain after the second stage is so high that the absence of an attenuator would make it ridiculously difficult, if not impossible, to adjust the controls for varying degrees of overdrive. The wiper of R11 is the output of the Real McTube. The final signal passes through the contacts of RY1 to output jack J2.

Building the Real McTube. The prototype for the Real McTube was built in a plastic box with an aluminum lid for the controls; the size of the unit was large enough to hold all of the components yet small enough to be portable. Admittedly, the resulting layout is a little tight—the layout of the author's prototype is shown in Fig. 2.

As in most traditional vacuum-tube units, there is no PC board for the Real McTube; all of the components are mounted onto terminal strips and connected directly to each other. The tube socket was mounted on an L-shaped metal bracket that measures about 2-inches square with terminal strips mounted to the same screws that are used to hold the socket to the bracket. The various biasing and coupling components are then soldered between the socket and the terminal strips.

The power supply was built in the case itself, again using terminal strips to hold all of the components except the transformers, S1, and NE1. The input and output jacks were installed on the front of the box, and the remote footswitch jack on the rear.

You might want to leave yourself a bit more space for experimenting—if so, you should obviously use a larger box. With a single 12AX7, heat is not a big consideration so you don't have to worry about ventilation. Orientation of the tube doesn't matter either; the 12AX7 family can operate in any orientation—which is not necessarily a given for all tubes!

Be careful about wiring, especially in the comparatively high-voltage plate circuits. Be sure to use capacitors that will stand the voltage; most standard ceramic-disc capacitors are only rated for 25 or 50 volts. Having a capacitor explode into flames a few minutes after powering up the Real McTube for the first time is definitely an experience that you'd like to avoid at all costs! On a similar note, it is also a good idea to stay away from carbon-composition resistors, especially for R4 and R6, or you can get another classic tube sound—lots of hiss.

All of the signal lines, such as the lines to J1, J2, and RY1 should be wired with good quality shielded cable. A good choice would be the RG174 variety. Keep the component leads as short as possible by mounting them as close to their associated tube socket pins as is practical. The input to the first stage is especially critical; we're dealing with a very high input impedance and low signal level. Hum and noise pickup is a real concern under those conditions.

Some components in the power supply can be substituted without affecting the operation of the Real McTube; if you have an item on hand, it can help keep the cost of the project down. For example, the 6-volt transformers can be replaced with 12-volt units. If you do that, the tube's heaters will need to be wired in series instead of in parallel as shown. Simply connect the supply to pins 4 and 5; leave pin 9 unconnected. A 12-volt relay will also have to be used for RY1. If you want to use 12-volt transformers but have a 6-volt relay, increase the value of R2 to compensate. That is done by measuring the DC resistance of the relay coil and choosing the next higher standard value for R2. For example, if the resistance of your relay is 50 ohms, use a 56-ohm resistor for R2.

Diodes D1-D4 can be substituted with a single bridge rectifier.

One important safety consideration: **DO NOT** be tempted to omit the second transformer! Although the circuit will work if you derive the 120 VAC directly from the line, you can seriously injure or even kill yourself or somebody else. At best, you can ruin your gear if you don't isolate the high-voltage supply from the AC line.

Testing the Real McTube. Once the circuit is wired up, stop and check your work for errors or accidental shorts. Once you are satisfied with your workmanship, plug the unit into a wall socket and turn it on *without* V1 being plugged into its socket. With a voltmeter, measure the voltages at pins 1 and 6 of the tube socket; you should read about 145 volts DC. At pin 9, you should read about 7 volts AC. At all of the other pins, you should read 0 volts.

If all is well so far, unplug the unit and insert the tube into the socket. You should be careful not to accidentally touch the filter capacitors—they will carry a residual charge under those conditions. A good safety tip is to short them to ground with a 1000-ohm resistor for several seconds whenever you work on the unit after having powered it up. While monitoring the B+ voltage at the positive end of C2, turn the unit on. You should see the heaters in the tube start to glow. After about 10 seconds, the B+ voltage should sag a bit as the triodes start conducting. The voltage should drop no lower than about 135–140 volts DC.

Measure the voltages on the pins of the tube again. If you used the component values suggested, your readings should be close to the values shown in Table 1. If the plate voltages are excessively low or if one or both of the grids are positive with respect to ground, power down right away and find the problem. The same advice applies if you see blue flashes in the tube or smell anything unusual. Re-examine your work and double-check the values of the components. Be sure that you are using good quality Mylar or similar capacitors for C6 and C8, and that they have at least a 150-volt rating.

Assuming that the voltages are correct, turn the unit off. Connect the output to an amplifier and the input to your instrument. Turn the gain and output controls to minimum, and power up. Slowly bring up the controls until you hear your instrument through your amplifier.

With the Real McTube working, you can now start using and experimenting with it.

Using the Real McTube. What sound you get from your guitar or other instrument with the Real McTube will depend greatly on the settings of the various controls—specifically, the volume and tone controls on your instrument and the Real McTube's gain control. The output control has little or no effect on the sound, and is used primarily to balance the volume of the sound through the unit.

Note that both stages are inverting amplifiers; the overall phase of your signal will therefore not change. However, the adjustments of your controls will determine what portion of your signal will be clipped. The first stage will tend to clip more on negative half-cycles as the tube reaches cutoff—remember the discussion above regarding cutoff versus saturation. The second stage, however, will tend to clip more on positive half-cycles, since it sees an inverted signal at its input. By carefully balancing your instrument controls and the gain control, virtually any distortion sound from a mild "warm-fuzzy-feeling" to a hard "monster-metal-shred-head" sound, with lots of odd-harmonic distortion, can be attained.

A compressor before the Real

(continued on page 50)

TABLE 1—VOLTAGE MEASUREMENTS AT V1

Pin	Description	Voltage
1	Plate A	+108 VDC
2	Grid A	−0.001 VDC
3	Cathode A	+1.5 VDC
4,5	Filaments	0 volts
6	Plate B	+60 VDC
7	Grid B	−0.1 VDC
8	Cathode B	+0.7 VDC
9	Filament	6.3 VAC

BUILD THE Q-SORT

Test and sort those bipolar transistors in a jiffy!

LARRY BALL

What do you do when you need to test and sort your ever-growing collection of bipolar-junction transistors (BJTs) or a newly-purchased "economy assortment?" To make matters worse, that "economy assortment" might have (horror of horrors!) "house" part numbers that have no relation to the actual devices that they're supposed to be. You could use a digital voltmeter (DVM) with a built-in transistor tester; these days, such DVMs are readily available. But when you're looking at 20 to 40 unknown BJTs, the thought of swapping the test leads up to six times for each transistor (as well as changing the NPN/PNP switch for each lead position) is pretty discouraging. If you're lucky enough to have "real" part numbers, you could look them up in a semiconductor-replacement guide, which usually takes longer than using a DVM in the first place.

Clearly, a better way is needed. That is why the Q-Sort was created. With the Q-Sort, you can test and sort up to 40 unknown BJTs in less than six minutes—without touching an NPN/PNP selector switch or swapping a test lead! The Q-Sort can tell you if a BJT is an NPN or a PNP type, as well as identifying the emitter, base, and collector terminals. There are no adjustments to make, and you won't waste time changing Q-Sort's NPN/PNP selector switch because it doesn't have one. It automatically determines if a BJT is an NPN or a PNP, and turns on one of two LEDs to display the transistor type. All that you have to do is insert the transistor into the Q-Sort's test slots (or use the built-in test leads) and rotate a six-position switch to determine the transistor's emitter, base, and collector leads.

It's practically effortless and best of all—it's fast! Why spend up to $200 on a transistor tester/sorter when the Q-Sort can be built for under $20? Of course, the Q-Sort won't give you all the features of a full-featured transistor tester/sorter. For example, the Q-Sort does not measure gain, but a DVM with a built-in h_{fe} test can be purchased for less than $17. Chances are that you might already have such a DVM available.

Circuit Description. The Q-Sort consists of three sections: a three-pole, three-position switch, an oscillator; and a polarity-reversing circuit for the oscillator's power supply.

We'll look at the polarity-reversing circuit first. As shown in Fig. 1, IC1 is set up as an astable multivibrator. Its output (labeled OUTPUT A) is a 10-Hz squarewave with an amplitude from ground to about 1½ volts less than the power supply. That signal is coupled through R3 and R4 to Q1 and Q2. Those transistors invert the 10-Hz squarewave, labeled OUTPUT B. Together, the two signals provide an AC squarewave to the oscillator section. Using that signal is how the Q-Sort determines if a transistor under test is an NPN or a PNP type without using a polarity switch. Transistors Q1 and Q2 do that by grounding OUTPUT B when OUTPUT A is high, and by connecting OUTPUT B to the power supply when OUTPUT A is grounded. Non-polarized capacitor C3 smoothes the output of OUTPUT A and OUTPUT B.

A tapped-coil oscillator is formed by R5, R6, C4, T1, and the transistor under test. Light-emitting diodes LED1 and LED2 are connected to the secondary winding of T1. When a BJT is correctly connected to the test leads or J1, the circuit will oscillate for half the time regardless of whether the transistor is an NPN or a PNP because of the circuit's AC input. However, since an NPN or a PNP transistor placed in the circuit will conduct in opposite directions, the transistor's type can be displayed with LED1 (for NPN types) or LED2 (for PNP types).

The Q-Sort will not oscillate unless the transistor under test is connected correctly. By turning S2, the three lead wires to J1 (or the built-in test leads) are quickly and easily swapped among the various possible combinations of connec

SOURCES OF PARTS AND MATERIALS

4-position, 6-pole switch:
Mouser Electronics
958 N. Main St.
Mansfield, TX 76063-4827
800-346-6873
part number: 10WR046

Budget priced DVM with built-in h_{fe} tester:
Hosfelt Electronics Inc.
2700 Sunset Blvd.
Steubenville, OH 43952
800-524-6464
part number: 9202

Card 192

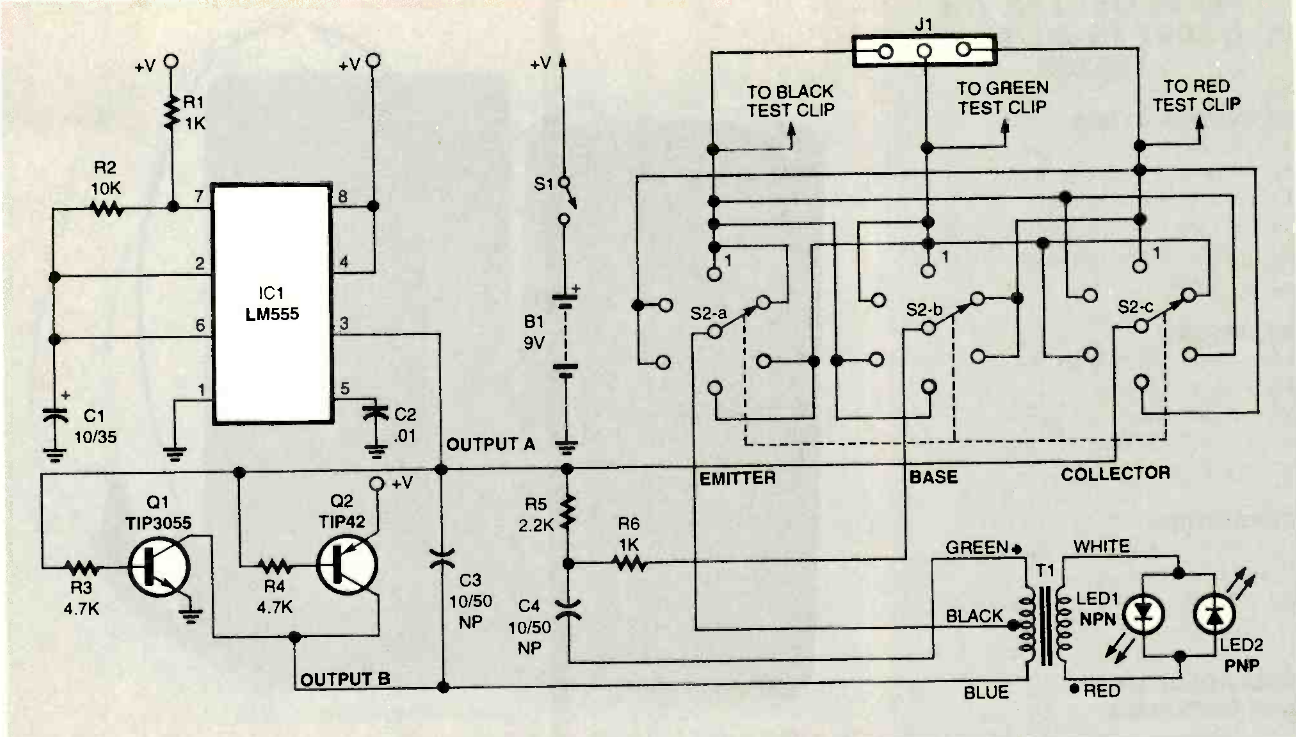


Fig. 1. The Q-Sort is a simple circuit with three sections: a switch, an oscillator, and a circuit that reverses the polarity of the oscillator's power supply ten times per second.

tions without having to physically rearrange the wires. The steering logic is handled by the complex interconnections among S2-a, S2-b, and S2-c.

Construction. The Q-Sort is simple enough to be built on a piece of perfboard using standard construction techniques. However, a single-sided PC board can also be used to help reduce wiring errors. If you'd like to use a PC board, a foil pattern has been included here. Alternately, an etched board is avaliable from the source given in the Parts List.

If you use a purchased PC board or etch one using the provided foil pattern, the parts-placement diagram in Fig. 2 should be followed for component location. Before mounting the parts on the PC board, you might want to drill two additional holes for the mounting tabs of T1. Note that ordinary LEDs shouldn't be substituted for the high-brightness LEDs specified in the Parts List. Ordinary LEDs will result in poor performance at lower battery voltages, or possibly no performance at all.

The author's prototype was built

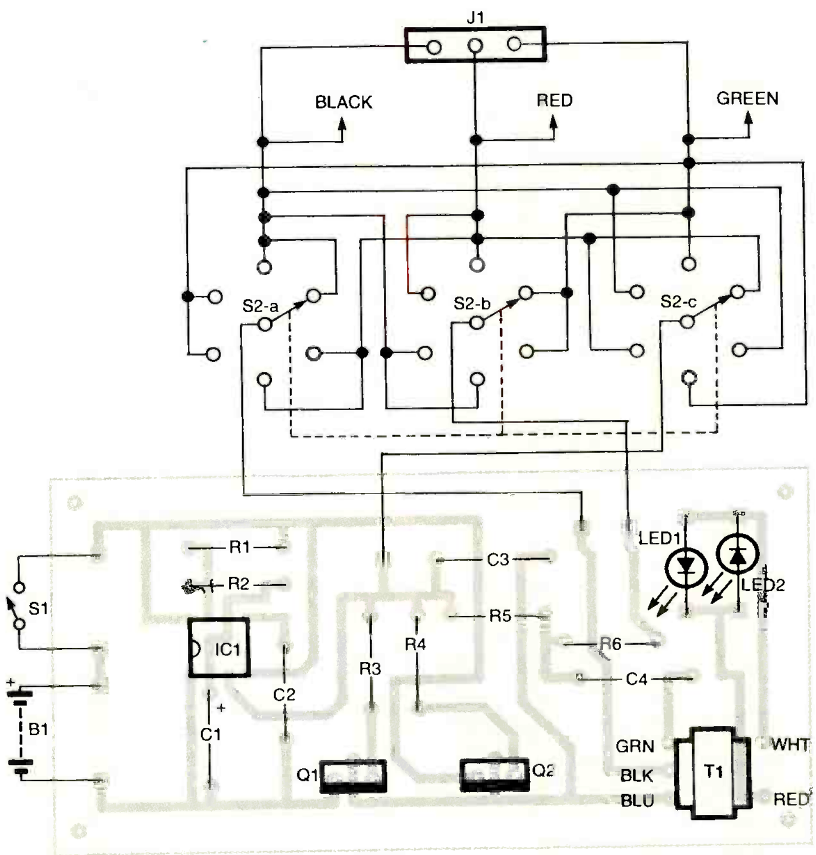


Fig. 2. Use this parts-placement diagram to assemble this fast, convenient, and inexpensive transistor tester/sorter for your test bench.

PARTS LIST FOR THE Q-SORT TRANSISTOR TESTER

SEMICONDUCTORS

IC1—LM555 timer, integrated circuit
Q1—TIP3055 NPN transistor
Q2—TIP42 PNP transistor
LED1, LED2—Light-emitting diodes, high-brightness (RadioShack 276-066 or similar)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R6—1000-ohm
R2—10,000-ohm
R3, R4—4700-ohm
R5—2200-ohm

CAPACITORS

C1—10-µF, 35-WVDC, electrolytic
C2—0.01-µF, ceramic-disc
C3, C4—10-µF, 50-WVDC, non-polarized electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—Battery, 9-volt
J1—Header, three-pin
S1—Single-pole, single-throw switch
S2—3-pole, 6-position rotary switch
T1—Audio-output transformer 1000-ohm/ 8-ohm (RadioShack 273-1380 or similar)
Case, alligator clips, battery clip, battery holder, solder, wire, hardware, etc.

Note: An etched and drilled PC board is available from: Futuretech, PO Box 6291, Gulf Breeze, FL 32561 for $12 plus $3 for shipping and handling. FL residents, please add 7% sales tax.

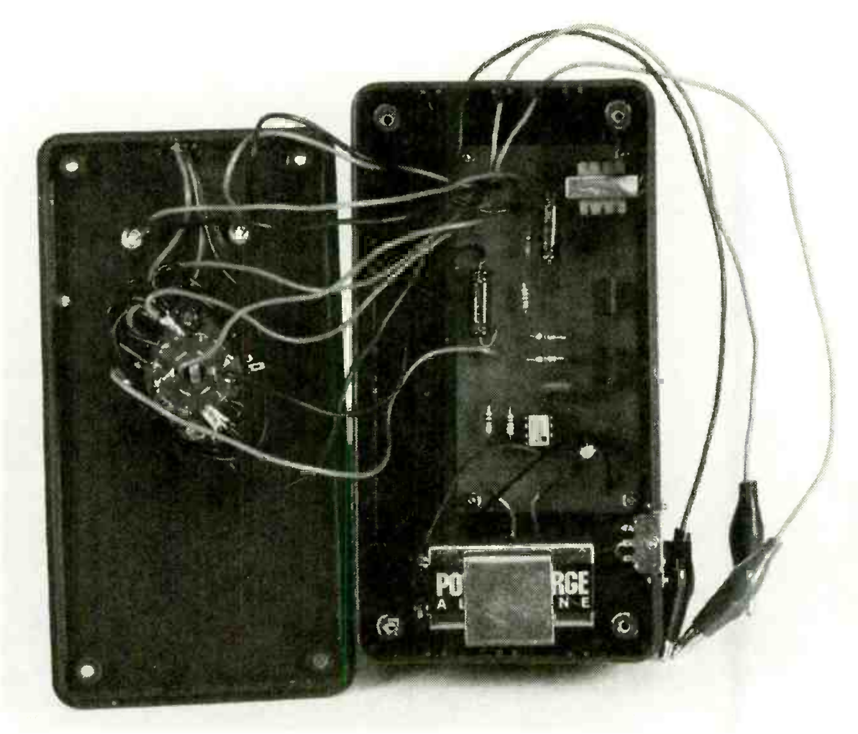
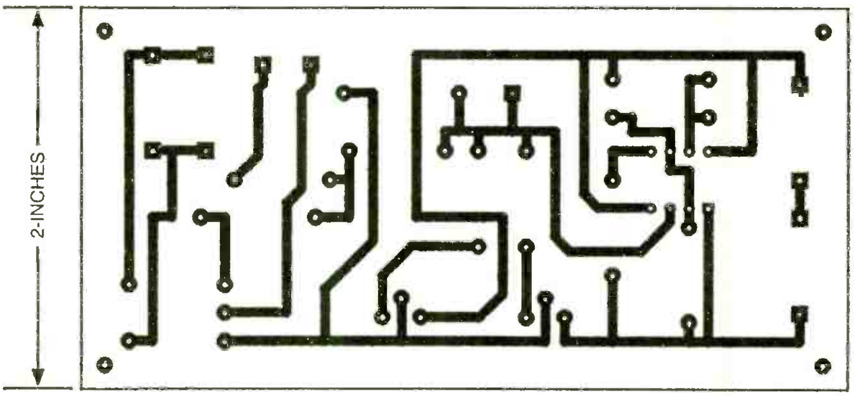


Fig. 3. Note that Q2 isn't crowded by other components and that the header is glued to the lip of the enclosure's cover for support.



Here's the foil pattern for the Q-Sort. Although a PC board is not required to build the Q-Sort, it will make the job easier and neater.

in a 2-inch by 3-inch by 6-inch plastic enclosure. It was found that this size had enough space for the components yet was small enough for convenient use. The internal arrangement of the Q-Sort's components is shown in Fig. 3. Note that at least ¼-inch of space was left around Q2—it can become quite warm during operation.

The Q-Sort's front panel should be clearly labeled to identify the type of transistor the LEDs are indicating. Additionally, the various positions of S2 should be marked to indicate what leads are connected to which terminals on the transistor being tested.

Mount S2 centrally on the enclosure's front panel; S1 can be mounted on either the front or the side. Header J1 is mounted through a hole cut near the top edge of the front panel. Glue it in place with a suitable adhesive. Be careful not to get any adhesive inside the contacts of J1. Similarly, glue LED1 and LED2 in place in suitable holes.

We'll refer to S2's extreme counter-clockwise position (when viewed from the front) as the num

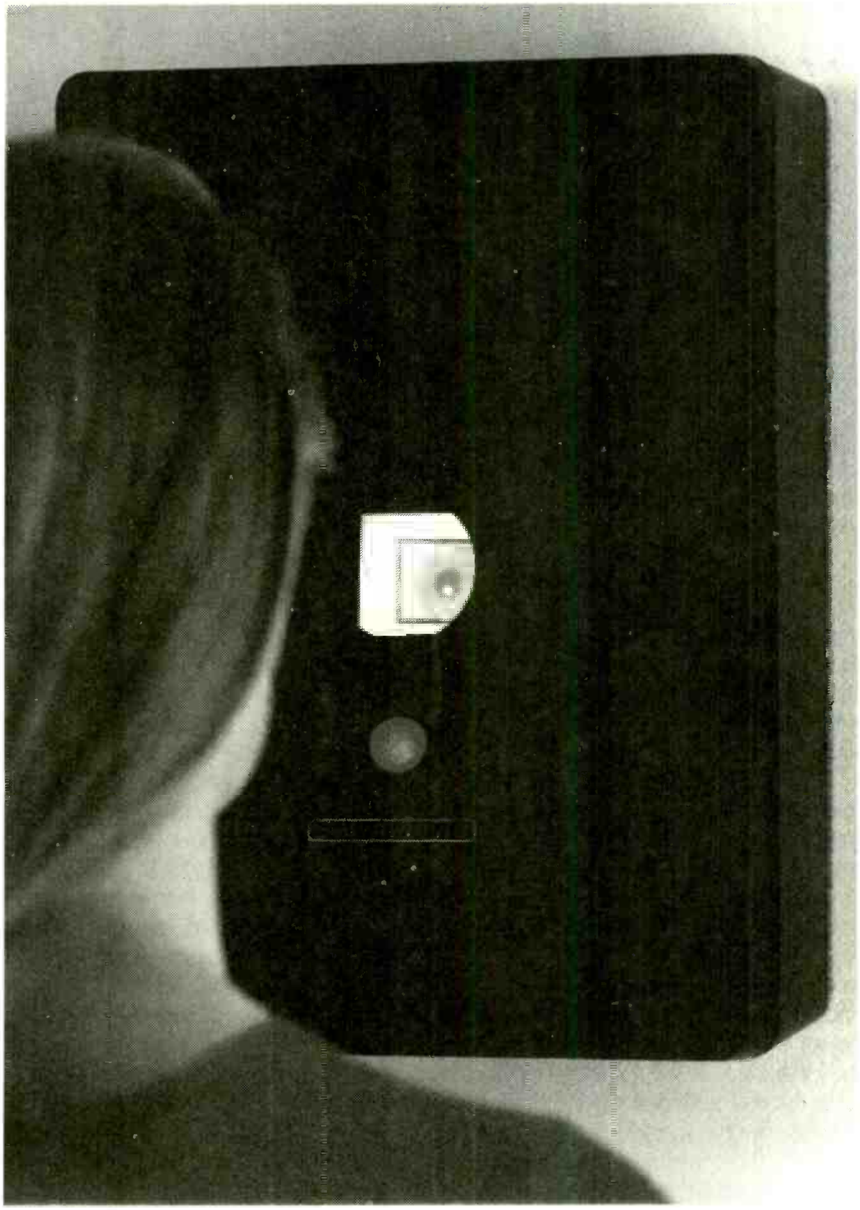
(continued on page 43)

TABLE 1

S2 Position	Transistor	Lead Configuration
1 Emitter	Base	Collector
2 Emitter	Collector	Base
3 Collector	Emitter	Base
4 Base	Emitter	Collector
5 Base	Collector	Emitter
6 Collector	Base	Emitter

IRIS RECOGNITION SYSTEMS

BILL SIURU



These fast, positive, easy, and non-intrusive systems put the "eye" in ID

Each commuter quickly looks into a box containing a video camera and within seconds each passes through the turnstile and onto the subway train without using coins, tokens or tickets. A woman walks up to the ATM and then walks away, cash in hand, without using a card or entering a PIN. A man and his son go through the turnstile at the ballpark without a ticket. A woman looks into a camera to identify herself before she is issued a welfare check.

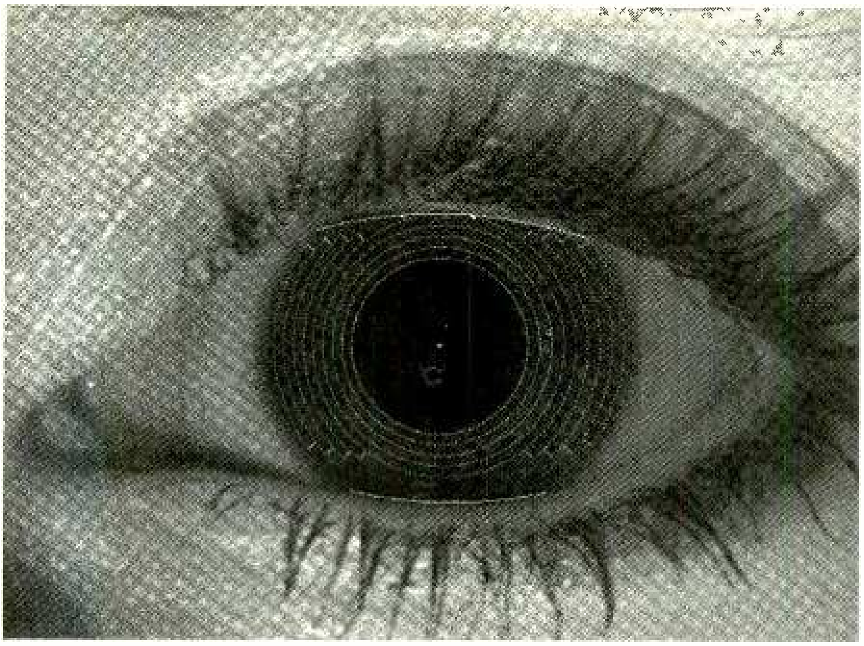
In each scenario above, the person's identity was verified using iris recognition, one of the techniques in the field of biometric recognition. Biometric recognition—the use of automated techniques for identifying individuals by their unique physical characteristics—is a rapidly growing industry around the world.

Fool-Proof Security. Much of the explosion in biometric identification is being driven by a growing concern for security in virtually every facet of life. It seems that as security technology gets more sophisticated, the bad guys get smarter. With color copiers, scanners, and printers, counterfeiters can produce IDs, concert and sports-event tickets and many other documents that cannot be told from the real McCoy. Other criminals use pilfered PINs at ATM machines, make purchases with stolen credit cards, gain access to secure buildings and computer databases, or collect entitlements like welfare and health care that they are not entitled to.

Biometric identification systems that prevent fraud and unauthorized access are now being used for everything from issuing driver's licenses to keeping track of inmates in prisons. They are replacing PINs at ATM machines, meal cards in university cafeterias, time clocks in the workplace, tokens on subways, tickets at sporting events, and even ensuring that only authorized persons pick up children from daycare centers.

Fingerprints are the oldest and most widely used biometric identifier. Other physiological identifiers that can be used for positive identification include hand geometry, iris and retina patterns, and facial features. Biometric identification systems are difficult if not impossible to circumvent, even by the most cunning criminals. Unlike cards, the dishonest cannot steal or counterfeit fingerprints, eyes, hands, or faces.

All biometric techniques include four basic steps. First, they capture the biometric characteristics during the enrollment process. Then unique features are extracted and converted into a mathematical code that is stored as a biometric template for a particular person. Templates can be stored in a computer database, on a smart card, or as a bar-code. Then when the person's identity



During the enrollment process, a video image of the iris is captured and the zones indicated here are analyzed and recorded to provide positive identification later.

is checked for recognition and verification, another biometric sample is taken and compared against the template. If the template and the new sample match, approval or access is granted.

So, then, why is a lot of attention being paid to iris and retina recognition? It is because both the eye's retina and iris are unique. As the eye develops, the blood-vessel pattern of the retina forms and does not change over a lifetime. Retinal recognition uses optics to map the capillary pattern of the eye's retina layer of blood vessels to produce a unique image. The primary application for this technology has been in high-security access control, including the most secure buildings at the Department of Energy, Cape Canaveral and other NASA facilities, the CIA, and FBI buildings.

However, iris recognition is even more promising, and for a wider range of applications. That's because less-sophisticated equipment is needed to implement an iris-recognition system.

Iris Recognition. The random patterns of the iris can be thought of as a complex human barcode that is created by a tangled meshwork of connective tissue and other visible features. Most important, for all the people on the face of the earth, no two have identical irises, not even among identical twins. Nor do they change during a person's life or can they be altered by medical procedures.

IriScan, Inc. in Mt. Laurel, NJ, has perfected the concept of iris recognition originally patented by two ophthalmologists, Drs. Leonard Flom and Aran Safir, in 1987. It is now marketing its IriScan technology and equipment for a variety of biometric-identification applications.

One example is the IriScan System 2100. Authorized individuals are "enrolled" (that is, their iris characteristics are recorded and entered into the system's database) by having them look into a camera lens so that a video image of the iris is recorded. The image is then digitized and processed into an IrisCode that is stored for future recognition. Both eyeglasses and contact lenses are accommodated easily, and the whole process takes about 30 seconds.

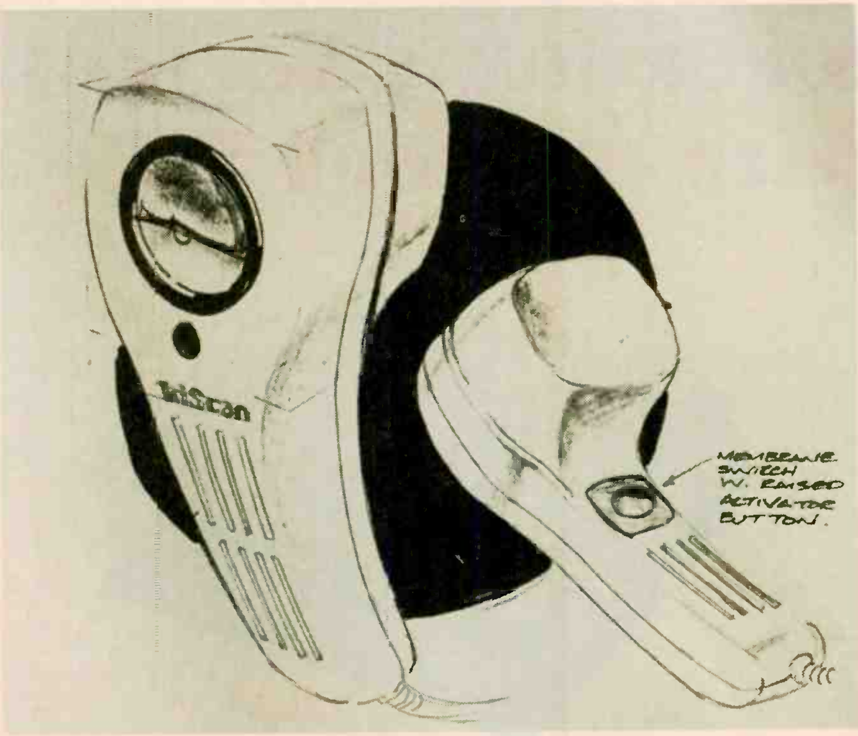
Then to gain access to restricted areas or information, or to make purchases, or for general identity verification, the enrolled individual looks into an IriScan reader and, if the iris matches the valid IrisCode for that person, the identity is verified. Since the technique relies on the physiological response to light and natural pupillary oscillation, it cannot be fooled by a photograph or another substitute for a real human eye. The recognition process takes only about 2 seconds, even with very large databases of IrisCodes.

For most databases of enrollees, the system will work with a reasonably capable PC running under NT 4.0. That PC can act as a central host computer and be connected to a network of several remote readers. In that way, a single system can be used for many access locations, though larger databases may need more storage capacity.

One of the first applications of the technology is for absolute identification of inmates in detention centers and correction facilities. The first system was installed at the Lancaster County Prison in Lancaster, PA in 1996, where all inmates are enrolled into the system to create an active file of current inmates and a historical record of previous residents. The latter provides early exposure of aliases should the same person return under a different name. Currently, the system is also being installed at the Sarasota County Detention Center in Sarasota, FL. There it is used to identify and confirm identities of inmates prior to being released from the facility for court appearances, work release, or at sentence completion.

As an added benefit, the inmates don't have to touch anything. They simply stand about one foot away from the camera and look into the lens for a few seconds. However, IriScan requires a minimal amount of cooperation because the individual must look at a camera. Therefore it may not be appropriate for use where individuals may be uncooperative or incapacitated.

Other Applications. As important as the prison applications are, there are other areas where iris recognition could make a more significant impact in your life (at least we hope so!). For example, Spring Technologies in Falls Church, VA is using iris recognition technology licensed from IriScan for its TranScan commuter-access system for subways and train stations. There, an automated biometric-identification system would eliminate the need to insert a card, pass, or token. In addi-



Here's an artist's concept of a portable system using the IriScan technology.

Among the possible applications, IriScan could be used to allow transactions at a bank ATM

tion to substantially reducing the costs of ticket production and collection, there will be a more orderly flow of traffic. Spring Technologies will introduce a TranScan prototype within the year, with a trial period slated to begin in one metropolitan city immediately thereafter. Seven of the country's largest mass transit agencies are being considered for possible testing sites. A portable system has also been developed that could be used, for example, on buses.

Another application from Spring Technologies is SportScan, which would allow ticketless entry to sporting events at stadiums, arenas, and other venues. The system would use biometric information on spectators to debit or charge their accounts.

The American Red Cross is planning to use the IriScan to protect the nation's blood supply while maintaining privacy and anonymity, as well as to reduce time needed to fill out forms. Once a donor is registered, all of their information would be stored in the database and from then on, donations become a private procedure.

One of the most significant users of iris recognition technology could be the banking industry. Indeed, Oki Electric Industry Co., Ltd. in Japan is now field testing an access control system it developed for the Suruga Bank, Ltd. Other applications include credit-card transactions, e-commerce and Internet security, point-of-sale identification, and even horse identification.

Eventually, all IriScan system could be networked together. Therefore, once enrolled, for example, at your bank, the same IrisCode would be used for identification and account debiting when using TranScan, SportScan, a credit card, an ATM, etc. Ω

THE Q-SORT

(continued from page 40)

ber one position. Wiring S2 can be confusing, but you can make the task more straightforward by soldering the appropriate wires to each pole's number one position all at once, rather than individually. That will save you from creating a piecemeal "bird's nest" of wires. Follow the wiring for S2 as shown in either Figs. 1 or 2. Black, green, and red test leads terminated with alligator clips are connected in parallel with the pins of J1 and are run through holes in either the side or front of the case.

Checkout and Use. To test the Q-Sort, you'll need both an NPN and a PNP transistor that are known to be good. Small signal transistors are best for testing J1, while larger power transistors can be used to check the test clips.

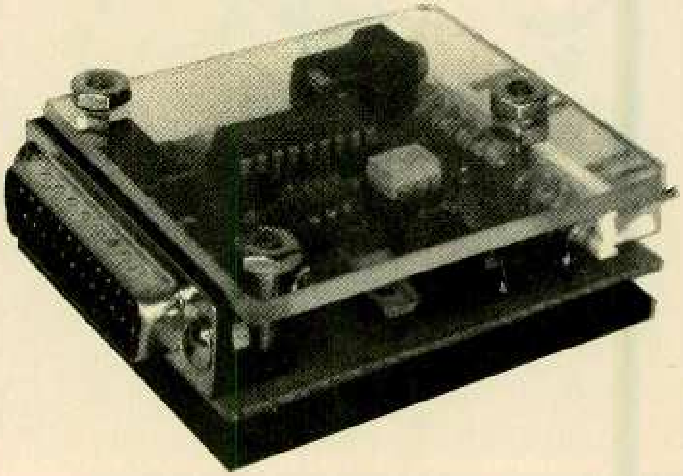
Turn the Q-Sort on and insert a transistor into J1. As you rotate S2, either LED1 or LED2, as appropriate, should come on when S2 is set to the position that correctly indicates the transistor leads. If the wrong LED or no LED lights, recheck your work. Most errors are usually found in the wiring of S2.

Since LED1 and LED2 are wired in inverse parallel, an incorrect indication usually means that one or both devices are installed backwards. For example, if both LEDs light up for one type of transistor but not for the other, the LED that lights up wrong is installed backwards. If both LEDs work but the wrong one lights up for both types of transistors, *both* devices are installed backwards. In that case, it might be easier to simply swap the LEDs in the front panel.

Using the Q-Sort couldn't be easier. Simply connect a BJT to either the Q-Sort's test leads or J1. Rotate S2 until either the NPN or the PNP LED blinks on. If neither LED comes on (and you've confirmed that the Q-Sort is working properly), the device under test is either defective or possibly not a BJT at all. Ω

An AC Proportional Voltage Controller for your PC

NEIL BUNGARD



Use your PC to control appliance voltage levels.

While it is easy to control appliances from a PC, that type of control usually has one of two conditions: on or off. There are many applications where it would be desirable to proportionally control the voltage level of an appliance that uses 110-volt AC service. Light dimming is one obvious application. Other uses include motor-speed control; heater control; and the ability to easily create an inexpensive, programmable DC power source.

In this article, we're going to show you how to use the parallel port of a PC, a few optical-coupling devices, and a Microchip PIC microcontroller to control the conduction angle of a 110-volt AC source, and hence to proportionally control a device connected to the PC's parallel port.

Controlling AC. Let's begin by looking at a 60-Hz 110-volt AC sine wave and talk about the concept of *conduction angle*. Figure 1A is the circuit that will be used for this discussion. We'll assume that S1 is an electronic switch that can be activated instantly at any time. If S1 is closed and remains closed, Fig. 1B would represent a single cycle of the signal that would be seen by load resistor R1. In that case, the load draws current during the entire cycle and would have a conduction angle of 360 degrees. In Fig. 1C, S1 does not close until the sinewave reaches 90 degrees in the cycle. As the signal passes through zero at 180 degrees, S1 is opened, stopping the flow of current to R1 for the next 90 degrees. At 270 degrees, S1 closes again and current once again flows through R1 until the zero crossing at 360 degrees. The signal in Fig. 1C has a conduction angle of 180 degrees. Since, in general, the conduction angle is the number of degrees that current passes through the load in each cycle, that means that the amount of current seen by R1 would be half the amount that would otherwise have passed through it.

In general, that is the way that an ordinary wall-mounted light dimmer works. The physical position of the light-dimmer knob sets the conduction angle at which conduction will begin after each zero crossing. Additionally, when the sinewave passes through zero, conduction is automatically stopped. Of course, that example controls the conduction angle mechanically. Such an arrangement is fine for open-loop control applications where you set the control once and leave it alone. For many control applications, however, you are not interested in just setting a conduction angle and letting the process run. You will want to monitor the process and dynamically adjust the conduction angle to keep the process operating at a preset level.

To dynamically control the conduction angle, you will need to know precisely what the angle is and be able to make adjustments accordingly. That is done by finding when the sinewave passes through zero volts. There are many circuits for determining the zero-crossing point. If you need a high degree of precision, op-amps can be used to get within a few microvolts. Most applications, however, do not need that level of precision and a "quick and dirty" way of determining the zero-crossing point with a TTL-compatible output signal is to use an opto-coupler.

The opto-coupler circuit shown in Fig. 2A will work well but has some inherent shortcomings. Current-limiting resistor R1 must limit the forward current through the opto-coupler's diode and the external clamping diode to within the maximum limits for the devices at the peak voltage, which is about 156 volts when using wall current. The peak-inverse-voltage ratings of the diodes should also be at least 160 volts.

Another consideration is that the opto-coupler's output waveform will be non-symmetrical. That is because the input signal on the opto-coupler's diode must exceed the diode's forward-bias turn-on voltage before the diode conducts. That phenomenon has been exaggerated in Fig. 2B to illustrate the concept. Since the actual turn-on voltage is slightly above zero volts, the output will not have a perfect

50% duty cycle. Another problem that is related to the turn-on-voltage condition—and is much subtler—is that the diode's turn-on and turn-off voltages are not exactly the same. This principle, called *hysteresis*, is exhibited by most electronic components. It is especially noticeable in devices that monitor or control threshold activities such as zero crossing. The symmetry and hystersis effects can be compensated for; we will see how to use software to compensate for those conditions later in this article.

Now that we are able to detect the zero-crossing portion of an AC cycle with a TTL output signal, how do we control the current to a load with a desired conduction angle? A general solution to that problem is shown in Fig. 3. A PIC microcontroller monitors both the zero-crossing signal from the opto-coupler and an 8-bit data byte from the PC's parallel port, which represents the desired conduction angle. By comparing the two pieces of input data, the PIC decides when to trigger the electronic switch. The electronic switch we'll use in our controller circuit is actually a Triac that is triggered by the PIC. The sidebar, "Triacs, Diacs, and Control", explains the basics of how four-layer semiconductors are designed and used.

Using an 8-bit word to represent the desired conduction angle lets us control the conduction angle of the AC waveform in 256 discrete steps. That is probably more than enough resolution for most applications and appears continuous when being used in light-dimmer or heater-control applications. The sidebar, "The Parallel Port," reviews the operation of the PC parallel port and how it interfaces to the outside world.

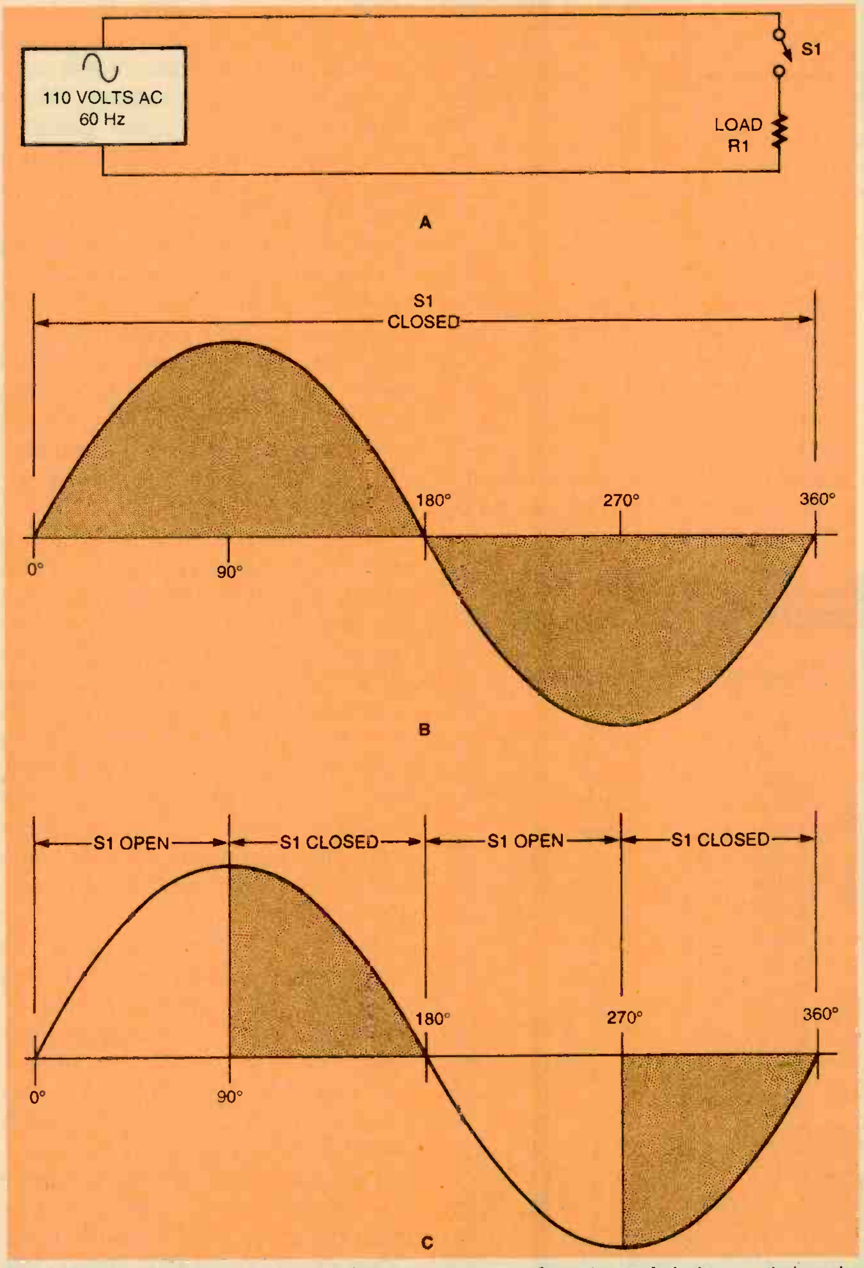


Fig. 1. Varying the AC current to a load is simply a matter of opening and closing a switch at the right time (A). If the switch is left closed for the entire cycle, the load will see full power (B). However, if the switch is opened and closed at the same points in the cycle, the apparent voltage applied to the load will be averaged out. In example (C), the load will only see 50% of full power.

Circuit Description. Bringing all of the concepts we've discussed so far together yields our project, called the Parallel-Port Controller. Its schematic drawing is shown in Fig. 4. Hardware operation for the entire circuit should be familiar based on the previous discussions.

Wall-socket current is applied to

PARTS LIST FOR THE PARALLEL-PORT CONTROLLER

SEMICONDUCTORS

IC1—PIC16C54 microcontroller, integrated circuit
IC2—H11AX optoisolator, transistor-based, integrated circuit
IC3—MOC3010 optoisolator, Triac output, integrated circuit
TR1—2N6347 Triac,
D1—1N4004 silicon diode
D2—1N5231 Zener diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R5—100-ohm
R2—1000-ohm
R3—11,000-ohm, ½-watt
R4—180-ohm

ADDITIONAL PARTS AND MATERIALS

C1—0.01-µF capacitor, ceramic-disc
J1, J2—4-pin right-angle connector (Molex 26-60-5040 or similar)
J3—DB25 right-angle male connector (Mouser 152-3325 or similar)
J4—Co-axial power connector, male (Mouser 161-3112 or similar)
RES1—8-MHz ceramic resonator
Wall transformer, Plexiglas covers, hardware, etc.

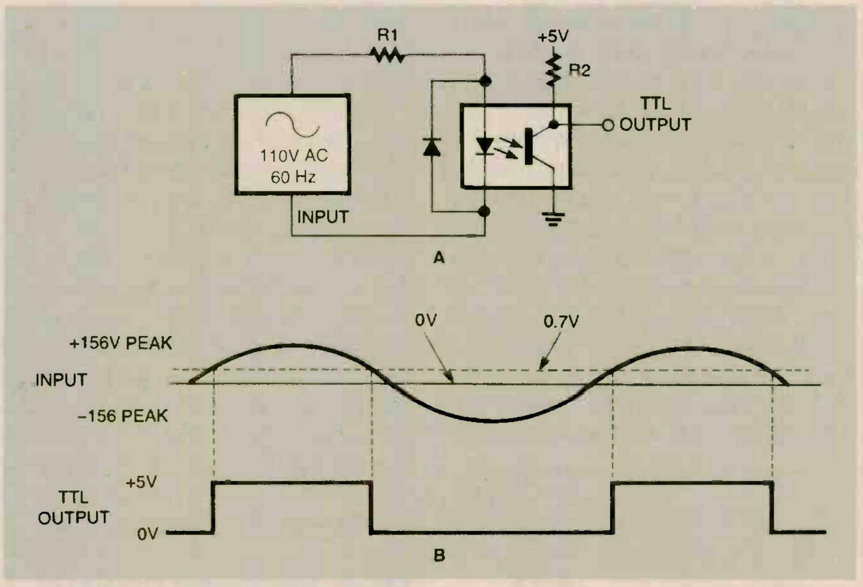


Fig. 2. It is very easy to sense the zero-crossing point of an AC cycle with a simple optoisolator circuit (A). Unfortunately, the digital output of such a circuit will not be a perfect squarewave because of the voltage drop across the internal photodiode (B).

J2. The AC waveform is applied to IC2 through R3 with D1 providing a reverse path as discussed before. The TTL squarewave is applied to pin 17 of IC1.

When the PIC program decides that the output should be turned on, an output signal from pin 18 of IC1 activates the photodiode of IC3. Current for the diode is supplied by R1. The output of IC3 is applied to the gate of TR1, which completes a path between the main connections of J1 and J2. The load being controlled is connected to J1.

An 8-bit value for the amount of delay is applied to J3 from a PC's parallel port. Power for the circuit is connected to J4 and regulated by D2.

TABLE 1—
SPP MODE PHYSICAL AND LOGICAL PIN ASSIGNMENTS

Pin	Signal	In/Out	Register	Inverted
1	Strobe	In/Out	Control	Yes
2	Data 0	Out	Data	No
3	Data 1	Out	Data	No
4	Data 2	Out	Data	No
5	Data 3	Out	Data	No
6	Data 4	Out	Data	No
7	Data 5	Out	Data	No
8	Data 6	Out	Data	No
9	Data 7	Out	Data	No
10	Ack	In	Status	No
11	Busy	In	Status	Yes
12	Paper	Out / End In	Status	No
13	Select	In	Status	No
14	Auto Linefeed	In/Out	Control	Yes
15	Error/Fault	In	Status	No
16	Initialize	In/Out	Control	No
17	Select Printer	In/Out	Control	Yes
18	Ground	Gnd		
19	Ground	Gnd		
20	Ground	Gnd		
21	Ground	Gnd		
22	Ground	Gnd		
23	Ground	Gnd		
24	Ground	Gnd		
25	Ground	Gnd		

Software. Overall operation of the Parallel-Port Controller is really a function of the program running in IC1. Compensation for the non-symmetry and hysteresis problems mentioned before are accomplished by "tweaking" certain variables in the program.

The block diagram of the PIC program is shown in Fig. 5. After initializing the variables that the program uses, the PIC waits for a positive-going zero crossing to occur. At that time, a value from the parallel port is read and used to determine when to trigger the Triac. Once the Triac has been pulsed on, the program waits for the negative-going zero crossing. When that occurs, the current parallel-port value is again obtained and the precise turn-on time for the negative half of the cycle is calculated. Once the Triac is triggered on for the negative half cycle, the program loops back to the top and the process is repeated.

A study of the source code will show the inner workings of The Parallel-Port Controller. The source code is available at the Gernsback FTP site (ftp.gernsback.com/pub/EN/ppc.txt).

After initialization of the program variables, a starting point is established and the "wait_for_pos" routine begins looking for a positive-going zero crossing. When the zero crossing is detected, the PIC moves a value from the parallel port into the variable "temp1". At this point, a check is made to see if the Triac should be full on (temp1=0) or full off (temp1=255); if so, the appropriate action is performed, otherwise a call is made to a subroutine called "dwell".

The "dwell" subroutine does two things. First, it executes a timing loop that compensates for the premature zero crossing caused by the forward voltage drop of the detection diode. At the same time, the loop compensates for the hysteresis effect. The values for the compensation loop were found by testing several diodes and looking at their responses on an oscilloscope. Once an average time delay until the actual zero crossing occurs was found, compensation for the difference was done by manipulating

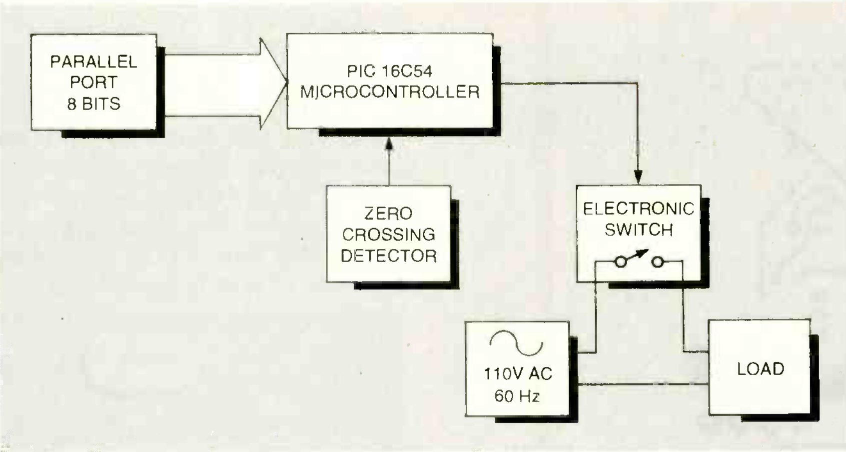


Fig. 3. Here's how to use a PIC 16C54 microcontroller to control the delay between the zero crossing of the AC cycle and switching on an output. An 8-bit number from the parallel port tells the PIC how long to wait.

the loop variables "await_cntr1" and "await_cntr2".

The second thing that dwell does is to use the value obtained from the parallel port in a second timing loop that decides when to turn on the Triac. The larger the parallel-port value, the longer the loop runs before it times out. A longer delay will fire the Triac later in the cycle resulting in less average current through the load.

When the second loop times out, program execution resumes at the "wait_for_pos" routine where the Triac is actually turned on by clearing and setting RA.1. Once the Triac is turned on, the "wait_for_neg" loop looks for a negative-going zero crossing. When that condition is found, dwell1 is called again, using the parallel-port value to determine when to activate the Triac during the negative half cycle. Notice that compensation for the diode drop and the hysteresis is missing in the positive-going zero-crossing case. That is because the detection occurs *after* the actual zero crossing. Since it is very difficult to travel into the past, the program code has been kept simple by ignoring that section of the waveform. The result is a small loss of control in terms of the entire cycle time. However, that presents no problem for most control applications. If that loss of precision is troublesome in your particular application, you can always replace the detection circuit (IC2) with an op-amp circuit to detect true zero crossing and regain the lost precision. Of course, sections of the program would have to be modified to ignore hysterisis and symmetry compensation; those types of modifications are beyond the scope of this article.

Construction. While the Parallel-Port Controller can be built on a perfboard using standard construction techniques, a PC board is recommended because of the high voltages involved. Any error in construction can damage equipment or

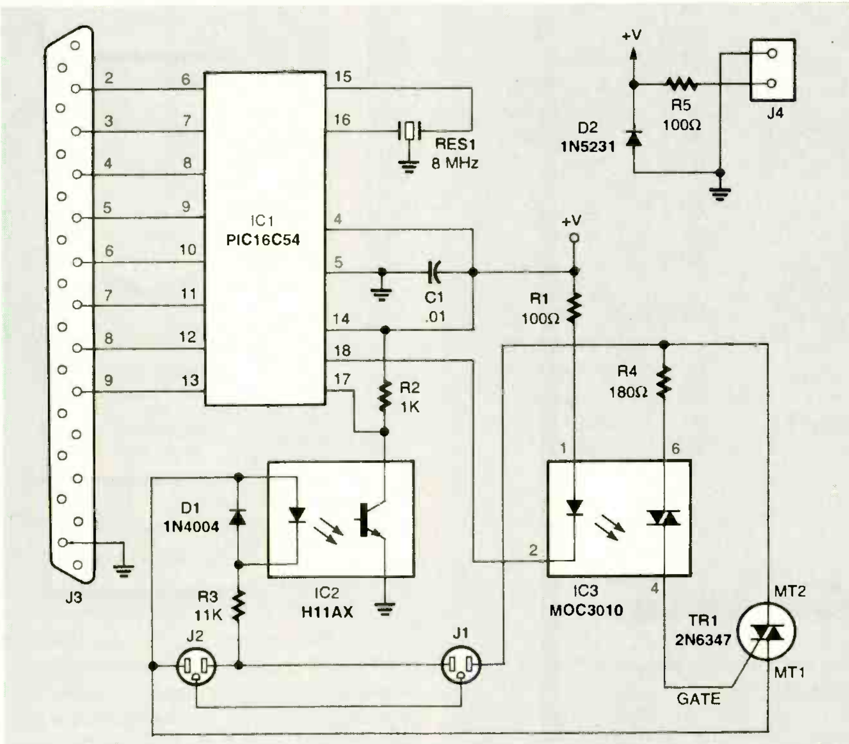


Fig. 4. The Parallel-Port Controller's schematic shows how simple the hardware is. Note that the output is also optoisolated by a Triac-output isolator.

TRIACS, DIACS AND CONTROL

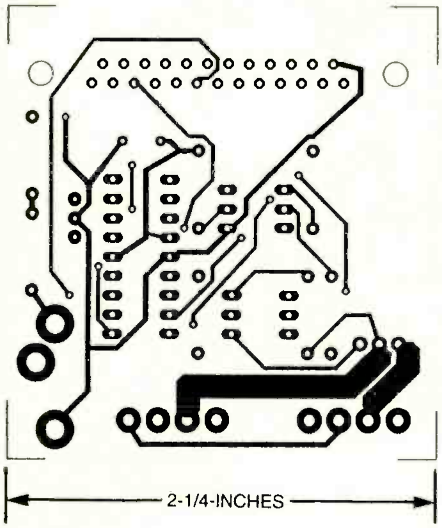
Both Triacs and diacs are four-layer semiconductor devices that can conduct current in either direction. The diac has two terminals. It is normally in an "off" state until a certain voltage level (the *breakover* voltage) is reached. At that point, the diac begins conducting current in the direction of the voltage polarity that is being applied across it.

The Triac, on the other hand, is like a diac with a third *gate* terminal. The Triac can be turned on by a pulse of gate current; there is no fixed breakover voltage needed. The breakover voltage in the Triac actually decreases with an increase in the gate current. The Triac can be thought of as two silicon-controlled rectifiers (SCRs) connected in inverse parallel with a common gate terminal. With that arrangement, the Triac can conduct current in either direction when it is triggered on. Like the diac, the current direction depends on the polarity of the voltage across the Triac's main terminals. Like the SCR, the Triac turns off when the anode current drops below a specified value, called the *holding current*. The only way to turn off a Triac is to reduce the anode current to a sufficiently low level.

Triacs are primarily used to control average power to a load by *phase control*. In that method, the Triac is not triggered until a certain amount of time after the zero-crossing point of an AC waveform for both the positive and negative portions of the cycle.

result in severe injury. A double-sided foil pattern has been included here.

Start by cutting a pair of plastic covers that are the same size as the PC board. Drill three holes in the covers large enough for a 6-32 screw to pass through. Two of them should match the mounting holes for J3; the third should be drilled between J1 and J2 such that a 6-32



Here's the foil pattern for the solder side of the Parallel-Port Controller.

TABLE 2—SOFTWARE REGISTERS

Offset	Name	Read/Write	Bit No.	Properties
Base +0	Data Port	Write (Read/Write if port is bidirectional)	Bit 7	*Data 7*
			Bit 6	*Data 6*
			Bit 5	*Data 5*
			Bit 4	*Data 4*
			Bit 3	*Data 3*
			Bit 2	*Data 2*
			Bit 1	*Data 1*
			Bit 0	*Data 0*
Base +1	Status Port	Read Only	Bit 7	*Busy*
			Bit 6	*Ack*
			Bit 5	*Paper Out/End*
			Bit 4	*Select*
			Bit 3	*Error/Fault*
			Bit 2	IRQ (Active Low)
			Bit 1	Reserved
			Bit 0	Reserved
Base +2	Control Port	Read/Write	Bit 7	Unused
			Bit 6	Unused
			Bit 5	Enable Bi-Directional Port
			Bit 4	Enable IRQ Via Ack Line
			Bit 3	*Select Printer*
			Bit 2	*Initialize*
			Bit 1	*Auto Linefeed*
			Bit 0	*Strobe*

Note: Italics indicates external signals

TABLE 3— LOGICAL PARALLEL PORT ADDRESSES

Address	Notes:
3BCh - 3BFh	Used for Parallel Ports which were incorporated on to Video Card—Doesn't Support ECP Addresses
378h - 37Fh	Standard Address For LPT 1
278h - 27Fh	Standard Address For LPT 2
300h - 340h	Used for Prototype Board Development (64 individual Addresses)

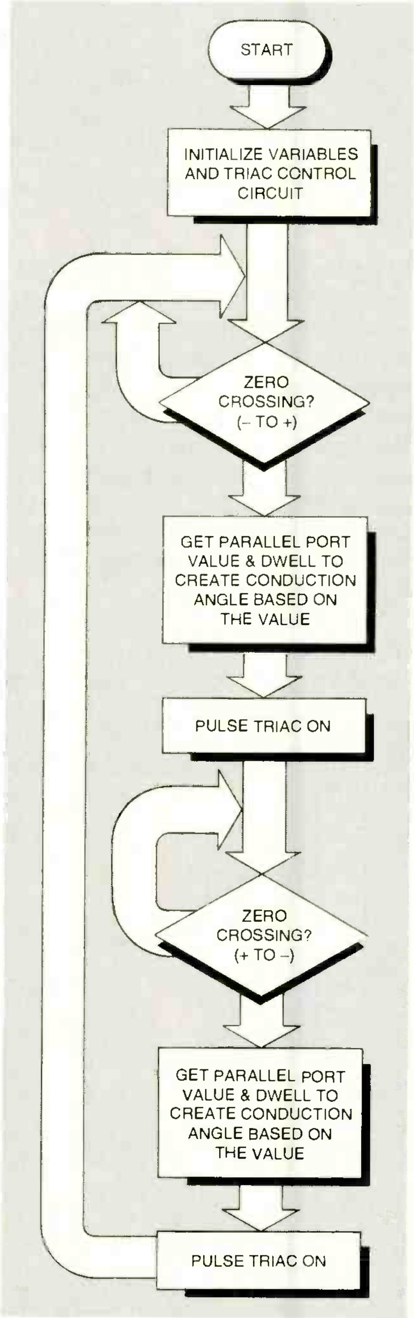
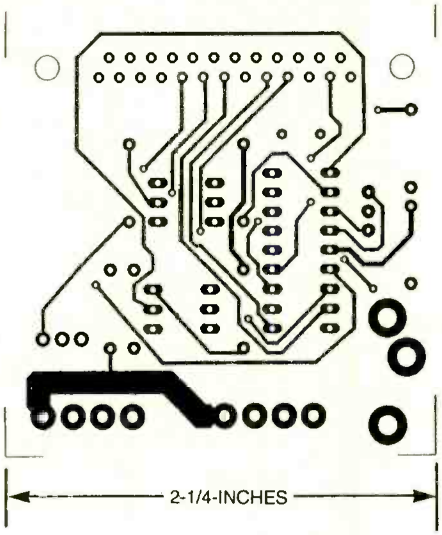


Fig. 5. The software for The Parallel-Port Controller is a simple loop that watches for the zero-crossing indicator, reads the delay time from the parallel port, and calculates how long to wait before turning the Triac on. The calculation also takes the delay effects of the sensing circuit into account.



Here's the foil pattern for the component side of the Parallel-Port Controller.

THE PARALLEL PORT

Prior to 1994, the interface to parallel ports was not formally standardized other than the information released by IBM when the first PC came out in the early 1980s. That lead to some frustration when trying to develop devices that could be used universally on different computers. In 1994, a formal standard, IEEE 1284-1994, was developed that defined the electrical, physical, and logical standards for the parallel port. That standardization eliminated many of the problems connected with designing hardware that could be used on any machine reliably. However, even today you will find hardware vendors that do not adhere to the IEEE 1284 standard—still making interfacing to a particular parallel port a process full of testing and guesswork.

The IEEE 1284-1994 Standard defines 5 modes of operation:

1. Compatibility Mode
2. Nibble Mode
3. Byte Mode
4. EPP (Enhanced Parallel Port) Mode
5. ECP (Extended Capabilities Port) Mode

The idea was to create a new standard that improved performance (speed and control) over the existing parallel-port specification, while at the same time maintaining backward comparability. The compatibility, nibble, and byte modes can use the original hardware without any redesigning needed; they are collectively referred to as the SPP (standard parallel port) mode. The EPP and ECP modes are improved performance modes that imply backward comparability with the earlier SPP standard.

The compatibility mode is also referred to as the "Centronics" (named after the printer manufacturer that devised the hardware connector and pinout specifications) mode and is a write-only specification. In that mode, data can be transferred from the computer to a device at a maximum rate of 150 bytes per second. The nibble and byte modes are used for read operations and transfer data from external devices to the computer at a speed similar to the compatibility mode. All three of those standards use software handshaking techniques, which is responsible for their relatively low transfer rates. The EPP and ECP modes rely on additional hardware that is used for handshaking. That means that fewer I/O instructions are needed to transfer the same amount of data—increasing the data-transfer rate up to about two megabyte per second. The ECP has the additional advantages of *direct-memory access* (DMA) capability, which eliminates the I/O bottleneck and gives the port direct access to the microprocessor bus. In addition, ECP mode utilizes *run-length-encoded* (RLE) data compression to improve the overall speed of data transfer.

The connector standard specified by IEEE 1284 will work physically with SPP-, EPP, and ECP-mode devices. However, the logical pin assignments are different for the three modes, and are backward compatible from the ECP mode. In other words, SPP-mode devices will work with SPP-, EPC-, and EPP-mode interface boards. The EPP-mode devices will work with both EPP- and ECP-mode interface boards, and the ECP-mode devices only work with ECP-mode interface boards.

nut will not touch any of the PC board traces.

Microcontroller IC1 will have to be programmed before installing it in the circuit. Note that object code has not been supplied—only source code. That source code will have to be "compiled" into the numbers that IC1 will recognize as machine-code instructions. While it is tempting to "tinker" with the program, it is a good idea to compile the original source code first. Once the Parallel-Port Controller is working, modifications will no doubt suggest themselves to the person who has the knowledge and ability to rewrite the program. Again, those topics are beyond the scope of this article.

Follow the parts-placement diagram in Fig. 6. Before mounting J1 and J2, it's a good idea to "key" the two connectors in order to prevent anyone from accidentally attaching the AC voltage source to the wrong connector. Clip the fourth pin from J1 and the third pin from J2.

An important consideration is that all of the components be below the height of J3. When mounting TR1, bend the leads over so that the component lies flat on the PC board. Sockets can be used for the integrated circuits; their use will not make the height of the components excessive as long as low-profile sockets are used.

The plastic shields are held in place with screws and nuts. Start by placing the screws through the shield that will protect the solder side of the PC board. Use nuts to tighten the screws in place. Next, place the PC board over the screws. Run another nut down the screw that is between J1 and J2. The height of the nut should match the height of J3. Place the upper shield over the screws and tighten it down with three additional nuts. The whole unit will become a solid assembly.

Testing. Checking the Parallel-Port Controller can be done without writing a single line of code by using the old MS-DOS utility DEBUG. That programming utility still exists in today's operating systems; it can be found in the WINDOWS\COMMAND folder under Windows 95 or Windows 98.

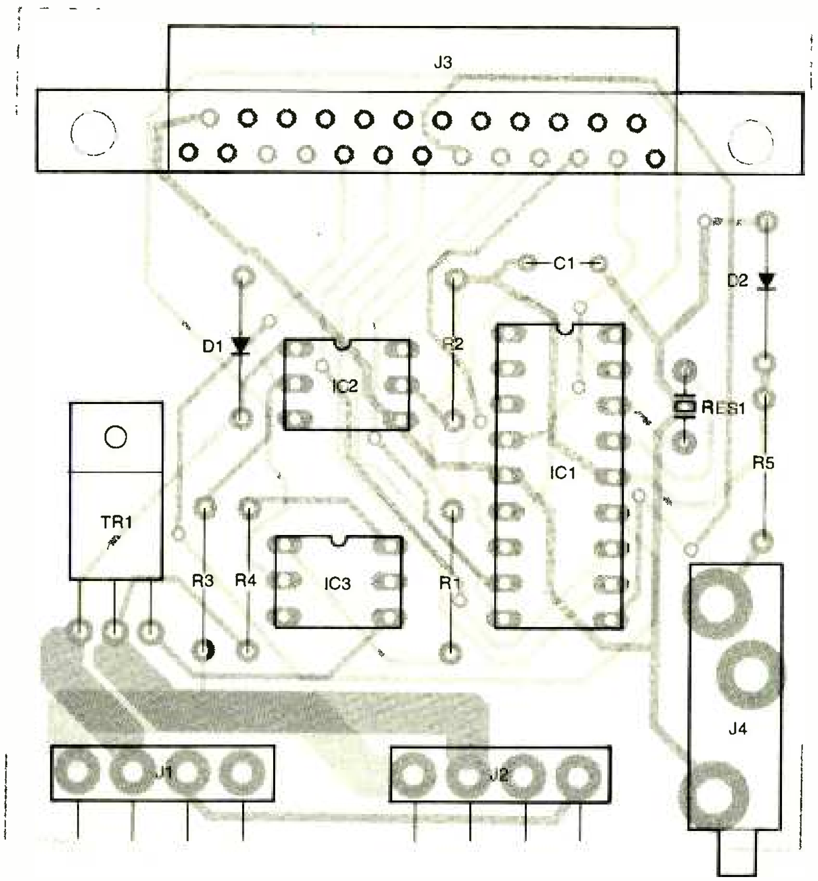


Fig. 6. The Parallel-Port Controller is a very simple device to build, thanks to the use of a pre-programmed microcontroller.

To test the Parallel-Port Controller, plug the controller directly into the PC's parallel port (LPT1) or use a 25-pin extension cable between the controller and the PC. Using an extension cable has the advantage of making the controller more accessible, which can be a big help if any troubleshooting is needed.

Connect a common lamp to J1; be sure that the lamp switch is on and that the bulb is good. Carefully connect a 110-volt AC cable to J2 and to a 110-volt outlet. Start DEBUG by going to a DOS prompt (or opening a DOS window). Change to a directory that contains the debug program and type DEBUG at the DOS prompt. Debug will respond to the command with a prompt of its own (-). That is known as the *debug prompt* (as opposed to the more familiar DOS prompt). At the debug prompt, you will type a simple output port command to send hexadecimal values between 00 and FF to LPT1. The command to turn the lamp full on is:

o 378,0

To turn the lamp full off again is:

o 378,ff

The command starts with the letter "o" followed by a space and the address of the printer port. If you are using LPT1, the address is 378; for LPT2, it is 278. Separate the data from the address with a comma. Any number between 00 and ff (hex) in the output port command will vary the intensity of the lamp between full on and full off. Try several values; remember that the higher the value, the dimmer the lamp.

With the Parallel-Port Controller working, you can now control the world from your desktop...or at least a few handy appliances! Ω

THE REAL McTUBE

(continued from page 35)

McTube will make it easier to get consistent sounds, but will also greatly affect the change of sound with varying dynamics. If you have multiple effects, experiment with the various combinations. Where you place The Real McTube in your chain of effects will have a lot to do with the final sound.

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The circuit is extremely forgiving. Feel free to experiment with the values of the various components. Use the values shown as a starting point, and experiment. As a word of caution, however, it is a good idea not to use a value for R4 and R6 lower than about 22,000 ohms. That will prevent possible damage to the tube or power supply.

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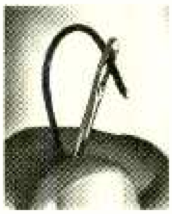

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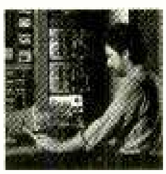

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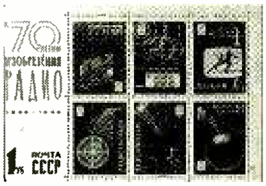

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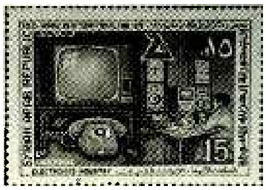
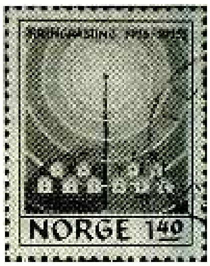




The history of the world can be seen through postage stamps, and that includes nearly every significant event and individual involved in radio.

JAMES E. BIE and
RAYMOND SCHUESSLER

Ever since England issued the first postage stamp over 150 years ago, postmaster generals from around the globe have commemorated the great events and people of history in stamps. Those accorded such a distinction have a permanent niche in world history. In fact, stamps have become such a depository of historical data that, if archaeologists from some future civilization excavated a 20th-century stamp collection, they would be able to deduce from it the importance of an individual or an event in our society.

Therefore, considering the important role radio has played in world events and how dramatically the technology has altered civilization over the past century, it is hardly surprising that you can find a detailed pictorial history of radio in the postage stamps of the world.

A Who's Who of Radio. The individuals and advances that have marked the history of radio certainly deserve such an accolade, and the contributors to the phenomenon read like a Who's Who of Great Scientists. Stamps have been issued to commemorate Hertz, Armstrong, Branly, Fessenden, and more (see Fig. 1).

Even the question of who invented radio is "debated" in stamps. Guglielmo Marconi, pictured on a Radio Centennial stamp issued in Ireland and shown in Fig. 2, is credited by many with the invention of radio. However, that claim does not go unchallenged.

Russia has always stood firm in its claim that Aleksandr Popov invented radio. They issued stamps honoring his accomplishments in 1925, 1927, 1945, 1949, 1955, 1959, and a new centennial stamp in 1995. On the colorful example from 1989 shown in Fig. 3, Popov is seen demonstrating his wireless transmission device to government and academic dignitaries at the University of St. Petersburg.

Radio in Times of Trouble. While stamps are used to celebrate humanity's achievements, they can also be used to serve as a reminder of our darkest hours. For example, three stamps in Fig 4, from South Africa, Germany, and the Soviet Union, illustrate a variety of war-time radio operations. Radio's use in international crime fighting is illustrated

Fig. 1. Stamps often commemorate the great individuals and their achievements. Shown here are stamps that honor Hertz, Armstrong, Branly, and Fessenden.

on a 1973 Austrian stamp that shows a grim-faced Interpol operator (see Fig. 5).

Radio can play a key role in life saving operations. The stamp in Fig. 6 shows an ambulance driver radioing information to a hospital. The stamp was issued in Grenada as part of the 1983 World Communications Year.

Combining Your Hobbies. In a short article like this, we can only touch on some of the hundreds of radio-related stamps issued by the many countries of the World. If we've whetted you interest, the rest is up to you. There are many ways to learn more and perhaps gain a second hobby.

Fig. 2. Italian Guglielmo Marconi, shown here on an Irish stamp, is credited by most with the invention of radio.

The best place to start might be your local library. There you can peruse the *Scott Catalog of Stamps,* which lists and often illustrates all the stamps of the world ever issued. The catalog is revised annually to include all new stamps and price changes. Jot down the call number for the stamps you are interested in for later reference.

While at the library, you might want to look at issues of a stamp newspaper such as *Linn's Stamp News* (P.O. Box 29, Sidney, OH 45365; Web: www.linns.com) and find dealers who specialize in the countries whose stamps you need. These papers also contain data on all new stamps being planned and those just released.

Fig. 3. Marconi's claim is challenged by the supporters of Aleksandr Popov, shown demonstrating his radio apparatus in this stamp issued in 1989 by the former Soviet Union.

You also should visit a local stamp shop. By seeing first-hand all there is to see, you will begin to appreciate the infinite variety of stamps, the prices involved, and the equipment available to accommodate your collection.

Stamp collecting is twice as much fun when you can talk and swap stamps with other collectors. The best way to start is to join a local stamp club. Most stamp clubs will make you a welcome visitor. Sit in on a few meetings. See it all for yourself and get reliable information from these experts. You can

Fig. 4. As commemorated by these stamps, radio is a vital part of wartime operations.

Fig. 5. This Austrian stamp illustrates radio's use in the hunt for international criminals.

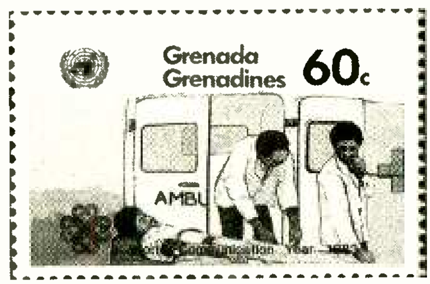


Fig. 6. Radio can play a key role in life saving operations, as shown in this stamp issued by Grenada.

find information on local stamp clubs from your town newspaper or you local stamp shop.

Stamps are a great way to learn about history, appreciate art, or just have fun. And while you might think that the worlds of radio and stamp collecting are as far removed as can be, as we've just shown, nothing could be further from the truth. Ω

BY DON LANCASTER

Measuring Luminosity, Hydrogen Absurdities Exposed, and A Remote Control For Your Cat

WE SEEM TO HAVE A WILD MIX OF TOPICS THIS MONTH, SO LET US JUST JUMP RIGHT IN. WE MIGHT START OUR QUEST BY LOOKING AT . . . .

Visual Luminosity

Light is electromagnetic radiation at incredibly high frequencies. It occupies just under an octave's bandwidth, ranging from high-frequency blue, which has a wavelength of around 400 nanometers, to low-frequency red, which has a wavelength of somewhat under 700 nanometers.

Things get real sticky in a hurry when you try to measure light. Do you, as an astronomer, want to know the exact amount of energy received? If so, you should be interested in the brightness of a source. If, instead, as an architect, you'll want to know the amount of energy perceived by the human eye, then you are interested in the luminosity of a source.

The human eye long ago adapted itself to center its response on solar radiation, combined with foliage and sky reflections. Figure 1 shows the Standard Observer Luminosity Curve, otherwise known as the "standard eyeball". We see that the eye is best at seeing green and poorer at red and blue, tapering off to zero at the visual band limits. Crudely, it takes five or so parts of blue or two parts of red to equal one part of green. Here is a more specific (but rather phosphor-dependent) formula used by PostScript and NTSC TV:

gray = 0.60 green + 0.29 red + 0.11 blue

A luminosity-measuring scheme is shown in Fig. 2. You focus upon the intended surface or source and then run through a special calibrated filter that converts "raw" broadband sensor response into the desired CIE response. Calibration curves are carefully provided for each sensor.

The Tektronix J6523 narrow-angle luminance probe is a good example of the instruments used for this application. It can be used with their J-16 digital photometer, or else can be adapted to most any DVM or data acquisition system. More information on this potent instrument front end appears at www.tinaja.com/bargte01.html, and more information on getting colors to print properly as grays is found at www.tinaja.com/acrob01.html

Shattering Some Hydrogen Myths

There's some outrageous postings knocking around the Web these days. Of course, I feel I must comment on some of them. Two involve hydrogen energy, so let's take a closer look.

The first claim is that if you ignite a stochiometric mixture of hydrogen and oxygen, instead of exploding, an "implosion" occurs and a vacuum of sixty three inches of mercury results! Well, a vacuum is simply nothing. There's no known way to get less than nothing. Yes, you might be able to owe money but no way is known to owe mass.

Package a one-square-inch column of all the air directly above you and weigh it under earth gravity. You'll find it measures something like 14.7 pounds, which is equal to around 39 inches of mercury or 32 feet of water.

Now, empty a solid box, creating a "fairly good" vacuum. The resulting pressure will be 14.7 psi. Now build a "darn good" vacuum. How does the pressure on the box change? So little that you'll barely notice!

Next, build up a "perfect" vacuum. Your pressure will change even less. Since you can't get less than nothing, no way can you get a vacuum better than 39 inches of mercury.

For similar reasons, the ultimate limit on a lift pump or a drafting fire engine is 32 feet at sea level. But in practice, 24 feet is the best you will usually be able to do. You can't suck out something that is not there!

Wait—it gets even worse. Put some water in your reduced pressure box. A fraction of your liquid water should rapidly convert to vapor. Figure 3 shows you how the vapor pressure of water varies with temperature. Somewhat above room temperature, the vapor pressure of water is around one pound per square inch.

Thus, there is no way to create a vacuum of less than one psi in any box that still contains warm liquid water! That's especially true if the only activity creating the reduced pressure in the first place is water condensation.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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

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

What about the implosion part? What usually happens is a normal explosion sometimes followed up by condensation of the vapor into liquid water. Yes, the final pressure can end up less than atmospheric. But if you repeat this experiment several times, things will warm up, and this curious reduced pressure disappears. Above the boiling point of water, you will usually get an explosion only.

This sometimes reduced pressure can create severe safety problems, especially when an unarrested flame gets sucked back into a tank, hoses, or an electrolyzer. One "free energy" proponent recently and dramatically verified this experiment.

Much more on amateur vacuum techniques is in Steve Hansen's Bell Jar and at his supporting Web site, www.tiac.net/users/shansen/belljar

Another outrageous claim is that it is simple, cheap, and easy for solar electricity to generate hydrogen. Yes, solar cells output low voltage DC, electrolysis needs low voltage DC, and hydrogen storage nicely averages out day and night. So the two eventually should provide an interesting match. We saw how the NREL paper in *Science* for April 17, 1998, pp. 425-427 doubled the usual solar-to-H2 efficiency in a direct conversion process, but still using only uneconomic materials.

Sadly, generating hydrogen is not the problem. There's much better and cheaper ways to make hydrogen that do not use water electrolysis. Your key unsolved problems are dense and efficient storage, user-safety issues, and long-life engines or cost-effective fuel cells. Nonetheless, let us run a quick reality check:

Say you have a large 400-watt solar panel? How much hydrogen can you generate how fast? Well there's 9600 watt-hours per liter in gasoline, and 3.5 watt-hours energy per liter in STP hydrogen. Allowing for inefficiency, figure around 15 kilowatt hours off the panel for the hydrogen equivalent of one liter of gasoline, or well over one week per hydrogen equivalent gallon of gas—weather permitting!

The key problem here is that solar energy is very diffuse and inefficient. Hydrogen energy is also diffuse and inefficient. Combining them using today's tools only makes things much worse. Today, solar electrical energy is much too valuable to waste on water electrolysis, but keep on trying, anyway. More hydrogen tutorials and links can be found at www.tinaja.com/h2gas01.html

I Taut I Taw A Puddy Tat

The Catfinder from Curtis Electro Devices is a cute new variation on midrange remote controls. You have a small four-channel UHF handheld transmitter and up to four miniature beeping

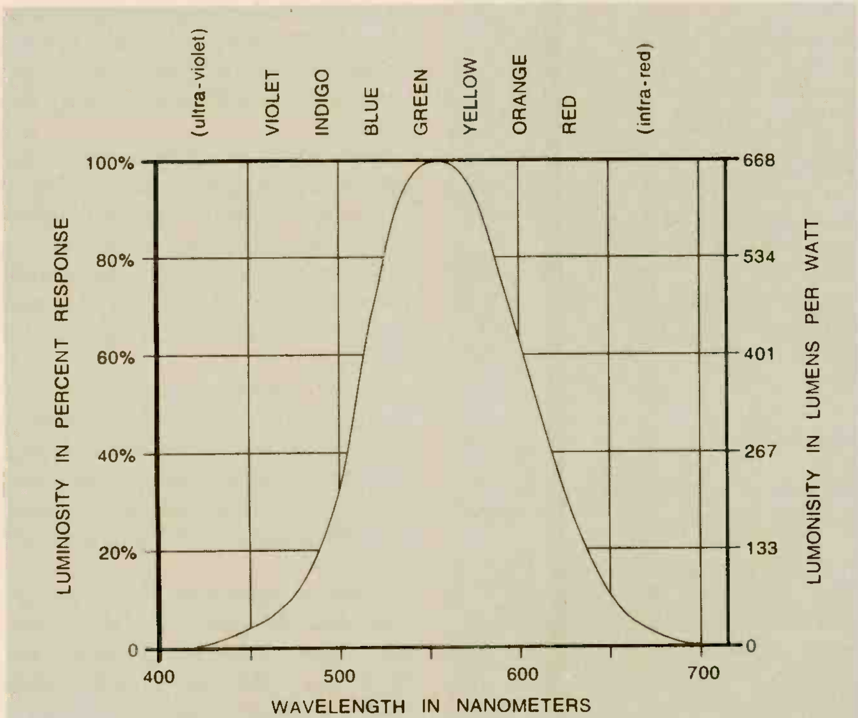


FIG. 1—THIS STANDARD LUMINOSITY CURVE shows how human perception of light intensity varies with color and frequency.

receivers. By attaching the receiver to the cat's collar, you can find Percival Pussival whenever it is time for his bath or a trip to the vet. There's also an 800 tracking number and registration should your cat get stolen, lost, or wander off.

The unit is also useful for people who continuously lose stuff, such as remote controls. You simply attach a receiver onto your TV remote and it beeps when you press the Catfinder controller. There's also potential here for wandering grandmothers, smaller children, or disability aides.

The price is $29 for the controller and one receiver, plus $15 for each extra receiver. Receivers are programmed to a particular channel during power up. You hold the selected transmitter button down while you insert the battery into the receiver. The receiver double beeps when programming is complete. The claimed range is fifty to seventy feet, which would cover nearly half an acre. But my own tests did not deliver nearly that range.

I did not look too close, but the circuitry probably works in the typical 350-MHz remote control band. The receivers are superregenerative, or possibly something newer and better, such as time-gated TRF.

The latest versions are now newly waterproofed. Seems the cats quickly discovered that they could defeat the Catfinder by soaking it in their water dish. The issues of finding the cat to install the Catfinder or losing your Catfinder remote have not been addressed.

NAMES AND NUMBERS

Advance Transformer
10275 W Higgins Rd.
Rosemont, IL 60018
(708) 390-5000

Aremco
PO Box 429
Ossining, NY 10562
(914) 762-0685

Bell Jar
35 Windsor Dr.
Amherst, NH 03031
(603) 429-0948

Biomass & Bioenergy
PO Box 882
New York, NY 10159
(212) 633-3730

Curtis Catfinder
4345 Pacific Street
Rocklin, CA 95677
(800) 337-0901

Figaro
3703 W. Lake Ave., Ste. 203
Glenview, IL 60025
(847) 832-1701

Infotronix
PO Box 2045
Waterbury, CT 06722
(203) 756-6376

International Rectifier
233 Kansas St.
El Segundo, CA 90245
(310) 322-3331

Machine Design
1100 Superior Ave.
Cleveland, OH 44144
(216) 696-7000

Maxim
120 San Gabriel Dr.
Sunnyvale, CA 94086
(800) 998-8800

Microchip Technology
2355 W Chandler Blvd.
Chandler, AZ 85224
(602) 786-7200

Science/AAAS
1333 H St. NW
Washington, DC 20005
(202) 326-6400

Space-Time Productions
219 N Vale Ave.
Rockford, IL 61107

SPIE
PO Box 10
Bellingham, WA 98227
(206) 676-3290

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

Tektronix
PO Box 500
Beaverton, OR 97077
(800) 835-9433

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

Ultra Technology
2512 10th Street
Berkeley, CA 94710
(510) 838-2149

Vacuum Tube Valley
1095 E Duane Ave. Ste. 106
Sunnyvale, CA 94086
(408) 733-6146

Xilinx
2100 Logic Dr.
San Jose, CA 95124
(800) 244-7778

Catfinder Contest

The Catfinder folks have agreed to a special contest just for readers of this column. Just tell them something unique or unusual you would like to do with one or more Catfinders. They will promptly award a dozen or more free systems to the best entrants.

There's some unique opportunities here, so let's hear them. Send your written entries to John Curtis at the Curtis Catfinder address in the "Names And Numbers" box, or e-mail: jgcurtis@inreach.com

Please note that this is different from our usual contests, so please do NOT send your entries to me, Synergetics, or **Electronics Now** Magazine.

Some Tesla Books

As our resource sidebar for this month, I've gathered together a few of the more credible books that are by or about Nikola Tesla. Tesla's development of AC-power distribution, induction motors, and transformers was absolutely brilliant. His latter-day involvement with "free energy" and "earth resonant" sources clearly was not.

Tesla was quite strong in the lab but very weak in underlying theories. While he did experiment with radio and fluorescent lamps, so did many others. Sadly, a fundamentally wrong confusion between a resonant stored energy and actual sourced energy did seem to prevail in his later work.

Sorely misguided latter-day cultists have tried to deify Tesla, claiming lost secrets suppressed by the men in black, free-energy results, and even extra-terrestrial origins. Believable hard evidence for these outrageous claims has not been forthcoming.

Building one of those "lots of sparks" Tesla coils was once a rite of passage for techno-nerds who could not understand or afford girls. But these days, Tesla coils are just an illegal way of taking out a neighbor's TV set. Thousands of man hours of continuing research in EHV transmission and color TV and monitor

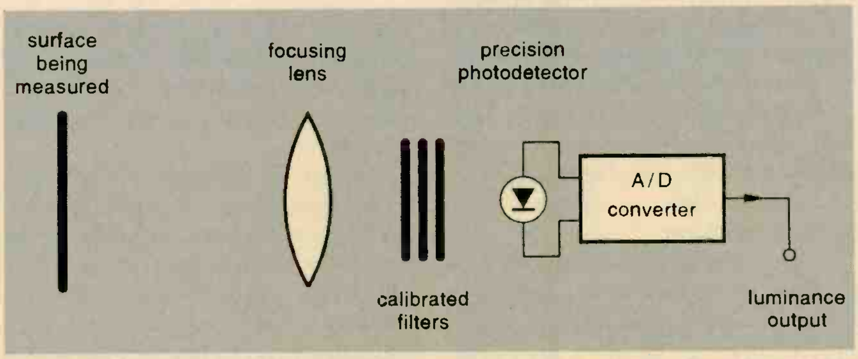


FIG. 2—LUMINOSITY IS MEASURED by imaging a surface, careful filtering, precision photodetection, and A/D conversion. The Tektronix J6523 is a typical instrument front end.

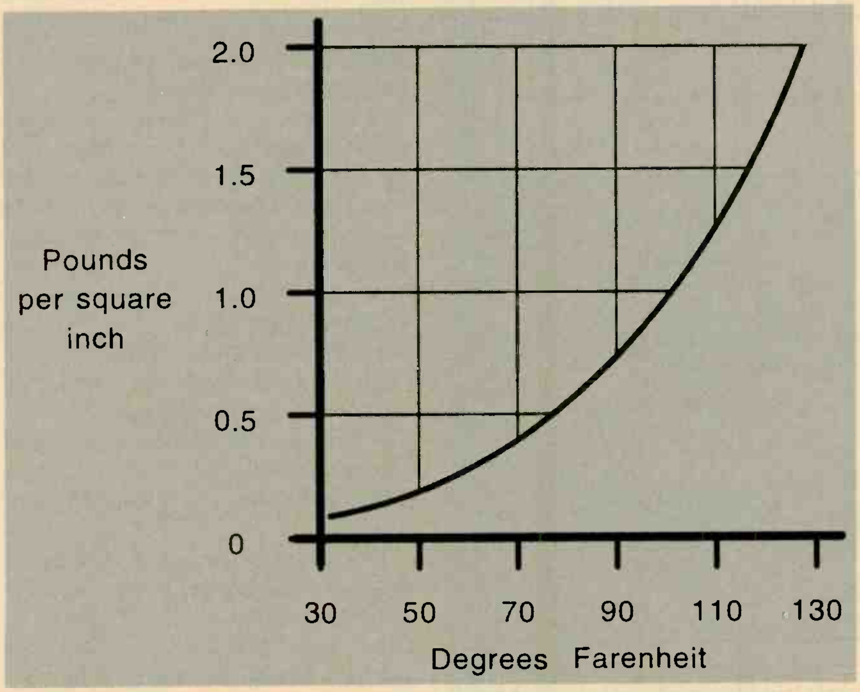


FIG. 3—HOW THE VAPOR PRESSURE OF WATER varies with temperature is shown here. When warm water remains present, only a weak vacuum can be created.

deflection leaves very little wiggle room for very much new or exciting. Other Tesla developments (such as bladeless turbines) largely remain inefficient lab curiosities.

Did Tesla get the credit he rightly and surely deserved? For openers, having a fundamental magnetic measurement unit named after you ain't half bad. Innovative originators rarely are recognized. For instance, powered human-attended heavier-than-air flight first originated in Australia. The most important thing the Wright brothers did was set back American aviation for decades through all their interminable patent battles on obsolete technology.

It seems that Edison had an aggressive propaganda mill that clearly forced Tesla out of the limelight. And for a crucial time, the US was at war with Tesla's native country.

Ongoing information on new titles can be located at www.tinaja.com/amlink01.html Always start with the books by Tesla, rather than about him.

Log Graph Paper

A long-time Web site visitor asked me to repeat how to create your own log, semilog, or other graph paper by using PostScript. Some sample code is shown in Fig. 4. A more detailed example can be found in HACK59.PDF on my Web site.

What I really find amazing about a PostScript plot or graph is that it can easily do the underlying math. For instance, the Web version of Fig. 1 actually calculates out the luminosity curve, giving good color matches. Decibel conversions, of course, end up trivial. Most of the fancy plots you see in these columns are in fact calculated directly from theory. This can be done once under PostScript-as-language and then is shoved into Distiller to make a fast (and calculation free) final image.

I've shown the code here in "raw" PostScript. My own PostScript "gonzo" utilities would normally be used to add power and convenience.

PostScript can be a superb general-purpose computer language that is easy to use and scads of fun to play with, especially for graphics, video, and robotics. Additional details are found at www.tinaja.com/post01.html and www.tinaja.com/acrob01.html

BOOKS ON OR ABOUT NIKOLA TESLA

My Inventions (Nikola Tesla)
Advances in Tesla Technology (Nick Begich)
Fantastic Inventions of Nikola Tesla (David Hatcher)
In Search of Nikola Tesla (David Peat)
Nikola Tesla: A Spark of Genius (Carol Donnermuth-Costa)
Nikola Tesla's Earthquake Machine (Dale Pond)
Nikola Tesla Returns (Robert Reichtman)
Streams of Lenard and Roentgen (Nikola Tesla)
TCBA Guide to the Colorado Springs Notes (Richard Hull)
Tesla: Man Out of Time (Margaret Cheney)
Wizard: The Life and Times of Nikola Tesla (Marc Seifer)

New Tech Lit

From Texas Instruments, there's the new Convert Analog data CD. And from Microchip Technology, comes a new update of their Technical Library CD.

I just got wind of a new scheme that lets you design your own custom microprocessors, microcontrollers, or DSPs—ones that do your things your way. The trick is to start with a large and cheap programmable gate array, such as the XC4005L from Xilinx or others. It turns out there is an outfit called Space-Time Productions who provide evaluation and configuration cards, along with lots of free support software in the form of a Forth-based scripting language. More DYOP details can be found at www.tefbbs.com/spacetime/index.html One DYOP distributor is Ultra Technology, whose Web site is found at www.dnai.com/~jfox/store.htm I'll try to do a lot more on this one after I find time for a closer look.

Some interesting castable ceramic products and materials are provided by Aremco, while a wide range of gas sensors is offered by Figaro.

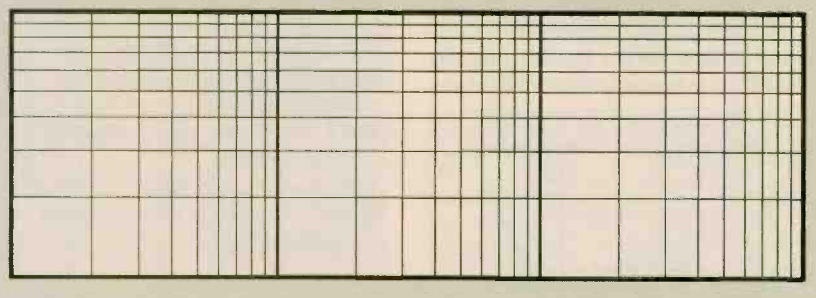
SPIE is a little-known and low-profile outfit that puts on conferences and resells great heaping bunches of first-rate optical and sensing technical papers and tutorials.

Low Cost Electronics Projects is a new Fred Blechman book. Details at www.tinaja.com/amlink01.html

Information on tiny gas turbines small enough to easily and efficiently replace a size D flashlight cell appeared on page 8 in the October, 8, 1998 issue of *Machine Design*. A typical premium flashlight cell offers 50-watt-hours of energy per liter; gasoline can offer 9600.

A new electrical safety site is up at www.safetylink.com

Fluorescent lamp dimmers with a full dimming range are newly offered by Advance. A MAX1005 sampler IC for digital radio downconversion has been announced by Maxim. Lots of possibilities here.



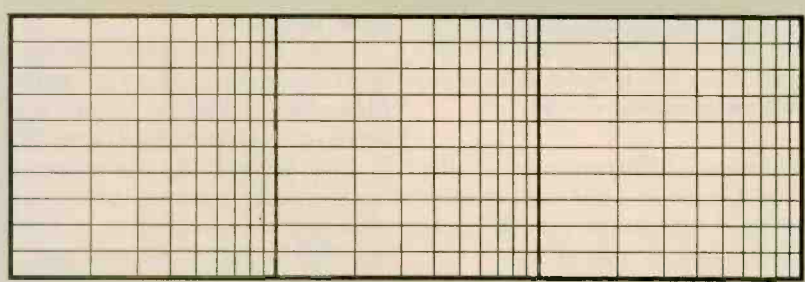
```
gsave 100 100 translate 10 dup scale      % position and scale

72 600 div setlinewidth                   % draw log lines
1 1 10 {log 10 mul 0 moveto 0 10 rlineto stroke} for
10 10 100 {log 10 mul 0 moveto 0 10 rlineto stroke} for
100 100 1000 {log 10 mul 0 moveto 0 10 rlineto stroke} for
1 1 10{log 10 mul 0 exch moveto 30 0 rlineto stroke} for

72 300 div setlinewidth                   % emphasize decades
10 0 moveto 0 10 rlineto stroke
20 0 moveto 0 10 rlineto stroke

72 150 div setlinewidth                   % emphasize outlines
0 0 moveto 0 10 rlineto 30 0 rlineto 0 -10 rlineto closepath stroke
grestore

showpage
```



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gsave 100 100 translate 10 dup scale      % position and scale

72 600 div setlinewidth                   % draw log lines
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10 10 100 {log 10 mul 0 moveto 0 10 rlineto stroke} for
100 100 1000 {log 10 mul 0 moveto 0 10 rlineto stroke} for
1 1 10{0 exch moveto 30 0 rlineto stroke} for

72 300 div setlinewidth                   % emphasize decades
10 0 moveto 0 10 rlineto stroke
20 0 moveto 0 10 rlineto stroke

72 150 div setlinewidth                   % emphasize outlines
0 0 moveto 0 10 rlineto 30 0 rlineto 0 -10 rlineto closepath stroke
grestore

showpage
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FIG. 4—HERE'S THE POSTSCRIPT CODE you can use to make log and semilog graph paper.

Biomass & Bioenergy is a scholarly journal from Elsevier. *Vacuum Tube Valley* has an interesting and useful mix of historic and modern vacuum tube stuff in it. One useful source for antique amateur and amateur radio manuals is Infotronix. More details on finding tech manuals in general are at www.tinaja.com/resbn01.html

Free samples of FETKY miniature powerMOS transistors can be obtained from International Rectifier.

For the insider secrets of easily designing your own op-amp filters, read my *Active Filter Cookbook*, either by itself or as a portion of my Lancaster Classics Library. Find more details per my nearby Synergetics ad.

Latest Web-site additions include Webmastering secrets, new "virtual ways" Hexapod robotic links, 24/7 publishing, a brand new user forum, and much more on military surplus electronics. You'll find all of these at www.tinaja.com/whtnu01.html More on instant technical solutions at www.tinaja.com/info01.html

I've got some great new bargains on my surplus Web page. Everything from Tektronix plug-ins to new AC motors to classic Apple collectibles to load banks for windmill testing. You can pick up your free catalog at www.tinaja.com/bargte01.html

As usual, most of the mentioned items should appear in our Names and Numbers and Books On or About Nikola Tesla sidebars. Be sure to check here before calling our US technical helpline. EN

Let's hear from you.

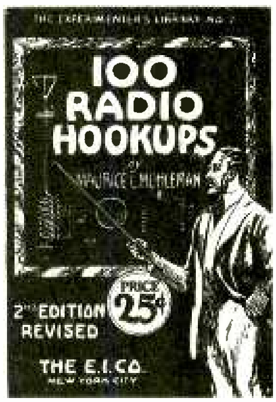
Electronic SHOPPER®

Paperback Books

GREAT BOOKS AT BUDGET PRICES

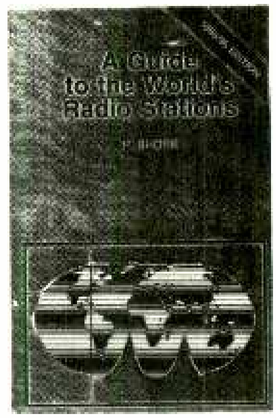
☐ 100 RADIO HOOKUPS —#7—$3.00

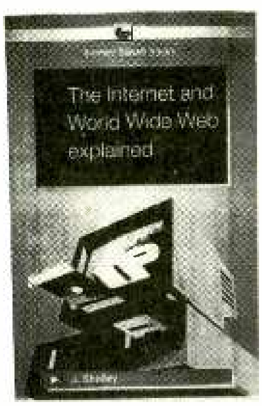
First published in May, 1923 this popular booklet went into reprint editions nine times. It is packed with circuits, theory, antenna installation and tips on consumer radio receivers that were popular in the early 1920's. Antique radio buffs and those inquisitive about the early days of radio will find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



☐ GUIDE TO THE WORLD'S RADIO STATIONS —BP355—$10.99

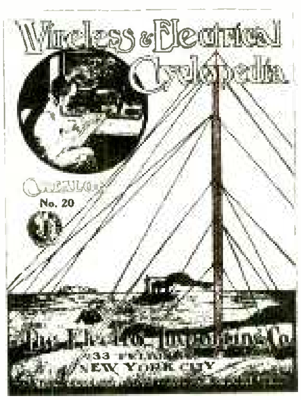
An easy-to-read guide for trhe casual listener and top notch QSL getter! The Guide is an essential reference work designed to steer the listener around the ever more complex radio bands. Listings cover world-wide shortwave stations with a special emphasis on international broadcasts in English. Medium and long-wave listings are also included for the US, Canada, European, Middle and Near East, and North Africa regions





☐ THE INTERNET AND WORLD WIDE WEB EXPLAINED —BP403— $10.99

Strip away the hype and mystery of the WWW and you'll be cruising on the information Superhighway! Understand the jargon used: ftp, protocols, TCP, hypertex, http, URL, home pages, threads, HTML, domains, FAQs, etc. Discover that e-mail is easy, fast and free! Learn how to guard against hackers and viruses. Develop friendships and "buddies" in Singapore, India, Cape Town, Peru—just about anywhere!



☐ WIRELESS & ELECTRICAL CYCLOPEDIA —ETT1—$5.75

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

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ET01

BREAK-THROUGH IN SURFACE MOUNT REWORK

We have put together a very inexpensive package for reworking fine pitch surface mount components with a minimum amount of expertise and technical ability. If you can use a soldering iron effectively, then you can remove and replace most surface mount components fast , effectively and at a very low temperature. You will soon make them look like they have never been replaced. Read on to find out more about this exciting new product.

With the EDSYN soldering iron pictured, or any EDSYN Soldering Iron, and a special EDSYN soldering tip called the Mini-Wave Soldasip®, and the patented SMD-1 rework kit from CHIP QUIK®, most SMD's can be replaced very effectively and inexpensive. CHIP QUIK® alloy (which melts at 136° F), is applied to the solder points of the device. The 136° melting point of the low temperature alloy is mixed with the solder on the chip, to bring the melting point of the mixture much lower than normal, allowing the SMD to be removed with a set of tweezers. Clean-up is then accomplished with the accessories in the kit. After clean-up the IC is aligned and tacked down with regular solder on opposing corners.

The new Mini-Wave Soldasip® tip from EDSYN is a cylindrical tip cut at a 45° angle on the end. The tip end is cupped, or concave, so it will hold solder in the cup. Flux is then applied to the leads of the IC and regular wire solder applied to the cup of the mini-wave tip. Holding the iron at a 45° angle, drag the solder tip parallel to the body of the IC or perpendicular to the leads. The solder in the cup of the tip is then applied to leads of the IC making a permanent bond between the leads and the pads of the PC Board. If bridging occurs, it is usually because of to much solder in the cup. Clean the tip with the sponge and wipe the bridge away from the IC with the tip. If the bridge does not clear, simply apply more flux and repeat the wipe and it will clear.

In my years of experience, I have never seen a more effective way of replacing a surface mount. It also happens to be the most inexpensive. Check out our package price and you will see why I am so excited about this. For more information on this package go to http://www.heinc.com/951sxtp.html.

Five Easy Steps

Apply Flux

Apply Alloy

Remove IC

Clean up Area

Replace IC

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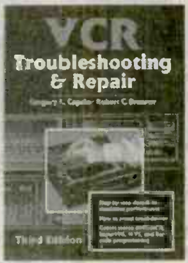

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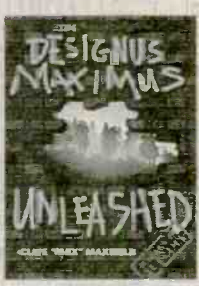

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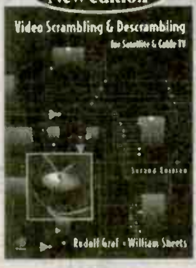

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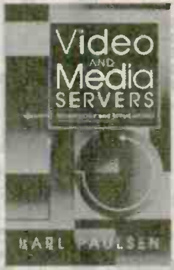

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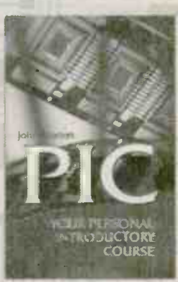

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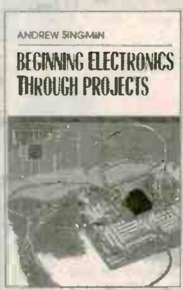

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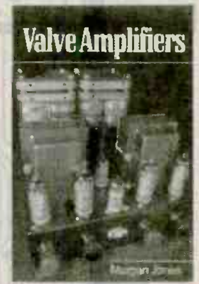

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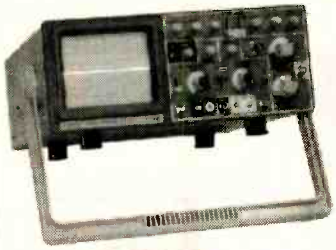

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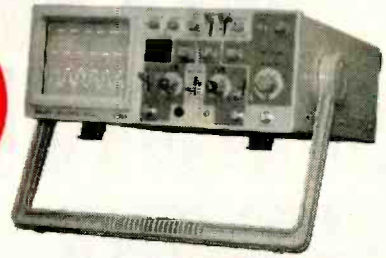

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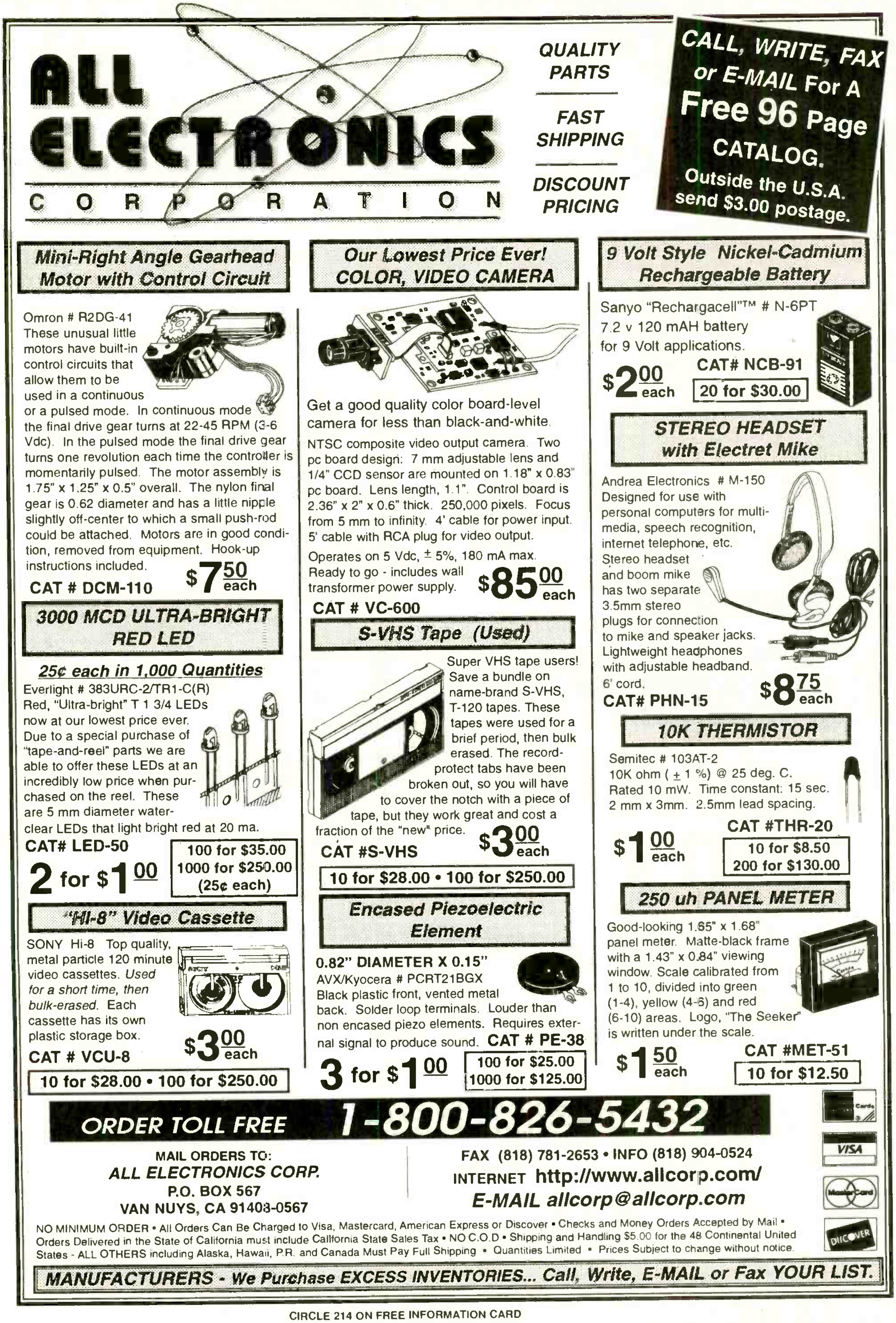

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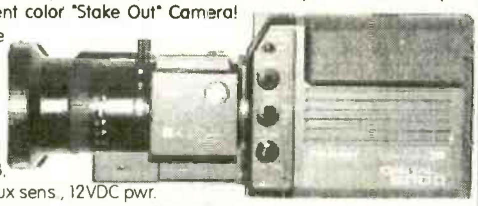

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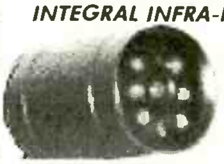

Sleek black anodized, BRASS, housing is O-Ring sealed & WATERPROOF. Adjustabe mount included. Specs: 1/3" CCD, 400 Lines resolution, 0.05 Lux sensitivity, AGC, Auto Shutter. Operates on 12VDC @225mA, 3.6mm, 92° FOV glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25"d. X 2" long. With 60 ft. cable. Great for gen'l outdoor use also. **GM-300K...$199**

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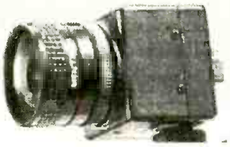

GM412, less lens..$119, GM410, less lens..$169

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WARNING: Don't confuse these models with LOW RESOLUTION, HIGH LUX C-MOS CAMERAS.

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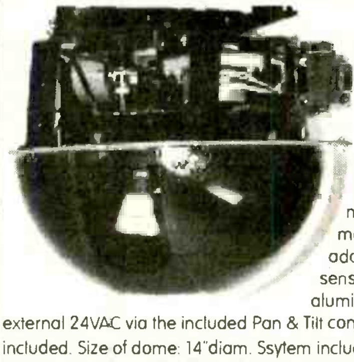

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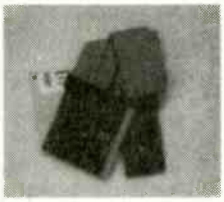

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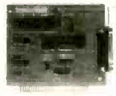

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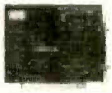

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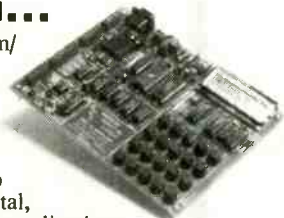

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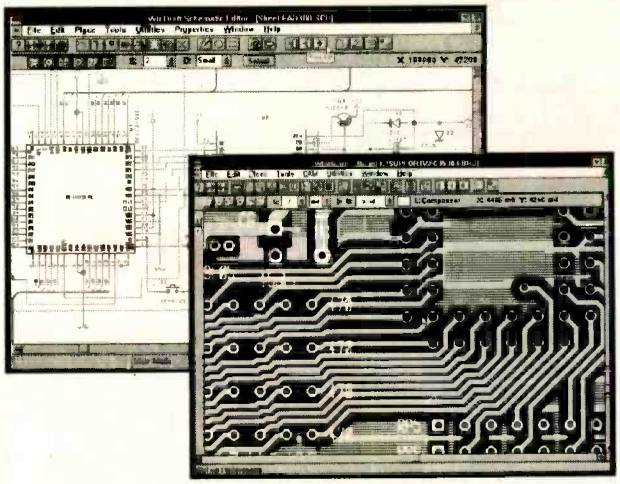

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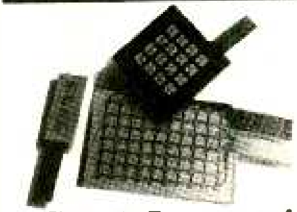

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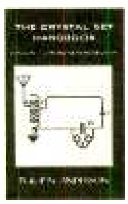

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Protolab 4.0 Software

A low-cost circuit design and simulation software.

- Includes 3.5" diskette and basic instructions
- System requirments: IBM PC 386; 4MB RAM, SVGA graphics, Windows® 3.1 or 95

Part No.	Description	Price
150682	Protolab 4.0 Software	$49.95

Robotics

OWI Robotic Arm Trainer Kit

Five Axis of Motion

Teaches the basic robotic sensing and locomotion principles while testing your motor skills as you build and control the arm. This unit can be commanded or instructed through its five switch wired controller with lights to grab, release, lift, lower, rotate wrist, and pivot sideways.

- 109 pc. kit - Advanced level

Part No.	Description	Price
157366	Robotic Arm Kit	$69.95

Sprockets and Chain

Precision Molded

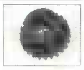
157083/157091

157075

Part No.	Description	Price
157083	9 teeth sprocket, 1/8" bore	$1.49
157091	20 teeth sprocket, 1/4" bore	1.95
157075	Drive chain (12"L)	9.95

48 Pitch Gears

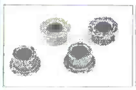
Precision Molded



157139

Part No.	Description	Price
157121	10 teeth, 3/32" bore	$2.95
157139	24 teeth, 3/16" bore	2.95
157147	48 teeth, 1/4" bore	3.95
157155	100 teeth, 1/4" bore	4.95
157112	93 teeth, 3/8" bore for P/N 157104 (below)	4.95
157104	1/4" bore aluminum mounting hub w/ set screws	3.95

Robot Accessories



157198/ 157201

157171

Part No.	Description	Price
157198	1/8" bore bronze wheel bushings for P/N 157219 (below)	$1.95
157201	1/4" bore bronze wheel bushings for P/N 157198	2.19
157171	1/4" x 5.75" axle shaft	4.95

Robot Wheels

(Steering & Drive)

157219

- Extremely high traction foam rubber compound
- For surface use only
- P/N 157219 size: 2.5" x 1.1"
- P/N 157227 size: 2.5" x 2.0" • 2 pack

Part No.	Description	Price
157219	For 1/8" wheel bushing	$19.95
157227	W/locking hubs for .25" shaft	24.95

Test Equipment

Tektronix Analog Oscilloscope

Reconditioned

Offers upgraded performance, improved trace quality, easier maintenance and greater operator flexibility.

- Bandwidth: 100MHz • 2 input channels
- Dual (delayed) time base
- Inlcudes 2 10x voltage probes and instruction manual

Special

Part No.	Product No.	Price
155993	465B	$874.95

BK PRECISION

Power Supply

Reconditioned

- Output: 0–50VDC @ 2A
- Weight: 11 lbs.
- Size: 4.7"W x 12.0"D x 6.8"H

Special

Part No.	Product No.	Price
156013	BK1611	$399.95

HEWLETT PACKARD

General Purpose DC Power Supplies

Reconditioned

- Constant voltage/current operation
- Remote sensing and programming
- Front and rear output terminals
- Floating output – use as positive or negative source

Part No.	Output (V)	Output (A)	Price
156363	0-20	0-3	$399.95
156347	0-10	0-10	489.95
156380	0-40	0-5	749.95

HEWLETT PACKARD

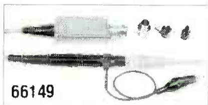
Function Generator

Reconditioned

- Aberrations: <10%
- Frequency range: 0.1Hz–13MHz over 8 decade ranges • Impedance: 50Ω ±10%
- Size: 8.4"W x 14.8"D x 4.0"H • Wt: 13 lbs.

Part No.	Product No.	Price
156312	HP3312A	$899.95

JAMECO Modular Oscilloscope Probes



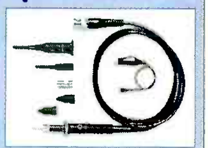
66149

- Standard BNC male connector
- Alligator clip ground wire
- Hook and pointed probe • 5' cable
- Max: 600VDC • Weight: 0.3 lbs.

Part No.	Product No.	1-9	10-24
66149	LF210 (100MHz)	$29.95	$26.95
22891	LF189 (60MHz)	19.95	17.95

Pomona® Accessories

Ocsilloscope Probe Set



These general purpose oscilloscope probes feature high performance for greater flexibility.

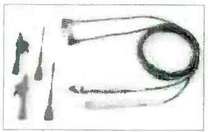
- Risetime: 3.5ns
- Attenuation: X10 • Capacitance: 9.5pF
- Input resistance: 10MΩ • Length: 48"
- Bandwidth: 100MHz (-3dB)
- Compensation range: 10–60pF
- Complete accessory kit included

Special

Part No.	Prod. No.	Description	Price
156443	5795A	X10 probe kit	$34.95

Basic Electronic DMM Test Lead Kit

Kit contains 2 each (black/red)



- 48" leads
- Test probes w/ silicone insulated leads (banana plugs on meter end have no sleeve)
- Slide-on extended tips and alligator clips
- Fits most multimeters and other equipment with banana jacks

Part No.	Prod. No.	Description	Price
155942	5672A	Test lead kit	$22.95

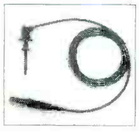
Maxigrabber® Cord Kit

- Kit contains 10 pcs. one each of ten colors: black, brown, red, blue, orange, yellow, green, violet, gray & white • 24" leads

Part No.	Prod. No.	Description	Price
156494	5523	Patch cord	$29.95

Minigrabber® Test Clips

To Straight Sheathed Banana Plug



- 18 AWG silicone insulated wire
- 48" leads
- Rating: 1000V, 5 amps per IEC1010-2-031 CAT III P2

Part No.	Description	Price
156398	Test clip black	$6.95
156401	Test clip red	6.95

Test Lead Holders

155985

- 155985: Max cable dia.: 0.210"
- 155977: Max cable dia.: 0.320"
- 155985: Max cable dia.: 0.450"

Part No.	Color	No. of Slots	Price
155985	Blue	9	$5.95
155969	Black	10	5.95
155969	Orange	14	5.95

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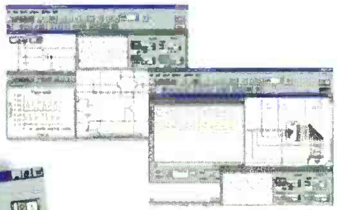

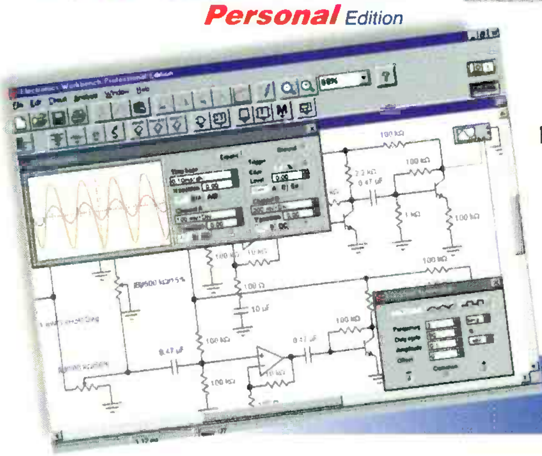

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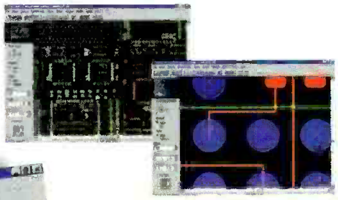

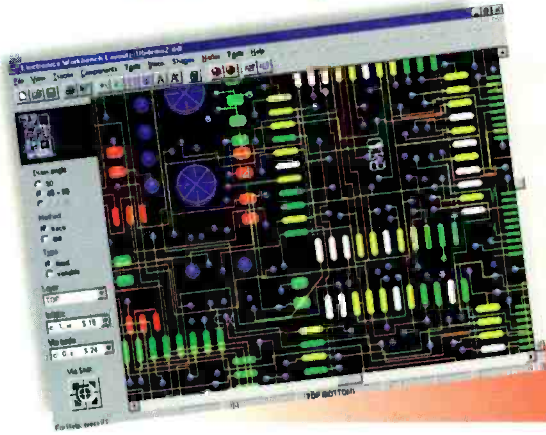

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