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Vol. 69 No. 12

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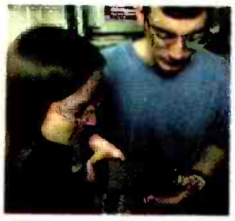

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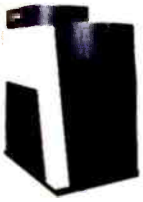

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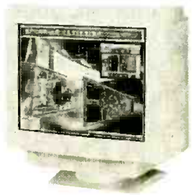

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EDITORIAL

A New Year's Resolution

It's hard to believe that another year is almost gone. I don't know how you feel about that, but I definitely have mixed feelings.

One is good riddance. In a lot of ways, 1998 was a real stinker. Lousy weather, Y2K jitters, lousy politics, lousy behavior by our politicians, lousy media coverage of our politicians and their behavior, lousy . . . well, you get the idea.

The thing is, I'm afraid that 1999 will be worse. For one thing, though it is NOT the true millennium (that will occur on Jan. 1, 2001), the coming of the year 2000 is sure to bring all of the wackos out of the woodwork. Even so-called normal people (who, me?) are likely to be a little disquieted should things get a bit weird out there. The whole thing is silly of course, but people will be people.

Speaking of silly, barring a miracle, the soap opera in Washington is sure to drag on. And, of course, I could complain about the weather, but why bother?

That's not to say that there are not real problems with the coming of 2000. The chief one, and the one that's been getting a LOT of press, is the so-called Y2K "bug." Of course, it's not really a bug—if anything, it is a problem that has cropped up because too many systems have worked satisfactorily for too long. Anyway, companies and governments that have lived by the "if it ain't broke don't fix it" philosophy will be scrambling like mad to update computers and computer-based systems that, in many cases, simply were not designed to work as long as they have. Those that aren't scrambling either had the foresight to look after things before true panic set in, or are resigned to picking up the pieces that will come crashing around their ears when the fateful day comes.

How about you? Are you "Y2K compliant?" Are you sure?

Well, if I haven't completely depressed you by now, let's close with a positive thought: It's a great time to have a hobby like electronics to take your mind off the troubles around you, and it's a great time to have a magazine like **Electronics Now** to help you get the most out of that hobby. And here's a New Year's resolution for 1999: You'll never see the names "Bill" and "Monica" on our pages.

Merry Christmas and Happy New Year!

Carl Laron

Carl Laron
Editor

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

Spam I Am—Not!

Q *You authored an article on Internet ethics in the September, 1997 issue of* **Electronics Now**, *so I am turning to you for advice: I want to make sure that if I open a business as an Internet bulk e-mailer, I'm not violating any laws. Can you help?—Name withheld, CA*

A By bulk e-mailing do you mean "spamming," *i.e.*, sending people advertising that they didn't request? If so, please don't, for two reasons: there's no money in it, and it's universally hated.

If spamming were a legitimate way to advertise, major corporations would be using it. They aren't. The spam we receive is almost invariably from people selling get-rich-quick schemes, pornography, or other dubious products, and 99% of it comes from forged (faked) e-mail addresses—which convinces us right away that the senders are not trustworthy. We see no evidence that any of these people are making money.

More importantly, the Internet community objects very strongly to spam because the costs are paid by the recipients, not the sender. Despite the name, e-mail is more like a collect phone call than a piece of ordinary mail. Spamming may be technically legal, but that doesn't make it popular. Do you really want a million people to consider you a pest? That would ruin your chances of future business success.

By the time you read this, Congress will probably have passed legislation to restrict spam in some way. But Congress is not all you have to fear. Lawyers in several state governments, federal agencies, and private organizations are looking at the spam problem from the standpoint of existing laws. Some common spamming tactics, such as forging e-mail addresses and "stealth mailing" (relaying through other people's computers without their consent), appear to violate existing laws and it's just a matter of time until spammers find themselves on the losing end of expensive lawsuits. What's more, the ads transmitted as spam are often deceptive, and the Federal Trade Commission is conducting a crackdown. See *http://www.ftc.gov* for more information.

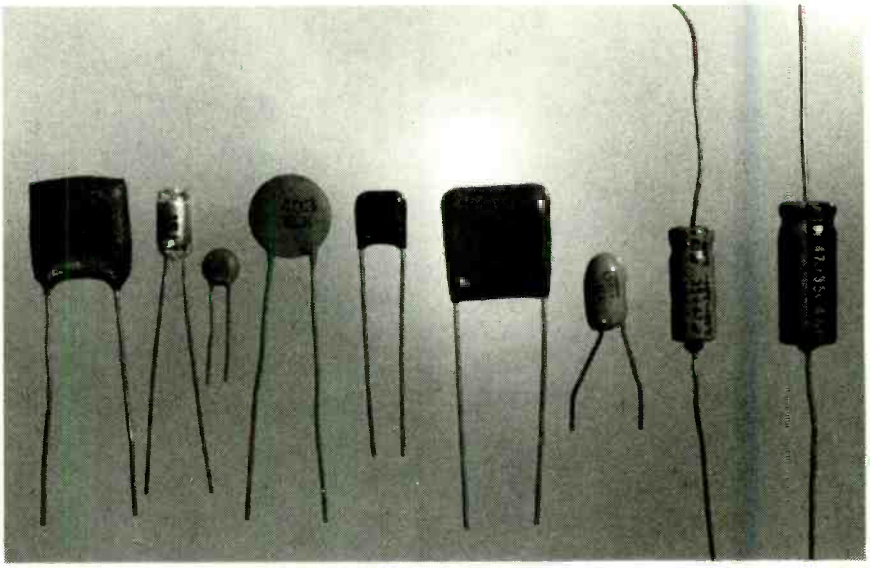


FIG. 1—LEFT TO RIGHT, THE CAPACITORS shown here are silver mica, polystyrene, ceramic disc (2), polyester (2), tantalum electrolytic, and aluminum electrolytic (2).

All Kinds Of Capacitors

Q *There are lots of kinds of capacitors (Mylar, silver mica, monolithic, etc.); how can I recognize them by looking at them, and what are the different types good for? On an electrolytic capacitor, does 16 WVDC mean the same as 16 VDC? What are low-ESR capacitors, and if one is specified, can I use a regular capacitor?—R. A., Toronto, Ontario, Canada*

A As you surmised, no capacitor is perfect, but different kinds have different imperfections. The most important of these are voltage limits, leakage (self-discharge), series resistance (like a resistor in series with the capacitor), and change of capacitance with temperature.

Capacitors are named for the insulating material used between their thin conductive layers. Figure 1 shows some common varieties; those are, from left to right, 330-pF silver mica, 150-pF polystyrene (shiny), 22-pF and 0.4-μF disc ceramic, 0.1-μF and 0.33-μF polyester (Mylar is a Du Pont's brand of polyester), 22-μF tantalum electrolytic, and 4.7- and 47-μF aluminum electrolytics. You can't always identify capacitors at sight; nowadays most of them look like plastic blobs or boxes regardless of internal composition. In older equipment you will find tubular paper capacitors (with a wax coating) and flat mica capacitors, often marked with six circles.

Capacitor values are sometimes marked directly in pF or μF, and sometimes indicated with a three digit code consisting of two digits and the number of zeroes to be added; thus 151 means 150 (15 and 1 zero), and 334 means 330,000 (33 and 4 zeroes). When the three-digit code is used, the value is always in pF (where 1 μF = 1,000,000 pF, so a 1-μF capacitor would be marked 105). In European schematics, you'll also see nanofarads (nF), where 1 nF = 1000 pF.

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

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

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

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

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

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

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

Millifarads (mF) are never used, but µF and pF were formerly abbreviated mF and mmF respectively. A letter indicates tolerance; J is 5% and K is 10%. The three-digit code is also used on resistors and inductors, with values in ohms and microhenries respectively.

The uses of different kinds of capacitors could fill a book. In the middle-value range (say 500 pF to 0.5 µF), polyester capacitors usually perform best, and polystyrene is better yet, but ceramic discs are cheaper and almost always acceptable. Below 500 pF, ceramic-disk, mica, or polystyrene capacitors are usually used, and some of them are marked with specific temperature characteristics, such as N750 (negative 750 parts per million per degree C) or NP0 (negative-positive zero, *i.e.*, as stable as possible).

Electrolytics are far worse; they have lots of leakage and series resistance, and they deteriorate with age, but their one redeeming virtue is that large values are practical. Polyester or ceramic disk capacitors larger than 0.5 µF are too bulky to use in modern miniature equipment, and above 3 µF or so they don't exist at all, but you can get electrolytics as large as several farads. So the 4700-µF filter capacitor in a power supply is sure to be electrolytic, and the 1-µF coupling capacitor in an audio amplifier is likely to be one. Tantalum electrolytics are more compact than conventional aluminum types.

As the name suggests, electrolytics rely on an action similar to electroplating to keep the insulating layer intact. That means they are polarity-sensitive; if you apply voltage backward, they suffer damage and can even explode. (Make sure the positive terminal is always positive.) Also, if you use too low a voltage—like 1 volt on a 35-volt electrolytic capacitor—or leave the capacitor on the shelf unused for several years, it eventually deteriorates. That's why DC working voltage (WVDC) is so important. And, yes, WVDC is the same thing as VDC. Don't run too close to the limit; we usually specify 16-volt capacitors for 5-volt circuits and 35-volt capacitors for 12-volt circuits.

If a project requires a particular kind of capacitor, the parts list will say so; otherwise, any capacitor with the correct capacitance and an adequate voltage rating will do. If a low-ESR capacitor is specified for a project, that's what you should use; in a pinch you can sometimes substitute a conventional electrolytic with a higher capacitance. You can always substitute low-ESR capacitors for regular ones.

Pushbutton Volume Control (Again)

Q *I'm looking for a circuit for a volume control where the volume is raised and lowered by pushing buttons. Can someone help me with this?—R. A., Toronto, Ontario, Canada*

A On pushbutton volume controls, see this column in the October, 1997 issue of **Electronics Now**. Since then, digital control of audio volume has gotten even easier because Philips has introduced a new amplifier chip, the TDA8551, with pushbutton volume control built in. A circuit based on Philips' published data is shown in Fig.

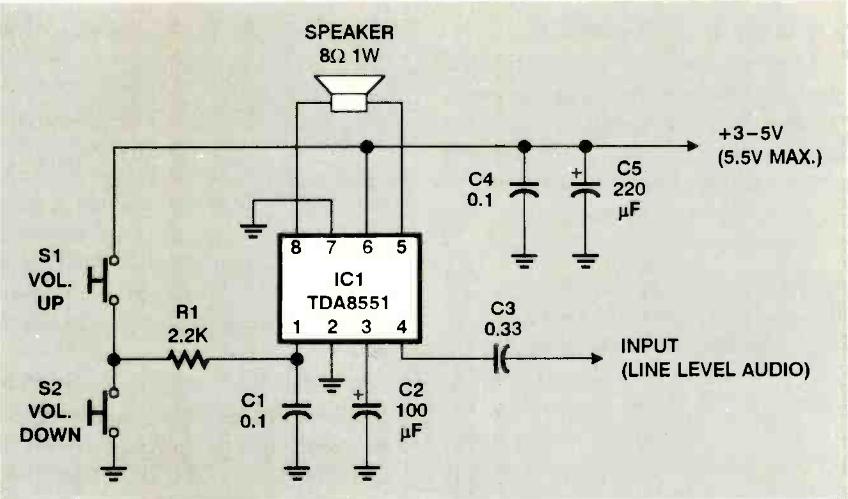


FIG. 2—PUSHBUTTON VOLUME CONTROL is now easier than ever to achieve thanks to a new Philips amplifier. This circuit is based on data from Philips.

2; we haven't yet had a chance to actually try the chip out, but it sounds like a real winner for hobbyists and experimenters. The advantage of pushbuttons, of course, is that the audio signal doesn't actually go through them, so if their contacts get dirty, the sound quality isn't affected. Also, they're cheaper than potentiometers, and smaller.

FM Preamplifier

Q *I would like to adapt a preamplifier kit designed for use on the 2-meter amateur band (140 MHz) for use as an extreme deep fringe FM antenna amplifier. Can this be done with the Ramsey PR-10?—S. J., Palmerton, PA*

A Indeed it can! We obtained a sample kit from Ramsey Electronics (793 Canning Parkway, Victor, NY 14564), assembled it (which took only 15 minutes), made sure it worked on 140 MHz, and then went to work on the modifications. The circuit is shown in Fig. 3. All we had to do was change C2 to 22 pF, and we had a deep-fringe FM preamplifier.

"Deep-fringe" is important here—we're assuming you are not near *any* strong FM stations. If you are, they're likely to overload this or any other antenna preamplifier.

We suggest you either build the preamp inside your FM receiver or put it in a shielded metal enclosure. Use BNC connectors, F connectors, or phono jacks for the input and output.

Note that the transistor used in this kit, a 2SC2498, is a special high-frequency type with an unusual pinout (base, emitter, and collector, in that order from right to left as viewed from the front). Suitable substitutes are ECG10 and SK9139.

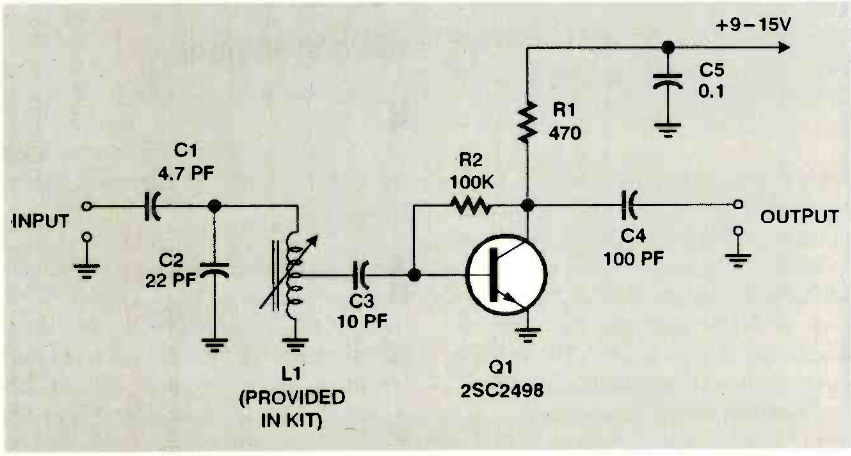


FIG. 3—HERE'S THE CIRCUIT for the "modified" Ramsey PR-10 kit. To convert it to a deep fringe preamp for FM radio, C2 was changed from 8.2 pF to 22 pF.

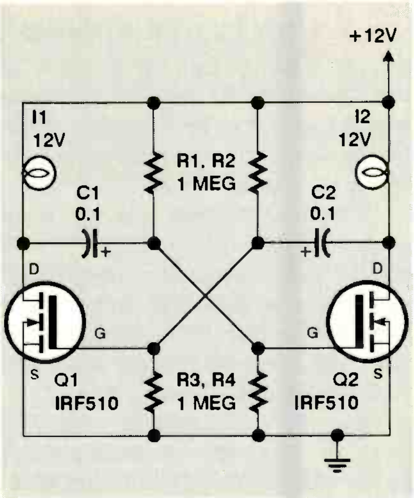


FIG. 4—THIS VERY RELIABLE light flasher uses two MOSFETs and no electrolytic capacitors. Each bulb can draw up to 4 amps (48 watts). Use a heat sink if Q1 and/or Q2 get hot.

Flashing Lights

Q *I will be extremely delighted if you will publish a circuit that can alternately flash two bulbs (12 to 24 watts) from a 12-volt auto battery.—J. R. S., Dhahran, Saudi Arabia*

A Try the circuit in Figure 4—a MOSFET version of a classic astable multivibrator circuit. It does not require large electrolytic capacitors—hence it should hold up a lot better under extremes of temperature than circuits that do. With the component values shown, the bulbs flash quite rapidly; for slower flashing, you can increase the resistors to 10 megohms or use larger capacitors. If you do end up using electrolytics (necessary for values larger than about 0.5 µF), observe the polarity indicated in the diagram.

Hit It Harder

Q *My son and I are both into the martial arts. We practice on a heavy punching bag and would like to know which of us can hit it harder. Is there a sensor we could mount in it to give an electronic readout of the force?—B. G., Burl, Ontario, Canada*

A Maybe, but this sounds like something that would be easier to do mechanically. Could you simply measure how far the bag swings in response to the punch?

Pinball Parts Found

In the latest installment in our continuing saga of questions about pinball-machine parts, we've learned that The Pinball Resource, 8 Commerce St., Poughkeepsie, NY 12603; Tel: 914-473-7114: e-mail: PBResource@idsi.net, supplies parts and manuals for Premier/Gottlieb, Williams, Bally/Midway, Data East, and Sega machines. They even manufacture reproductions of parts no longer available.

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). Please write to: Q&A, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. **EN**

BY JEFF HOLTZMAN
COMPUTER EDITOR

Going Mobile

WHILE PLANNING A RECENT FAMILY VACATION TO A REMOTE AREA, I PROMISED MY WIFE I WOULDN'T BRING MY LAPTOP. I DIDN'T SAY ANYTHING ABOUT MY PILOT, HOWEVER. I DIDN'T WANT TO DO ANY REAL WORK, BUT I DID WANT to keep in e-mail contact. No problem, right? Pilot + Pilot modem + adapter + cell phone = communications—right? Well, it's not that easy, not by a long shot. It's not so cheap, either. As it turned out, it would have been easier simply to have brought a laptop. But I wanted to push this experiment as far as it could go to see where the weak links are.

Figure 1 shows the setup. The Pilot Modem snaps on the bottom of the Pilot. A standard phone cable connects the modem to a $150 adapter made by Motorola that is supposed to allow you to connect any standard analog telephone device to a cell phone. The output of the adapter is a jack into which you plug a special cable with an RJ-45 network connector on one end, and a Motorola cell phone plug on the other. Adapter cables are available for other models.

A few notes about several devices in the chain. The Pilot Modem lists for about $129, and its maximum connect speed is 14.4 kbps. Like the Pilot itself, it runs off two AA batteries. Unlike the Pilot, there is no battery gauge, so judging remaining power is difficult to impossible. Newer Duracells and Energizers with built-in power gauges alleviate the problem somewhat, but pulling out the batteries to see how much life they have left is mighty inconvenient. It's also frustrating, given that the Pilot itself has such a nice user interface for power. Oh, and if the modem seems overpriced, it is. But the size and shape are just right.

The adapter is officially known as The Portable Cellular Connection Interface. It allows you to use most standard analog devices (desk phones, answering machines, fax machines, PC with modem, amplified headsets, and telemetry monitors such as EKG) with a cell phone. In addition to the in and out jacks, it has a power jack, a power switch, and a small LED. Power is supplied by a rechargeable 7.2 volt NiCd battery. In an emergency you can use a 9-volt battery. According to the 10-page "Installation and User Instructions," it takes 7 hours to recharge the battery. The NiCd provides about two hours of "talk time," and a 9-volt battery provides about four hours. The LED flashes when the NiCd needs recharging. The unit also comes with a belt-clip, so conceivably you could receive faxes while on safari. Note: The manual says to turn the cell phone on last, but I had better luck turning on the phone, adapter, and Pilot in that order.

The cell phone is a MicroTac 650. It's nothing special, although I did supplement its battery pack with a much more robust one from MCM Electronics.

The Pilot is a standard Palm Pilot Professional model, which comes with a built-in TCP/IP stack and a bare-bones e-mail application. I also tested two third-party e-mail apps: Hand Stamp Pro and MultiMail Pro. If I had to choose one, I'd go with MultiMail Pro, mostly as the lesser of multiple evils.

Getting Connected

Before we left, I connected everything and ensured that I could connect to my local ISP. No sweat in our small university town about 40 miles from a major metropolitan area. My ISP has a local access number, plus an 800 number that costs $6/hour above any other charges. I ended up using both. I often got more reliable results dialing my local number long distance than the toll-free 800 number.

After arriving at our cabin and getting set up, I reconnected everything and began a very frustrating session of trying to establish a reliable connection.

There are three aspects of the configuration: modem, network, and applications (the e-mail apps). Setting up the modem is simple, at least if you're using a modem on the list. Select the modem, speed, speaker volume, and flow control. Depending on the modem you select, the Pilot itself then fills in a modem initialization string. If you edit that string, the Pilot creates a new entry called Custom.

Network setup is more complex. First you select or create a service. Built-in services include CompuServe, Earthlink, UUNet, and several others. Then you enter your login user name and password, and the dial-up telephone number. A Details button takes you to a subsidiary screen where you specify the primary and secondary DNS settings, IP address, connection type (typically PPP), and an idle timeout. You can also enter a simple login script. Typically, you would clone the settings you use in your desktop PC here. For my testing, I created two identical network setups: one with the 800 access number, and one with the local access number (preceded by the area code).

FIG. 1—WIRELESS E-MAIL IS POSSIBLE USING A PILOT, a modem, a cell phone, and a black-box adapter. The modem clips on the Pilot, and the adapter connects between the cell phone and the modem.

RESOURCES

Serial Port Complete ($39.95)
by Jan Axelson
Lakeview Research
Madison, WI 53704
Web: www.lvr.com
ISBN 096508192-3

SuperPilot Memory Board II ($250)
Technology Resource Group
2851 104th St.
Suite H
Des Moines, IA 50322
Tel: 515-252-7522
Web: www.trgnet.com

MultiMail Pro ($29.95)
Actual Software Corporation
P.O. Box 276
Andover, MA 01810
Tel: 978-475-2690
Web: www.actualsoft.com

The Portable Cellular Connection Interface ($150)
My Pilot Communications
Tel: 309-828-1419
Web: www.mypilot.com

POP3 and IMAP4

The next task was configuring the application. I'll discuss MultiMail Pro only, because it's the one I settled on and am now most familiar with. The program allows you to set up four mail servers or accounts from which it will retrieve mail. That's important to me because I have several accounts for different venues. Each account can use either POP3 or IMAP4 protocol. Most ISPs still use POP3, even though IMAP4 is much more versatile and much better adapted to the type of roaming use under discussion.

For each account you can specify a title (which later shows up in a pick list), a server (*e.g.*, somewhere.com), type, mailbox (*e.g.*, jeff), and a password. A subsidiary screen allows you to specify an SMTP server, e-mail address, name, port number, and a signature, all of which are used for sending mail. Another subsidiary screen allows you to specify the POP3 port number, and whether to leave mail on the server. Why would you want to do that? Good question, and one that highlights the core difference between the POP and IMAP ways of doing things.

With POP, the basic assumption is that the account on the server is a very temporary storage bin. Under normal circumstances, you download your messages via your e-mail client, which then takes responsibility for management, distribution, storage, deletion, etc. Normally, as soon as they are downloaded, messages are deleted, although most e-mail clients allow you to specify a delay (*e.g.*, delete messages older than n days).

With IMAP, the client becomes dumb, and the server takes on the responsibility for message management. The advantage is that you can log into your e-mail account from any machine anywhere and be assured that everything you see is up to date. With POP, access from multiple machines is almost guaranteed to cause synchronization problems.

In my case, I'm currently using Eudora Pro 3.x as my main desktop client. All my e-mail is organized and searchable through Eudora, and it must stay that way. (Eudora has its own problems, but that's a different story.) If I didn't care about maintaining my primary message store in Eudora, I could configure the Pilot to just read and delete messages. That's the simplest solution, but it's unacceptable. On the other hand, by telling MultiMail Pro not to delete messages, I end up with duplicates on both machines. Purging them from the Pilot is not a problem. The really annoying thing is having to review all those messages a second time on the PC after returning from vacation.

We really need to put POP3 out to pasture and move on to IMAP4. Tell your ISP! Tell your grandmother! Tell anyone else who will listen!

Another problem is that responses generated on the Pilot don't get into the desktop system. As I said, it's a nightmare of synchronization.

Yet another problem is that the first time you access a POP3 account from a "virgin" machine (such as the Pilot), all messages on the server are downloaded. Doing so can take quite a bit of time and

(Continued on page 29)

EQUIPMENT REPORT

CHECKPOINT LASER TOOLS SA-S PRO LASER LEVEL

Get perfect speaker placement the way professionals have done for years with the SA-S Pro laser level.

CIRCLE 15 ON FREE INFORMATION CARD

Most people probably set up a pair of stereo speakers where they look right and then completely forget about their placement. While that's adequate for some listeners, professional audio-system installers and audio enthusiasts have higher demands and need to have their speakers placed more precisely.

Audio professionals have known for years that the best way to align a sound system, especially for large-scale productions, is to use a laser level. Simple in theory, those high-tech tools look similar to regular levels (the carpenter's tool with the bubble in it), but have a laser diode built in. Laser light is coherent, basically meaning that a laser beam can travel great distances without spreading out. The laser diode inside a laser level is aligned so that the beam comes out straight and true. If held level, the light coming out of a laser level can help one draw level lines, line up exact heights at great distances, and, as it turns out, align speakers

Speaker positioning is a critical element in having good sound come from any audio system. It is particularly important that speakers are properly positioned according to listener seating in multi-speaker home-theater setups. Setting up speakers in a small room can usually be done without special tools, and listeners often have little choice where they sit anyway. But it's much harder to line up speakers "by eye" in a large auditorium, and professional installers have to do it on a regular basis. That's why a laser level can be so useful for audio professionals.

The SA-S Pro reviewed here is the professional version of a laser level customized for easier use with audio systems. It can be used as a laser level for countless other projects as well.

SA-S Pro

The base model SA-S tool from Checkpoint Laser Tools (4025 Spencer Street, Suite 304, Torrance, CA 90503; Tel: 310-793-5500; Web: www.checkpoint3d.com) sells for $159.95. It's a basic laser level made out of anodized aluminum, with a special precision base on one end that looks like the end of a doctor's stethoscope. Whatever surface the level is held against, the laser will project perpendicularly away from it. You simply hold the level against the face of a speaker cabinet, and the red dot shows where the speaker is pointed.

The base is also a threaded switch that turns on the laser when the switch is screwed tighter into the level. Unscrewing the switch reveals two AAA batteries.

The SA-S Pro (model P-770), which sells for $189.95 and is the unit we reviewed, adds a lot more functionality to the base model. SA-S Pro comes with the stethoscope-like base/switch plus another base/switch that has a built-in bull's-eye bubble level. When the bull's-eye level is centered, the laser in the unit points straight down.

The Pro version also has a conventional bubble level built into its body. Combined with the bull's-eye bubble, the tool can be positioned precisely in any number of settings. The Pro version also includes a padded carrying case for the level.

Using the level is simple. The sides of a speaker cabinet are usually at right angles with the face of the cabinet where the speakers are mounted. Holding the SA-S Pro against the side of a speaker and centering the bubble level will project the laser exactly where the speaker is pointing.

Accessories

Of course there are options for the SA-S Pro that add greater functionality to the tool. An optional switch for the tool has a precision magnetic base. To use it, you must also buy a precision base plate for each speaker. The base plates mount with a wood screw onto the face of a speaker cabinet, behind the cloth grilles. Special precision spacers are available if necessary.

With the magnetic base, it's a simple matter to stick the level on each speaker for quick alignment. It's also an easy way to check the sturdiness of a speaker case or mount by seeing how much the dot "dances" when the speaker reproduces sound. Traveling audio-support personnel who are always setting up and tearing down stages will love these. The magnetic base/switch costs $28.95 and base plates cost $16.95 each. Spacers, actually called stackers, cost $12.95 for a pack of three. Some high-end speakers actually come from the factory with SA-S base plates installed.

Another useful accessory costs nearly as much as the level itself, but it is the perfect companion to the level no matter where it's used. Its miniature tripod-like stand has a precision mount on top for the level. It also has a built-in bull's-eye level and height-adjustable legs. The legs have removable pointed brass tips and rubber feet for better footing on various surfaces. It's a simple matter to make the base perfectly level on any surface. The bottom plate of the stand is threaded

(Continued on page 62)

Prototype

New Process Lights The Way For Optical Computing

The future for optical computers looks bright, thanks to a process discovered at Purdue University to stabilize the surface of porous silicon, a light-emitting material that offers great promise for combining light and electronics.

Porous silicon is identical in makeup to the silicon used in many current technological applications, except its surface contains tiny openings or pores. The pores in porous silicon contain microscopic silicon structures that emit light when ultraviolet light is applied to them. It is made from bulk silicon which has been partially dissolved by electrochemical treatment in solutions containing hydrofluoric acid. The resulting porosity can be on a scale of less than 2 nanometers, between 2 and 50 nm, or greater than 50 nm. These nanostructures within the silicon, which are made without the use of lithography, form something called "quantum wires" (a nanostructure proportioned like a wire so that electron behavior is strongly constrained by quantum mechanical effects in two dimensions) having high luminescent efficiency that does not occur in untreated bulk silicon.

Porous silicon was discovered 40 years ago, when it was noticed that silicon could not always be smoothly polished during manufacturing. It wasn't until 1990 that this "rough" or porous silicon was found to have photoluminescent properties. Two years later, scientists discovered that it also emits light when electrical current is applied—a finding that opened the door to coupling light and electronics in computers and other devices.

PERDUE STUDENT MATTHEW ALLEN shines ultraviolet light on a dish containing small gray structures made of porous silicon, causing the structures to emit a bright orange light. Principal researcher Jillian Buriak is shown at the left. (Purdue News Service Photo by David Umberger)

Applications

"Because most of our current technology is based on silicon, it may be relatively easy to develop the optical applications and combine them with current technologies, since the manufacturing processes are already in place," says principal researcher Jillian Buriak, Purdue professor of chemistry. For example, porous silicon could serve as a flat, millimeter-thick display area for computer screens, replacing large, bulky monitors that depend on cathode-ray tubes.

The properties of porous silicon also make it an ideal material to develop computers based on light signals instead of electrical signals. Those types of computers would be faster, since beams of light can transmit information much more quickly than electrons making their way through a solid material. Using light to transmit data would also eliminate heat buildup in electronic components, allowing engineers to design smaller devices by stacking multiple layers of chips made of porous silicon. Optical chips would also be immune to electrical noise. The Purdue development may also lead to fine-tuned sensors that can be used to perform real-time measurements in manufacturing and medicine.

Though the properties of porous silicon promise powerful new technologies, until now the untreated material was too fragile to support these applications. Oxygen and water molecules in the air create a glass-like coating that interrupts the photoluminescence process. Within a matter of weeks, the material rusts, or oxidizes, Buriak says. In this case, however, instead of leaving a rough, brownish coating, the oxidation process produces a smoother, glass-like surface that limits the function of the material.

"A lot of reactions involve chemical bonds similar to the ones that develop on the surface of porous silicon," says Buriak. "So I listed these reactions and came up with one that I thought had the best chance of working without damaging the surface." Buriak, along with undergraduate researcher Matthew Allen, came up with a clean, room temperature, one-hour reaction that allows them to stabilize the surface.

Buriak's process involves coating the porous surface of the silicon with Lewis acid, a solution that produces a greasy protective coating on the surface while still allowing the material to maintain its light properties.

"This is the most stable porous silicon to date," says Buriak. "Using our treatment, we can produce an incredibly stable surface that should stand up to the rigor of use. The porous silicon functionalization allows incorporation of just about any chemical group on the surface, attached through stable silicon-carbon bonds."

This is important for a couple of reasons. "It dramatically stabilizes the surface. Normally, porous silicon dissolves in boiling water through rapid oxidation," says Buriak. "If we derivatize our surfaces with hydrophobic groups, they are inert under these conditions, even at an elevated pH (pH 10). Since about any functional group can be incorporated, we are studying the effects of these groups on the electronics of the silicon nanocrystallites embedded in the porous silicon."

It is known that functionalization can affect the electronics, and hence the photoluminescence, of the porous silicon. Buriak's method provides the first rational approach to doing this.

Many researchers are interested in using porous silicon for sensor applications. "We can now make surfaces selective by incorporating binding sites, for instance, to recognize specific analytes," she says.

Details of the discovery were announced earlier this year in the Journal of the American Chemical Society. Another paper is pending, concerning in-depth photoluminescence studies. "I can tell you now that surface functionalization has dramatic effects on light-emitting properties and we are now trying to use this method to tune the electronics, although this may take six months to a year to perfect," she says.

—By Doug Page PT

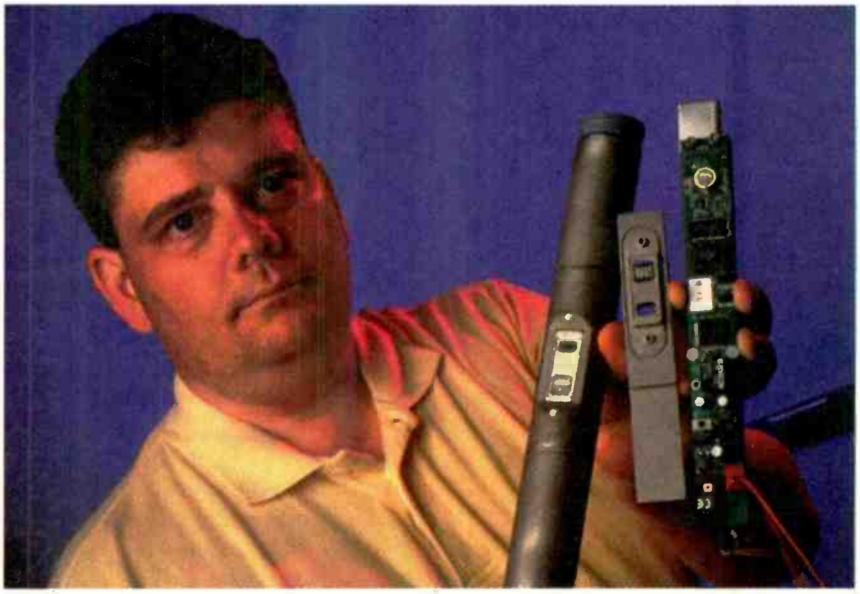
Environmental Monitoring System

A revolutionary environmental monitoring and analysis system that promises to reduce the time and costs involved in analyzing contaminants was designed by a team of researchers that includes Georgia Institute of Technology engineers. They predict the system—called E-SMART (Environmental Systems Management Analysis and Reporting neTwork)—will dramatically improve the efficiency and effectiveness of environmental monitoring.

Consisting of data management hardware and software and integrated optic chemical sensors, the system operates in real time and measures very small amounts of contaminants in the parts-per-billion range. In addition, researchers said it will reduce health and safety risks and help ensure environmental compliance.

"Right now the only way technicians have for field analysis is to go out and take samples, bring them back to the laboratory and perform wet chemistry tests," said Nile Hartman, a principal research engineer at the Georgia Tech Research Institute (GTRI). "It's expensive—about $200 a sample plus the technician's time. So instead we have developed a sensor that operates in situ (at the site of contamination) and continuously monitors the site. So you have huge savings in time and cost."

At the heart of the project are smart sensors that detect a variety of chemical contaminants, including heavy metals, solvents, and petroleum oil, and lubricants. The integrated optic interferometric sensors were developed over the past decade and patented in 1997 by Hartman and the Georgia Tech Research



RESEARCHER JEFF MOORE HOLDS environmental monitors that contain integrated optic interferometric sensors developed at Georgia Tech.

Corporation. The sensor was licensed commercially by the Atlanta-based Photonic Sensor Systems Inc.

Laser-based technology originally developed for optical communications allows the multichannel microsensor fitted with the proper chemical coatings to detect multiple contaminants in soil, groundwater, and air. The speed of light increases or decreases when passing through materials of differing optical properties, Hartman explained. Detection becomes possible by measuring a contaminant's influence on the optical properties of the sensor. Then researchers observe the effects on these properties through changes in the transmitted laser light.

An E-SMART field test will probably be conducted at a U.S. Air Force base where cleaning agents used to degrease metal aircraft parts have seeped into soil and groundwater. Researchers will install sensors in monitoring wells, streams, and in cone potentiometers—rods driven 200 to 300 feet into the ground. The sensors will be designed to detect benzene, toluene, ethyl benzene, and xylene (BTEX compounds). With the contaminant type and concentration data collected by the sensors, E-SMART will map the contaminant plume at the site. Site managers can use this easily interpreted analysis to take appropriate corrective action, if needed.

When it becomes commercially available, the E-SMART system—and even the sensor as a stand-alone environmental monitor—is expected to have numerous applications in the private sector. Manufacturing facilities could use the sensor to monitor output; monitoring personnel could check their exposure to dangerous chemicals; and water-treatment plant managers could use sensors to ensure that the water is properly cleaned. Food safety and medical testing are other potential applications. PT

DR. PROBAL BANNERJEE, post-doctoral fellow at Auburn University, adjusts the operation of a viscometer, during measurements on a cast-iron alloy.

Breaking the Mold

Research in low gravity has taken an important first step toward making metal products used in homes, automobiles, and aircraft less expensive, safer, and more durable. Auburn University in Auburn, AL and industry are partnering with NASA to develop one of the first accurate computer model predictions of molten medals and molding materials used in a manufacturing process called casting. Cast alloy parts are formed by mixing and pouring melted metals into a mold.

The first commercial use of the new computer information is being made by Howmet Industries of Whitehall, MI to more precisely design and cast aircraft turbine blades. In a similar activity, Ford Motor Company's casting plant in Cleveland, OH is using the information developed by the new computer models to improve the casting process of automobile and light truck engine blocks.

Cast metal parts are used in 90 percent of all durable goods such as washing machines, refrigerators, stoves, lawn mowers, cars, boats, and aircraft. Sales of cast parts in the U.S. alone total $25 to $30 billion a year, according to the American Foundrymen's Society in Des Plaines, IL.

High-temperature metal alloy parts for the aerospace and auto industry can make aircraft and vehicles stronger, lighter, and more efficient, but casting typically requires three to four years to develop an effective process. "We started with experiments on the ground," Dr. Tony Overfelt, director of the Solidification Design Center at Auburn University said. "Then went aboard a NASA KC-135 aircraft flying an arc pattern in low gravity to refine our research. Our goal is to continue to produce accurate measurements for all the alloys used by the casting industry. This information can be used by American manufacturers to standardize metal-mixing 'recipes' and to compete more effectively in the worldwide market."

Auburn University is one of NASA's 10 Commercial Space Centers. These centers serve as a focal point for NASA partnerships with industry and universities, encouraging unique space-related research opportunities to develop new products and services. Also participating in the Auburn University-led casting research consortium are Anter Corp. in Pittsburgh, PA; Thermophysical Properties Research Laboratory Inc. in West Lafayette, IN; PCC Airfoils Inc. of Beechwood, OH; and the American Foundrymen's Society, Inc. PT

Electric Vehicles Make Progress

Electric vehicles will have more pickup, run longer distances, and consume less energy with the aid of new technology being developed by Jian H. Zhao, an associate professor in the department of electrical and computer engineering at Rutgers' College of Engineering. A new semiconductor switching device, crafted from a revolutionary material called silicon carbide (SiC), will be used to process the electricity and transfer energy from an electric vehicle's battery to its power train.

The power train controls all of the vehicle's electrical devices from power windows to the motor.

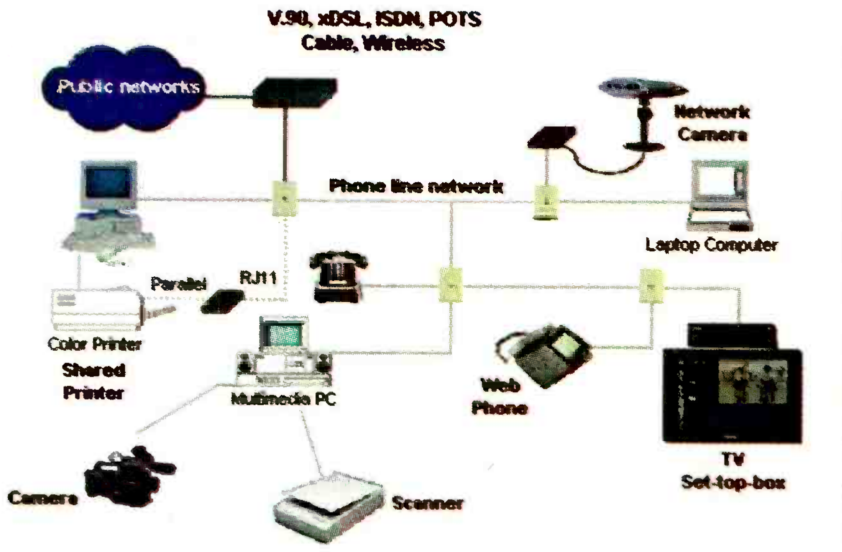
Zhao is leading the SiC research effort for the Electric Vehicle Consortium (Electricore) to develop advanced technology and materials for hybrid and all-electric vehicles. Authorized under the recent Transportation Equity Act for the 21st Century to receive $50 million a year over six years (a total of $300 million), Electricore is a nonprofit association of private sector companies, universities, and organizations. Members of the consortium are partners in the development of advanced electric vehicle technologies and related infrastructure for commercial and military applications.

According to Zhao, SiC, which outperforms silicon semiconductors in power density, energy efficiency, and durability, is expected to become the industry standard for electric vehicles. SiC is a synthetically produced semiconductor that occurs naturally only as a mineral in meteorites.

"The SiC device promises to increase power density by at least 100 times compared to a similarly sized silicon device. At the same time, it promises to reduce power consumption by 100 times," explained Zhao. Testing has proven the SiC device capable of supporting two megawatts of power per square centimeter, and switching (turning on and off) currents up to 5000 amps per square centimeter. In addition, it can operate at much higher temperatures, up to 600 degrees Celsius versus 125 degrees Celsius—the point at which silicon devices malfunction.

"Since SiC quickly dissipates heat and can sustain much higher temperatures, the whole size and weight of the power train can be reduced," added Zhao. "There is a global race to develop SiC power devices, and countries like Sweden, Japan, and Germany are all heavily funding their own research efforts. All the major automobile manufacturers want to be the first to use it in their cars."

Although electric vehicles are the focus of the consortium, SiC technology has applications for numerous high-power-usage industries. These devices can significantly reduce or eliminate problems with power overloads, outages, brownouts, and delays in relay switching. PT



THIS DIAGRAM SHOWS how a typical user might set up a network of devices within a home using a home-phoneline network.

Home-Networking Standard

An alliance of the leading computing and communications companies has been established to help deliver easy-to-use, affordable, high-speed home networking solutions over existing telephone wires. The group, called the Home Phoneline Networking Alliance (HomePNA) includes founding members 3Com, AMD, AT&T Wireless, Compaq, Epigram, Hewlett-Packard, IBM, Intel, Lucent Technologies, Rockwell Semiconductor Systems and Tut Systems. HomePNA's immediate mission is to accelerate the development and marketplace introduction of a home networking specification.

"In the business world, the real power of the PC revolution was unleashed when PCs were networked together. The goal of HomePNA is to extend that revolution into the home," said Rod Schrock, Vice President and General Manager, Consumer Products Group, Compaq Computer Corporation. "But since most households don't have a system administrator, a successful home networking specification has to be simple, foolproof, and inexpensive."

More than 15 million homes in the U.S. have two or more PCs, and half of these access the Internet regularly. Not only is the number of home PCs expected to double over the next two years, but analysts project that the purchase of information-appliance products other than PCs will soar as well. The need to share Internet access, digital information, and computing resources among PCs and other information appliances will spark consumer demand for a home-networking solution.

Among the advantages of home phoneline-based networks are that these networks use existing telephone wiring to connect computers and devices without interrupting phone service; they will work with existing Internet access technologies; and they enable sharing Internet access, data, applications, and peripherals.

HomePNA will develop specifications for creation of industry-wide standards and will promote this technology as an open reference specification for all vendors to implement. They will work closely with IEEE and other industry standard committees for submission and adoption of the specifications as the industry standard. The group will be providing field certification and interoperability test suites. They will also serve as a forum for technological and consumer issues.

The alliance had adopted innovative and proven networking technology from Tut Systems that allows home networks to operate over common telephone wires at 1Mbit/s. Future specifications for even higher speed home phoneline networks are already being developed. Additional information is available at www.homepna.org. PT

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Values Reversed

It has come to our attention that there was a slight mix-up in the "Add Daytime Running Lights to Your Car" article in the October issue of **Electronics Now**. The values for R4 and R5 were reversed in both the schematic diagram and the Parts List. The value for R4 should be 10,000 ohms and the value for R5 should be 4700 ohms—*Editor*

What's My Line?

In preparing the artwork for the "Using Constant-Current Sources" article in the October issue, an error crept in. In particular, in Figs. 1 and 2 there is an extra line connecting the positive and negative sides of the circuits. As this line creates a short, it obviously does not belong and should be removed. We are sorry for any confusion that this error has caused—*Editor*

NOPPP On the Web

In regard to my article "Burn PIC Microcontrollers With a 'No Parts' PIC Programmer," which appeared in the September issue, I am happy to announce that NOPPP now has its own Web page. The address is http://www.mindspring.com/ ~covington/noppp/index.html

So far, I've posted the schematic, the NOPPP.ZIP file, some answers to frequently asked questions, and links to PIC-related sites. If you are interested in my project, or in programming PICs in general, please be sure to check it out.
MICHAEL A. COVINGTON

More What Do You Want

I like your magazine. I don't know what I would change to make it better. I know you must balance the content to appeal to a broad range of readers, and I don't feel I should complain if some of the material doesn't interest me (that's fair).

Most of my professional career, I have been a technician of one kind or another, most often an electronics technician. For the last 15 years, I've been in operations, at a console, flying geosynchronous satellites. But, I still design and fabricate some occasional equipment for use at my job. I identify as an electronics professional.

I'm 56 years old (retired once and back at another job). I still try to fix everything I own, electronic or mechanical. But I don't play with electronics like I used to...I read your magazine mostly for the entertainment value. When I say entertainment value, I mean intellectual stimulation.

It does help me to keep current with new concepts and consumer products. And I do read the articles that remind me of the basics, or sometimes bring me a clearer understanding than I had before. I sure like Don Lancaster. I use your advertising to make many of my purchases; almost all the companies that I buy from advertise in **Electronics Now**.

The last magazine that I had a powerful fondness for was *Elector*, the American edition, which is no longer published. I am currently interested in home-security-related subjects, video, sensors and their installation, PIR, etc., anything Don Lancaster has to say, and the Service Clinic. But I'd be glad to see whatever you are going to plug into the next issue. There is a definite need for a magazine like yours; without it, there would be a definite hole in the magazine industry.
ERIC SCHAEFER
via e-mail

EN

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

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

BY SAM GOLDWASSER
SERVICE EDITOR

Servicing Monitors

WITH THIS ARTICLE WE BEGIN A SERIES ON SERVICING CRT-BASED MONITORS. MOSTLY, THIS REFERS TO COMPUTER MONITORS BUT THE INFORMATION APPLIES TO STUDIO VIDEO (RGB AND NTSC/PAL/SECAM) AND CCTV TYPES AS WELL.

Monitor technology has advanced significantly in the last few years. The good news is that newer models are cheaper, higher in performance, easier to use, and smarter than older ones. The bad news is that with many functions squeezed into integrated circuits and with schematics harder to obtain, repair of more esoteric problems can be a real nightmare. However, there are many, many common faults that can be dealt with using minimal test equipment and common tools.

Monitors, Monitors, and More Monitors

In the early days of small computers, a 110-baud teletype with a personal paper-tape reader was the "preferred" input/output device (meaning that this was a great improvement over punched cards and having to deal with the bozos in the computer room!).

The earliest true personal computers didn't come with a display—you connected them to the family TV. You and your kids shared the single TV, and the Flintstones often won out. The Commodore 64 would never have been as successful as it was if an expensive monitor had been a requirement rather than an option.

However, as computer performance improved, it quickly became clear that a dedicated display was essential. Even for simple text, a TV can only display 40 characters across the screen with any degree of clarity.

When the IBM PC was introduced, it came with a nice 80 × 25 green monochrome text display. It was bright, crisp, and stable. Mono graphics (MGA or MDA) was added at 720 × 350, CGA at a range of resolutions from 160 × 200 to 640 × 200 at 2 to 16 colors, and EGA extended things up to a spectacular resolution of 640 × 350. This was really fine until the introduction of Windows (well, at least once Windows stayed up long enough for you to care).

All of those displays used digital video—TTL signals that were coded for a specific discrete number of possible colors and intensities. Both the video adapter and the monitor were limited to 2, 4, 16, or a whopping 64 colors depending on the graphics standard. The video signals were logic bits—0s and 1s.

With the introduction of the VGA standard, personal computer graphics became "real." VGA and its successors—PGA, XGA, and all of the SVGA (non) standards use analog video—each of the R, G, and B signals is a continuous voltage that can represent a continuous range of intensities for each color. In principle, an analog monitor is capable of an unlimited number of possible colors and intensities. (In practice, unavoidable noise and limitations of the CRT restricts the actual number to an order of 64–256 distinguishable intensities for each channel.) Note that analog video was only new to the PC world. TVs and other video equipment, workstations, and image-analysis systems had used analog signals for many years prior to the PC's "discovery" of that approach. In all fairness, both the display adapter and monitor are more expensive, so it is not surprising that early PCs did not use analog video.

Most of the information in this series of articles applies to color computer video monitors and TV studio monitors as well as the display portions of television sets. Black and white, gray scale, and monochrome monitors use a subset of the circuitry (and generally at lower power levels) in color monitors so much of it applies to those as well.

For most descriptions of symptoms, testing, diagnosis, and repair, an auto-scan PC SVGA monitor is assumed. For a fixed frequency workstation monitor, studio video monitor, or closed circuit TV monitor, only a subset of the possible faults and procedures will apply.

Note: We use the term "auto-scan" to describe a monitor that accepts a wide (and possibly continuous) range of scan rates. Usually, that refers mostly to the horizontal frequency, as the vertical refresh rate is quite flexible on many monitors of all types. Fixed-scan or fixed-frequency monitors are designed to work with a single scan rate (though a 5% or so variation may actually be acceptable). Multi-scan monitors sync at two or more distinct scan rates. While not very common anymore, multi-scan monitors may still be found in some specific applications.

Monitor Fundamentals

Monitors designed for PCs, workstations, and studio video have many characteristics in common. Modern computer monitors share many similarities with TVs, but the auto-scan and high scan-rate deflection circuitry and more sophisticated power supplies complicates their servicing.

Currently, most computer monitors are still based on the Cathode Ray Tube (CRT) as the display device. However, handheld equipment, laptop computers, and the screens inside video projectors now use flat panel technology, mostly Liquid Crystal Displays—LCDs. LCD desktop displays have also recently begun to appear. Liquid crystal displays are a lot less bulky than CRTs, use less power, and have better geometry—but suffer from certain flaws.

First, the picture quality in terms of gray scale and color is generally inferior to a decent analog monitor. The number of distinct shades of gray or distinct colors is a lot more limited. They are generally not as responsive as CRTs when it comes to real-time video, which is becoming increasingly important with multimedia computers. Brightness is generally not as good as a decent CRT display. And last but not least, the cost is still much, much higher due both to the increased complexity of flat panel technology and lower production volumes (though this is certainly increasing dramatically). It is really hard to beat the simplicity of the shadow mask CRT. For example, a decent quality active-matrix color LCD panel may add $1000 to the cost of a notebook computer compared to $200 for a VGA monitor. More of these panels go into the dumpster than make it to product due to manufacturing imperfections.

However, a variety of technologies are currently competing for use in the flat-panel displays of the future. Among those are advanced LCD, plasma-discharge, and field-emission displays. Only time will tell which, if any, survives to become "the" picture-on-the-wall or notepad display—at reasonable cost. The DMD (Digital Multiple Mirror) approach from Texas Instruments is another interesting technology worth watching (no pun intended) especially for large screen displays.

Monitor Characteristics

The following describe the capabilities that characterize a display:

1. Resolution—the number of resolvable pixels on each line and the number of scanning lines. Bandwidth of the video source, cable, and monitor video amplifiers as well as CRT focus spot size are all critical. However, maximum resolution on a color CRT is limited by the

TODAY'S AUTO-SCAN MONITORS use digital controls—buttons (like on this IBM unit) and menus—for almost all adjustments.

dot/slot/line pitch of the CRT shadow/slot mask or aperture grille.

2. Refresh rate—the number of complete images "painted" on the screen each second. Non-interlaced or progressive scanning posts the entire frame during each sweep from top to bottom. Interlaced scanning posts $^1/_2$ of the frame called a field—first the even field and then the odd field. That interleaving reduces the apparent flicker for a given display bandwidth when displaying smooth imagery, such as for TV. It is usually not acceptable for computer graphics, however, as thin horizontal lines tend to flicker at $^1/_2$ the vertical scan rate. The refresh rate is the predominant factor that affects the flicker of the display, though the persistence of the CRT phosphors are also a consideration. Long-persistence phosphors decrease flicker at the expense of smearing when the picture changes or moves. Vertical scan rate is equal to the refresh rate for non-interlaced monitors but is the twice the refresh rate for interlaced monitors (1 frame equals 2 fields). Non-interlaced vertical refresh rates of 70–75 Hz are considered desirable for computer displays. Television uses 25 or 30 Hz (frame rate) interlaced scanning in most countries.

3. Horizontal-scan rate—the frequency at which the electron beam(s) move across the screen. The horizontal-scan rate is often the limiting factor in supporting high refresh-rate, high-resolution displays. It is what may cause failure if scan-rate speed limits are exceeded due to the component stress levels in high-performance deflection systems.

4. Color or monochrome—a color monitor has a CRT with three electron guns each associated with a primary color—red, green, or blue. Nearly all visible colors can be created from a mix of primaries with suitable spectral characteristics using this additive color system. A monochrome monitor has a CRT with a single electron gun. However, the actual color of the display might be white, amber, green, or whatever single color is desired as determined by the phosphor of the CRT selected.

5. Digital or analog signal—a digital input can only assume a discrete number of states depending on how many bits are provided. A single bit input can only produce two levels—usually black or white (or amber, green, etc.). Four bits can display up to 16 colors (with a color monitor) or 16 shades of gray (with a monochrome monitor). Analog inputs allow for a theoretically unlimited number of possible gray levels or colors. However, physical limitations of the display, unavoidable noise, and other characteristics of the CRT—and ultimately, limitations in the psychovisual eye/brain system—will limit this to a practical maximum of 64–256 discernible levels for a gray-scale display or for each color channel.

Types of Monitors

Monitors can be classified into three general categories:

1. Studio video monitors—fixed scanning rate for the TV standards in the country in which they are used. They feature high quality, often high cost, utilitarian case (read: ugly), and an underscan option. Small closed-circuit TV monitors fall into the class. Input is usually composite video (*i.e.*, NTSC or PAL), although RGB types are available.

2. Fixed frequency RGB—high-resolution, fixed scan-rate units that are high quality, high cost, and offer a very stable display. Inputs are analog RGB using either separate BNC connectors or a 13W3 (Sun) connector. These often have multiple sync options. The BNC variety permit multiple monitors to be driven off of the same source by daisy-chaining. These monitors are generally used underscanned for computer workstation (*e.g.*, X-windows) applications so that the entire frame buffer is visible. There are also fixed-frequency monochrome monitors that may be digital or analog input using BNC, 13W3, or a special connector.

3. Multi scan or auto scan—these monitors support multiple resolutions and scan rates or multiple ranges of resolutions and scan rates. The quality and cost of these monitors ranges all over the

map. While cost is not a strict measure of picture quality and reliability, there is a strong correlation. Input is most often analog RGB, but some older monitors of this type (*e.g.*, Mitsubishi AUM1381) support a variety of digital (TTL) modes as well. A full complement of user controls permits adjustment of brightness, contrast, position, size, etc. to taste. Circuitry in the monitor identifies the video scan rate automatically and sets up the appropriate circuitry. With more sophisticated (and expensive) designs, the monitor automatically sets the appropriate parameters for user preferences from memory as well. The DB15 high density VGA connector is most common here, though BNCs may be used or may be present as an auxiliary (and better quality) input.

Why Auto Scan?

Thank IBM for this one. Since the PC has evolved over a period of 15 years, display adapters have changed and improved a number of times. With an open system, vendors with more vision (and willing to take more risks) than IBM were continuously coming up with improved higher resolution display adapters. With workstations and the Apple MacIntosh, the primary vendor can control most aspects of the hardware and software of the computer system. Not so with PCs. New improved hardware adapters that were not following any standards for the high-resolution modes (but attempted to be backward compatible with the original VGA as well as EGA and CGA) were being introduced regularly. Vast numbers of programs were written that were designed to directly control the CGA, EGA, and VGA hardware. Adapter cards could be designed to emulate those older modes on a fixed-frequency high-resolution monitor (and those exist to permit high-quality fixed scan-rate workstation monitors to be used on PCs). However, those would be (and are) much more expensive than basic display adapters that simply switch scan rates based on mode. Thus, auto-scan monitors evolved to accommodate the multiple resolutions that different programs required.

Ultimately, the fixed scan-rate monitor may reappear for PCs. Consider one simple fact: It is becoming cheaper to design and manufacture complex digital-processing hardware than to produce the reliable high-quality analog and power electronics needed for an auto-scan monitor. That is being done in the specialty market now. Eventually, the development of accelerated chipsets for graphics-mode emulation may be forced by the increasing popularity of flat panel displays—which are basically similar to fixed scan rate monitors in terms of their interfacing requirements.

Analog *vs.* Digital Monitors

There are two aspects of monitor design that can be described in terms of analog or digital characteristics:

1. The video inputs—early PC monitors, video display terminal (VDT) monitors, and mono workstation monitors use digital input signals that are usually TTL, but some very high-resolution monitors may use ECL instead.

2. The monitor control and user interface—originally, monitors all used knobs (sometimes quite a number of them) to control all functions like brightness, contrast, position, size, linearity, pincushion, convergence, etc. However, as the costs of digital circuitry came down—and the need to remember settings for multiple scan rates and resolutions arose—digital (microprocessor) control became an attractive alternative in terms of design, manufacturing costs, and user convenience. Now, most better quality monitors use digital controls—buttons and menus—for almost all adjustments except possibly brightness and contrast where knobs are still more convenient.

Since monitors with digital-signal inputs are almost extinct today except for specialized applications, it is usually safe to assume that "digital" monitor refers to the user interface and microprocessor control.

Interlacing

Whether a monitor runs interlaced or non-interlaced is almost always strictly a function of the video-source timing. The vertical sync pulse is offset an amount equal to $1/2$ the line time on alternate fields (vertical scans—two fields make up a frame when interlaced scanning is used).

Generally, a monitor that runs at a given resolution non-interlaced can run interlaced at a resolution with the same number of pixels per line but twice the number of lines vertically at roughly the same horizontal and vertical scan rates and video bandwidth (but half the frame rate). Alternatively, it might be possible to increase the resolution in both directions while keeping the horizontal scan rate the same, thus permitting a monitor to display the next larger size format. However, in this case, the video bandwidth will increase. Whether the image is usable at the higher resolution of course depends on many other factors (in addition to flicker) including the dot pitch of the CRT, video bandwidth of the video card and monitor video amplifiers, and cable quality and termination.

Monitor Performance

The ultimate perceived quality of your display is influenced by many aspects of the total video source/computer-cable-monitor system. Among them are:

1. Resolution of the video source—for a computer display, this is determined by the number of pixels on each visible scan line and the number of visible scan lines on the entire picture.

2. The pitch of the shadow mask or aperture grille of the CRT—the smallest color element on the face of the CRT is determined by the spacing of the groups of R, G, and B colors phosphors. The actual conversion from dot or line pitch to resolution differs slightly among dot or slot mask and aperture grille CRTs, but in general, the finer, the better—and more expensive. Typical television CRTs are rather coarse—0.75 mm might be a reasonable specification for a 20 inch set. High-resolution computer monitors may have dot pitches as small as 0.22 mm for a similar size screen. A rough indication of the maximum possible resolution of the CRT can be found by determining how many complete phosphor dot groups can fit across the visible part of the screen. Running at too high a resolution for a given CRT may result in *Moire*—an interference pattern that will manifest itself as contour lines in smooth bright areas of the picture. However, many factors influence to what extent that may be a problem.

3. Bandwidth of the video source or display card—use of high-performance video amplifiers or digital to analog converters.

4. Signal quality of the video source or display card—properly designed circuitry with adequate power supply filtering and high quality components.

5. Cables—high-quality cables with correct termination should be used. Also, cables should be as short as possible, and extensions or switch boxes should not be used unless they are designed specifically for high-bandwidth video.

6. Sharpness of focus—even if the

CRT dot pitch is very fine, a fuzzy scanning beam will result in a poor-quality picture.

7. Stability of the monitor electronics—well-regulated power supplies and low-noise shielded electronics contribute to a rock-solid image.

8. Anti-glare treatment of screen and ambient lighting conditions—no matter how good the monitor's electronics are, the display can still be washed out and difficult or tiring to view if there is annoying glare or reflections. The lighting and location are probably more important than how the screen itself is designed to minimize glare.

9. Electromagnetic interference—proximity to sources of magnetic fields and power-line noise can degrade the performance of any monitor, no matter how well shielded it is.

Performance Testing

Before we go further, here's a warning: No monitor is perfect. Running comprehensive tests on your monitor or one you are considering purchasing might make you aware of deficiencies you never realized were even possible. You might never be happy with any monitor for the rest of your life!

Also note that the intent of these tests is **not** to evaluate or calibrate a monitor for photometric accuracy. Rather they are for functional testing of the monitor's performance.

Obviously, the ideal situation is to be able to perform these tests before purchase. With a small customer-oriented store, that might be possible. However, the best that can be done when ordering by mail is to examine a similar model in a store for gross characteristics and then do a thorough test when your monitor arrives. The following should be evaluated:

- Screen size and general appearance
- Brightness and screen uniformity, purity and color saturation
- Stability
- Convergence
- Edge geometry
- Linearity
- Tilt
- Size and position control range
- Ghosting or trailing streaks
- Sharpness
- Moire
- Scan rate switching
- Acoustic noise

A document at my Web site (www.repairfaq.org) "Performance Testing of Computer and Video Monitors" provides detailed procedures for the evaluation of each of these criteria.

CAUTION: Since there is no risk-free way of evaluating the actual scan rate limits of a monitor, this is not an objective of those tests. It is assumed that the specifications of both the video source/card

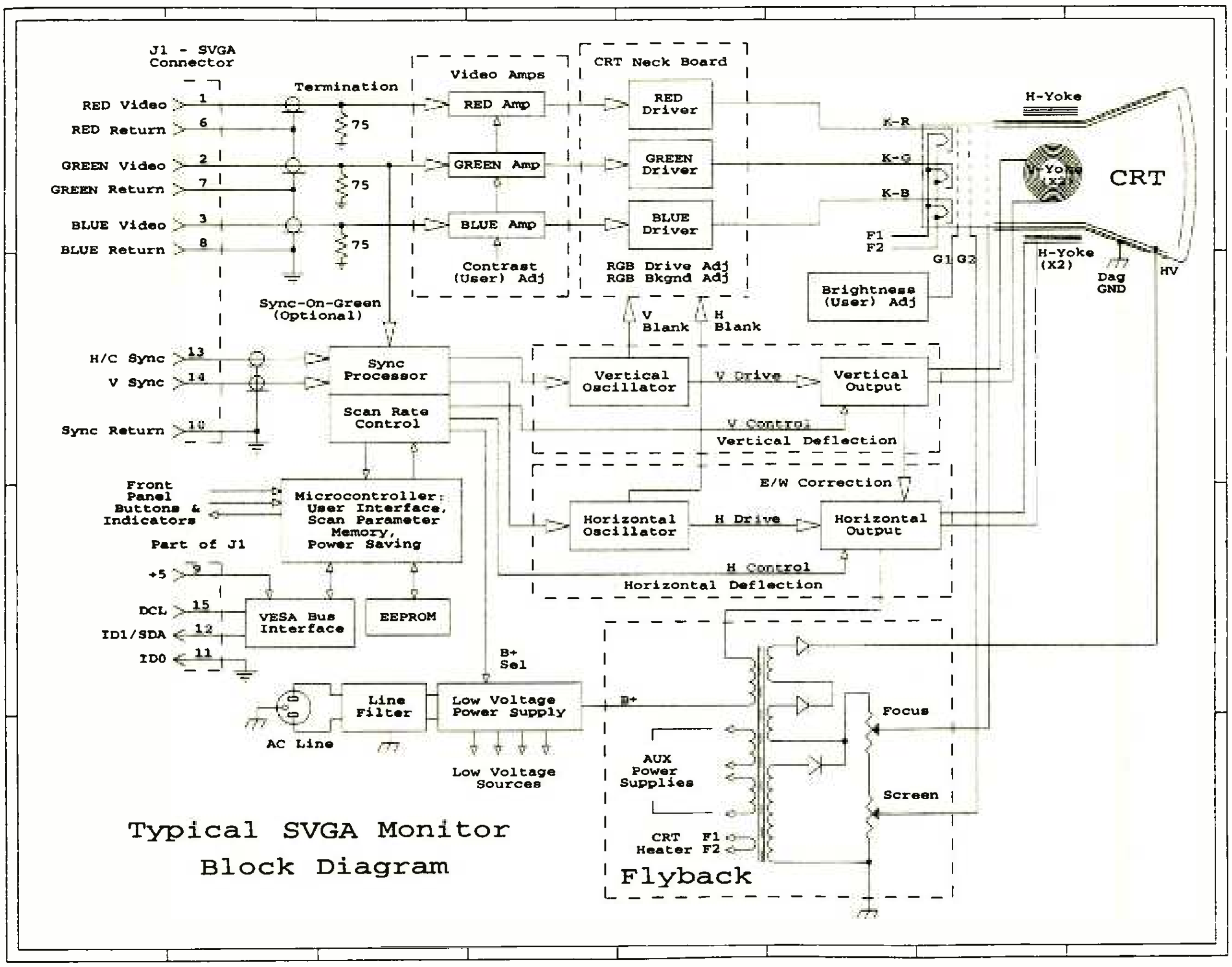


FIG. 1—HERE'S A BLOCK DIAGRAM for a typical SVGA monitor. While details will vary, most of the circuitry here will be found in almost every unit.

and the monitor are known and that supported scan rates are not exceeded. Some monitors will operate perfectly happily at well beyond the specified range, will shut down without damage, or will display an error message. Others will simply blow up instantly and require expensive repairs.

Monitor Repair

WARNING: The inside of a TV or monitor is no place for the careless or naive. If you are not sure of yourself or your knowledge, stay away. Unlike PC system boards where any disasters are likely to only affect your pocketbook, monitors can be very dangerous. Read, understand, and follow the set of safety guidelines that will be provided next month whenever working on TVs, monitors, or other similar high-voltage equipment.

If you do go inside, remember that line voltage (on large capacitors) and high voltage (on the CRT) could be present for a long time after the plug is pulled. There is the added danger of CRT implosion caused by carelessly dropped tools, and there are often sharp sheet-metal shields that could injure you if you should have a reflex reaction upon touching something you should not touch.

Having said that, a basic knowledge of how a monitor works and what can go wrong can be of great value even if you do not attempt the repair yourself. It will enable you to intelligently deal with the service technician. You will be more likely to be able to recognize if you are being taken for a ride by a dishonest or just plain incompetent repair center. For example, a faulty picture tube CANNOT be the cause of a color monitor only displaying in black-and-white (this is probably a software or compatibility problem). The majority of consumers—and computer professionals—might not know even this simple fact.

This series will provide you with the knowledge to deal with a large percentage of the problems you are likely to encounter with your monitors. It will enable you to diagnose problems and in many cases, correct them as well. With minor exceptions, specific manufacturers and models will not be covered as there are so many variations that such a treatment would require a huge and very detailed text. Rather, the most common problems will be addressed and enough basic principles of operation will be provided to enable you to narrow the problem down and likely determine a course of action for repair. In many cases, you will be able to do what is required for a fraction of the cost that would be charged by a repair center.

Should you still not be able to find a solution, you will have learned a great deal and be able to ask appropriate questions and supply relevant information if, for example, you decide to post your problem to the sci.electronics.repair newsgroup on the Internet. It will also be easier to do further research using a repair text such as the ones listed at the end of this month's column. In any case, you will have the satisfaction of knowing you did as much as you could before taking it in for professional repair.

Most Common Problems

The following probably account for 95% or more of the common monitor ailments:

- Intermittent changes in color, brightness, size, or position—bad connections inside the monitor or at the cable connection to the computer or video source.
- Ghosts, shadows, or streaks adjacent to vertical edges in the picture—problems with input-signal termination including use of cable extensions, excessively long cables, cheap or improperly made video cables, improper daisy-chaining of monitors, or problems in the video source or monitor circuitry.
- Color blotches or other color or distortion problems—these are caused by magnetization of the CRT. Locate and eliminate sources of magnetic fields if relevant and degauss the CRT.
- Wiggling, rippling, or other effects—electromagnetic Interference (EMI) is the culprit here. Nearby equipment (including and especially other monitors), power lines, or electrical wiring behind walls, may produce electromagnetic fields strong enough to cause noticeable distortion. Relocate the monitor or offending equipment. Shielding is difficult and expensive.
- Noise bars and similar effects—these are caused by noisy AC power reaching your monitor through the power cord. It is produced by such things as equipment using electric motors (*e.g.*, vacuum cleaners), lamp dimmers or motor-speed controls (shop tools), fluorescent lamps, and other high power devices. The source is likely local—in your house—but could be several miles away. The effects could be barely visible as a couple of jiggling scan lines or be broad bars of salt and pepper noise, snow, or distorted video. Plugging the monitor into another outlet or the use of a line filter could help. If possible, replace or repair the offending device.
- Monitor not locking on one or more video scan ranges—settings of the video adapter are incorrect. Use software setup program to set these. This could also be a fault in the video source or monitor dealing with the sync signals.
- Adjustments needed for background brightness or focus—as a CRT ages, its brightness is reduced. However, note that other components may affect focus. Fortunately, these can often be fixed using easy internal (or sometimes external) adjustments.
- Dead monitor due to power supply problems—very often the causes are simple such as bad connections, blown fuse or other component.

Repair or Replace

If you need to send or take the monitor to a service center, the repair could easily exceed half the cost of a new monitor. Service centers may charge up to $50 or more for providing an initial estimate of repair costs, but that will usually be credited toward the total cost of the repair.

Some places offer attractive flat rates for repairs involving anything but the CRT, yoke, and flyback. Such offers are attractive if the repair center is reputable. However, if by mail, you will be stuck with a tough decision if they find that one of these expensive components is actually bad.

Monitors become obsolete at a somewhat slower rate than most other electronic equipment. Therefore, unless you need the higher resolution and scan rates that newer monitors provide, repairing an older one may make sense as long as the CRT is in good condition (adequate brightness, no burn marks, good focus). However, if a monitor fails, it might just be a good excuse to upgrade.

If you can do the repairs yourself, the equation changes dramatically as your parts costs will be $^1/_2$ to $^1/_4$ of what a professional will charge and, of course, your time is free. The educational aspects may also be appealing. You will learn a lot in the process. Thus, it may make sense to repair that old clunker for your 2nd PC (or your 3rd or your 4th or . . .).

Monitors 101

Now that the preliminaries are out of the way, it is time to get to work. We'll begin by looking at the subsystems of a monitor. It will be helpful to refer to Fig. 1, which is a block diagram of a typical unit, as we proceed.

A computer or video monitor includes the following functional blocks:

1. Low voltage power supply: Most of the lower voltages used in the monitor may be derived from the horizontal deflection circuits (which we will look at next), a separate switching power supply, or a combination of the two. A rectifier/filter-capacitor/regulator circuit fed from the AC line provides the B+ to the switching power supply or horizontal-deflection system. Auto-scan monitors may have multiple outputs from the low voltage power supply that are selectively switched or enabled depending on the scan rate. The degauss circuit operates off of the line whenever power is turned on (after having been off for a few minutes) to demagnetize the CRT. Better monitors will have a degauss button that activates the circuitry as well since even rotating the monitor on its tilt-swivel base could make degaussing necessary.

2. Horizontal deflection: These circuits provide the waveforms needed to sweep the electron beam in the CRT across and back at anywhere from 15 kHz to over 100 kHz depending on scan rate and resolution. The horizontal sync pulse from the sync separator or the horizontal sync input locks the horizontal deflection to the video signal. Auto-scan monitors have sophisticated circuitry to permit the scanning range of horizontal deflection to be automatically varied over a wide range.

3. Vertical deflection: These circuits provide the waveforms needed to sweep the electron beam in the CRT from top to bottom and back at anywhere from 50 to 120 or more times per second. The vertical sync pulse from the sync separator or vertical sync input locks the vertical deflection to the video signal. Auto-scan monitors have additional circuitry to lock to a wide range of vertical scan rates.

4. CRT high voltage "flyback" power supply: A modern color CRT requires up to 30 kV for a crisp bright picture. Rather than having a totally separate power supply, most monitors derive the high voltage (as well as many other voltages) from the horizontal deflection using a special transformer called a "flyback" or "Line Output Transformer" (LOPT) for those of you on the other side of the pond. Some high-performance monitors use a separate high-voltage board or module that is a self contained high-frequency inverter.

5. Video amplifiers: These buffer the low-level inputs from the computer or video source. On monitors with TTL inputs (MGA, CGA, and EGA), a resistor network also combines the intensity and color signals in a kind of poor man's D/A. Analog video amplifiers will usually also include DC restore (black-level retention, back-porch clamping) circuitry to stabilize the black level on AC-coupled video systems.

6. Video drivers (RGB): These are almost always located on a little circuit board plugged directly onto the neck of the CRT. They boost the output of the video amplifiers to the hundred volts or so needed to drive the cathodes (usually) of the CRT.

7. Sync processor: This accepts separate, composite, or "sync-on-green" signals to control the timing of the horizontal and vertical deflection systems. Where input is composite rather than separate H and V sync signals (as is used with VGA/SVGA), this circuit extracts the individual sync signals. For workstation monitors, which often have the sync combined with the green video signals, it needs to separate that as well. The output of the sync processor is horizontal and vertical sync pulses used to control the deflection circuits.

8. System control: Most higher-quality monitors use a microcontroller to perform all user interface and control functions from the front panel (and sometimes even from a remote control). So called "digital monitors"—meaning digital controls not digital inputs—use buttons for everything except possibly user brightness and contrast. Settings for horizontal and vertical size and position, pincushion, and color balance for each scan rate may be stored in non-volatile memory. The microprocessor also analyzes the input video timing and selects the appropriate scan range and components for the detected resolution. While these circuits rarely fail, if they do, debugging can be quite a treat.

Most problems occur in the horizontal deflection and power supply sections. Those run at relatively high power levels and some components run hot. This results in both wear and tear on the components as well as increased likelihood of bad connections developing from repeated thermal cycles. The high voltage section is prone to breakdown and arcing as a result of hairline cracks, humidity, dirt, *etc.*

The video circuitry is generally quite reliable. However, it seems that even after 15+ years, manufacturers still cannot turn out circuit boards that are free of bad solder connections or that do not develop them with time and use.

For More Information

For an on-line introduction to TV and monitor technology, check out the Philips/Magnavox Electronics Reference Web site (www.philipsmagnavox.com/product/pe33.html). There you will find links to a number of articles on the basic principles of operation of CD players, laserdisc and optical drives, TVs, VCRs, camcorders, loudspeakers, satellite receivers, and other consumer A/V equipment. Specifically, see the article on the TV-set operating principles since a monitor is a high quality subset of a television receiver. (We will deal with TV sets in a future Service Clinic series.)

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronics equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since the identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database might quickly identify your problem and solution.

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general—this has nothing to do with any one in particular—is that symptoms can sometimes be deceiving and a solution that works in one instance might not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old-fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage—at least from one point of view—is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis

(Continued on page 62)

NEW PRODUCTS

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

AC Power Line Analyzer

DESIGNED TO MEET THE MOST demanding test and measurement applications, the Model 1521 True RMS AC Power Line Analyzer provides all the necessary information about any electrical load that is connected to the AC line. It is ideal for use by appliance manufacturers and R & D facilities where all the AC parameters must be gathered and evaluated to meet published specifications and any applicable regulatory commission standards.

This analyzer features accurate true RMS measurements of voltage up to 130 VAC, current up to 10 amps, power up to 1300 watts, volt-amps to 1300VA, power factor, and line frequency up to 65 Hz. It comes standard with an RS-232 interface for data logging. Through this feature, the user can control the instrument through a PC.

This unit also features a unique user-settable scan mode, which enables continuous monitoring of all parameters sequentially, including the power factor. To provide for maximum usability, any parameter can also be selected manually for separate measurement.

User operation is very simple. The load that is to be monitored is connected to the 'Line Output' Socket provided on the front panel. The 1521 is then connected to the AC line. All the parameters are then displayed on an easy-to-read green 7-segment LED display with over-range indicator.

The 1521 measures 9.5 × 2.6 × 9.8 inches and weighs approximately 7 pounds. The suggested list price of the unit is $595.

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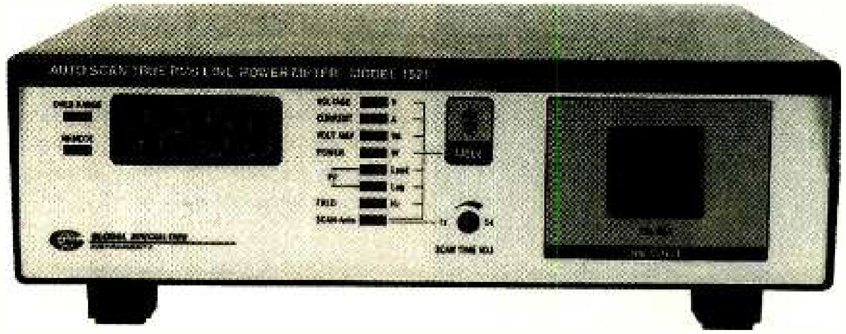

CIRCLE 20 ON FREE INFORMATION CARD

Data Interface Adapters

USING PCs, THESE DATA INTERface adapters log data from global positioning systems, depth sounders, radar, and other marine navigational devices. The plug-in connectors convert NMEA (National Marine Electronics Assn.) standard data signals so they can communicate with any RS-232, RS-422, or RS-485 device such as a PC.

There are two adapter models to fit either the older NMEA or the latest NMEA specifications. Version 1.x, the original standard, is an unbalanced signal, similar to RS-232, but with higher current-handling capabilities and optical isolation on the receive line. The newer standard, version 2.0 and above, uses an RS-422 transmitter combined with an optically isolated receiver.

Model 183COR converts the earlier NMEA0183 version 1.x data signal to EIA RS-232, RS-422, or RS-485 signals. Model 183V2C is for NMEA0183 version 2.x. It converts one data signal in each direction between NMEA0183 and EIA RS-232. Either converter costs $99.95.

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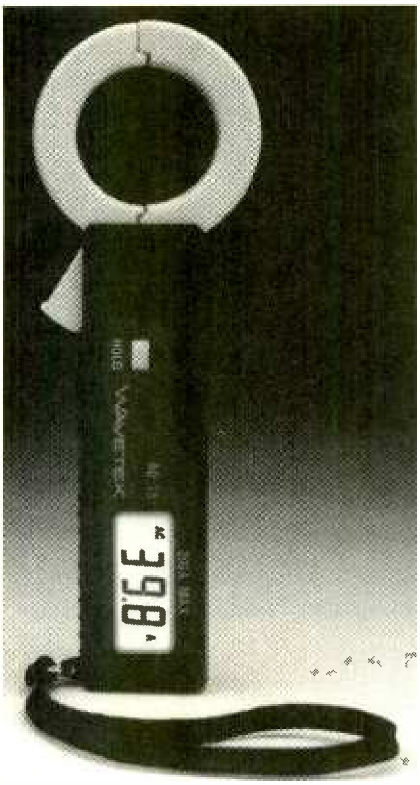
CIRCLE 21 ON FREE INFORMATION CARD

AC Ammeter

IDEAL FOR THE ELECTRICAL contractor, the handyman, building-maintenance departments, HVAC/R service personnel, and light commercial and residential electrical applications, the miniature AD15 DMM can take measurements in even the tightest spaces. Its size (2.1 by 6.1 by 0.8 inches) and its digital display make it a useful tool for field work.

Two measuring ranges of 20A AC and 200A AC make the AD15 perfect for most commonly measured currents. In addition, the low 20A range results in better resolution on measurements down to one amp.

Features of the AD15 include a Data Hold function for measuring in difficult-to-read areas and slip-proof grip on the sides. The ammeter comes with batteries installed and a wrist strap. It retails for $49.95.



CIRCLE 23 ON FREE INFORMATION CARD

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Internet Fax Machine

THE PANAFAX UF-770i VIRTUALLY eliminates long-distance charges for organizations that send frequent global and/or long-distance faxes. It sends and receives documents, pictures, photos, handwritten messages, and e-mail over the Internet by the simple push of a one-touch key. Instead of entering a telephone number, the user dials in an e-mail address on the keypad. People working away from the office can retrieve faxes when they get their e-mail.

First a document is scanned in and the image is compressed. The Internet Fax wraps the compressed image data with TIFF (Tagged Image File Format) headers and tags and then encodes the TIFF file in base64. The data is then attached to a MIME file (Multipurpose Internet Mail Extension) and passed through a predetermined mail server with SMPT (Simple Mail Transfer Protocol). A heavy-duty, hardware-based unit, the Internet Fax (16.9 by 18 by 11 inches) automatically prints e-mail messages it receives, making it an all-in-one communications center.

Panasonic offers free software utilities to send and receive Internet faxes. A TIFF viewer and Internet fax converter is available from Panasonic's Web site. The TIFF viewer allows quick and easy viewing of Internet faxes received in a PC's e-mail in-box, and the TIFF converter lets the user create Internet fax files.

The Panafax UF-770i offers high-quality, plain paper printing in letter, legal, and A4 formats. Other features include a 50-page automatic document feeder; and an all-in-one, high-yield print cartridge. Up to 24 department codes are provided. The unit also automatically reports low toner status and certain mechanical failures.

CIRCLE 24 ON FREE INFORMATION CARD

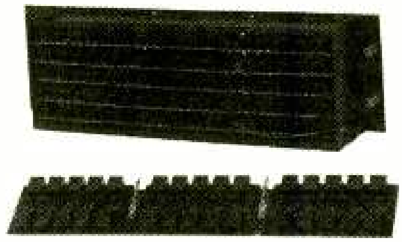
Current users of the Panafax UF-770 can upgrade their unit to include all the functions of the UF-770i. The UF-770i Internet Fax has a suggested retail price of $3295.

PANASONIC OFFICE PRODUCTS COMPANY
2 Panasonic Way
Secaucus, NJ 07094
Tel: 800-742-8086 or 201-348-7000
Web: www.panasonic.com/internetfax.com

Ethernet Surge Protection

AS ETHERNET LOCAL AREA NETworks (LANs) proliferate at an explosive rate, many of these LANs have a large number of lines that terminate at a computer room/closet with large capacity switches/hubs. Often, these lines need surge protection due to the environment in which their associated workstations are found. For example, LANs are now serving more industrial users and therefore harsh environments are common.

The 10Base-T surge protection system from Telebyte Technology provides individual port protection for up to 75 Ethernet ports. This system is composed of the Model 3310 Card Cage and the Model 3311 Multi-Port Protection Card. The 10Base-T signals for each Ethernet port are applied to standard RJ-45 connectors. Each signal in each port incorporates protection with response times measured in picoseconds. The output port is also provided in an RJ-45 connector. This circuitry is all mounted on the Model 3311 Protection Card.



CIRCLE 25 ON FREE INFORMATION CARD

The Model 3311 offers 15 protected ports on a single printed circuit, which is one of five cards in a rack-mounted enclosure—the Model 3310 Card Cage—yielding an overall capacity of 75 ports in a single card cage. This 5.25-inch high housing is designed for standard 19-inch equipment racks.

Each card provides two, high-capacity, ground pins that are accommodated in ground bars located in the card cage. There are ground connections on each bar. The Card Cage includes a hinge and locking screws so that an installer and maintenance personnel have access to the rear of the cage. The Card Cage is locked in position using two captive thumbscrews. Individual cards are locked in position via a captive retaining rod.

The Model 3310 Card Cage sells for $483 and the Model 3311 Protection Cards sell for $317 each.

TELEBYTE TECHNOLOGY, INC.
270 Pulaski Road
Greenlawn, NY 11740
Tel: 800-835-3298
Fax: 516-385-8184
e-mail: sales@telebyte.com
Web: www.telebyteusa.com

EN

NEW LITERATURE

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1998 General Catalog

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Web: www.contacteast.com
Free

CIRCLE 338 ON FREE INFORMATION CARD

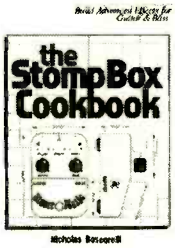
Aimed at engineers, technicians, hobbyists, and general users, this 292-page catalog is filled with new tools and test instruments. Featured are quality products for testing, repairing, and assembling electrical and electronic equipment. Each product is accompanied by a full-color illustration.

Among the manufacturers represented are Fluke, Tektronix, Weller, Hewlett-Packard, Metcal, OK, Pace, Milwaukee, Makita, Xcelite, Loctite, Leatherman, and 3M. New product highlights include Tektronix' TX-DMM Series of True RMS DMMs with built-in RS-232 interface, Weller's electronically-controlled Silver Series soldering stations, and Erem "2200 Series" ergonomic cutters and pliers.

Also featured is a full selection of DMMs and oscilloscopes, power supplies, solder/desoldering equipment, heat guns, precision and hard-to-find hand tools, cordless power tools, measuring instruments, ESD protection products, adhesives, custom-made tool kits, magnification and lighting devices, storage and handling containers, and workbenches and chairs.

The Stomp Box Cookbook

by Nicholas Boscorelli
Guitar Project Books
200 Union Blvd., #425
Denver, CO 80228
$22.95 plus $3 shipping



CIRCLE 339 ON FREE INFORMATION CARD

Written for a skilled audience, this 144-page book guides readers to building advanced effects for electric guitar and bass. It contains no beginner-level projects, and assumes the reader to have access to standard electronic test gear. While the projects demand skill to build, anyone interested in how stomp boxes work will find a wealth of detail in this collection.

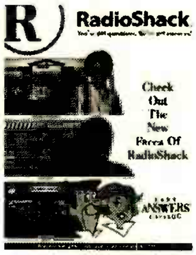
The projects take their respective functions far beyond basic databook circuits, and they include several effects unavailable commercially. Projects include five unique distortion boxes, a tri-mode tremolo, and a dual-mode sustain box for guitar and bass. There is also a studio-quality compressor, a full-featured noise gate, a true parametric equalizer, and an advanced envelope follower. A functional duplicate of the Ampeg SVT tone block (with inductor), a stereo tremolo pan box, a transformer isolation box, and six more designs complete the 20 projects in the book.

Each project includes a circuit description, schematic, royalty-free printed circuit layout, clear wiring diagram, and large prototype photo. Many feature oscilloscope photographs that dramatize how the boxes work.

The author has also presented a wide-ranging tutorial of stomp-box "ingredients" to help ambitious builders cook up new effects. Fleshed out with more than 200 photos and diagrams, the book explores tone shaping, hum, noise, distortion, and compression in depth.

1999 Answers Catalog

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



CIRCLE 340 ON FREE INFORMATION CARD

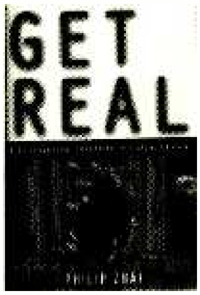
The latest RadioShack catalog contains a large assortment of telephony products, such as corded and cordless phones, answering machines, caller-ID units, and cellular phones. In addition, the color-coded divisions in the over 300-page catalog include a wide variety of products for home and office electronic needs: communications, audio, video, calculators, and computer equipment; as well as tools for the do-it-yourselfer, security devices, power controllers, adapters, clocks and weather meters, and automotive instruments. There are also electronic toys and games, and products for people with special needs.

Among the highlights is the extensive line-up of telecommunications products and services offered by the Sprint Store at RadioShack. Featured among the Sprint products is the latest in wireless technology, the 900-MHz digital spread spectrum cordless phone.

This year RadioShack is introducing Compaq Creative Learning Centers, featuring Compaq PCs especially designed for children in grades K-12. Among the Compaq products are the 2500, 5000, and 5600 series computers, and the 1200 series notebook computer. Information on choosing the best monitor and printer for your needs is included.

Get Real: A Philosophical Adventure in Virtual Reality

by Philip Zhai
Rowman & Littlefield Publishers, Inc.
4720 Boston Way
Lanham, MA 20706
Tel: 800-462-6420
$24.95



CIRCLE 341 ON FREE INFORMATION CARD

Is virtual reality merely a video game tool? Or is it an immaterial world beckoning people to a better world inside computers?

The author tackles these questions with keen logical analysis. He concludes by advocating a position that transcends these two opposing views of virtual reality. Zhai argues that the combination of three technologies: digital simulation, sensory immersion, and functional teleoperation, amounts to a re-creation of the empirically perceived universe. His analysis of the nature and significance of this re-creation is thought provoking and original.

1998-1999 Catalog

Jensen Tools, Inc.
7815 S. 46th Street
Phoenix, AZ 85044-5399
Tel: 800-426-1194 or 602-968-6231
Fax: 800-366-9662 or 602-438-1690
Web: www.jensentools.com
Free

CIRCLE 342 ON FREE INFORMATION CARD

Over 5000 products for the worldwide electronic/electrical industries are offered in this over 300-page full-color catalog. New products, such as mini-tool kits, shears and crimp tools, test signal generators, true RMS multimeters, power analyzer, cable testers, and EPROM programmers are featured.

In addition to Jensen's top-of-the-line tool kits, the products offered include test equipment, computers and LAN tools, wire and cable, telecommunication devices, hand and power tools, soldering gear, and devices for storage and handling. Work stations, shop supplies, lighting, and optical equipment are also featured.

Among the manufacturers represented are Fluke, Hewlett-Packard, Leatherman, Loctite, Panasonic, Stanley, Tektronix, and Weller. A full-color photo accompanies each item. A complete index is found at the back of the catalog.

The Future of Emulation

Hewlett-Packard Company
P.O. Box 2197
Colorado Springs, CO 80901-2197
Tel: 800-453-4844
Web: www.hp.com/info/uPIsolutions
Free


CIRCLE 343 ON FREE INFORMATION CARD

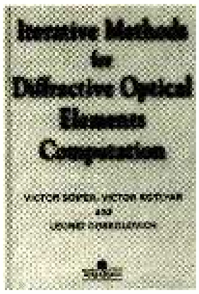
Is your emulator keeping up with the speed and complexity of your latest embedded-system designs? Tired of replacing your emulator every time you choose a new processor? This booklet gives you a new approach to emulation that's ready to tackle your toughest design challenges.

By combining on-chip simulation with powerful state and timing analysis, HP emulation solutions solve the problems of traditional emulation while meeting the new challenges of today's complex processors. Developed in conjunction with leading processor and tool vendors, these modular systems are easy to scale and reconfigure from user to user and project to project.

HP emulation solutions make it easy to analyze everything from source code to analog I/O signals. The HP 16600A and 16700A Series lets developers see every aspect of the problem at hand, even with complex system-integration problems. In addition to run control, real-time trace, and other features, this emulation solution series offers insight into hardware/software interaction, software performance, and other system-wide behavior that extends beyond the processor.

Iterative Methods for Diffractive Optical Elements Computation

by Victor Soifer, Victor Kotlyar, and Leonid Doskolovich
Taylor & Francis
1900 Frost Road, Suite 101
Bristol, PA 19007
Tel: 215-785-5800
$110



CIRCLE 344 ON FREE INFORMATION CARD

This book is devoted to methods of computer-aided design of non-conventional optics. This class of optics has been given many names: computer optics, diffractive optics, planar optics, or micro-optics. Their general purpose is to perform highly efficient transformations of laser beams. The design algorithms for such optics feature an iterative character which allows a trade-off between two competing parameters: high-energy efficiency and a high degree of accuracy of light field transformation.

The book includes accounts of well-established methods and algorithms for calculating Diffractive Optical Elements (DOEs), but its major contribution is to include new methods and to examine the theoretical and practical aspects of synthesizing optical components. It will be a valuable sourcebook for methods and algorithms in this central area of optics measurement.

Electronics Parts and Accessories Catalog

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Springboro, OH 45066
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Web: www.parts-express.com
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CIRCLE 345 ON FREE INFORMATION CARD

Geared toward the consumer-electronics industry and the technical hobbyist, this 266-page catalog features full lines of electronic parts and accessories. It includes an impressive selection of products, including alarm systems for home and automotive applications; speaker design software; CATV and VCR repair parts; home-theater and home-automation systems; telephone and cellular phone products and accessories; computer accessories; stage lighting; professional sound equipment, and raw loudspeaker drivers. Semiconductors, tools and technician aids, test equipment, chemicals, wire connectors, instructional books and videos are just some of the other items offered.

Among the exciting new products featured are affordable LCD video/TV screens for the mobile market, high-tech home A/V distribution systems, "no-hands" digital multimeters, miniature board cameras, optical A/V cables, as well as material for the renewed interest in tube technology. Throughout the catalog, there are tech tips that provide helpful information on applications, design ideas, and repair tips.

PIC'n Up The Pace: An Applications Guide to Using PIC16/17 Microcontrollers

by David Benson
Square 1 Electronics
P.O. Box 501
Kelseyville, CA 95451
Tel: 707-279-8881
Web: www.sq-1.com
$34.95

CIRCLE 346 ON FREE INFORMATION CARD

This book gives the reader the tools to design and build intermediate-level microcontroller-based instrumentation and systems. It covers Microchip Technology's PIC16/17 microcontrollers and describes serial communication as a means of transferring data between two PIC16/17s or between PIC16/17s and peripheral chips. Using the 93C46 serial EEPROM is explained in detail as an example.

Since we live in an analog world, A/D and D/A conversion are discussed, with several methods illustrated for each. Conditioning signals from sensors with an analog-voltage output is described. There are chapters on math routines, binary-to-decimal conversion and vice versa, alphanumeric LCD interfacing, and scanning keypads.

Projects that can be built by the reader are presented, including single wire communication with a PIC16/17-controlled LCD module, and a digital thermometer that incorporates many elements of PIC microcontroller design. Other topics covered are PIC16C84/PIC16F84 data EEPROM memory, program memory paging, and locating tables in program memory. EN

COMPUTER CONNECTIONS

continued from page 11

space on the target machine. It's frustrating because you've almost certainly seen and dealt with all those messages a long time ago.

Staying Connected

The POP3 *vs.* IMAP4 issue was not the biggest problem I had. The real problem was achieving a reliable connection! I spent lots of time and energy tweaking various delays and other settings in MultiMail Pro. Eventually, I found that the only way I could get it to operate reliably was to drop the transmission rate to 4800 bps. I thought that the 14.4 kbps rate of the Pilot Modem was bad, but this was ridiculous. And I doubt I achieved anywhere near 4800 bps in actual throughput. It felt more like a 300 bps modem from fifteen years ago. I thought the low throughput might have something to do with the "out-back" area we were in. I thought that perhaps the terrain or distance from a large city were factors. But after returning home, I achieved similar results. Just for the heck of it, I even tried connecting up during the long drive home. No dice.

Evaluation

The whole experience was a roller coaster. In a way, it's amazing that it works at all. Wireless e-mail, out in the middle of nowhere? On the other hand, configuration was so touchy, and performance so poor, that the overall experience ended up being pretty disappointing. I met my goal of staying in touch, and I learned a lot about how poorly current-day technology supports truly mobile e-mail access. I'll continue using the setup, but I'm eagerly awaiting the next generation.

I know what I want. Hardware: something the size of the Pilot with everything built in, so it wouldn't require a cell phone, an adapter, cables, batteries, and AC adapters. Software: IMAP4 support, and a fast, responsive application. MultiMail Pro worked OK, but with a large number of messages, things slow down tremendously. The app should support more than four e-mail accounts too. Between my wife and me, we use more than that. The app should also have a search function.

Incidentally, I couldn't have done this at all without a TRG memory board. The company sells memory upgrade boards for all Pilot models. The top-of-the line unit holds 8 MB of DRAM. My model contains 3 MB of SRAM and 2 MB of flash. Most third party apps run fine from flash. I chose the SRAM board because it provides lower power consumption. Highly recommended.

Bookshelf

Jan Axelson has done it again. Her prior effort, *Parallel Port Complete*, is an excellent introduction to using a parallel port for general purpose PC-hosted I/O. Along comes *Serial Port Complete*, which provides a very readable, in-depth discussion of serial I/O, and this time not just from a PC perspective. For example, Jan also discusses serial programming using microcontrollers. In addition, roughly a third of the book covers RS-422 and RS-485, providing an excellent tutorial on the subject, and includes cables, connectors, line length limits, effects of cable impedance, network topologies, network programming, and quite a bit more. As usual, Jan goes light on theory and heavy on practice. Even if you've never seen a 485 network before, there is enough info here for you to implement your own. So dust that smart-home project off the back burner and get cookin'!

In the meantime, stay in touch via e-mail at jeff@ingeninc.com EN

RETAILERS THAT SELL OUR MAGAZINE EVERY MONTH

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California Electronics
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Livonia, MI 48150

The Elec. Connection
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A MICROCONTROLLER-BASED PRECISION PULSE GENERATOR

Here's a benchtop pulse generator with crystal-controlled timing. What's more, it's built around a PIC microcontroller!

TOM NAPIER

Whether you're developing analog or digital circuits, one of the handiest pieces of test equipment anyone can have is a pulse generator. After all, without some source of signals, most circuits just sit there doing nothing. If you're like most experimenters, you probably find it a little tiring having to hook a timer chip into a circuit in order to test a new idea. As an added drawback, those types of pulse-generator circuits have limits as to their available range and accuracy.

Wouldn't it be nice to have a pulse generator that is inexpensive, accurate, and has a wide range? The Precision Pulse Generator described here is just such a unit. Since it is built around a microcontroller chip, no calibration is needed for pinpoint accuracy when dialing in a particular pulse width or repetition rate. The tradeoff for that ease-of-use feature is that the settings can only be changed in finite steps. However, those steps are small enough so that the unit will be useful on any technician's workbench.

Microcontroller-Based Pulse Generators. In selecting a microcontroller that could do the job of generating accurate and repeatable pulse widths, the PIC 16C55 from Microchip Technologies has several advantages in its favor. At the top of the list is that they are easy to program; the best chip in the world is worthless to the do-it-yourselfer if it can only be programmed with expensive equipment. Another advantage is speed: Most of the various families of Microchip devices can run at speeds up to 20 MHz. However, the most important feature is that each instruction, other than a jump command, has the same execution time. For those who have spent years working with microprocessors such as the Intel 8085 (whose instructions can vary from 1.3 to 5.2 microseconds), it's a pleasant change to find a chip that can generate accurately-timed events just 200 nanoseconds apart.

That 200-nanosecond figure is based on a 20-MHz clock frequency; the instruction rate of a PIC chip is one quarter of that. The main question that then needs to be asked is if a PIC chip could generate an uninterrupted stream of pulses with an arbitrary length and period while still monitoring the front panel controls for any changes. Unfortunately, the short answer is no—unless you want to accept certain restrictions on the pulse period. However, with many months of tinkering with the programming code, it is possible to build a useful bench-top pulse generator with not much more than a Microchip PIC16C55 microcontroller, a crystal oscillator, and four thumb-wheel switches. Specifications for the unit are shown in the sidebar.

The Precision Pulse Generator has both normal and inverted TTL-level outputs. The output's rise and fall times are less than 10 nanoseconds. The timing of the pulse lengths and periods is as good as the accuracy of the microcontroller's clock. A pair of two-digit thumb-wheel switches is used to set the pulse period and the pulse length. A six-position rotary switch selects the range. On the five slower ranges, the pulse period can be set from 1 to 99 units; on the fastest range, the period is settable from 5 to 99 units. The length of a unit, depending on the range selected, varies from 1 microsecond to 100 milliseconds.

The pulse length can be set over the range of 0.1 to 9.9 units. On any range, each step of the pulse-length switch is one tenth of the period switch step. For example, on range 1 the minimum off time is 2.1 microseconds if the period is below 10 microseconds. Above 10 microseconds, it is 4.1 microseconds. At the lower ranges, the minimum off time is 0.1 unit. Those are the limits on the pulse length as discussed above; a front-panel LED warns if any particular switch settings exceed those limits.

Although it might seem that the pulse widths must be less than a tenth of the pulse period, each range is ten times slower than the one above but the switch settings have a 100-to-1 range. The result is that many periods can be set equally easily on either of two ranges depending on the pulse length that you want. For example, if you wanted a period of 50 microseconds, you could set a period of 50 on range 1 (which is one-microsecond units) or a period of 05 on range 2 (which is ten-microsecond units). In the first case, the longest pulse length that you can set is 9.9 microseconds with one-microsecond changes in the period. In the second case, the pulses can be up to 49 microseconds long but the period could only be set in 10-microsecond steps. Because of the limitations, you can't have a pulse with a period of 49 microseconds and a length of 48 microseconds.

A Finer Step. As you can see, it is not too hard to make a PIC-based pulse generator that sets the pulse length in 1-microsecond steps. Naturally, any piece of test equipment will always leave someone asking if the limits can be increased; can the unit be made "better"—and that includes the author!

A desirable minimum-pulse length of 0.1 microseconds is a bit difficult to do if the fastest PIC controller has a 0.2-microsecond instruction cycle. In this case, the problem is solved with the addition of some circuitry. That circuit can be seen in the schematic diagram, which is shown in Fig. 1. The circuit consists of IC5 and IC6.

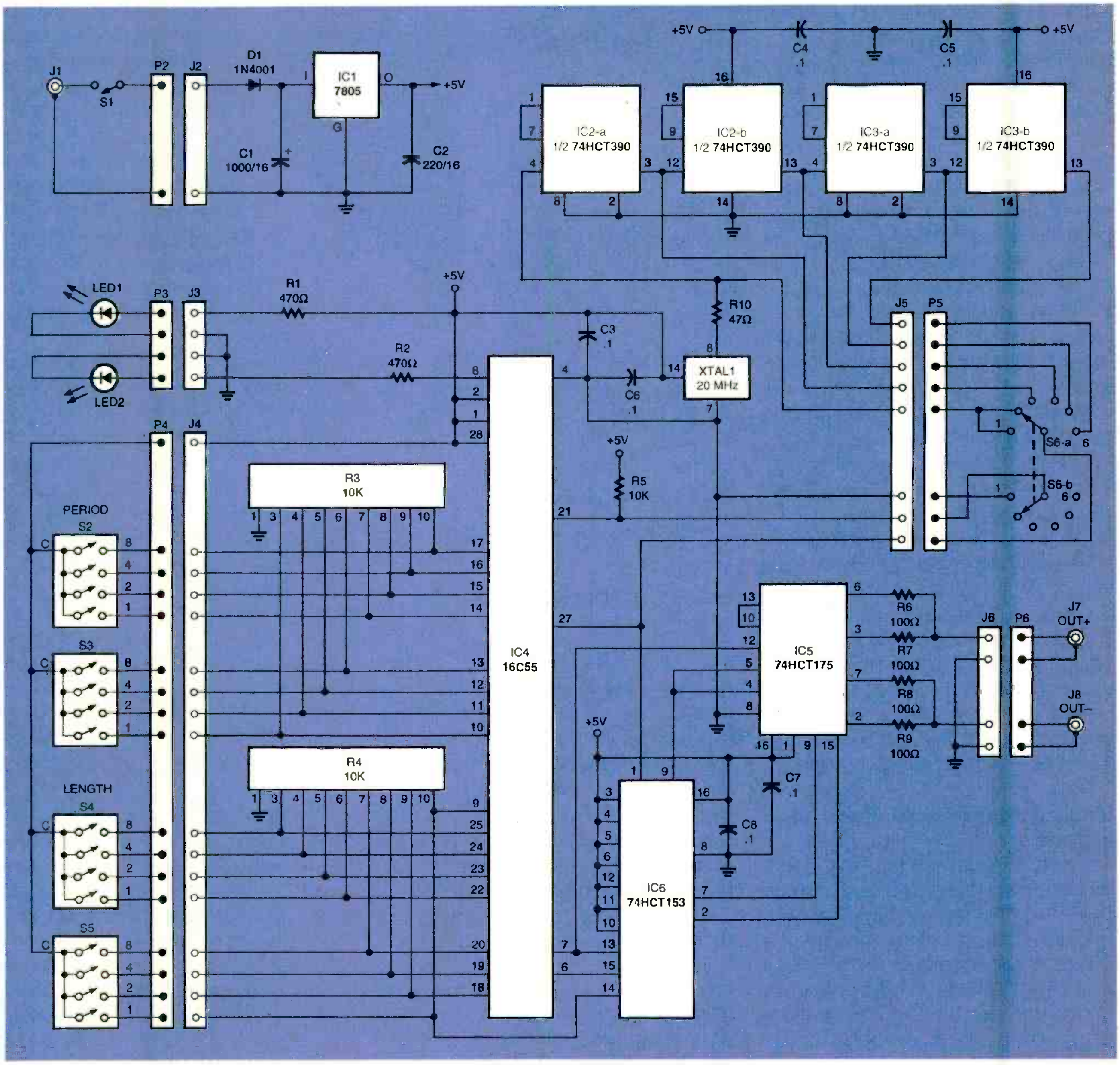


Fig. 1. The Precision Pulse Generator is built around a PIC 16C55 microcontroller. Although it might seem to be impossible, pulses as short as 100 nanoseconds can be generated thanks to a careful balance of hardware and software.

The trick is to add 0.1 microseconds to the pulse length whenever the fastest range is selected and the least-significant length switch is showing an odd number. The amazing part of the solution is that it works even when the switch reads 0.1 and the PIC is not generating a normal output pulse—after all, 0+0.1=0.1!

Range Switching. The timing for the Precision Pulse Generator is set by XTAL1, a 20-MHz crystal clock. When the two highest ranges are selected, the PIC (IC4) runs from the 20-MHz clock. The clock frequency is sent to IC4 through S6-a. The clock frequency is also divided by IC2 and IC3. Their outputs are also selected by S6-a. At the lowest range setting, the clock frequency is only 2 kHz, making responses to any switch changes a bit sluggish! By using that arrangement, the same software can be used for the different ranges.

The highest range is a bit different. The PIC chip must be told to use a different software program in order to create the extra short pulses with IC5 and IC6. That command is supplied by S6-b. When S6-b grounds pin 21 of IC4, the program knows to use the fine-range technique discussed above.

The clock signals are all sent to the range switch through a length of ribbon cable, and the selected one is returned to IC4. Although that arrangement is not an example of good engineering practice, it does work. Keeping the clock signals on the PC board would have required additional circuitry to switch the various signals, complicating the design. The ribbon cable carries the clock signals on alternating wires, with the unused wires in between grounded. That tends to shield the signals from each other, minimizing cross-talk. A 47-ohm source-termination resistor (R10) is connected to the output of XTAL1 so that the 20-MHz signal is somewhat cleaner when it finally reaches IC4 after its trip to the switch and back.

Hardware, Software, and "Firmware." The 16C55 microcontroller has two eight-bit ports and one four-bit port. The two eight-bit ports are directly connected to S2–S5, with R3 and R4 acting as pull-up resistors so that there is always a valid logic level on IC4's input pins. The software looks at the thumb-wheel switches twice per pulse. The time needed to read and process that information is the reason that the minimum pulse period is five microseconds.

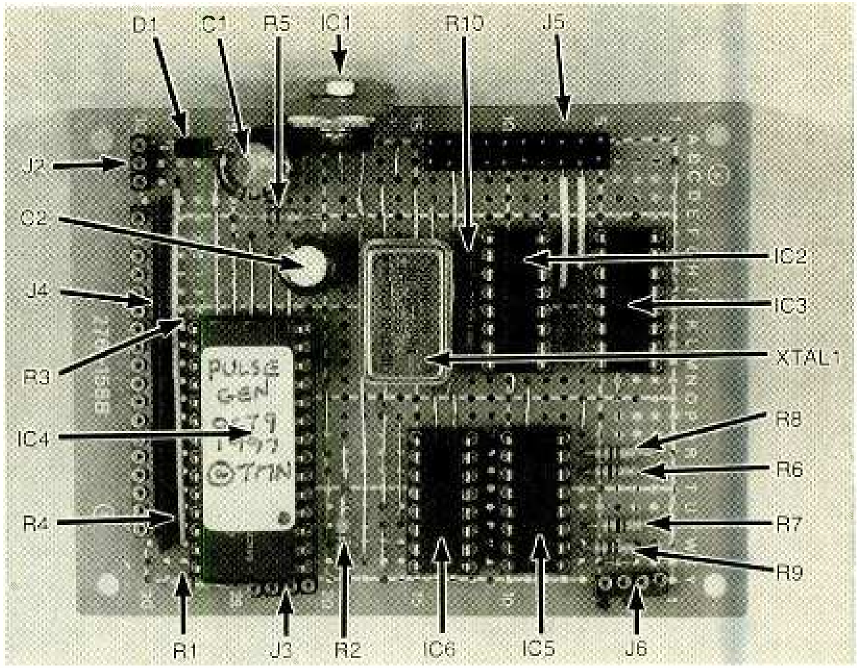


Fig. 2. The Precision Pulse Generator can be easily built on a perfboard. Keep the connections short and direct. Here you can see part of the author's construction technique: the interconnect wires are neatly and carefully laid out in the same direction on this side of the board; the other side has the wires all running at right angles.

The lowest bit of S5 is not connected to the same input port as the rest of the pulse-length input since it controls the hardware "add-0.1-microsecond" function. Switch S6-b is connected in its place. However, since that bit is needed on the higher ranges, it is hooked up through the controller's four-bit port. It might seem to be an odd arrangement, but it is an example of the balance needed between the hardware and the software in order to get the necessary processing speed.

The software generates the pulses in two stages—the length of "on" time and the length of "off" time. When calculating the length of "off" time needed, the amount of processing time before starting another pulse cycle is taken into consideration. If the amount of "off" time is less than the cycle time, IC4 will light up LED2 to let the operator know that the switch settings are "improper;" that is, the Precision Pulse Generator cannot create the pulse widths and repetition rates that have been set on the front-panel controls.

Pulse Processing. It would be expected that only one pin of IC4 would be needed for the actual output pulse. Since we have additional circuitry that can stretch the output pulse by 0.1 microsecond, two outputs are used. The main pulse output is a positive-going pulse with a 0.2-microsecond resolution. The secondary output is a 0.2-microsecond negative pulse that immediately follows the main pulse with a 0.1-microsecond delay. That pulse drives the lengthening circuit when the units-digit length switch is set to an odd number. Since the secondary pulse is needed only at the fastest range, it is only generated when it is needed.

The lengthening circuit is built around IC6 to generate a pulse that is either the same length as IC4's output pulse or is exactly 0.1 microseconds longer than IC4's output. To do that, a 0.1-microsecond pulse that starts just as the main pulse stops is needed; that is the reason for the secondary output.

Pulse Outputs. In order to provide the most accurate possible timing,

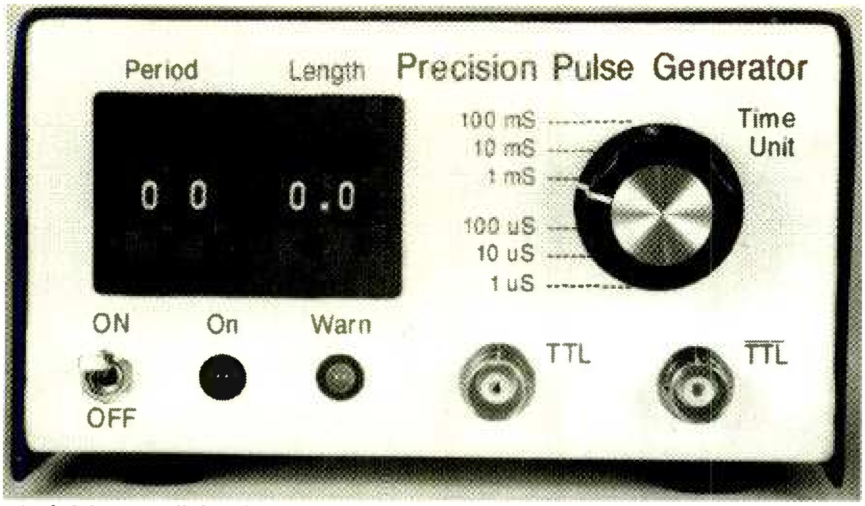


Fig. 3. Like any well-thought-out piece of test equipment, a neat and orderly front panel arrangement is the hallmark of a high-quality unit.

the final pulse from IC5 is resynchronized to the main clock. Two flip-flops in IC5 are tied together in parallel to drive the output load. An added advantage is that the output is available in both inverted and non-inverted form. The HCT-series of chips was selected because their outputs have a fast rise and fall time without excessive overshoot. The AC- and ACT-series are still faster parts, but they tend to have a lot of overshoot on their outputs, and they are somewhat difficult to find in the various "hobbyist-friendly" component distributors.

The outputs are wired to BNC sockets J7 and J8 through R6–R9. The resistors serve three purposes. One is to protect IC5 from momentary short circuits to ground or +5 volts. Another is to share the load current equally between the flip-flops. The third is to provide source termination.

Connecting the output of the Precision Pulse Generator with an unterminated 50-ohm cable will give a reasonably clean TTL-level signal. Using 50-ohm terminators on the cable will speed up the signal edges but leave the pulse voltage level at about two volts—too low to drive a TTL input. The ideal termination would be a 68-ohm resistor tied to ground and a 180-ohm resistor tied to a +5-volt source. That will result in a fast signal capable of meeting the input requirements of TTL.

The normal output-current range of IC5 will not drive a 50-ohm load without risking damage to the IC itself. However, that risk only occurs if the output is shorted to ground or +5 volts. If you are concerned about that situation, you can substitute a 74AC175 for IC5; that family of devices has a higher output-current rating.

Clock Timing. The clock that drives IC5 has to arrive when the flip-flops all have valid inputs. Unfortunately, the designers of the microcontroller didn't specify its clock-to-output delay when it is used with an external clock. After testing the performance of several chips, the author found that the delay from the negative-going clock edge to an output change is about 25 nanoseconds. That is just half the clock period on the fastest two ranges. In that case, the output change occurs at the same time as the positive-going edge of the clock—exactly the worst place for it to be if we want to drive a flip-flop. The cure for that situation is to invert the clock before sending it to the flip-flops. It was at first tempting to use IC4's OSC2 pin as an inverted clock, but that output was designed with a linear output for driving a crystal, which makes it a poor logic signal. Luckily, IC6 has an unused section. By connecting the clock to its enable pin, we not only get an inverted output but we get a little extra delay. That matches the pulse delay through the other half of the chip and makes latching the pulses into the flip-flops just a little bit more reliable.

Power. The Precision Pulse Generator uses only a single 5-volt supply. With a current draw of only 20 mA, it could run on batteries. However, a 9-volt AC or DC wall adapter is connected to J1 as a power source. Even if a DC supply is used, D1 and C1 still provide polarity-reversal protection and additional smoothing. The input voltage is regulated by IC1. The low current demands mean a heatsink is not required for IC1, but a small one can be used just to be on the safe side.

The unit is turned on and off by S1. LED1 indicates whether the Precision Pulse Generator is in the on or off state.

Construction. The Precision Pulse Generator is simple enough to be built on a piece of perfboard using standard construction techniques. Since some portions of the circuit have high-frequency signals with fast rise and fall times, the wiring should be kept as short and as direct as possible. The layout used on the author's prototype is shown in Fig. 2. Note that you cannot see the bypass capacitors C3–C8. Those components are underneath the integrated circuits in order to save space on the board. In fact, the capacitors are built into the IC sockets themselves. Although such sockets save both construction time and space, they are a bit on the expensive side. Using standard sockets and ceramic-disc capacitors will work just as well. After the board is built, do not plug in any chips until after it is tested; set the board aside for now.

Microcontroller IC4 needs to be programmed before being used. A pre-programmed part is available from the source given in the Parts List or you can program a blank part yourself. If you want to program your own part, the compiled code is available for download at the Gernsback FTP site (ftp.gernsback.com/pub/EN/pulsegen.cod).

As with any piece of test gear, the layout of the front panel makes the difference between a unit that is easy to use and one that gets relegated to the top shelf. Details on the author's panel design and layout can be seen in Fig. 3. Most cabinets of the type used here have

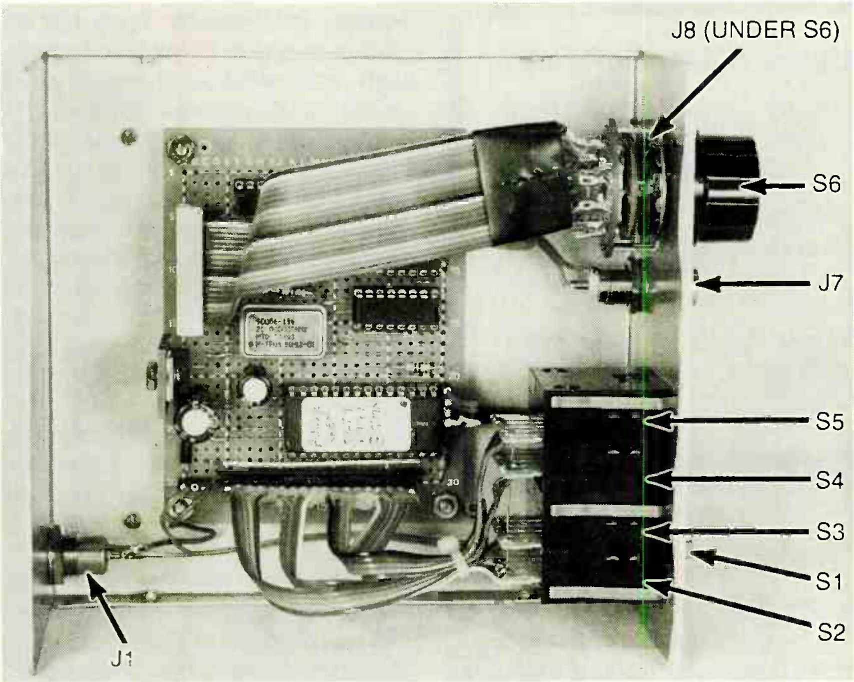


Fig. 4. The inside of the Precision Pulse Generator is neatly laid out thanks to the use of ribbon cable.

aluminum front panels. If yours is like that, be careful when cutting out the rectangular hole needed for the thumb-wheel switches; haste in cutting might result in bending the panel, making the finished product somewhat unsightly.

Once all of the holes in the front panel are cut and drilled, the panel should be labeled. Again, any method that you are comfortable with will work well. The author used a sheet of peel-off self-stick label material and a laser printer. A disadvantage to that method is that the label will become dirty very fast. Spraying a coating of fixative will keep the label looking clean and neat. If you do spray your label, do not use acrylic laquer—it will soak into the paper and destroy the label's glue. Experiment on some scrap before making the final label.

The interior layout of the Precision Pulse Generator is shown in Fig. 4. The connection from J4 to the thumb-wheel switches is most neatly done with a short length of ribbon cable. A socket-plug arrangement can be made from two pieces of strip socket as mentioned in the Parts List. As an alternative, a direct solder connection can be used in place of the socket. However, having a connector makes it possible to take the unit apart should any repairs be needed in the future.

Thumb-wheel switches might look rather old-fashioned in these days of keypads and liquid-crystal displays, but they have the advantage of combining the functions of input, storage and display. The microcontroller doesn't need to store the switch settings; it reads the switches twice per pulse period and uses the result immediately in its calculations. A display is not needed, either; the pulse length and period can be read directly from the switches. The downside is that thumb-wheel switches retail for around $10 a digit. The complete switch assembly, with end pieces and a blank section in the middle will set you back about $50. However, the cost compares reasonably with that of a keypad and LCD display, even if we had the extra processing power to use them.

The switches used here are ten-position Binary-Coded Decimal (BCD) types. It is worth checking the various surplus-dealer catalogues for switches that can be dismantled and reassembled for use in the Precision Pulse Generator.

The thumb-wheel switch assembly consists of seven components stacked together: an end plate, two digit switches, a blank section, two more digits, and a second end plate. The individual pieces have little plastic pins that align them; the stack is held together by two long screws and nuts. If you are a perfectionist, drill a dimple in the face of S5 and fill it with a drop of white paint

PARTS LIST FOR THE PRECISION PULSE GENERATOR

SEMICONDUCTORS

IC1—7805 5-volt regulator, integrated circuit
IC2, IC3—74HCT390 dual decade divider, integrated circuit
IC4—16C55 PIC Microcontroller, integrated circuit
IC5—74HCT175 quad flip-flop, integrated circuit
IC6—74HCT153 dual 4-way multiplexer, integrated circuit
D1—1N4001 silicon diode
LED2—Light-emitting diode, yellow
LED1—Light-emitting diode, green

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—470-ohm
R3, R4—10,000-ohm, 10-pin resistor network, single-inline package (Digi-Key Q9103-ND or similar)
R5—10,000-ohm
R6–R9—100-ohm
R10—47-ohm

CAPACITORS

C1—1000-µF, 16-WVDC, electrolytic
C2—220-µF, 16-WVDC, electrolytic
C3–C8—0.1-µF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

J1—Co-axial power connector
J2–J4, J6— Socket strip (Digi-Key ED7064-ND or similar)
J5—36-pin 2-row header strip (Digi-Key S2012-36-ND or similar)
J7, J8—BNC connector, panel-mount
P1—not used
P2–P4,P6—Socket strip (Digi-Key ED7064-ND or similar)
P5—20-pin, 2-row plug with ribbon cable (Digi-Key A1AXA-2036M-ND or similar)
S1—Single-pole, single-throw switch
S2–S5—Thumb-wheel switch, binary-coded decimal output (Digi-Key CKN5014-ND or similar)
S6—2-pole, 6-position switch
XTAL1—20-MHz crystal oscillator
IC sockets, thumb-wheel switch end plates, thumb-wheel switch spacer, LED holders, knob, wire, case, 9-volt AC wall adapter, hardware, etc.

Note: A pre-programmed IC4 is available for $12 (includes shipping and handling) from: Tom Napeir, PO Box 3155, Maple Glen, PA 19002-8155. PA residents must add sales tax.

to make a decimal point.

There are two types of mounting arrangements for thumb-wheel switches: those that drop in from the front and snap in place, and those that are bolted in place from behind. The snap-in design is easier to mount as well as covering any imperfections in the panel hole, but the wiring must be threaded through the hole when installing or removing them. The rear-mounted type is more difficult to line up with the front-panel hole, but you don't have to worry about damaging the wires if they should catch on the edges of the panel hole.

Each switch segment on the thumb-wheel switches has five contacts on a little printed circuit board marked "C," "1," "2," "4," and "8." It is easier to solder the ribbon cable to the switch segments before they are assembled into a block. One wire goes to each BCD pin of each switch. A piece of bus wire is threaded through all four common connections after the switch is assembled. That way, only one common wire is needed to connect to the PC board.

In a similar fashion, a length of ribbon cable is used to make the connections from J5 to S6. While you can make your own cable assembly, the Parts List suggests a pre-assembled unit that can be used to save time and effort. Only about six inches of cable will be needed to reach S6; the remainder of the cable can be used to wire up the rest of the unit.

Any two-pole six-way switch can be used for S6. A word of caution on the rotary switches from RadioShack: those units have a 6-mm shaft, making a sloppy fit to their ¼-inch standard knobs unless you either wrap some electrical tape around the shaft or use a metric knob.

Testing. Using an ohmmeter, check for shorts between the power and ground pins of any chip socket. If there are none, it should be safe to connect the 9-volt supply. Check that there is about 12 volts across C1 and very close to five volts across C2. If those tests fail or if IC1 is getting hot, you might have wired D1 backwards.

If all is well at this point, check for 5 volts between pins 8 and 16 on the IC sockets, between pins 7 and 14 of the socket for XTAL1, and pins 4 and 2 on the socket for IC4. Disconnect the power and install XTAL1, IC2, and IC3. With power applied, check pin 4 of IC2 with an oscilloscope; there should be a 20-MHz signal. It should be square but it probably looks more like a sine wave. Pin 3 should have a 2-MHz signal, and pin 13 should have a 200-kHz signal. Moving on to IC3, its pin 3 should show 20 kHz and its pin 13 should show 2 kHz.

When S6 is connected, pin 27 of the socket for IC4 should have a signal that changes between 20 MHz, 20 MHz, 2 MHz, 200 kHz, 20 kHz and 2 kHz as S6 is turned clockwise through its range. Connect S2–S5 and check that the proper voltage levels are reaching the appropriate pins on IC4's socket using either an oscilloscope or a voltmeter.

If everything has tested OK up to this point, you can now plug in IC4. Be careful that none of its pins are bent under during installation. Set S6 to position 2, set the period to 10, and the length to 2.0. Pin 6 of IC4 should show a pulse that is positive for 20 microseconds and zero for 80 microseconds. When you change the settings on S2–S5, the pulse length and period should change correspondingly. If you set a period that is less than or equal to the length, LED2 should light. That test can be repeated for the other low ranges. It should show the correct pulse lengths and periods on all of them.

Switch the unit to the highest range. Set up a period of 10 microseconds and a length of 2.0 microseconds. Pin 6 of IC4 should show a 2.0-microsecond positive pulse and pin 7 should show a 0.2-microsecond negative pulse immediately following it. When you change the lower digit of the length switch (S5), the pulse length should only step on every second position. The negative pulse on pin 7 should always be present even when the length is set to 0.0. Check pin 9 of the IC6; the output pulse should be negative-going with a step that changes with every digit change.

If you connect an oscilloscope to either J7 or J8, you should see that the output pulses match the front-panel settings. Check also that all of the illegal settings, light LED2. If everything checks out, the Precision Pulse Generator is ready to use. Happy pulsing. Ω

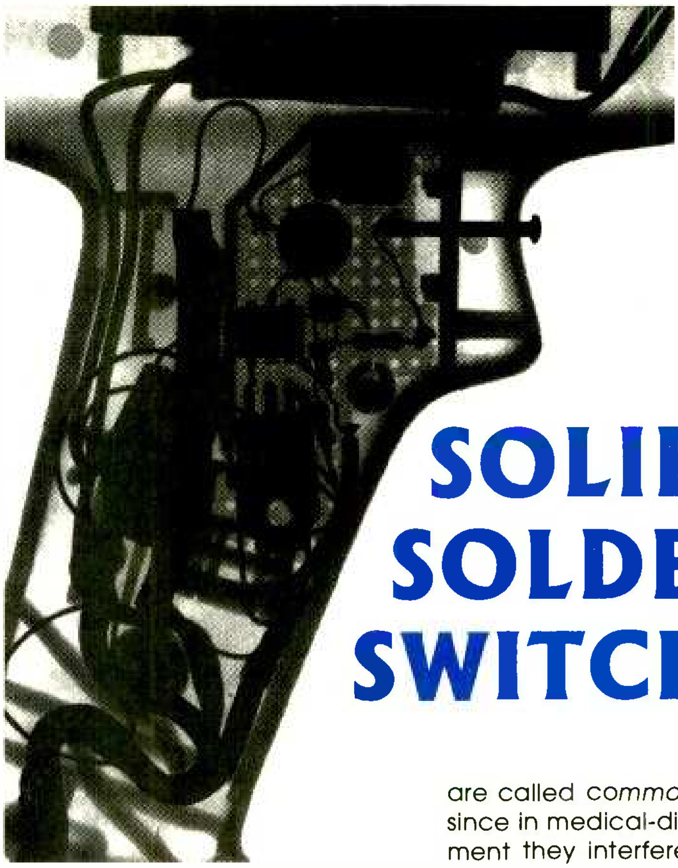
Precision Pulse Generator Specifications

Pulse output level: TTL and complementary TTL unterminated
2 volts with 50-ohm termination
Rise/fall times: Less than 10 nanoseconds
Timing precision: 100 ppm ±2 nanoseconds

	Pulse period	Pulse length
Range 1	5–99 microseconds	(See below)
Range 2	10–990 microseconds	1–99 microseconds
Range 3	0.1–9.9 milliseconds	10–990 microseconds
Range 4	1–99 milliseconds	0.1–9.9 milliseconds
Range 5	10–990 milliseconds	1–99 milliseconds
Range 6	0.1–9.9 seconds	10–990 milliseconds

Range 1:	Pulse period	Pulse length
	5 microseconds	0.1–2.9 microseconds
	6 microseconds	0.1–3.9 microseconds
	7 microseconds	0.1–4.9 microseconds
	8 microseconds	0.1–5.9 microseconds
	9 microseconds	0.1–6.9 microseconds
	10 microseconds	0.1–5.9 microseconds
	11 microseconds	0.1–6.9 microseconds
	12 microseconds	0.1–7.9 microseconds
	13 microseconds	0.1–8.9 microseconds
	14 microseconds and above	0.1–9.9 microseconds

A square wave output can be set for all periods.



Replace that stiff switch on your soldering gun with this space-age tactile sensor!

SOLID-STATE SOLDERING GUN SWITCH

DEAN F. POETH II

The switch on a large soldering gun can require a lot of force to operate. Some soldering gun switches require over four *pounds* of force before they will close! That much effort can result in a cramped trigger finger very fast!

Here's an idea: why not save your hand by replacing that heavy switch with a space-age tactile sensor. The Solid-State Soldering Gun Switch described here needs no force at all to operate and, because it is solid-state, it is more reliable than its mechanical counterpart. The modification costs only a few dollars, and is a simple one-evening project.

How it Works. An electronic circuit replaces the gun's mechanical power switch with a sensor. That lets the hand activate the gun while exerting effectively zero force with the trigger finger.

The sensor on the soldering gun detects the voltages present in every human body. Those voltages are called *common-mode noise*, since in medical-diagnosis equipment they interfere with the desired signal (for example, an EKG recording) and are "common" to all electrodes.

Those voltages exist because the human body is a large conductor, and therefore is both inductively and capacitively coupled to the surrounding electromagnetic environment (such as house wiring, fluorescent lights, electronic equipment, etc.). That coupling results in voltages being induced into the body. The effect can be demonstrated by touching the center contact on the input of an old audio amplifier. Various sounds will be heard through the speakers when that connection is touched, including a loud 60-Hz hum and (frequently) one or more local radio stations.

Circuit Description. The schematic diagram of the Solid-State Soldering Gun Switch is shown in Fig. 1. The common-mode-noise signal is picked up by a metal contact that is located at the top of the soldering gun's handgrip. That voltage is coupled by R1 into a Darlington-pair amplifier made up of Q1 and Q2. That circuit has a high input impedance with very high gain. The type of transistor chosen for Q2 has a low conduction resistance. Having a low resistance helps the amplifier deliver as much current as possible to drive the input of IC1 while having an extremely low input current. The input of IC2 is connected internally to an infrared light-emitting diode. The current through that LED is limited to about 8 milliamps by R2. Voltage variations in the common-mode-noise signal are filtered by C1.

The output of IC1 is in the form of a light-activated Triac. The output of IC1 triggers TR1, with a return path for the signal provided by R3. When TR1 is turned on, AC line current flows through the soldering gun's transformer. That transformer normally has two secondaries: one for the soldering-gun tip and one for a small spotlight. A metal-oxide varistor (MOV1) protects TR1 from any transient damage.

Two fuses are used in the circuit. A 2-amp slow-blow fuse protects the main power circuit and a 315-milliamp fast-acting fuse is used to protect the sensor circuit. Both fuses are mounted in the gun's handle.

Power for the tactile circuit is obtained from a wall-mounted DC adapter that is also used as an isolation transformer. That adapter provides 8.3 volts DC at 10 milliamps for the sensor.

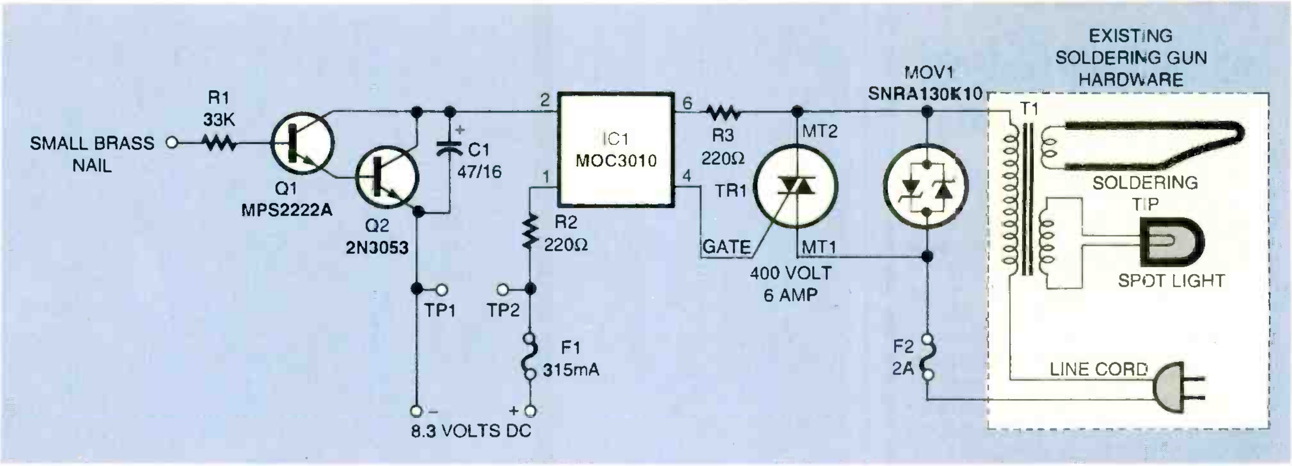


Fig. 1. The Solid-State Soldering Gun uses a touch-switch circuit to sense when to turn the unit on and off.

Construction. Adding the Solid-State Soldering Gun Switch to a soldering gun is very simple. The circuit is simple enough to be built on a small piece of perfboard using standard construction techniques. In fact, the entire circuit can easily fit into the soldering gun's handle, taking up no more space than the original mechanical switch that it will be replacing.

Begin by opening up the soldering gun and removing the power switch. Cut a piece of perfboard that will fit into the empty space in the gun's handle. Mount the components to the board and make the connections between the various parts. Once the circuit is built and mounted in the handle, check your work to make sure that all of the connections are correct and that there are no short circuits. Do not leave out F1 and F2—safety first! An example of the circuit fitted into a handle is shown in Fig. 2.

The sensor is simply a small brass nail that has been mounted in a small block of rigid packing foam that has been cut to fit the gun's switch opening. Once the block of foam has been cut to shape, press the nail through the foam to make a small hole. Remove the nail and solder a short length of insulated wire onto the pointed end. Once the connection has cooled, thread the wire through the hole in the foam. Place a small drop of epoxy adhesive onto the nail shank and glue it into position. Make sure that there is no epoxy on the head of the nail. Solder the other end of the wire to R1.

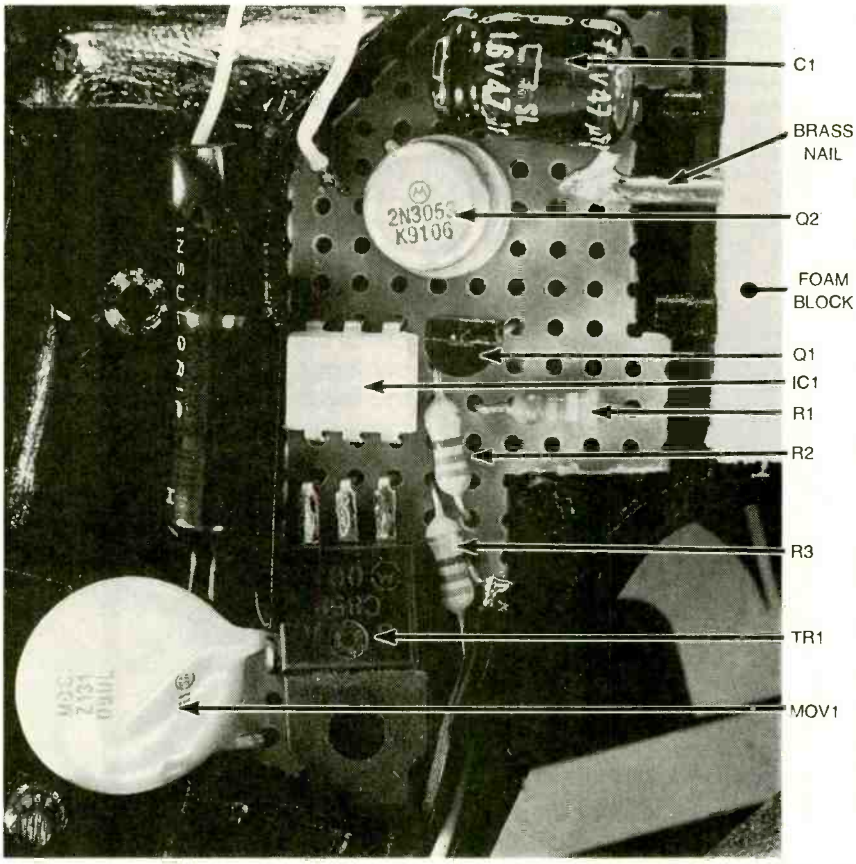


Fig. 2. Although a perfboard was used in the prototype, a PC board could also be used. While this photo can be used as a parts-placement guide, you might have to use a different arrangement for your particular gun.

When you have finished mounting the electronics in the gun handle, wrap the power cord and the cord from the wall adapter with spiral cable wrap. That will prevent the two cords from tangling and will give the project a neat appearance. A completed unit ready to be closed up and tested is shown in Fig. 3.

Testing. Again, visually inspect your work for any cold-solder joints or short circuits. **Check to make sure that the sensor circuit is electrically isolated from the AC power line. If it is not isolated, there is the danger of a shock hazard!**

Check the soldering gun's transformer for leakage by placing an ohmmeter on its highest resistance

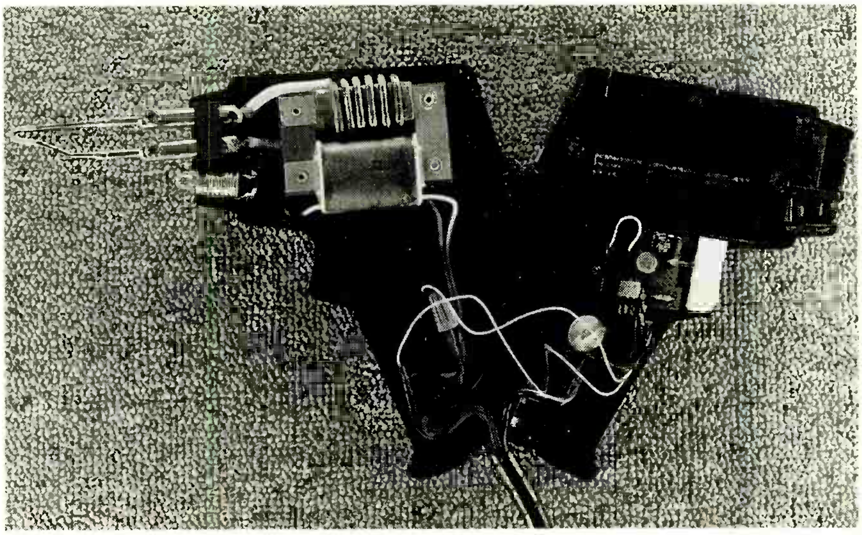


Fig. 3. The completed Solid-State Soldering Gun opened for inspection. The circuit board is cut to fit into the space left by the mechanical switch.

scale between the wall plug contacts and the output connector contacts. The ohmmeter should show infinite resistance (open circuit). Of course, if you have access to a "hi-pot" tester (a high-voltage device used to test for circuit isolation at very high voltages), use that device to do the isolation test. Next, check between the solder-gun plug contacts and various points in the tactile sensor circuit. Again, the ohmmeter should show infinite resistance.

To test the gun, first plug in the wall transformer with the soldering gun's power cord unplugged. Check for about 8.3 volts DC between TP1 and TP2. Next, monitor the current being drawn by the tactile sensor circuit by inserting an ammeter in series with positive lead from the wall transformer. Without touching the sensor, the current should be zero. Touch the sensor, and the current should rise to about 6–8 mA. If the circuit passes those tests, plug in the soldering gun power cord and touch the sensor. The soldering gun's spotlight should come on and the tip should get hot.

Once the gun passes these tests, unplug the gun and pack the circuit carefully into the soldering gun handle. Glue anything that could move into position using epoxy.

PARTS LIST FOR THE SOLID-STATE SOLDERING GUN SWITCH

SEMICONDUCTORS
IC1—MOC3010 optocoupler, Triac output
TR1—Triac, 400-volt, 6-amp
Q1—MPS2222A NPN silicon transistor
Q2—2N3053 NPN silicon transistor

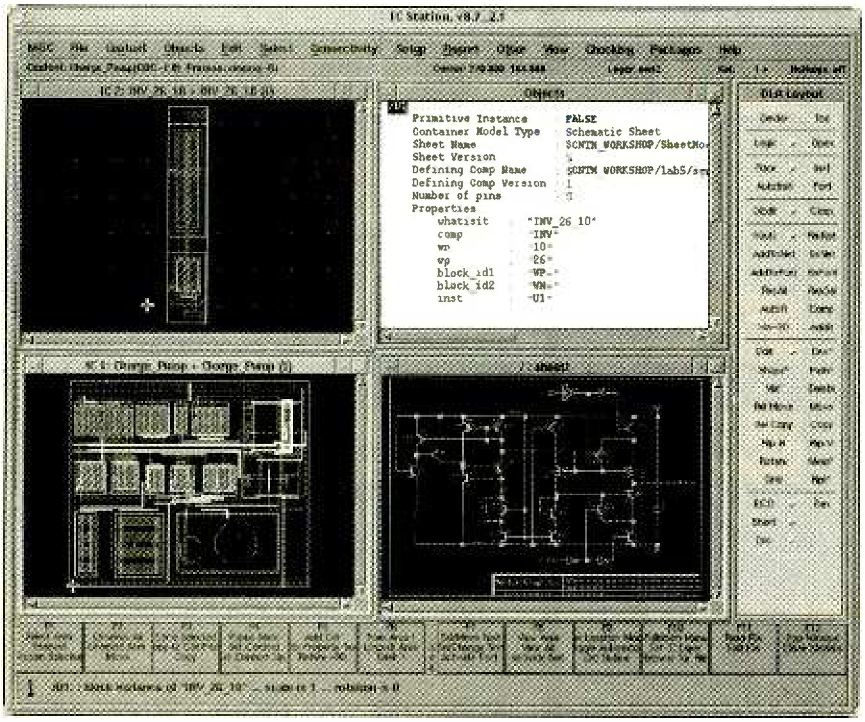
RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—33,000-ohms
R2, R3—220-ohms

ADDITIONAL PARTS AND MATERIALS
C1—47-µF, 16-WVDC, electrolytic capacitor
F1—Fuse, 315-mA, fast-acting
F2—Fuse, 2-amp, slow-blow
MOV1—SNRA130K10 metal-oxide varistor
8.3-volt DC, 10-mA wall adapter, brass nail, foam, cable wrap, fuse holders, hardware, wire, etc.

Operation. The sensor on the Solid-State Soldering Gun Switch senses the common-mode voltages in the operator's hand. That requires contact with a relatively large conductor to provide the needed coupling to the local electromagnetic environment. Because of that, small objects such as a screwdriver will not activate the gun unless there is an electrical path to the person holding the tool. Similarly, you cannot activate the gun's sensor while wearing gloves.

Treat the unit with the same respect and caution as any soldering gun. Of course, unplug the Solid-State Soldering Gun when not in use to prevent a fire or burn hazard. Ω

Designing Integrated Circuits



While they are literally everywhere, and usually taken for granted, the path an IC takes from concept to finished product is far from simple.

STEVEN STECKLER*

It almost goes without saying that if an item is electronic in nature, it uses integrated circuits. But have you ever stopped to think how those ubiquitous ICs are designed and made? What steps are needed between the original concept and the finished device? How do IC makers pack hundreds, thousands, or even millions of transistors and other components on a tiny wafer? Those questions and others will be answered in this article.

Planning, Planning, Planning. As in any major project, the planning stage is vital. Each application is unique and has its own special considerations. Everyone involved in the project must agree on what the goals are. The very first step, therefore, is to write a specification and create a project time-line.

A target specification is written at the outset for two reasons. First, the customer must know exactly what the circuit is going to do. If it's a chip going into a TV receiver, for example, it is essential to know whether or not it includes specific functions such as audio demodulation, auto-tint, or IF amplification. It is essential that the customer and the designers agree on the power-supply voltages, the operating-temperature range, and the output signal levels. In that way, the engineering-integration team can get on with their board and final product design at the same time that the often-lengthy development of the IC itself takes place.

At the same time that product design goals are being finalized, the choice of design tools must be made. Because of their high cost, that is an important issue that must be resolved early!

When we speak of design tools, for the most part we are referring to software. The present level of complexity of integrated-circuit development precludes the ability to breadboard any significant piece of the final design. There might be one or two critical systems or systems using new algorithms that need to be verified by breadboarding, but that's usually as far as it goes. Instead, computer design tools are used for the bulk of the task.

In selecting the tools, there are large number of factors that must be considered. For example, the design team might have already invested a large sum of money in software tools. Also, changing software usually entails a significant investment in training. On the other hand, the customer might express a strong preference in using particular software tools, perhaps due to a need to integrate the product into their existing systems and methodology.

The other important consideration in selecting software tools is the foundry where the chip itself will be made. Some foundries are fairly inflexible about the tool set. Some even specify the tools to be used, provide some supervisory software for the design flow, or insist that the designers purchase the foundry's own proprietary tools.

One more item remains under the category of preliminaries—the choice of the process and foundry itself. Mixed-signal devices often require mixed processes. There are still a few foundries that specialize in bipolar or BiCMOS processes that offer good analog performance, and the majority of existing television chips use either of those processes. However, a few design companies are now trying to apply pure CMOS technology to television receiver chips (with mixed suc-

*Head, Analog Systems, Sarnoff Corporation

cess). That's because doing so allows them to use a CMOS foundry, which these days is the most common type by far.

System Design. The typical design process is illustrated in the flow chart shown in Fig. 1. After the specifications, time-line, and tool choices have been completed, and all the parties have signed off on them, it is time for the work to begin in earnest. It should go without saying that the system-design phase, which usually begins on paper or in the mind of the project leader, is critical to the overall success of the design. That's because the decisions that are made during that phase will directly impact the performance of the final product. This is a highly creative stage where the concepts eventually take form as a block diagram. Brainstorming by the design group is often instrumental in solving a myriad of conflicting requirements.

In general, system design centers around exactly what device partitioning needs to be done to implement the details described in the device specifications. The system design for a TV integrated circuit, for example, will probably include one or more phase-locked loops. The performance of those loops may be directly specified in the system specifications or may indirectly affect the specification. It is important then that the PLL has a pull-in range, noise bandwidth, and output duty cycle that is consistent with the overall requirements.

During the system-design stage, one of two paths are usually followed: Depending on the complexity and uniqueness of the system design, either a system simulation is carried out using the appropriate software tool, or the circuit design is started immediately.

System simulations can be done using a variety of tools, among them MATLAB, SPW, TESLA, and VHDL or VHDL-A. MATLAB is a mathematics-intensive tool that is excellent at modeling complex functions. SPW and TESLA are block-diagram oriented tools that permit moving blocks around on the screen, wiring them together, and simulating their operation. Typical blocks included in those tools are various filters, integrators, multiplexers, signal sources, and measurement instruments. Those simulators do not worry about the transistors that will eventually appear at the lowest level, but instead provide software implementation of system functionality. They generally have the ability to add some of the real-world anomalies of noise and non-linearities. With some innovation, the simulators can be connected to displays or other electronic or mechanical devices to produce emulations of how the final product will work.

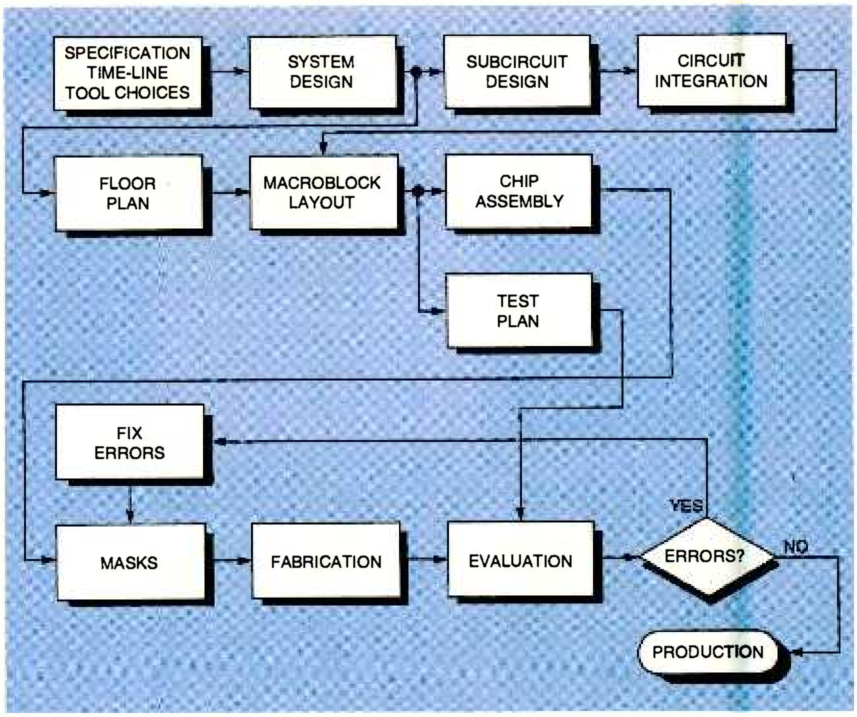


Fig. 1. This flow chart illustrates the typical path an integrated circuit takes as it moves through the design process.

Let's look at one of the above-named simulators in a little more detail. Figure 2 shows a demo screen view of the TESLA simulator. TESLA uses the ORCAD schematic-capture tool. Netlists describing the connectivity of a system can also be entered manually, but that is a very time-consuming and highly error-prone process. Figure 3 shows the results of a simulation; it is a frequency-spectrum plot of one of the nodes of the block diagram in Fig. 2.

TESLA works at a very high level of abstraction, and the circuit blocks are described by equations or graphical functions. That approach allows optimizing such things as AGC time constants and AGC amplifier gains before a single transistor has been wired.

There are some important reasons to take that approach. First, that type of simulation runs much faster than a transistor-level simulator, and it is practical to do many iterative "what-if" types of analyses. Second, it doesn't make sense to spend a lot of time optimizing circuit-level designs before the system configuration has been finalized. Another reason for the power of that approach is that a system simulation produces a standard of comparison that makes it easier to tell if the final circuit has achieved optimum performance.

Another technique in wide use is applying the VHDL or VHDL-A languages to create circuit simulations. In that approach, the operation of each system block is described by programming statements. That gives an enormous amount of flexibility and provides the ability to mix system-level and lower abstractions together.

A complete system can be put together using this approach, and then one-by-one, the VHDL blocks can be replaced by transistor-level circuit blocks. In fact, the circuit blocks can be inserted and removed one-at-a-time until all cir-

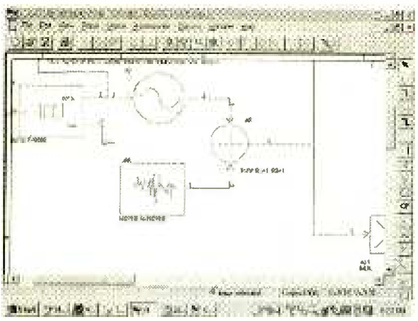


Fig. 2. A demo screen of the TESLA circuit simulator, which uses ORCAD for schematic capture.

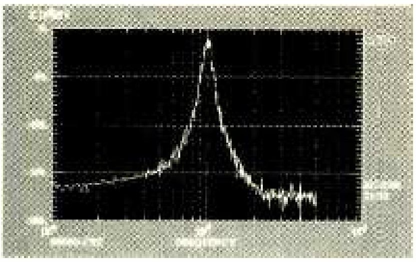


Fig. 3. The results of a circuit simulation—a frequency-spectrum plot at one of the nodes of the block diagram in Fig. 2.

cuits have been checked in the total system while keeping the system-simulation time to a minimum.

There are some graphical block-diagram system tools that simplify that approach by automatically producing VHDL code for blocks supplied in a component library. The advantage to those is that the majority of the work can be done quickly, and fine-tuning of the system can later be done by working directly on the code. Incidentally, "VHDL" is one of the buzz-words that IC designers are almost always asked about on job interviews.

Circuit Design At Last. Now, three months or more into the project, it is time to begin the actual transistor-level sub-circuit design. Each individual amplifier, PLL, and clamp circuit is implemented in the most area- and power-efficient method that gives adequate performance. One interesting thing about integrated-circuit design is that transistors are used much more freely than resistors would be in a discrete design. In an integrated circuit, it is very important to eliminate coupling capacitors since only small ones can be implemented on-chip. If larger ones are required, then they will have to be provided externally and precious package pins will have to be provided for them. It is easy to see, then, that the number of pins initially allocated at the beginning of the project can be rapidly consumed. An inside joke among IC designers is that you always need one more pin to complete the circuit than is available in the package.

IC-design techniques rely heavily on resistor and capacitance matching. The gain of an amplifier usually depends on resistor ratios rather than the absolute value of any one resistor. Fortunately, that is an area in which ICs excel. Since resistors and capacitors are fabricated very close together with identical processing, they tend to match very closely. In particularly sensitive applications, they can be oriented in the same direction on the chip and even interdigitated so they practically occupy the identical space on the chip.

It is at this point in the development that circuit simulators, mostly based on SPICE, are used heavily. Even if the design is mostly digital, a SPICE-level analog simulator is needed to verify the operation of the individual logic circuits.

A view of the PSPICE schematic capture tool is shown in Fig. 4. This tool uses a library of components such as bipolar and MOS transistors, resistors, capacitors, inductors, etc. Pull-down menus and shortcut keys are used to place, rotate, and flip the components. A wiring tool is used to connect single wires or multiple-wire buses to the terminals on the devices.

After the components are inserted and wired, an electrical-rule check determines whether all device pins have been used and verifies that the circuit does not contain such anomalies as short circuits between the power supply and ground. A netlist describing the electrical interconnection of the components is then compiled.

To test circuit performance, simulated waveforms are applied to the input pins, and outputs are connected to software probes. Figure 5 is a typical PSPICE output waveform. PSPICE can perform single simulations or Monte Carlo simulations in which the values of components are varied according to

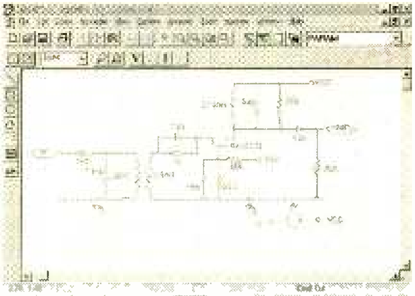


Fig. 4. During the design process, circuit simulators, mostly based on SPICE, are used extensively.

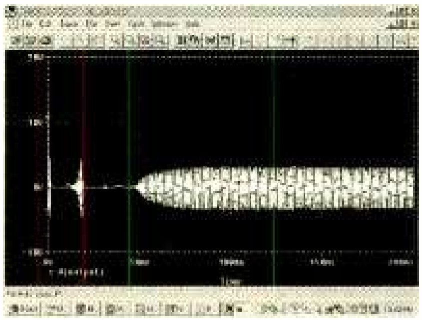


Fig. 5. A typical PSPICE output waveform.

specified tolerances. In the latter case, a family of plots are produced that are useful for centering component values or predicting yield. In addition, simulations might be done over the range of expected process variations.

When satisfactory sub-block performance has been achieved, it is then necessary to do a series of simulations over the operating-temperature range. That process must be repeated for each circuit sub-block and, if possible, for the entire circuit. Note that for large analog circuits, a total circuit simulation is often impossible and detailed interface simulations are often done instead. That task requires careful attention to detail to assure that each circuit properly drives the succeeding one. DC and AC interface levels, and drive and loading impedances must be compatible.

It goes without saying that the detailed circuit design is the most intense and time-consuming part of the design process. During this phase it could be discovered that it is extremely difficult to implement particular system concepts with low-level circuitry. It then would be necessary to "go back to the drawing board" and return to the system-design and simulation phase.

Floor Planning and Layout. As the sub-circuits are designed, the physical dimensions of the layout microblocks can be estimated. This is a convenient time to construct a floor plan showing the relative positions of the various sub-circuits, the positions of the IC-package pins, and a first look at the position of external components associated with the IC.

At this stage, decisions must be made about keeping sensitive circuitry apart, reducing the common impedance of power-supply metalization, and eliminating parasitic devices. Parasitic devices are not only stray capacitors and inductors, but also unwanted active transistors that are formed unintentionally among the various circuit diffusions. With experience, those devices are predictable and are controlled by inserting structures that block their gain.

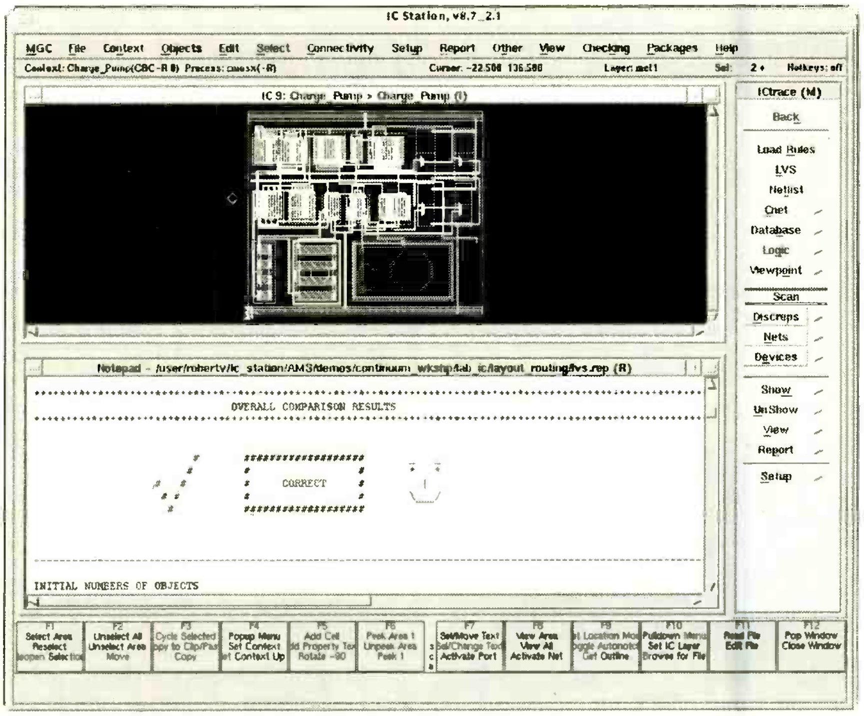


Fig. 6. The output of an LVS run showing a perfect one-to-one correspondence between the schematic and the layout. The software package shown here is ICStation from Mentor Graphics (photo courtesy of Mentor Graphics, Wilsonville, OR).

Assembly and Verification. The next step is assembling the chip. That entails connecting together the previously designed microblocks according to the chip plan. It might be necessary to insert "design-for-test" circuit blocks at this stage so that key internal functions that normally are isolated from the package pins can be accessed.

When the chip assembly is completed, an LVS, or Layout Versus Schematic check is executed. This is a very sophisticated check in which each device on the layout is cross-checked with each device on the schematic. The result of a successful run, indicating a perfect one-to-one correspondence between schematic and layout, is shown in Fig. 6.

Unfortunately, things don't always go as well; Fig. 7 shows the result of a discrepancy reported in the LVS run. Although this screen shows just the layout, the errors can be highlighted simultaneously on both the layout and schematic, making identification and correction relatively simple.

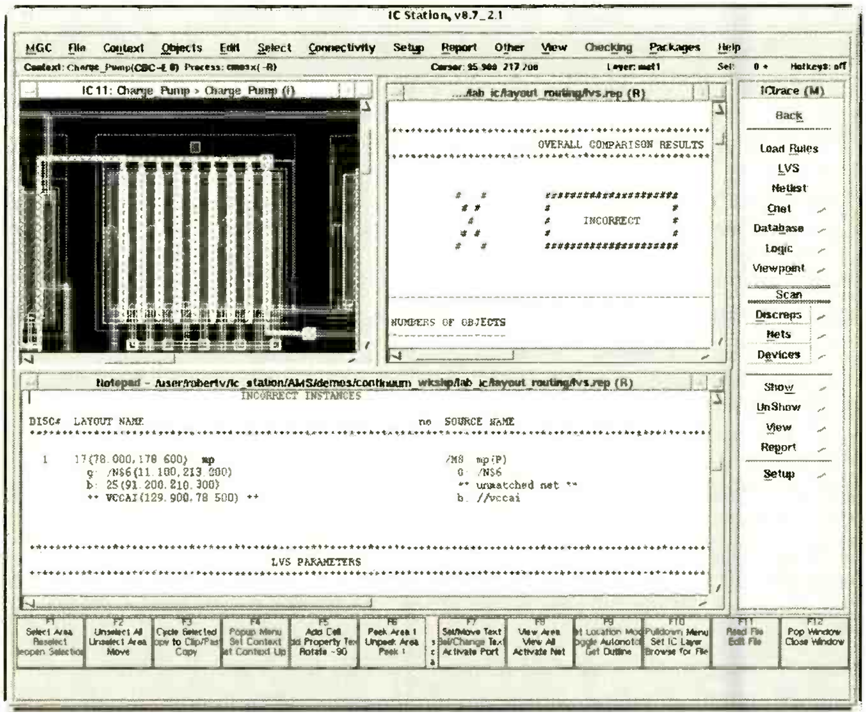


Fig. 7. Here, the LVS run reports a discrepancy between the schematic and the layout (photo courtesy of Mentor Graphics, Wilsonville, OR).

Usually the first LVS run produces a rather long error report that requires some time-consuming detective work to unravel. LPE, or Layout Parameter Extraction, is then used to extract parasitic capacitance and resistance that are then inserted into the schematic to allow for more accurate circuit simulations.

Test Strategy. There are two or more types of tests that need to be planned for. First, wafer tests will take place before the individual die is sliced and separated from the wafer. A wafer probe will come down on the pads of each of the circuits as the wafer is mechanically stepped in two dimensions. Basic DC tests are used to eliminate the grossly

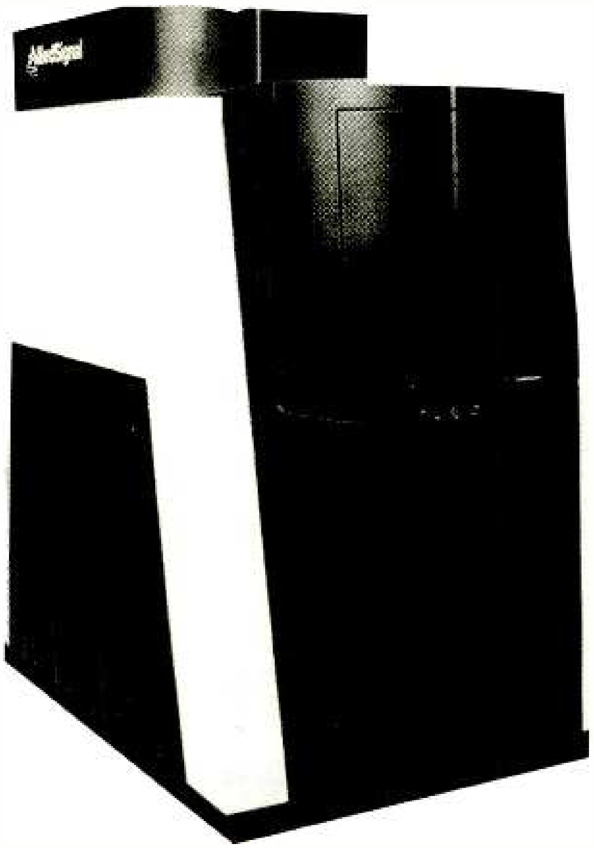
(Continued on page 50)

ALTERNATE ENERGY SOURCES FOR YOUR HOME

Two new techniques for "on-site" power generation that could someday mean cheaper, less polluting, and more reliable electric power for everyone.

BILL SIURU

The deregulation of America's utility companies could someday change the way they supply electric power to their customers. That's because deregulation will require utilities to become more competitive by being more innovative and serving the special needs of "niche" markets. For example, technology could allow utilities to reduce their reliance on large, centrally located power plants and massive distribution systems that can be disrupted by weather and other events. In their place, utilities could install single user power sources. While the traditional approach to single-user energy sources usually involves wind, solar, and geothermal power, new approaches such as residential fuel cells and "microturbines" could be the long-term answer



Residential Fuel Cells. Residential fuel cells operating on natural gas, propane, and gasoline to produce electricity electrochemically could generate electricity for 20 to 30% less cost compared to more traditional methods of delivering power to homes. By using a reformer, hydrogen needed for the electrochemical reaction in a fuel cell could be extracted from carbon-based fuels. Someday, hydrogen itself could even be delivered and stored in homes. Using pure hydrogen is even more efficient and produces negligible pollutants. Ambient air is used for the oxygen needed in the electrochemical process.

The main byproducts of the fuel cell are heat and water. Instead of merely being released into the atmosphere, a significant amount of that heat an be captured and used for home and water heating. The water could be used for household water needs. Compared to traditional fossil-fueled power plants, less than half the amount of carbon dioxide, a greenhouse gas, would be produced by fuel cells operating on natural gas or propane. Fuel cells operating on pure hydrogen would produce no carbon dioxide. By producing electricity through a electrochemical process rather than combustion, there are little or no other pollutants such as nitrogen and sulfur oxides.

Fuel cells can efficiently supply the power demands of the typical home, even during peak energy-demand hours, without connection to a utility's electrical distribution system. Because they do not need to be connected to power lines, power outages would be a thing of the past. Self-sustaining fuel cells have no moving parts. Corrosion-resistant alloys and state-of-the-art polymers make them essentially maintenance-free.

It is estimated that as many as 25-million U.S. households could benefit from fuel-cell power generation. Electric and natural-gas utilities in the U. S. and abroad have already expressed strong interest in residential fuel cells.

So, with all these apparent benefits, why are fuel cells still not in widespread use? It's because until recently fuel cells were prohibitively expensive. However, technological advances coupled with a reduction in the cost of materials have helped reduce those costs substantially. There's also an "economy of scale" factor at work as fuel cells are being actively developed for other applications, most importantly for automobiles and buses.

One company developing affordable fuel-cell systems for both home and automotive applications is Plug Power LLC. Plug Power is a joint venture between the Edison Development Corporation and Mechanical Technology Inc. a long-standing developer of automotive fuel-cell technologies. Plug Power fuel cells use the newer polymer electrolyte membrane (PEM) fuel-cell technology, which has advanced rapidly in the last couple of years.

In a program sponsored by the U.S. Department of Energy's Los Alamos National Laboratory and Arthur D. Little, Plug Power was the first to successfully demonstrate direct conversion of gasoline into electricity with its fuel cell. The demonstration completed in October 1997 was a very important breakthrough for fuel-cell applications because it postpones the need to develop a new fueling infrastructure. Eventually, most fuel cells would probably operate directly on hydrogen for maximum efficiency and environmental reasons. However, being able to operate on gasoline, as well as other hydrocarbon fuels, means fuel cells could be put into widespread use without having to wait for the infrastructure for transporting and distributing hydrogen to be developed and installed.

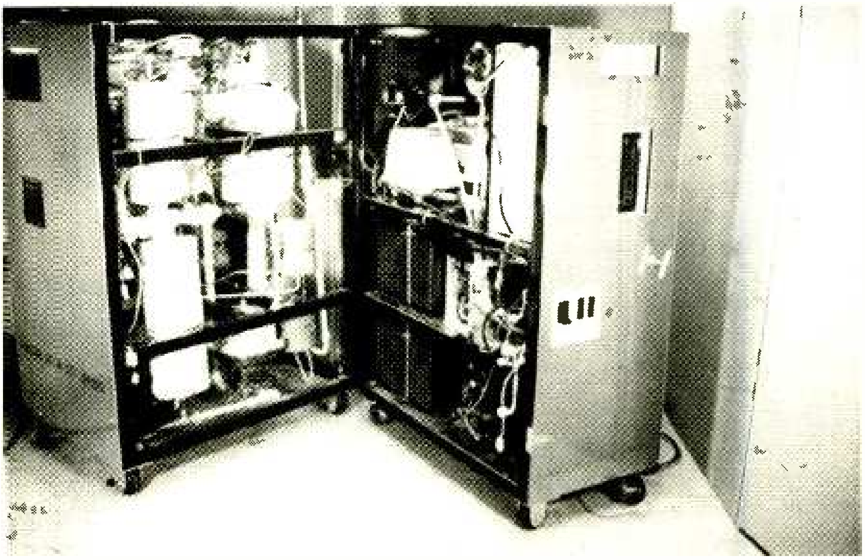
After the development and testing phase is complete, Plug Power plans to begin distributing their residential fuel cell system throughout the U.S. and also in global markets. Commercial production is planned for the year 2000.

The American Power Corporation (APC) and the Electric Power Research Institute (EPRI) are also working on home- and small business-sized fuel cells. American Power is already offering fuel cells ranging in size from 1 kW up to several megawatts for niche markets such as "premium" power for telecommunications and remote power applications. Like Plug Power, APC is using the more advanced PEM fuel cell technology in its Residential Power Generator (RPG).

APC and EPRI, together with participating utilities, plan to test a minimum of 25 small, 0–10 kW "alpha series" fuel-cell systems for the residential and commercial markets this year. The tests are aimed at assessing their technical and economic potential for serving residential and commercial users with power requirements in the 1–50 kW range. A typical residence uses 1–2 kW-per-hour over a 24-hour period. These fuel cell systems produce a maximum 3 kW base power. Batteries provide backup for short period peak loads of up to10 kW. The batteries are recharged by the fuel cell during off-peak demand periods. APC estimates the RPG could cost around $5,000 when it is produced in moderate quantities.

APC is also working with a large German gas company on adapting its RPG for the European market where hydronic heating systems are very popular. In those systems, hot water produced by a central boiler is circulated through either wall

THIS RESIDENTIAL POWER GENERATOR (RPG) from American Power Corporation is about the size of the traditional furnace it could replace. Besides space and water heating, it could produce all the electricity most homes use.



INSIDE THE AMERICAN POWER CORPORATION RPG. On the left is the reformer that extracts hydrogen from natural gas or other hydrocarbon fuels. Fuel cells, batteries, inverter, heat exchanger, compressor and electronic controls are located on the right-hand side.

ALLIEDSIGNAL'S SMALL, COMPACT *TURBOGENERATOR* has its turbine, compressor, and generator all mounted on a single high-speed shaft.

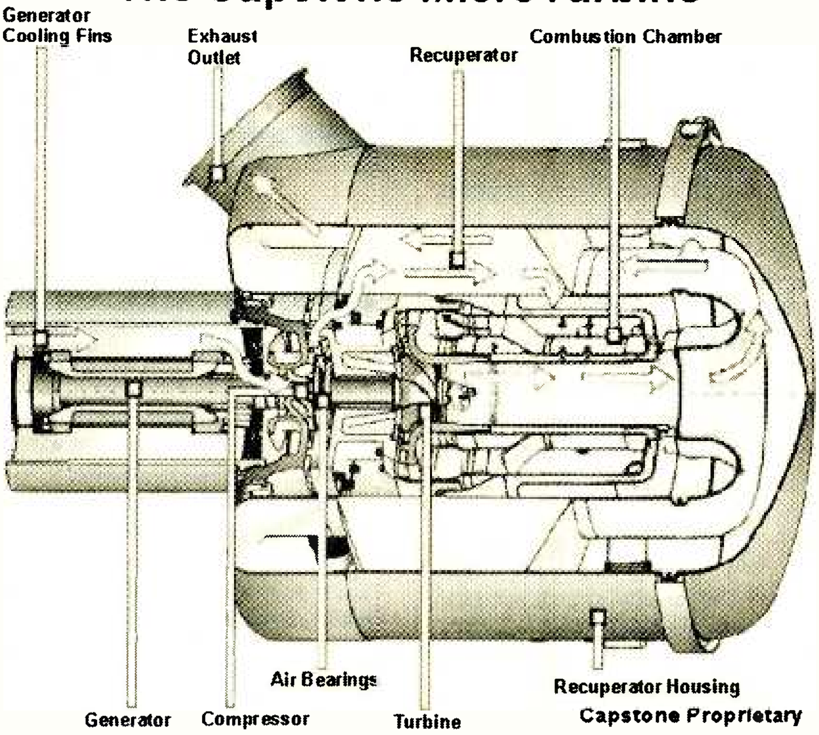
radiators or floor heating systems. If a RPG replaced the boiler, it could produce electricity as well. That could eliminate expensive "chimney" fees for conventional furnaces as well as equally expensive "connecting fees" to hook up new homes to the electric grid. The higher efficiency of fuel cells should be especially attractive to Europeans who pay significantly more for their electricity. If RPGs catch on in Europe, they could help reduce costs for the North American market by amortizing development costs and through larger production volumes.

Microturbines. Portable gasoline- or diesel-powered generators are commonly used to supply power to remote locations, for backup emergency service, at construction sites, and so forth. While portable generators are usually not considered competition for utility power plants, miniature turbo-generators, or microturbines—small, lightweight, self-contained power supplies—could mean competition, or more realistically, a practical alternative for utilities to economically generate power for special situations. By hooking up several units in a microgrid, they could be used to economically supply power for short-duration, peak loads. For example, many microturbines hooked together could quickly supply electricity to a new neighborhood before permanent power-transmission lines are installed. They could also be used to permanently supply neighborhoods that would otherwise be very expensive to wire due to distances or geography. By placing units near the end users, high-cost transmission and distribution upgrades can be avoided. Because output power can be easily tailored, microturbines could be used to supply specialized power for individual customers such as high-tech industries that need higher quality power.

Miniature turbogenerators are spin-offs of the auxiliary power units (APU) found in most airliners and many military aircraft. One examples is the Capstone *MicroTurbine*, consisting of a gas turbine and electric generator integrated into a single compact unit. The MicroTurbine runs on natural gas, gasoline, or diesel fuel. Power output is from 24–30 kW and can be set up to supply 120-, 220- or 480-volt AC power at 50, 60, or 1600 Hz, or DC power. Humming at 65 dB at 30 feet without any sound insulation, it is much quieter than a diesel-powered generator.

The single-stage turbine operates at a relatively low—at least for gas turbines—1625 degrees F turbine-inlet temperature allowing use of cast steel alloys rather than more costly exotic metals and ceramics. The single-stage centrifugal compressor is made of cast aluminum and the outer housing uses stainless steel. The generator has copper

The Capstone MicroTurbine™



THE CAPSTONE *MICROTURBINE* can run on natural gas, gasoline, or diesel fuel and produces between 24 and 30 kW of electric power.

FOR MORE INFORMATION

AlliedSignal Power Systems
2525 W. 190th Street
Torrance, CA 90504-6099
Web: www.alliedsignal.com/turbogen

American Power Corporation
268 Summer Street
Boston, MA 02210
Web: www.analyticpower.com

Capstone Turbine Corp.
6025 Yolanda Ave.
Tarzana, CA 91356
Web: www.capstoneturbine.com

Plug Power L.L.C.
968 Albany-Shaker Road
Latham, NY 12110
Web: www.plugpower.com

windings rather than more expensive silver-copper alloys. The turbine and generator shaft are combined into a single nickel-alloy shaft, eliminating the need for an expensive transmission. The shaft spins at 96,000 rpm on air bearings that eliminate the need for lubrication, and the unit is designed for 40,000 hours of operation with only periodic air filter changes.

While new to the utility power-generation market, AlliedSignal Power Systems has been a longtime producer of aircraft turbine-powered electric generators and more recently APUs installed in U.S. Army tanks. AlliedSignal's small, compact *TurboGenerator* has its turbine, compressor and generator all mounted on a single high-speed shaft so, again, a gearbox is not needed. Air bearings are also used here, eliminating the need for an oil-based lubrication system and associated maintenance requirements. The bottom line is a system that is more reliable, quieter, has lower vibration, and lower cost.

The AlliedSignal unit is self-contained in a weatherproof enclosure. The modular design, single moving part, and easy access makes maintenance relatively simple. Following the recommended maintenance program, the TurboGenerator can be expected to provide in excess of 40,000 hours of reliable operation. AlliedSignal plans to have a TurboGenerator model with a maximum continuous rating of 75 kW in volume production by next year.

Both the Capstone MicroTurbine and AlliedSignal TurboGenerator are serious contenders for use in Hybrid Electric Vehicles (HEV). Either unit could very well fill the internal-combustion-engine role in the system, and would be used in conjunction with storage batteries and electric motors. These microturbines could be used to keep batteries charged and for additional power for acceleration and hill climbing. For instance, Southern California Edison is evaluating a GMC van converted to a HEV using a Capstone unit. AlliedSignal's turbogeneration technology has been shared with the U.S. Department of Energy and Ford, as well as French automakers Renault and Peugeot. Ω

INTEGRATED CIRCUITS

(continued from page 46)

inoperative devices, and those are marked with ink. Since the bonding, packaging, and final device testing may cost more than the chip itself, it is prudent not to assemble chips that are nonfunctional. As the project nears production, a personality board might be built that allows detailed functional tests to be made on the wafer itself. Once again, the idea is to reduce final cost.

After the wafer is scribed and diced, the pellets are mounted in packages ready for further evaluation. Prototypes are often mounted in ceramic packages without their lids in place so that mechanical inspection and mechanical probing can be used to isolate problems. In addition, there are some laser drilling and deposition instruments that can actually make repairs to the circuit to verify proposed changes before they are made.

Fabrication. It is finally time to see the realization of our efforts. The twenty or so masks that will be used in the fabrication process are now produced. Those masks are photographic films that contain the physical definitions of the various device layers and diffusions. Depending on priority, samples are fabricated in a couple of days to a couple of months, with six weeks being about typical.

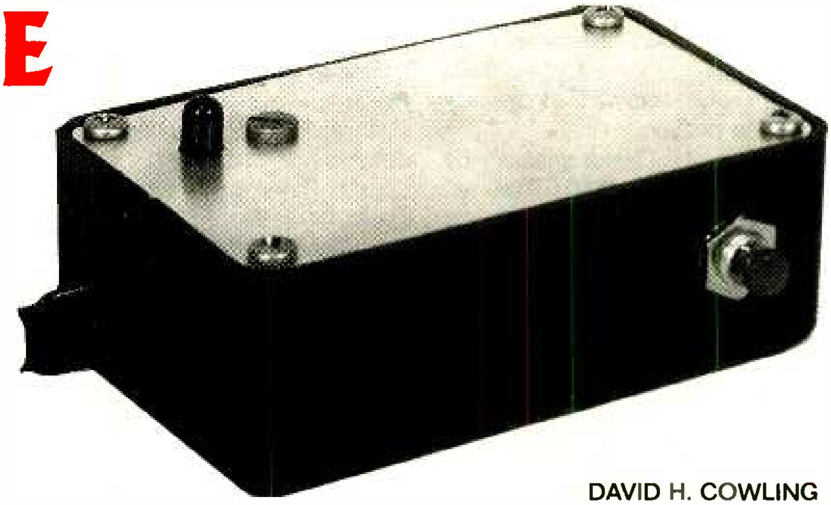
Once the samples are finished, functional tests are performed. If the devices have sufficient functionality, they will be tested in a prototype of the final product. It may be necessary to add some external components to make up for any non-working portions of the sample's circuitry.

As Fig. 1 shows, the evaluation/fabrication cycle is an iterative one. There are some chips that are fully functional the first time around, but that is generally not the case except in fairly straightforward digital devices. That's why a project plan invariably includes at least two cuts.

If serious problems are encountered at this stage, the cost can be enormous. The cost of an additional fabrication cycle outside the plan might be over $100,000. The cost of lost production and missed marketing windows could be $100,000 a day or more.

There you have it: the complete path an IC takes from concept to final product. As you can see, though ICs are all around us, designing and building one is far from a simple process. And with the continuing demand for more and more complex devices, it is not likely to become easier any time soon. Ω

Check For Live AC Wires With This ELECTROSTATIC VOLTAGE PROBE



Determine if terminals, sockets, or extension cords are hot without connecting a voltmeter.

DAVID H. COWLING

How many times have you wanted to know if a wall socket, lamp, or some other electrical device that you are getting ready to repair is still electrically "hot"? You may have pulled the circuit breaker, but unless you actually check the socket or lamp with a voltmeter, you don't know for sure.

The Electrostatic Voltage Probe presented here will give you a warning if voltage is present. What's more, it doesn't need to be connected to the circuit. You only need to hold the test probe next to the terminal or wire under question and a warning will be given if the circuit is energized.

How It Works. The Electrostatic Voltage Probe makes use of the phenomenon knows as *stray capacitance*. That occurs when any two conductors come close to each other without actually touching. In effect, a capacitor is formed with the two conductors becoming the plates, and whatever separates them serving as the dielectric.

One feature of capacitors is their ability to "conduct" alternating current while blocking any DC voltage. That feature is taken advantage of by the Electrostatic Voltage Probe to sense the presence of AC current in a wire. The small AC signal that is coupled to the Electrostatic Voltage Probe is amplified, triggering an alarm buzzer as well as an LED. The effect is to give both a visual and an audible warning. The circuit is sensitive enough to spot the "hot" terminals in a junction box. It can also tell when an extension cord is connected to a live wall socket. In that case, it is only necessary to hold the probe alongside the cord. Additionally, by plugging a wire into a wall socket, the Electrostatic Voltage Probe can tell the difference between the hot and neutral wires.

Circuit Description. Refer to the schematic diagram shown in Fig. 1 during the following description. The probe plate is connected to Q2, a very high-impedance amplifier, through C1. Although C1 is not needed for proper operation of the circuit, it is a necessary part from a safety standpoint. Should any lethal voltages accidentally be connected to the probe, they will be blocked by C1.

Once the input signal is amplified by Q2, it passes through a negative-voltage clamp formed by C2 and D1. The clamp output is rectified by D2 so that only negative voltages will affect Q2. That transistor is normally turned on by R4, but when the clamp is active, Q2 turns off.

When Q2 turns off, pin 4 (the reset line) of IC1 is released. A positive voltage is applied by R5, allowing IC1 to begin oscillating. The output of IC1 (pin 3) drives both a piezoelectric buzzer and an LED. The current through LED1 is limited by R8. The frequency that IC1 oscillates at is set by R6, R7, and C5.

Part Substitutions. One nice feature of the Electrostatic Voltage Probe's design is that all of the parts are easy to find—possibly being no farther than your "junk" box. If that will be your main source of components, here are some points to keep in mind concerning substitutions:

The field-effect transistor used for Q2 is listed as a 2N3819 type. However, any good N-channel JFET, such as a 2N5458 or 2N5459, will work equally well. Likewise, there are lots of acceptable substitutes for Q1. For example, while a 2N2222 is recommended, any good NPN-type audio or switching transistor such as a 2N3904 will work fine.

The piezoelectric buzzer is also non-critical. Note however that some devices have their own built-in drive electronics. Those units will not work well with the Electrostatic Voltage Probe since IC1 is already driving the buzzer.

The value of C1 is not critical. Any value from 100 pF to 0.01 µF will work well. The only requirement for C1 is that its working voltage should be a minimum of 500 volts. That is for protection in case the probe head comes in direct contact with a bare wire that is carrying high voltage. The rest of the components are generic; values that are close to the listed ones will work fine.

The author's prototype used a molded plastic case with an aluminum lid. Any type of case will do, although cases made only of metal should be avoided for safety reasons. The size of the case should be as small as possible yet still have room for the PC board, a battery, a switch, and a buzzer.

Building the Electrostatic Voltage Probe. Although the Electrostatic Voltage Probe is a very simple circuit, do not try to build it on a perfboard. Potentially lethal voltages could be present at the probe tip should something go wrong such as touching the probe tip to a bare wire that is carrying house current. A foil pattern has been included here—it is a single-sided design that does not need any jumper wires. As an added feature, the surface plate for the probe is a part of the pattern.

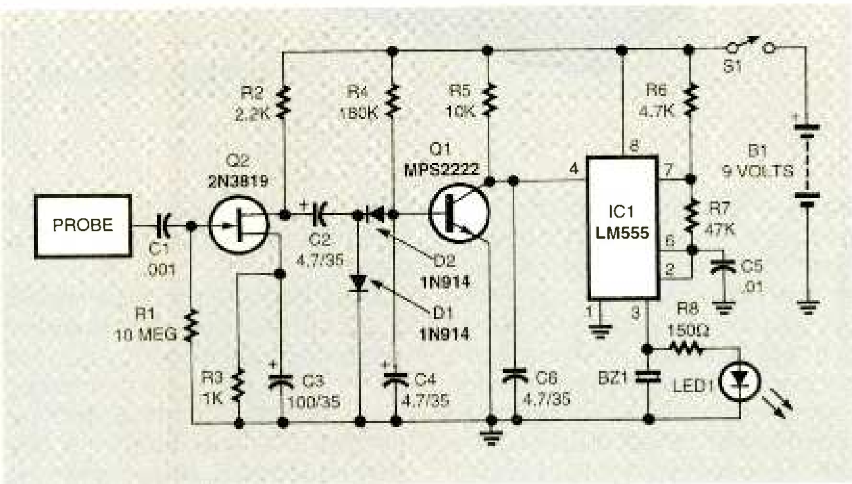


Fig. 1. The Electrostatic Voltage Probe is a simple circuit that is designed to detect AC signals through the phenomenon of stray capacitance. The probe plate forms one side of a capacitor. AC signals are amplified, rectified, and used to trigger a 555 timer that drives a buzzer and an LED.

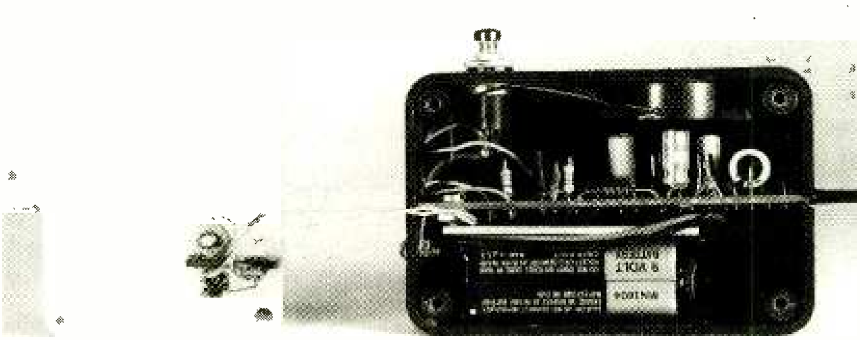


Fig. 2. Here is the author's prototype unit with the cover removed. Note how the PC board is mounted in the case along with the additional components. A piece of scrap plastic is wedged between the battery and the PC board so that the battery's metal case won't short out the circuit. A piece of heat-shrink tubing over the probe will help prevent accidental shocks if the probe touches a bare live wire.

Traditionally, construction of any electronic project starts with soldering the components to the PC board. Although that approach can be taken with the Electrostatic Voltage Probe, it is a better idea to start by preparing the case first. That way, you will be sure that the PC board will fit in the case without having to cut or file any excess material from the board after the components have been soldered in place.

The layout of the author's prototype is shown in Fig. 2. Assuming you want to follow that, begin by cutting a slot in one side of the case. It should be the width of the PC board—the probe will slide into it. Test-fit the blank PC board in the case. If needed, trim the PC board to fit. Once the PC board fits in the case with the lid closed, set the PC board aside.

Drill a hole for an angle bracket that will hold the back end of the PC board in place. A small hole (or a series of small holes) should also be drilled where BZ1 will be mounted; they will act like a speaker grille. A hole for S1 should be drilled near BZ1.

Suitable holes for LED1 should be drilled in the case lid. If you wish, you can use a panel-mount clip for LED1. An alternative method that was used in the author's prototype is to use a short length of terminal strip. The LED is soldered to the terminals, and insulated wires are used to connect LED1 to the PC board. You can vary the positioning of the various parts depending on personal taste and size of the selected case. An important consideration for placement of S1 and LED1 is that of safety. Although it might feel more comfortable, do not place S1 near the probe. That will keep your hands as far away from any wires under test as possible. You should also be able to easily see LED1 while holding the unit.

Glue BZ1 in place inside the case, making sure that it is centered over the hole that was drilled for it. If you are using the buzzer suggested in the Parts List, it will have three wires—red, black, and blue. The blue wire is meant for feedback in a single-transistor oscillator, and is not needed here; cut it off at the body of BZ1. Mount LED1 to the case lid by whatever method you've selected. If you are going to use a terminal strip, be sure to solder the cathode of LED1 to the terminal that goes to the case lid. Solder three-inch lengths of insulated wire to the LED connections.

Solder the red lead from a 9-volt battery connector to one terminal of S1; a two-inch length of wire goes to the other terminal. Mount S1 in the case. The case is now ready for the PC board; set it aside.

The PC board is assembled according to the parts-placement diagram shown in Fig. 3. Keep the leads fairly short and mount the component bodies as close to the board as possible. Before soldering any polarized components such as the semiconductors, C2, C3, and C4, double-check their orientation. Resistors R6, R7, and R8 are mounted vertically in order to fit the available space. When mounting the transistors, shape the leads to fit the hole pattern in the board before soldering them. Any stress on the leads could cause the component to crack and fail when heated during the soldering process. To help position IC1 correctly, there is a "dot" in the foil pattern next to pin 1.

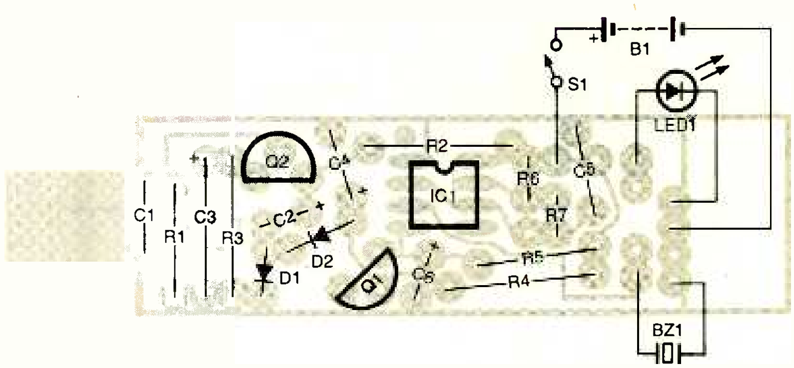


Fig. 3. All of the components for the Electrostatic Voltage Probe fit neatly on a small single-sided PC board. Several resistors are mounted vertically to save space. Note the large foil pad next to C1. That pad is the probe—neatly designed into the board layout!

With the PC board completed, check your workmanship for any bad solder joints, wrong values, or reversed polarities.

Final Assembly and Testing. Test-fit the PC board in the case to check that the components do not get in the way of BZ1, S1, LED1, or B1. Connect the wires from those components to the PC board using Fig. 3 as a guide. When connecting BZ1, the black lead goes to the common ground along with the negative terminal of B1 and the cathode of LED1.

Connect a 9-volt battery to the Electrostatic Voltage Probe. When S1 is pressed, LED1 should flash briefly while BZ1 sounds as C4 charges up. If that happens, the circuit is probably working correctly. The final test is to bring an extension cord that is plugged into a wall socket near the probe while S1 is being held closed. The cord should be placed against the flat side of the probe; pointing the probe tip at a wire will do nothing. See Fig. 4 for the proper way to hold and use the Electrostatic Voltage Probe. The LED should light and the buzzer should beep steadily. Remove the extension cord; both LED1 and BZ1 should go out.

If the Electrostatic Voltage Probe passes that test, it is working properly. Mount the PC board in the case, route the wires from B1, S1, and LED1 around the end of the PC board between the board and the case. Bolt the PC to a right-angle bracket to hold the board in position. A scrap piece of plastic, cardboard, or blank PC board without any copper on it should be inserted between B1 and the PC board. Close up the case and put a piece of heatshrink tubing over the probe where it comes out of the case. Cut the tubing slightly longer than the probe itself so that there will be no bare PC board metal exposed.

A good test is to walk around the house and check some extension cords. Note that you will be able to detect which side of a parallel-conductor lamp cord is the hot side. If the cord is of twisted-pair construction, then the voltage probe will beep intermittently as you slide the probe down the cord.

Troubleshooting. It is hoped that your Electrostatic Voltage Probe worked perfectly the first time you tried using it; if so, you can skip this section. In case things haven't gone as planned, refer to the schematic diagram in Fig. 1 and the parts-placement diagram in Fig. 3 as we look at some spots that might cause problems.

Difficulties with the Electrostatic Voltage Probe will probably fit into one of two categories. The first category is when LED1 and BZ1 are on continuously whether there is an AC

PARTS LIST FOR THE ELECTROSTATIC VOLTAGE PROBE

SEMICONDUCTORS

IC1—LM555 timer, integrated circuit
Q1—MPS2222 NPN silicon transistor
Q2—2N3819 N-channel junction-type field-effect transistor
D1, D2—1N914 silicon diode
LED1—Light-emitting diode, red

RESISTORS

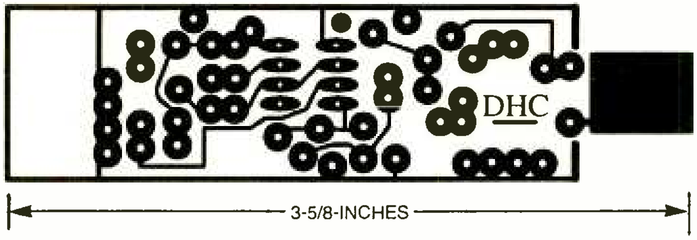
(All resistors are ¼-watt, 5% units.)
R1—10-megohm
R2—2200-ohm
R3—1000-ohm
R4—180,000-ohm
R5—10,000-ohm
R6—4700-ohm
R7—47,000-ohm
R8—150-ohm

CAPACITORS

C1—0.001-µF, 500-WVDC, ceramic disc
C2, C4, C6—4.7-µF, 35-WVDC, electrolytic
C3—100-µF, 35-WVDC, electrolytic
C5—0.01-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
BZ1—Piezo-electric buzzer
S1—Single-pole, single-throw, momentary-contact switch, normally-open
Case, 9-volt battery connector, heatshrink tubing, wire, hardware, etc.



Here's the foil pattern for the Electrostatic Voltage Probe. Not only is the design an easy-to-fabricate single-sided layout, it is also compact and doesn't require any jumper wires!

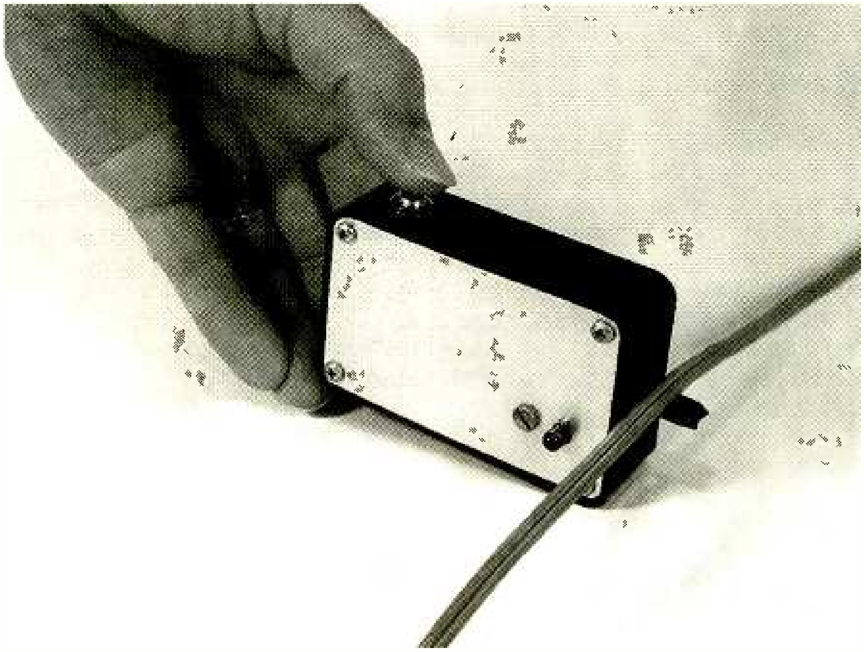


Fig. 4. Here is how to use the Electrostatic Voltage Probe when checking an AC line cord. If the cord is hot, then the Electrostatic Voltage Probe will emit a warning tone and the red LED will glow. The unit is sensitive enough to let you find which side of the line cord is the "hot" side.

power cord nearby or not. If that occurs, make sure that a fluorescent desk lamp that might be near (perhaps lighting your bench) is not causing the problem. If that doesn't clear the problem, then the problem will be caused by Q1 not saturating and pulling the reset pin (pin 4) of IC1 low. Using a voltmeter, check that the base of Q1 is at least 0.7 volts above ground. The collector of Q1 should be almost at ground potential. If both the base and collector are high, replace Q1. If the base is high and collector is low, look for a bad solder joint at pin 4 of IC1. If the base is low (less than 0.7 volts to ground), C4 might be either bad or installed backwards. If it was installed backwards, it might already be ruined.

Capacitor C6 is needed to prevent any noise that might be induced onto the 9-volt bus from retriggering IC1. If an oscilloscope shows noise being picked up that is greater than about one volt in amplitude on pin 4 of IC1, replace C6.

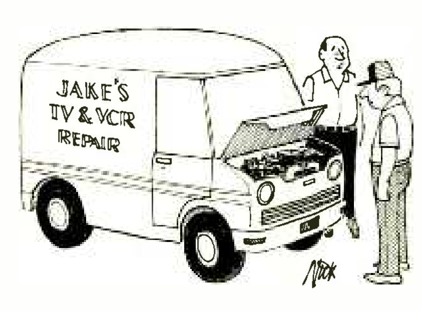
The second category is the exact opposite: LED1 won't light and BZ1 will not beep when the probe is exposed to a 120-volt AC field. There are several causes for that condition, including:

- IC1 is defective
- Q1 is shorted between collector-emitter or collector-base
- D1 or D2 are either bad or installed backwards
- C2 is either bad or installed backwards
- Q2 is either bad or installed incorrectly
- C3 is either open or installed backwards

We'll start with IC1. First, we'll check that the voltages are as they should be. With the probe lying close to a live extension cord, pin 4 should be above 8 volts. If it is, check all of the connections and solder joints near IC1; replace IC1 if needed. If the voltage on pin 4 is low, check Q1. The base of Q1 should be near ground potential. If it is being exposed to a very strong AC field, it might even be at a negative voltage with respect to ground. If the base is less than 0.5 volts and pin 4 of IC1 is still low, replace Q1. If Q1 has 0.7 volts or higher on its base, then check D1 and D2. They might be either bad (open or shorted) or be installed backwards. The same effect can be caused by C2 either being open or installed backwards. If the circuit checks good all the way back to Q2, check to make sure that Q2 is biased correctly. The DC voltage on the source of Q2 should be at about 3.2 volts, and the drain should be at about 6.8 volts. If those values (within 0.5 volts) are off, Q2 might be installed incorrectly. Compare the pinouts of Q2 to the schematic and the parts-placement diagram. Some manufacturers package field-effect transistors differently. The devices will still work; you just have to be careful to correctly identify the drain, gate, and source leads!

If Q2 is soldered in correctly, it should be replaced. Also check to see if source-bypass capacitor C3 is bad. Finally, measure the value of R1. Substituting a 1-megohm resistor for the 10-megohm unit specified will also cause this same problem.

With the AC Electrostatic Voltage Probe, accidentally working on a live wire will become a memory. But remember, safety should always come first! Ω



"It won't fast-forward."

BY DON LANCASTER

Experimenting With Rail Guns, and More

THIS MONTH I THOUGHT WE JUST MIGHT TAKE A LOOK INTO TWO WILDLY DIFFERENT TOPICS. EACH WITH ITS OWN SET OF PROBLEMS AND UNIQUE OPPORTUNITIES.

Rail Guns

Michael Faraday once ran a rather profound experiment. It went something like what is shown in Fig. 1. He took a block of wood and milled two long parallel slots in it. Those slots were then filled with mercury. Mercury is one of those very rare liquids that conducts electricity fairly well. It is also dense enough to let you float most metals. Mercury is also a deadly cumulative poison, so do not try this experiment on your own.

He then took a "U" shaped wire and bent it so it would float in the mercury pools as shown. When a DC current was applied, the wire quickly moved away from the terminals. Thus proving one of the two fundamental two motor laws:

$$f = Bli$$

Or that the force acting on any conductor will be proportional to the magnetic field strength multiplied by the length of the conductor at right angles to it times the current through the wire. We saw a lot of details on this back in November, 1997. That article is also available as MUSE117.PDF on my www.tinaja.com Web site.

When your circuit is closed, a current loop is formed by the battery, the mercury channels, and the wire float. That single-turn current loop sets up a magnetic field. Thus, the interaction from the above equation creates a force on the loop.

A rail gun is simply any modern rerun of that experiment. Figure 2 shows us several possibilities.

The conductive carrier or projectile in a *sabot* is sent down the rails when a high current is discharged into the rails from a bank of capacitors. The usual object of the game is to get the carrier to quickly leave the rails.

The term *sabot* literally means a "shoe." Especially a wooden Dutch one. And sabotage might come about whenever you throw the shoes into machinery. In military parlance, a *sabot* is any expendable carrier for a projectile. In the case of a rail gun, the *sabot* should end up both highly conductive and a good lubricant.

In nuclear-fusion lab experiments, a rail gun can cleanly and directly shove a solid hydrogen pellet exactly where it is required. As a terrestrial weapon, a rail gun would have no theoretical limit on muzzle velocity. There would often be no observable muzzle flash as well.

As a launch vehicle, the rail gun spreads the acceleration out over much longer periods of time, thus being much more gentle on human riders and cargo. It also gives you a way to launch to orbit without fuel. Out in space, a rail gun gives us a fuel-free means of accelerating a second stage or a smaller vehicle.

And, of course, as a science-fair project a rail gun can be a sure-fire winner since it could literally blast past all of your competition. As you can see, there are lots of benefits here.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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Thatcher AZ, 85552
Tel: 520-428-4073

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

Limitations

The only tiny little problem is that nobody has figured out how to build a really good rail gun. The currents involved are extreme, and approach tens to hundreds of millions of amps. There is often a fundamental conflict between electrical and mechanical friction. You want to minimize both. While graphite is an obvious choice, its conductivity is only moderate at best. Rail-to-projectile welding can be a serious problem; if the projectile leaves your rails for even an instant, extreme voltages result, which causes arcs and welding.

Longer rail guns work best under vacuum to minimize frictional air losses. A major but subtle problem is what takes place when the projectile leaves the rail ends. If there is still current, you get a destructive arc. If you shut the current off too soon, you end up with a dynamic brake.

Usually, multiple hits from many capacitor banks are needed. Properly profiling and switching the currents is not trivial. Speed sensing feedback is a must. Finally, rail-gun efficiency is ridiculously low, and is made even worse by the extremely high energy levels involved.

Special capacitors are required. They must have an ultra-low ESR, or equivalent series resistance. They also have to provide extreme levels of energy storage and be capable of being rapidly discharged. Note that most conventional capacitors will violently explode when subjected to rail-gun conditions.

As far as I know, all rail guns to date are still in the lab. Any practical applications remain elusive, and are likely to stay that way.

The best starting point on rail guns is found in the January, 1995 issue of *IEEE Transactions on Magnetics* issue. A good, but difficult, book on the fundamental physics is *Newtonian Electrodynamics* by Peter Graneau. More details on that title appears at www.tinaja.com/amlink01html

Yes, you can build your home rail gun. But most efforts so far barely manage to get the projectile to leave the rail ends. This is not a technology that scales down well because of the extreme currents involved, and some serious electrical safety issues might keep you from making a science fair project out of this.

Still, if you want to pursue this, there are two fine Web sites to get you going. Those are "Bill Beatty's Science Hobbyist" at www.eskimo.com/~billb and "The Rail Gun Page" you will find at www.hmc.edu/~jengel/rail.html

I've gathered together a few other railgun Web-site resources for you as this month's resource sidebar, but watch out for false hits on rail guns if you decide to surf out on your own. There's a lot of sci-fi dreck and pseudoscience garbage on this topic. I sure got sucked in on the "weapons list" showing barely believable rail guns as installed on a recently deployed UN tactical aircraft, only to find out later that it was really just an RPG role-playing game. I also learned that Railgun's last album is one of their best.

Industrial Strength Servos

The air conditioning people have been keeping a big bunch of "secret" rotary actuators all to themselves. One in particular seems to have some heavy tail-twisting capabilities that can be applied anywhere. But before we get into that, let's review:

Say you want to precisely control the position or speed of a shaft. Your choices are to use an open loop with a stepper, or a closed loop with a servo.

Servo is short for servomechanism. In a servo, position is continually sensed and used as correctional feedback. Servos are usually more complex but more accurate than steppers—generally, it is easier to accurately measure something than it is to precisely move somewhere under variable load.

You might be familiar with the small servos used in model airplanes. Those accept a duty cycle modulated rectangular wave and output a mechanical position. A low duty cycle twists it left, a mid duty cycle of 50% centers it, and a high duty cycle twists it right.

Combining these servos with PIC's and the Basic Stamp or other micros leads to all sorts of interesting new options. Go to www.parallaxinc.com, www.micromint.com, and www.see.com for lots of applications information.

But what if you need some serious tail-twisting? Honeywell has a Modutrol IV air conditioning servo that just might work well for you. Some details on this beast appear in Figs. 3 and 4.

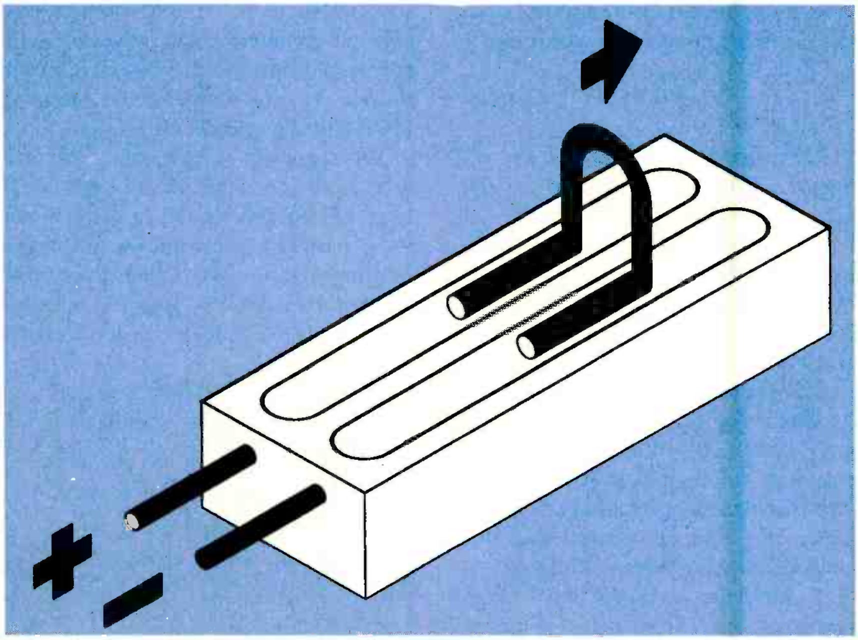

FIG. 1—IN THIS FARADAY EXPERIMENT, the wire floats away as current is applied, thus proving the fundamental f = Bli motor rule.

A typical Modutrol sits in a zinc die-cast box about 4 by 6 by 7 inches. There is a half-inch shaft coming out both ends of the box.

Most Modutrols accept the usual "furnace control" 24-volt AC as the line-power input. Some include an internal transformer for direct 110-volt operation.

There are three input control lines that you can connect to a 1K volume control or some ratiometric voltage source. When you adjust the volume control, the shaft position precisely follows. Typical Modutrols offer 35 inch-pounds of torque, and twist 90 degrees in thirty seconds. A pair of programmable limit switches may be optionally provided.

The usual application is to open or close a damper in an A/C duct, providing just enough cooling to meet the room's needs. But the torque is more than enough to open or close nearly any reasonable sized valve. And there should be all sorts of new mid-sized robotics uses for these units.

The Modutrol IV has an internal potentiometer that senses the current shaft position, which is compared against the input control voltage with a comparator. If low, an AC back-gear motor is powered in a clockwise direction. If high, the same motor is powered counter-clockwise. A modest amount of hysteresis is added to the comparator. That prevents continuous "hunting" for small input changes. The hysteresis will also dramatically reduce power consumption, because with it, the motor starts and then stops only on significant input changes.

The entire motor and gear train is apparently sealed in oil for long life and maintenance-free operation. The power when actually operating is 27 watts or so. Standby power is quite low. A humongous gear ratio lets a small high-speed motor generate a lot of low-speed torque. The other end of the shaft also comes out of the case, but Honeywell recommends using that end only for an indicator or a pointer or for some other light load. Both ends of the shaft have two flats and a grooved ring on them.

Yeah, the thirty seconds pin to pin is kind of slow. And they prefer a 25-percent duty cycle under heavy load. But my, oh my, the tail twisting that's available here makes that worth dealing with. You should be able to come up with all sorts of new shop or farm remote-control uses for one or more of these, and there's all sorts of heavy-duty robotics applications possible.

No, these Modutrols are not cheap. Their wholesale price through Grainger is several hundred dollars, but lower-cost competitors surely must exist, as must a used and auction market. And these sure are a superb starting point for serious robotics.

I do have a few surplus Modutrols at www.tinaja.com/bargte01.html if you want to play with them. Let me have your thoughts on what you can do with a powerful and convenient rotary actuator. Or tell me about any other higher power actuators that you may have run across.

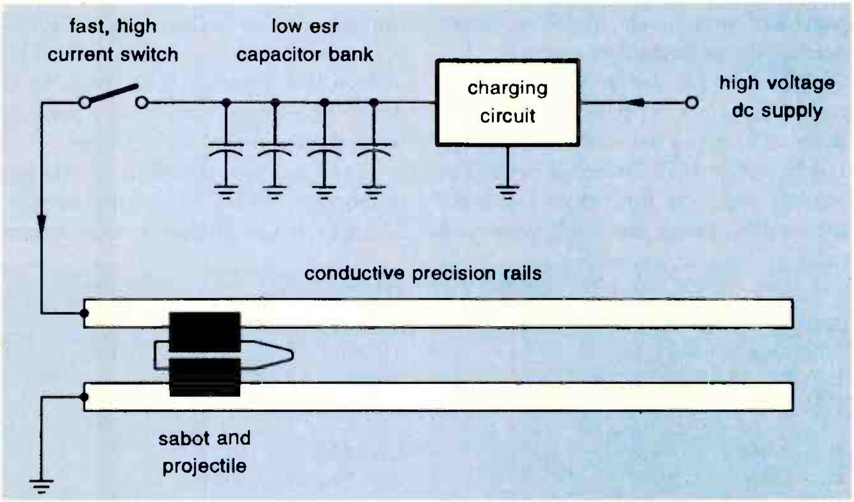

FIG. 2—A RAIL GUN is simply the Faraday f=Bli experiment in disguise. Discharging the capacitors accelerates the carrier.

SOME RAIL-GUN WEB SITES

http://129.7.21.70/enl/annrep94-95/rail.html
http://es.epa.gov/techinfo/facts/railgun.html
http://fpl.firemoth.com/
http://http.bsd.uchicago.edu/~c-henkle/btech2/0966.html
http://iml.umkc.edu/physics/sps/railgun/railgun.html
http://madsci.wustl.edu/posts/archives/dec96/851510255.Eg.r.html
http://me.udel.edu/~morrison/rail.html

http://sunflower.singnet.com.sg/~wspclip/Books/physics/2770.html
http://web.nps.navy.mil/~pao/railgun.html
http://weber.u.washington.edu/~buckwadl/RAM/ram.html
http://www.access1.net/ninteach/research.html
http://www.eecs.kumamoto-u.ac.jp/.eecs/labs/akiyama-lab/subjects/railgun
http://www.engr.uiuc.edu/Publications/summary97/ece/FUSION.html
http://www.eskimo.com/~billb/amateur/capexpt.html

http://www.iap.com/jbarber.html
http://www.io.com/~bolie/Tech/railguns.html
http://www.isd.net/anowicki/SPBI1112.HTM
http://www.mhi.co.jp/tech/htm/e633213a.htm
http://www.millennial.org/~jwills/orbit/SPBI113.HTM
http://www.nrl.navy.mil/nrl/heritage/review8.html
http://www.onr.com/user/shadow/RiftsFolder/Railgun.html

http://www.sandia.gov/pulspowr/peng/seraphim.html
http://www.sover.net/~geoffk/coilgun.html
http://www.sti.nasa.gov/thesaurus/R/word12648.html
http://www.uiuc.edu/colleges/eng/summary/ece/FUSION.html
http://www.utexas.edu/research/cen/rd/rd02/02.html
http://www.west.net/~steamer/massdriv.htm
http://www3.hmc.edu/~jengel/rail.html

Whither Windows 98?

I just lost several days and some monumental frustration in trying to upgrade an older cheap computer to Windows 98. It finally worked, but not without some rather rude surprises along the way.

First, note that Windows 98 is an evolutionary not revolutionary improvement. For most people, there's no urgent need to do an immediate upgrade. Win 98 is somewhat faster and somewhat more stable than its predecessor. It eventually will let you use multiple monitors and far better USB Universal Serial Bus printers and such. But before you make the switch, make absolutely sure you have got everything currently and freshly backed up.

My klutzy old Packard Bell was picking up a few bad habits (such as a memory leak, difficult restarts, and excessive clacking), so I thought an upgrade would miraculously repair things. The Win 98 upgrade promptly caused a fatal exception blowup and trashed all my IDE drivers. This left me without a CD-ROM drive, a 120-Meg floppy, and even the A: drive. The latter of which was removed when the big floppy was installed.

A call to Packard Bell (their 900-line support has worked well for me) suggested a new BIOS patch upgrade—Agoura 1.20 in this case. I got their patch using another computer and then reinstalled the original A: drive. This cured the fatal exception, but not the trashed IDE drivers. It used to be you could reset blown drivers by changing a NoIDE flag with Resedit, but that flag is apparently gone.

After that, I tried reinstalling Win 95. That was a big-time mistake that really caused problems. I then used 125 floppy disks to back up every file I could. Besides my work files, that included fonts, Netscape Mail, the internal tax files, sig files, other apps, and more.

Next, I tried completely clearing the Windows folder and did a W95 reinstall. This did not work because the registry was apparently blown at this point. So (gulp) I re-initiated the C: hard drive and reinstalled Win 95. I then reinstalled Win 98. Everything worked just fine.

Well, sort of: I still can not get Netscape's "You Have Mail" flag to work. And Wordpad is ridiculously slower than it used to be. A hint or two would certainly be welcome.

The bottom line: The best way to upgrade to Windows 98 is to avoid doing it at all on an older or flakey computer. If you must, the route of a full save, an online compatibility check, a hard disk re-initiation, and full reinstallation is probably the fastest, safest, and cheapest way to go.

NAMES AND NUMBERS

Atmel
2325 Orchard Pkwy.
San Jose, CA 95131
(408) 441-0311

BookTech
401 N Broad St. 5th Fl
Philadelphia, PA 19108
(215) 238-5300

FlexiForce
307 W 1st St.
Boston, MA 02127
(617) 269-8373

Forming & Fabricating
One SME Drive
Dearborn, MI 48128
(313) 271-1500

Grainger
2738 Fulton St.
Chicago, IL 60612
(312) 638-0536

Honeywell
1985 N Douglas Dr.
Golden Valley. MN 55422
(800) 328-5111

IEEE Transactions on Magnetics
445 Hoes Ln.
Piscataway, NJ 08855
(800) 678-IEEE

Interlink Electronics
546 Flynn Rd.
Camarillo, CA 93012
(805) 484-8989

Kepro Circuit Systems
640 Scarlet Oak Blvd.
St Louis, MO 63122
(800) 325-3878

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

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

Reid Tool
2265 Black Creek Rd.
Muskegon, MI 49444
(800) 253-0421

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

SprayChip Systems
9841 Greenbelt Rd., #101
Seabrook, MD 20706
(301) 552-5570

Stamping Journal
833 Featherstone Rd.
Rockford, IL 61107
(815) 399-8700

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

TelCom Semiconductor
1300 Terra Bella Avenue
Mountain View, CA 94043
(800) 888-9966

Tra-Con
45 Wiggins Ave.
Bedford, MA 01730
(800)-TRA-CON1

Trimble Navigation
585 N Mary Ave.
Sunnyvale, CA 94086
(800) 545-7762

Unitrode
7 Continental Blvd.
Merrimack, NH 03054
(603) 424-8610

New Tech Lit

The July 17, 1998 issue of *Science* magazine on page 329 asks us "How good is the error correction on the DNA code?" Incredibly so, it seems. For DNA cleanly beat out millions of other trial codes. It was not even close. Very intriguing research here. There is still a buck to be made by publishing a complete DNA pocket card.

Microchip Technology is now offering their latest Technical Library on PIC Microcontrollers on CD ROM. Alternates to the PIC appear in a similar CD ROM from Atmel. A third CD ROM from TelCom Semiconductor covers charge pumps, fan controllers, temperature sensors, and MOSFET drivers. Lots more PIC support is found at www.tinaja.com/pic01.html

From Unitrode there's a new UCC3926 integrated current sensor. This has a 20-amp rating and includes an internal shunt resistor.

New VersaPad combination touch pads and signature grabbers are now offered by the Interlink Electronics folks,

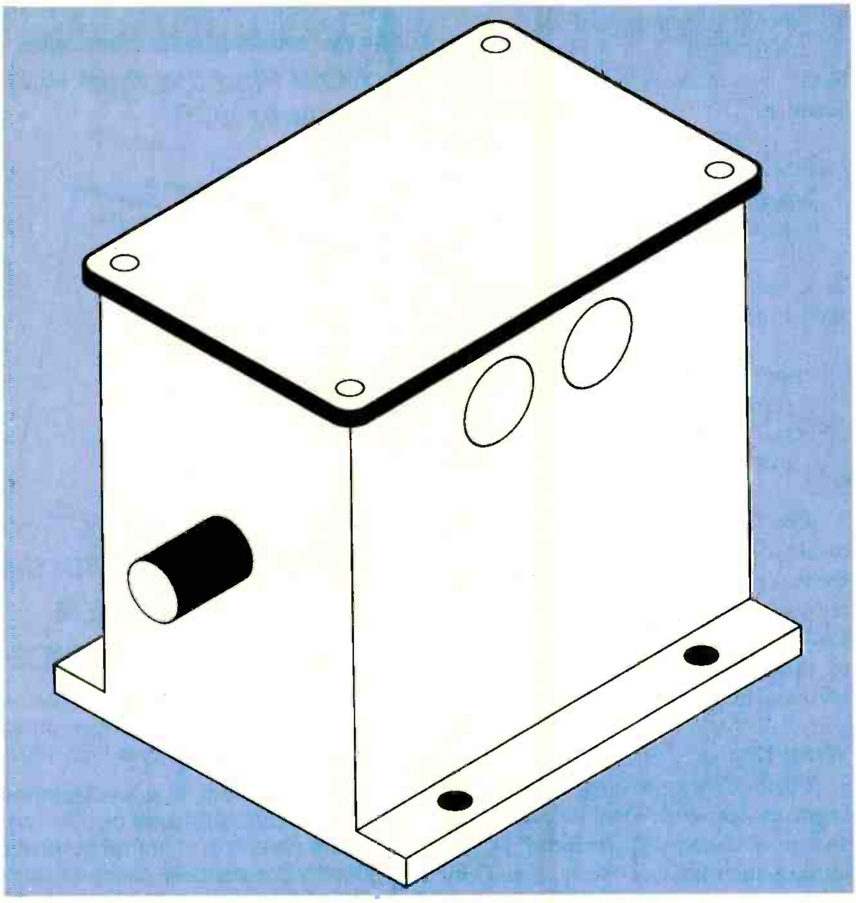

FIG. 3—THE MODUTROL IV is a servo normally used in air conditioning. On a control voltage input, the shaft goes to selected position at high torque. The 90-degree peg-to-peg time is 30 seconds.

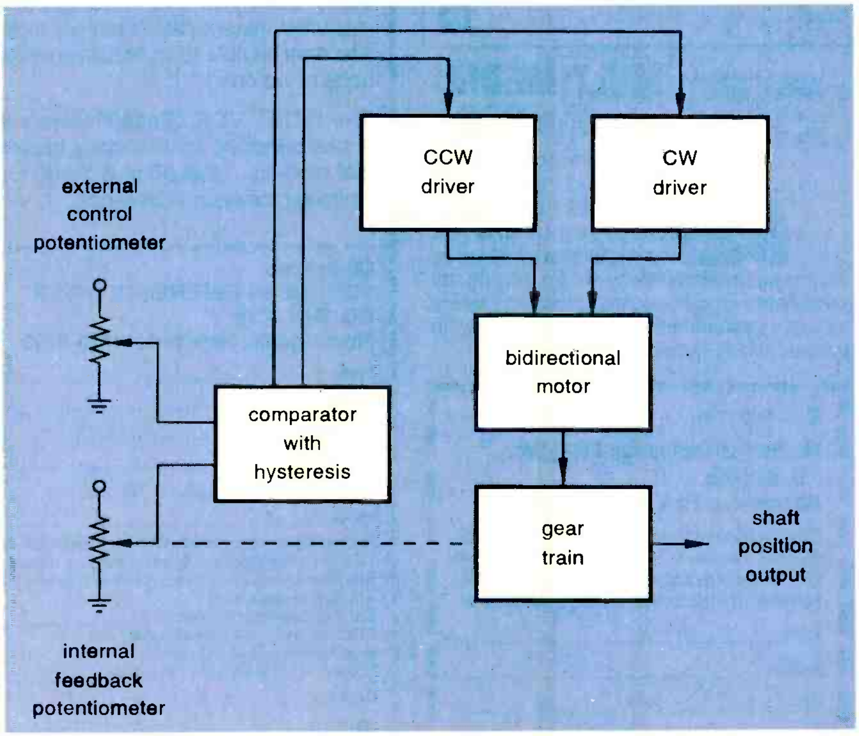

FIG. 4—INSIDE THE MODUTROL is a classic servo that has dead-band hysteresis. High torque results from a small motor and a very large gear reduction train. The mechanism is sealed in oil.

as are several new development kits.

Details on micromachined spray techniques are in a new app note from Spray Chip Systems. And FlexiForce now offers a new system of ultra-thin force-sensing transducers.

Several different epoxy samples are available from Tra-Con. Reid Tool Supply has their interesting catalog full of all sorts of tools and mechanical items.

Three trade journals for this month include *Forming & Fabricating* and *Stamping Journal* on sheet-metal work, and *BookTech* for book-publishing insiders. The latter title is adding Book-on-demand publishing information in it. More on BOD is found at www.tinaja.com/bod01.html

FactsFinder is a free GPS navigation house organ from Trimble.

Parallel Port Complete seems to be a definitive book on dealing with PC parallel-printer ports. More details on that Jan Axelson book from Lakeview Research is at www.tinaja.com/amlink01.html

A new extended tutorial on buying military-surplus electronics can be found at www.tinaja.com/glib/resbn81.pdf Examples of the kinds of goodies you can get from Uncle can be found at www. tinaja.com/barg01.html Secret test-equipment manual sources at available at www.tinaja.com/glib/resbn80.pdf

Military surplus can now be bought direct over the web, and often for less than a penny on the dollar. You can now pay by VISA, and sometimes the feds will even deliver. You can also find out who paid how much for what.

Again that's all done online. But you do have to know what you are getting and definitely must have a plan for pickup, use, and storage. With a little care, though, astounding bargains abound.

I also have got a nearly new and complete printed circuit plate-through lab by Kepro available at one quarter the new cost. E-mail don@tinaja.com or see www.tinaja.com/bargte01.html for details.

For all the fundamentals of digital-integrated circuits, check out my CMOS and TTL cookbooks, either by themselves or as part of my Lancaster Classics Library. Details per my nearby Synergetics ad. Instant book access is available at www.tinaja.com/amlink01. html

As usual, most of those mentioned items are in our Names & Numbers or Railgun-Websites sidebars. Always look here first before calling our free US technical helpline. Let's hear from you. EN

EQUIPMENT REPORT

continued from page 12

with holes for tripod mounting. The stand costs $149.95.

While not everybody needs a laser tool to align their speakers, audio professionals have long found laser levels to be useful. And this is "the" laser level for audio professionals who have had to make do with a carpenter's laser level all these years. But even the high-tech home-audio enthusiast might be able to justify the cost of this tool given its usefulness around the home. There are plenty of people out there doing all sorts of handyman projects where a laser level would surely come in handy. And when it comes time to align their speakers, those people will know that their speakers have been aligned with laser precision. All it takes is the SA-S Pro Sound Alignment System from Checkpoint Laser Tools. For more information on the SA-S Pro or the base model SA-S, contact the manufacturer directly at the address given earlier in this article, or circle 15 on the Free Information Card. EN

SERVICE CLINIC

continued from page 24

was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and therefore might fail in the future. Replacing Q701 and C725 might get your equipment going again, but that will not help you to repair a different model in the future.

Having said that, here are three tech-tips sites for computer monitors, TVs, and VCRs:

http://www.anatekcorp.com/techforum.htm (Free)
http://www.repairworld.com/ ($8/month)
http://elmswood.guernsey.net/ (Free, somewhat limited)

The following is just for monitors. Some portions are free, but others require a $5 charge. However, that might include a personal reply from a technician experienced with your monitor, so it could be well worth it:

http://www.netis.com/members/bcollins/monitor.htm

Some free monitor repair tips can be found at:

http://www.kmrtech.com/
http://www.metrosites.com/amr/monitor_repair_tips.htm

Tech-tips of the month and "ask a wizard" options are at:

http://members.tripod.com/~ADCC/ (Home page)
http://members.tripod.com/~ADCC/tips.htm (Tech-tips of the month)

The Resolve Monitor Tech-Tips database is a diskette that is priced out of the reach of most hobbyists. However, a reduced shareware version can be downloaded from a number of web sites. Go to http://www.filez.com/ and look for res16sw.zip.

Wrap Up

That's it for now. Next time we will begin to deal with monitor adjustment and troubleshooting, preceded by the most important safety information. Until then, check out my Web site, www.repairfaq.org. I welcome comments (via e-mail) of all types and will reply promptly to requests for information. See you next time! EN

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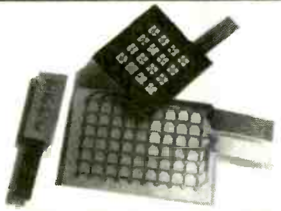

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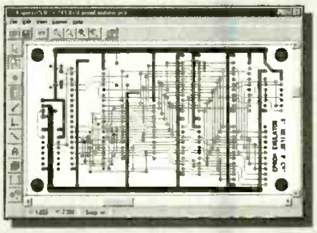

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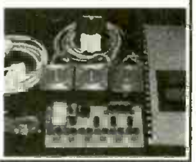

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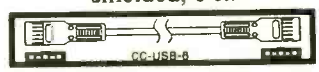

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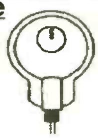

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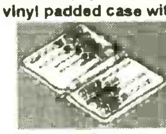

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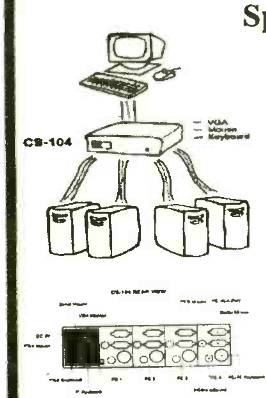

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C-2000, Basic Video Transmitter Cube....................................$89.95
C-3000, Basic Video and Audio Transmitter Cube..............$149.95
C-2001, High Power Video Transmitter Cube......................$179.95
C-3001, High Power Video and Audio Transmitter Cube.....$229.95

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

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

FM-100, Professional FM Stereo Transmitter Kit...............$299.95
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AM Band Radio Transmitter

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

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CAM, Matching Case Set for AM-1......................................$14.95

CCD Video Cameras

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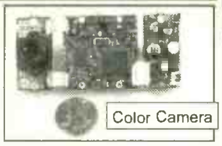

Color Camera

If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays with over 440 line resolution, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. Also, a new strain of CMOS single chip cameras are entering the market, those units have about 1/2 the resolution and draw over twice the current that these cameras do - don't be fooled! Our cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, the black & white models are super IR (Infra-Red) sensitive. Our IR-1 Illuminator kit is invisible to the human eye, but lights the scene like a flashlight at night! Color camera has Auto White Balance, Auto Gain, Back Light Compensation and DSP! Available with Wide-angle (80º) or super slim Pin-hole style lens. They run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our IB-1 Interface board for audio sound pick-up and super easy direct wire hook-up connection to any Video monitor, VCR or TV with video/audio input jacks. Cameras fully assembled, including pre-wired connector.

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IR-1, IR Illuminator Kit for B&W cameras...................$24.95
IB-1, Interface Board Kit..$24.95

FM Stereo Radio Transmitters

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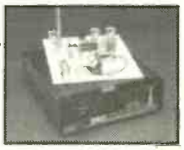
FM-25, Synthesized FM Stereo Transmitter Kit........$129.95



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

FM-10A, Tunable FM Stereo Transmitter Kit.............$34.95
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LPA-1, Power Booster Amplifier Kit.............................$39.95
CLPA, Matching Case Set for LPA-1 Kit......................$14.95
LPA-1WT, Fully Wired LPA-1 with Case.......................$99.95

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

TF-1, Treasure Finder Kit..$39.95

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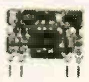

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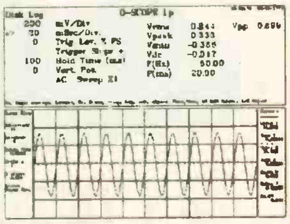

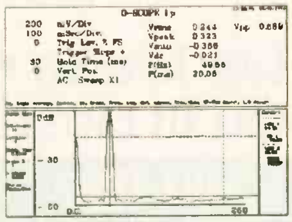

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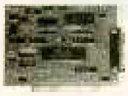

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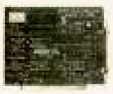

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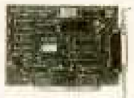

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HOW TO WRITE YOUR AD

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

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

WHAT WE DO

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

RATES

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

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

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

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

DEADLINES

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

CONTENT

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

AD RATES: $2.50 per word, Minimum $37.50

Send you ad payments to:
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9 - $37.50	10 - $37.50	11 - $37.50	12 - $37.50	37 - $92.50	38 - $95.00	39 - $97.50	40- $100.00
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25 - $ 62.50	26 - $65.00	27 - $67.50	28 - $70.00				

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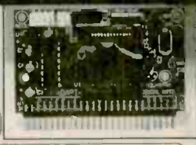

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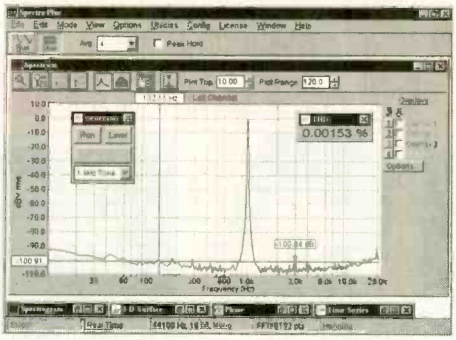

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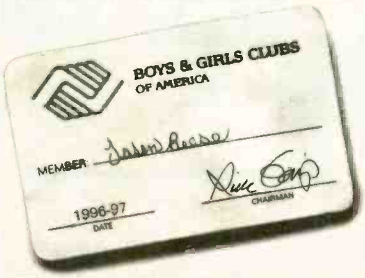

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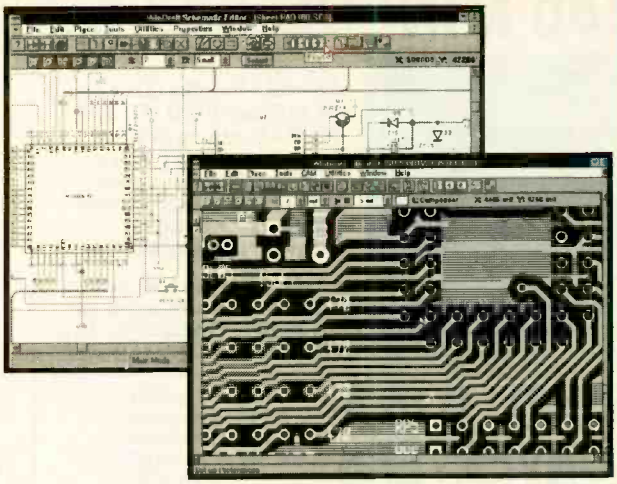

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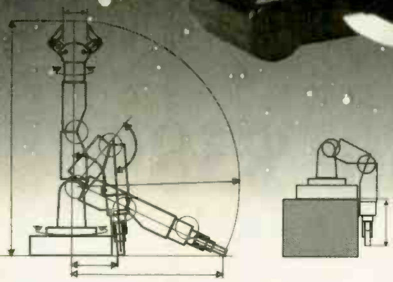

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TA-83 ▲

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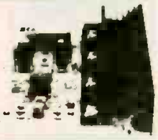

Power Output: 300W into 8 ohms RMS. 540W music power into 8 ohms. Frequency Response: 10Hz-20KHz. THD: < 0.05%. Sensitivity: 1V RMS at 47K. Power Requirement: 60 to 75 VDC at 8A. May use Mark V Model 007 or 009 Transformer. Suggested Capacitor: 8,200uf 100V Model 020 Capacitor. Suggested Metal Cabinet LG-1925.

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39.94
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1. **Confirm price and merchandise information** with the seller, including brand, model, color or finish, accessories and rebates included in the price.

2. **Understand the seller's return and/or refund policy**, including the allowable return period, who pays the postage for returned merchandise and whether there is any "restocking" or "return" charge.

3. **Understand the product's warranty**. Is there a manufacturer's warranty, and if so, is it for a U.S. or foreign manufacturer? Note that many manufacturers assert that, even if the product comes with a U.S. manufacturer's warranty, if you purchase from an unauthorized dealer, you are not covered by the manufacturer's warranty. If in doubt, contact the manufacturer directly. In addition to, or instead of the manufacturer's warranty, the seller may offer its own warranty. In either case, what is covered by warranty, how long is the warranty period, where will the product be serviced, is there a charge for service, what do you have to do to obtain service and will the product be repaired or replaced? You may want to receive a copy of the written warranty before placing your order.

4. **Keep a copy of all transactions**, including but not limited to cancelled check, receipt and correspondence. For phone orders, make a note of the order including merchandise ordered, price, order date, expected delivery date and salesperson's name.

5. **If the merchandise is not shipped within the promised time**, or if no time was promised, within 30 days of receipt of the order, you generally have the right to cancel the order and get a refund.

6. **Merchandise substitution** without your express prior consent is generally not allowed.

7. **If you have a problem with your order or the merchandise**, write a letter to the seller with all the pertinent information and keep a copy.

8. **If you are unable to obtain satisfaction from the seller**, contact the consumer protection agency in the seller's state and your local Post Office.

If, after following the guidelines, you experience a problem with a mail order advertiser that you are unable to resolve, please let us know. Write to Advertising Department, Gernsback Publications Inc., 500B Bi-County Blvd. Farmingdale, NY 11735.

Be sure to include copies of all correspondence.

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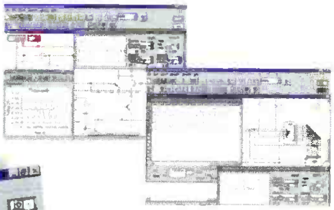

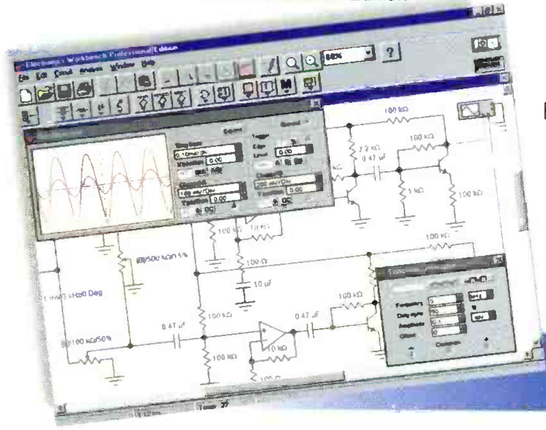

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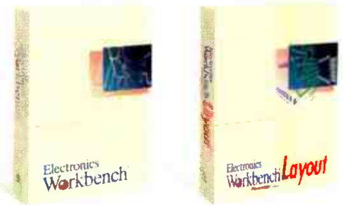

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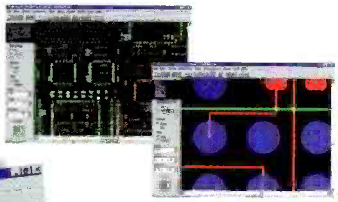

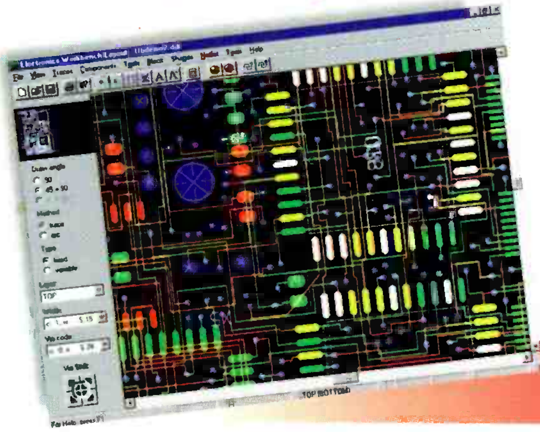

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