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Editorial

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TEOTMAWKI

Well, we made it to the end of another millennium. No second Ice Age, no natural disaster, no cataclysm, no apocalyptic war. The planets still follow their orbits, and the Earth's tilt is still about 23½°. All in all, it hasn't been the best of years for the doom-sayers.

Personally, I'll take "dull and boring" any day!

Isn't it amazing how time flies? Why, it just seems like it was only 12 months ago we were celebrating the end of a millennium, and here we are doing it again. Were we in a rush to get the hoopla over with, or was it just a "dress rehearsal" for the real thing?

Oddly enough, we—as a society—seemed to get the century-change date right in the past. What's so different about today? What makes the 20th Century so special that we're so desperate to condemn it to the dustbin of the past, we wanted to shorten it to 99 years?

Odder still is that most people seem afraid of the future; they desperately cling to the past. This is like a strange variation of the "Jekyll-and-Hyde" syndrome: we can't get ahead fast enough, yet we have an overwhelming need to stay in one place. No matter how we try to meet the demands of both goals, we end up with a "les-stalt:" the result is less than the sum of the parts, and very unsatisfying.

There's nothing wrong with the past. The past is the foundation upon which we build our future—for ourselves, our children, and our children's children. Many important lessons are available from our mistakes—and our successes as well. While we may enjoy reminiscing over what has gone before, we shouldn't dwell on it. Think of the past as taking a dip in a swimming pool. It's refreshing, relaxing, and a joy to savor...but I wouldn't want to *live* in a swimming pool. Would you?

Of course, there's also the "Good Ol' Days" mentality. Were they really that good? Think long and hard on that one: serial killers, gas shortages, recessions, depressions, assassinations, living with the threat of annihilation—real or imagined. Those are just a few highlights of the 20th Century's worst offerings. Of course, every downside can be counterbalanced with a positive accomplishment. Memory can be very selective. Don't just pick the good memories and gloss over the bad ones. Make sure that the past is a package deal.

It's "The End Of The Millenium As We Know It." The best is yet to come. We don't have much choice in the matter: God's Universe keeps carrying us into the future every minute of the day.

Joseph Suda
Managing Editor

LETTERS

mailto: letters@gernsback.com

"Unreal" Real Networks Dialogue

I greatly enjoy your magazine, and I think that home networking is a worthwhile topic. However, the subject of networking is sufficiently complicated that it can not easily be covered in a couple of pages. As a result, there were a few important errors and omissions in the "Computer Bits" column, entitled "Real Networks, Real Quick" by Ted Needleman (**Poptronics**, October 2000):

1. The article says that the networking kits include 25 cables. That should say "25-foot-long cables."

2. The most glaring technical mistake was the discussion about the difference between hubs and switches, which basically got the technology backwards.

Switches are the technically superior solution. Much like a telephone central office (CO) allows multiple phone calls to occur simultaneously (conceptually a big matrix switch), a network switch does the same thing. As such, switches *increase* network bandwidth by allowing multiple communications to occur at the same time. I recommend the nearly 500-page book *Switching Technology in the Local Area Network* by Mathias Hein and David Griffiths, which goes into enormous details about this technology.

3. The article suggests that program (file) sharing is a great use of a home LAN. It is, but once you hook the LAN up to the Internet, you have a huge new set of security issues. This problem should have been greatly stressed. In addition, the local cable company recommends the software firewall *Black ICE* as a way to protect computers from the threats of the Internet.

Of course, I also recommend cryptography to protect any sensitive files.
TONY PATTI
Editor & Publisher
Cryptosystems Journal
Holland, PA

Tony Patti is correct; I did have hubs and switches backwards. Nice catch. He is also correct about the security issues in attaching a network to a high-bandwidth connection without a firewall. Unfortunately, I'm one of those poor souls who can't get a connection to the Net that runs faster than 28K at best, so I don't always think in Broadband terms. Also, because of the length constraints in these columns, I just can't cover all of the relevant bases.

Black ICE is a neat product, and there are other such products available from Norton and McAfee. Anybody who is considering *Black ICE* and is also thinking of upgrading to Windows ME will need a new version of the firewall.

Thanks, Tony, for catching the errors and for bringing up the very relevant firewall issue.
TED NEEDLEMAN

Klondike Cell Always Gets His Call

In reference to the "Buying Cell-Phone Services" ("Net Watch," August, 2000), your Canadian readers might be interested to know there's a similar consumer Web site service in Canada allowing you to compare cell-phone plans and ensure you're on the best plan for your money and needs. The Web site is *www.comparecellular.com*.
AL KILBURN
via e-mail

[Note: Mr. Kilburn is president of comparecellular.com]

Buying Cell Phone Services

I just tried to locate cell phone plans using *point.com* and *decide.com*, as discussed in your August 2000 "Net Watch" column. There seems to be a slight problem.

Neither site recognizes an area nearer to me than Dallas (70 miles) or OK City (150 miles). Cellular is available here; contractors use it in my driveway every day.

I can go ten miles east to Bonham, TX and buy service at Wal-Mart or RadioShack; I can go 20 miles west to Sherman/Denison, TX and pick from six vendors without even opening the phone book. The above sites appear to be skimming the easy sales and ignoring those for whom shopping on the Internet can be a real help.
GEORGE PHILLIPS
via e-mail

Sorry that the sites did not help you with your search. You may be correct about them skimming the best markets, but there was no way to check various individual locations at these sites. That's why we value input from our readers.
JOE BLACK

It's Not Just For Cats Anymore

What a super article in the August issue on the ScatCat! This is exactly what I need for my two cats (Jockey and Straps) and my Jack Russell terrier (Pika) to keep them away from those "forbidden zones" around the house. If it takes sounding an alarm to do so, then the ScatCat it is!

This issue of **Poptronics** was full of great information, and I will be taking this issue and a few back issues with me to New Zealand. Who knows what else I might learn by reading your magazines on that long flight down under.

PAUL DALE ROBERTS
via e-mail

Complete URLs

In a recent "Letters" column (**Poptronics**, May 2000), you requested info about browsers that don't require a complete URL. Netscape, at least up to 3.01, didn't require anything more than the middle part of a ".com" address (using CTRL+ l). I think that Internet Explorer, up to version 4, worked the same way.

Due to some unsuspecting "newbies" and some clever domain names, people typed in perfectly clean names and got a pornography site instead! I think that factor and others have convinced Netscape and Microsoft to require a complete URL name.

Some compensation is attempted in, for instance, Netscape, who wants to become a "gateway" to the Internet. If the .com is registered in Netscape's database, then the complete URL isn't required. Netscape will take you there, with a generous helping of Netscape advertising.

I wish some shareware guru would release a Java program to reconstitute the CTRL-l functionality!!

PHILLIP MILKS
via e-mail

We use Lynx on our Solaris machines at work, and FSU uses them on AIX. Neither of them require the protocol prefix for Web browsing. I also came across a version of Mosaic for the Amiga that does not require it.

ALAN W. RATELIFF, II
via e-mail

In the "Letters" column (**Poptronics**, May 2000), the second letter contains an error in the reply. The reply states "... on a Unix-based mainframe that supplies the text-based Lynx browser for Web access; that software requires the http:// prefix." I would ask that you have that system's administrator get a more modern version of Lynx. Ever since I can remember, Lynx does not (and never has) required the http:// prefix in its operation.

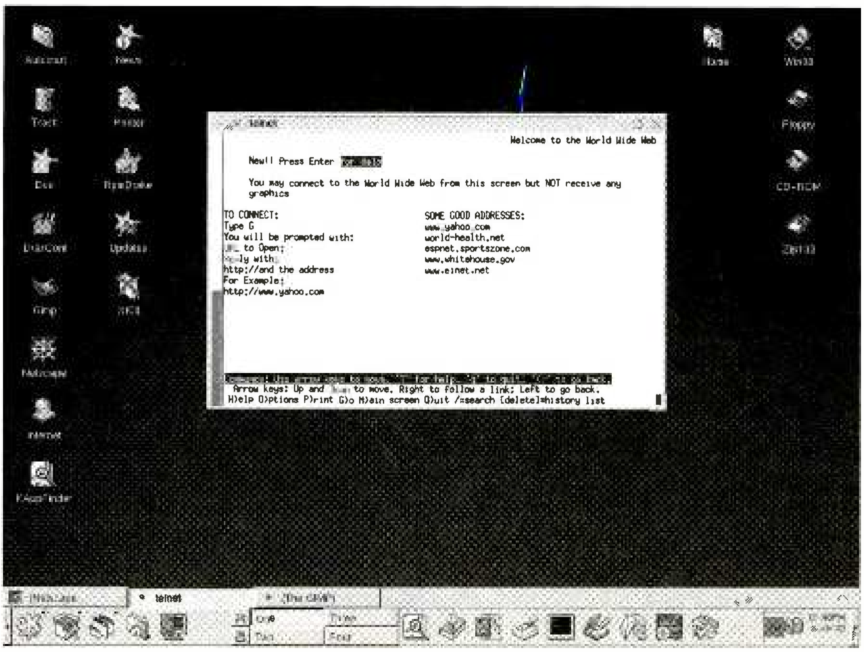
Now, I will admit that I have been using Unix-type systems (with Lynx) for about 3-4 years now so I can not answer for prior to that time.

The most recent version of Lynx may be downloaded from the Internet at *lynx.browser.org*.

RON GAGE
Saginaw, MI

[Be that as it may, the shell account that I used quite specifically said to insert the prefix. What's more, it complained if you didn't follow the instructions to the letter. Note the screen capture to the left. For those that don't understand, a shell account gives you the right to dial into a specific machine and use it as a proxy to access other networks—like the Internet. You don't have control over the proxy machine. In fact, a text-only shell account has all of the look, feel, and charm of a 1980s bulletin-board system (BBS).

In terms of upgrading, my only recourse would be to plead with the system administrator. This particular account is through my local public library, in cooperation with several other area libraries and school districts. I don't expect it to be maintained to state-of-the-art revisions of the software. Besides, I haven't used the shell feature of the account for a couple of years. It's free, you get what you pay for. —Editor.



KEEP IN TOUCH

We appreciate letters from our readers. Comments, suggestions, questions, bouquets, or brickbats ... we want to hear from you and find out what you like and what you dislike. If there are projects you want to see or articles you want to submit—we want to know about them. And now there are more ways than ever to contact us at **Poptronics**.

You can write via snail mail to:

Letters
Poptronics
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Hauppauge, NY 11788

Please note the above address is the snail-mail way to get the quickest response. Some readers send letters to our subscription address, and although the mail is forwarded to our editorial offices, it does increase the time it takes to answer or publish your letters.

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And don't forget to visit our Web site: *www.gernsback.com*.

TED NEEDLEMAN

mailto: peakcomputing@gernsback.com

A Panoply of Optical-Drive Upgrades

If it's been a while since you investigated upgrades for that creaking old CD-ROM drive in either your desktop or your laptop, you're in for a pleasant surprise. In the past few months, a bevy of new optical drives were introduced that made it easier than ever to get more "oomph" for your optical-storage needs.

One of the more frequent upgrades is to replace or supplement an existing IDE-based CD-ROM drive with a DVD drive. Either operation is a snap to do, but you need to set the Master/Slave jumpers at the back of both drives correctly. Generally, you want the faster drive to be the Master; the slower drive on the same data cable will be the slave. If you have a fairly new CD-ROM drive—capable of perhaps a 40X maximum read speed—you may want to keep it, and leave it as the Master drive.

The Evergreen Technologies fireLINE IEEE-1394 CD-RW can interface via a PC Card or an add-in PCI card like this one from Belkin.

THE CHAIN'S WEAK LINK

Most of the newest DVD drives offer a fast read speed on standard CD-ROM discs. One example is Acer Peripherals' 1640A model. With a retail price of about $180, the 1640A offers a 16X DVD speed and a claimed 40X CD-ROM maximum read speed. Actually, the way CD-ROM and DVD drives measure their read speeds is somewhat misleading. A 1X DVD is twice the data-transfer rate of a 1X CD-ROM. Therefore, a 16X DVD drive should really be equivalent to a 32X CD-ROM. For some reason, most of the new 16X DVD drives actually squeeze out a bit more read performance when they are reading CD-ROM discs and are therefore rated at 40X for this operation.

DVD media is read at 1X speed regardless of the drive's rated speed. A moderately large buffer, such as the 1640A's 512K, is more important in determining whether the drive will be subject to skips, hesitations, artifacting, or aliasing; none of those drawbacks were observed in testing this drive. Also important is the system that is using the DVD drive. Unless you buy a fairly expensive upgrade kit that also includes a hardware decoder board, the actual decoding of the DVD's MPEG-2 files is done by the DVD player utility included with the drive or your video card.

If your PC is an older one—say, less powerful than a 300-MHz Pentium II—there might be noticeable lags as the software decoding struggles to keep up with the drive's data stream. Our tests were conducted with a 600-MHz Micron Pentium III desktop and a 500-MHz Pentium III-equipped Compaq Presario 1600XL laptop.

The Acer Peripherals 1640 comes with the necessary mounting hardware, cables, and a CD-ROM with a CyberLink's *PowerDVD* player

Can you tell the difference? The Acer drive on the left is strictly a DVD drive, while the Afreey drive on the right is both a DVD drive and CD-RW burner in a single package.

and *PowerPlayer* utilities. Our review unit also included a diskette with DOS drivers, so the drive can be used as a CD-ROM reader under DOS.

HIGHER-END UNITS

The second internal IDE drive that we tested was Afreey's RW9060A. At a $329 suggested retail, this drive was almost twice the price of the Acer Peripherals 1640A. Aside from the price differential, the Afreey RW9060A is the perfect choice for an optical-drive upgrade, because it provides both a DVD player and a CD-RW drive in a single package. As a DVD drive, the Afreey drive offers 4X DVD performance and includes *PowerDVD* to do the MPEG-2 decoding.

DVD reading and CD-R/RW burning require lasers with different wavelengths; the RW9060A covers that need with two read/write lasers. The second laser lets the Afreey drive burn CD-Rs at up to 6X speeds and rewrite CD-RWs at up to 4X. Afreey provides Adaptec's *Easy CD Creator 3.5c* for burning CD-Rs, and the *DirectCD 2.5* packet-writing software for CD-RW rewriting. As with the DVD-only Acer drive, we found the Afreey delivered excellent DVD playback performance. It also lived up to its speed claims on writing both CD-Rs and CD-RWs.

ADD, DON'T REPLACE

If you already have a DVD drive or are interested in just adding a CD-RW drive, here's a report on two easy-to-add external CD-RW drives. One of the newest and hottest external drives is the $299 Evergreen Technologies' fireLINE IEEE-1394 CD-RW. Unlike the two internal IDE drives discussed before, Evergreen Technologies' drive can be used with both PCs and Apple's Macintosh line. The drive uses the IEEE-1394 (or FireWire) interface that has been available on Apple's systems for some time, but is only starting to show up on PCs now.

Obviously, to use the fireLINE drive, your PC or laptop has to have an IEEE-1394 interface. An increasing number of laptops are adding this interface; all Sony VAIO desktops and some Compaq Presario desktops provide this interface as standard.

If your PC doesn't have one, it's easy to add. Evergreen Technologies sent us its PC Card adapter, which simply plugs into a laptop's PCMCIA card slot. We also tested the drive with a PCI card adapter from Belkin Components that we installed in our Micron desktop. Both worked flawlessly. The fireLINE drive is moderately fast: It can burn CD-Rs at 6X and rewrite at 4X. Standard CD-ROMs are read at a maximum speed of 32X, which is fast enough for most any multimedia task.

If you want drive portability, consider this external drive: the latest "Backpack CD-rewriter" from Micro Solutions. This $269 drive is not as fast as some of the other CD-RW drives on the market, writing both CD-Rs and CD-RWs at 4X and reading CD-ROM discs at 24X. It is, however, affordable and easy to connect to most any PC. The drive comes with both a parallel-port cable to plug into a PC's or laptop's printer port and special USB cable that has a parallel-port connector on one end (connecting to the CD-rewriter) and a USB connector on the other end.

In the interest of full disclosure, we have a smaller "Backpack Bantam" CD-rewriter that we move between the few systems that don't have a CD-R or CD-RW drive. It gets a tremendous amount of use (and abuse), and we'd kill before we'd lend it out. With its dual parallel-port/USB connectivity, however, the new Backpack CD-rewriter may just take its place.

The Backpack CD-rewriter drive from Micro Solutions is an external drive that can connect to your PC or laptop using a parallel-port cable or through a USB interface.

MAKE YOUR CHOICE

We've just scratched the surface with the quartet of drives presented here. If you're looking for an optical-drive upgrade, you will uncover a dozen or more possibilities in a short trip to a local computer superstore. Moreover, with the great selection of full-featured drives now available, it will be hard to make a bad choice. P

SOURCE INFORMATION

Acer Peripherals America
2641 Orchard Pkwy.
Bldg. 3
San Jose, CA 95134
800-379-2237
www.acerperipherals.com

Afreey, Inc.
48511 Warm Spring Blvd.
Suite #201
Fremont, CA 94539
510-979-0453
www.afreey.com

Evergreen Technologies
808 NW Buchanan Ave.
Corvallis, OR 97330
541-757-0934
www.evergreennow.com

Micro Solutions
132 West Lincoln Hwy.
DeKalb, IL 60115
800-890-7227
www.micro-solutions.com

GIZMO®

Happy Holidays — and some electronic gift-giving ideas — from Gizmo!

PlayStation 2

No question about it—if you've got kids, the one sure-fire hit gift this holiday season is Sony's *PlayStation 2* ($299). PS2 made its North American debut in October, with more than 50 new titles expected to be available in time for the holidays.

Designed to bring together games, music, and movies in one device, PS2 is described as a computer entertainment system. The game console supports original PlayStation software, PlayStation 2 games, audio CDs, and DVDs. It has a bay for a 3.5-inch hard disk drive and an expansion unit for network interfacing in the broadband era. The unit provides an optical digital output, two USB ports, and an IEEE 1394 (i.LINK) connector.

But, let's face it—PS2 is, first and foremost, a gaming platform, with greater speed and higher resolution than its predecessor. Sony's 128-bit "Emotion Engine" single-chip CPU (which has an on-board MPEG-2 decoder) enables complicated physical calculations, 3-D geometric transformations, and curved-surface generation—all of which translates to more realistic, faster action.

With the exception of the START and SELECT buttons, all functions of the DualShock 2 controller—which comes with the PlayStation 2—are analog. Additional controllers, memory cards, stands, and a multi-tap adapter are sold separately.

Sony Computer Entertainment America, 919 East Hillsdale Blvd., Foster City, CA 94404-2175; 650-655-8000; *www.playstation.com.*

CIRCLE 50 ON FREE INFORMATION CARD

MP3 and FM, Too

Thomson's next-generation *RCA RD2211 Lyra2* ($299) MP3 music player sports a pared-down profile and beefed-up versatility. The portable device now boasts a digital FM tuner with remote control and the ability to play back Windows Media Audio (WMA) and G2 music files. It is also compatible with *MusicMatch* jukebox music-management software for Mac users. *MusicMatch* and *RealJukebox* software packages are included, and the Lyra2 can be upgraded to handle future music formats.

Downloading files from your PC to the Lyra2's CompactFlash card has been simplified with the addition of a USB-enabled card reader. The Lyra2 comes with a 64-MB CompactFlash memory card. "Backphones" and a car kit with power and cassette adapters are also included.

Thomson Consumer Electronics, 10330 North Meridian St., Indianapolis, IN 46290-1024; 317-587-3000; *www.rca.com.*

CIRCLE 51 ON FREE INFORMATION CARD

MP3 Carrying Case

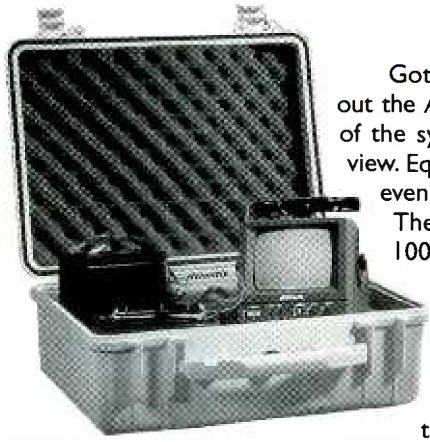
Here's a good stocking stuffer for anyone who owns (or is about to receive) a portable MP3 player: Case Logic's *MP-3 Player Case* ($11.99). The 4½- × 5¾-inch case holds most portable downloadable music players. It also stores memory cards, headphones, and a car-adapter kit in a zippered inside pocket.

The weather-resistant, expandable neoprene case protects MP3 gear. Sure to be a hit with young people, the case makes a fashion statement with its choice of popular colors: red, bright blue, or olive green. The convenient carrying strap attaches easily to a belt or backpack.

Case Logic, 6303 Dry Creek Parkway, Longmont, CO 80503; 310-374-6893; *www.caselogic.com.*

CIRCLE 52 ON FREE INFORMATION CARD

Under-The-Deep Camera System



Got a diver on your gift-giving list? How about a fisherman or boater? Then check out the *Atlantis Underwater Camera System* ($649.95) from JJCommunications. At the heart of the system is a 420-line black-and-white waterproof camera with a 25-foot field of view. Equipped with built-in NightVision infrared illumination, it can spot schools of fish even in total darkness.

The camera comes with a 5½-inch monitor, a nine-hour rechargeable battery, and 100 feet of steel-mesh cable. The self-contained video system—which also includes a monitor sunscreen, recharging cables, and a 12-volt cigarette-lighter plug—is packaged in a rugged yellow waterproof case that floats when closed.

Divers can bring the compact Atlantis camera just by itself down with them; it's only 5 inches long with a 1-inch diameter. Fishermen can drop the camera over the side of the boat and comfortably observe the underwater action on the monitor—without getting wet. The camera includes two user-adjustable outboard metal ballast tanks that let it sink into the water on a level plane or at an upward or downward angle. A second video camera or a VCR can be used to record the real-time view captured by the Atlantis.

The underwater camera offers a 92-degree viewing angle, giving an up-close panorama of undersea activity. Its mirror-image switch reverses the field of view. A ring of infrared LEDs surrounding the camera's lens provides light. The 32-volt rechargeable DC power supply permits up to nine hours of constant use.

JJCommunications, 18 West Forest Ave., Englewood, NJ 07631; 800-226-9671; *www.atlantiscamera.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Flat Monitor Doubles as Stand-Alone TV

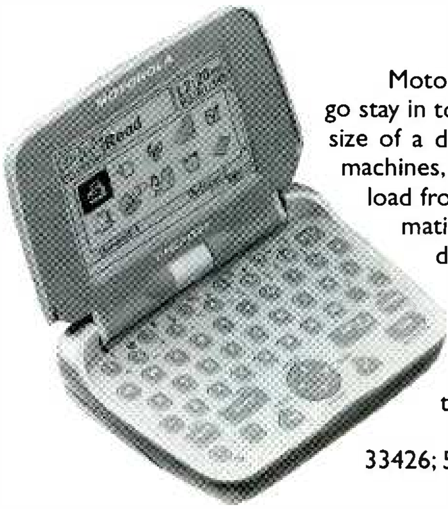
SyncMaster flat-screen computer monitors from Samsung are complete audio/video multimedia devices that come in two models—the 15-inch screen (150MP priced at $1119) and the 17-inch screen (170MP priced at $1769). These monitors allow users to view two input sources at the same time—thanks to the built-in picture-in-picture. For example, viewers can watch their favorite TV show while reading e-mail; or they can check stock prices while following the latest market news on TV.

The Digital zoom feature magnifies any part of the on-screen image up to 64 times. The monitor comes complete with an infrared remote control and built-in stereo speakers.

Samsung Electronics America, Inc., 105 Challenger Road, Ridgefield Park, NJ 07660-0511; 800-SAMSUNG; *www.samsungmonitor.com*.

CIRCLE 54 ON FREE INFORMATION CARD

Handheld Communicator



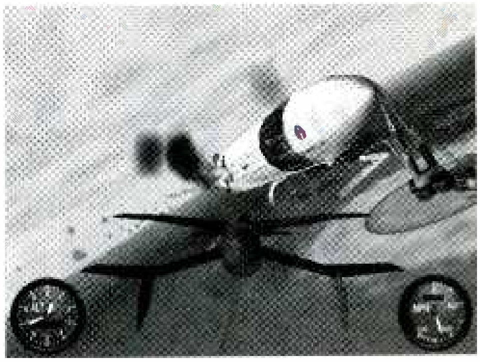
Motorola's *P935 Personal Interactive Communicator* ($400) will help executives on the go stay in touch and stay on top of things. The two-way communicator, which is about the size of a deck of playing cards, provides wireless access to Internet e-mail, pagers, fax machines, and other two-way messaging devices. The P935 also allows users to download from the Web—to request and receive up-to-the-minute facts, figures, and information. (There's no need to create a special e-mail address—the current one will do.) Its infrared (IrDA-compatible) port also makes it easy to transfer, receive, and exchange information from compatible PCs, and from other P935s and IrDA-capable devices.

In addition, the P935 is a full-featured personal information manager (PIM). It includes an address book, scheduler, notepad, and to-do list, as well as customizable, audible alerts.

Motorola Paging Products Group, 901 N. Congress Ave., Boynton Beach, FL 33426; 561-739-3220; *www.motorola.com*.

CIRCLE 55 ON FREE INFORMATION CARD

New PC Games



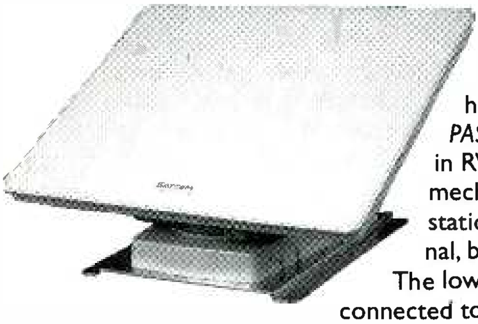
Every time we turn around, there are new computer games. Here are two from Microsoft. Just in time to get ready for the 2001 baseball season, we have *Baseball 2001* ($34.95). It lets users play baseball and manage the team as well, as they not only trade and sign players but handle the financial side. By coupling simulation with realistic baseball play, this program brings the excitement of an authentic Major League baseball game to players of all skill levels.

Crimson Skies ($49.95) combines Indiana Jones action with Errol Flynn adventure. Players enter an alternate 1937 world of warring nations, where they are confronted by a sky full of air pirates, double-crossing privateers, giant aircraft-carrier zeppelins, and evil pilots. There are more than 24 fast-paced missions and 12 exotic, specially fitted fighting planes.

Microsoft Corp., One Microsoft Way, Redmond, WA 98502; 888-218-5617; *www.microsoft.com/games/baseball2001* and *www.microsoft.com/games/crimsonskies*.

CIRCLE 56 ON FREE INFORMATION CARD

Video to Go



Know someone who has to be dragged kicking and screaming away from his favorite TV shows? Untether him from the couch with the SatCom *PASSPort MDBS-AA2000* flat-panel satellite antenna ($1249.95), designed for use in RVs, SUVs, or minivans. Equipped with an intelligent automatic satellite-search mechanism, the antenna easily picks up satellite signals whenever the vehicle is stationary. Once powered up, it automatically searches for the best satellite signal, bringing a picture in within minutes.

The low-profile mobile DBS antenna rests on a multi-axis positioner platform and is connected to a separate satellite auto-acquiring controller housed inside the vehicle. The antenna features a one-piece, flat design with a dual-output LNB located on the back. Its weather-resistant coating lets it withstand harsh outdoor conditions. The PASSPort comes with all required attachment and interface cables.

A portable model that requires manual aiming is also available—the PASSPort Mini Plus ($349.95).

SatCom Electronics, Inc., 13400-B Danielson St., Poway, CA 92064; 858-486-6600; *www.satcomweb.com*.

CIRCLE 57 ON FREE INFORMATION CARD

Color eBook Reads Like Paper

Designed for readers who want to view color-intensive content such as magazines, catalogs, and newspapers, the *RCA REB1200 eBook* features an 8.5-inch (diagonal measurement) color LCD touch-screen. It offers nearly 12 times the screen resolution of a typical handheld personal digital assistant that includes additional Compact Flash memory cards. Weighing just over two pounds, it comes with 8MB of memory—the equivalent of approximately 5000 pages of color content and text.

Memory capacity can be supplemented. In addition to a 56K modem, the unit also includes an Ethernet port for fast book downloads over a broadband network, cable modem, or DSL line. Suggested retail prices for the base unit and the eBooks that it displays were not available at press time but will be by the holiday season.

Thomson Consumer Electronics, 10330 North Meridian St., Indianapolis, IN 46290-1024; 317-587-3000; *www.thomson-multimedia.com*.

CIRCLE 58 ON FREE INFORMATION CARD

Gizmo is published by Gernsback Publications, Inc., 275-G Marcus Blvd., Hauppauge, NY 11788. Senior Writers: Christopher Scott and Teri Scaduto.

CHRIS LAMORTE

mailto: netwatch@gernsback.com

Register Your Own Domain Name

Nowadays people from all walks of life are building their own Web sites. One major concern of fledgling Web proprietors is domain-name registration. The Internet Corporation for Assigned Names and Numbers (ICANN) is the governing body for Internet matters concerning domain names, IP addresses, and protocol. ICAAN has made it possible for the public to register their own .com, .net, or .org sites in an amazingly simple process.

Recently I visited the ICANN home page at *www.icann.org*, where there is a complete list of accredited domain-name-registration sites. All the links you could possibly need are found at the ICANN site—whether you are starting a new business Web site, starting a page for your family, or are just curious as to what domain names are already taken. Here are three of the popular free domain-search/registration sites listed there.

NETWORK SOLUTIONS

Arguably one of the oldest and best-known registration sites, Network Solutions is located at *www.networksolutions.com*. You can check the name you desire from the opening page. If it is already in use, a selection of alternate names will be presented. If it is available, you will be sent directly to the registration screens. There are five steps to the process:

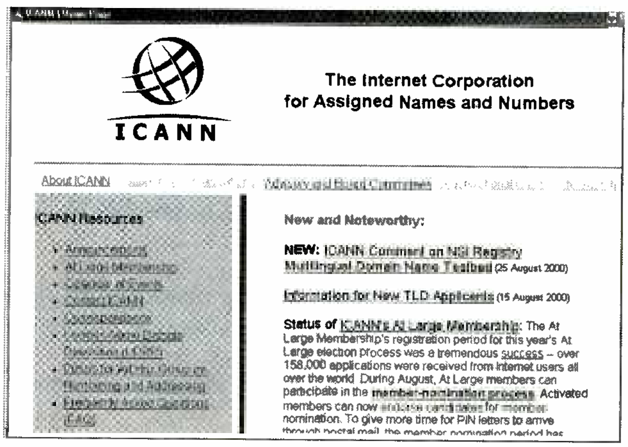
1. Name your Web site
2. Choose your services
3. Review your shopping cart
4. Provide your information
5. Payment and checkout

Once you have named your Web site, you will be presented with four choices: the domain name only for $35 per year, a three-page Web site and matching e-mail for about $11 per month, a one-page Web site and matching e-mail for $68 per year, or a one-page Web site (no e-mail) for $48 per year.

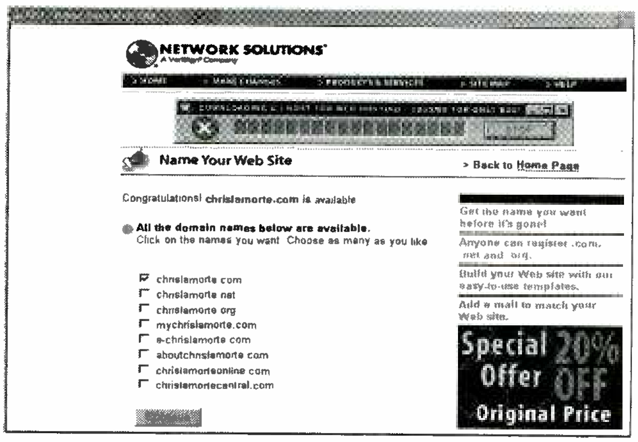
After that choice is made, you simply verify what items you are purchasing, provide all the needed information, and proceed to pay by credit card. It's quick and simple.

REGISTER.COM

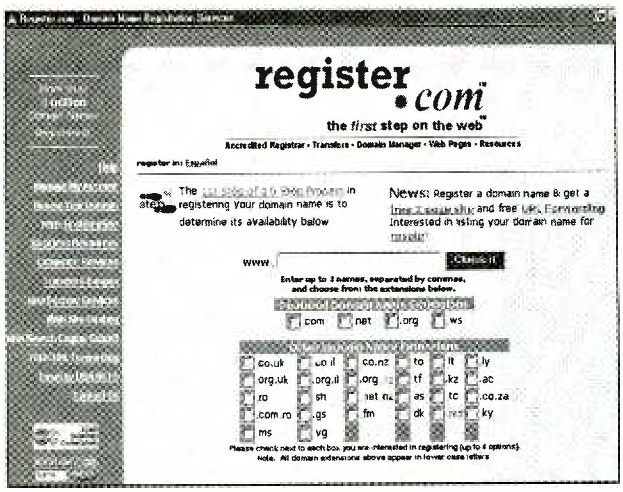
The *www.register.com* site is simple yet informative. The home page is a straightforward layout consisting of a search engine and a few hyperlinks for basic information. As you might expect, the search engine is the first step in registration. Their FAQ section impressed me. It provided an in-depth description of Top-Level Domain names (TLDs), rules governing the creation of domain names, and a myriad of answers to questions about the legalities, such as



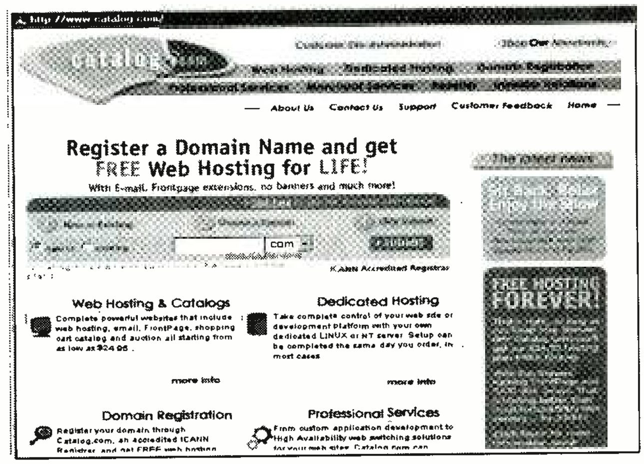
If you want to register a domain name, the Internet Corporation for Assigned Names and Numbers (ICANN) is the last word as to what does or does not fly.



Network Solutions—better known to the average computer user for owning the McAfee anti-virus software—is the oldest administrator for Internet domain names.



Register.com, *another Internet domain-name registration site, sports an in-depth FAQ (frequently-asked questions) page that can teach you more than you want to know about domain names.*



If your goal for an Internet domain is business, catalog.com *should be your first stop for one-stop shopping. Services from domain registration to Web hosting to e-commerce solutions are all conveniently located at one site.*

ownership. I certainly recommend browsing this section before deciding that you are ready to purchase your first domain name.

The registration process here consists of six steps. First is a search to see if someone else has beaten you to ownership of your prospective name. Hopefully, the name you select is unique and available. If the name is available, the site will ask you to confirm your intent on registering. Then you will need to provide a password for an account and some contact information for billing and record-keeping purposes. After you review all the information you have provided, you enter your credit-card information. In a matter of minutes, you can be the owner of your very own domain (cyber speaking, of course).

The one-year registration fee is $25, which seems to be the average rate offered by ICANN-accredited sites. The search engine is free of charge and can be used without even setting up an account. If you plan to obtain a domain name, stop by *register.com*, if only to read up on the free and extensive facts available on the subject of domain names.

CATALOG.COM

If you are an aspiring Web entrepreneur, then perhaps you should visit *www.catalog.com*. It may well be the place for you to begin. This well-designed site is an all-inclusive Web page that offers not only domain-name registration, but also many business solutions including affordable Web hosting, dedicated server packages, custom applications, and credit-card clearing systems. Small-business owners interested in branching out into cyberspace will want to visit this site and browse the available options.

Catalog.com has been in the Web business for more than six years and is a leading provider of quality Internet-based services. Navigating the *catalog.com* site is a breeze. Within a few clicks, you can see the bargain packages offered, including a complete Web-hosting service for under $30 a month. They also offer a rate of $65 for a two-year domain-name registration. The process is straightforward and similar to that for *register.com*; a simple form that you fill out follows an availability search.

WHAT ARE YOU WAITING FOR?

Now that you know where to begin, what is stopping you from starting your very own Web page? Just check out *www.icann.org* for a list of domain-name registration sites and begin your reign of your very own cyber-domain. Whether you want to open a virtual store or just share a little bit of yourself with the world, domain registration is easy, affordable and readily available. Good luck and enjoy the endless opportunities offered by the Internet. **P**

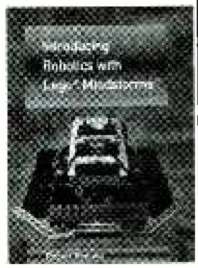
HOT SITES

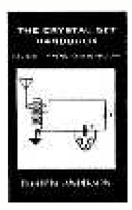
catalog.com
www.catalog.com

The Internet Corporation for Assigned Names and Numbers
www.icann.org

Network Solutions
www.networksolutions.com

register.com
www.register.com



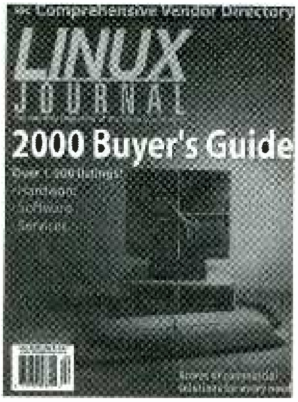


NEW LITERATURE

2000 Buyer's Guide

Specialized Systems Consultants, Inc. (SSC)
P.O. Box 55549
Seattle, WA 98155
206-782-7733
www.linuxjournal.com
$9.95

With Linux quickly gaining acceptance as a mainstream OS, people worldwide are searching for Linux hardware, software, and services. This guide fills that need. Beginning with a discussion of what Linux is and featuring over 15,000 listings, this is the most comprehensive source of Linux products and services to date.

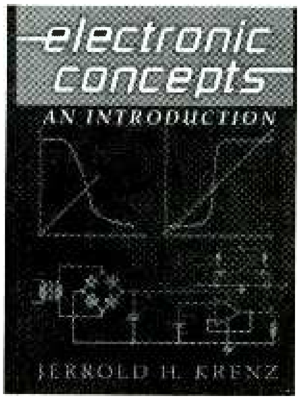


Headings include business software, system software, development tools, and hardware. In addition, there are sections on publications and services.

Electronic Concepts: An Introduction

by Jerrold H. Krenz
Cambridge University Press
40 W. 20th St.
New York, NY 10011-4211
800-872-7423
www.cup.org
$49.95

Designed for use either as a textbook or for self-study, this book is a clear, self-contained introduction to modern microelectronics. Both analog and digital circuits are stressed equally, and the applications are described within actual electronic systems. The text begins with an overview of important electronic systems, with detailed discussions of the types of signals that circuits process.

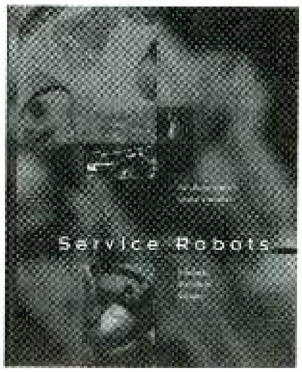


In the following chapters, each device is described briefly; and different models that illustrate particular applications are presented. The author uses SPICE computer simulations extensively to supplement analytic descriptions. The book contains over 500 circuit diagrams and figures, over 400 homework problems, and over 100 simulations and design exercises; and related laboratory experiments are on the Web.

Service Robots

by Rolf Dieter Schraft and
Gernot Schmierer
A K Peters Ltd.
63 South Ave.
Natick, MA 01760-4626
508-655-9933
www.akpeters.com
$47.50

Service robot are robots that perform tasks—fully or partially autonomously, and they are mobile or manipulative or a combination. Among other things, they refuel vehicles, perform surgery, renovate nuclear power stations, keep watch over museums, explore space, and clean airplanes.

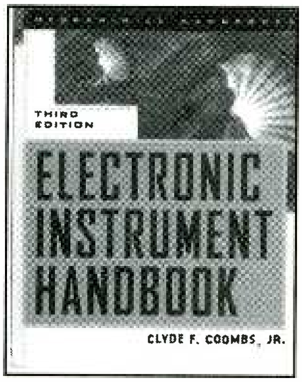


This book surveys service robots in a multitude of fields, describing the creation of such robots from the initial idea to the final product, as well as current research and future applications. First published in German, this edition is a revised and updated English translation. It is lavishly illustrated with over 250 photos and drawings.

Electronic Instrument Handbook, Third Edition

edited by Clyde F. Coombs, Jr.
McGraw-Hill
2 Penn Plaza
New York, NY 10121
800-2MCGRAW
www.ee.mcgraw-hill.com
$125

This new edition examines electronic instruments in detail, providing an up-close view of both the latest generation of electronic measurement tools and conventional electronic instruments. Focusing on the essentials of electronic instruments, this update contains contributions from 37 experts.



The handbook describes all types of electronic instruments—what they do, how they do it, and how to get the most from them. Subjects covered include electrical standards, distributed measurement, microwave passive devices, smart transducers, signal- and waveform-generation instruments, and digital-domain and virtual instruments. Ten new chapters explore software, computer, and network technology in the field of electronic instruments.

(Continued on page 63)

SURVEYING THE
DIGITAL DOMAIN

REID GOLDSBOROUGH

mailto: digitaldomain@gernsback.com

Is the PC Dead or Just Getting Its Second Wind?

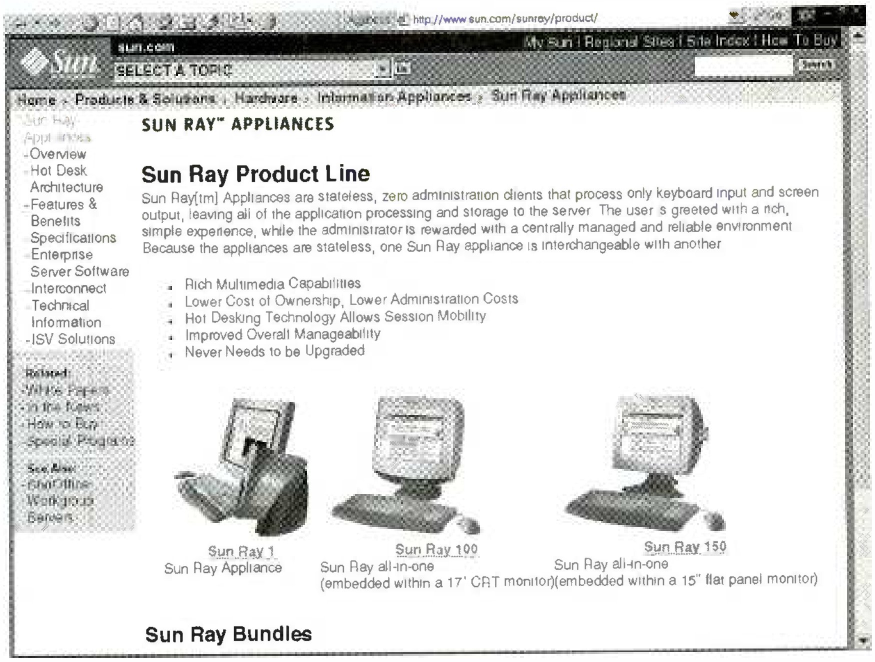
Is it time to scrap your PC or dump your investments in the likes of PC kingpins Intel and Microsoft?

For the past five years, a vocal group of pundits and industry leaders has been predicting the death of the PC. It's complicated, expensive, unreliable, and underutilized, they say. IBM, the mainframe-computer giant that legitimized the personal computer with the introduction of the IBM PC in 1981, included a section in its annual report last year titled, "The PC Era Is Over."

Scores of companies are racing to introduce PC replacements. Computer trade shows, such as Comdex and PC Expo—traditional showcases for new PC products—are increasingly dominated by announcements about non-PC devices.

What's happening is the Internet, and it is indeed leading to profound changes in the world of personal computing. Rather than an end unto itself, the PC is seen more and more as just one of a number of Internet-access devices.

Internet appliances, such as the i-Opener (*www.netpliance.com*), are easier to set up and use than a PC and less expensive, too. Handheld computers, such as the Palm VII (*www.palm.com*), are portable, popular, and increasingly connected.



Sun Microsystems—long a champion of the Network Computer, or NC—manufactures and markets their Sunray series of terminals.

THE OFFICE OF THE POST-PC WORLD

For business use, network computers—which haven't been as popular as predicted by Sun Microsystems and Oracle, among others—are quietly encroaching upon the office. A recent survey by *Computerworld* magazine found that 35% of businesses are using network computers or other "thin clients," including PCs that run Microsoft Windows but don't have hard, floppy, and CD-ROM drives.

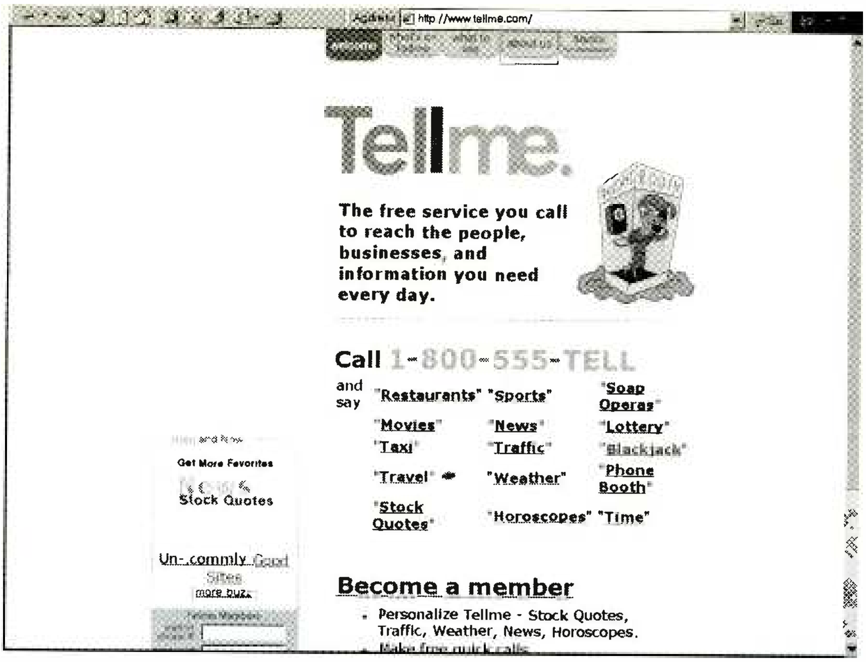
Network computers—such as the Sun Ray (*www.sun.com/sunray*)—cost less to buy and, more importantly, to maintain than PCs because programs are accessed and upgraded from a central server computer instead of individual hard disks.

AT HOME IN THIS "BRAVE, NEW WORLD"

For the consumer, there are "set-top boxes" that access the Internet through the TV, such as Microsoft's *WebTV* (*www.webtv.com*), and Web phones, such as the Sprint PCS Touchpoint (*www.sprintpcs.com/wireless*).

To round out this list, there are "voice portals" such as *Tellme* (*www.tellme.com* or 800-555-8355). Using this portal, you can obtain snippets of information, such as stock quotes and weather forecasts, over the Internet for free using a plain old telephone.

It might seem that, like the mainframe computer before it, the PC is about to be supplanted by newer and simpler technologies. Even Microsoft, which has a vested interest in



By calling a special toll-free number, TellMe lets you access all sorts of Internet-based information using voice-recognition technology—no PC necessary!

consumers buying as many PCs as possible, is hedging and planning to adapt its software to the Internet.

The thinking behind this Net-centric vision is elegant. As spelled out by one of its architects, Sun Microsystems CEO Scott McNealy, the crucial resource isn't the PC but information, which should be as easy to get as electricity. You shouldn't have to think about, let alone wrestle with, over-engineered access devices.

"OL' RELIABLE"

There's much to be said for this vision. However, it ignores one important reality. No non-PC device on the market or the drawing boards is as versatile as the PC. You can use a PC for the most wide-ranging of tasks, from budgeting or game playing to letter writing or to video editing.

That versatility has validated the "personal" in "personal computer." By choosing your components, peripherals, and software and by customizing your programs with interface tweaks and productivity-boosting shortcuts, you can adapt a PC, to a remarkable degree, to the way you think.

Sacrificing that versatility for a more stable and less expensive networked or portable machine is like going back to public transportation after buying your first car. Sure, it's more efficient in a planetary sense, but you lose the element of control.

The versatility of the PC is also responsible for its popularity, which isn't likely to fall any time soon. The PC industry continues to experience annual double-digit growth, and more than half of all homes in the U.S. now have PCs.

FUTURE? TENSE!

This doesn't mean that non-PC devices won't catch on. However, I predict they will supplement, not supplant, PCs. eTForecasts, an Illinois-based market-research company, agrees. It recently projected that Internet appliances, handheld computers, and other non-PC devices in use worldwide will grow from 21.5 million units today to 596 million in 2005, a huge increase. Yet it also projected that, over the same time period, the number of PCs in use worldwide will grow from 521 million units to a staggering one billion units.

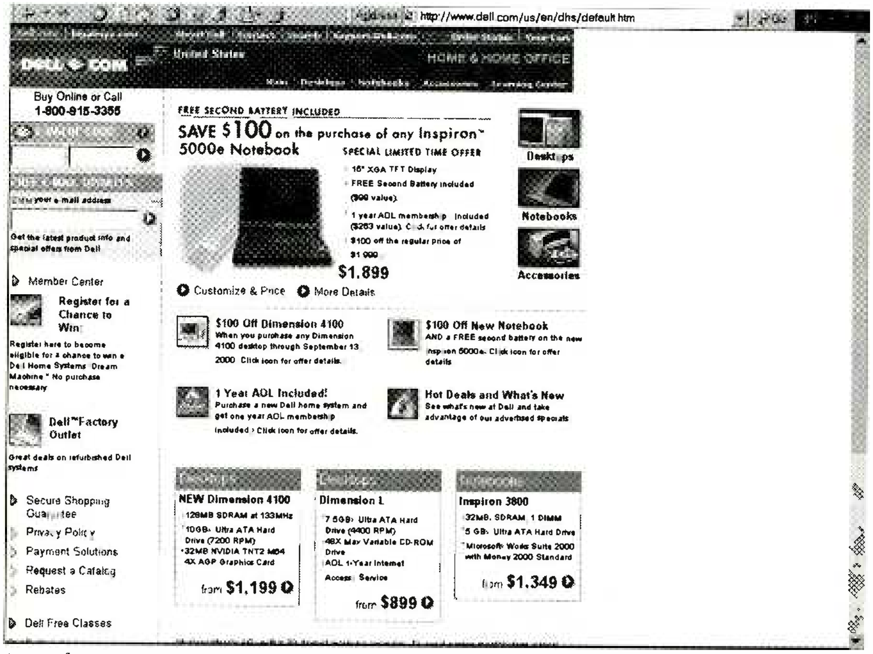
Later this century, you might walk around with computer chips embedded in your body. In the meantime, however, you'll likely be sitting in front of a PC.

The beige box isn't buried yet.

BUYING A RELIABLE PC

So the computer's not dead yet! All the more important to choose one that offers the most for your money. More than ever, personal computers are commodities with little differentiation between vendors.

Sure, you can choose a PC with a faster or slower processor, more or less memory, or a larger or smaller hard disk. Nevertheless, a high-end machine from one vendor is much like that from another, as is a



Year after year, survey after survey, Dell repeatedly wins awards for building the best PCs with the fewest problems.

budget offering.

On the other hand, despite nearly twenty years of mass production, PCs continue to be fickle beasts. Too often, after you unpack your spanking new PC and try booting it up, nothing happens. To use the revealing industry term, it's "dead on arrival," or *DOA*.

And that's not all. Even if it's not completely unusable, components may conflict with one another or otherwise may not work correctly. Moreover, when a unit does run fine initially, frequently it needs repair within the first year.

Estimates indicate that as many as one out of four personal computers break down each year.

YOU GET WHAT YOU PAY FOR

All this spells hassle. Who wants a machine you paid good money for to cause downtime and lost productivity? The single most important factor in buying a PC, therefore, becomes reliability.

To maximize the chances of buying a reliable PC, you can use your past experiences and those of colleagues or friends. However, you'll get a clearer picture of a system's likely reliability from surveys that tally the experiences of thousands of people.

Among the most thorough surveys of PC reliability are those by computer publications. In recent issues, *PC World* and *PC* magazines—the two most widely read national-computer publications—reported their findings in surveying computer users. *Consumer Reports* periodically surveys computer users as well.

THE TOP OF THE HEAP

As it has in the recent past, the vendor that surpassed all others in reported reliability was Dell. *PC World* readers deemed Dell "outstanding" for both work and home use, the only vendor of the eight ranked to receive this designation. *PC* magazine readers gave Dell the only "A" grade among the 16 desktop-PC makers rated. *Consumer Reports* gave Dell the top reliability score of the nine PC makers ranked in its latest findings.

Dell was a mail-order pioneer,

While rated fourth by Consumers Reports *in reliability, the Apple Macintosh has persevered despite whatever twists or turns the PC industry has thrown at it.*

and then an e-commerce pioneer. It serves the corporate, small business, and home markets; and it has an excellent Web site at *www.dell.com*.

WIN, PLACE, AND SHOW

Dell's PCs aren't for everyone, of course. Other vendors might offer a system more attractively priced or available through a more appropriate channel. IBM, which received the second-best reliability rankings overall, has long been known for its attentive service through its worldwide system of dealers. However, it has stumbled over the years in the PC market.

After legitimizing the PC in the early 1980s, IBM (*www.pc.ibm.com*) nearly knocked itself out of the market—a victim of proprietary designs and bureaucratic inefficiencies. Lately, it has made a comeback. Today, it's a leader in many areas, including notebook PCs, hard disks, and e-business.

Hewlett-Packard, (*www.hp.com*), is best known for its printers, but, in recent years, it has grown its PC business in both quantity and quality and now ranks third overall for PC reliability. HP is a major player in the retail market and is a good choice when shopping at a local computer, office supply, or consumer-electronics store.

THE REST OF THE PACK

While still a niche product, the Apple Macintosh, (*www.apple.com*), has a legendarily loyal user base. Its reliability scores, though, are middle of the pack. *Consumer Reports* readers placed the Mac in fourth place out of nine vendors ranked; and *PC* magazine readers, not the most fervid of Mac fans, gave it only a "C" grade.

Locally built PCs, often called "white boxes," are popular and frequently cost-effective choices when shopping in person rather than over the phone or Internet. Reliability here depends on the individual store, particularly for smaller stores.

In general, though, *PC* magazine readers gave white boxes a respectable "B" grade. Among the national retail chains, *PC World* readers gave Circuit City and Office Depot better scores than Best Buy, CompUSA, and Staples.

After reliability comes support, since even the most reliable PCs can have problems. Dell also received the top support scores, followed by Gateway and Hewlett-Packard.

Although playing the percentages doesn't guarantee you'll have a hassle-free experience, it can stack the odds in your favor. Buying from vendors that rank high in reliability also sends a strong signal to the entire computer industry that it needs to pay more attention to quality control. P

POINT AND CLICK

Apple Computer
www.apple.com

Dell Computer
www.dell.com

Hewlett-Packard
www.hp.com

IBM Personal Computer
www.pc.ibm.com

Microsoft WebTV
www.webtv.com

Netpliance I-Opener
www.netpliance.com

Palm Computing
www.palm.com

Sprint PCS Touchpoint
www.sprintpcs.com/wireless

Sun Microsystems Sun Ray
www.sun.com/sunray

Tellme
www.tellme.com
800-555-8355

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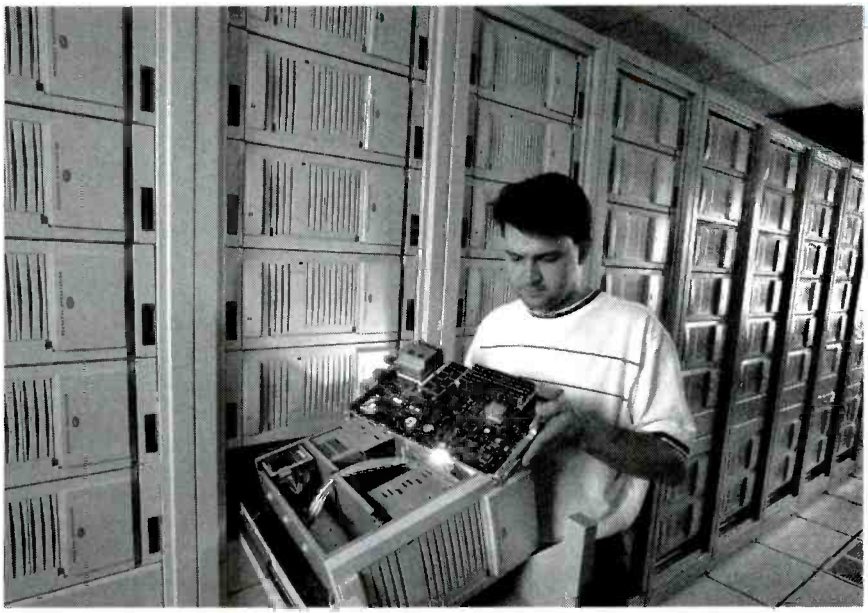
Prototype

"Garage-Built" Supercomputer

The latest version of Cplant Antarctica is expected by researchers at Sandia National Laboratory to become the 20th fastest computer in the world after integrating 1300 off-the-shelf computers from Compaq Computer Corporation. The new Cplant will include 1600 Compaq Alpha computers, also called nodes. (Three hundred older nodes will be used for other purposes.)



Ron Brightwell examines the motherboard from a personal workstation for one of the Cplant's computers. The Antarctica subcluster, in New Mexico, is the largest group and has 1632 processors. (*Photo by Randy Montoya.*)

Getting Up to Speed

The term Cplant, for Computational Plant, has a double meaning: physical computational hardware (as in industrial plant) and an organic plant that grows, evolves, and is pruned.

Formerly composed of only 600 Alpha workstations, the "home-grown" Sandia computational cluster had already been ranked 44th among the world's fastest supercomputers. It is also the largest "production" Linux cluster—a cluster that produces technical results to aid ongoing science projects.

Cplant is a true, multipurpose supercomputer, according to Bill Camp, director of Sandia's Computations, Computers, and Math Center. Scientists can run any program in exactly the same fashion as though they were using the Sandia supercomputer. Currently second fastest in the world, it is known as ASCI Red or the teraflops computer. Cplant's current use is to provide backup for the oversubscribed Red machine. With Cplant's new capabilities, driven by Compaq's Alpha DS10L processors, it should run from one-half to two-thirds the top computer's speed.

Cplant Design

The Compaq AlphaServer systems run a modified version of RedHat Linux, plus the parallel systems software developed in the Cplant project. The DS10L processor is less than two inches tall, allowing up to 42 DS10L systems to be packaged in a standard rack. The Sandia design packages 33 systems in a rack, leaving room for other required components, such as high-performance interconnections, networking, and system management. This is a significant expansion, since current Cplant designs allow only eight systems in a rack with little space for other components.

Internal communications among processors are carried out over a series of links and switches called Myrinet, developed by Myricom Corp. The several internal communications networks in Cplant are critical to managing the computer as a single resource and to carrying large parallel jobs. The newest Myrinet switches and links arrived in July.

Sandia now has 2600 Compaq Alpha computers as nodes in Cplant clusters of various configurations, with 512 at Sandia's California site. The Antarctica subcluster, in New Mexico, is the largest and has 1632 processors. This system is really three systems, with 256 processors always in a classified partition, 256 always in a secure but unclassified partition, and 64 always in a "open" partition. The last are available to uncleared staff and partners from industry and academia. The other 1056 processors will be switched among the three elements as demand for the types of calculations warrants.

Little Shop of Hardware

The idea of hooking together off-the-shelf computers to create an inexpensive computational cluster with supercomputer functionality is generally credited to Thomas Sterling, now at the Jet Propulsion Laboratory in California. Sterling was one of the creators of the Beowulf system (which was developed to run very specific programs for small groups of users) in the mid-1990s. Beowulf achieves cost savings and simplicity, but sacrifices scalability, balance, and generality. Beowulf systems are typically loosely coupled and devoted to doing one or a few applications for small groups of researchers. In such roles they have proven to be extremely significant resources with a huge cost advantage over commercially provided solutions.

"Most researchers have a hard time convincing their sponsors that this approach is feasible; ordinarily, the software out there doesn't scale to such numbers of nodes," says lead Cplant software developer Rolf Riesen of Sandia. "Our software, on the other hand, has already run. So Sandia jumped out ahead of the pack.

"But not that ahead—only a year or two. Eventually, other people will get there too. People all over the world are already using Beowulf. We are hoping to release our software to the general public soon. Then everyone in the world will help us improve it."

"Supercomputers for the past decade have traditionally been purchased as turnkey machines from the world's largest computer makers," says Neil Pundit, manager of Cplant software development. "Such machines have cables, connection boxes, as well as monitors and testing equipment, already built in place. In Cplant, we are following a new path, assembling a supercomputer out of parts, open-source software, and our own developments."

The Poor Man's Supercomputer

The fastest supercomputers in the world are an integral part of DOE's science-based stockpile stewardship program, which requires extremely high computational speeds to simulate nuclear explosions and to make sense of the torrent of data obtained from those simulations. ASCI Red, Sandia's Intel-built supercomputer, was the fastest machine in the world for several years until bested in early July by another DOE supercomputer —ASCI White, an IBM-built supercomputer at Lawrence Livermore National Laboratory. The factory-built machines are still far superior to any off-the-shelf products.

However, Sandia researchers decided they could create a "poor man's" ASCI Red architecture by combining high-performance commodity parts with Sandia software developed by Riesen and his colleagues at Sandia's sites in New Mexico and California. They called this idea Cplant. Because they had helped develop the system software that made Red into the fastest computer in the world, they believed they could succeed with an off-the-shelf version.

Sandia took up the task of physically linking the highest performance commodity PCs in the world into a tightly knit cluster—really a virtual supercomputer. The researchers then developed the software to make this work.

Bill Blake, vice president of Compaq's High Performance Technical Computing Group, says, "Sandia is doing pioneering work in building truly large Linux systems, using a combination of open source software along with their researchers' own development, along with hardware, tools and compilers from Compaq." PT

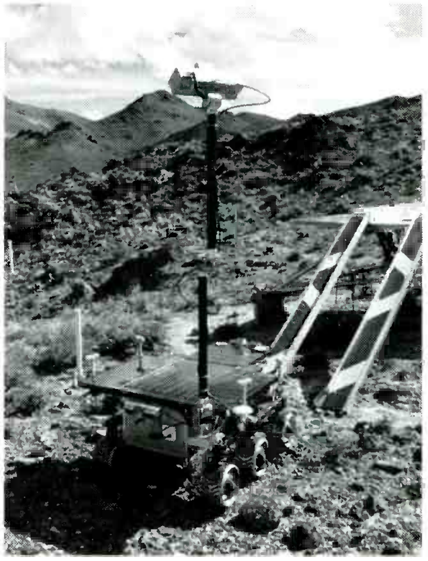
Calling K-9

NASA recently deployed a prototype planetary rover named K9 in the Nevada desert as part of an ongoing field test program designed to simulate robotic exploration on other planets.

During the joint field operation between NASA Ames Research Center at Moffett Field and the Jet Propulsion Laboratory (JPL) in Pasadena (both in California), K9 acted as a "scout" for JPL's rover, called FIDO. K9 assists FIDO by searching ahead for the best candidate rocks for it to sample. Planning for the rover's actions was supported by a suite of software tools called "Viz", which were developed at Ames by the Autonomy and Robotics group. Viz uses images from stereo cameras on-board K9 to create a photo-realistic 3D model of the surrounding environment. This model is displayed as a virtual-reality environment within which scientists and rover operators travel, measuring distances and object sizes, to choose the best sampling sites and routes.

"We've developed a systems-oriented approach with the ability to quickly bring diverse robotics technologies, advanced instrument designs, and a close-knit science and engineering operations team together in a realistic field test," said Dr. Nicola Muscettola, leader of Ames' Autonomy and Robotics group. "The FIDO-K9 project is a terrific design tool for advancing NASA capabilities and dramatically reducing risk during future exploration missions."

The main purpose of the test was to simulate the use of multiple cooperating robots in planetary exploration, and it showed how the two robots would work together in such a planetary exploration mission.

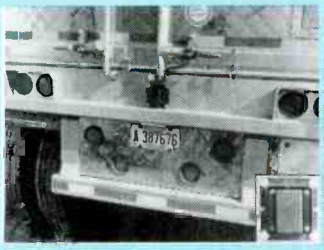


Having just rolled off his flatbed truck, FIDO is ready to explore the Nevada desert as part of an ongoing field test that simulates robotic exploration on other planets.

The test also familiarized the Athena science team, a group of researchers from several universities selected for the next Mars rover mission, with Ames' science visualization technologies. "This will allow the team to evaluate these technologies, recommend changes and improvements, and have better capabilities when their missions occur," explained Maria Bualat, project manager for K9.

"In this test, K9 was exploring for interesting things, while FIDO was performing detailed analysis," she said. During the tests, the FIDO science and engineering teams were kept sequestered in the mission control room at JPL's Planetary Robotics Laboratory while the two rovers explored the site, whose

➤ Eyes in Back of Your Head



A next-generation microwave device, the Guardian Alert is an environmentally sealed, high-impact unit that provides drivers with both visual and audible warnings when they are backing up of objects behind them. Based on Doppler Shift motion-activated microwave radar, this system detects objects and indicates the distance—up to 12 feet—that the object is behind the vehicle.

According to the Department of Transportation, back-up crashes account for 20 percent of all motor vehicle crashes. However, research conducted by the National Highway Traffic Safety Administration (NHTSA) showed that an estimated 70 percent of these accidents could have been prevented with the use of a collision-avoidance system.

A next-generation microwave device, the Guardian Alert from Sense Technologies could make this type of accident a thing of the past. This environmentally sealed, high-impact unit provides the driver with both visual and audible warnings of objects up to 12 feet behind a vehicle, when it is backing up.

Based on Doppler Shift motion-activated microwave radar, this Warning System is described as the first available microwave system that detects objects and indicates the distance that the object is behind the vehicle. It works in all kinds of weather and light conditions, making it ideal for truckers who must operate their vehicles in a wide range of conditions, including rain, snow, sleet, and ice.

Designed for mounting at the rear of a vehicle, it is self-contained in a rugged housing unit. The device is powered by a vehicle's reverse light circuitry and is instantly activated once the vehicle is put into reverse. It automatically shuts off when in neutral or forward.

The interior indicator, which features three LED lights and a speaker, can be installed in any location within the driver's compartment with access to the electrical system. A green light indicates the unit is on and functioning, and flashing yellow and an intermittent beep indicates a person or object is within 12 feet. A flashing red and more frequent beep indicates an obstacle within six feet, and solid red with a continuous beep indicates an obstacle is within three feet of the vehicle. The detection zone extends eight feet across the width of the vehicle and six feet in height.

For more information on the Guardian Alert, call 800-988-0555 or visit their Web site at *www.guardianalert.com*. PT

location was kept secret.

"The teams only see the site through the eyes of the rovers just like it would be on a planet like Mars," said Dr. Carol Stoker, Ames chief scientist for the test. The science and engineering teams "see" the remote field site through the rover's instruments that collect black and white and color panoramic images, near-infrared spectra, and close-up measurements at the site, she said.

FIDO and K9 are each about the size of a St. Bernard. K9 weighs about 90 pounds and is 33 inches wide, 41 inches long, and 22 inches high. The rover moves at an average speed of 200 meters (less than one mile) per hour over smooth terrain. During the tests, K9 was powered both by solar panels and by rechargeable batteries. K9 is about twice the size of Mars Pathfinder's "sojourner" rover and is capable of performing tasks without much human help.

K9 was named for the robotic assistant in the British science fiction television series *Dr. Who*. Its chassis was built at the Jet Propulsion Laboratory to be mechanically identical to FIDO. Its electronics, avionics, and instruments were built at NASA Ames. "Our engineering team designed K9's electronics to consume very little power and to enable remote control of the robot's power subsystems," said Bualat. "This allows our autonomy software to selectively manage resources and power systems on and off, depending on the type of operations we are performing."

K9 is controlled through the "Virtual Dashboard," a GUI, designed and built at Ames, that lets the rover operator send single commands or build and up-link a sequence of commands. Command sequences are up-linked to the robot over a satellite and executed autonomously by K9's on-board executive software. The Dashboard automatically generates Web pages, which let scientists view sequence logs and downlinked images in real time. PT

Out of Time

While recovering from an illness in 1665, Dutch astronomer and physicist Christiaan Huygens noticed something very odd. Two of the large pendulum clocks in his room were beating in unison and would return to this synchronized pattern regardless of how they were started, stopped, or otherwise disturbed.

An inventor who had patented the pendulum clock only eight years earlier, Huygens was understandably intrigued. He set out to investigate this phenomenon, and the records of his experiments were preserved in a letter to his father. Written in Latin, the letter provides what is believed to be the first recorded example of synchronized oscillators—a physical phenomenon that has become increasingly important to physicists and engineers in modern times.

More than 300 years after Huygens' letter, physicists at the Georgia Institute of Technology have recreated his original experiment. Beyond the historical curiosity, the researchers hope this straightforward mechanical system of gears, springs, weights and levers may help them gain insights into more modern and complex synchronized oscillators.

"Having a system available that lends itself to an intuitive and physical understanding could be quite useful," said Dr. Kurt Wiesenfeld, a Georgia Tech professor of physics. "We might be able to learn how this system is like laser systems or superconducting electronic systems. If there are general mechanisms affecting coupled oscillators, then perhaps we can learn about these mechanisms by using the clocks as mechanical analogs for electronic systems."

In particular, Wiesenfeld says the clocks may offer a new way to look at a type of electronic device known as a Josephson Junction.

"It's a very old-fashioned idea, not the way people who study coupled oscillators have been thinking about nonlinear dynamics over the past decade or so," he added. "Classical physics still has things to teach us."

The system under study consists of

two spring-powered pendulum clocks attached to a wooden platform with metal weights added. The platform is set on wheels, free to move along a level metal track. Though the clocks are much smaller than those built by Huygens, the relationship between the masses of the pendulum bobs and that of the overall platform is similar. The clocks' period time between ticks is also approximately the same. The modern clock system includes a feature not available to Huygens: laser monitoring that records the pendulum swings for computer analysis.

Undergraduate researcher Matthew Bennett adjusts the pendulum of one clock under study in this recreation of a 1665 experiment. More than 300 years later, physicists at the Georgia Institute of Technology have recreated the original experiment of Dutch astronomer and physicist Christiaan Huygens. The system consists of two spring-powered pendulum clocks attached to a wooden platform, which is set on wheels and freely moves along a level metal track. The modern clock system includes a feature not available to Huygens: laser monitoring that records the pendulum swings for computer analysis.

So far, the clocks have shown an ability to synchronize only in anti-phase—that is, with their pendulums swinging in opposite directions. This is true even when the pendulums are started in-phase—swinging in the same direction. The 1665 letter recounts that Huygens also observed only anti-phase synchronization, helping confirm that the Georgia Tech researchers have successfully duplicated his experimental conditions.

But the Georgia Tech clocks also display behavior Huygens did not describe: what the researchers call "amplitude death." Instead of synchronizing, one or both pendulums ultimately stop moving altogether. This becomes more likely as weight is removed from the platform carrying the clocks.

Unlike Huygens, Wiesenfeld and collaborators Dr. Michael Schatz and undergraduate student Matthew Bennett do have theories to explain what they see.

"In modern terms, the general motion of pendulums can be roughly described as a combination of in-phase and anti-phase synchronized motions, which are 'normal modes,'" explained Schatz, an assistant professor of physics. "A key feature of our understanding of Huygens' clocks is that the in-phase motion doesn't couple to the platform in the same way as the anti-phase motion. In-phase motion can drive the very small platform movement, which drains energy out of the system through friction between the platform and the surface on which it rests."

But when the clocks are synchronized in anti-phase, the swinging pendulums balance each other, generating no movement in the platform. This conserves their energy, thus providing a mechanism for favoring anti-phase motion by the system, he suggested. "The heavier the platform, the smaller the coupling between the two clocks," Schatz said. "If it's really heavy, the platform doesn't move at all, and there is no coupling and no synchronization. But on the other hand, if the platform is too light and there is too much motion, it will damp out the clocks' energy and create 'amplitude death.'"

Despite the differences introduced by improved clock making, the fact that both systems display stable anti-phase synchronization shows the robustness of that feature, Wiesenfeld pointed out.

But questions remain. "There's a lot of detective work in this," said Wiesenfeld. "You can get some pieces of it, but you're not sure what to fill in. The more you think about it, the more you can imagine other possibilities." PT

No Pirates Allowed

PanelLink, a new transmitter and controller from Silicon Image, Inc., will allow consumer electronics manufacturers to securely transmit and display content-protected, high-definition Hollywood video without fear of piracy. The SiI 168 PanelLink transmitter and SiI 861 PanelLink controller are the first end-to-end Digital Visual Interface (DVI) 1.0-compliant semiconductor chips to incorporate High-bandwidth Digital Content Protection (HDCP).

This HDCP capability has been heralded by the Motion Picture Association of America (MPAA) as a means of providing consumers with the high-definition, Hollywood-studio content they desire, while also preventing illegal and unauthorized duplication. This industry milestone paves the way for consumers to receive previously unreleased and unavailable high-quality video-on-demand.

The additional HDCP circuitry in the SiI 168 allows the transmitter to encrypt the data so that it's content-protected by using special "keys" provided by the system manufacturer. The SiI 168 along with the new SiI 861 controller embedded in a display—such as a liquid-crystal display (LCD), digital projector, or high-definition TV (HDTV)—verifies that the display is the correct recipient for the data. Upon verification, the SiI 168 transmits the encrypted, uncompressed data, such as high-definition digital video, which is then authenticated by the SiI 861 controller and displayed for the end-user.

The SiI 168 operates with any PanelLink receiver to transmit standard DVI 1.0 video. Two SiI 168 transmitters may be used in a dual link mode to achieve data transfer up to 10 gigabits per second, supporting very-high resolution displays up to 2056 × 2048. All PanelLink transmitters introduced in 2001 will be HDCP-enabled. They are designed for set-top boxes, which are projected to reach 28 million units in 2000, as well as DVD players, digital VHS recorders, and PCs.

For high-end, flat-panel-display monitors, the SiI 861 controller is a single-chip solution incorporating a PanelLink receiver and additional display functionality. In addition to offering HDCP capability, the SiI 861 controller features advanced scalar and color enhancing technologies, which provide consumers with crystal clear, pure-digital images. The SiI 861 supports resolutions up to SXGA+ (1400 × 1050) with its parallel and integrated LVDS output enabling support of dual digital monitors. The SiI 861 is a simple, pure-digital controller that does not require a microcontroller, thus lowering system cost. PT

TALKING STATION FOR YOUR MODEL RAILROAD

This versatile add-on brings excitement and life to your model railroad. A simple circuit using an inexpensive audio-memory chip makes it easy to build. Your voice makes the announcements.

DENNIS EICHENBERG

The American Flyer No. 755 *Talking Station* was very clever when it was introduced in 1939. It consisted of a record that played, producing railroad chatter around the station whenever the train approached. The unit had many shortcomings. The records would wear out. The stylus, or needle, would wear out. The sound quality was marginal. However, the concept was excellent and in high demand.

Thanks to modern electronics, it is easy to produce a talking station today. I made an ISD1000A integrated circuit the heart of my electronic talking station. The device provides twenty seconds of electronically recorded sound and can be cascaded to provide many minutes, if so desired.

The circuit is easy to build and fun to use. It is compact, reliable, and inexpensive. With a little imagination, hobbyists can also use the circuit for a talking switch tower, water tower, newsstand, or anywhere else that sound would—or would not—be expected. One humorous idea is a stock car with a pinball-like "tilt" switch. If the car is jostled too hard, a recording of crying animals (sheep, cattle, horses, etc.) could sound their protest for being bumped!

Circuit Description. The Talking Station schematic is shown in Fig. 1. The main component is IC1, an ISD1000A voice record/playback integrated circuit. This device is an analog-sampled data system with an on-chip microphone preamplifier, automatic gain control (AGC), anti-aliasing and smoothing filters, storage array, speaker driver, control interface, and internal precision reference clock.

As the ISD1000A takes each sample, it temporarily stores it in a sample-and-hold circuit and eventually records it into a single electrically-erasable programmable read-only memory (EEPROM) cell. The ISD1000A stores up to twenty seconds of sound using a sample rate of 6.4 kHz.

Thanks to the EEPROM technology, no power is required to maintain memory; the recorded sound remains intact until it is recorded over. Re-recording may be done an almost infinite number of times. The integrated circuit is very versatile and can be configured for many different applications, but a basic configuration was used for the Talking Station.

To power IC1 requires five volts DC for proper operation. The full-wave bridge rectifier, BR1, together with IC3 (a 5-volt three-terminal regulator), provides the power. This supply circuit will work from any source from 5 to 20 volts AC or DC; polarity is not critical. The entire circuit uses about 50 mA when operating at normal volume, so heat sinking is not required. Capacitors C1–C4 are filters that enable the circuit to deliver good sound output quality.

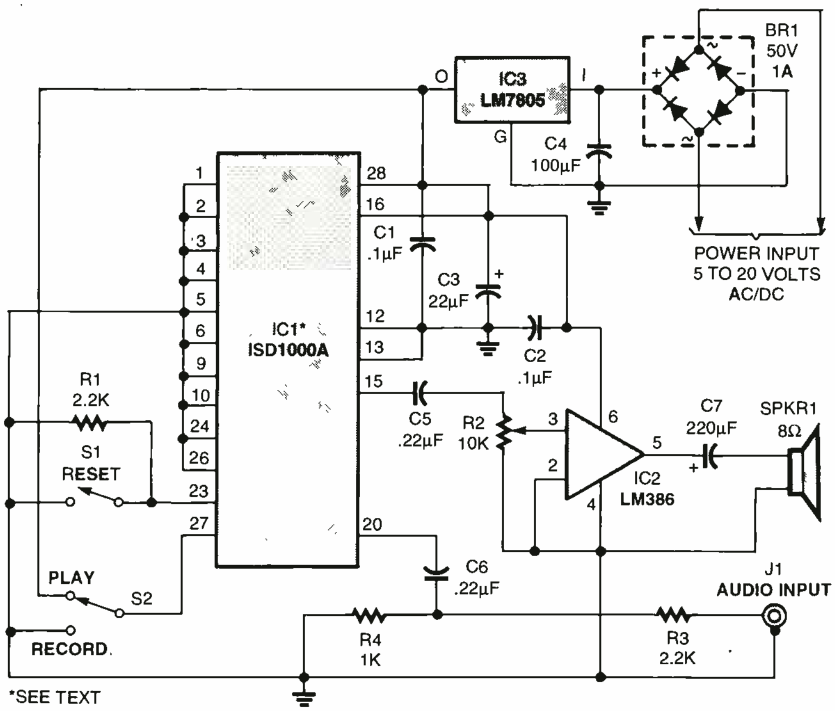


Fig. 1. The full schematic of the Talking Station.

To keep cost down, I use the analog input of IC1 rather than the microphone input. Resistors R3 and R4 comprise a voltage divider to make the standard line-output signal from an audio system compatible with IC1. Capacitor C6 couples the audio signal into IC1.

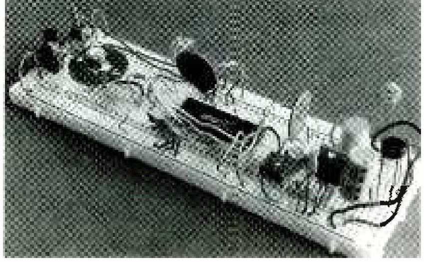
In many applications, IC1 can drive a speaker directly, but the output level is a bit low for most model-railroad applications. To overcome this limitation, I added audio amplifier IC2 to provide a good strong sound-output level that drives a speaker to the required volume. The volume is adjusted with potentiometer R2. The output from IC1 is coupled to IC2's input via capacitor C5. To drive a standard speaker, IC2's output needs a coupling capacitor; C7 fills that task.

The speaker can be any 8-ohm unit. Some experimentation with speaker type, size, location, and mounting is required to obtain the best results.

Switches S1 and S2 are used primarily for recording. Once a recording has been completed, you only need to power the circuit to make it play back. Switch S1 is a momentary pushbutton switch that is used to reset the circuit. Toggle switch S2 is used to select the record or playback function.

Building the Circuit. The circuit was built with parts that can be found almost anywhere. Most can be picked up at any local RadioShack store. I used a solderless breadboard to make assembly easy and to provide access for modifications if desired at some later date. Simply inserting the component leads into the breadboard as required makes all connections. The components can be easily removed and the circuit reconfigured at any time. The entire circuit is small esnough to fit into an O-gauge railroad station.

Construction is not critical, but good wiring practices will assure satisfactory operation. Keep all of the components close together and make all lead lengths as short as possible.



The assembled breadboard. Only four leads go off the board; two to the power supply and two to the speaker. See text for details.

VOICE CHIP AVAILABILITY

As we were going to press, we discovered that ISD, the ISD1000A manufacturer, has discontinued this device. While the device should be available from various surplus sources, it may be difficult to obtain in the future. However, a wide variety of similar devices are being manufactured and are readily available from many different sources. A visit to the manufacturer's Web site (*www.isd.com*) reveals numerous new-generation record/playback chips with longer playback times and the ability to store several messages on one chip. It is no longer necessary to cascade units to get longer periods of recording time; you simply purchase a device with that desired recording time.

The schematic and construction details shown in this article are all drawn around the ISD1000A. To use a replacement, it will be necessary to check the specification sheet and make some circuit changes as these devices DO NOT all have the same pinouts. Full data sheets—including pinouts and sample application circuits—are available for download from ISD's Web site.

All of the ICs and the bridge rectifier are compatible with the solderless breadboard and can be plugged right in. Switches S1 and S2 can also be plugged in. If you come up with a switch that cannot plug in because its pins won't fit the holes, simply solder on a short pigtail lead to each contact. The pigtails then plug into the board. Capacitors C1, C2, C5, and C6 are non-polarized units and can be connected in either direction. Capacitors C3, C4, and C7 are polarized units; proper polarity must be observed. The resistors are (obviously) non-polarized, but potentiometer R2 should be connected so that the wiper (center terminal) is at ground when set fully counterclockwise and at C5 when set fully clockwise. That way, R2's setting will "read correctly" to our home-stereo-trained minds.

Four wires must be brought off the board: two for power and two for the speaker. There is no need to be concerned about power polarity. Proper speaker polarity, however, should be observed. There is normally a red dot or a plus sign on the

(Continued on page 31)

There's a lot of smart electronics INSIDE A FURBY

Theres much more to a Furby than meets the eye. Let's peel back the fur and take a peek inside.

JULIAN EDGAR

A child's toy might seem to be a strange subject for an electronics magazine like **Poptronics**. But as you'll soon see, it isn't. Packed inside a Furby's five-inch-high furry body is an amazing complexity of mechanical and electronic components—and software.

Unconvinced? How's this then? The software boasts the ability to actually change the toy's output behavior in response to the preferences of the child who owns it. Yes, the Furby can adaptively learn! When you consider the retail cost—just $30, throw in a spoken vocabulary of 160 words (capable of being incorporated into no less than 1000 different phrases), and the ability of Furbys to automatically communicate with one another via a built-in infrared port, then you have state-of-the-art in a very unassuming package indeed!

The Toy. The Furby is a fur-covered pseudo-animal with fixed feet and a movable mouth, ears, and eyes. In addition, the Furby can rock forward on its base platform. The movable parts of the toy are mechanically driven by an internal electric motor (more on this in a moment) that operates the eyelids, opens and close the mouth, and waggles the ears up and down. Also hidden under the fur are pushbutton switch-

Originally published in the Australian electronics magazine *Silicon Chip*, May 2000.

This Furby's head, stripped of its outer covering and fur, reveals the light sensor between the eyes. On either side are infrared transmitter and receiver LEDs. Furbys can automatically communicate with one another via this infrared link.

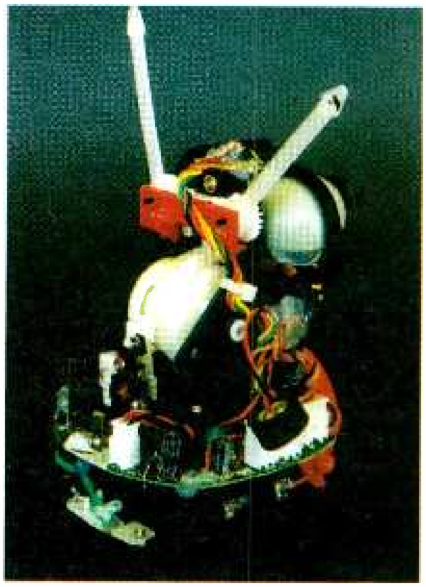
es on the front and back as well as a switch inside the mouth that is triggered whenever the mouth is opened manually.

A big factor in the toy's success is its language skills, with an internal speaker able to clearly communicate "spoken" words and phrases. There are also additional inputs and outputs, but more about these later.

A short description of the toy does not do it justice; it is the way that it works which is so interesting. For example, as I write this, my Furby (yes, I bought one as part of the research for this story!) is "asleep." How do I know? Well, it made snoring noises, and then rocked forward and closed its eyes.

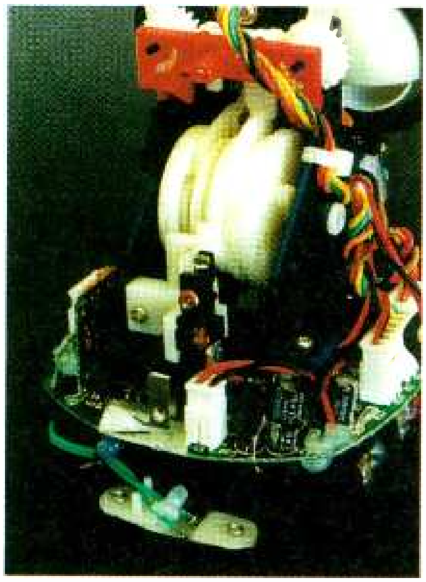
Loud noises or changes in light or other stimuli will not wake it. To rouse the beast, you must pick it up and tilt it to trigger an internal tilt switch. By the way, early Furbys were apparently much harder to put to sleep, requiring a certain sequence of events including lots of pats on the back. However, Furby manufacturer Tiger Electronics Ltd. changed the design, fearing a backlash from exasperated parents. Furbys don't have an on/off switch, you see.

Here's an example of its behavior: I just picked up the toy and it said "Mmmmmmm, me love you." However, the last time I roused it from its sleep, it said "Sun's up."



This photo shows just how jam-packed a Furby is inside. A semicircular PC board is located just above the battery compartment, with the mechanical module mounted on top of that. The sound-sensing microphone is hanging on its lead in the foreground.

This lack of predictability in response to stimuli lifts the personality realism to a totally different plane compared to most toys. When awakened, it might have just as possibly said, "Me sleep again" or "Cock-a-doodle-do, big light!" Or it might have sneezed, giggled, or made one of many other sounds. Each Furby picks its own



In this view, the horizontal axis camshaft can be seen, with plastic cranks moved by the cam lobes connecting to the eyes, ears, and mouth. The cam-position switch is located in the middle of this picture, with the reset switch at the bottom. The wiring harness is held in place with many globs of hot-melt glue.

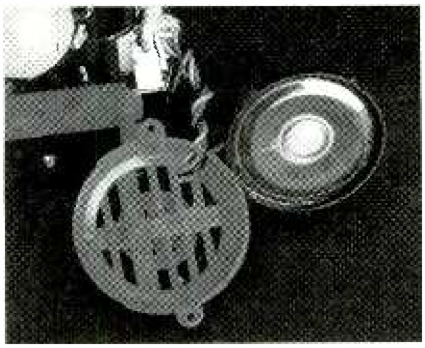
name from its available list of sounds (mine says "Me Too Loo"), and individual Furbys have differently pitched voices.

If left unstimulated for a few minutes (no noises, no changes in light intensity, or no switches pressed), a Furby will sometimes say "Mmmmm ...boring!" If still ignored, it will go to sleep. When taken for a ride in a car, a Furby will say "Wheeeeee!" whenever the car corners; and it will suggest that it wants to play "hide and seek" when the intensity of the light suddenly changes. When it is held upside down, it will initially giggle, which will sometimes

Kevin & Kell **© 1999, Bill Holbrook**

How *NOT* to treat a Furby.

For background, see www.ruben.org/holbrook, www.herdthinners.com, *or* www.kevinandkell.com.

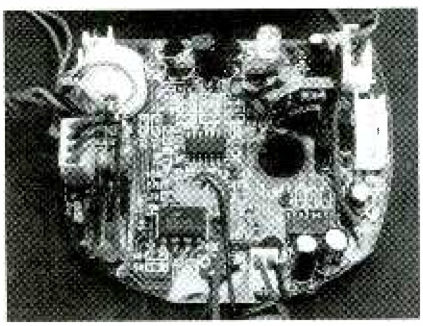


The Furby's 2-inch speaker is capable of very clear sound reproduction.

change to "I'm scared" if it is held in this position for too long.

Games. There are several games built into the toy. For example, to place a Furby into the "hide-and-seek" mode, you need to cover and uncover the light sensor located between the eyes three times, and then the front pressure switch is activated ("tummy tickled" in Furby-speak). The beast then needs to be hidden within a minute, following which it will be quiet for three minutes. Once this time has elapsed, it will start saying "nah, nah, nah" at intervals until it is found.

When batteries are first inserted into it, a Furby speaks no English words or phrases. Instead it speaks in "Furbish," and a dictionary with 44 entries lists the English translations. However, after a few hours of stimulation, the toy starts to speak some English; and after a day or two, it speaks mostly English. Note, however, that English words are not actually being learned; instead, it would appear that after Furbish phrases and words have been "spoken" a set number of times, that word or phrase is replaced by English.



The main PC board contains most of the electronic circuitry. The position sensor is at the upper left corner, while two daughter boards (each with a custom microporcessor) are located at the left.

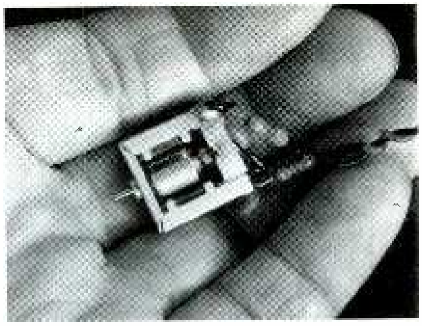
The developmental stage that the Furby has reached is maintained when the batteries are changed. However, there is a reset mechanism that can be activated to return a Furby to infancy!

If a Furby initiates a pattern of behavior (for example, it makes kissing sounds when the front "tickle" switch is activated), patting it on the back (i.e., activating the rear switch twice) will reinforce this behavior. Consequently, individual Furbys can adopt slightly different behaviors on the basis of their owner's preferences.

So you can see that, from a child's perspective, a Furby is a very attractive toy indeed. It has a distinct personality (sometimes with negative character traits like belching and breaking wind!) and initially has its own language but soon learns English. It has its own demands: if it isn't fed, a Furby becomes ill and sneezes a lot. It's easy to see why Furbys have become so popular.

The Mechanics. As mentioned earlier, an internal motor drives the movable parts of a Furby. This reversible DC motor is mounted to one side of a "movement module" positioned inside the top half of the toy. The motor drives a series of reduction spur gears that rotate a worm drive. The worm drive, in turn, acts on a large cog attached to a shaft that has a series of cam lobes. These lobes bear on connecting rods that move the eyelids, mouth, and ears, and rock the Furby backwards and forwards.

Rotating the shaft in a single direction causes each moving part to be operated in sequence. Since each movable item has its own cam arranged so the lobe center angles do not overlap, each movable item can also be operated independently if the camshaft is rotated back and forth within a narrow rotational angle. For example, during "dancing" (where the Furby rocks back and forth), the shaft is rotated so that only the rocking motion lobe is operated. This position of the camshaft behaves as a "dead spot" for the lobes that drive the eyelids and



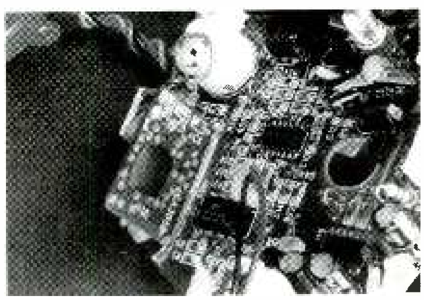
The small reversible DC motor works hard for its living; if the toy is used for extended periods, a strong "electric-motor" smell is emitted!

ears. During dancing, the eyes and ears stay still.

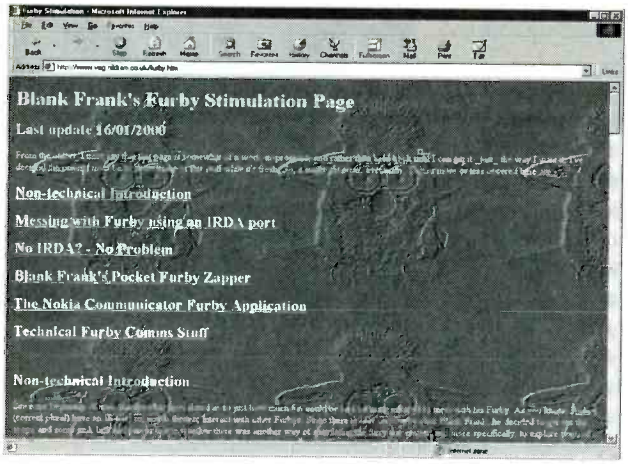
Because the main worm drive cannot transmit torque in the opposite direction (e.g., the motor cannot be turned by moving the ears), a slip mechanism is built into each movable body part. This mechanism allows these parts to be manually moved without causing damage.

The motor uses sprung copper leaves to transfer power to the commutator. Carbon brushes aren't used—instead there appears to be some type of conductive grease spread over the relevant area. This probably explains the strong "electric motor" smell if the toy has been operating continuously (e.g., held upside down) for some time.

The Electronics. The electronics comprise a main, double-sided PC board with surface-mount and conventional components on it. Additionally, there are two small daughter PC boards mounted on the main board at right angles, each carrying a custom COB (chip on board) microcontroller. Serial data is transferred



The microprocessors are custom designs, bonded directly to the PC board and encapsulated in black epoxy. With the Furby manufactured literally by the millions, this approach is very cost effective.



There are entire Web Sites devoted to Furbys and hacking techniques. One of the best is "Blank Frank's Furby Stimulation Page" at www.veg.nildram.co.uk/furby.html.

This Web site, at www.geocities.com/SiliconValley/Pines/7438/furby.html *includes a program that lets you record, save, and play back a Furby's infrared signal.*

between these two microcontrollers, which are run at 3.58 MHz.

A 93C46 non-volatile EEPROM with 1K of storage is mounted on the main board. This probably contains the Furby's name, developmental state, and adaptive memory. It would appear that a separate chip is solely responsible for generating the sound output—perhaps this approach has been taken to allow easy implementation of Furbys that speak other languages.

The system's inputs and sensors are as follows:

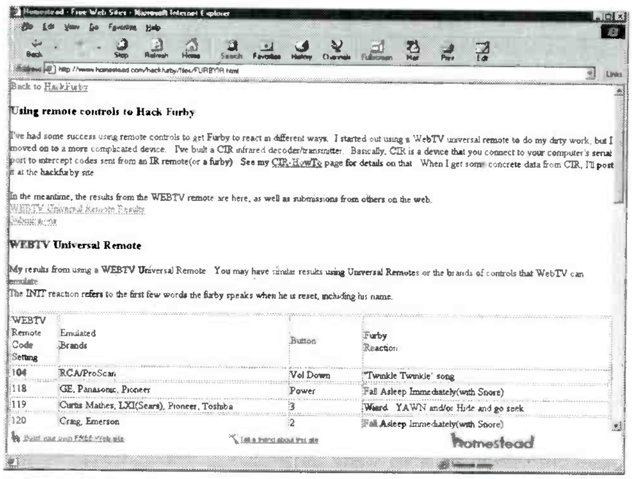
- A reset switch (next to the battery compartment under the toy)
- A back switch (senses back pats)
- A front switch (senses tickling)
- A cam-position sensor (a small leaf switch)
- A gear-speed sensor (an LED and sensor blocked by a black plastic gear with four slots)
- A ball-tilt switch (detects level, tilt, and upside-down orientations)
- A light sensor behind a panel between the eyes
- An infrared-receiver LED (near the light sensor)
- A microswitch "feed sensor" behind the mouth

The outputs are as follows:

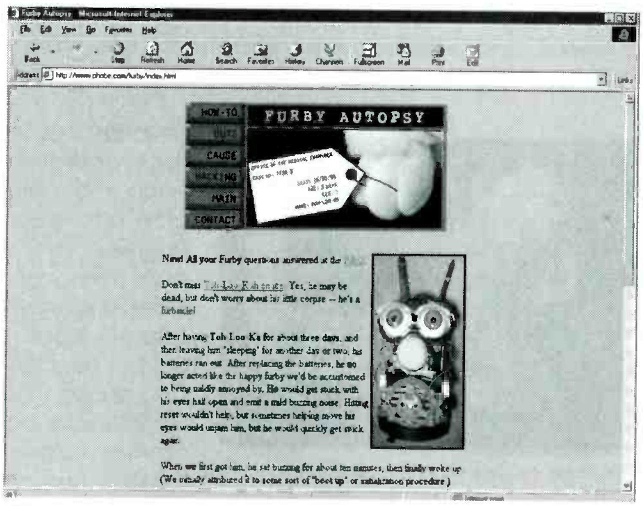
- A 2-inch loudspeaker with a clear plastic cone
- An infrared-transmitter LED (near the light sensor in the forehead)
- Forward and reverse motor operations.

The motor is driven at battery voltage (6 volts nominal), while a pair of diodes is used to provide 5.3-volt and 4.8-volt supplies for the rest of the circuitry.

Infrared Communications. One interesting aspect of the toy is its ability to use infrared transmissions to communicate with other Furbys. Furbys can normally communicate with each other when placed in close proximity, although my sample Furby steadfastly refused to communicate with another Furby whose access was arranged for just that purpose. Apparently, they are capable of transferring colds (the healthy Furby starts to sneeze as well) and developmental stages—a Furby can speak more English after being in contact with a more advanced Furby!



Furbys include an infrared port for communication with other Furbys and can often be tricked into responding to IR remote controls. There's lots of information on this at www.homestead.com/hackfurby/files/FURBYIR.html.



What do you do if your Furby "dies?" Tie a "toe-tag" to him and conduct a thorough autopsy, of course. You can find out the cause of Toh Loo-Kah's untimely demise at www.phobe.com/furby/cause.html.

THE FURBY FILES

There's **lots** more information on the Furby on the Internet. Much of the information **for this** article was derived from the many Web sites devoted to the history, dissection, **hacking**, and electronics of the Furby. Here is a representative list to get you started in your quest for all knowledge Furbish:

ai.tqn.com/compute/ai/library/weekly/aa101398.htmFurby

freeload.homestead.com/_ksi0701961574651052/hackfurby/files/furby.pdf

www.blueneptune.com/~maznliz/marius/furby.htm

www.geocities.com/SiliconValley/Pines/7438/furby.html

www.homestead.com/hackfurby/files/FURBYIR.html

www.phobe.com/furby/faq2.html

www.veg.nildram.co.uk/furby.html

www.wired.com/wired/archive/6.09/furby_pr.html

For the hackers, the infrared port also allows another pursuit—fooling a Furby into doing odd things by stimulating it with foreign infrared signals! IR-emitting devices that have been used for confusing Furbys include PC IRDA ports, purpose-built standalone Furby IR transmitters, the Palm III hand-held computer with *OmniRemote* software, TV and VCR remote controls, and even a Nokia 9110 mobile phone!

If you want to find out how to do this, refer to the Web sites listed in the sidebar. That's right; there are entire Web sites devoted to Furbys and hacking techniques. Take a look at "Blank Frank's Furby Stimulation Page" (*www.veg.nildram.co.uk/furby.htm*), for example. Among other things, he shows you how to control a Furby using a computer's IRDA port.

What, no IRDA port? Blank Frank's got that covered as well, with a simple circuit that you can build yourself.

For the technically minded, here's how Furbys communicate: they use IR pulses approximately 150–200 mS wide with a bit time of 2 mS. The communication packets consist of nine bits sent six times, with silence between each set of nine bits, giving a repeat rate of about 100 mS. The nine bits consist of a start bit, four data bits, and then the same four data bits inverted. There are a total of 16 different signals that can be communicated.

A few years ago, a self-learning toy that talked, communicated "intelligently" with other toys of the same type, and contained internal software that gave a very real simulation of "personality" would have been the stuff of dreams—especially at this price! Furbys show that not all electronic advances are confined to esoteric areas. **P**

TALKING TRAIN STATION

(continued from page 26)

positive terminal of the speaker. Connect this side to C7 and the other terminal to ground. Audio input goes through J1. Its center terminal connects to R3; the outer terminal goes to ground. Double-check all wiring against the schematic to verify that it is correct before applying power.

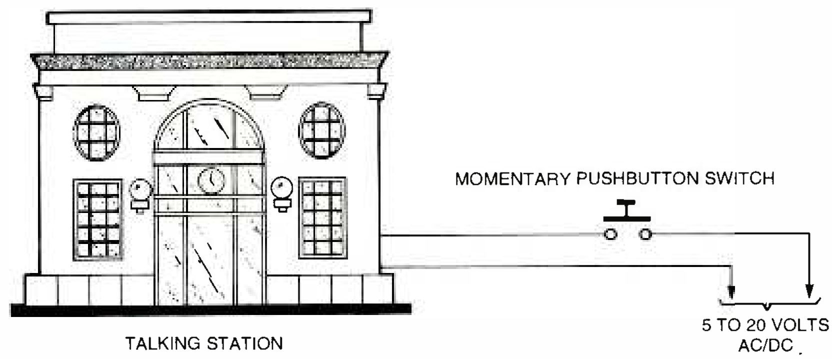
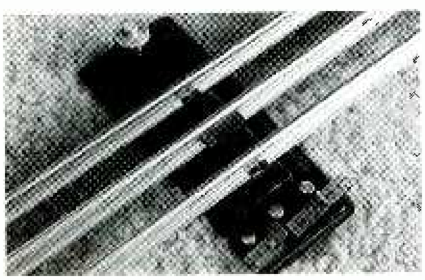


Fig. 2. How to set up the Talking Station circuit for manual operation.

Setup. Connect the completed Talking Station as shown in Fig. 2. Adjust R2 to its center position and connect an audio source to J1.



For automatic operation, a conventional Lionel sensor is used to trigger the speech module.

Prepare whatever you want the Talking Station to say. To make sure that you get the best recording quality, make a tape recording with the desired twenty seconds of sound on a good quality tape deck. A voiceover with background sounds from an actual railroad station can be quite effective

When you are ready to commit your announcement to silicon, set S2 to the "record" position. Turn the power on. Turn the audio source on. Momentarily press S1 to reset the unit; IC1 is now recording. Play back the tape recording into the circuit. Record for at least twenty seconds. Turn the audio source off. Turn the power off. I have done this with great success, and it can be done as many times as required to achieve the desired results.

On The Layout. Set S2 to the "play"

(Continued on page 64)

The GameEnhancer

An adaptable, fun, and educational microcontroller kit with a PC interface.

STEVE HENRY

Playing the board version of TV quiz games can sometimes be dull. Unless you have some type of buzzer or other signaling device, taking turns lacks the thrill of racing to see who can answer the question first. How can you determine with some degree of fairness who was first off the bench? With the *GameEnhancer* presented here, you can do just that and liven up those games. Up to four contestants can compete to answer a question now.

Adding to its similarity to TV game shows, a selectable theme song can be played in the background while the contestants compete to be the first to respond! While playing up to 16 different programmable and selectable songs, the GameEnhancer detects and displays on a seven-segment LED which game-control button was pressed first.

The unit itself is compact and runs on batteries or from a 9- to12-volt DC wall transformer. It comes with a combination on/off switch and volume control.

In addition to livening up some board games, this design is easy to build and use. It is based around Microchip's 16F873 flash-programmable microcontroller. You don't need a PIC programmer—the programming circuit is included in the design. For those who understand the PIC programming language, commented source code is provided for easy modification. You can even use the main unit to program and debug other PIC16F873 processors when the project isn't pressed into service making games more exciting. If you know something about designing or modifying PIC software, you can create and compile your own assembly-language file using Microchip's free software; see

www.microchip.com for details and download instructions. In fact, the GameEnhancer can also be used as a 16F87X-series programmer.

What's unique about the Game-Enhancer is its adaptability. With Microchip's free assembler and linking software, the GameEnhancer software can be modified to build a number of other projects. The peripheral circuits (audio output, LED display, serial EEPROM memory, A/D converter, buttons, and serial interface to a PC) can be combined in different ways. For example, the GameEnhancer—with modified software—can display a "count-down" and trigger a 5-volt relay to launch a model rocket (while a science-fiction movie theme is played, of course!). With the serial PC data interface, the A/D converter, and unused pins on the microcontroller, the GameEnhancer can log data for science projects or home-control applications. Those examples are beyond the scope of this article—but not beyond the scope of an inquisitive mind!

The software comes with several useful tools and runs under Windows 95/98/NT. It includes not only the ability to download code for the PIC processor and values for the EEPROM, but also has diagnostics and debugging capabilities. These can come in handy when you want to modify and test changes in the software.

Basic Operation and Game Playing. When you turn on the Game-Enhancer, it starts to play a theme song stored digitally in the EEPROM. It then flashes random displays on the LED while waiting for the first contestant to press the button on a game handle. When a button press is detected, the theme music stops and the winning contestant's number is flashed on the display. After (hopefully) answering the question correctly, the person who pressed the game button first presses the button again to re-start the theme music, and the whole process is repeated.

I've already mentioned the power options for the Game-Enhancer. With four AA batteries, about eight hours of game play are possible before a battery change is necessary. The microcontroller's analog-to-digital converter is combined with a voltage-reference chip to signal when battery power gets low.

Notes for the songs to play are programmed into the serial EEPROM using the software and a spread-sheet or word processor to input the data. About 4000 notes can be programmed into the 64K-bit serial EEPROM. Song selection is done by holding down any of the game buttons while the power is turned on. This puts the device in a special setup mode, which allows you to repeatedly press any button to cycle through and select one of 16 different songs. The next time the unit is turned on, it will play the selected melody.

Circuit Description. The schematic diagram of the GameEnhancer is shown in Fig. 1. Please refer to it during the following discussion.

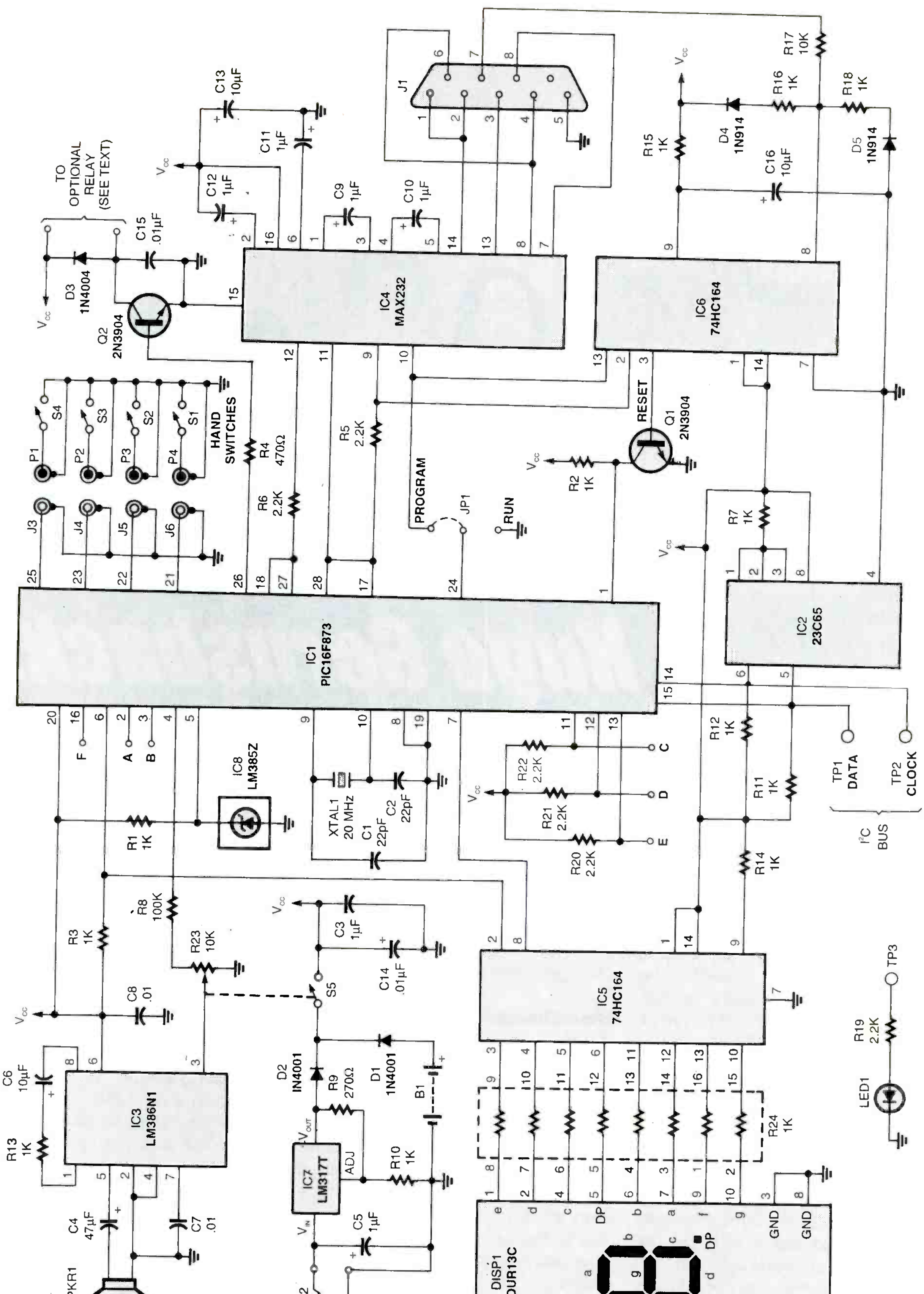


Fig. 1. The GameEnhancer, built around a 16F873 microcontroller, has many features that can be used in projects other than enhancing board games. With new software, the same hardware can do many different tasks, such as triggering a model rocket.

The heart of the GameEnhancer is IC1, a PIC 16F873 flash-memory microcontroller. This new-generation chip sports not only a rich set of peripheral functions, but also an in-circuit programming ability.

Grounding pin 24 of IC1 with JP1 puts IC1 into its in-circuit programming state. Unlike other flash-memory microcontrollers in the PIC line, this part can be programmed using standard 5-volt supply voltages. Other processors (such as the 16F84) require 13 volts for programming, resulting in a more complex circuit.

An RS-232 serial interface provides for that in-circuit-programming capability as well as data communications with a PC and diagnostics of hardware and software. Low cost, simplicity, and availability were the deciding factors in choosing that protocol.

A MAX232 (IC4) translates the voltage levels between RS-232 and the digital logic within the GameEnhancer. That chip can handle four lines; we need five for the programming-control feature. For the fifth line, a simple diode and resistor circuit (R16, R17, R18, D4, and D5) translates the RS-232 voltages into a range of –0.7 volts to V_{cc}–0.7 volts. Using discrete components for a single input line was cheaper than an additional multi-line converter chip. Resistors R16 and R18 prevent short circuits in case the diodes are accidentally inserted backwards.

To clarify the relation between the RS-232 circuit and its use in PIC programming, let's look at the relevant components shown in Fig. 2. The RTS line clocks data on the DTR line into IC6, a serial-to-parallel shift register. The outputs of IC6 control IC1's reset, program, and run modes. The levels of the PGM (pin 24) and the nMCLR (pin 1) lines set those modes.

To program, pin 24 of IC1 must be held high. Note that jumper JP1 can be set to force pin 24 low and disconnect pin 13 of IC6 from IC1; that "write protects" the PIC chip from accidental writing to its program memory.

Let's look at an example of how the circuit behaves. To put the PIC into "program" mode, the string of digits 10000000 is cycled into IC6 from the serial port (J1) using the RTS and DTR signals. The first shift puts the "one" bit into serial-register line "A". That immediately resets IC1.

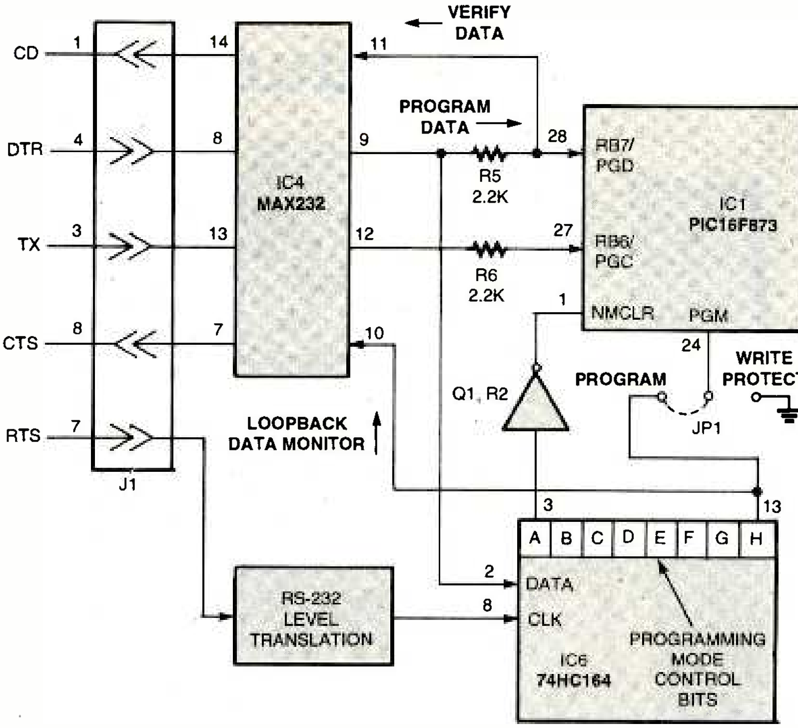


Fig. 2. This detail shows the PIC-programming portion of the GameEnhancer.

Over the next several clock pulses, zero bits are shifted into IC6; the one bit moves down the line. Each zero bit that enters IC6 lets IC1 run. When the one bit finally reaches the last serial register, "H," the PIC enters its programming mode.

You might wonder why the reset control is inverted by Q1. Keep in mind that this circuit must also work properly with no serial interface connected. To do that, R15 and C16 create a reset pulse during power up so IC6 contains zeros. A zero is fine for IC1's program pin, but will hold the PIC in a continual reset condition. Inverting the zero to a one solves that situation. More importantly, that start condition must be done before IC1 completes its own startup sequence.

A "loop-back" test is also built into the circuit. Note that pin 13 of IC6 is connected to the CTS line on J1. Any data from the serial interface is clocked back to the CTS line eight clocks later. Sending a pattern of ones and zeros is a quick and easy way for the host software on the other side of the RS-232 interface to see if the control circuit is working properly.

Once IC1 is in its programming mode, the data to be stored must be entered. That is done with three additional serial lines. The DTR signal presents each data bit to be stored, and the TX signal clocks it in. To verify that the bit is properly stored, the TX line clocks out each bit, which is made available on the CD line. The DTR line is held high to act as a pull-up voltage in conjunction with R5.

Song notes and configuration information is stored in IC2, a 64K serial EEPROM. With the note format chosen for this design, the GameEnhancer can store just over 4000 notes. Pull-up resistors R11 and R12 and address-encoding resistor R7 are necessary to support the "inter-IC" protocol—or I^2C—developed by Philips. The advantage of using I^2C is future expandability. It is feasible, for example, to add I^2C parts such as temperature sensors, voice recorder/playback chips, USB-interface circuits, or additional memory by connecting them to TP1 and TP2. All that is necessary for the hardware interface is that a different address is set with pull-up resistors for each peripheral chip. Of course, the software controlling IC1 would have to be modified to take advantage of the new hardware.

Up to four players can use the GameEnhancer. Each player controls one of the switches, S1–S4. Those momentary-contact switches are connected to IC1. Internal pull-up resis-

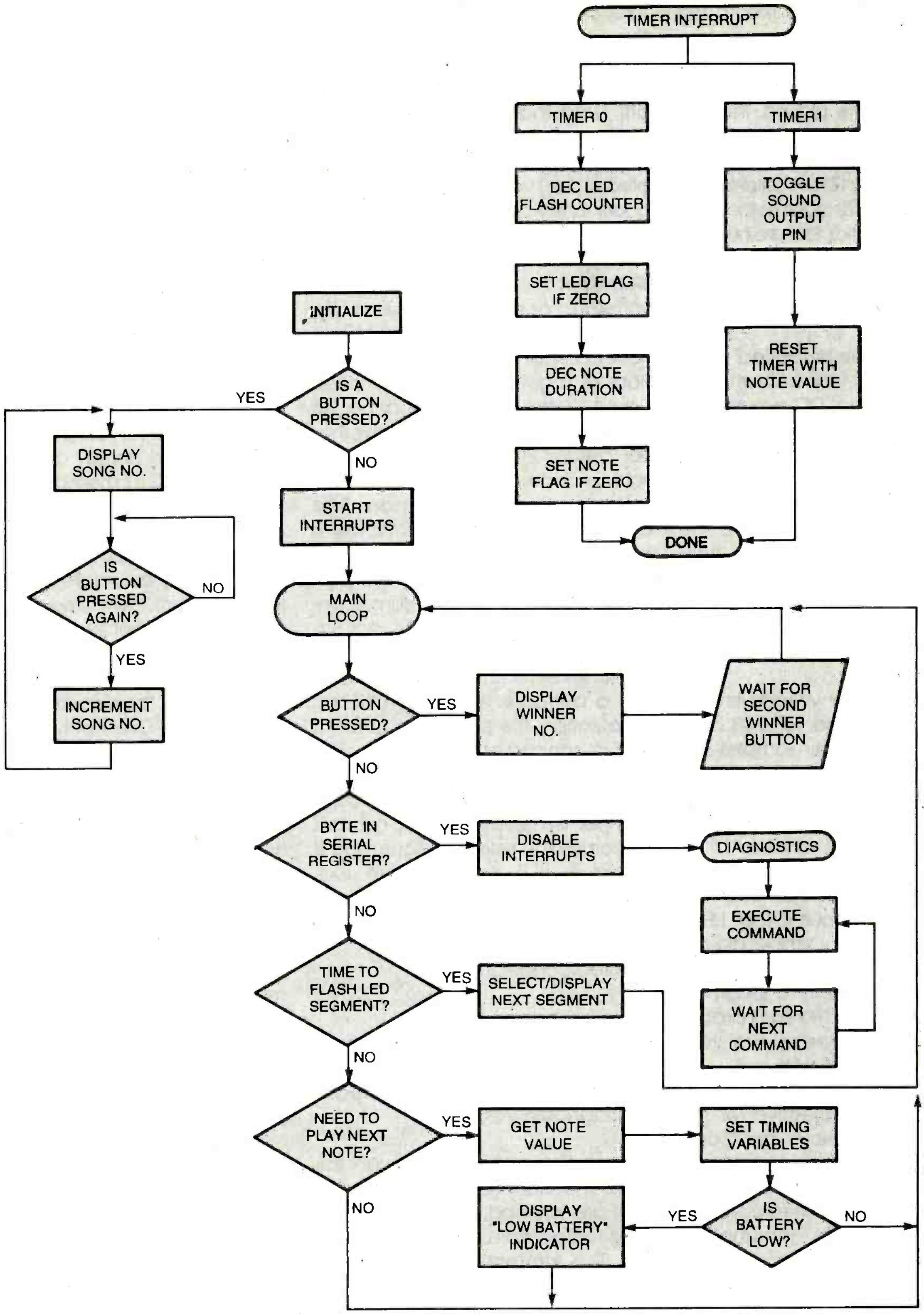


Fig. 3. The GameEnhancer software has many features, from normal operation and setup to debugging and executing special commands from a PC.

tors within the PIC provide a valid logic level when the switches are open.

Songs played by the Game-Enhancer are squarewaves generated by IC1's software. Those squarewaves appear on pin 4 and are attenuated by volume control R23. This signal is then amplified by IC3, an LM386. The LM386 is a popular audio-amplifier chip that drives SPKR1, a miniature 0.4-watt speaker. The components in the audio-amplifier circuit set the gain level to prevent unwanted feedback from the output back to the input. Capacitor

C4 AC couples the speaker to the amplifier.

The LED display, DISP1, presents three things: a flashing pattern while the background song is playing, the winning contestant number, and a low-power indication as needed. Display current is limited by R24. A serial-to-parallel shift register (IC5) reduces the number of PIC output lines that are needed to drive DISP1 from eight to two. One line clocks data on the other line into IC5, and the data pattern sets which segments light.

Power can be supplied from either B1 (a set of four AA batteries) or from an external DC power supply connected to J2. The external voltage source is regulated by IC7, an LM317T voltage regulator. Protection diodes D1 and D2 prevent regulated DC from going into the batteries. Bypass capacitors help to eliminate switching noise on the power-supply rails. Capacitor C13 is especially critical to dampen the switching-power-supply oscillations generated by IC4.

The power supply voltage level is monitored by IC1. The 16F873's analog-to-digital converter samples the supply voltage, comparing it against a reference voltage supplied by IC8. If the power supply voltage falls below 3.7 volts, DISP1 will blink "L" followed by "O" while playing music.

A handy feature built into the GameEnhancer circuit is that LED1 and R19 form a very simple digital-logic probe, although not used for normal operation. With a length of wire connected to TP3 as a probe, LED1 will light up when several volts are detected on the wire.

Future expandability was an important design objective for this kit. Beyond the various input and output circuits already described, there are six unused I/O pins that have been brought out to connection points labeled "A" through "F." While they are not used with the GameEnhancer, you can write special software that uses those pins for whatever you want.

One additional capability built into the GameEnhancer's hardware, though not used in this device, is Q2. That transistor can be used to control a 5-volt relay; again, with special PIC software that you must write if you want to use that feature. Diode D3 prevents any inductive "kickback" from the relay's coil from damaging the GameEnhancer's circuitry when the relay is turned off. Note that if you are contemplating connecting this optional relay to high voltages or currents, please be very careful to follow good safety precautions and design techniques.

Software. The GameEnhancer's PIC software contains several major sections. Figure 3 shows the basic flow chart of how the various sections fit together. A full description could fill the entire magazine, so we'll only touch on the highlights. For details, study the commented source code.

We'll start with initialization. That code executes whenever power is applied to the GameEnhancer and configures items like the processor's peripheral functions, control register and variable values, and the external circuits such as the I^2C system and the RS-232 interface.

If a button is held down during initialization, the program branches to the song-selection section. The current song is displayed. Each time any button is pressed, the next song number is displayed. That number becomes the selected song and is stored in IC2. Note that to exit, power must be cycled.

After initialization, IC1 enters the main loop. This loop exits under one of three conditions:

- Power is removed
- The serial port sends a diagnostic command
- The song contains a special diagnostic value

Each time IC1 goes through the loop, the buttons are checked. If any are pressed, the button-handling routine stores that button number. The internal timers (used for song playback) are disabled. The winning button number is flashed several times accompanied by a couple of beeps. Once the button is released, the system waits for that button to be pressed again. When it is, the main loop is re-entered.

A "tie-breaker" algorithm is used to select the winner if more than one button was pressed: A semi-random number chooses among the pressed button numbers. Note that special switch de-bouncing algorithms are not used. Bouncing switch contacts seem to work as an effective random tiebreaker for switches that are pressed within a few milliseconds of each other.

If a command is available on the serial line, the loop exits to a special diagnostics-command routine. Whatever value is in the serial register is treated as a command and is processed accordingly. The PIC can return serial information to the host PC through the serial line as well. Once the diagnostic mode is entered, power must be cycled to exit.

The flashing display uses a designated bit in IC1's memory. If that bit is set, it's time to change the display. That bit, called a *flag* in "software-speak," is controlled by a software routine associated with IC1's internal countdown timers; we'll discuss that aspect of the program later.

A loop-counter variable chooses which segment flashes next. The selection acts like a "pseudo-random" number selector—DISP1 only looks like it is randomly flashing. There is also a flag for the low-voltage display.

A check is made to see if the current note has reached the end of its designated playing period. Like the flag discussed in the display routine, the same timer controls another flag for note duration. If the flag is set, then the oscillator must be stopped, the next note must be retrieved from IC2, and the timers set to play the new note's pitch and duration. The oscillator is then restarted with the new note period loaded into the appropriate hardware timer.

As a last step before repeating the loop, the A/D section of IC1 checks the battery voltage by converting the voltage on pin 5. The A/D converter provides an output between 0 and 255 based on the voltage at the A/D input. Since the A/D uses ground and IC1's supply voltage as references and IC8 fixes the input voltage at 2.5 volts, the converted value has an inverse-linear relationship to the supply voltage; as the supply voltage drops, the A/D value rises. If the A/D converter reads 128, then the voltage present is 128/255 of the supply

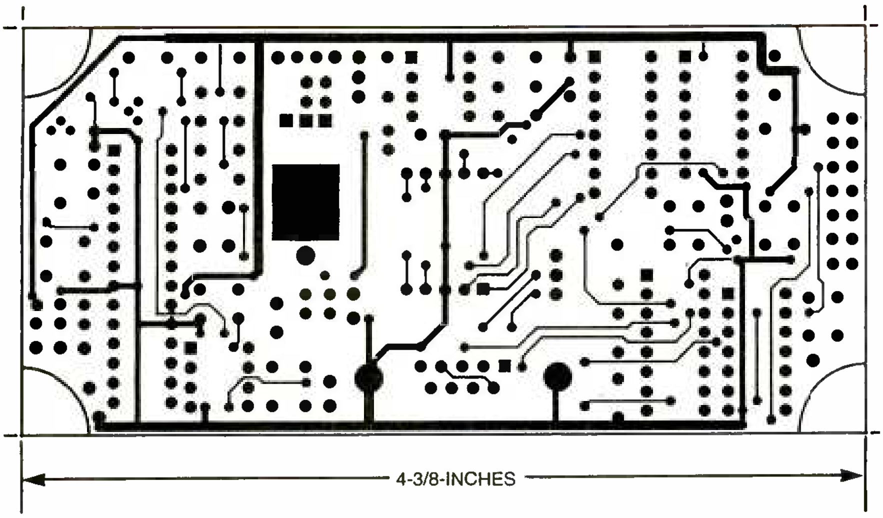


Fig. 4. This foil pattern for the component side of a double-sided PC board reduces wiring errors when building the GameEnhancer.

voltage. Determining the actual voltage is a matter of applying the linear algorithm in reverse: dividing 255 by the number read and multiplying it by 2.5. For example, if the A/D readout is 145, then 255/146 × 2 represents a measured supply voltage of 4.4 volts. When the calculated voltage falls below a set threshold, the algorithm will cause the LED to signal the low-power condition.

Interrupts. The GameEnhancer uses two hardware timers within IC1 to control time-sensitive functions: playing music and flashing the display. Each timer has a signal to tell the central-processing unit (CPU) to stop what it's doing and run special code. When that special code, called an *interrupt routine*, completes, the values in the CPU's registers are restored to their original values before the timer interrupted the CPU. The original program then continues execution as if nothing happened.

One of the timers, designated TIMER0, interrupts program execution every 7.8 mS. This timer handles duration of the display flashes and note duration. Two special memory locations keep track of how many times TIMER0 interrupts the CPU. One of those locations is associated with the display and the other with the musical note. One at a time, the values of the memory locations are decremented by one. If either reaches zero, the interrupt routine sets the appropriate flag to signal when it is time to change the display or play the next note in the song.

The other timer, TIMER1, takes care of generating the actual note pitch. Fast response and precision are important to this routine for audio quality. Each time the timer triggers an interrupt, the service routine toggles the audio-output pin. The initial time value (stored in a special memory location) is reloaded into TIMER1's countdown register. That way, precise squarewaves are generated for the song.

Storing and Playing Songs. As we've said before, TIMER1 counts the delay for each cycle of a note's pitch. One way to store the notes would be to simply store the values that need to be loaded into TIMER1. Since TIMER1 needs a 16-bit value, that is not as efficient as it could be in terms of storage space. Also, it would take a great amount of calculation to find the actual frequencies and associated timer values.

There is a better way, and the GameEnhancer uses it: a look-up table that stores the pre-calculated timer values. If, for example, we want to play the sixth note, we simply count 12 bytes (two bytes for each note) from the beginning of the table and load the next two numbers into timer1. A standard piano keyboard has 88 notes, so it is very easy to create a table for, say, 73 notes—from C two octaves below Middle C to C four octaves above Middle C. The notes can be stored as single bytes.

Playing the right pitch is only half of the story; length is the other. Again, we've discussed how TIMER0 does that, but what are the "magic values?" The time-out value of 7.81 mS plus software overhead can play a maximum of about 60 notes per second; the rest should be simple math. For example, if our song—say, any Sousa march—is 120 beats per minute, a quarter note is 500 mS (½ second), or 64 "ticks" of the timer (7.81 × 64 = 499.84).

With that method, the longest note would be 7.81 × 255, or about 1.9 seconds. What if we want a longer note?

Longer notes need a modification to the duration scheme; they don't need as much resolution. Counts from 128 through 255 increase the base time period to 100 mS. The number 128 is subtracted from the count number, and the result becomes the number of 100-mS counts in the duration. For example, a count number of 129 becomes (129–128) × 100 mS as a duration. A count number of 145 results in a duration of (145–128) × 100 mS, or 1.7 seconds. With this scheme, a note duration can range from 100 mS to 12.7 seconds.

Using the notation scheme for notes just described enables slightly over 4000 notes to be stored in IC2's 8K capacity. A simple quiz game song such as the 32-measure theme from "Jeopardy™" uses about 260 notes including rests and the repeat at the end. Thus, about 520 bytes out of the 8K bytes are required.

To round out our discussion on musical notation as it applies to the GameEnhancer are some special "codes" that can be embedded in the song. The value "0" for the note pitch represents a rest; the oscillator is turned off for the duration of the note period. The entry value 120 followed by a zero or a one indicates that the song should be repeated. The note value 127 indicates that the song should stop. The oscillator is turned off, and the diagnostics loop is entered.

The "120" code is useful when debugging songs. By specifying a second value between 2 and 4096, you can jump to any note in the song—just like a "goto" statement. The target note is relative to the beginning of the song. For example, the entry "120 200" would go to the 200th note of the song. Note that if the number is greater than the number of notes in the song, the jump goes to the last note of the song.

See the sidebar for an alternative music-notation format.

Construction. The GameEnhancer can be built on a perfboard using standard construction techniques. However, the use of a printed-circuit board is recommended; reduced wiring errors and greater stability of high-frequency signals are the advantages. Foil patterns are shown in Figs. 4 and 5 for the component and solder sides, respectively. Due to the complexity of etching a double-sided board, you might want to consider purchasing a pre-etched board from the source given in the Parts List. If you do etch your own board, note that the foil patterns yield a board that has no need to solder component leads on the top side of the board—with one exception. Of course, you will need to make connections at all places where the circuit path jumps from one side to the other.

If you are using a board from the source given in the Parts List or one etched from the foil patterns, follow the parts-placement diagram shown in Fig. 6 in locating the various components. Start by mounting the IC sockets; IC1 requires a socket. It is strongly recommended that you use a socket for IC2 as well. The other integrated circuits don't need sockets, but their use makes replacing damaged or faulty components a snap.

In general, start with smaller components and work your way up to the larger devices. Resistors and capacitors should be mounted before the semiconductors. Following that order exposes the active devices to the least amount of soldering heat and possible electrostatic discharge due to handling during construction. Note that the resistors tend to be mounted vertically as a space-saving technique.

Some of the capacitors and all of the semiconductors are polarized; double-check their orientation before soldering them. If you install a part backwards, you might ruin it as well as the rest of the board when power is first applied. Integrated circuits tend to die in an instant when exposed to the wrong voltages; capacitors like to explode and burst into flames!

You can mount J1 directly to the board or make a remote connection to a panel-mounted connector with a series of insulated wires.

Finally, DISP1 is mounted on the *solder* side of the board—the one exception that we mentioned earlier. Check the polarity and seating of the component before you solder—it is very difficult to remove.

For initial tests, you need to connect J1, J2, B1, R23, SPKR1, and S5 to the PC board. When everything is ready for the "smoke test," look over your work for any "dumb" errors such as missing or incorrect components, solder splashes, cold or unsoldered joints, and the like. It's usually a good idea to set the unit aside and come back to it the next day when your mind is fresh and alert.

One final step before testing—***remove*** IC1 if you inserted it into its socket. We'll be using a PC to test the board.

Programming and Testing. To initially program and test the GameEnhancer, download the special software from the Gernsback FTP site; it can be found at *ftp.gernsback.com/pub/pop/game_enhancer.zip*. Functions include diagnostic tests of the GameEnhancer, programming IC1, storing data in IC2, and song entry. The application software requires one of the 32-bit Microsoft Windows operating systems (95, 98, or NT).

Check your work one more time for any mistakes. Be sure that the socket for IC1 is empty. If you have an ohmmeter, check for connectivity between J2 and the input pin of IC7. Make sure that the battery holder is properly connected as well. There shouldn't be a direct short between the power and ground traces on the board. If everything passes muster, connect J2 to a 9–12-volt DC power supply; you can also use batteries if you so choose.

Close S5 by turning R23. Connect J1 to the serial connector on the back of a PC using suitable cable. Install and start the downloaded software. You will be instructed to follow a diagnostic turn-on procedure. This includes connecting each peripheral chip (serial section, audio amplifier, LED display, EEPROM, switch connections, etc.) to the serial lines to check out that the sections are working. Connections are made using two wire-wrap jumpers that you hook from pins 27 and 28 of IC1's socket to various other pins. The PC software will toggle signals on these lines that will enable checkout of each section.

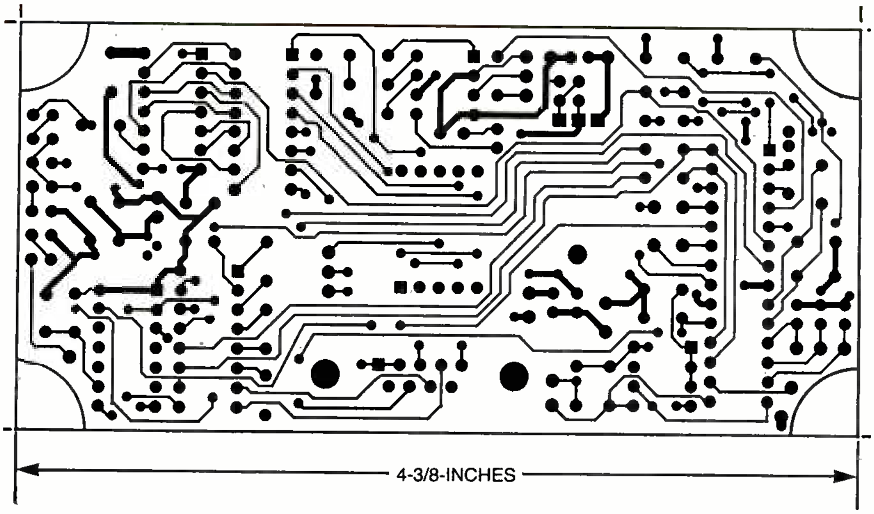


Fig. 5. Here's the foil pattern for the solder side of the GameEnhancer. Note that the board was designed so that soldering components on the component side is not required; only the via holes carry signals between the two sides.

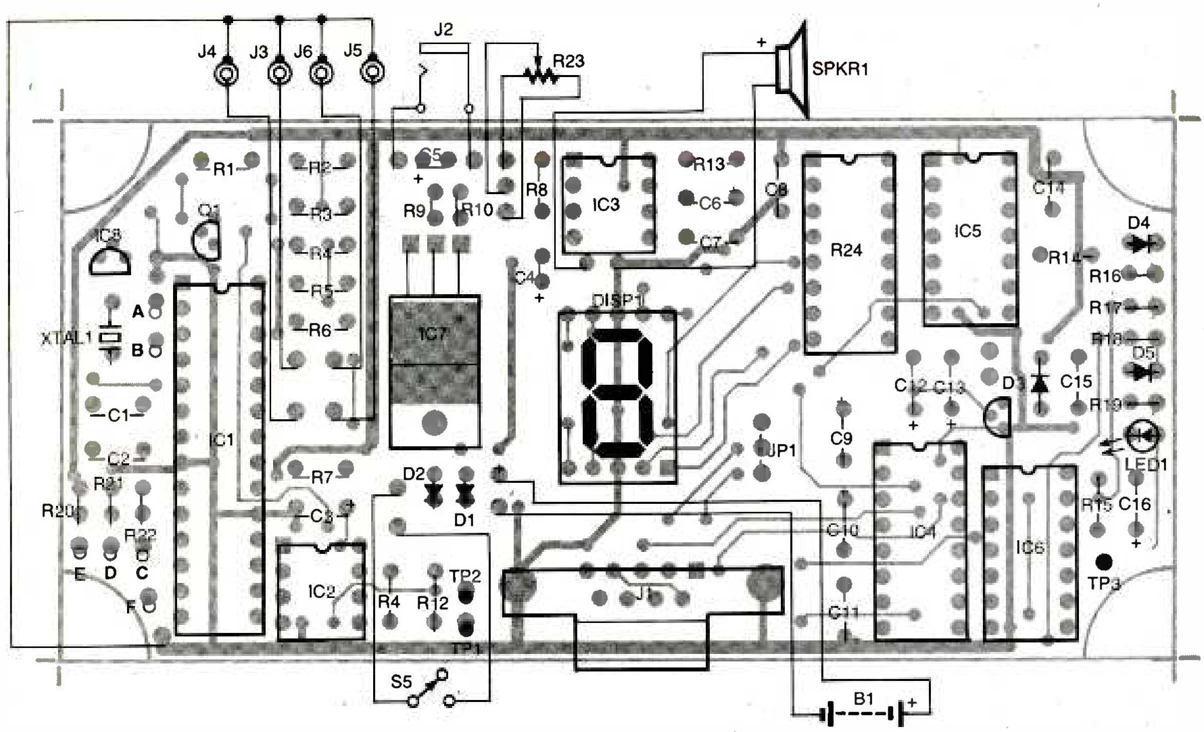


Fig. 6. Use this parts-placement diagram when building the GameEnhancer. All resistors are mounted vertically to save "real-estate" space on the PC board.

Once the diagnostics checkout is completed, power down the GameEnhancer. Insert IC1 into its socket and reapply power. Make sure that JP1 is in its "program" position; pin 24 of IC1 should be connected to pin 13 of IC6. If pin 24 is grounded, IC1 can't be programmed.

The next step tests IC1. If the microcontroller tests good, you are ready to program IC1 with a selectable object-code file. Obviously, you'll want to select the GameEnhancer's software. A programming technique that Microchip recently introduced—which is implemented here—helps speed up reprogramming a PIC during program development if you are modifying the GameEnhancer software. Each memory location is read prior to writing a value. If the value read is already correct, that location is skipped. When making many changes, this speedup is very handy, especially if only a few bytes need to be changed.

The final step is to download the song information into IC2. You simply select an ASCII text file that has the proper codes; the software handles the rest.

With the GameEnhancer tested and programmed, you should now hear the song play and see DISP1 flash. If you don't, you might need to verify that you have sent the correct files to the unit.

Final Assembly. Now that the circuit board is working properly, we need a case to hold the unit. Any suitable size plastic case will do; it should be as wide and long as the PC board and thick enough for the battery holder.

Several holes are needed for mounting the controls and external components. Mark the locations with a center punch; that will keep the drill from wandering during the drilling operation. Drill holes for R23 and J2–J6. You can choose any location you want. The author's prototype uses the edges of the case for those items.

A square hole is needed on the front panel for DISP1; measure the PC board for location. Drill several small holes at each corner and along the edges. Punch out the plastic and file the edges smooth. You could also use a rotary cutter if you have access to one. If you do, run the tool slowly so the case plastic doesn't melt. Whatever method you choose, cut the hole too small and enlarge it bit by bit, test-fitting the PC board after each cut.

Holes are also needed for the speaker. Mount the speaker to the solder side of the PC board with double-sided tape, foam tape, or epoxy. A good location is next to DISP1. Whatever method you choose should not short any metal parts of the speaker to the traces on the PC board. Measure the speaker's location and mark the case. Drill a hole pattern of your own choice within the marked area of the case. A pattern of concentric circles is a pleasing combination; you can see that in Fig. 7.

Connect the various components to the PC board with suitable lengths of insulated wire. Fit the PC board into the case, securing it with double-sided foam tape; screws, spacers, and nuts; or any method of your choosing. You can leave it free-floating if the battery holder presses against it when the case is closed. Any components wired to the PC board from the test should now be mounted to the case. The GameEnhancer should now look like the unit depicted in Fig. 8.

Before closing the case, turn on the GameEnhancer and short the connections from J3–J6 one at a time. The correct number should be displayed on DISP1. Shorting the con-

PARTS LIST FOR THE GAMEENHANCER

SEMICONDUCTORS

IC1—16F873 PIC microcontroller, integrated circuit
IC2—24C65 serial EEPROM, integrated circuit
IC3—LM386-N1 audio amplifier, integrated circuit
IC4—MAX232-CPE RS-232 transceiver, integrated circuit
IC5, IC6—74HC164 serial-to-parallel shift register, integrated circuit
IC7—LM317T three-terminal adjustable voltage regulator, TO-220 case, integrated circuit
IC8—LM385Z 2.5-volt reference, integrated circuit
Q1, Q2—2N3904 NPN silicon transistor
DISP1—DUR13C seven-segment light-emitting diode display, common cathode
LED1—Light-emitting diode, any color
D1, D2—1N4001 silicon rectifier diode
D3—1N4004 silicon rectifier diode
D4, D5—1N914 (or 1N4148) silicon signal diode

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1–R3, R7, R10–R16, R18—1000-ohm
R4—470-ohm
R5, R6, R19–R22—2200-ohm
R8—100,000-ohm
R9—270-ohm
R17—10,000-ohm
R23—10,000-ohm potentiometer, audio taper, panel-mount with integral on-off switch
R24—1000-ohm, 8-element resistor network

CAPACITORS

C1, C2—22-pF, NPO ceramic-disc
C3, C5, C9–C12—1-µF, 25-WVDC, tantalum electrolytic
C4—47-µF, 16-WVDC, electrolytic
C6, C13, C16—10-µF, 16-WVDC, tantalum electrolytic
C7, C8, C14, C15—0.01-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

B1—6-volt battery (4 AA or equivelant)
J1—DB-9 female connector, PC mount
J2—2.1-mm male power jack, panel mount
J3–J6—RCA-style jack, panel-mount
JP1—Three-pin header with jumper block
P1–P4—RCA-style plug, inline
S1–S4—Single-pole, single-throw, normally open momentary-contact pushbutton switch
S5—Single-pole, single-throw switch (part of R23)
SPKR1—8-ohm miniature flat speaker, 0.4-watt
XTAL1—20-MHz parallel-cut crystal, low profile
Knob for R23, case, battery holder for four AA cells, optional 9–12-volt DC wall-mounted power supply, ½-inch PVC pipe and cap, IC sockets, wire, hardware, etc.

Note: The following items are available from: QuestKit, 3124 Appaloosa Ct., Ft. Collins, CO 80526; 970-206-1292; *www.questkit.com*: Complete kit of electronic parts, switches, sockets, PC board, pre-drilled case, handle assemblies with precut holes, handle wire, CD with software, and detailed assembly instructions, $74.95 plus $7.50 for standard ground shipping/handling; partial kit of all above-listed items minus case, handle assemblies, connectors, and hookup wire, $59.95 plus $5 for standard ground shipping/handling; printed-circuit board, pre-programmed IC1, and IC2, $29.95 plus $4 for standard ground shipping/handling; commented source code and software license for PC interface and high-level algorithms, $19.95 plus $3 for standard ground shipping/handling. CO residents please add 3% sales tax. MasterCard, Visa, personal checks, or money orders accepted.

nector a second time should restart the music. Finally, you can screw the cover in place. If you have a large case, you might need to put in some non-conductive foam material on top of the battery holders to keep everything in place.

Game Handles. The four game handles (see Fig. 9) are constructed using six-inch lengths of ½-inch PVC pipe and end caps. Drill a hole in the center of each end cap for S1–S4. You may want to use a vise and a towel to hold each end cap in place for drilling. Note that you might need to remove some plastic from within the end cap to get the switch to tighten properly. That can be done carefully with a knife or a rotary tool.

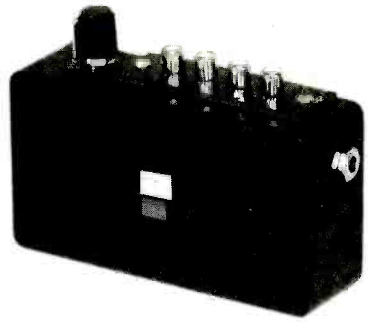


Fig. 7. Several holes need to be located and drilled for mounting the external components of the GameEnhancer. Note the rectangular hole for DISP1 and the "speaker-grille" hole pattern.

If you want to paint the handles, now is the time. A semi-gloss spray paint works well. Black or blue paint matches most available plastic enclosures, as well as looking good. You can either leave the end caps white or spray paint them also.

Solder a ten-foot length of two-conductor lamp cord to each switch; black wire looks better. If available, shrink a piece of head-shrink tubing around each solder connection. Mount a switch in each end cap, thread the wire through one of the tubes, and cement the end cap to the tube using PVC pipe cement.

Solder the other end of the wire to P1-P4. Again, a piece of shrink tube around each connection is a good idea.

It is helpful to label the plugs and handles with an identical number (1, 2, 3, and 4). You can use rub-on transfer numbers, plastic-model decals, or clear envelope labels and a printer or marker pen to make those labels.

The completed and tested Game-

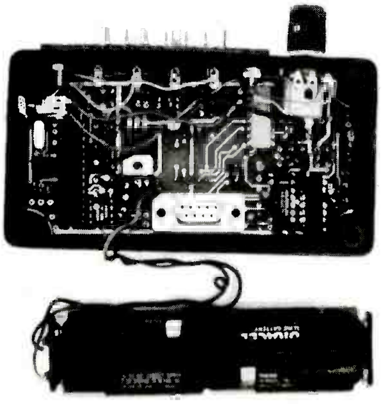


Fig. 8. With all of the components installed and wired, the GameEnhancer's case is ready to be closed.

Fig. 9. Each game handle is a length of PVC pipe with a momentary-contact pushbutton mounted on an end cap. Painting the handles an appropriate color gives the GameEnhancer a slick look.

Enhancer is shown in Fig. 10.

Using the GameEnhancer. Any games that require taking turns to respond are candidates for the Game-Enhancer. Games in the TV quiz-show format are naturals—you can play them just like the television versions. "*Jeopardy*™" is a natural fit—and is made more exciting by following the rules used in the TV quiz form of the game.

With a little thought, other games can be modified to take advantage of the GameEnhancer's properties. For example, with *Trivial Pursuit*™, the first person to "buzz in" and answer the question could be the one able to move a piece and select the category for the next question.

A list of public-domain songs is provided at *www.questkit.com*. You can augment that list with standard theme songs appropriate to the game you are playing. You can obtain music for many TV quiz games at a local sheet-music store. Use either a spreadsheet program or a word processor program to fill in a table of note values that you can then download to the unit as described elsewhere in this article.

Remember: The player whose button was detected is the one who must clear the GameEnhancer once DISP1 stops blinking. This is accomplished by pressing the button once.

The GameEnhancer is a fun addition to most board games, helping to identify the quick and the clever.

Is that your final answer?

SONG FORMATS

There are two possible file formats used for encoding the songs. One type is discussed in the section "Storing and Playing Songs." While it matches the GameEnhancer's internal-storage format and gives much more flexibility and control over the musical rendition, it is more tedious to convert from sheet music. The alternative format discussed here is simpler and is closely related to music notation. It is translated into the second format by the PC host software when downloading a song to the Game-sEnhancer. Any formatting errors are reported prior to downloading.

The alternative format starts with a single number on the first line representing the tempo in quarter notes per minute and ranges from 40 to 210. Each subsequent line is one note value and duration. The note values are represented as capital letters. These consist of the letters C, D, E, F, G, A, and B for the names of the musical notes, and R to represent a rest. Sharps and flats—the black keys on a piano—are added after the note value as a "#" sign or as a lower-case "b." Putting one, two, or three minus signs in front of the note lowers the octave by one, two, or three octaves below middle C. Putting one, two, three, or four plus signs in front of the note raises the octave by one, two, or three octaves above middle C. For example, to indicate C# two octaves below middle C; the notation would be

- - C#

Spaces or tabs are permitted between any of the characters.

The duration is placed on the same line after the note value and modifiers. There are a number of different note lengths encountered in written music. These include whole notes up to 128th notes, dotted notes, and tie notes. In our notation system, whole notes are represented by the number "1," half notes by the number "2," quarter notes by "4," and so on up to 128th notes represented by the number 128. Incidentally, 128th notes use up storage space very quickly with only a 4000-note capacity; fortunately, they aren't used very often!.

Up to 3 periods can be added after each note to represent the dotted notation used in written musical notation. Each period will lengthen the note by half its value. For example, the representation

C 4..

will play middle C for a duration of ¼ + ⅛ + ⅛ or ½ note. Adding additional length numbers on the same line makes tie notes. For example, two tied middle-C ¼ notes would be represented as "C 44." Lastly, triplet eighth notes are indicated by the number "3."

To make a song sound more realistic and musical, it is necessary that you add very short rests between phrases and after tie notes. In addition, the duration of notes at the end of phrases and tie notes needs to be shortened just slightly. Musicians do this naturally; it's called "phrasing." To make this easy to encode, add the letter "p" (for "phrasing") after any note that needs this adjustment. That note will be played with a shorter duration followed by a very brief pause. Another timing mark is the staccato notation (dot under the note). Add the letter "s" after the timing value to adjust for staccato.

There are two notations used to direct which note is played next. No special notation means play the next note in the sequence. At the end of each song, the letter "R" is placed to indicate that the song should repeat. On any line, the letter "S" followed by the note number (counted from the beginning of the song) causes a jump to that note number in the song. This is very helpful when first debugging a song. Placing the repeat mark at various places can help focus debugging efforts.

As an example, here is the first bar of "Pop Goes the Weasel" (from an unknown 18th-Century English composer).

```
60
C 4
F 4p
F 4
G 4p
G 4
A 4
C 4
A 4p
F 4p
C 4
F 4p
F 4
G 4p
Bb 4
G 4.
F 4.p
R
```

Fig. 10. The completed GameEnhancer is ready to liven up your next hot session of Trivial Pursuit™!

What A Long, Strange Trip It's Been

Dear Readers:

This is the last Q&A column that I will write for **Poptronics**, *although I'll probably help with portions of future columns and will certainly continue to write articles. I've had great fun writing Q&A since 1995, and I will miss you.*

Writing Q&A is a part-time job; I work full-time as a research scientist at the University of Georgia's Artificial Intelligence Center. My specialty is computer modeling of human thought and language. This has suddenly become a hot area, with lots of industry interest, lots of eager students, and more consulting clients than I can handle. Recent research projects include a Web page that answers user questions asked in plain English, new techniques for encoding the logic of microcontroller programs, and a talking oscilloscope. Regrettably, I have only one life to live, so I must drop some activities in order to pursue others.

You're all invited to come visit me at my University Web page, www.ai.uga.edu/~mc. *I'll never forget my roots as an electronic hobbyist; writing Q&A for these five years was a very satisfying way to give something back to the hobbyist community. To my ham radio friends in particular: TNX ES VY 73!—Michael A. Covington, Ph.D., N4TMI*

Building A Test Bench

Q *I'm building a portable test bench and have three questions.*

First, I want to build a digital voltmeter with an Intersil ICL7139 IC. How can I make this chip drive 7-segment LEDs instead of the LCD displays for which it was designed?

Second, I need positive and negative 5-volt supplies. If I were using batteries, I could connect two of them in series and ground the middle point in order to get +5 and –5 volts. Can this be done with two linear 5-volt supplies? When can and can't you do this?

Third, I've read about being able to print meter faces on label sheets with an HP graphics printer. I have some old meters that I can take apart and measure the angles and arcs; but how can I print new faces for them?—J. H., Elwood, IN

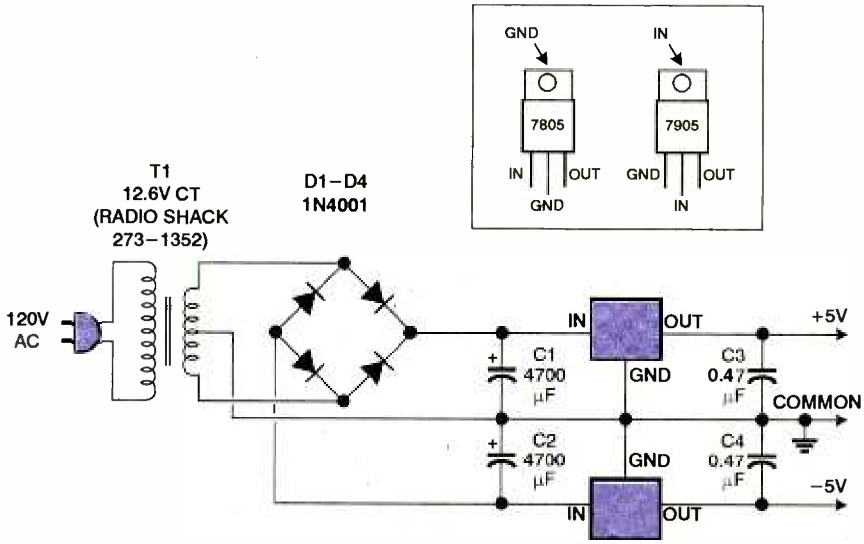


Fig. 1. When building this simple split 5-volt power supply, note that the voltage regulators have different pinouts (as shown in inset). If high current is not needed, T1 can be a RadioShack 273-1265; C1 and C2, 1000 µF.

A The ICL 7139 is designed for a specific LCD display that is quite hard to find (in fact, in ten minutes of searching I couldn't find them anywhere). Less than $2.50 will buy you an ICL 7107 digital-voltmeter chip, which is designed for LEDs. The chip and suitable displays are available from Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002; *www.jameco.com*; data sheets and application notes are at *www.intersil.com*. If you decide to go with LCDs after all, Jameco has both the ICL 7106 and an LCD display that works with it. Bear in mind also that you can buy a complete digital-panel meter for about $15.

Can you connect power supply outputs in series like batteries? Only if there is no DC connection between the power supplies anywhere else. They can still be driven from the same AC line through separate power transformers, but no parts of their DC circuitry can be grounded or connected together, except for the one connection that you are making. Look especially for hidden connections to power-line ground. It's generally better to build a split power supply like that shown in Fig. 1, which is good for at least 0.5 amp with proper heatsinks; see also Radio Shack's book, *Building Power Supplies.*

Finally, making meter faces is no trick; you can do it with any computer-graphics program—such as *Micrografx Draw*, *Corel Draw*, or *Adobe Illustrator*—and any printer that prints graphics. With care, you can even make meter faces with the *Paint* program that is included in Microsoft *Windows*. Just draw it, print it, and stick it on. Instead of label stock, I prefer to use plain paper and a bit of rubber cement.

Camera-shutter Tester

Q *I would like to make a camera-shutter tester with an LCD to show the exposure time.—A. D., Athens, Greece*

A Such a project would be too complex for this column, though it would make a good construction-project article. All you have to do is measure how long the light is shining on a switching phototransistor. The old-fashioned way to do this is to measure the voltage to which a capacitor can charge while the phototransistor is conducting. Plans for a simple tester of this kind are given in the book *Camera Maintenance and Repair*

(Vol. 1) by Thomas Tomosy (Amherst Media, 1993).

Several Web sites feature interesting shutter-tester circuits. See *www.smu.edu/~rmonagha/mf/shutterspeed.html* and *www.geocities.com/Yosemite/2131/shspeed.html.* The latter site uses your computer's sound card to capture the brief pulse and measure its length. All the circuits are very simple because they use an external voltmeter, frequency counter, or computer as the display device.

Your Name In Lights

Q *I would like to build a sign board on which 25 to 35 different names could be spelled out in LEDs, and then light each name for a few seconds. I'd rather use individual ICs and relays instead of computer technology. What is the best way to do this?—H. F., Thiells, NY*

A See this column in **Electronics Now**, August 1997, for a diode-matrix circuit that enables you to light up the same set of LEDs in a different combination for each name.

However, if you don't use computer circuitry, what you're building could get very complicated. To close a number of relays in succession, you might use a series of CD4017 decade counters in cascade, driven by a 555 oscillator. See this column, last month, for a similar arrangement to energize five optocouplers in sequence. The CD4017 data sheet describes how to cascade chips to get more than 10 outputs.

Origin Of "Ham" Revisited

Q *Further to your August column, I researched the origin of the term "ham radio" several years ago and found that in the early 1900s, there was a magazine called* Home Amateur Mechanic *that included many radio projects. I believe the term "ham" was derived from the title of this publication.—R. J., Citrus Heights, CA*

An ancient (1940s) radio book that I have explains that "ham" stands for Hertz, Ampere, and Marconi, three of the greatest scientists whose work led to the invention of radio. Radio dials are also labeled in Hertz's memory (kilohertz, megahertz, etc.).— D. S. C., Modesto, CA

A In historical research, as in science, it's not enough to have a plausible theory; you have to test it against the evidence and to remember that even an old book can be quite mistaken. (I'm not sure 1940 counts as "ancient," though!)

The fact is that amateur telegraph experimenters were called "hams" well before 1900s. The word was short for "ham-fisted," i.e., clumsy. Amateur actors were also called "hams" well before 1900, apparently referring to the title of a popular minstrel show. The weight of the evidence is that "ham radio" is derived from one or the other of these.

I can't verify the existence of *Home Amateur Mechanic*; it's not in the Library of Congress online catalog (*www.loc.gov*). There have been publications named Home Mechanics, but their initials don't spell "ham."

And the "Hertz, Ampere, Marconi" theory is one I've never heard anywhere else; the trouble with it is that the term "ham" was in use among telegraphers before Marconi started his experiments in 1895.

Desperately Seeking Transformer

Q *I'm writing to you out of desperation. I'm trying to fix an old GE stereo, model C445g (vintage 1971). The main problem is an open primary in the power transformer, whose two secondaries are rated to deliver 60 volts AC center-tapped (0.6 A rectified DC) and 5.8 volts AC (0.28 A AC), respectively. Where can I get such a transformer?—Phillip N. Pfeiffer, 5324 Kenneth Road, Milton, FL 32583*

A We're publishing your full name and address in case a reader knows where to get the exact transformer. What I suggest, though, is that you contact Signal Transformer Company (*www.signaltransformer.com*); 500 Bayview Avenue, Inwood, NY 11096-1792; 516-239-5777 and ask them to recommend a substitute, probably two transformers with their primaries in parallel. Despite their name, this company makes power transformers, not signal transformers; they're very good to work with and the products are of high quality.

Alternatively, you can do some scrounging. You can surely use a 6.3-volt transformer in place of the 5.8-volt winding; the 60-volt center-tapped winding is harder to replace, but suitable transformers do exist. Yet another option is to see if a local electric-motor shop can rewind the broken primary—or do it yourself.

Voltage Regulator Correction

Q *In your September column, your calculations are incorrect. Regulating 35 volts down to 12 volts at 0.5 amp, the regulator dissipation is (35–12) × 0.5 = 11.5 watts, not 7 watts as you state.—S. M. Wartenberg, Philadelphia, PA*

A Oops! That's the result of switching from one example to another while I was doing the final revision. Fortunately, 11.5 watts is still within the capacity of an LM7805 on a good heatsink.

Another Voltage Regulator Correction

Q *In your September column, p. 22, the formula for R1 (the resistor in a Zener shunt regulator) seems to be missing the regulated voltage. It should be R1 = (min. input voltage–reg. voltage) × (max. current + 0.001).*

In your worked example, R1 should be 24 ohms—or 22, using the nearest standard value—and a 22-ohm resistor could dissipate as much as 24 watts.—Norman Mahler, Wolcott, CT

A Oops, again—you're right. This particular example got badly mangled as I was in the process of revising it. Fortunately, the main point stands, which is that this particular voltage regulator is not practical.

Need PS/2 Mouse Port

Q *The PS/2 mouse port on my computer's motherboard has failed. Does anybody make an ISA, EISA, or PCI bus card with a PS/2 mouse port on it? For reasons I won't go into, I can't use a serial mouse.—B. L., Kent, WA*

A Such a card ought to exist, but we haven't been able to find one. The obvious difficulty is that the port address assigned to the PS/2 mouse is already taken up by the hardware on the motherboard. How about using a USB mouse?

Intermittent TV Problem

Q *I work for an electric utility, and we occasionally find a problem we call "half out." One of the two phases from the 240-volt service to the house is damaged or disconnected. Often the connection is loose and intermittently heals itself.*

When this condition exists, TVs and other electric appliances function erratically. When the customer takes the appliance to the shop, it works perfectly since the line voltage at the shop is normal. Perhaps this information will help the frustrated repairman who wrote to you from Florida.—Dan Okrasinski, Gresham, OR

A Thanks for writing. Indeed, there are lots of things that can go wrong with house wiring; one that once drove me batty was an intermittent open connection in a circuit breaker, so that the power would cut out for a few milliseconds at a time. This looked for all the world like RF interference or an intermittent fault in all my radios. Replacing the circuit breaker cured it.

The moral of the story? Check the customer's line voltage and try lending the customer a known-good TV for use at the same location.

Port Access From *Visual Basic*

Q *In the July Q&A, a reader asked about port access from* Visual Basic. *I have found "VBASM," a DLL available free from SoftCircuits Programming (Salt Lake City, Utah), to be extremely useful for this sort of access. It can be downloaded from* www.softcircuits.com *and distributed freely.—E. A. Grens, Rio Vista, CA*

A Thanks! VBASM is one of many good programming tools available at that site.

60-LED Clock

Q *What I'd like to do is make a round digital clock (digits in the middle) with 60 LEDs around the outside. At the start of each minute, the LEDs would light up in sequence, one each minute, until all 60 would be lit. Then they'd all go off, and the sequence would repeat. I've seen such clocks in TV newsrooms but they are very expensive.—J. R., Portland, OR*

A If you'll settle for lighting the 60 LEDs one at a time, see this column in **Electronics Now**, November 1995, pages 8–9 (reprints are available from the Gernsback Reprint Bookstore at *bookstore@gernsback.com*).

Writing To Q&A

As always, we welcome your questions. The most interesting ones are answered in print. Please be sure to:

(1) include plenty of background information (we'll shorten your letter for publication);

(2) give your full name and address on your letter (not just the envelope);

(3) type your letter if possible, or write very neatly; and

(4) if you are asking about a circuit, include a complete diagram.

Questions can be sent to Q&A, **Poptronics** Magazine, 275 G Marcus Blvd., Hauppauge, NY 11788, or e-mailed to *q&a@gernsback.com*, but please do not expect an immediate reply in these pages (because of our backlog) and please don't send graphics files larger than 100K. Due to the volume of mail, we regret that we cannot give personal replies. **P**

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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.

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

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JOHN IOVINE

The World's "Smartest" Metal

Who said being backwards is a bad thing? Who said that inanimate objects can't have a memory? This time around we're going to look at a metal alloy that not only does things backwards, but it's smart. "Impossible!" you might say. "How can a metal be 'smart'?" If your education is a bit wanting in that area, then let me introduce our star pupil, *Nitinol.*

Nitinol is an alloy of nickel and titanium that belongs to a class of materials called *shaped-memory alloys* (SMA). SMAs have interesting mechanical properties. For example, Nitinol *contracts* when heated—the opposite of what standard metals do when heated (expand). Not only does the alloy contract, but it also produces a 100X greater thermal movement (expansion, contraction) than standard metals.

Another interesting property of SMAs is the *shaped-memory effect* (SME). The alloy can be heat treated to "remember" a particular shape. Afterwards, if the shape is bent and distorted, the alloy may be heated to regain its original shape. The SME property is used in a few toys like the "Livewire," shown in Fig. 1.

Fig. 1. Livewire is a Nitinol-wire product that demonstrates the shape-memory effect.

The Livewire is a fun little toy. The directions tell you to place it in cold water, bend the wire into any shape you want, and then place it in hot water—and the wire pops back into shape.

The Livewire toy is made of a particular Nitinol formula that has a low transition temperature—the temperature of hot water. When placed in hot water, the wire will unfold and unbend itself (if bent out of shape), reverting back to its original shape. If hot water isn't readily available, you could also pass an electric current through the Livewire to heat it up.

History

Although people have known about and experimented with SMAs since 1932, it wasn't until 1961 that SMAs came out of the laboratory. William Beuhler, working at the U.S. Naval Ordinance Laboratory, discovered the SME effect in an alloy of nickel and titanium. At the time, the scientific team was trying to develop a heat- and corrosive-resistant alloy. What they discovered was a relatively inexpensive and safer (non-toxic) SMA.

The team named the new alloy Nitinol (pronounced "night-in-all"). The name represents its elemental components and place of origin. The "Ni" and "Ti" are the atomic symbols for nickel and titanium. The "NOL" stands for the Naval Ordinance Laboratory where it was discovered.

The mixture of nickel to titanium in Nitinol is about equal. The smallest change in the ratio of the two compounds has a dramatic effect on the transition temperature of the resulting alloy. For instance, a 1% difference in the ratio varies the transition temperature from –100° to +100° C. Every company manufacturing Nitinol products must hold the ratio of the components to a precise level to insure a stable and repeatable transition temperature. The Nitinol alloy we are experimenting with has a transition temperature of 70° C.

SOURCE INFORMATION

Images Company
39 Seneca Loop
Staten Island, NY 10314
718-698-8305
www.imagesco.com

Livewire—$5
6-mil Nitinol wire (70° C transition temperature)—$5 per foot
15-mil Nitinol wire (70° C transition temperature)—$12.50 per foot

How It Works

The properties of Nitinol rely on its dynamic crystalline structure. The molecular structure is sensitive to external stress and temperature. The alloy has three defined temperature phases:

Austenite Phase—This is when the temperature is above the *transition temperature.* The transition temperature varies depending upon the exact composition of the Nitinol alloy; commercial alloys usually have transitional temperatures between 70° to 130° C (158° to 266° F). The yield strength with which the material tries to return to its original shape is considerable: 35,000 to 70,000 psi. The crystalline structure is cubic.

Martensitic Phase—A low-temperature phase. The crystal structure is needle-like and collects in small *domains.* Within the small domains, the needle-like crystals are aligned. The alloy may be bent or formed easily. The deformation pressure ranges from 10,000 to 20,000 psi. Bending transforms the crystalline structure of the alloy producing an internal stress.

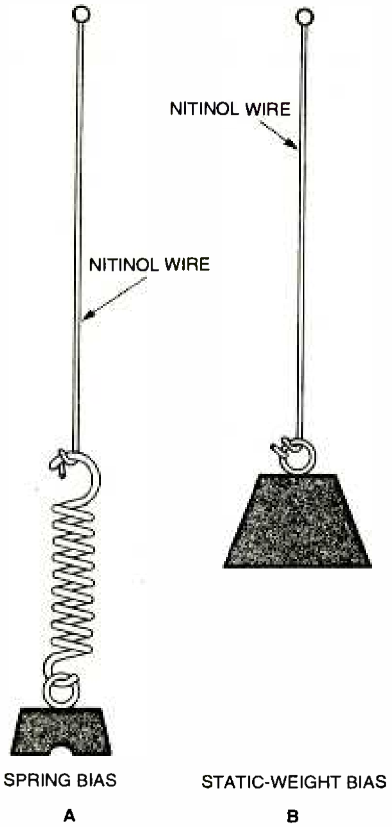

Fig. 2. Once Nitinol contracts, you need to "bias" it with some method to stretch the wire back to its relaxed position.

Annealing Phase—The high-temperature phase. The alloy will reorient its (cubic) crystalline structure to "remember" its present shape. The annealing phase for the Nitinol wire we are working with is 540° C.

The physical properties of our Nitinol wire sample are shown in Table 1.

TABLE 1

Physical Properties

Tensile Strength—200,000 psi
Melting Point—1250° C (2282° F)
Resistance—1.25 ohms per inch for 0.0060-inch diameter wire
Corrosion Resistant

When Nitinol is at room temperature, it is in the martensitic phase. When the alloy is bent, the needle-like crystalline structure within the domains deforms, creating internal stress. When the alloy is heated above its transitional temperature (austenite phase), the crystalline structure changes from needle-like to cubic. The cubic structure of the alloy doesn't fit into the same space as the needle-like domain structures formed when the alloy was bent. The alloy relieves the stress by returning to its "remembered" crystalline cubic shape.

If the alloy hasn't been deformed or stressed, the crystalline structure changes still occur, but it doesn't result in any net movement.

Nitinol Wire

Nitinol generates a shape-resuming force of 22,000 pound per square inch. In our experiments, we will work with either 6-mil (0.006-inch diameter) or 15-mil (0.015-inch diameter) wire. The 6-mil wire has a contractive force of 11 ounces; the 15-mil wire has a contractive force of 63 ounces (4 lbs.).

The wire can contract up to 8%–10% of its length. For a longer lifetime (greater than 1,000,000 cycles), you should restrict the contraction to only 6% of its length.

Contraction and relaxation depend solely on the temperature of the Nitinol alloy wire. Any method of heating and cooling may be used. An easy way to heat the wire—a common method—is passing an electric current through it. Nitinol wire has a high resistance, approximately 1.25 ohms per inch for the 6-mil wire. The resistance of the wire to the electric current generates sufficient heat (ohmic heating) to bring the wire through its transition temperature.

Nitinol wire usually has a counterforce applied to it in the opposite direction of its contraction. The counter force resets, or stretches, the wire back to its original length when in the low-temperature phase. This is called the *bias force*.

If the Nitinol wire is brought to its transition temperature without a bias force, it will contract; however, when it cools it will not return to its original length. Consequently, reheating the wire without a bias force will not produce any further contractions. In most applications, a bias force is applied to the wire constantly. Figure 2 illustrates two methods of applying a bias force: a spring and a static weight.

The speed and strength of the wire contraction depend upon how fast and how high the temperature of the wire is increased. For example, 400 mA of current through the 6-mil Nitinol wire will produce a maximum pull of 11 ounces and full contraction in one second.

Reaction time can be faster—in the millisecond range. To achieve that rate, high-current, short-duration pulses are used. When you use such pulses, you must consider the mass and speed of the material to move. The faster you move a given mass, the greater the inertia that must be overcome. If the inertia becomes greater than six pounds for the 6-mil wire, it will snap.

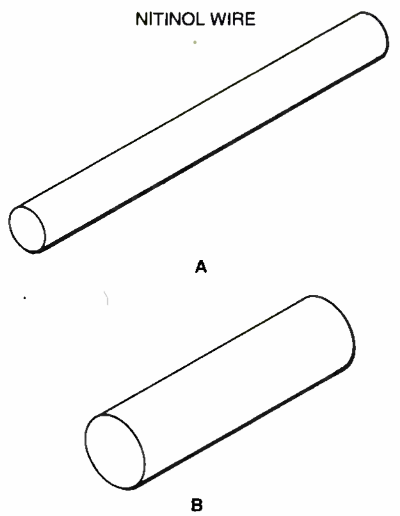

Fig. 3. Nitinol wire's volume remains constant whether relaxed or contracted.

Full contractive force is produced at the *beginning* of a cycle. In contrast, standard electrical solenoids develop full strength near the *end* of their cycle.

Activating Nitinol Wire

As mentioned before, Nitinol wire may be heated by simply passing an electrical current through the wire. The resistance heats the wire and it contracts. The volume of the wire doesn't change during contraction; see Fig. 3. As the wire decreases in length, its diameter increases by a proportional amount, keeping the volume of the wire constant. Once again, the activation temperature of the wire is 70° C or 158° F.

Direct Electrical Heating

Nitinol wire can be activated using a low voltage DC (6–12volts) power supply. A simple system (Fig. 4) need be no more complicated than a battery, a

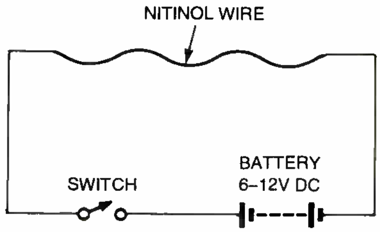

Fig. 4. A DC-battery power supply is ample to test Nitinol wire's unusual properties.

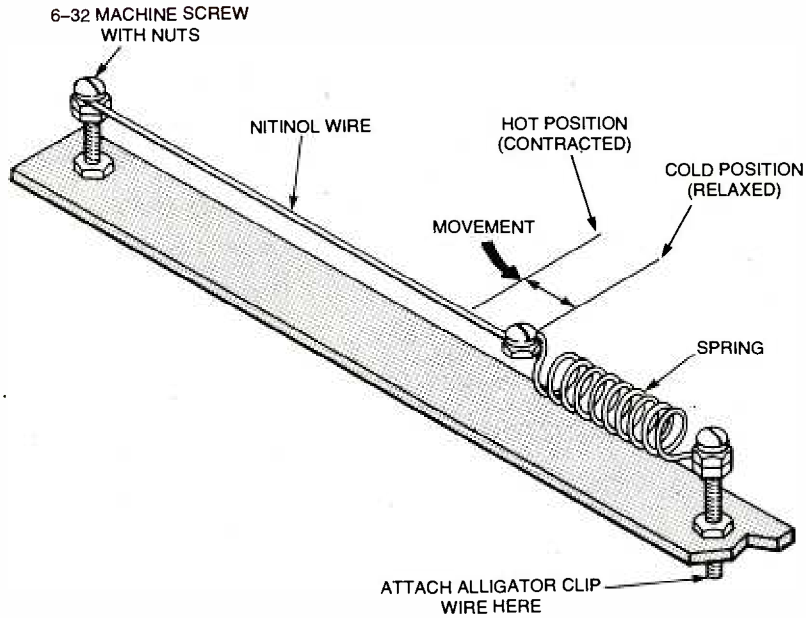

Fig. 5. This device demonstrates and tests Nitinol's contraction property.

switch, and a small length of Nitinol wire. When activating a wire using DC current, it is important not to overheat the wire, or its properties will degrade. Direct current doesn't heat the wire evenly. A better method is to heat the wire using pulse-width modulation.

Annealing a New Shape into Livewire

Here's some more fun you can have with the Livewire toy. You can "teach" the Livewire a new shape. Twist the Livewire into a new shape, holding the new shape using a pair of pliers. Place the Livewire into the flame of a candle until it is slightly red and it stops trying to straighten out. Remove the Livewire from the flame and dip it into cold water. Now the Livewire will "remember" this new shape.

To test the Livewire, bend it into another shape, heat it, and it will return to its new "remembered" shape.

A simple shape that I used for training is a coil. I wrapped the Livewire around a machine screw, held it in place with pliers, and placed it in a flame. It takes a little longer to work (get red hot), because the screw acts like a heatsink.

A Simple Nitinol Demonstration

Figure 5 is a simple mechanical demonstration to display the properties of Nitinol wire: flexing an electric "muscle." The materials you need are three machine screws (6-32 × 2 inches) with nine nuts; a piece of wood or plastic about 12 inches long; a small expansion spring (about 2 to 3 inches long); and, of course, a length of Nitinol wire.

The machine screws, nuts, and expansion spring may be purchased at a local hardware store. To make the device, drill two holes in the wood on opposite ends as shown to accommodate a machine screw and nut. The third screw and nut connect the Nitonol wire to the spring. That screw/nut is *not* secured to the wood, but is free standing. The Nitinol wire is connected to the left screw, see detail in Fig. 5. Loop the spring around the right end screw.

Keep in mind that the 6-mil Nitinol wire has a pull of about 11 ounces; stretching the spring too far will create too much tension for the Nitinol wire to overcome. At the same time, it should be tight enough to take the slack of the relaxed Nitinol wire.

To make the connections from the DC power supply to the demonstration, use small alligator clips and jumper wires to the back of the two end screws. The machine screws as well as the spring are electrically conductive, allowing current to flow to the Nitinol wire.

When you switch on the current to the Nitinol wire demonstration unit, the wire heats up quickly, contracts and pulls the freestanding machine screw closer to the right side. If you mark the starting position of the freestanding machine screw, you can accurately measure the contraction of the wire. When power is removed, the wire cools, allowing the spring to elongate the Nitinol wire and return it to its initial position.

Because we are using a DC power supply, it's too easy to overheat the wire and degrade the Nitinol properties. So it's important to only connect the power momentarily.

But Wait...There's More

Next month, we will finish experimenting with Nitinol. We will build a PWM circuit for the Nitinol wire, which will allow us to keep the power on for longer periods, build a few more Nitinol devices, and examine heat engines that use Nitinol. **P**

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GORDON MCCOMB

Collision Avoidance and Detection: Part 1

You've spent hundreds of hours designing and building your latest robot creation. It's filled with complex little doo-dads and precision instrumentation. You bring it into your living room, fire it up, and step back. Promptly, the beautiful new robot smashes into the fireplace and scatters itself over the living room rug. You remembered things like motor-speed controls, electronic eyes and ears, even a synthetic voice, but you forgot to provide your robot with the ability to look before it leaps.

Collision-avoidance and -detection systems take on many forms, and many of the basic systems are easy to build and use. In this column, I'll begin a multi-part discussion of passive- and active-detection systems for use in robots, beginning with using infrared light to detect nearby objects.

Design Overview

Collision avoidance and collision detection are two similar, but separate, aspects of robot design. With *collision avoidance*, the robot uses non-contact techniques to determine the proximity and/or distance to objects around it. Any detected objects are then avoided. *Collision detection* deals with what happens when the robot has already gone too far, and contact has been made with whatever foreign object was unlucky enough to be in the machine's path.

Collision avoidance can be further broken down into two sub-types: *near-object* and *far-object* detection. By its nature, collision detection deals in all cases with making contact with nearby objects. Note: I make a distinction between a robot hitting something in its path ("collision") and its tactile sense using grippers or feelers ("touch"). Both may involve the same kinds of sensors, but the object of the sensations is for different reasons—collision sensing is *reactive* with an emphasis on avoidance; tactile sensing is *active* with an emphasis on exploring.

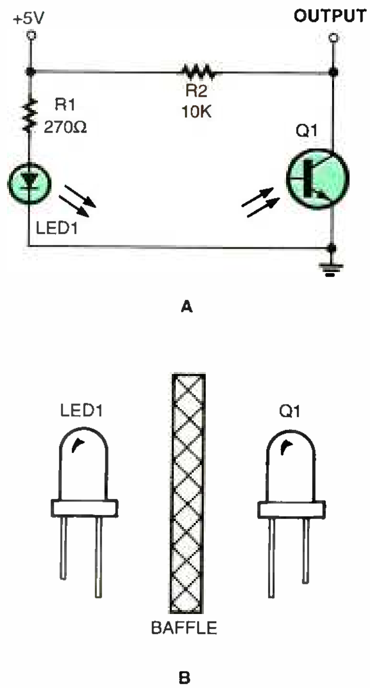


Fig. 1. The basic design of the infrared proximity sensor.

Additionally, certain object-detection methods are commonly used in navigating a robot from one spot to the next.

Near-Object Detection

Near-object detection is as its name implies: sensing objects that are close by—perhaps from just a breath away to as much as eight or ten feet. These are objects that a robot can consider to be in its immediate environment: objects it might have to deal with, and soon. These objects might be people, animals, furniture, or other robots. By detecting them, your robot can take appropriate action, defined by the program you give it. Your 'bot may be programmed to come up to people and ask them their name. On the other hand, it might be programmed to run away whenever it sees movement. In either case, it won't be able to accomplish either behavior unless it can detect objects in its immediate area.

There are two ways to affect near-object detection: proximity and distance:

Proximity sensors—They only care that some object is within a zone of relevance. That is, if an object is near enough in the scene the robot is surveying, the sensor detects it and triggers the appropriate circuit in the robot. Objects that are beyond the proximal range of a sensor are effectively ignored because they cannot be detected.

Distance measurement sensors—These sensors determine the distance between the sensor and whatever object is within range. Distance-measurement techniques vary; almost all have notable minimums and maximums. Few yield accurate data if an object is smack-dab next to the robot; likewise, objects just outside range can yield inaccurate results (large objects far away may appear closer than they really are; very close small objects may appear abnormally larger than they really are, etc.).

Sensors have depth and breadth limitations: *Depth* is the maximum distance at which an object can be detected by the sensor and *breadth* is the maximum height and width of the sensor-detection area. Some sensors see in a relatively narrow pattern, typically conical in shape. Light sensors are a good example. Adding a lens in front of the sensor narrows the pattern even more. Other sensors have specific breadth patterns. The typical passive-infrared sensor (the kind used on motion alarms) uses a Fresnel lens that expands the field of coverage on the top, but collapses it on the bottom. This makes the sensor better suited

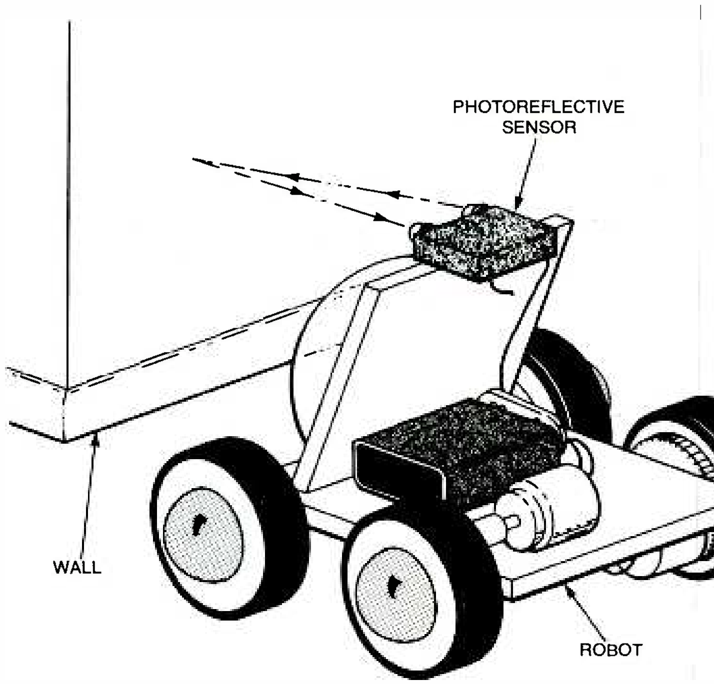


Fig. 2. This figure shows how the sensor is used to test the proximity to a nearby object.

for detecting human motion, rather than that of cats, dogs, and other furry creatures (humans, on average, being taller than furry creatures). The detector uses a pyroelectric element to sense changes in heat patterns in front of it.

Far-Object Detection

Far-object detection worries about objects that are reasonably outside the robot's primary area of interest, but are still within detection range. A wall 50 feet away is not of critical importance to a robot (conversely, the same wall one foot away is *very* important). Far-object detection is typically used for area and scene mapping to allow the robot to get a sense of its environment. Most hobby robots don't employ far-object detection to any degree, because it requires sophisticated sensors such as narrow-beam radar or pulsed lasers.

The difference between near- and far-object detection is relative. As the designer, builder, and master of your robot, you get to decide the threshold between near and far objects. Perhaps your robot is small and travels slowly. Therefore, far objects are those 4–5 feet away; anything closer is near. With such a robot, ordinary sonar-distance systems can be employed for far-object detection, including area mapping.

In this column and the several to follow, I'll concentrate on near-object detection methods, as traditional far-object detection is beyond the reach and riches of most hobby-robot makers (with the exception or sonar systems, which have a maximum range of about 30 feet). If you wish, you may employ near-object techniques to detect objects that are far away, relative to the world your robot lives in.

Remembering The *KISS* Principle

Engineering texts like to tout the concept of KISS: "Keep it Simple, Stupid." The admonition is intentionally insulting to remind all of us that it's usually the simple techniques that are the best. Of course, "simplicity" is relative: an ant is simple compared to a human being, but so far, no scientist has ever created the equivalent of a living ant (some cartoons have come close: who remembers Atom Ant?).

KISS certainly applies to robotic sensors for object detection. We'd all like to put eyes on our robots to help them see the world the same way we do; in fact, such eyes already exist in the form of CCD and CMOS video imagers. They're relatively cheap, too—less than $50 retail. What's missing in the case of vision systems is the way to use the wealth of information provided by the sensor. How do you make a robot differentiate between a can of Dr. Pepper and Mrs. Johnson's slobbering two year old—both of which are very wet when tipped over.

When thinking about which object-detection sensor or system to add to your robot, consider the relative complexity in relation to the rest of the project. If all your small 'bot needs is a bumper switch, then avoid going overboard with a $100 sonar system. Conversely, if the context of the robot merits it, don't *under*-power your robot with inadequate sensors. Larger, heavier robots cry out for more effective object-detection systems—if for no other reason than preventing injury to its master if your creation happens to run into you.

Redundancy

Are two heads better than one? Maybe. One thing is for sure: two eyes are definitely better than one. The same goes for ears, and many other kinds of sensors. This is *sensor redundancy* at work. Having two eyes and ears also provides stereo vision or hearing, which aids in perception. Sensor redundancy—especially for object detection—is not primarily to compensate for system failure, the way NASA builds back-ups in their space projects in case some key system fails 25,000 miles up in space. Rather, sensor redundancy is meant as a way to "smooth out" and balance the results from sensors. If one sensor says an object is 10

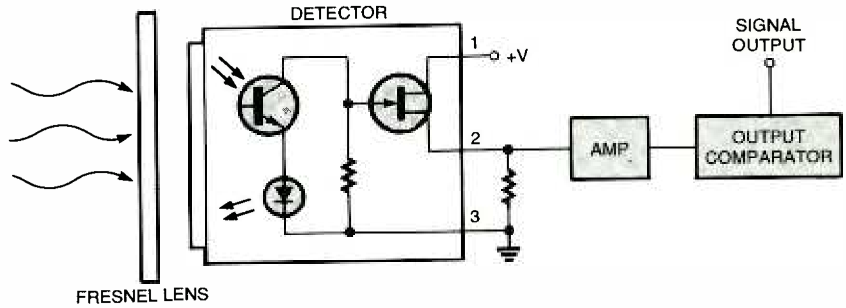


Fig. 3. Most PIR sensors are large, transistor-like devices with a somewhat common pinout arrangement, like the one shown here.

feet away, and another says it's a foot away, the robot's control computer knows something is amiss and can go about determining the truth.

With only one sensor, the robot must blindly (excuse the pun) trust that the sensor data is reliable. This is not a good idea; even with the best sensors, their data is not 100% reliable.

Sensor redundancy falls into one of two general categories:

Same-sensor redundancy—This form relies on two or more sensors of an identical type. Each sensor more or less sees the same scene. Sensor data can be used in either (or both) of two ways: *statistical analysis* or *interpolated* (my terms, for better or worse). With statistical analysis, the robot's control circuitry combines the input from the sensors and uses a statistical formula to whittle the data to a most likely result. For example, sensors with wildly disparate results may be rejected out of hand, with the values of the remaining sensors averaged out. With interpolated, the data of two or more sensors are combined and cross-correlated to provide a kind of 3-D representation, just like having two eyes and two ears adds depth to our visual and aural senses.

Complementary-sensor redundancy—Here we rely on two or more sensors of different types. Since the sensors are fundamentally different—including, but not limited to, using completely different collection methods—the data from the sensors is always interpolated. For instance, if a robot has both a sonar and an infrared distance-measuring system, the robot uses both, understanding that for some kinds of objects the data from the infrared system will be more reliable, and for other objects, the data from the sonar system will be more reliable.

Budget and time constraints will likely be the limiting factors in employing redundant-sensor systems in your robots. When combining sensors, do so logically: consider which sensors make good complements to others and if they can be reasonably added. For example, both sonar and infrared proximity sensors can use the same 40-kHz modulation system. If you have one, adding the other need not be difficult, expensive, or time-consuming.

Non-Contact Near-Object Detection

Avoiding a collision is better than

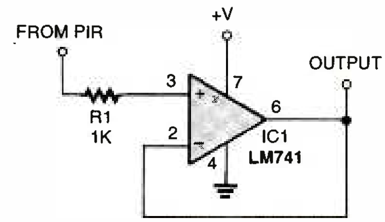


Fig. 4. Use a buffer circuit between the output of the amplified PIR device and the microcontroller or other logic input.

detecting it once it has happened. Short of building some elaborate radar-distance-measurement system, there are two general ways of providing proximity detection for avoiding collisions: light and sound. In the following section, we'll take a closer look at several light- and sound-based techniques.

Simple Infrared-Light-Proximity Sensor

Light may always travel in a straight line, but it bounces off nearly everything. You can use this to your advantage to build an infrared collision-detection system. You can mount several infrared "bumper" sensors around the periphery of your robot. Tied together, they tell the robot that "something is out there," or they can provide specific details of the outside environment to a computer or control circuit.

The basic infrared detector (Fig. 1) uses an infrared LED and infrared phototransistor. The output of the transistor can be connected to any number of control circuits. The comparator circuit for the whisker switches provides a go/no go output to a computer. Figure 2 shows how the LED and phototransistor might be mounted around the base of the robot for detecting an obstacle like a wall, chair, or person.

The set-point adjustment, R3, provides a means to increase or decrease the sensitivity of the circuit (sensitivity can

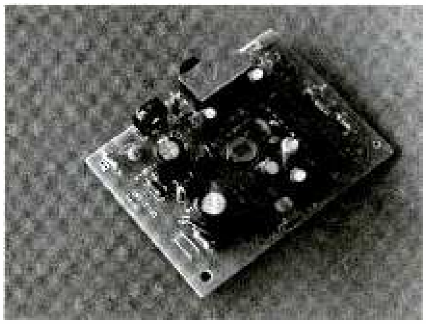


Fig. 5. Here is a hacked PIR detector, showing the DC-operating circuit board.

also be adjusted by changing the value of R2; reduce the value to increase sensitivity). An increase in sensitivity means that the robot will be able to detect objects farther away. A decrease in sensitivity means that the robot must be fairly close to the object for detection.

Bear in mind that all objects reflect light in different ways. You'll probably want to adjust the sensitivity so that the robot best behaves itself in a room with white walls. However, that sensitivity may not be as great when the robot comes to a dark brown couch or the coal gray suit of your boss.

The infrared phototransistor should be baffled—blocked—from both ambient room light and direct light from the LED. The positioning of the LED and phototransistor is very important; the two must be properly aligned. You may wish to mount the LED-phototransistor pair in a small block of wood. Drill holes for the LED and phototransistor.

Passive Infrared-Light Detection

Commonly available passive infrared-detection systems can be used to detect the proximity of humans and animals. Those systems, popular in both indoor and outdoor security systems, work by detecting the change in infrared thermal-heat patterns in front of a sensor. This sensor uses a pair of pyroelectric elements that react to changes in temperature. An instantaneous difference in the output of the two elements is detected as movement, especially movement by a heat-bearing object, such as a human.

Pyroelectric sensors—commonly referred to as *PIR* for passive infrared—can be purchased new or salvaged from an existing motion detector. When salvaging one from an existing detector, you can opt to unsolder the sensor itself and construct an amplification circuit around the removed sensor, or you can attempt to "tap" into the existing circuit of the detector to locate a suitable signal. Both methods are described below.

Using A New Or Removed-From-Circuit Detector

Using a new PIR sensor is by far the easiest approach, as new PIR sensors will come with a datasheet from the manufacturer (or one will be readily available on the Internet). Some sensors—such as the Eltec 422-3—have built-in amplification, allowing for direct connection to a microcontroller or computer. Others require extra circuitry, including amplification, signal filtering, and conditioning.

If you prefer, you can attempt to salvage a PIR sensor from a discarded motion detector. Disassemble the motion detector and carefully unsolder the sensor from its circuit board. The sensor will likely be securely soldered to the board in order to reduce the effects of vibration. Therefore, the unsoldered sensor will have short connection leads. You'll want to resolder the sensor onto another board, being careful to avoid applying excessive heat.

Figure 3 shows a typical three-lead PIR device. The pinouts are not industry-standard, but the arrangement shown is common. Pin 1 connects to +V (often 5 volts); pin 2 is the output, and pin 3 is ground. Physically, PIR sensors look a lot like old-style transistors and come in metal cans with a dark rectangular window on top. Often, a tab or notch will be located near pin 1. As even "unamplified" PIR sensors include an internal FET transistor for amplification, the outputs of the sensor are commonly referred to by their common FET pinout names of *drain* and *source*:

Pin	Name
1	Drain
2	Source
3	Ground

If the sensor has an internal output amplifier and signal conditioner, its output will be suitable for direct connection to a microcontroller or other logic input. A buffer circuit, like that shown in Fig. 4, increases input impedance. The circuit uses an op-amp in a unity-gain configuration.

For both of those circuits, the ideal interface to a robot computer or microcontroller is via an analog-to-digital converter (ADC). Many microcontrollers offer these onboard; if your control circuit lacks a built-in ADC, you can add your own.

The output of the PIR sensor will be a voltage between ground and +V. For example, let's assume that the output will be the full 0–5 volts, though in practice the actual voltage switch will be more restricted (e.g. 2.2 to 4.3 volts, depending on the circuitry you use). Assuming a zero- to 5-volt DC output, with no movement detected the output of the sensor will be 2.5 volts. As movement is detected, the output will swing first in one direction, then the other. This action is important to keep in mind and is caused by the nature of the pyroelectric element inside the sensor. It is also important to keep in mind that a heat source, even directly in front of the sensor, will not be detected if it doesn't move. For a PIR device to work, the heat source must be in motion. When programming your computer or microcontroller, you can look for variances in the voltage that will indicate a rise or fall in the output of the sensor.

SOURCE INFORMATION

Eltec 442-3 Pyroelectric Sensor
Acroname
www.acroname.com

PIR detectors and interfacing circuits
Glolab
www.glolab.com

Enhanced pyroelectric sensors and background information
Intrel
www.intrel.com

Low-cost pyroelectric sensors
Microsystem
home.netcom.com/~gtb/sensor/sensor.html

Hacking Into A Motion-Detector Board

Rather than unsoldering the PIR sensor from a motion-detector unit, you may be able to hack into the motion-detector's circuit board to find a suitable output signal. The advantage of that approach is that you don't have to build a new amplifier for the sensor. The disadvantage is that it can be hard to do, depending on the make and model of the motion-control unit that you use.

For best results, use a motion-detector unit that is battery powered. This avoids any possibility that the circuit board in the unit also includes components to rectify and reduce an incoming AC voltage. After disassembling the motion-detector unit, connect a 5-volt DC power source to the board. Using a multimeter or oscilloscope (the scope is the preferred method), *carefully* probe various points on the circuit board and observe the reading on the meter or scope. Wave your hand over the sensor and watch the meter or scope. If you're lucky, you'll find two kinds of useful signals:

- *Digital (on/off) output.* The output will be normally low, going high when movement is detected. After a brief period (less than one second), the output will go low again; movement is no longer detected. With this output, you do not need to connect the sensor to an analog-to-digital converter.

- *Analog output.* The output will vary several volts and is the amplified output of the PIR sensor. With this output, you will need to connect the sensor to an analog-to-digital converter (or an analog comparator).

You may also locate a timed output, where the output will stay high for a period of time—up to several minutes—after movement is detected. This output is not as useful. Figure 5 shows the innards of a hacked motion detector. In this model, I found a suitable analog output located near a diode. I then soldered a wire to that diode.

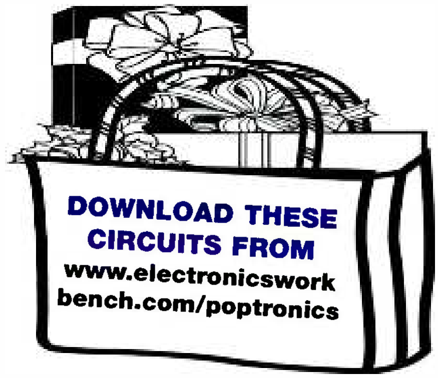
Be careful when poking around inside the motion detector. In one unit that I tried to hack, I accidentally shorted out two pins of an IC, which promptly wrecked the device. Fortunately, I was still able to salvage the PIR sensor itself, so all was not lost.

(Continued on page 64)

BASIC CIRCUITRY

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES



The Psychologically Ultimate Alarm System

Last month, we looked at a number of basic alarm circuits. Before we could combine some of the circuits into a complete burglar-alarm system, we ran out of space and time. This visit, we're going to continue and look at a couple of alarm systems that can be used as examples for building your very own secure and secret system.

Before getting into the system's circuitry, I would like to share some tips on installation and the art of spreading "red herrings." It's almost always best to keep your alarm system out of sight, except when a fake or non-working unit is used as a decoy to distract and possibly help catch a burglar. If a burglar comes across a legitimate-appearing control unit with the control key still in place to deactivate the system, there's a good chance it will be done. If the key switch just happens to be wired into the sensor circuit of the "real" alarm system and the perpetrator bites, then priorities shift from stealing to getting away before the authorities arrive. The successful burglar likes working in a peaceful and tranquil place, and anything your alarm system can do to change that serene setting into a chaotic trap betters the chances that nothing will be taken in the process.

Another area where good installation techniques can help make your system more difficult to penetrate is to hide your door and window sensors or at least not allow the connecting wires or terminals to show. A well-placed "looking good" door or window sensor can confuse or delay the burglars or cause them to become confident that the system can easily be breached by wiring across the exposed contacts. Surprise!

Using a dual-alarm system with both actually operating is a good way to real-

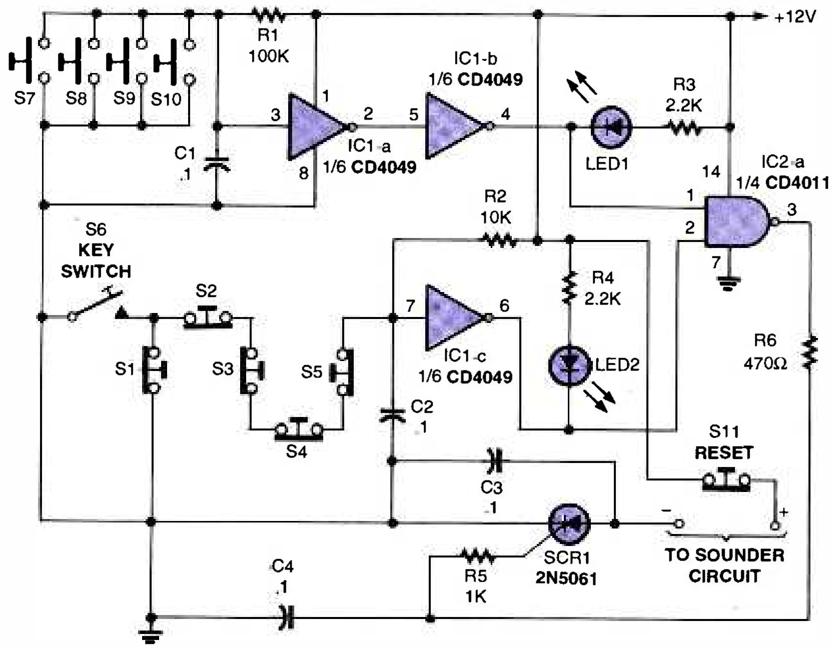


Fig. 1. This alarm circuit can handle both normally open and normally closed sensor switches. All you need to add is a suitable power supply and a siren.

PARTS LIST FOR THE INVERTER-BASED ALARM CIRCUIT (FIG. 1)

SEMICONDUCTORS

IC1—CD4049 hex inverting buffer, integrated circuit

IC2—CD4011 quad 2-input NAND gate, integrated circuit

LED1, LED2—Light-emitting diode, any color

SCR1—2N5061 silicon-controlled rectifier (see text)

RESISTORS

(All resistors are ¼-watt, 5% units.)

R1—100,000-ohm

R2—10,000-ohm

R3, R4—2200-ohm

R5—1000-ohm

R6—470-ohm

ADDITIONAL PARTS AND MATERIALS

C1–C4—0.1-µF, ceramic-disc capacitor

S1–S5—Single-pole, single-throw, normally closed sensor switch

S6—Single-pole, single-throw, key-operated switch

S7–S10—Single-pole, single-throw, normally open sensor switch

S11—Single-pole, single-throw, normally closed pushbutton switch

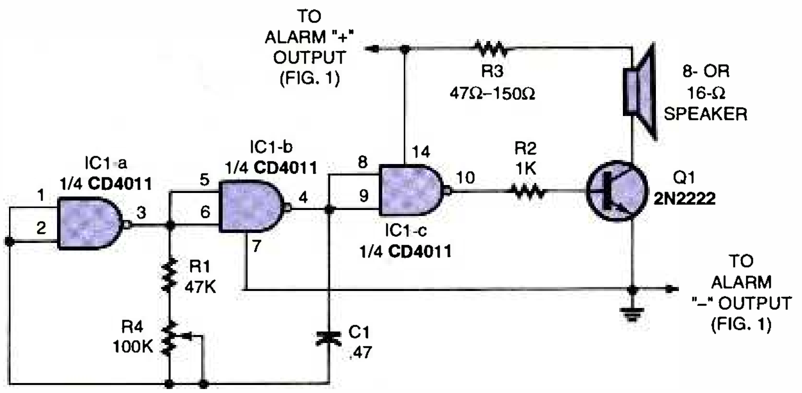


Fig. 2. A pair of inverting gates form an oscillator that "sounds the alarm" when power is applied.

PARTS LIST FOR THE SIMPLE SOUNDER CIRCUIT (FIG. 2)

IC1—CD4011 quad 2-input NAND gate, integrated circuit
Q1—2N2222 NPN silicon transistor
C1—0.047-µF, ceramic-disc or similar capacitor
R1—47,000-ohm, ¼-watt, 5% resistor
R2—1000-ohm, ¼-watt, 5% resistor
R3—47-ohm, ¼-watt, 5% resistor
R4—100,000-ohm, ¼-watt, 5% resistor
SPKR1—Small 8- or 16-ohm speaker

ly confuse a would-be burglar and to up the security of an alarm system. One system could be used to cover all areas, and the secondary system could be used to double-cover critical areas. In any case, it would make penetrating the system much more difficult.

Always have a rechargeable backup battery for your alarm system. If the power fails or the intruder turns the power off, the alarm will still operate. Also, never fully rely on an alarm system that uses a phone dialer as the only outlet for your alarm system. Phone lines are just too easy for a knowledgeable burglar to disable or cut. Using a cellular phone system might be a better answer when a dialer is part of the alarm system. At least, it would be an area worth examining.

Okay, I think you get the picture—now on to building the alarm system.

A Complete Alarm System

Our first complete burglar alarm system is shown in Fig. 1. The circuit is set up to operate with both normally open and normally closed sensor circuits. The normally open sensor circuit operates with two CD4049 inverting buffers that supply a high input to IC2-a, a CD4011 NAND gate. The normally closed sensor circuit operates with a single CD4049 inverter supplying a high to the second input of IC2-a. With both inputs high, the NAND gate's output is low. As long as the gate's output is low, the SCR will remain off and the alarm will remain silent. Any number of normally open or closed sensors may be used with the alarm circuit. The number of sensors does not matter—only the change in condition makes a difference.

Light-emitting diodes LED1 and LED2 remain dark as long as all sensors are in their normal operating condition. The two 0.1-µF ceramic-disc capacitors tied across the inputs of IC1-a and IC1-c help keep stray RF and noise out of the system. If RF or random noise becomes a problem, an RF choke can be inserted in series with the sensor string and the input of the CD4049s.

A key-operated entrance/exit switch, S6, allows passage through a protected door without setting off the alarm. A similar switch could be used in the normally open sensor circuit by connecting the key switch in series with the normally open door switch.

Silicon-controlled rectifier SCR1 is the latching and memory device that turns on the alarm sounder when any one (or more) of the input sensors changes state. A low-current SCR, such as the 2N5061, will supply up to 800 mA to the alarm-sounder circuit. A low-cost, 4-amp, sensitive-gate SCR from Mouser Electronics will handle most high-power 12-volt alarm-sounder circuits, home built or commercial.

Before moving on, let's discuss how the circuit sends the alarm signal. If a normally open sensor switch closes, the input of inverter IC1-a goes low. The high output of IC1-a takes the input of IC1-b high as well. The output of IC1-b goes low, taking the input at pin 1 of IC2-a low as well. That action switches

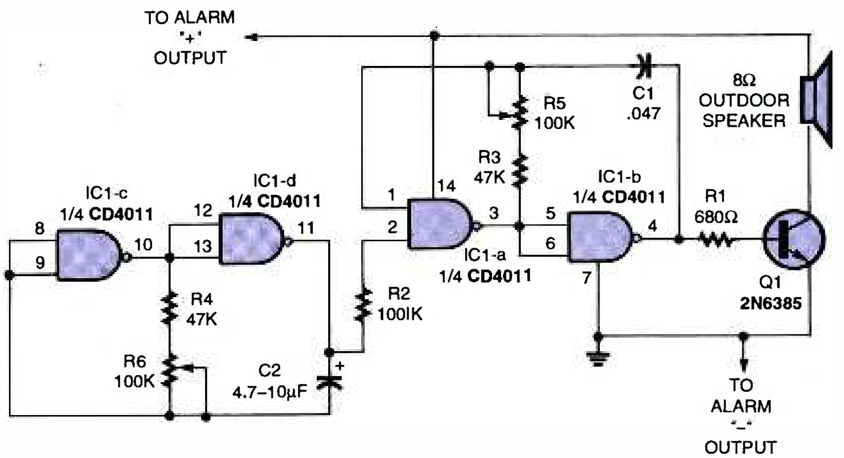


Fig. 3. To increase the "attention-getting" aspect of the siren, this circuit uses two oscillators—one to generate the base audio tone and one to modulate the tone generator.

PARTS LIST FOR THE COMPLEX SOUNDER CIRCUIT (FIG. 3)

IC1—CD4011 quad 2-input NAND gate, integrated circuit
Q1—2N6385 NPN Darlington power transistor
C1—0.047-µF, ceramic-disc or similar capacitor
C2—4.7–10-µF, 25-WVDC, electrolytic capacitor
R1—680-ohm, ¼-watt, 5% resistor
R2—100,000-ohm, ¼-watt, 5% resistor
R3, R4—47000-ohm, ¼-watt, 5% resistor
R5, R6—100,000-ohm potentiometer
SPKR1—8-ohm, outdoor-type metal-cone speaker

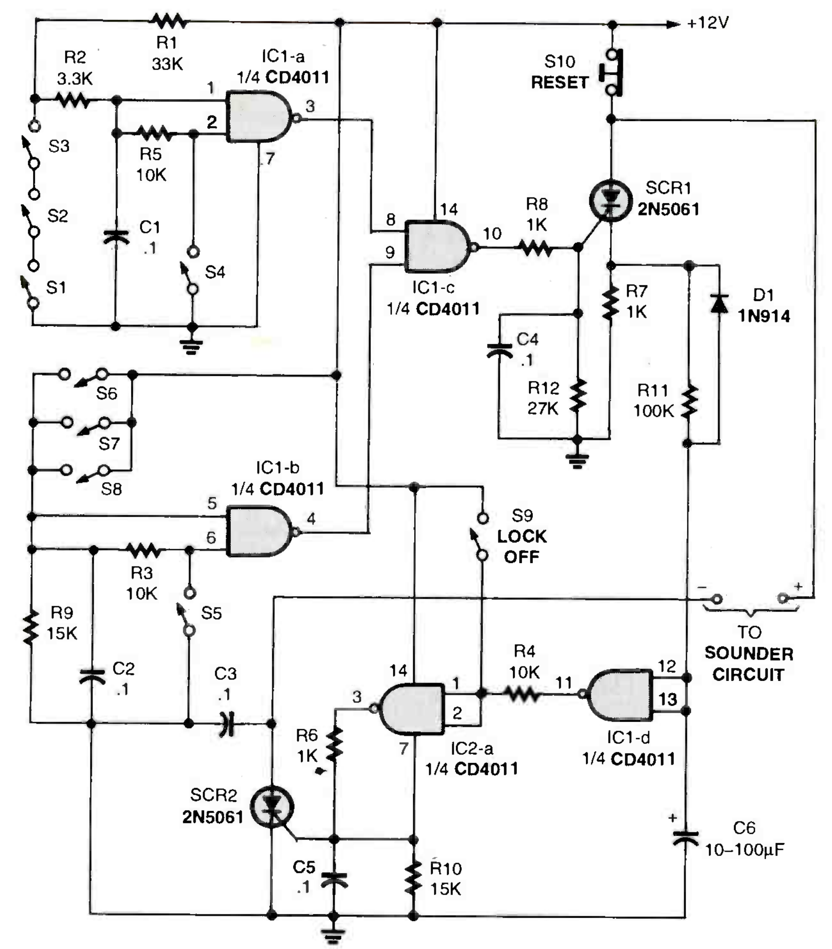


Fig. 4. A more sophisticated version of Fig. 1 uses NAND gates to bypass faulty sensors during troubleshooting and repair.

PARTS LIST FOR THE NAND-GATE-BASED ALARM CIRCUIT (FIG. 4)

SEMICONDUCTORS

IC1, IC2—CD4011 quad 2-input NAND gate, integrated circuit
D1—1N914 silicon signal diode
SCR1—2N5061 0.8-amp silicon-controlled rectifier
SCR2—4-amp, sensitive-gate silicon-controlled rectifier (Mouser 511-X0402BE or similar)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—33,000-ohm
R2—3300-ohm
R3–R5—10,000-ohm
R6–R8—1000-ohm
R9, R10—15,000-ohm
R11—100,000-ohm

ADDITIONAL PARTS AND MATERIALS

C1–C5—0.1-µF, ceramic-disc capacitor
C6—10–100-µF, 25-WVDC, electrolytic capacitor
S1–S3— Single-pole, single-throw, normally closed sensor switch
S4–S5, S9—Single-pole, single-throw toggle switch
S6–S8—Single-pole, single-throw, normally open sensor switch
S10—Single-pole, single-throw, normally closed pushbutton switch

IC2-a's output (pin 3) high, turning on the SCR and sounding the alarm. Switch S11 is a normally closed switch that's connected in series with the alarm-sounder circuitry. When momentarily opened, the alarm is reset. The reset function will only work if all input sensors have been returned to their normal operating condition. If not, the alarm's power must be turned off to silence the alarm.

The same holds true for the normally closed sensor circuit. When any one of the normally-closed sensors open, the input at IC1-c (pin 7) goes high. Its output goes low, taking the input at pin 2 of IC2-a low. That causes IC2-a's output to go high, which turns on the SCR and sounds the alarm.

Simple Screeching Sirens

A simple low-volume sounder circuit is shown in Fig 2. This is a handy circuit for testing purposes and for any low security at the office or home where a loud alarm sounder is not needed. Three gates of a quad 2-input CD4011 NAND gate make up the sounder's oscillator and driver circuit. A single 2N2222 transistor serves as the speaker driver. Adjusting R4 sets the frequency tone to suit, and changing the value of C1 can vary the operating frequency range. Use a larger capacitor value for lower tones and vice versa for higher tones.

The sounder circuit connects to the alarm system in Fig. 1 by connecting the sounder's ground circuit to the anode of the SCR and the sounder's positive terminal to the system's positive sounder-output terminal.

Red Alert!

A more powerful and attention-getting alarm-sounder circuit is shown in Fig. 3. A single CD4011 2-input quad NAND gate IC makes up the sound-generating circuitry, and a special type of Darlington power transistor moves the speaker cone. Gates IC1-a and IC1-b make up the attention-getting alarm-oscillator circuit, with the tone frequency set by C1, R3, and R5. The attention-getting part of the alarm sounder is the low-frequency-oscillator circuit—made up of gates IC1-c and IC1-d—that modulates the alarm oscillator circuit, giving it an interrupted output. The comparison of this output to a steady tone is as a steady light source compared to one that rapidly flashes on and off.

Both oscillator circuits operate in a fashion similar to the oscillator circuit in Fig. 2, with input pin 1 of IC1-a connecting to the output of the low-frequency oscillator circuit, pin 11 of IC1-d. When the output of the low-frequency oscillator goes high, the tone generator turns on and sends out a loud tone. When the low-frequency oscillator's output goes low, the tone ceases for that time period. The interrupted tone is a hard one to ignore, especially if you're the burglar. The tone frequency and the interrupted rate may be varied with R5 and R6, respectively.

Bells And Whistles

Our next complete alarm system, see Fig. 4, is slightly more complex than our first, but the parts count isn't anything to get concerned about. It is offered as an example to get you started on your very own alarm design. This system also operates with both normally open and normally closed sensors. A delay timer has been added as well as several "lockout" switches, which allow more control over the sensor and timing circuits.

The sensor input circuitry is very similar to our first alarm system. This time, we've replaced the inverters with NAND gates. The use of NAND gates allows another input for additional control. The extra gate inputs allows for a "lockout" feature to easily be added to the alarm's sensor and timer circuits.

The lockout switches, S4 and S5, allow all of the sensors to be disabled—or "locked out"—unable to influence or trigger the alarm sounder. The timer lockout switch, S9, terminates the timer's output and keeps the alarm from sounding when the timer times out.

Here's how the alarm system operates with all three lockout switches not in operation and all sensors in their normal circuit condition. Both inputs of IC1-a and IC1-b are low, and their outputs are high. That puts both inputs of IC1-c high as well and its output low. Silicon-controlled rectifier SCR1 remains off, and the voltage at the top of R7 is near ground level. The timer circuit is not activated, and the output at IC2-a is low. That keeps SCR2's gate voltage near ground level. With SCR2 off, no alarm is sounded.

If a sensor changes from its normal operating condition to an alarm condition, the output of IC1-a or IC1-b will go low, producing a high output at pin 10 of IC1-c. That signal turns on SCR1. The voltage at the top of R7 will go high, charging C4 through timing resistor R11. When the voltage across C4 increases to about 6 or 7 volts, IC1-d changes output state, taking the inputs (pins 1 and 2) of IC2-a low. The output of IC2-a goes high (pin 3), turning on SCR2 and sounding the alarm.

Opening S10 will reset the alarm if all the sensors are returned to their normal operating condition. If, for some reason, a sensor was intermittingly operating or just giving trouble, the lockout switch associated with that sensor group could be turned on, and the circuit would still operate with the other input sensors while you make repairs. Light-emitting diodes can be added to the outputs of the sensor gates IC1-a and IC1-b by duplicating the LED circuits in Fig. 1.

Selecting component values for R11 and C6 sets the delay timer. Larger values for both extend the time, and smaller values reduce the time. Resistor values for R11 should not go much higher than about one megohm, as the leakage resistance of C6 could keep the timer from operating. A one-megohm resistor and a 47-µF good quality electrolytic capacitor will give a time delay of about 30 seconds; however, most electrolytic capacitors have a very broad tolerance range. To obtain an exact timing period, some experimenting will be needed. Besides, that is where all of the fun in electronics happens!

We could go on forever on alarm circuits, but it's about time to close for now; so get busy and design and build a super burglar alarm system!

Who knows what interesting circuits will emerge here next time? To find out, be here! P

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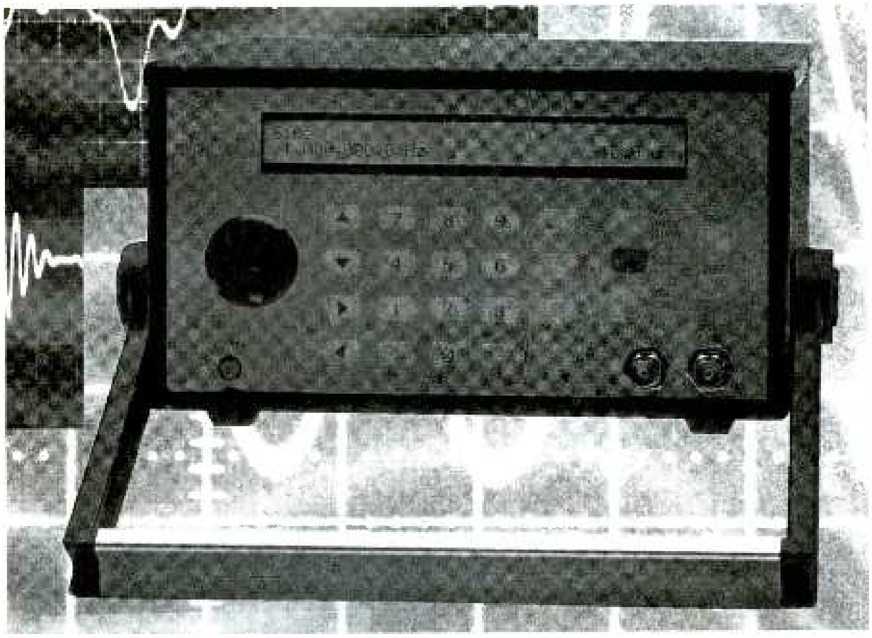
Function Generator



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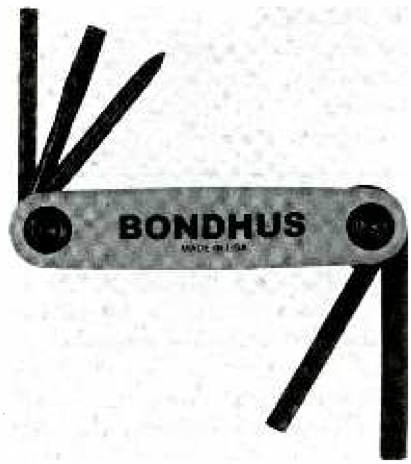

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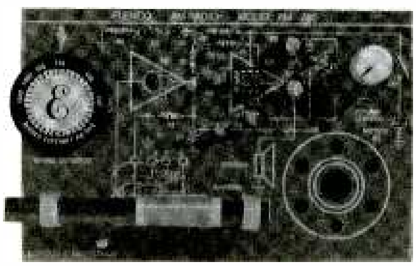

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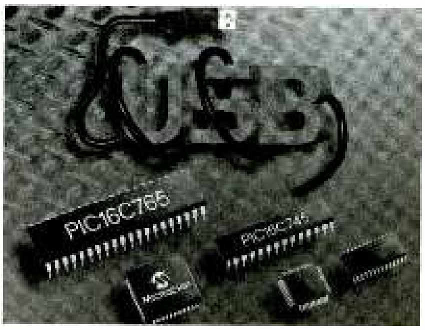
fied, and there is a troubleshooting section in case of problems.

The AM-780 AM Radio Kit (5.3 by 3.5 inches) lists for $13.25.

ELENCO ELECTRONICS, INC.
150 W. Carpenter Ave.
Wheeling, IL 60090
847-541-3800
www.elenco.com

PIC Microcontroller

EXPANDING CONNECTIVITY OPtions for its PICmicro 8-bit microcontrollers , Microchip recently introduced a family of two one-time programmable (OTP) devices supporting the USB 1.1 low-speed interface. The *PIC16C745* and *PIC16C765* 8-bit microcontrollers feature a software detachment mechanism that allows the peripheral to remove itself from the system without removing the cable. They also offer ample processing bandwidth to enable USB functionality and other control functions in a single-chip microcontroller.



CIRCLE 65 ON FREE INFORMATION CARD

The 745 and the 765 feature 22 and 33 I/O ports and 5-channel and 8-channel 8-bit analog-to-digital converters, respectively. The 28-pin 745 and the 40-pin 765 both contain 8k by 14 words of program memory and 256 bytes of user RAM. Both devices provide an on-chip bandgap voltage reference, oscillator mode, brown-out detection, enhanced Capture/Compare/Pulse-Width Modulation, USART interface, one 16-bit timer, and a Watchdog timer.

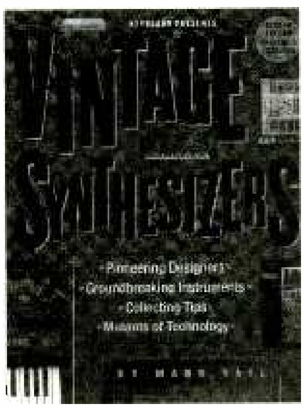
No price has been set for individual PIC16C745/65 8-bit microcontrollers at press time, but they will be available through Digi-Key (*www.digikey.com*) by the time this is published.

MICROCHIP TECHNOLOGY INC.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199
480-786-7668
www.microchip.com

Vintage Synthesizers, Second Edition

by Mark Vail
Miller Freeman Books
55 Hawthorne St., Suite 600
San Francisco, CA 94105
800-848-5594 or 408-848-5296
www.books.mfi.com
$27.95

Tracing the development of the analog, modular, and digital synthesizers and samplers that began in the early 60s, this tour showcases dozens of vintage models. Groundbreaking instruments are seen in a colorful photographic gallery. The book features in-depth interviews with pioneering synth designers, including the famed Bob Moog and Alan R. Pearlman of Moog Music and ARP Instruments, respectively. These innovators discuss their original designs and reflect on their successes and failures.

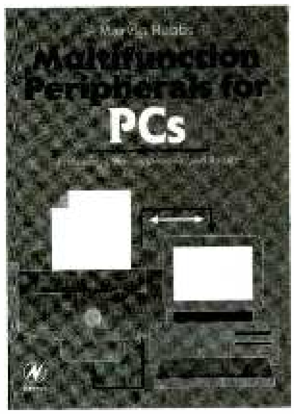


In addition to interviews and photos, there is completely revised and updated information on pricing and products, an expanded section on support services, coverage of Japanese synthesizers, and a discography of must-hear synth recordings. The estimated values of over 300 instruments; dealers' tips on finding, buying, restoring, and maintaining vintage synths; recommended books and Web sites—all are found in these helpful pages.

Multifunction Peripherals for PCs: Technology, Troubleshooting, and Repair

by Marvin Hobbs
Newnes, Butterworth-Heinemann
225 Wildwood Ave.
Woburn, MA 01801
800-366-2665 or 781-904-2500
www.newnespress.com
$32.95

Multifunction devices combine the functions of a fax machine, printer, scanner, and copier into one peripheral device meant for SOHOs. This resource explains how multifunction peripherals work in theory and in practice, with lots of hands-on examples and important troubleshooting and repair tips.

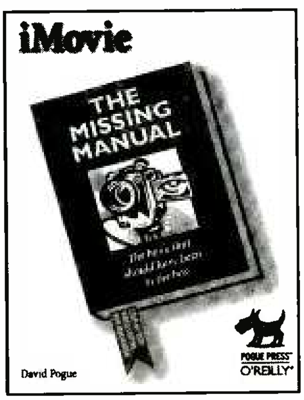


Contents include descriptions of all types of printing, from plain paper to electrophotographic; discussions of service mode options, adjustments, and various test modes; explanations of scanner and print mechanisms, circuitry, and power supplies; troubleshooting flow charts, disassembly and reassembly instructions, and remote safety precautions.

iMovie: The Missing Manual

by David Pogue
O'Reilly and Associates, Inc.
101 Morris St.
Sebastopol, CA 95472
800-998-9938 or 707-829-0515
www.oreilly.com
$19.95

In 1999, Apple Computer made digital video editing easy by building circuitry into their MacDV computers that can record video directly from a digital camcorder and send the edited movie back to either TV or tape. The pre-installed editing software *iMovie* makes it all possible. However, no published manual comes with this software, and that's where the Missing Manual series comes in.



The iMovie book in this series takes readers through every step of iMovie video production, from choosing a camcorder to burning finished films onto CDs. The author shows iMovie-makers how to maximize their use of the software and reduce the cost, complexity, and difficulty of desktop video production.

Exploring the World of SCSI

by Louis Columbus
Prompt Publications
Sam's Technical Publishing
5436 W. 78th St.
Indianapolis, IN 46268
800-428-7267
www.samswebsite.com
$34.95

Focusing on the needs of the hobbyist, PC enthusiast, and/or systems administrator, this comprehensive book is for anyone interested in learning the hands-on aspects of SCSI. It discusses bus mastering and caching and working with the Logical Unit Numbers (LUNs) within SCSI, in addition to explaining termination and the different performance levels of RAID.

This book contains both real-world applications and theoretical information. It can be used as both a desktop reference, and a guide to configuring SCSI on a workstation or server. There are troubleshooting tips and tricks for networking SCSI devices, as well as information about the role of SCSI in network-based storage.

TALKING TRAIN STATION

(continued from page 31)

position. When power is applied, the circuit will automatically play back whatever sound is stored within IC1 once. Adjust R2 to the desired volume level. To repeat the recording, the power switch must be opened and re-closed. For manual operation, the Fig. 2 setup will do just fine. Simply close the power switch, and the Talking Station will begin playing.

An alternative wiring configuration, shown in Fig. 3, is for automatic operation. A Lionel No. 145C contactor is a good choice for such control. It is essentially a single-pole, single-throw, normally open momentary-contact switch that is closed by the weight of a passing train. The recording plays once and stops until the train departs and returns. Of course, if the train is an express or stops for less than the length of the recording, the sound will cut off when the contactor opens.

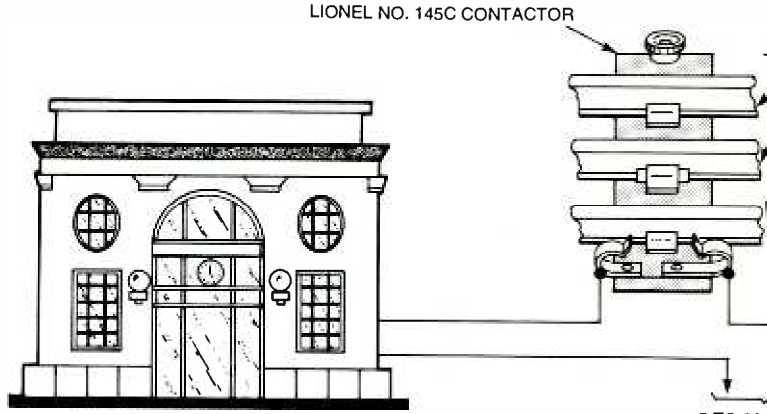


Fig. 3. How to set up the Talking Station for automatic operation.

PARTS LIST FOR THE TALKING STATION

SEMICONDUCTORS

IC1—ISD1000A voice record/playback, integrated circuit
IC2—LM386 audio amplifier, integrated circuit
IC3—LM7805 5-volt DC fixed-voltage regulator, integrated circuit
BR1—Full-wave Bridge Rectifier, 1-amp, 50-volt

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R3—2200-ohm
R2—10,000-ohm potentiometer
R4—1000-ohm

CAPACITORS

C1, C2—0.1-µF, ceramic-disc
C3—22-µF, 35-WVDC, tantalum electrolytic
C4—100-µF, 35-WVDC, electrolytic
C5, C6—0.22-µF, ceramic-disc
C7—220-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—Phono jack
S1—Single-pole, single-throw, normally open momentary-contact pushbutton switch
S2—Single-pole, double-throw toggle switch
SPKR1—8-ohm, 3-inch speaker
Breadboard, wire, hardware, etc.

Those who are familiar with model-train-detection circuits and methods could use other ways to activate the Talking Station. For example, an insulated outer rail that is "grounded" to the other rail by the train's wheels can power the station without the adjustment headaches associated with the 145C. If you have a two-rail system, such as HO or N scales, one of the many detector circuits that sense motor current or lamp current in lighted cars can activate a relay to power the Talking Station. Such circuits are beyond the scope of this article; information on them is widely available in the model-railroading community.

The Talking Station is a very flexible circuit and can be used in a number of ways to bring your layout to life. Experiment with different recording techniques and speaker placements until you find the most satisfactory combination.

Now your model stations can actually yell, "All aboard!" ■

ROBOTICS WORKSHOP

(continued from page 56)

Using A Focusing Lens

PIR sensors work by detecting electromagnetic radiation in the infrared region, specifically about 5 to 15 micrometers (5000 to 15,000 nanometers). Infrared radiation in this part of the spectrum can be focused using visible-light optics. While you can use a PIR device without focusing, you'll find that the range and sensitivity is greatly enhanced when you use a lens. Most motion detectors use a specially designed Fresnel lens to focus infrared radiation. The lens, a piece of plastic with grooves, is made to gather more light at the top than at the bottom. With this geometry and with the sensor mounted high and pointing down, the motion detector is more sensitive to movement further away than right underneath.

If you've gotten your PIR sensor from hacking a motion detector, you can use the same Fresnel lens for your robot. You may wish to invert the lens, in reverse of its usual orientation (because your robot will likely be near the ground, looking up). Or, you can substitute an ordinary positive-diopter lens and mount it in front of the PIR sensor. Note that, oddly enough, plastic lenses are probably the better choice than glass lenses. Several kinds of glass actively absorb infrared radiation. You may need to experiment with the lens material you use or obtain a specialty lens (either regular or Fresnel) designed for use with PIR devices.

Next month: ultrasonic sound, contact pressure sensors, and more. ■

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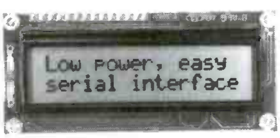

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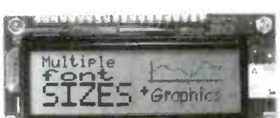

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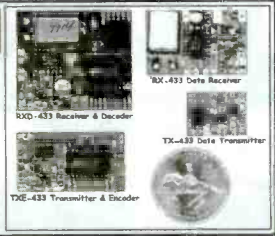
RAMSEY

Doppler Direction Finder

Track down jammers and hidden transmitters with ease! This is the famous WA2EBY DF'er featured in April 99 QST. Shows direct bearing to transmitter on compass style LED display, easy to hook up to any FM receiver. The transmitter - the object of your DF'ing - need not be FM, it can be AM, FM or CW. Easily connects to receiver's speaker jack and antenna, unit runs on 12 VDC. We even include 4 handy home-brew "mag mount" antennas and cable for quick set up and operation! Whips can be cut and optimized for any frequency from 130-1000 MHz. Track down that jammer, win that fox hunt, zero in on that downed Cessna - this is an easy to build, reliable kit that compares most favorably to commercial units costing upwards of $1000.00! This is a neat kit!!

DDF-1, Doppler Direction Finder Kit **$149.95**

Wireless RF Data Link Modules



RF link boards are perfect for any wireless control application; alarms, data transmission, electronic monitoring...you name it. Very stable SAW resonator transmitter, crystal controlled receiver - no frequency drift! Range up to 600 feet, license free 433 MHz band. Encoder/decoder units have 12 bit Holtek HT-12 series chips allowing multiple units all individually addressable, see web site for full details. Super small size - that's a quarter in the picture! Run on 3-12 VDC. Fully wired and tested, ready to go and easy to use!

RX-433 Data Receiver.......... **$16.95** **TX-433 Data Transmitter**............. **$14.95**
RXD-433 Receiver/Decoder..... **$21.95** **TXE-433 Transmitter/Encoder**..... **$19.95**

World's Smallest TV Transmitters

We call them the 'Cubes'.... Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies - that's a nickel in the picture! Transmits color or B&W with fantastic quality - almost like a direct wired connection to any TV tuned to cable channel 59. Crystal controlled for no frequency drift with performance that equals models that cost hundreds more! Basic 20 mW model transmits up to 300' while the high power 100 mW unit goes up to 1/4 mile. Their very light weight and size make them ideal for balloon and rocket launches, R/C models, robots - you name it! Units run on 9 volts and hook-up to most any CCD camera or standard video source. In fact, all of our cameras have been tested to mate perfectly with our Cubes and work great. Fully assembled - just hook-up power and you're on the air! One customer even put one on his dog!

C-2000, Basic Video Transmitter..............**$89.95** **C-2001, High Power Video Transmitter**...**$179.95**

CCD Video Cameras

Top quality Japanese Class 'A' CCD array, over 440 line line resolution, not the off-spec arrays that are found on many other cameras. Don't be fooled by the cheap CMOS single chip cameras which have 1/2 the resolution, 1/4 the light sensitivity and draw over twice the current! The black & white models are also super IR (Infra-Red) sensitive. Add our invisible to the eye, IR-1 illuminator kit to see in the dark! Color camera has Auto gain, white balance, Back Light Compensation and DSP! Available with Wide-angle (80º) or super slim Pin-hole style lens. Run on 9 VDC, standard 1 volt p-p video. Use our transmitters for wireless transmission to TV set, or add our IB-1 Interface board kit for super easy direct wire hook-up to any Video monitor, VCR or TV with A/V input. Fully assembled, with pre-wired connector.

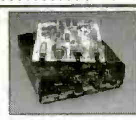
CCDWA-2, B&W CCD Camera, wide-angle lens **$69.95**
CCDPH-2, B&W CCD Camera, slim fit pin-hole lens. . **$69.95**
CCDCC-1, Color CCD Camera, wide-angle lens **$129.95**
IR-1, IR Illuminator Kit for B&W cameras **$24.95**
IB-1, Interface Board Kit **$14.95**

AM Radio Transmitter

Operates in standard AM broadcast band. Pro version, AM-25, is synthesized for stable, no-drift frequency and is setable for high power output where regulations allow, typical range of 1-2 miles. Entry-level AM-1 is tunable, runs FCC maximum 100 mW, range 1/4 mile. Both accept line-level inputs from tape decks, CD players or mike mixers, run on 12 volts DC. Pro AM-25 includes AC power adapter, matching case and bottom loaded wire antenna. Entry-level AM-1 has an available matching case and knob set that dresses up the unit. Great sound, easy to build - you can be on the air in an evening!

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

Mini Radio Receivers



Imagine the fun of tuning into aircraft a hundred miles away, the local police/fire department, ham operators, or how about Radio Moscow or the BBC in London? Now imagine doing this on a little radio you built yourself - in just an evening! These popular little receivers are the nuts for catching all the action on the local ham, aircraft, standard FM broadcast radio, shortwave or WWV National Time Standard radio bands. Pick the receiver of your choice, each easy to build, sensitive receiver has plenty of crystal clear audio to drive any speaker or earphone. Easy one evening assembly, run on 9 volt battery, all have squelch except for shortwave and FM broadcast receiver which has subcarrier output for hook-up to our SCA adapter. The SCA-1 will tune in commercial-free music and other 'hidden' special services when connected to FM receiver. Add our snazzy matching case and knob set for that smart finished look!

AR-1, Airband 108-136 MHz Kit................. **$29.95**
HFRC-1, WWV 10 MHz (crystal controlled) Kit..... **$34.95**
FR-1, FM Broadcast Band 88-108 MHz Kit........ **$24.95**
SR-1, Shortwave 4-11 MHz Band Kit **$29.95**
SCA-1 SCA Subcarrier Adapter kit for FM radio.... **$27.95**
FR-6, 6 Meter FM Ham Band Kit **$34.95**
FR-10, 10 Meter FM Ham Band Kit.......... **$34.95**
FR-146, 2 Meter FM Ham Band Kit.......... **$34.95**
FR-220, 220 MHz FM Ham Band Kit......... **$34.95**
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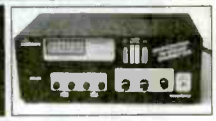
RSG-1000B RF Signal Generator....................... **$1995.00**

Super Pro FM Stereo Transmitter



Professional synthesized FM Stereo station in 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 freq with Up/Down buttons, big LED display. Input low pass filter gives great sound (no more squeals or swishing from cheap CD inputs!) Limiters for max 'punch' in audio - without over mod, LED meters to easily set audio levels, built-in mixer with mike, line level inputs. Churches, drive-ins, schools, colleges find the FM-100 the answer to their transmitting needs, you will too. Great features, great price! Kit includes cabinet, whip antenna, 120 VAC supply. *We also offer a high power export version of the FM-100 fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped if accompanied by a signed statement that the unit will be exported.*

FM-100, Pro FM Stereo Transmitter Kit **$249.95**
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FM Stereo Radio Transmitters

No drift, microprocessor synthesized! Great audio quality, connect to CD player, tape deck or mike mixer and you're on-the-air. Strapable for high or low power! Runs on 12 VDC or 120 VAC. Kit includes snazzy case, whip antenna, 120 VAC power adapter - easy one evening assembly.

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Lower cost alternative to our high performance transmitters. Great value, easily tunable, fun to build. Manual goes into great detail about antennas, range and FCC rules. Handy for sending music thru house and yard, ideal for school projects too - you'll be amazed at the exceptional audio quality! Runs on 9V battery or 5 to 15 VDC. Add matching case and whip antenna set for nice 'pro' look.

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FM Station Antennas

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TM-100, FM Antenna Kit **$39.95**
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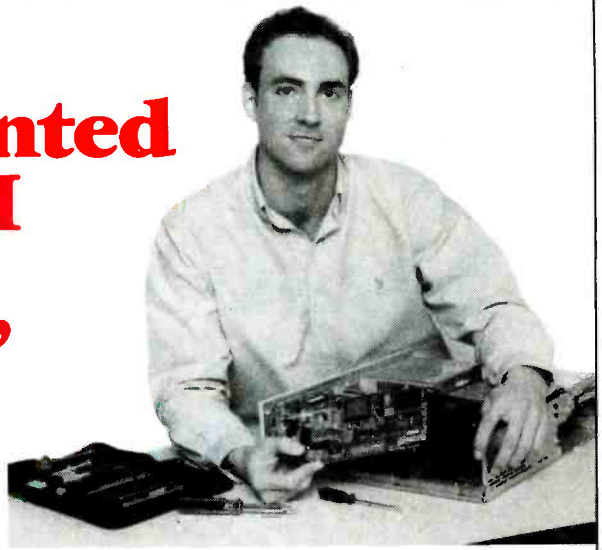

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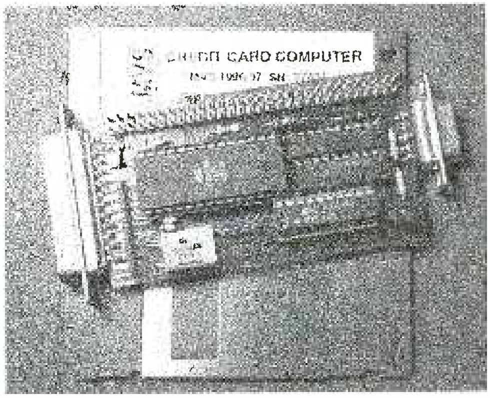

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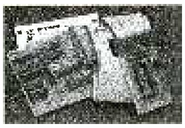

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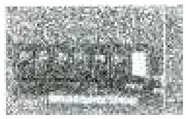

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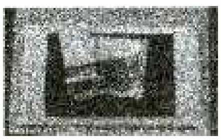

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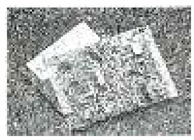

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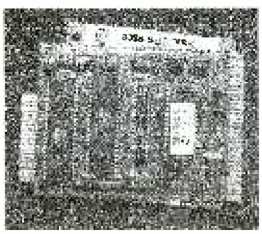

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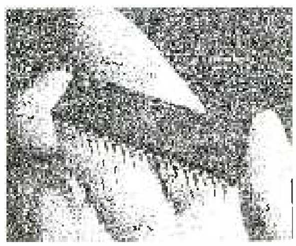

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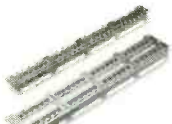

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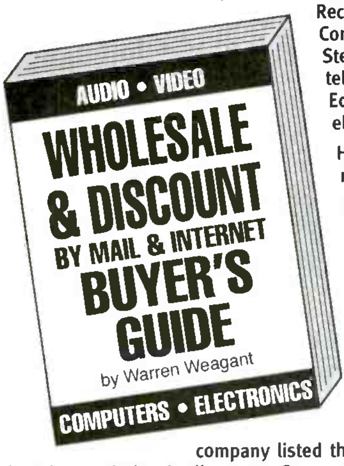

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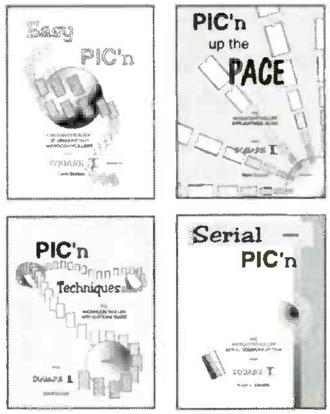

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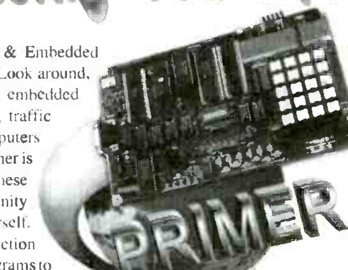

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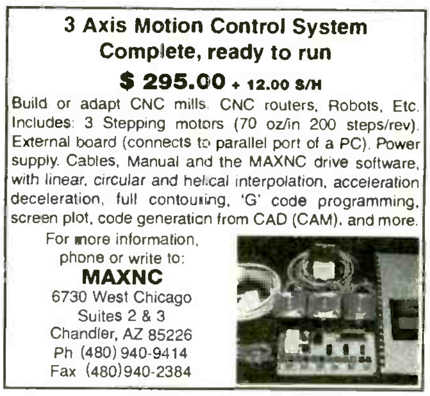

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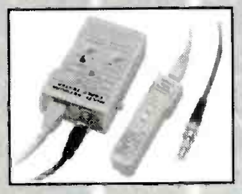

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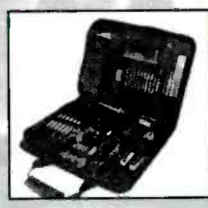

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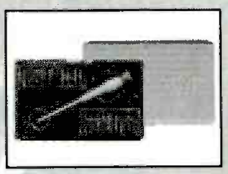

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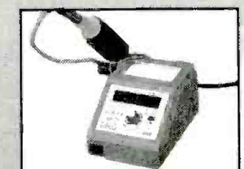

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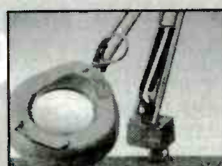

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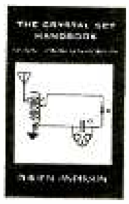

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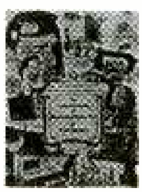

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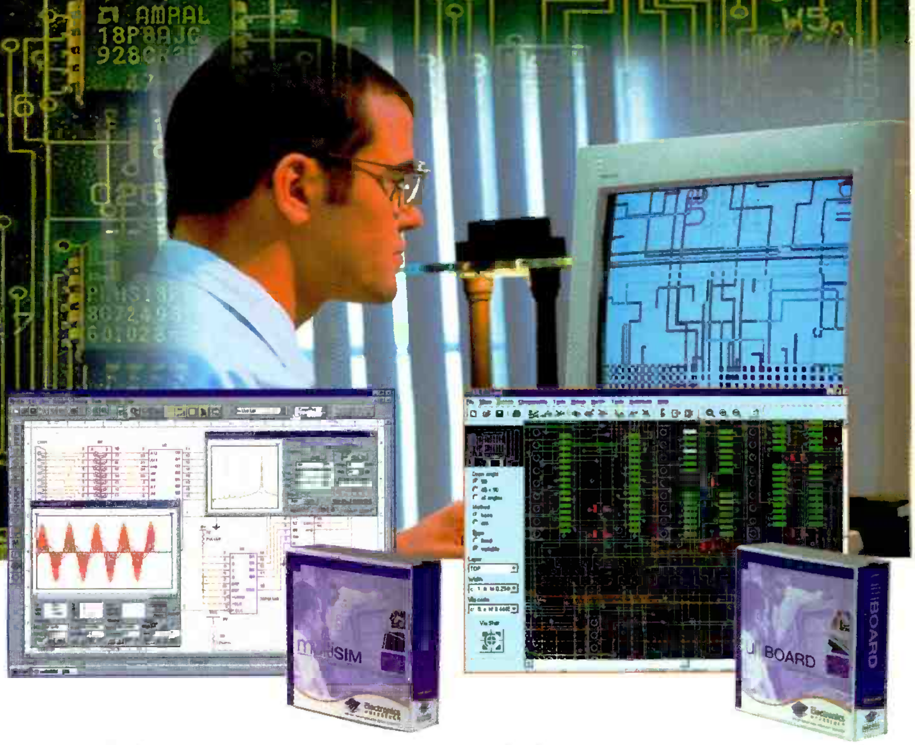

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