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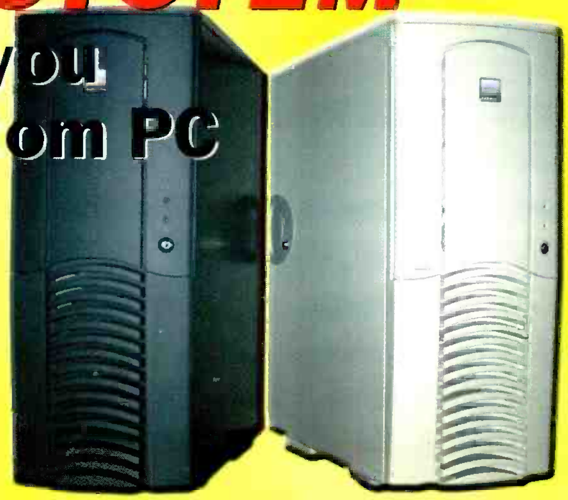

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TEST YOUR KNOWLEDGE

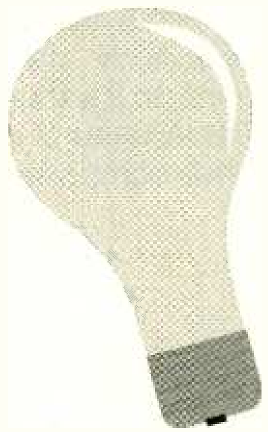
Can you match the following components with their proper description?

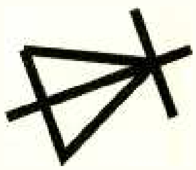
A. Transformer

B. Transistors

C. Resistor

D. Capacitor





1. This component is used as a blocking device in DC circuits and as a coupling device in AC circuits. This device stores energy between two plates separated by a substance known as dielectric. The non-polarized types of these components are made of polystyrene, polyester, and ceramic. The polarized types are often referred to as electrolytic.

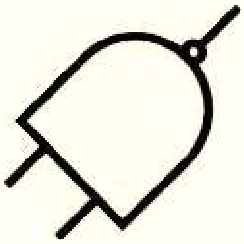
2. These components are designed to have low ohmic-resistance and a very high reactance at radio frequencies. They will pass DC, but will block high-frequency AC if both AC and DC are present in the same circuit. At low frequencies, this device will react similar to a series-resonant circuit, and at high frequencies it will react similar to a parallel-resonant circuit.

3. This component consists of two coils that have mutual inductance. One coil is referred to as the primary winding, and the other is referred to as the secondary winding. This component is used in AC circuits in order to step-up/step-down voltage.

4. This component is the equivalent of two diodes placed back-to-back with a common middle layer. It contains three elements—base, collector, and emitter—and is categorized as either a PNP or NPN. Common uses for this component are as an amplifier, a switch, or a detector in a simple radio circuit.

E. RF Choke

F. LED



5. This component is a two-element semiconductor that releases energy in the form of light when conduction occurs in a specific direction. A ballast resistor is used in conjunction with this device in order to limit the voltage applied to it, as well as limit the current flowing through it.

6. This component is designed to absorb energy, which is dissipated in the form of heat. Frequency does not affect this component, so it is found in both AC and DC circuits. A series of color bands is used to label the component's value and tolerance.

A3, B4, C6, D1, E2, F5

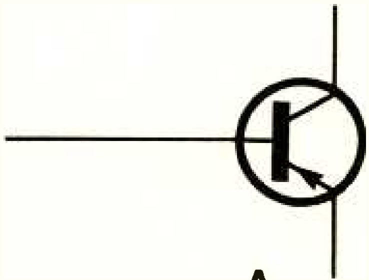
Now, let's test your knowledge of schematic symbols. Match each symbol with the correct component name.

1. Tunnel Diode

2. PNP Transistor

3. Varactor Diode

4. Crystal



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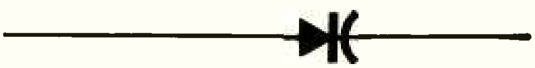

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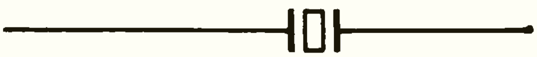

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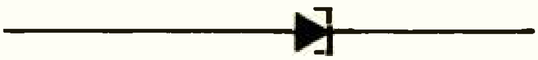

D

1D, 2A, 3B, 4C

NEW LITERATURE

The ARRL Handbook for Radio Amateurs 2002

Edited by Dana George Reed, KD1CW
ARRL
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888-277-5289
www.arrl.org
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Providing a wealth of technical information, this handbook is a classic in its field—a valuable, highly respected resource for hams, engineers, and technicians at all skill and knowledge levels. The 79th edition covers the latest in DSP and wireless technology and includes new projects, such as a VHF receiver, a UPS, and a modular RF voltmeter.

Newnes Guide To Television & Video Technology

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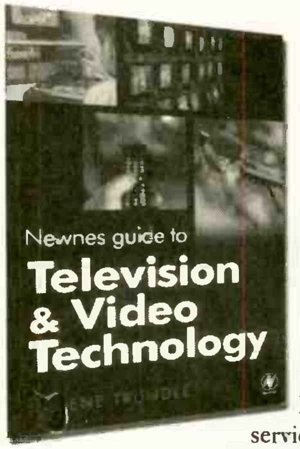

Designed for electronic servicing students and professional service engineers alike, this guide to television and video technology offers fundamental information about Digital TV (satellite, cable, and terrestrial) and Digital Video. It also includes a thorough foundation in analog systems. No matter what area of television you're interested in or even to simply gain a better understanding of your home-video equipment, you may want to add this to your technical library.

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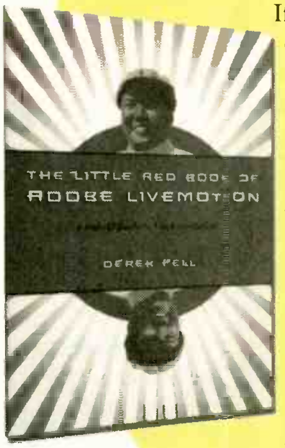
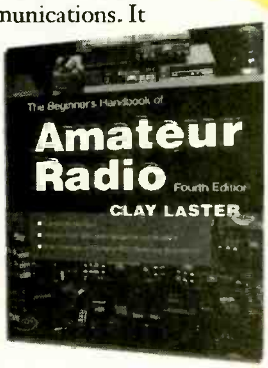


If you are looking for a humorous, original approach to learning flash animation, this book may be for you. The satirical how-to guide pokes political fun while providing legitimate tools to navigate *Adobe LiveMotion*. Not the ordinary textbook style, this manual uses innovative methods to tap the reader's creativity and to introduce graphics design for the Web. Learn to create *Javascript* rollovers, use *Photoshop* to enhance Flash animations, build Preloaders, and much more.

The Beginner's Handbook of Amateur Radio, Fourth Edition

by Clay Laster
McGraw-Hill
Two Penn Plaza
New York, NY 10121-2298
800-2MCGRAW
www.books.mcgraw-hill.com
$34.95

A useful tool for anyone interested in amateur radio, this handbook is a comprehensive guide to radio communications. It offers a mini-course in electronics, a study guide for FCC exams, recent FCC safety rules and regulations, short-wave operator's procedures, and more. The combination of theory and practice provided, complete with numerous illustrations, makes the material clear and easy to understand.



Phonons in Nanostructures

by Michael A. Stroscio
and Mitra Dutta
Cambridge University Press
40 West 20th St.
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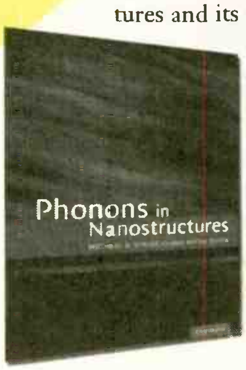
212-924-3900
www.cambridge.org
$100

The authors present the theory of phonon interactions in nanoscale structures and its application to modern nanostructure-based devices, particularly modern electronic and optoelectronic devices. Appropriate for both graduate and undergraduate students of physics and engineering, the text emphasizes models of confined phonons and how they apply to semiconductor heterostructures.



The Extreme Covert Catalog

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Intelligence Here
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Unofficially labeled the source for the hottest electronic surveillance toys and equipment, this catalog is chock-full of cell-phone detectors, automobile-tracking systems, miniature video recorders, computer interception gear, and much more. Organized by the type of equipment, the catalog includes detailed descriptions, photos, and supplier information.

Video and Camcorder Servicing and Technology

by Steven Beeching
Newnes, Butterworth-Heinemann
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Woburn, MA 01801-2041
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The scope of this manual includes practical, up-to-date coverage of the entire range of current home-video equipment—analog and digital. It furnishes readers with everything they need to know about troubleshooting and repairing traditional VCRs, video cameras designed for home use and editing systems, and the latest DVD equipment. The aim is to give the service engineer and student alike the base of technological knowledge that's not usually found in the servicing data from the manufacturers.

On The Air With Ham Radio

by Steve Ford, WB8IMY
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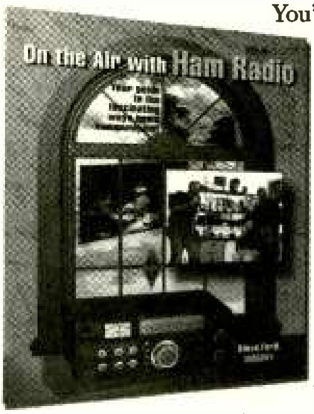
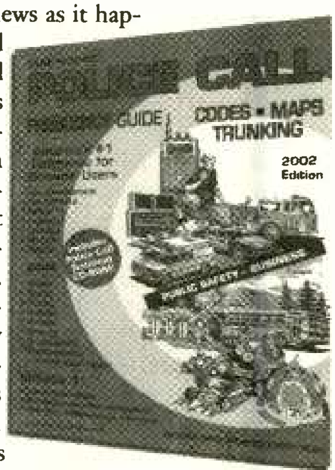
www.arrl.org
$17.95



You're invited to explore the world of amateur radio through this concise guide filled with practical advice and technical know-how. All the information you need to get started is right here. Find out about satellite communications, hooking up hardware, shopping for transducers and antennae, and more. You'll be able to set up an amateur radio station, make air contacts through your computer, exchange pictures with other hams, and discover a host of other projects.

Police Call, 2002 Edition

by Gene Hughes
Hollins Radio Data
P.O. Box 35002
Los Angeles, CA 90035
www.policecall.com
$19.95 each plus S&H



Radio scanners hear news as it happens. Bearing in mind that there are laws and legal issues which this book covers in detail, listeners can hone in on police-pursuit communications, follow aircraft across the skies, or witness a rescue situation. With the included CD-ROM, this frequency guide serves as a reference and contains codes, maps, and many useful hints for getting the most out of your scanner. There are nine regional volumes.

GIZMO®

For more information go to page 82A

or e-mail: requests@berkshire-is.com

Pack Some Power

Designed for use on the road or at home during blackouts, the *Jazz Portable Power 250* ($119.95) uses an inverter to produce AC or DC power from a battery source. Its two AC outlets can supply power to TVs, lamps, and computers; and DC power from the unit can jumpstart cars or boats. It can be recharged through a car cigarette lighter socket or a standard wall outlet. A safety feature warns you if the cables are connected incorrectly.

Xantrex Technology Inc., 8999 Nelson Way, Burnaby, BC, Canada V5A 4B5; 604-422.8595; *www.xantrex.com.*

CIRCLE 50 ON FREE INFORMATION CARD

Quick Charge

Using patented Neotherm technology, the *Mach I Speed Charger* ($99.95) is said to charge lithium-ion camcorder and digital-camera batteries three times faster than any other charger—30 minutes to fully charge a standard battery. Because it also works with 12-volt sources, you can charge batteries en route to an event. A microprocessor dynamically controls the charging process to deliver the maximum energy level and to test and condition the battery without overheating it, thus extending battery life.

Lenmar Enterprises, Inc., 31328 Via Colinas #102, Westlake Village, CA 91362; 818-879-2700; *www.lenmar.com.*

CIRCLE 52 ON FREE INFORMATION CARD

3-2-1 Blast Off!

The *3-2-1 home entertainment system* ($999) provides realistic surround sound from just two speaker arrays. Bose Videostage 5 decoding and post-processing circuitry generates and processes five discrete channels for a full surround effect from Dolby Digital, DTS, or even mono sources, as sound seems to come from where there are no speakers. The media center includes a tuner, DVD player, amplification, equalization, and three inputs for additional sources. Basic setup requires only four simple connections.

Bose Corp., The Mountain, Framingham, MA 01701-9168; 800-444-BOSE; *www.bose.com.*

CIRCLE 51 ON FREE INFORMATION CARD

Web-Browsing Phone

The *CDM-8100* is a slim, tri-mode phone with built-in UP 4.1 Web browser and advanced data/fax capabilities. Weighing less than four ounces, the phone operates on the 800-MHz and 1900-MHz frequencies. It features two-way SMS, T9 predictive text messaging, a one-way speakerphone, and 100 memory locations. Two soft-touch navigation keys provide easy Internet access.

Audiovox Communications Corp., 555 Wireless Blvd., Hauppauge, NY 11788; 631-233-3300; *www.audiovox.com.*

CIRCLE 53 ON FREE INFORMATION CARD

Whole-House Sound

The *CT 610* multi-zone receiver ($3498) features two AM/FM tuners, six programmable IR inputs and nine programmable IR outputs; and it delivers 12- × 55-watts of power. Whole-house A/V distribution can be configured via B&K's proprietary *Software Suite*, making it easy to manage all of the receiver's basic parameters and functions.

B&K Components, Ltd., 2100 Old Union Road, Buffalo, NY 14227; 800-543-5252; *www.bkcomp.com.*

CIRCLE 54 ON FREE INFORMATION CARD

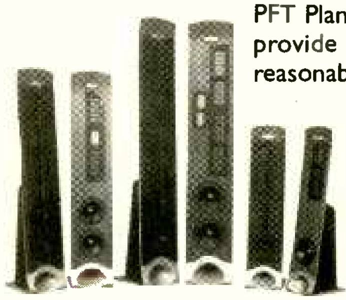
Pet-Free Zone

What do your pets do while you're not home? If their favorite pastime is shedding on—or shredding up—your favorite furniture, the *Pet Peeve* ($49.95) could help. The device combines a vibration sensor with a voice recorder. When your pet jumps on the couch, the sensor triggers an ultrasonic tone (not audible to humans) followed by a digital recording of a command in your voice: "Off the couch, Spot!"

The Sharper Image; P.O. Box 7031, San Francisco, CA 94120-9703; 800-344-4444; *www.sharperimage.com.*

CIRCLE 55 ON FREE INFORMATION CARD

Flat-Panel Speakers



Monsoon floor-standing speakers use PFT Planar Focus Technology to provide high performance at reasonable prices. Models *FPF-600* ($599/pair), *FPF-1000* ($999/pair), and *FPF-1600* ($1599/pair) each use a hybrid design to increase dynamic range and are said to provide excellent spatial imaging, clarity, and sound positioning.

Sonigistix Corp., 11782 Hammersmith Way, Suite 201, Richmond, BC, Canada, V7A 5E3; 604-271-2237; *www.monsoonaudio.com.*

CIRCLE 57 ON FREE INFORMATION CARD

Mobile Subwoofers

The *High Energy HED Series* mobile audio subwoofers are available in 8-, 10-, 12-, and 15-inch sizes and in single-voice coil (SVC) or double-voice coil (DVC) designs, with prices ranging from $89 to $149.

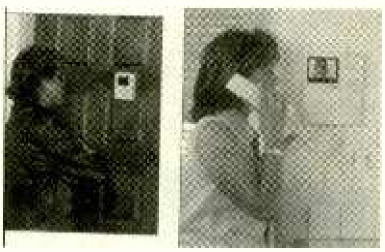
Each sports a unique surround with proprietary V-Flex suspension, said to mechanically resist lateral "cone drift." The cone is attached to a metal frame, which allows greater voice-coil suspension for increased mechanical power handling (150 watts RMS or 200 watts RMS, depending on woofer size).

Cerwin-Vega, 555 East Easy St., Simi Valley, CA 93065-1805; 805-584-9332; *www.cerwin-vega.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Video Doorman

The *VES Video Entry System* ($249.99) features infrared technology to give users a clear view of their front-door area even in near-total darkness. The system consists of an intercom/doorbell with an IR TV camera, and a telephone-style monitoring station with a four-inch black-and-white video screen, handset, and speakerphone so you can see and talk with visitors. A continuous monitor function lets you maintain constant video and audio surveillance.



VOS Systems Inc., 13000 Danielson St., Suite J, Poway, CA 92164; 800-596-0061; *www.vossystems.com.*

CIRCLE 58 ON FREE INFORMATION CARD

Photo Printer

The *P500 Digital Photo Printer* ($249) produces high-resolution, pocket-sized Polaroid 500 prints directly from the SmartMedia or CompactFlash memory cards used in digital cameras—without a computer. The compact, handheld device combines the quality of digital imaging with the instant gratification of Polaroid snapshots. It creates color instant photos in 20 seconds or less and is powered by a unique battery in the film pack.

Polaroid Corp., 784 Memorial Drive, Cambridge, MA 12139; 781-386-2000; *www.polaroiddigital.com.*

CIRCLE 59 ON FREE INFORMATION CARD

PC GIZMO®

Concert in a Pocket

The *PocketConcert* ($299) is a portable digital audio player that can store up to four hours of MP3 or Windows Media Audio (WMA) files or more than 20 hours of spoken-word audio in its 128 MB of StrataFlash memory. Its intuitive software suite makes it fast and easy to play audio files downloaded from the Internet or created from CDs. It also includes PC tools to convert and encode CDs from audio files. An optional accessory kit ($50) provides a carrying case, car adapter, and StereoDock for connection to a home stereo.

Intel Corp.; 503-696-8080; *www.intel.com*.

Cool and Calculating

The translucent, metallic silver *TI-83 Plus Silver Edition* calculator ($129.99) has more than nine times the power and twice the speed of the popular TI-83 Plus. It has room for up to 94 software applications and comes bundled with nine: *CellSheet* portable spreadsheet (may need to be downloaded), *Organizer, Periodic Table, Probability Simulator, StudyCards* electronic flashcards, *Catalog Help* (mathematical functions), and *Start-Up Customization*. The *CBL/CBR* application lets students examine real-life world data using the Calculator-Based Laboratory or Calculator-Based Ranger tools and probes. With the included TI-GRAPH LINK cable, teens can connect the calculator with a PC to upgrade and add software and/or transfer files and data to be printed or stored on a disk.

Texas Instruments, Inc.; 972-644-5580; *www.ti.com*.

Driven to Learn

Drive Across the Americas ($59.99) is a driving and sightseeing game that uses 3-D graphics and digital sound to teach kids aged 8 and up about history, geography, and even driver safety. It includes a plastic steering-wheel console with built-in game controls, PC connection cable, and the software, which includes many kid-safe hot links for additional exploration.

Oregon Scientific; 800-853-8883; *www.oregonscientific.com*.

Personal Digital Data Bank

The *Terapin mine* ($599), a handheld personal digital data bank, lets you store, play, network, and even access the Internet, all at the touch of a button. The "mine" is like a portable hard disk with 10–12 Gb of internal mass storage and tremendous interconnectivity options. It has both host and master USB ports, a PC card slot, built-in 10-Mbps Ethernet connectivity, composite-video-out for digital photos, stereo-audio-out for MP3 and other formats, and Internet Plug-and-Play shared storage. It uses Linux OS, which allows it to act as either a master or slave device to various digital appliances.

Teraoptix Inc.; 888-654-0645; *www.mineterapin.com*.

Lightning-Fast Laser Printer

The *ML-6060* ($399) cranks out 1200- × 1200-dpi-resolution copy at 12 pages per minute. A special toner-saver feature allows you to get up to 40% more output from the cartridge by reducing the resolution during draft prints. The printer has a 100-sheet flip-down paper tray as well as a 550-sheet paper cassette that lets you load a full ream of paper. It features both parallel and USB interfaces.

Samsung Digital Information Technology Division; 888-887-8536; *www.samsungusa.com*.

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

Business Buzz

BATTERY BOOSTER
Texas Instruments' first chipset for capacity monitoring and safety protection in Lithium-Ion or Lithium-Polymer battery packs provides a high-performance battery-management solution while minimizing component count, cost, and board space. The highly integrated chipset has applications in notebook computers, handheld terminals, and medical and test equipment. The chipset, which consists of the bq2081 Smart Battery System Gas Gauge IC and the bq29311 Li-Ion Protector IC, can fit in less than one square inch of PCB space and reduces the number of required components by up to 40%.

SINGLE-MOLECULE COMPUTER
IBM researchers have created and demonstrated the world's first logic-performing computer circuit within a single molecule. The team made a "voltage inverter"—one of the three basic logic circuits at the heart of all computers—from a carbon nanotube, a tube-shaped molecule of carbon atoms 100,000 times thinner than a human hair. "Carbon nanotubes are now the top candidate to replace silicon when current chip features just can't be made any smaller," said Dr. Phaedon Avouris, lead scientist on the project. "Such 'beyond silicon' nanotube electronics may then lead to unimagined progress in computing miniaturization and power."

HACKER LOCK-OUT
A team at HP Labs Bristol (UK) has made Linux more secure. Their two-year research project has resulted in a product that can detect, prevent, and contain break-ins to the Linux operating system and applications. Dubbed *HP Secure OS Software for Linux*, the product prevents unauthorized communications between programs, networks, and files; locks a program if penetrated; and detects hacks and attempted hacks. After the team analyzed the potential threats to users and looked at existing security platforms, they developed an experimental secure platform—called Trusted Linux—to protect Internet gateway systems from some of the most common attacks. Sensitive information cannot be accessed or modified by a hacker, and an administrator's error can't compromise the system. No special training is required; and because it delivers security at the OS level, all applications are protected.

Clever Cars, Resourceful Roads

Cars in France are getting smarter. Playing host to as many as 200 microprocessors that are connected to multiple sensors, the cars boast increased reliability for the drive-train, steering, and braking systems. On-board navigation, multimedia, and communications systems benefit as well. Many new vehicles are also able to interact with the intelligent road infrastructure developed by the Application for Motorway Information (AIDA) project.

Smart Cards

One example of the French automobile's cleverness is Renault's Laguna II's keyless entry that uses a card-based system developed in conjunction with French auto-equipment manufacturer Valéo. A personal card, credit-card size, provides access to the car—without being inserted. Carrying his card, the driver touches the door handle, and the doors open automatically. A sensor embedded in the door handle initiates a recognition procedure that culminates in the door unlocking, the automatic positioning of the mirrors and seat, and even setting the sound system and climate-control to meet the driver's preferences. When the card is inserted into the dashboard-mounted card reader, the system's immobilizer and steering-column lock are deactivated; and a button is used to start the engine. The card also stores car-identification and maintenance information.

Informed Navigation

Renault's Laguna is also equipped with the Odysline integrated GPS and GSM system, providing access to services for guidance, traffic information, breakdown assistance, reservations, and medical and emergency assistance.

GPS systems might provide the best route; but the Carminat navigation, available on the Renault Laguna II, takes it a step further. It now includes traffic information transmitted by a network of FM transmitters fitted with RDS-TMC (*R*adio *D*ata *S*ystem-*T*raffic *M*essage *C*hannel) coders. The driver receives traffic warnings in real time. He is informed of traffic jams, roadwork, or accidents, and offered an alternative route.

The multi-functional center console on the Peugeot 607 includes a GSM telephone system and a CD-ROM navigation system.

Pressure Points

Other Renault vehicles benefit from a system, developed with Michelin, that monitors tire pressure. It can detect any defect, from poor inflation to a slow leak. Each wheel is fitted with a sensor in the valve that measures the internal pressure of the tire. The information is transmitted to an on-board computer that uses an advanced algorithm to distinguish between a real fault with pressure and a variation due to normal use or climatic changes.

Tail-Gate Terminator

Another innovation will be unveiled in the Renault Vel Satis, scheduled for a January 2002 launch. It is outfitted with Adaptive Cruise Control, a system that

TYPE

not only maintains the speed set by the driver, but also changes the speed according to traffic patterns. Radar built into the front bumper detects the presence and estimates the distance of moving vehicles in the same lane. The driver chooses a safe speed and distance, and the system automatically adjusts the speed to keep a constant space between vehicles.

Valéo is also currently developing *T*raffic *E*nvironment *S*ensing (TES) radar. This driver-assistance device detects obstacles and sounds a warning in the event of changing lanes or a dangerous bend. An Intelligent Cruise Control function protects the driver from being cut off by other vehicles, and a "Stop and Go" system operates in slow-moving city traffic.

Car Talk

In other developments in France, PSA Peugeot Citroën and Vivendi have formed a company called Egery to develop automotive telematics services, based on mobile telephony, Internet, and GPS technologies. Voice recognition and voice synthesis will be crucial elements in these new services.

Last year, Citroën marketed a special edition Xsara equipped with a built-in PC that enabled the driver to receive *S*hort *M*essaging *S*ervice (SMS) messages directly, to search automatically for previously selected radio stations, and to access a directory or navigation aids—all using voice control. The Peugot 607 includes a GSM telephone system that allows the driver, with the push of a button, to immediately contact a call center. The center provides emergency assistance and data on vehicle maintenance or repair. The 607 also boasts a built-CD-ROM navigation system with an option for GPS integration.

The tire-pressure monitoring system on a Renault Laguna keeps track of slow leaks or poor inflation.

Multiplexing

Adding all these advanced functions has forced manufacturers to re-examine the electrical and electronic architecture of vehicles. Multiplexing—using only one wire rather than numerous ones to carry coded information from several computers—improves reliability and allows increased information exchange.

PSA Peugot recently developed a multiplexed steering-column head. Known as Com2000, it provides a high level of functional integration. The Com2000 directly senses all steering wheel switching (lights, wipers, buttons, etc.), and sends the information electronically to the other systems via the multiplexed network.

On the AIDA screen, icons or short messages display information about road hazards.

Information Highway

In addition to the smart car, information is available from the very roadway itself. France's AIDA was a joint project, of French motorway companies Cofiroute and CSSIRoute, in connection with Renault and PSA Peugot Citroën. AIDA's goal is to inform the driver in real time of obstacles created by construction, accidents, or inclement weather. Similar to Easy Pass technology, the system uses beacons above the road at 6-mile intervals and vehicle hyper-frequency tags linked to a termi-

Research Notes

BAD VIBRATIONS

Researchers at the Center for Electromechanics of The University of Texas at Austin have designed an electrical suspension system to replace conventional spring/shock absorber systems. Tests conducted at the U.S. Army's Yuma Proving Grounds have demonstrated a fivefold reduction of shock and vibration to the passengers, double the off-road top speed, and better handling in cornering—all of which result in improved off-road fuel economy. The electrical suspension system uses a soft spring for a smooth ride and an electromechanical system to minimize pitch and roll. Key components include an electric motor driving a rack and pinion at each wheel, accelerometers, and an advanced control system. Dynamic adjustment of the vehicle's center of gravity during turns reduces rollover risk. Besides military applications, the technology could be used in ambulances, SUVs, and large trucks.

A BRIGHT IDEA

*O*rganic *l*ight-*e*mitting *d*iodes, or OLEDs, emit their own light and can be incorporated into arrays on very thin, flexible materials—but they are not very efficient. A standard OLED consists of a layer of organic polymer that emits light when excited by electrical current, sandwiched between two conducting layers. When voltage is applied to the conducting layers, a current runs through the polymer layer; and it emits photons, creating a light. Researchers at Los Alamos National Laboratory have applied an intermediate chemical layer a mere molecule thick that helps shuttle electrical charges between a conducting layer and the polymer layer to achieve more efficient current flow.

WATER SNIFFER

A real-time gas- and water-quality monitoring system developed by Sandia National Laboratories consists of a miniature sensor array in a waterproof housing. Unlike traditional methods, which require samples taken at the site to be sent to a lab for analysis, the "Sniffer" remains on-site, sending back to a data-collection station real-time data on solvents present and their concentrations. An array of miniature sensors, called a chemiresistor, detects and measures volatile organic compounds in water reservoirs or gas-storage tanks.

nal built into the dashboard. When the car passes under the beacons, information is transmitted to a central unit, where it is processed and sent to the cars. In the vehicle, it is displayed on a screen with icons or short text messages. Safety messages are received automatically and immediately, while general traffic and weather data is available upon request.

In a way that's invisible to the driver, the vehicle sends back information, as well. The system can determine traffic flow by calculating the time it takes the vehicle to pass between two successive beacons, can detect when windshield wipers have been switched on, or when the brakes have been applied sharply. The driver also has the ability to send messages—for instance, to report an accident or a hazard on the roadway.

From automobile architecture and roadways that provide information to smart-card entry and self-monitoring vehicles, the era of cars that practically drive themselves is on the way. PT

Biorhythm Passwords

In the old days, when telegraph operators sent messages by hand using Morse code, an experienced operator could tell who was sending by the "fist of the operator." Today, how a person types his or her user name and password on a computer keyboard is being used to identify the person for security purposes.

Now Net Nanny Software Inc., the developer of the *Net Nanny* filtering software, is commercializing a unique technology originally developed by the Stanford Research Institute to solve spiraling computer security problems. As its name implies, *BioPassword,* is a biometric identification technique. However, unlike other biometric ID technologies that are dependent on recognition and comparison of unique human characteristics such as fingerprints, hand geometry, faces, or the eye's iris and retina, *BioPassword* does not require any additional hardware.

It is all done with the *BioPassword* software installed on a computer or workstation. This software is based on keystroke dynamics—that is, the rhythm and speed an individual uses when typing-in user names and passwords to gain access to computers, databases, secure sites, and so forth. Like voiceprints and handwriting, keystroke dynamics is a *behavioral* biometric identification technique.

The Rhythm Method

The *BioPassword* log-on software is installed via a CD-ROM. To enroll, new users type in their user name and password repeatedly from 10 to 20 times. This allows *BioPassword* to "learn" the individual's keyboard dynamics. Once enrolled, the user types in a user name and password as usual. The *BioPassword* software then compares the typing rhythm with the stored biometric template. If a match is made, access is granted.

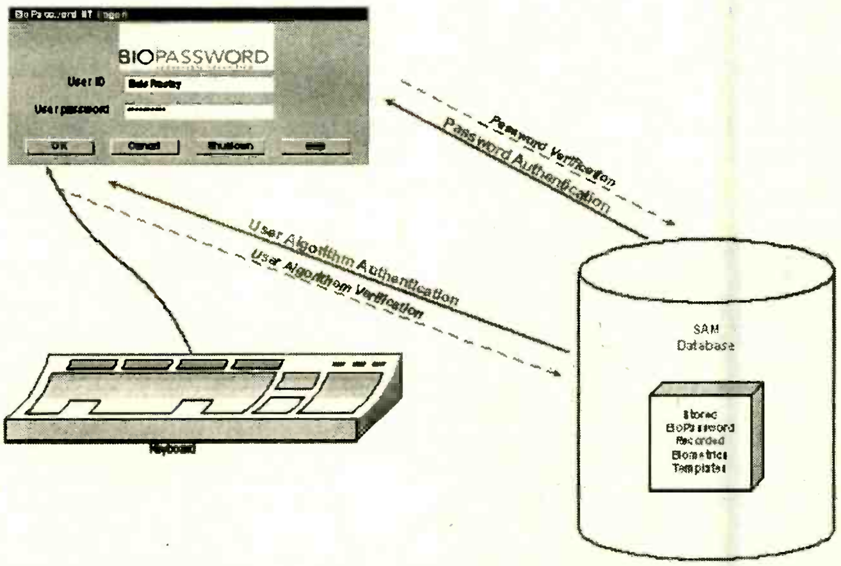
Just how much security does it provide? Surprisingly, it is virtually impossible for someone to duplicate another person's keystroke dynamics. They are unique. Of course, the person must have the correct username and password in the first place. *BioPassword* just adds another level of security. Security can be increased further by the choice of user name and password. Net Nanny recommends eight-character user names and passwords. Testing shows that this results in an error rate of less than two percent.

Several security levels are available, so registered users can tailor the system for optimum security desired. Too low a level and every one is accepted; too high and legitimate users are denied access. The *BioPassword* software can be disabled temporarily. For example, if a user has a temporary hand injury that affects his keystroke dynamics, a system administrator could disable the system so the user could still have access. If the change is more permanent, a new template is prepared.

The *BioPassword* software is currently available only for users of Windows NT and Windows 2000 in large workstation environments. The license fee ranges from about $4000 for 100 workstation to nearly $70,000 for 4000 "seats." However, like most everything in the computer world, availability should increase and cost should decrease as usage becomes more widespread. Future possible applications include added security for on-line banking and on-line credit-card transactions and for a user-friendly method to protect the intellectual property owned by record labels, artists, composers, publishers, and distributors.

Since it requires only software, keyboard dynamic biometric identification could be incorporated in all types of keyboard devices, from cell phones to building-access systems

For further information, contact Net Nanny Software; 15831 NE 8th St., Suite 200; Bellevue, WA 98008; 425-688-3008; *www.biopassword.com.*—**by Bill Siuru** PT



This diagram illustrates how *BioPassword* works. Based on keyboard dynamics, the software recognizes registered users' style of typing-in their passwords.

➤ Rising Broadband-Over-Airwaves

According to an *A*llied *B*usiness *I*ntelligence (ABI) study, wireless broadband technologies will become increasingly popular over the next five years. ABI predicts that wireless broadband subscribers, who accounted for just 2% of the total broadband subscriber base in 2001, will constitute 15% in 2006. Total revenues from broadband subscribers are expected to increase from $16.8 billion this year to $59.4 billion in 2006, with wireless technologies making a leap from 9% of total revenues in 2001 to 22% in 2006.

Because equipment and installation costs are so high (more than $3000 per subscriber), wireless broadband technologies have a hard time competing with cable and DSL.

Several factors will facilitate wireless broadband's rise in popularity. First and foremost, wireless broadband offers higher quality connections. The costs of deploying and maintaining the wireless infrastructure are lower, and wireless connections are not hindered by distance limitations. A large number of customers can be serviced by a single wireless node, particularly with satellite broadband services. "To make an impact on the market, wireless broadband providers must prove to consumers that their services are not only equal to cable and DSL, but actually better in terms of pricing, speed, reliability, and security," said Mark M. Fox, author of the ABI report, *Broadband Delivery in the Local Loop: By Land and By Air.* "The potential is there, but first they have to catch up to the wireline technologies in terms of available infrastructure." PT

Water Safety

In the wake of September 11, the concept of public safety has taken on a new significance. For almost two years now, Sandia National Laboratories researcher Jeffrey Danneels has been working with the EPA and the *A*merican *W*ater *W*orks *A*ssociation *R*esearch *F*oundation (AwwaRF) to develop a training program that would teach water utilities to assess the vulnerabilities of their systems and to institute measures to reduce the risks and decrease the consequences of terrorist attacks. The EPA is especially concerned about the water distribution systems serving the 340 cities that have 100,000 or more residents. Many of these systems are more than 60 years old and were built with little thought of security, and few are configured alike.

"We started exploring the possibility of working together to enhance the security of America's water infrastructure—supply, treatment, and distribution—well before the September 11 attacks on the World Trade Center and the Pentagon," says Danneels. "We are putting a program in place that involves on-site assessments of utilities and training sessions for utility personnel." Workshops for members of the AwwaRF and the *A*merican *W*ater *W*orks *A*ssociation (AWWA) were scheduled to begin in November 2001.

The program offers three steps for assessing the vulnerability of a utility's water infrastructure—detect, delay, and respond. The first step is to determine how well the system detects a problem, such as chemical contamination. (Sandia's "water sniffer," described in *Research Notes*, is one possible detection device.) The second is to measure delay capabilities to learn how well the system can stop undesired events. How long is water stored before being distributed? Are barriers, such as fences and walls, in place? Finally, response capabilities are examined. How quickly are private security forces and local, state, and federal authorities able to respond, and in what capacities? "It is important that utilities be able to detect the problem and delay it long enough for the response to arrive and defeat it," Danneels says.

Underlying the program is the need to fully understand the site, including its overall mission and operating procedures. The cost of security depends on the level of protection a facility wants and can afford. Hiring a security guard and installing some basic detectors "won't cost a lot," according to Danneels, "but to stop a fairly organized group from committing a terrorist act could be extremely expensive." PT

Pumped-Up Mileage

A technology originally developed by Ford Motor Company for use in diesel engines has the potential to improve fuel economy in gasoline engines by about 20 percent. Called DISI, for *D*irect *I*njection *S*park *I*gnition, it is being tested in a 1.1-liter three-cylinder engine that can achieve 70 HP. When used mainly in urban driving, DISI achieves a 21 percent improvement in fuel economy; while in mixed urban and highway driving, the improvement is expected to be 10 to 15 percent. Even greater savings might be realized by combining DISI with other new technologies that take advantage of its low-RPM efficiency.

In a conventional fuel-injected engine, all cylinders are supplied with a mist-like mix of air and fuel at a constant 14.7:1 ratio. One or more injector nozzles spray fuel into the air stream being fed to the intake valves. The spray is mixed with air during the intake stroke and flushed into the cylinder, where it is ignited by the spark plug. The throttle valve determines how much of the air-fuel mixture enters each cylinder. The mixture itself, however, cannot deviate much from the 14.7:1 ratio; mixtures that are too lean won't ignite.

DISI technology uses "stratified" charging to overcome this limitation. The injection nozzle is located inside the combustion chamber. When fuel is sprayed toward the spark plug just before ignition, the spark plug is surrounded by a small, precisely shaped volume of ignitable air-fuel mix. Only the area directly around the plug, at the top of the cylinder, contains the air-fuel mixture. The stratification of the charge allows the DISI engine to burn mixtures with a much higher ratio of air to fuel—up to 60:1. The cushion of non-combustible gas around the combustion chamber also requires less combustion heat, improving the engine's thermal efficiency. The charge-stratification process works best at low and medium loads in the lower half of the engine speed range, where traditional gasoline engines are least efficient. The technology also allows the compression ratio to be increased from 10:1 to approximately 11.7:1 without the need for premium fuel, because direct injection reduces engine knock. PT

REID GOLDSBOROUGH

mailto: digitaldomain@gernsback.com

Online Essentials: Connecting To The Internet

Let's say you're not yet online. You want to be connected to the Internet, but you don't want to mess with a complicated computer. Maybe your parents or grandparents fit this description. What should you do?

This dilemma has spawned an entire category of simple Internet access devices called Internet appliances. Yet, these devices have failed miserably in the marketplace. Exploring the reasons for their failure will shed light on the challenge of getting "Grandma" online, and, if you're Grandma, what your options are today.

Clearly, there's a potential market out there. The latest data from the market research firm Dataquest shows that 39 percent of U.S. households still aren't online. A whopping 85 percent of U.S. senior citizens don't yet have Internet access, according to the Pew Internet & American Life Project. Yet, within the past year, three major manufacturers of Internet appliances have dropped out of the market: Sony, 3Com, and Netpliance.

A SOLE SURVIVOR

The sole surviving stand-alone Internet appliance actively marketed to consumers is Compaq's iPAQ Home Internet Appliance. Designed for surfing the Web, sending and receiving e-mail, and engaging in instant messaging, it's also easy to set up and use. My 74-year-old father and I tested the unit in detail and, despite great potential, it has problems of its own.

Compaq sells two versions that are both attractively priced. The smaller and more portable IA-1 has a flat-panel screen and retails for $399, while the bulkier IA-2 has a conventional computer monitor and retails for $299. Prices at consumer electronics stores, where they're typically sold, are sometimes even less. Both units are similar. They look and act like PCs; but they lack a hard drive, which is appropriate since Internet appliances aren't meant for storing letters, budgets, and so on. Without a hard drive, there's no waiting for the device to "boot up" when you turn it on.

Easy to set up and use, the Compaq iPAQ Home Internet Appliance puts you online directly—without the help of a computer.

Let's look at some of the problems. The biggest drawback is that Compaq's System is inextricably bundled with MSN Companion, Microsoft's operating system for Internet appliances. MSN Companion is tied closely to MSN Internet Access, and like the MSN Internet Service Provider (ISP), it's slow and buggy. *Consumer Reports* recently ranked MSN last among eight national ISPs for speed, interruptions, and availability.

You don't have to use MSN to connect to the Internet with Compaq's Home Internet Appliance. However, as just one more example of Microsoft's monopolistic mindset, there is a catch. Because of Compaq's licensing agreement with Microsoft, if you use another ISP, you still have to pay Microsoft $9.95 per month in addition to the fee you pay your new ISP. On the positive side, if you stay with MSN, it's free for your first six months of access. After that, though, access will cost $21.95 per month.

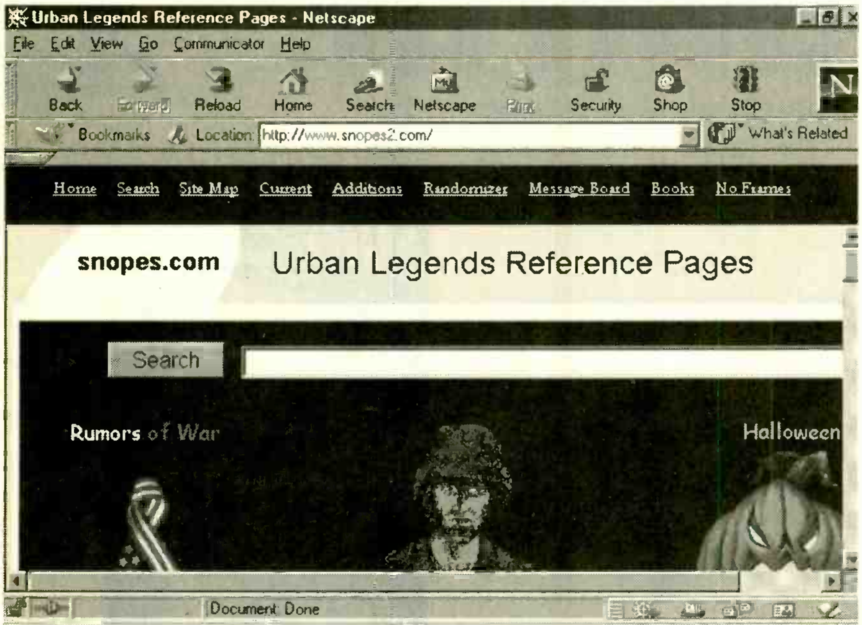
Another problem was that some reviewers found the screens too small and the touch-pad finicky, but we had no problems with either. More important is that the device doesn't support a number of widely used Internet formats from companies other than Microsoft, such as *Adobe Acrobat*, *RealAudio*, and *QuickTime*.

Browsing Internet forums revealed that advanced users typically found it too limiting, while beginners appreciated the ease of its use. This result leads to the core of the Internet appliance quandary for manufacturers.

TO MARKET, TO MARKET

They've failed, thus far, to market these devices to their logical audience, the "Net-laggards." Now they're marketing them to the "Net-sophisticates," who want more than one Internet-access device in their homes. However, it seems that this audience will not likely tolerate the devices' technological limitations. Compaq officially says it's committed to the Internet appliance market, and it seems to recognize the way to improve the device. "In the future we hope to provide access not tied to Microsoft," says Compaq spokesperson David Albritton.

However, the larger challenge



Anti-hoax Web sites such as the Urban Legends Reference Pages at www.snopes.com *can help eliminate the misinformation that circulates on the Web.*

remains—persuading Net-laggards that paying for Net access is worthwhile. "This audience will wait until they absolutely cannot do without," says Bryan Ma, an analyst from IDC, a market research firm in Framingham, MA.

Does it make sense to buy the Compaq Home Internet Appliance? Despite the current limitations, maybe. The price is right, and it's suitably simple if you're just getting started.

Another option is MSN-TV (formerly called Web-TV), a device that you connect to your TV for Internet access—ranging in price from $99 to $199. It's from Microsoft, easy to use, but even more limited. The older Web-TV Classic is also available, even less expensive, but even more restrictive than Compaq and MSN-TV. If you can swing it, it might make more sense to spend $600 to $800 on a low-end PC or Mac that's easier to use than ever and gives you freedom of choice.

ANOTHER INCENTIVE TO LOG ON?

For some, the importance of being connected to the Internet surpasses e-mailing, shopping, and surfing. For those who venture online to keep up with current events, there is the more serious, more significant, aspect of staying in touch with the world. However, to say that the Internet is the best source for explosive, timely, news stories is still somewhat arguable.

The question arises, during a disaster, where is the first place you should turn for information? You might think the Internet would be ideal. After all, it was set up by the military in the 60s to ensure communications during a nuclear war. Yet, as recent events have shown, during a crisis, other media sources might do a better job at delivering breaking news. Still, the Net is uniquely suited for certain things.

THE SET VS. THE NET

The Net's biggest problem stems from its very nature. To somewhat oversimplify, unlike TV networks that send one signal to millions of TV sets, Web sites have to send millions of signals to millions of computer screens. Web sites thus get overloaded if they receive too many visitors. During the hours immediately after the terrorist attacks of the World Trade Center and the Pentagon, the top news sites were completely bogged down. The Net's most popular news site, *CNN.com*, received 162 million page views on the day of the attacks, 12 times more than normal. Millions of people in offices throughout the country, without easy access to TV or radio, tried to find out what was happening through their computers, often without success. Some of the big news sites tried coping by slimming down the size of their pages and adding servers, but this helped only marginally.

Television surpassed the Internet at providing second-by-second coverage of the events. What's more, while the major Web news services had to scale down their content to provide any service at all, the television networks beefed up their programming to satisfy information-hungry viewers.

Once you go beyond breaking news at big-name sites, what the Net is exceptionally good at is providing depth. "In the same way people turn to newspapers instead of TV for more depth, people turn to the Internet," says Steve Outing, an online publishing consultant from Boulder, CO. On the Web, for instance, you can conveniently read overseas news sources, which provide a different, and sometimes eye-opening, perspective. If you're so inclined, you can view shockingly graphic images that the networks don't carry. With the Internet, "you're not as dependent as you were once were on hearing things that someone else wanted to tell you," says Ed Trayes, a Temple University journalism professor.

POINT AND CLICK

CNN.com
www.cnn.com

Compaq
www.compaq.com

MSN.com
www.msn.com

Urban Legends Reference Page
www.snopes.com

UP CLOSE AND PERSONAL

The Internet's most distinctive advantage is its personal nature. On September 11th, personal Web sites, sometimes called Web logs, sprung up with eyewitnesses providing unfiltered, first-hand accounts of the tragedy from their own perspectives. Likewise, Internet discussion groups disseminated personalized news. "The Internet

(Continued on page 62)

YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

1900

1910

1930

Dateline: January 1942 (60 years ago)

For the "Radio Month In Review," this issue of **Radio-Craft** mentions the Army's use of walkie-talkies for constant two-way communication, the use of television in national defense, and the apparatus used for Electro-shock therapy. Readers are shown how to build a "Wien Bridge" Audio Oscillator and how to refinish radio cabinets for a sleek, complete look.

1942

1950

1960

Dateline: January 1972 (30 years ago)

Just as Dorothy's perception and view changed when she stepped into the land of Oz, so do those of **Radio-Electronics'** readers as color TV steps into the public domain. This issue deals almost entirely with color TV, from automatic tint controls for tone regulation to a color convergence generator. Television accessories and enhancements are on the rise and in demand, as are solutions to simple problems such as how to eliminate hum bars.

1972

1980

Dateline: January 1992 (10 years ago)

Air pollution was as much a concern in the early 90s as it is today. **Popular Electronics** features building a negative-ion generator and asks the readers and builders to decide whether this high-voltage operation really improves one's health by sterilizing airborne bacteria. This issue also reviews new products such as a heart-rate monitor, a wireless video transmitter, and an 8mm camcorder, along with new ideas for an old pastime—HAM radios.

1992

2000

Seasons Greetings

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ELIZABETH JAMISON

mailto: technoscope@gernsback.com

GPS–Your Ticket to Ride

Today, when consumers are buying gadgets formerly reserved for NASA engineers and MIT research scientists, you never have to worry about finding your way again. The GPS (Global Positioning System) is available and affordable, and it's making the average road trip simple to navigate and a heck of a lot more interesting.

According to the *www.GPS Store.com* Web site, the Global Positioning System, "...is a constellation of satellites that orbit the earth twice a day, transmitting precise time and position (latitude, longitude and altitude)." With a GPS receiver, it is possible to determine your location anywhere on the Earth.

By the start of the new millennium, this $10 billion satellite-based navigational system became generally available, with new-model vehicles touting their dashboard-installed GPS as the wave of the future. Around the same time, hand-held versions that were simple to operate were also being offered by companies like Garmin.

So who has a need for such a high-tech piece of equipment when one can just as easily stop at a convenience store and ask for directions or—hold on to your hat, now—actually look at a map? The answer is, just about everyone. "Anyone who needs to know the precise time or the exact location of people or objects will benefit from GPS."—GPSStore.com

A GPS can be beneficial in a myriad of settings. Hunters will find that with the easy tracking, route setting and waypoint (points of interest, like a breadcrumb in a forest) creating, it is virtually impossible to get lost in the wilderness. For marine use, where a fixed reference point is not always visible, the GPS provides invaluable navigational aid in boating and sailing. "Surveyors, natural resource managers, wildlife managers, geologists, geographers, mappers, forestry managers, and mineral explorers are just some of the people taking advantage of the GPS."—GPSStore.com.

The Street Pilot III is one example of a GPS—this is a turn-by-turn voice-navigation system from Garmin.

Imagine getting through an entire road trip with no wrong turns. Now, you can chart your route beforehand, record waypoints, and see when, to the second, you will arrive at your destination. The GPS will also tell you things like highway exit information, time of sunset, speed, current location, and the nearest cities. With a GPS, you can drive on a deserted highway and plan when you're going to stop at that fast food restaurant that may be fifty miles down the road. The GPS will even tell you where the restaurant is once you take the exit!

So why hasn't the GPS caught on with more consumers? I've talked to a number of technically savvy people about the merits of owning one; and, while most of them understand the reasoning behind the high-tech instrument, they usually respond with a variation of the following statement: "I don't want to take the time to learn how to operate it—it looks too difficult."

Au contraire. While a GPS receiver is truly a marvel of technology, it does not take a rocket scientist to learn how to operate one. Like most video games or computer software programs, a GPS is user friendly and easy to operate.

THE 24-STEP CONNECTION

The complete Global Positioning System consists of twenty-four satellites that are in geosynchronous orbit approximately 12,000 miles above the Earth. Five ground stations manage these satellites, monitoring them twenty-four hours a day. These satellites provide continuous coverage for two- and three-dimensional positioning anywhere on the Earth.

The first thing that happens when you power up your GPS is a connection with these satellites. (Don't worry, this happens automatically. All you have to do is sit back and watch.) The GPS must receive signals from at least three of the satellites in order to track the location of the user. By measuring the interval of time between the transmission and the reception of the satellite signal, the GPS is then able to calculate the location of the user and each satellite. Information from three satellites is required for two-dimensional positioning (latitude and longitude), and four satellites are required for three-dimensional positioning (latitude, longitude, and altitude).

This process takes less than a minute—just enough time for you to start your car and pull out of the driveway.

THE DISPLAY

What may at first seem like a complicated remote control is actually a simple display panel with a few buttons. With one click you can change the view on the screen, alter fields, set routes, create waypoints, and check the distance from your chosen destination. You can even see your top driving speeds, the time of sunrise and sunset, the time in different zones, and detailed street maps across the globe.

SETTING THE ROUTE AND WAYPOINTS

This is where the fun begins. Each GPS has enough memory for many routes, so don't be shy about tracking every trip you take. Going out of town takes on a new color as you discover the best possible place for your waypoints, record the cleanest restrooms and quickest routes, and track your favorite restaurants along the way. As you drive, simply press the waypoint button at a point you'd like to return to on your route. Next, name the waypoint and save. That's it—simple and quick.

This is also where the investment on your GPS becomes worth the expense. How many times have you taken a road trip and had to stop the car, take out your atlas, find the right page, look up your exit or street number, etc. Finally, after several minutes of precious driving time has been spent locating your particular map, you now have to figure out where you are and plot a course. It's worse when you are in a new city and have forgotten your map. You have an appointment and are driving aimlessly—unsure of your destination and direction. With a GPS, you will never get lost; and you need never look at a paper map again. It's all there, instantaneously, at your fingertips.

Plotting a waypoint is as effortless as it is fun. As you are driving, walking, hiking, canoeing, flying, etc., you may reach a place that you want to remember. You press the waypoint button, name it and save it, and one more piece of your route is recorded.

Be frivolous and, above all, have fun, because your basic GPS can handle upwards of 500 of these little breadcrumbs. Go ahead, mark that gas station and record your trip to the dentist. Hey, if your favorite fast food restaurant happens to be Arby's, shouldn't you know the *exact* location of every one from here to Fresno? Sure—your GPS can take it, so plot on.

GPS TECHNOLOGY

There are a few basic steps to understanding the technology behind your GPS. These include triangulating, measuring distance, timing, and the satellite's position. The following section is an overview of these terms, coined and explained in full at *www.trimble.com,* a GPS informational site.

Triangulating—Satellites are used as a reference point for locations on Earth. In order to track a location, we would need to accurately measure our distance from a minimum of three satellites. So how do we do this?

"Suppose we measure our distance from a satellite and find it to be 11,000 miles. Knowing that we're 11,000 miles from a particular satellite narrows down all the possible locations we could be in the whole universe to the surface of a sphere that is centered on this satellite and has a radius of 11,000 miles"—*www.trimble.com.* If the second satellite is 12,000 miles away, we now know that we're somewhere on the circle where these two spheres intersect. When we make a final measurement and find that we're 13,000 miles away from the third satellite, that narrows our position down to only two possible points in space. We could then get a fourth measurement, but usually that is not necessary. One of the two possible points usually winds up being unrealistically far from Earth or moving at an impossible speed.

Measuring Distance—How do you measure something that is out in space? In order to calculate the distance to a satellite, you need to measure how long it takes a radio signal to reach your location from the satellite. This can be accomplished by using a formula that is taught in most high school math classes.

$$\text{Velocity} \times \text{Time} = \text{Distance}$$

Measuring travel time is the trickiest part of the equation. Each satellite has its own Pseudo-Random Code, a complicated digital code (sequence of "on" and "off") that it sends out. The complexity of this code ensures that the receiver doesn't accidentally join with another signal. It also drastically reduces the probability of another signal with the same exact shape. Since each satellite has its own unique signal, they can all use the same frequency. These crucial pseudo-random codes enable the GPS to function without a large satellite dish.

Timing—For the GPS, timing is crucial and must be exact. "If measuring the travel time of a radio signal is the key to GPS, then our stop watches had better be darn good, because if their timing is off by just a thousandth of a second, at the speed of light, that translates into almost 200 miles of error."—Trimble.com.

According to Trimble, extra measurement cures the timing offset. If the receiver's clocks were perfect, all the satellite ranges would intersect at a single point. However, with imperfect clocks, a fourth measurement taken will intersect at a different point.

The computer on the receiver sees this and realizes that it is out of sync with the universal time. It then looks for a single correction factor that it will subtract from all its measurements. This will get the four satellite ranges to intersect at a single point. The correction brings the receiver's clock back into universal sync, and atomic accuracy is achieved. Once it has that correction, it applies it to all the measurements, coming up with precise positioning.

Satellite Location—These twenty-four satellites are thousands of miles away, so how can we determine where they are, *exactly*? Each GPS satellite runs on a precise orbit, and since they are above the earth's atmosphere, the orbits are very predictable. With simple mathematics, we can determine their position.

The Department of Defense (DoD) constantly monitors these basic orbits with precise radar that checks each satellite's exact altitude, position, and speed. The agency checks for errors caused by gravitational pulls from the moon and sun and by pressure of solar radiation called "ephemeris errors," which affect the satellite's orbit. Once the DoD measures the satellite's exact position, it relays this information to that satellite, which then corrects its position.

The Global Positioning System is fun, simple to use, and well worth the expense. So next time you embark on a family vacation, why not take one along? When little Joey asks, "How much longer, Dad?" you'll be able to tell him—to the second. P

Begins on page 63

TED NEEDLEMAN

mailto: peakcomputing@gernsback.com

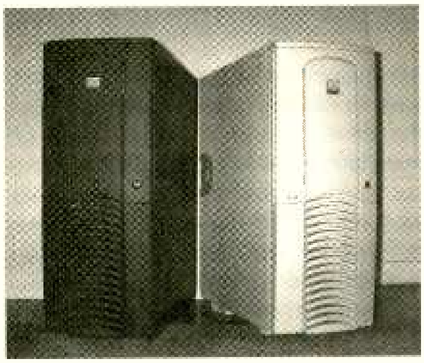
Another Chance for the P4

As hard as Intel has been pushing, sales of Pentium 4-based PCs have been slow to take off. Even with Intel having announced that it intended to phase out Pentium III desktop CPU production by the end of 2001, consumers have been slow to embrace the newer processor.

Part of the reason for this is that the Pentium 4, for all of the hype, simply hasn't yet provided any spectacular increase in performance over its main competitor, AMD's Athlon Thunderbird CPU. The Pentium 4 processor does have some new technology in its design, which will give it the edge on heavy graphics applications. However, these additional instructions and capabilities need to be taken advantage of in the application software, and vendors have been slow to release application upgrades that make use of the new functions that the Pentium 4 provides.

This is history repeating itself. The same thing happened when Intel released its first Pentium containing the now standard MMX extensions. It took a while for software vendors to recompile their applications so the software would use the new MMX instructions. Since the upcoming versions of AMD's Athlon XP will implement the newest SSE2 instruction set, perhaps vendors will finally get on the boat with this and provide applications that run faster on the new processors.

Another reason for the slow acceptance of the Pentium 4 has been price. When initially introduced, the CPUs were considerably more expensive than the previous Pentium III processors, which are at the end of their production life. Interim price reductions have dropped the per-unit price considerably. At the time this is being written, it is possible to buy a 1.7-GHz P4 using the new .13-micron fabrication for about $220. That price is for a retail box, which includes a fan, heat sink, and three-year warranty. If you can live with a "white box" version (no fan, heat sink, and with a 15- to 30-day warranty), the price drops to below $200.



Here are the two PCs that were used to perform the benchmark tests. One unit contains an Intel motherboard, while the other unit contains a Soyo motherboard.

One factor that's really contributed to high Pentium 4 system prices, however, is the need for RAMBUS, or RD RAM. Intel adopted this new type of memory when it first designed the P4, and reference motherboard design built around the i850 core logic chipset.

RDRAM is very high performance and offers a greater memory bandwidth. It is, however, produced by only a few memory module suppliers and costs more, for an equivalent amount of memory, than SDRAM or DDRRAM.

To help push the Pentium 4 into the mainstream, two new core logic chipsets have been introduced. The P4X266 from Via Technologies lets the Pentium 4 run with DDR RAM, which is faster than SDRAM, but slower than RD RAM. This core logic set also supports SDRAM, but most motherboard vendors are using it with DDR RAM. That's because Intel has also thrown its hat into the ring with the release of a second Pentium 4-oriented core logic set, the i845, or Brookdale, chipset. The i845 lets motherboard designers use standard, very affordable, PC133 SDRAM with the Pentium 4. It's somewhat slower than a motherboard using 800-MHz RDRAM, but also hundreds of dollars less expensive.

'CAUSE THEY'RE COUSINS, IDENTICAL COUSINS, IN EVERY WAY

How well do these Brookdale-based PCs perform? To test them, we built a pair of identical PCs, one with Intel's D845WN motherboard, the other with an SY-P4ISR motherboard from Soyo. Both motherboards are very similar in basic features, since they are both based around the Intel i845 core logic chipset. Both offer six PCI slots, embedded audio, and can accommodate up to 3GB of SDRAM using 1-GB DIMMs in each of the three available memory sockets.

The Intel motherboard is available as a retail product, selling for about $145, though its major market is to PC manufacturers who incorporate the board into their own systems. The Soyo P4ISR sells for about $10 more than the Intel, depending on where you buy it. It does, however, offer several additional features that make it very attractive if you are building your own PC or upgrading an older system. These include a built-in 10/100BaseT Ethernet adapter and a Promise Technology RAID controller. This RAID controller is in addition to the standard ATA/100 IDE controller, and it lets you add two additional ATA/100 hard disk drives using either RAID 0 or RAID 1

TABLE 1

Benchmark Used	I850-based P4 with RD RAM	Intel i845 Mobo with SDRAM	Soyo i845 Mobo with SDRAM	Soyo 1-GHz P3 System
Performance Test 3.3 Passmarks	183.6	208.9	210.8	131.9
Performance Test 3.3 MFLOPS	417.5	444.6	453.6	319.7
SANDRA CPU Test Dhrystone MIPS	3199	3141	3093	2632
SANDRA CPU TEST Whetstone FPU MFLOPS	1003	882	882	1335
SANDRA CPU TEST Whetsone SSE2 MFLOPS	2081	2089	2077	N/A
Dr. Hardware CPU TEST Hardstones	1615	1723	1746	1059
Dr. Hardware CPU Test Softstones	512	510	506	592

mode. These two modes accomplish different things. Striping puts sequential disk cylinders on alternating drives. This lets one drive start performing a "disk seek" while a data transfer is taking place on the other drive. This essentially almost doubles the data-transfer rate offered by a single drive. In this mode, the operating system sees the two attached drives as one large fast hard disk. The alternate RAID mode is called mirroring, and it writes everything identically on both drives. If the primary drive suffers a read or write error, the RAID controller automatically switches to the secondary, or mirrored, drive.

Both the Intel and Soyo motherboards use a new version of the Intel Pentium 4 CPU. This new version uses .13-micron fabrication technology, which makes the die size and CPU itself a bit smaller. That change also requires a new socket on the motherboard, called a Socket 478. For our test, we used two 1.7-GHz P4s so we could benchmark our test systems against the 1.7-GHz P4 we constructed with an i850 motherboard and RDRAM for the "Build A Personal Pentium 4 System" article in this issue. That PC had only 256MB of RD RAM, however, compared to the 1.5GB of SDRAM we used in the i845-based systems.

In all other respects, the two PCs we built were pretty much the same. Antec supplied us with two of its terrific SX1040 server cases—one in beige and the other in black. These both have the special power supply required by a Pentium 4 (or AMD Athlon Thunderbird) motherboard. You could save a few bucks using a less expensive case, but your PC won't look as nice as ours did. With bays for the drives that slide out for ease of installation and rolled edges that don't cut your hands to ribbons when you're working, Antec cases have become our favorite. They are widely available in a variety of styles and price ranges.

Because the real advantage of using an i845-based motherboard is SDRAM compatibility, we loaded up our test system with three 512MB DIMMs. We used Kingston ValueRAM in one PC and Crucial Technology RAM in the other, switching the DIMMs to make sure that the different vendors' offerings had no effect on the benchmark results (it didn't.) We've been using ValueRAM for years and have always loved it. Crucial Technologies is a division of Micron Electronics, one of the major producers of RAM in the world.

Finally, we installed identical Western Digital 40GB ATA/100 hard-disk drives in each of the test platforms and used Windows 2000 Professional as the operating system on all three systems.

AND THE WINNER IS?

I ran three sets of tests on the three P4 systems, as well as on a 1-GHz Pentium III system. This last system was included to provide a base point of reference. As expected, all three Pentium 4 PCs outperformed the 1-GHz Pentium III system by a substantial margin.

Most of the benchmark tests contained in the three applications I used, Passmark's *Performance Test*, *Dr. Hardware*, and *SANDRA*, are primarily CPU tests. Since the CPUs used in all three test PCs are 1.7-GHz Pentium 4s (though the two in the i845-based systems are slightly newer), there's not much variation between the RDRAM system (the i850 motherboard), and those PCs using SDRAM.

The most telling of the benchmarks is the PassMark scores from *Performance Test 3.3*. This is a totally synthetic benchmark, but does fold in memory, video, and even disk tests to come up with a "PassMark" score. If you are interested, sign on the vendor's Web site (*www.passmark.com*) to see a more thorough explanation of how the PassMark score is derived or to download a copy of the software for your own use.

On this particular test, the i845-based motherboard systems actually turned in a higher benchmark score than the i850-based system. This is largely due to the increased amount of RAM in the i845-based systems—almost eight times as much as that installed in the i850-based PC.

SOURCE INFORMATION

DR. HARDWARE
www.drhardware.de

SANDRA
www.3bsoftware.com

PASSMARK
www.passmark.com

PENTIUM 4
www.intel.com/pentium4

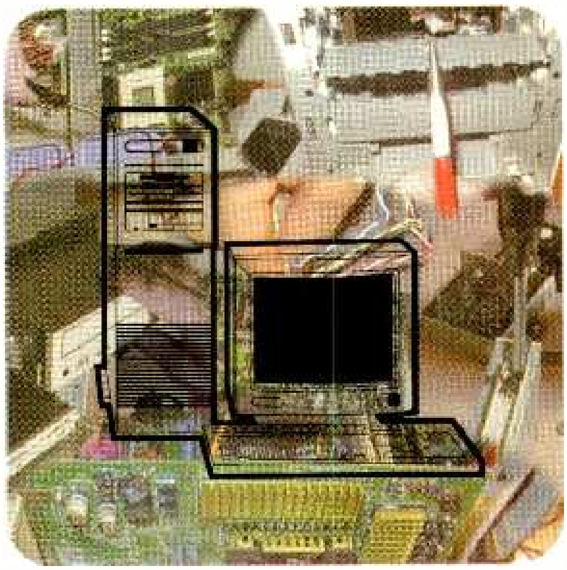
This pretty much supports the contention that in many applications, the newer i845-based motherboards will offer performance that's pretty equal to the RDRAM-based PCs. That's simply because while the memory subsystem operates at a slightly lower speed and bandwidth, SDRAM is still substantially less expensive. You can afford to really load your P4 system up with it, while you might not have the budget to add anywhere near as much RDRAM.

So if you've been wondering whether the new "Brookdale" chipset-based P4s offer a good reason to make the jump, for many users, the answer will be a resounding YES. P

Build A Personal Pentium 4 System

TED NEEDLEMAN

With PC prices sometimes dipping below the $500 mark, assembling your own PC is something that seems to have fallen out of vogue. That's unfortunate for those of us old enough to remember that **Popular Electronics** published the first popular Build-It-Yourself microcomputer project, the Altair 8080. That construction article was instrumental in launching the microcomputer revolution, with thousands of Altair 8080 kits sold, as well as thousands more microcomputers that were based on the Altair 8080's S-100 bus. In fact, Microsoft's first product was a BASIC language interpreter for the Altair machine. (Originally, Micro-soft was located in New Mexico, right next to the Altair factory.)



These days, it's just plain easier to walk into a store and walk out with a system you can just unpack. In a lot of cases, it's also just as economical to buy your PC already assembled. With a top-of-the-line PC, however, you can save several hundred dollars by putting the system together yourself. To prove this, we put together a top-of-the-line PC based on Intel's Pentium 4 CPU. The Pentium 4 is the next generation in Intel's consumer and business processor line and is optimized for exceptional graphic performance. As with previous iterations of the Pentium, especially the Pentium MMX, it will take a bit of time before software vendors completely incorporate the new capabilities that the Pentium 4 offers. (See the sidebar: "Taking It A Notch Higher.")

Fasten your seat belt—it's time to assemble a build-it-yourself powerful P4 system. Then boot it up and get ready to blast off.

Our *Build-It-Yourself P4 Project* was assembled from premium components—in many cases, the identical ones used by premium PC vendors, including Compaq and Dell. The Intel D850GB motherboard is, at the time of writing, the only OEM model available for the Pentium 4. So just about any Pentium 4 system currently being sold uses this identical motherboard, regardless of the vendor label on the case.

The same is true with other important components of the system. The hard disk, CD-RW drive, and video card are all top-of-the-line, the best the vendors have to offer. So is the RDRAM we installed—it's the same vendor that sells RAM to every major PC vendor.

Our system wasn't inexpensive to build, coming in at a bit under $2200 at the time this was written. At the same time, comparable systems from the major PC vendors were running about $500 more (both priced without a monitor or speakers).

Considering that our system took a little less than two hours to put together once we collected all the parts, it works out to about $250 per hour for your labor! The down side is that the system you assemble is not under warranty by a single source. If something goes wrong with it, you'll have to troubleshoot it yourself. Be sure to save all of the receipts!

Great to the Core. The center of any PC is its motherboard. This contains the core logic chipset that directs data throughout the computer, a socket for the CPU, a front-side bus that connects the CPU to the RAM, and PCI and AGP buses that provide a way to connect peripherals.

There are probably a dozen major vendors of motherboards, with some of the better-known ones being ASUS, Abit, Soyo, Gigabyte, MicroStar, and FIC. We're sure that we're leaving some other vendors out. One

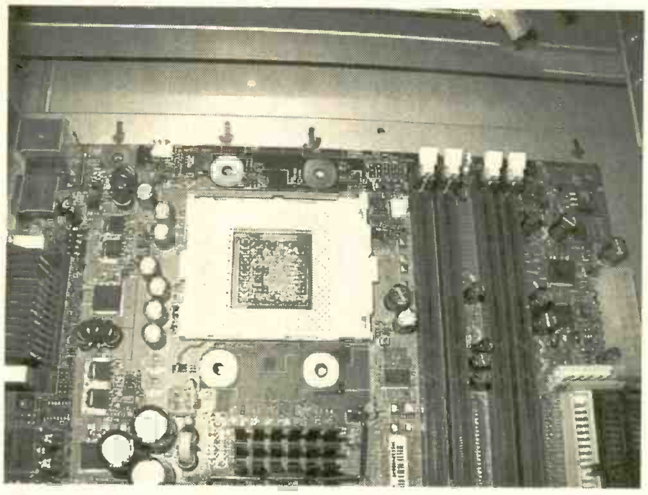


Photo 1. Shown above is the CPU socket surrounded by four plated-through holes.

major vendor of motherboards is Intel. Intel motherboards are among the most widely used, especially in products from premium PC vendors. That's the one we used for this project.

Intel's D850GB has a lot going for it. In addition to being specially configured to help support the humongous heat sink that the P4 requires (more on this later), it has embedded audio and Ethernet adapters. You can use the BIOS to disable the built-in audio if you'd rather add a premium card such as the Creative Labs SoundBlaster Live! or Hercules Game Theater XP. However, we found the sound quality of the built-in

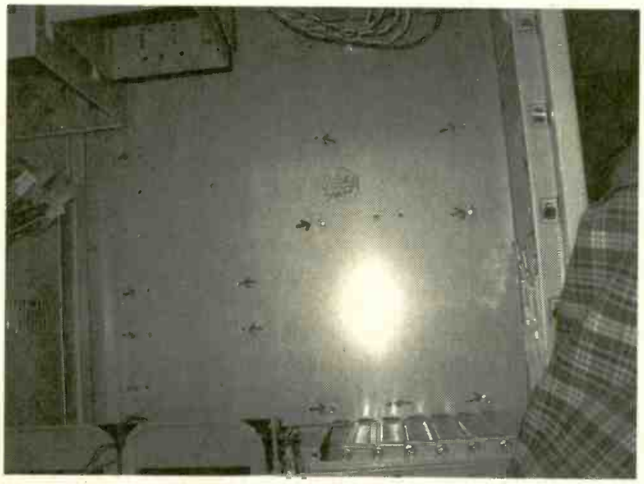


Photo 2. Make your markings as shown here, before screwing in the metal stand-offs.

audio more than satisfactory, especially with a set of good quality speakers.

We also appreciated the built-in 10/100BaseT Ethernet. We have 100BaseT Ethernet running throughout the house to take advantage of our StarBand satellite high-speed Internet access. We added a US Robotics Internet Call modem so that we could also use our AOL account. StarBand does allow us to access our AOL mail, but does not yet support any of AOL's other features.

The D850GB has four RIMM sockets, which require RDRAM modules. As with the older EDO RAM, you need to install RIMMs in pairs. If you're installing RIMMs in only two of the four sockets, use a special terminator in the opposite socket. That's because the P4 motherboard uses a dual bus for the memory, and you'll need to have half of the total memory on each side of the memory bus. It also means that you need

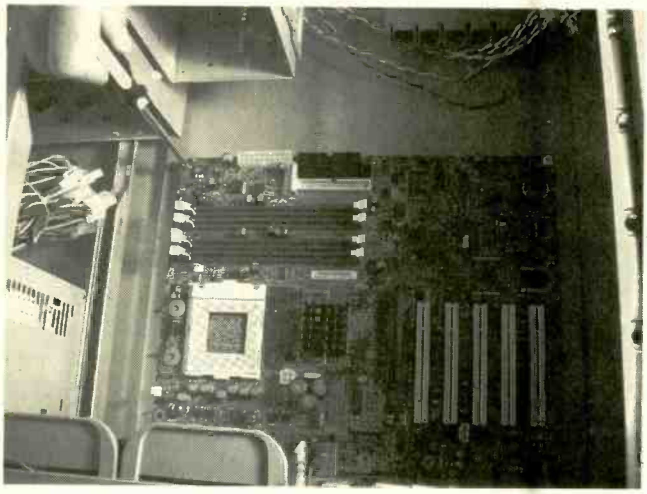


Photo 3. Here the motherboard is mounted to the stand-offs.

to balance the memory, using identical RIMMs. You can have two 128-MB and two 64-MB RIMMs, or two 256-MB RIMMs installed. You can't have a single 128-MB RIMM and three 64-MB RIMMs.

We installed two 128-MB RIMM modules and two terminator strips into the four RIMM sockets. The vendor we used was Kingston, who has a competitively priced ValueRAM line. These RIMMs were PC800 rated, which lets the P4's front-side bus operate at its full rated 400-MHz speed.

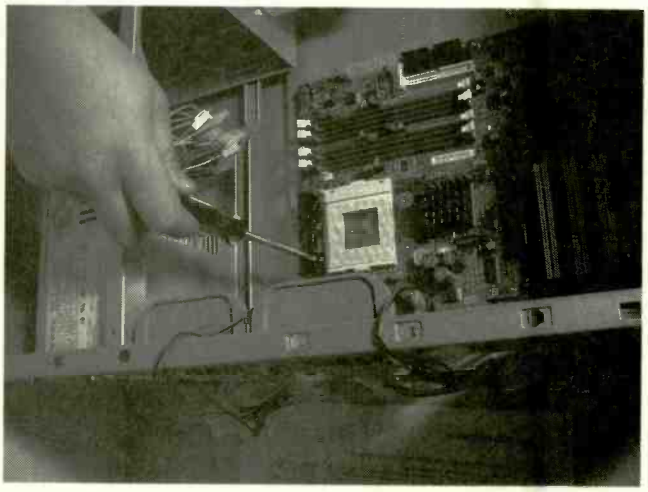


Photo 4. Insert a screw through the clips into the stand-offs.

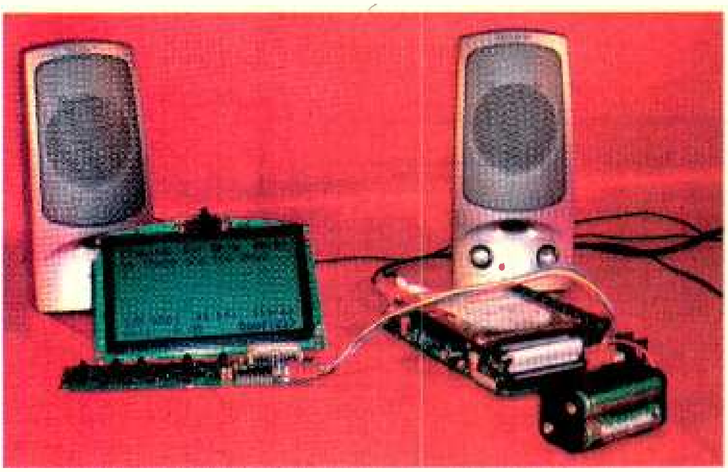
Making the Case. When putting together a Pentium III or Athlon system, it doesn't really matter what kind of case and power supply you use—as long as the power supply is hefty enough to handle whatever you decide to load on the system.

(Continued on page 39)

A High-Tech MP3 Player

PAUL STOFFREGEN

Perhaps you've wanted a CD changer with enough capacity for your entire CD collection for your car or home, or you've looked at portable MP3 players, but haven't been impressed with their limited memory. Maybe you've thought about doing a specialized project, but it required complex customized playback from large collections of audio samples.



This high-capacity *High-Tech MP3 Player* project, which plays MP3 files from a standard hard drive, may be the answer. Its maximum capacity of 137 gigabytes allows 91 days of music to be stored! Even an older model hard drive provides plenty of storage space. For example, a 1-gigabyte drive stores over 16 hours of music.

Not only is the completed project much smaller than a stack of hundreds of CDs, but those original and expensive discs can stay safely stored at home when you take the player with you or install it in a car or other location.

Store up to 91 days of music. This build-it-yourself MP3 player has humongous 137-GB capacity. See for yourself.

Unlike any commercial off-the-shelf devices, this project is an open-source design that you can customize to your own special requirements. The firmware source code is provided as a free download. The flash upgradable design allows you to download new code using a standard PC serial port, so no special EPROM programmer or other equipment is needed to reprogram the code. The C compiler and the other software needed to compile the project's firmware are also available as free downloads, making this a truly customizable and flexible design. (How and where to access these free downloads is discussed in the "Open Source Code" sidebar.)

Theory Of Operation. Before getting into the circuit details, let's take a quick look at the major sections of this MP3 player and how they work together. In the center is the DMA (*D*irect *M*emory *A*ccess) engine, which transfers data from the IDE hard drive to a large DRAM buffer. The DRAM buffer is implemented with a standard 72-pin SIMM, which may be 4, 8, 16, or 32 megabytes. Since many minutes of MP3 data can be held in the buffer, the hard drive can be placed in its full sleep mode to avoid draining batteries. This mode also minimizes the time that the drive's media is spinning, greatly increasing resistance to mechanical shock. The DMA engine also automatically transfers MP3 data from the DRAM buffer to the MP3 decoder, as it is needed.

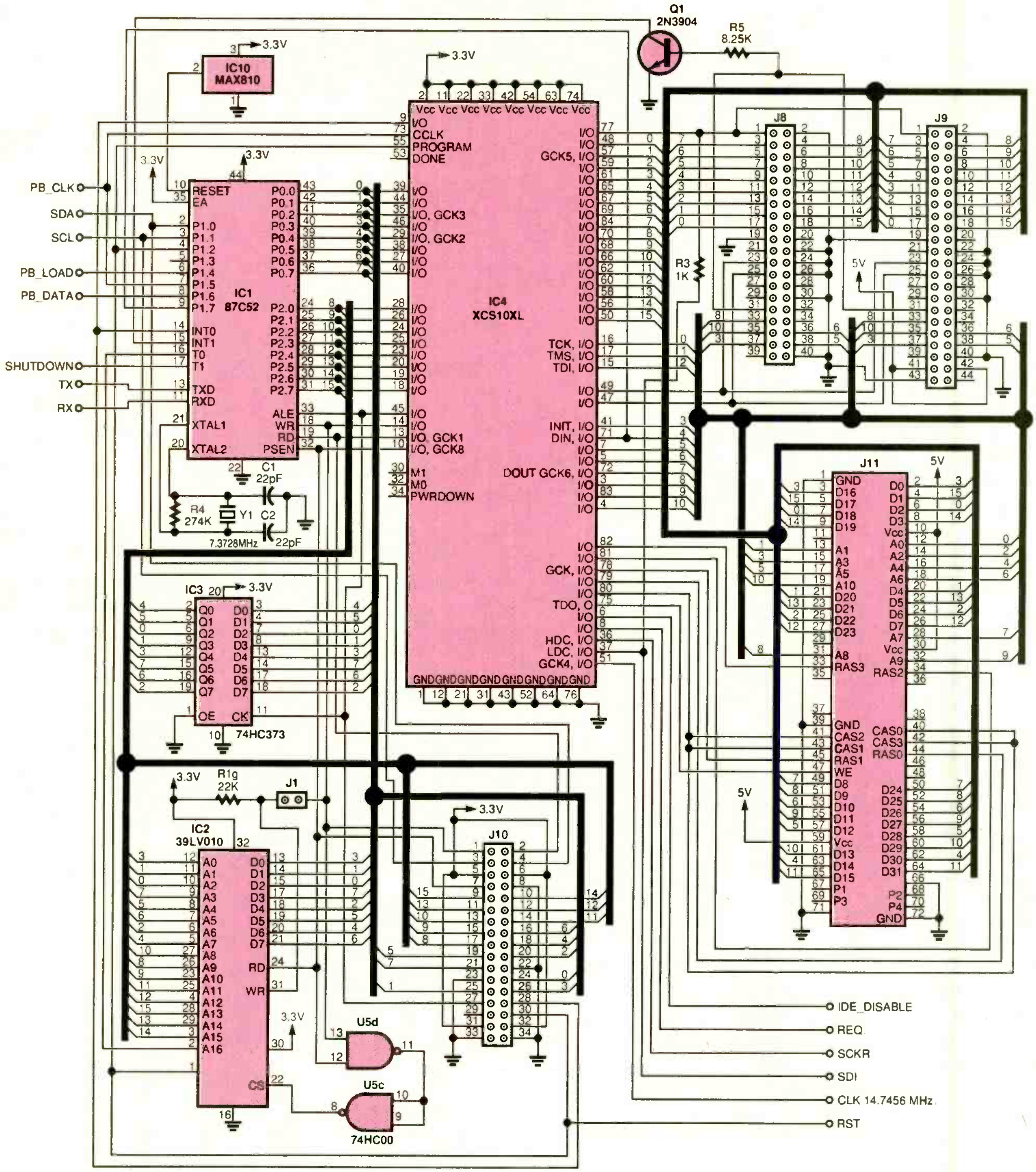


Fig. 1. The schematic above is for the project's main circuit board. An 87C52 chip performs the role of the microcontroller for the MP3 player.

The two DMA data transfers may be in progress at the same time; during these transfers, the microcontroller has full access to the DRAM. This flexible DMA-based approach provides very fast and efficient data transfers with minimal burden to the microcontroller.

The firmware executed by the microcontroller controls every aspect of the MP3 player. When the player is turned on, the firmware scans the hard drive. The firmware recognizes the FAT32 file system, which is the standard format used by Microsoft Windows. All that is needed is to copy files onto a drive using Windows Explorer or any other standard file-management software. The root directory and all subdirectories, up to five levels deep, are scanned; and the firmware builds a list of all MP3 files on the drive and the directories in which they were found.

Once all the files are located, the player enters normal playback mode. The player begins reading the first file into the DRAM buffer and begins playing it also. Since the data is read from the drive much more rapidly than the MP3 decoder plays it, the drive spins down and enters a low-power sleep mode after several seconds. The firmware continues to direct the DMA engine to play the remainder of the file. When the end of the file is reached, this process is repeated.

The firmware handles a variety of other tasks as it manages normal playback. It continuously scans the six pushbuttons and also accepts commands via the serial port. Messages are sent to the LCD display that cause it to show the filename, elapsed time, bit-rate, and other playback information. The MP3 ID3-tag information (specifying the song title, artist, and album) is extracted from the MP3 file and sent to the display.

Various playback modes are available, including sequential and random shuffle—both for the whole drive or for just the files in a single directory. A button on the board toggles random mode on and off. Buttons on the display change the mode and navigate between different directories, as well as between files within a particular directory. The display is constantly updated to reflect the current playback mode and the directory that's being played

The firmware also implements a cursor-based navigation system on the display and multiple screens to access different settings and features. Four buttons in a diamond pattern on the display, together with buttons for incrementing and decrementing and entering parameters, adjust a variety of special settings.

Because the firmware is so important and defines the overall character of the MP3 player, the board design uses an easily upgradable flash-ROM chip to store it. The microcontroller is programmed with a monitor program that allows the firmware to be downloaded to the flash ROM. The monitor program cannot be changed or erased by downloading, which makes it safe to experiment with changes to the firmware. It is always possible to interrupt the boot process with a

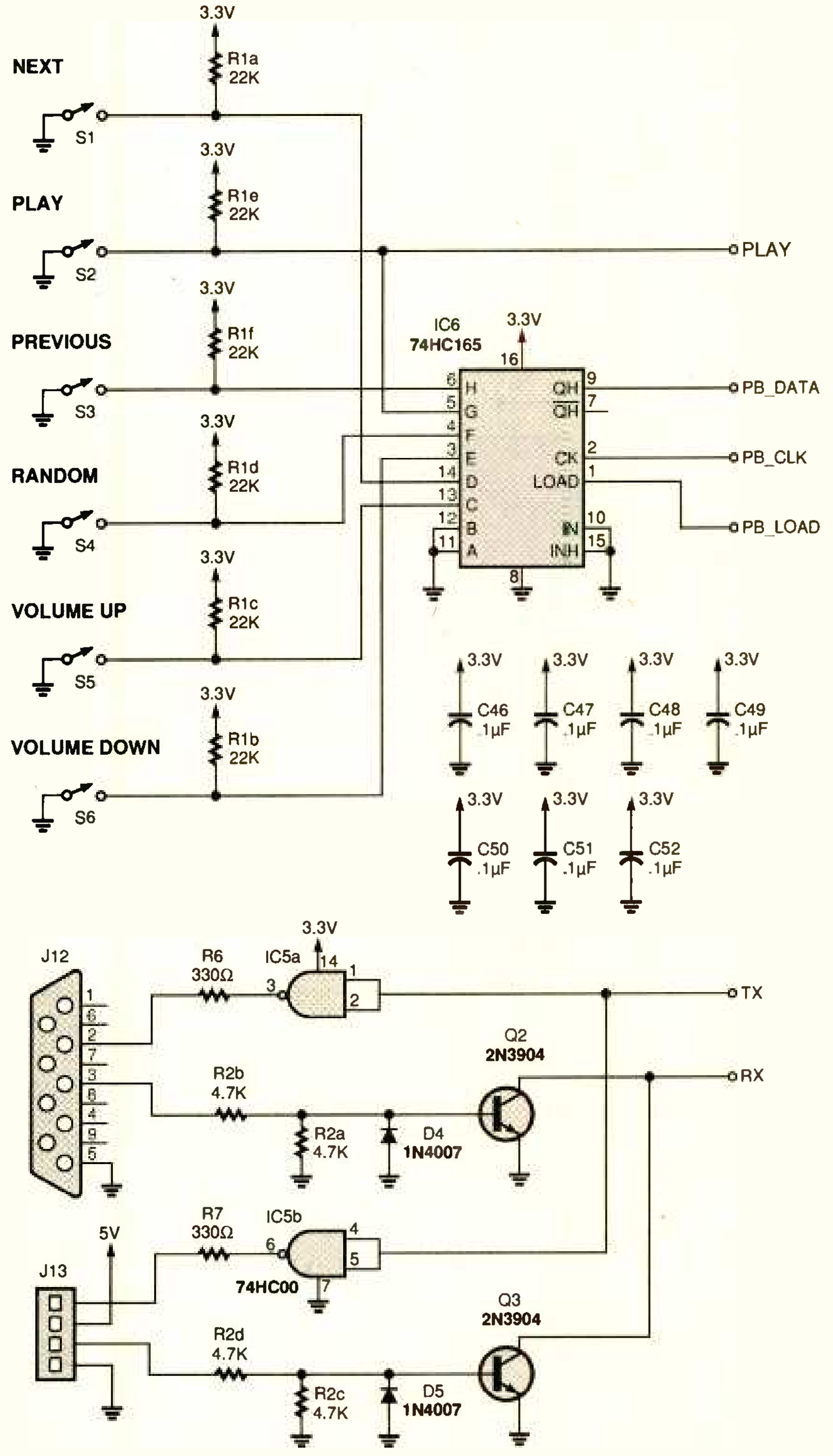


Fig. 2. This is the schematic for the pushbutton interface that is constructed separately. The 74HC165 Parallel-Input/Serial-Output Shift Register is the main interface between the pushbuttons and the microcontroller.

command via the serial port and then to erase the flash chip and download a new firmware image. We'll cover how to modify the firmware in the section on "Testing and Troubleshooting." First, we'll take a more detailed look at the hardware.

Circuit Details. The microcontroller system that controls every aspect of the MP3 player is made up of an 87C52 processor (IC1); the 39LV010 flash ROM that holds the firmware (IC2); and an octal D-latch (IC3). This latch is needed to interface the 87C52's multiplexed bus to the

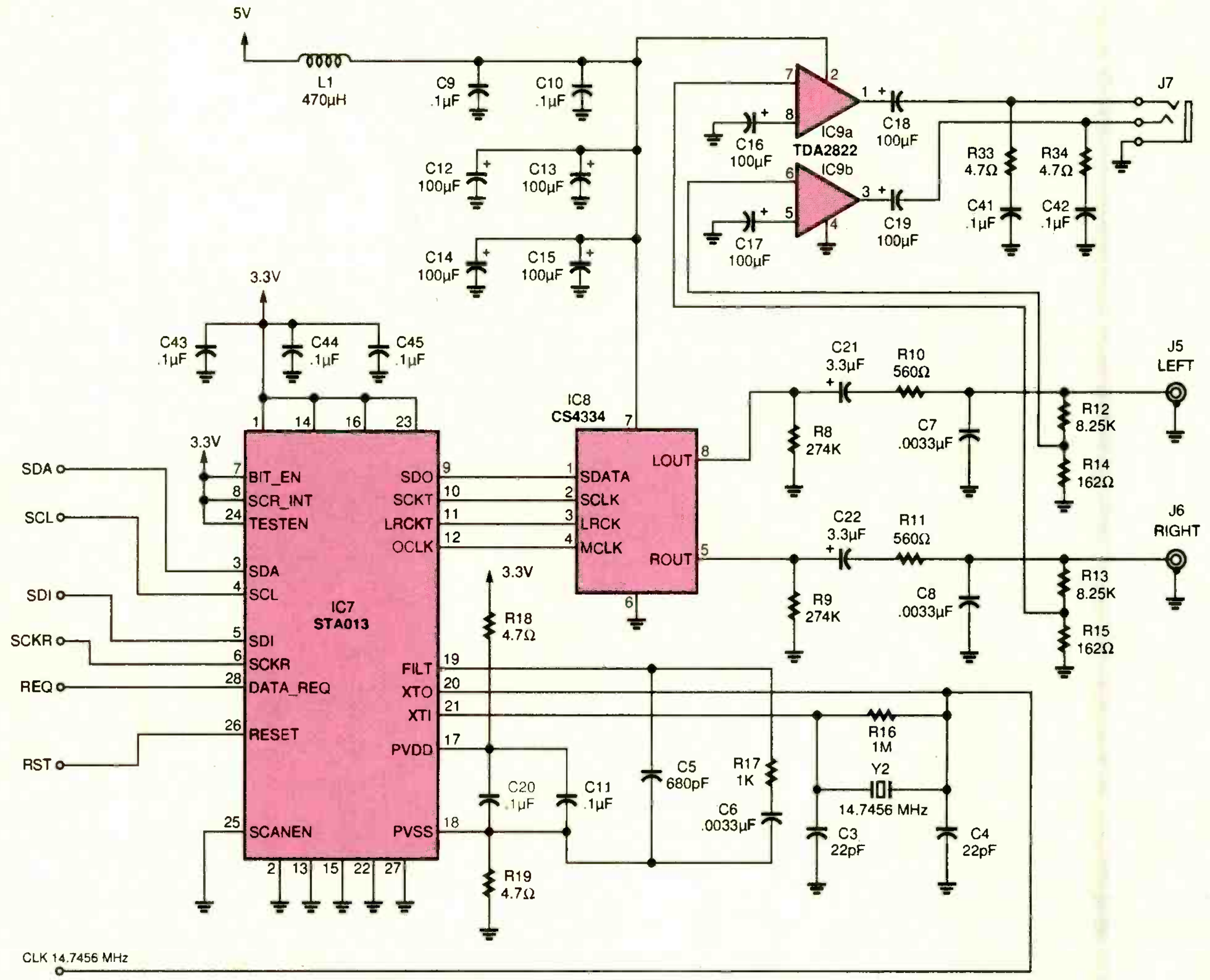


Fig. 3. The audio section schematic is centered around the STA013 MP3-decoder chip. This chip's output is sent to the CS4334 Digital-to-Analog Converter.

non-multiplexed bus of the flash ROM (see Fig. 1). A MAX810 reset-generator chip (IC10) ensures that the processor will not begin running until the power-supply voltage is stable. The NAND gates (IC5) cause the flash ROM to enter a low-power mode while it is not being accessed by the firmware. A 7.3728-MHz crystal (Y1) supplies the clock for the microcontroller. A 34-pin header in the center of the board (J10) provides all the important microcontroller signals to allow expansion cards to be developed in the future.

The DMA engine is implemented in the Xilinx XCS10XL Field Programmable Gate Array, or FPGA (IC4). This FPGA chip is programmed by the firmware as one of its first steps as it boots. The programming data is a small 12-Kb file embedded within the firmware code stored in the flash ROM. When programmed, the FPGA implements a DRAM-memory interface, the IDE interface, and the DMA controller with two concurrent channels. A bus arbitrator is implemented to sequence access to the DRAM between the microcontroller, the two DMA channels, and the required DRAM refresh.

The memory controller inside the FPGA divides the 32-MB DRAM SIMM into 8192 4-Kb blocks. A small page-lookup table allows the 87C52 to select any 15 of these 4-Kb blocks to fill 60 Kb of its 64 Kb of address space. The memory controller constantly monitors the 87C52's bus as it fetches code from the flash ROM. When an opcode is observed that will access the DRAM, the bus arbitrator finishes any in-progress operation to the DRAM and reserves the DRAM bus exclusively for the microcontroller. When the 87C52 sends signals to access the memory, the DRAM controller performs the requested operation and returns the data to the microcontroller for a read or stores data for a write. When the 87C52 is fetching code from the flash ROM or not making any access to its bus, the bus arbitrator inside the FPGA allows the DMA channels and DRAM refresh to have complete access to the DRAM.

The FPGA also implements an IDE interface and an interface to its own internal configuration registers. The DRAM memory, IDE interface, and configuration registers are each mapped to particular regions of the 87C52's address space. That way the appropriate actions can be taken to access each of these, depending on which address the 87C52 contacts.

A pair of registers controls each of the DMA channels. The 87C52

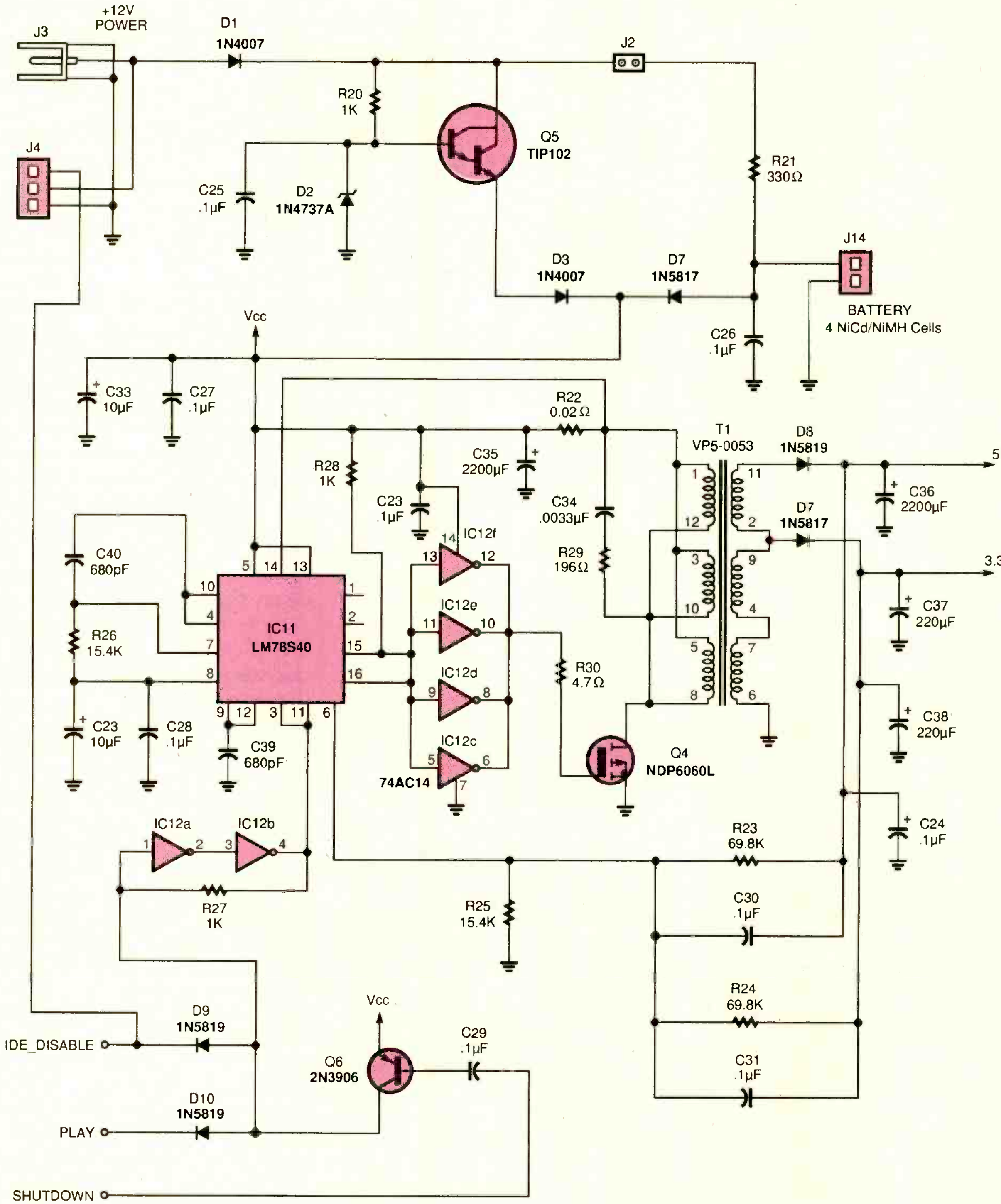


Fig. 4. The board contains a simple power supply that can create the required 5- and 3.3-volts of power from either a 10- to 15-volt or 4.5- to 6-volt input. An LM78S40 chip handles power regulation.

first configures the page-lookup table to map the desired section of the DRAM memory. It then writes the starting address and number of bytes to transfer into configuration registers; finally, it writes to a register to instruct the FPGA to begin automatically transferring the data. The FPGA sends an interrupt signal to the 87C52's INTO pin to alert the firmware that the requested transfer has been completed. DMA transfers from the IDE interface are executed as rapidly as possible. DMA transfers to the MP3 decoder are performed only when the MP3 decoder requests data. The firmware does not need to monitor if the MP3 decoder is requesting data, as it can simply instruct the DMA controller to transfer a large block and receive an interrupt when it has finished. The automatic data transfer using these two DMA channels relieves the 87C52 microcontroller of all substantial data-movement tasks and allows it to go about computing FAT32 sector addresses and servicing the user interface, while the DMA engine

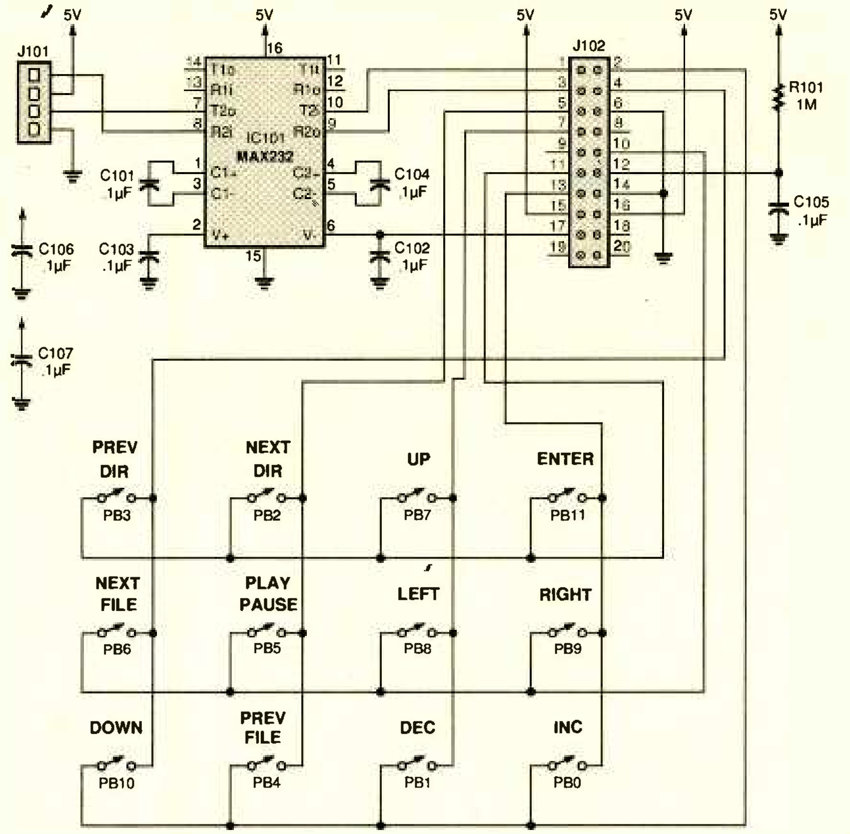


Fig. 5. The LCD display board interfaces with the MP3 player using serial communication. The serial-data inverting-function is handled by a MAX232 interface-chip.

moves the data very efficiently.

The actual IDE interface on the circuit board has two connectors—a 40-pin 0.1-inch header (J8) for connecting a standard 3.5-inch hard drive and a 44-pin 2-mm header (J9) for connecting a 2.5-inch laptop hard drive. An NPN transistor (Q1) and resistor R5 convert the active-high IDE interrupt signal to the active-low signal needed by the microcontroller's INT1 input. The DRAM interface is designed to use a standard 72-pin memory SIMM, installed in the SIMM connector (J11). Because there are only a limited number of pins on the FPGA chip, the 32-bit DRAM data is connected to the same 16-bit bus as the IDE interface. In addition, the DRAM control lines operate so that only half of the SIMM's 32 bits are used at any one time. This approach allows the use of an 84-pin FPGA chip and its through-hole socket, rather than the 144-pin FPGA version, which is supplied in a fine-pitch surface-mount package!

A 74HC165 parallel-input serial-output shift-register chip (IC6) is used to connect the six pushbuttons to pins on the 87C52 microcontroller (see Fig. 2). As the firmware runs, it scans these pushbuttons by pulsing the PB_LOAD signal and then extracting each signal on PB_DATA by applying clock pulses to PB_CLK. The firmware executes this scan every 20 ms, taking a sequence of steps to perform the user's request when it detects that the user has pressed a button.

The firmware communicates to both the display board and its serial port using the TX and RX signals. When the firmware transmits data, it is sent to both locations. The display listens for specific character sequences to start and stop the display of incoming characters and to perform various functions such as scrolling, cursor positioning, screen clear, etc. This design allows additional messages to be sent to the PC that will be ignored by the display, which is particularly helpful when testing new code in the firmware. The NAND gates (IC5) invert the signal as required by RS-232, and resistors R6 and R7 provide some protection against poorly connected cables. The output level is a 0- to 3-volt signal, which does not fully conform to the RS-232 spec (-3 to 3 volts). Yet, virtually all RS-232 receivers can properly receive this 0- to 3-volt signal.

Commands from both the PC and display are merged together and presented to the microcontroller. If both ports send a command at the same moment, the result is garbled data. However, in practice, one does not usually press the buttons on the display while communicating with the MP3 player via a PC. Transistors Q2 and Q3 invert the signals and merge them together. Diodes D4 and D5 protect the transistors from negative voltages, and the resistors in a resistor network (R2) limit the input current and establish a zero input when no signal is connected.

A dedicated STA013 MP3-decoder chip (IC7) performs the actual MP3 decoding (see Fig. 3). The STA013 accepts input data with just two wires, a clock (SCKR) and data (SDI). It automatically identifies the MP3 sample rate, bitrate, and other parameters and provides a data-request signal to indicate when it requires more data. The DMA controller inside the FPGA (IC4) receives the data-request signal and automatically sends more data when requested. It also suspends transmission when the STA013 cannot accept more input. The STA013 can be controlled using two wires and the *I2C protocol*. These wires connect to the microcontroller. The microcontroller initializes the STA013 using these pins. While the STA013 is running, it queries parameters and controls settings, including the output attenuation (volume). The actual MP3 data is never sent from the microcontroller; the DMA engine always transfers it.

The STA013 contains a *p*hase-*l*ocked-*l*oop (PLL) circuit, which creates clock signals corresponding to the sample rate selected by the MP3 data it is decoding. Components R18, R19, C20, and C21 comprise a filtered power source for the PLL; and R17, C5, and C6 provide required filtering for the PLL's feedback loop. A

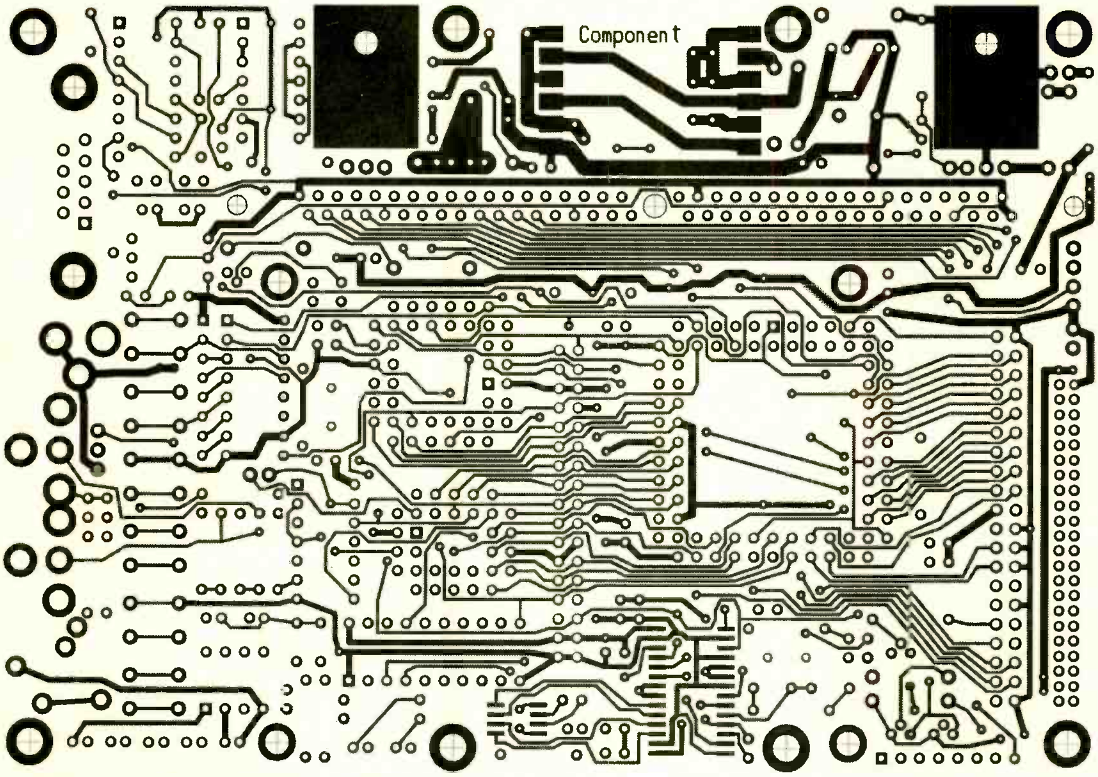


Fig. 6. Here is the component-side foil pattern. High-resolution images can be downloaded at www.pjrc.com/tech/mp3/pcb_layout_reva.html.

14.7456-MHz crystal (Y2) supplies the master clock for the STA013. This clock is also connected to the FPGA (IC4) and ultimately produces all the timing for the DRAM and IDE interfaces.

The STA013, which offers decoded digital output in I2S format, is directly connected to IC8—a 24-bit

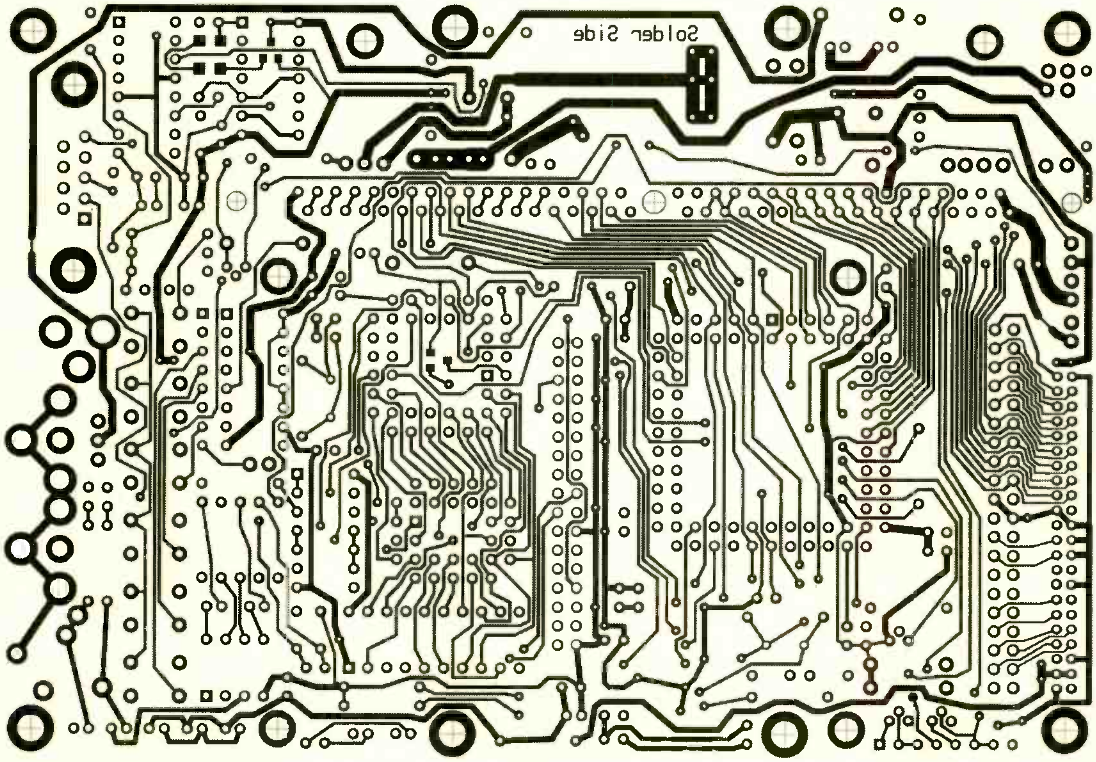


Fig. 7. Here is the solder-side foil pattern for the main board. A high-resolution image can be downloaded at www.pjrc.com/tech/mp3/pcb_layout_reva.html.

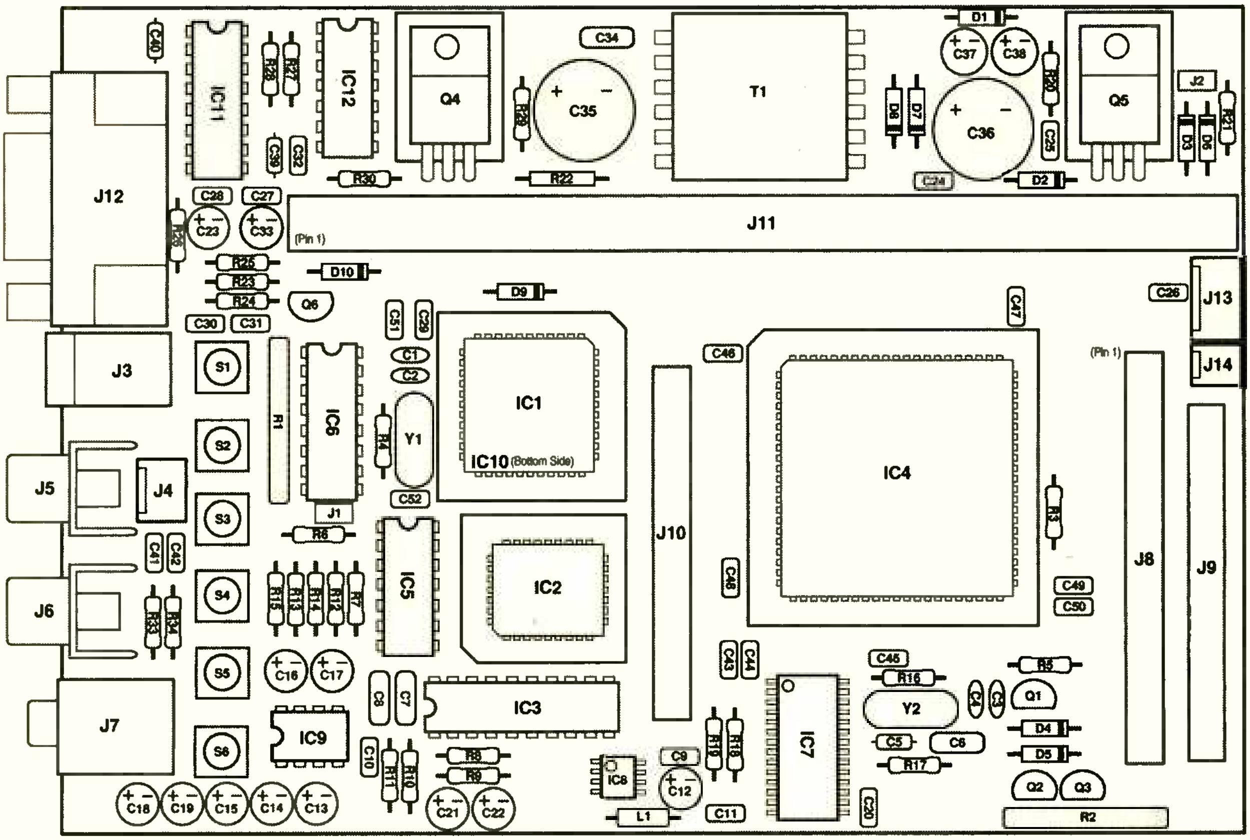


Fig. 8. This is the parts placement diagram for the main board. Be careful to observe polarity where necessary and protect against ESD when handling any sensitive semiconductors.

Digital-to-Analog Converter (DAC). Resistors R8 and R9 and capacitors C21 and C22 provide DC-level shifting from the DAC's internal DC bias to ground. Resistors R10 and R11 and capacitors C7 and C8 form a simple filter to remove aliased images of the DAC's sample frequency. The CS4334 DAC includes 4X interpolation and an internal filter, which allows this simple R-C filter to be used rather than a complex op-amp-based circuit that might add noise to the system.

The amplified headphone output used here is a TDA2822 dual amplifier (IC9). Capacitors C16–C19 provide the AC coupling required by the amplifier, and resistors R33 and R34 and capacitors C41 and C42 attenuate RF pickup that could otherwise couple into the amplifier. An inductor (L1) and a group of capacitors permit filtering of the 5-volt power supply to create a low-noise power source for the analog circuitry. The exact value of inductor L1 is not critical, and different inductors may be substituted with little or no impact on the analog outputs.

Power Supply. The board contains a simple power supply (see Fig. 4) that can create the required 5- and 3.3-volts of power from either a 10- to 15-volt or a 4.5- to 6-volt input. Transistor Q5 together with a Zener diode (D2) and resistor R20 forms a 6-volt pre-regulator. The pre-regulator provides protection against large voltages spikes—common in 12-volt automotive systems—and also protects the main portion of the power supply, which cannot safely run above 7 volts.

The power supply is a flyback-switching topology, with an LM78S40 PWM control chip (IC11). A power MOSFET (Q4) is driven by the inverters, IC12, which drives the primary of the transformer, T1. The outputs are rectified by diodes D7 and D8; and the resistors R23–R25 together with the output-turns ratio define the output voltages at 5 and 3.3 volts.

A pair of inverters (IC12) and a resistor (R27) form a simple 1-bit memory, which is used to implement a firmware-controlled shutdown. When pin 4 is high, the PWM chip is turned off; and the remainder of the power supply shuts down. The firmware can initiate shutdown by pulling low on the base of transistor Q6 via capacitor C29. Power is turned on by pulling low on pin 1, by either D9 or D10.

The flyback-switching power supply provides both of its outputs via rectifier diodes D7 and D8. Because these diodes will prevent externally applied power from flowing back into the transformer, it is possible to run the board using an external regulated power supply that offers both +5 and +3.3 volts.

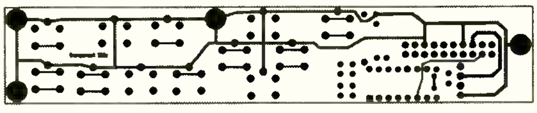


Fig. 9. Here is the component-side foil pattern for the pushbutton board. A high-resolution image can be downloaded at www.pjrc.com/tech/mp3/pcb_layout_reva.html.

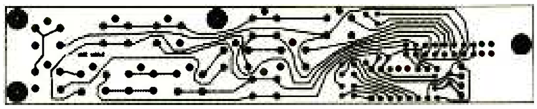


Fig. 10. Here is the solder-side foil pattern for the pushbutton board. A high-resolution image can be downloaded at www.pjrc.com/tech/mp3/pcb_layout_reva.html.

Display-Circuit Details. The LCD display board interfaces with the MP3 player using serial communication (see Fig. 5). The display circuit board contains its own microcontroller system, and its EPROM is programmed with *LCD.HEX*. A small adapter board provides the interface circuitry and 12 pushbuttons. A MAX232 RS-232 interface IC (IC101) inverts the serial data signals and also features a charge-pump power-supply using four capacitors (C101–C104). Negative 10 volts is produced at pin 6, which is fed to the display board to produce the negative bias voltage that it requires. Resistor R101 and capacitor C105 create a simple power-on reset for the display board. Twelve pushbuttons (PB0-PB11) are connected in a 3- × 4-matrix to the seven I/O lines from the display. The *LCD.HEX* firmware regularly scans these lines and sends messages to the MP3 player when the buttons are pressed.

Main Board Construction. PC board construction should be used to build this MP3 player. Though the digital circuit is not highly sensitive to the layout, there are numerous connections between the parts. The opportunity for a wiring error and the difficulty of locating an error among so many connections makes PC-board construction with the foil patterns essential. The power supply is sensitive to component layout and trace impedance; if breadboard assembly is attempted, an external regulated power supply should be substituted.

The PC board should be fabricated with plated-through holes. The PLCC sockets and SIMM socket require connections to the top of the board, and these sockets cover up the top side pads when they are installed. A bare board with plated-through holes may be ordered from the source listed in the Parts List. If you decide to fabricate your own circuit board, you may use the foil patterns printed in Figs. 6 and 7 or download high-resolution copies of these foil patterns at *www.pjrc.com/tech/mp3/pcb_layout_reva.html*.

As always, it is advisable to solder the low-profile components first and work up toward the taller parts to ease the assembly process. Follow the parts placement diagram in Fig. 8. Double-check the diode and electrolytic capacitor polarities. When soldering the PLCC sockets and SIMM socket, be very careful to align them correctly. It can be very difficult to desolder a component with so many pins.

Before applying power, double-check resistors R23, R24, and R5, and their connections to IC11. These parts set the power-supply voltage. If there is an error that holds pin 6 of IC11 near ground, the power supply can produce a relatively high output voltage and damage all of the other chips, so a few moments double-checking these few critical parts is time well spent.

Display Construction. The display pushbutton board may be built using a PC board. See the foil patterns in Figs. 9 and 10. Breadboard construction may also be used. If a socket is used for IC101, its height relative to the pushbuttons should be considered prior to soldering. Follow the parts placement diagram in Fig. 11. The polarity of J102, the ribbon cable, and its connection to the display itself should be carefully checked. Pin 17 conducts a -10-volt supply—one that could damage the display if connected to any other pin.

The display board uses its own firmware, stored in an EPROM chip. This EPROM must be programmed with *LCD.HEX*. If an EPROM programmer is not available, a pre-programmed EPROM or a display with the programmed EPROM may be purchased from PJRC. A proper PLCC extraction tool must be used, as the socket on the display board is easily damaged when excessive prying force is applied. Once the correct firmware is installed, the only assembly step remaining is connecting the ribbon cable. If stranded conductors are used in the cable, they should be twisted and tinned to assure a good connection. The display board's 17-pin connector has a latch that lifts slightly to release the pressure on its contacts. Carefully insert the 17 tinned leads, while paying careful attention to pin 17 (-10 volts). Press the latch firmly downward to secure the wires, and your display will be ready for use.

Testing and Troubleshooting. The first test should be to verify that the power supply is producing the correct +5- and +3.3-volt power for the rest of the board. This test can be performed before the other ICs are installed if a 100-ohm resistor is added from the +5-volt power-line to ground. When power is first applied, there can be a large in-

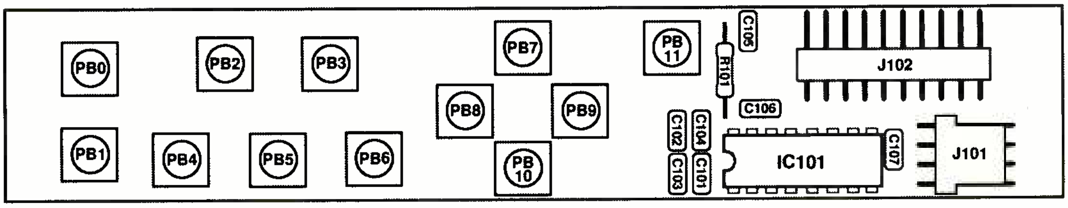


Fig. 11. This parts placement diagram for the push-button board will be helpful during the construction process.

PARTS LIST FOR THE MP3 PLAYER

SEMICONDUCTORS

IC1—87C52-SBAA, microcontroller with internal EPROM (programmed with *PM2_MP3.HEX*), Philips
IC2—SST39LV010, Flash ROM, 128Kb × 8, SST
IC3—74HC373, octal D-Latch
IC4—XCS10XL-PC84, Field Programmable Gate Array, Xilinx
IC5—74HC00, Quad NAND gate
IC6—74HC165, parallel in-serial out-shift register
IC7—STA013, MP3 decoder, ST Microelectronics
IC8—CS4334-KS, 24-bit stereo Digital-to-Analog Converter, Cirrus Logic
IC9—TDA2822-M, dual-power amplifier, ST Microelectronics
IC10—MAX810, reset generator, Microchip (or equivalent), Maxix
IC11—LM78S40, PWM regulator, National Semiconductor
IC12—74AC14, Hex-inverting Schmitt trigger (see text)
Q1–Q3—2N3904, NPN transistor
Q4—NDP6060L, N-channel power MOSFET, Fairchild Semiconductor
Q5—TIP102, NPN Darlington power transistor
Q6—2N3906, PNP transistor
D1, D3–D5—1N4007, general-purpose rectifier diode
D2—1N4737A, 7.5-volt Zener diode
D6, D7—1N5817, Schottkey diode
D8–D10—1N5819, Schottkey diode

RESISTORS

(All resistors are ¼-watt, 5% carbon-film units, unless otherwise noted.)
R1—22,000-ohm, resistor network, 8-lead, bussed (7 resistors)
R2—4700-ohm, resistor network, 8-lead, isolated (4 resistors)
R3, R17, R20, R27, R28—1000-ohm
R4, R8, R9—274,000-ohm, 1%, metal-film
R5, R12, R13—8250-ohm, 1%, metal-film
R6, R7, R21—330-ohm
R10, R11—560-ohm, 1%, metal-film
R14, R15—162-ohm, 1%, metal-film
R16—1,000,000-ohm
R18, R19, R30, R33, R34—4.7-ohm
R22—0.02-ohm
R23, R24—69,800-ohm, 1%, metal-film
R25, R26—15,400-ohm, 1%, metal-film
R29—196-ohm, 1%, metal-film

CAPACITORS

C1–C4—22-pF
C5, C39, C40—680-pF
C6–C8, C34—0.0033-µF
C9–C11, C20, C24–C32, C41–C52—0.1-µF
C12–C19—100-µF, 6.3-volt
C21, C22—3.3-µF, 16-volt
C23, C33—10-µF, 16-volt
C35, C36—2200-µF, 10-volt, low-ESR
C37, C38—220-µF, 10-volt, low-ESR

CONNECTORS

J1, J2—Header, 2-pin, 0.1-inch
J3—Power jack
J4—Header, 3-pin with locking ramp, Molex 22-23-2031
J5—RCA Audio, PCB-mount, white (left)
J6—RCA Audio, PCB-mount, red (right)
J7—Stereo headphone jack, ⅛-inch, PCB-mount
J8—Header, 40-pin, dual-row, 0.1-inch
J9—Header, 44-pin, dual-row, 2-mm
J10—Header, 34-pin, dual-row, 0.1-inch
J11—SIMM Socket, left polarized, Amp 822030-3
J12—D-subminiature, 9-pin socket, PCB-mount
J13—Header, 4-pin with locking ramp, Molex 22-23-2041
J14—Header, 2-pin with locking ramp, Molex 22-23-2021

ADDITIONAL PARTS AND MATERIALS

Y1—Crystal, 7.3728-MHz, parallel-type
Y2—Crystal, 14.7456-MHz, parallel-type
S1–S6—Switch, momentary, PCB-mount, 6-mm
L1—Inductor, 470-µH (see text)
T1—Transformer, VP5-0053, Coiltronics
44-pin PLCC socket, through-hole (for IC1)
32-pin PLCC socket, through-hole (for IC2)
84-pin PLCC socket, through-hole (for IC4)
Heatsinks, 4-40 ⅜-inch screws, 4-40 nuts
72-pin SIMM Memory Module, 4-, 8-, 16-, or 32-MB
Hard disk drive, 3.5- or 2.5-inch
Disk-drive cable
Standoffs or other mounting hardware, as desired

PARTS LIST FOR THE MP3 DISPLAY

IC101—MAX232, RS-232 interface
R101—1,000,000-ohm
C101–C107—0.1-uF
S101–S112—Switch, momentary, PCB-mount, 6-mm
J101—Header, 4-pin with locking ramp, right angle, Molex 22-05-3041
J102—Header, 20-pin, dual-row, 0.1-inch
PB0–PB11—Soft-contact pushbuttons, SPST
Display, JW-002, Earth Computer Tech; EPROM for JW-002, programmed with *LCD.HEX*; ribbon cable with 20-pin socket connector; display data cable: terminal housings (Molex 22-01-3047), crimp pins (Molex 08-50-0114), 24-AWG wire

A complete kit of all parts including a bare PC board may be ordered from PJRC for $140 at *www.pjrc.com/store/mp3_pcb_kit.html*. A fully assembled and tested board is also available for $150 at *www.pjrc.com/store/mp3_pcb_assem.html*. A bare PC board, with plated-through holes, is available for $25 at *www.pjrc.com/store/mp3_pcb_bare.html*. The LCD display and pushbutton adaptor board is available for $42 at *www.pjrc.com/store/mp3_display_beta.html*. Many of the semiconductors and other components, including the transformer, may be ordered from PJRC. Visit *www.pjrc.com/store/* for details.

rush current as the switcher charges the capacitors and stabilizes its feedback loop. This in-rush can trip the current limiting in some lab bench supplies, so a 12-volt, 1-amp unregulated "wall wart" style power supply is preferred.

Once it's verified that the power supply produces the correct voltage, it is safe to install all the chips. Apply power and check the output of the MAX810 chip (pin 10 on the 87C52 microcontroller). The MAX810 output should be high very briefly when power is applied and then go low to allow the processor to start running. If you have an oscilloscope, you could also check that the 7.3728-MHz crystal is oscillating, though this is rarely a problem.

If your 87C52 chip is blank, you must program it with the *PM2_MP3.HEX* file (built with the firmware). If you do not have an EPROM programmer capable of writing this chip, you can order an 87C52, pre-programmed with *PM2_MP3.HEX*, from the supplier listed in

The firmware for this project is open source. You may download the source code for free at *www.pjrc.com/tech/mp3/firmware .html.* To compile the source code, you will need the SDCC C compiler, the AS31 assembler, and a few other utility programs. Fortunately, all of this required software is also available for free download, and it is also open source. SDCC and AS31 may be downloaded at *www.pjrc. com/tech/8051/index.html#as31_a ssembler.* These programs will run on either Microsoft Windows or Linux systems. If you have a Linux-based system, then you probably have all the other tools already installed or available as part of the distribution.

If you use Microsoft Windows, a few more steps are needed to set up a working environment to successfully compile the firmware. There are two basic approaches. The first is to use *CYGWIN,* which provides a comprehensive Unix emulation layer and Unix environment running on top of Windows. Complete step-by-step instructions, specific to this project, may be found at this Web page: *www. pjrc.com/tech/mp3/cygwin_setup. html. CYGWIN* is a large download, and most of its functionality is not needed for this project.

The second Windows build approach is to set up 100% native programs. Fortunately, the AS31 and SDCC download is already native, and their package includes *GNU Make,* so the only major missing piece is the *Perl* scripting language. Fortunately, ActiveState provides a native *win32 Perl* package, available as a free download from their Web site, *www.activestate.com.* Some minor editing may be needed in the project "Makefile" for a native win32 environment. Also, the win32 GUI-based *CVS* client program can be downloaded at *www.wincvs.org.*

Regardless of which system you use to build the firmware, you simple type "make" from your command shell (or MSDOS prompt, as the case may be). The *GNU Make* program will run and execute the commands in the "Makefile." If some program is missing or improperly installed (or you've edited the code and made an error), the process will stop with some type of error message of some sort. If everything goes well, you should end up with *MP3PLAYER.HEX,* the downloadable firmware image. You should also get *MAIN.HEX* and *DEVMAIN.HEX,* which are partial firmware images files that correspond to the partial flash erasure ("X" and "Y" commands at the monitor). These partial images allow faster download, while hacking on the code and trying changes over and over. The Makefile will also build *LCD.HEX* and *PM2_MP3.HEX,* which are the firmware images for the display board and the 87C52 chip (IC1).

The MP3 player firmware is divided into two portions: the application-level code, which is written primarily in *C,* and the driver-level code, which is written entirely in assembly language. There are many files in the source code, but it is probably best to start by looking at *main.c,* which has the main program loop and other very important application-level code. At the beginning of the main function, there are many steps taken to set up the player. Ultimately, the code reaches a giant infinite loop, which runs all of the player's functions.

The player's user interface operates using an event queue. When various things occur, such as a pushbutton press, events are added to this queue. The first thing the main program does is fetch the next pending event (if any) and perform the action needed for that particular event. Much of the display updating is done here in response to events added by the timer-device driver.

Following the event processing is a software-state machine, which causes the player to perform the next required action, whatever that may be. Initially this is locating a file to play. Later, it is loading data from the file into the SIMM, and, shortly after, also delivering blocks of data to the STA013 decoder chip (if it is ready), and so on. The process of servicing a pending event (if any) followed by doing another step in the main state machine is repeated indefinitely.

There is much more code than can be described here, even briefly. Most of the application code is divided into distinct modules called from this main function, so it is fairly easy to locate portions of the application that are responsible for particular behavior of the player. Since it's an open-source project, a number of people from around the world have contributed to the firmware source code in one way or another. To facilitate this happening, the source code is maintained using a program called *CVS,* which stands for Concurrent Version System. *CVS* is software that allows many programmers to work together to develop code. Like all the other programs, it is free software. *CVS* has many advanced features, but most people use only three of them: Checkout, Update, and Commit. All of these communicate via the Internet to the server, which maintains a master copy of the code. "Checkout" downloads a fresh copy of the code. "Update" merges any changes on the server into your local copy, without discarding any changes you may have written. "Commit" causes changes you have made to the code to be merged into the master copy on the server. Commit requires a password, but Checkout and Update can be done by anybody using anonymous access.

To use *CVS* for the first time, you would type the command "cvs -d :pserver:anonymous@pjrc.com:/usr /local/cvs login" and simply press ENTER when prompted for a password. Then, to make an initial checkout of the code, you would use the command "cvs -z5 -d :pserver:anonymous@pjrc.com:/usr /local/cvs checkout mp3." After these two lengthy commands, you can always get the latest changes with *cvs update.*

At the time of this writing, people from several countries have contributed to the development of this project, using *CVS.* A developer forum is available here: *http:// groups.yahoo.com/group/pjrcmp3dev.* If you are interested in contributing to the project or just getting a few hints about how the code works, this is an excellent forum to join. Generally, a *CVS* commit password is assigned to anybody who is interested in the project and manages to demonstrate that they can make some reasonable edits to the code. Haphazard as this process seems, it leads to an environment where almost anyone is welcome to share their improvements with everyone else who built a player; and a constant stream of new features and improvements are added to the project.

the Parts List. *PM2_MP3.HEX* is the monitor program that will boot the board and provide you with the capability to download the firmware to the flash ROM

At this point, you should connect the board to your PC computer serial port and run a standard terminal-emulation program. *Hyperterminal* is a popular choice, because it is included with Microsoft Windows. If you use Linux, *minicom* is a terminal-emulator program installed with most Linux distributions. Nearly any terminal emulator will work. The baud rate must be set to 19200 baud, and the format to 8 bits, no parity, 1 stop bit. You should disable flow-control, if possible.

Hyperterminal may not work if flow control is set to the default "hardware" setting. When you turn on the board, a start-up message should appear. If the flash ROM is empty, you will get a prompt from the monitor. If there is firmware loaded in the flash ROM, it will run shortly after the start-up message appears, unless you press the s key to abort running the firmware automatically.

A bit of caution should be observed the first time you connect the board to your PC's serial port. The computer's ground will be connected to the ground from the power source for the board. Nearly all PCs connect their ground to the earth ground from their power cord. If your power source has a ground that is floating or connected to earth ground (the two common cases), there is no problem. If your power source is at a different ground, the board and possibly your computer could be damaged by the large current flow between the two grounds. This is an issue when connecting any two devices together joins their grounds.

Once you get the monitor prompt displayed, you are ready to download the firmware. The latest firmware (and many other earlier firmware revisions) may be obtained, including source code, at *www.pjrc.com/tech/mp3/firmware.html.* You must transmit the file *MP3PLAYER.HEX* to the board, using a plain ASCII transfer. In *Hyperterminal,* this appears as "Send Text File..." in the "Transfer" menu. Do not use a file transfer protocol (xmodem, zmodem, kermit, etc.). As the firmware downloads, you should see dots appearing on the screen. When it is completed, you should see a summary indicating the number of lines and bytes transferred and whether any errors occurred.

If an error occurs in the download, try erasing the flash chip (press z and confirm) and try downloading again. If errors remain, there is quite likely a faulty connection in one of the many wires between IC1, IC2, IC3, IC4, and J10. Often visual inspection is the best way to catch solder bridges and cold or missing solder joints.

If the problem isn't visible, you can attempt to use the memory editor and other monitor features that show a view of the memory that the 87C52 can "see." If the flash chip is poorly connected, it will not respond to any write attempts, so you should remove it. With no flash chip, each memory location should read the same as the LSB of the current address (because the lines are floating, but were pre-charged with the LSB earlier in the 87C52's time multiplexed bus access). If you see some locations that do not follow this pattern, how they differ can provide clues as to which wires may be disconnected. Finally, it is possible to connect a 1-Kb resistor pullup and/or pulldown resistor to each of the data lines (pins 36 to 43) on the 87C52 and to verify that each one is not shorted high or low or to another nearby signal. The same 1-Kb resistor trick can be used to attach each of the 16 address pins to one of the data pins and make sure it appears correctly in the memory views. Hopefully, this tedious testing won't be necessary, but if the flash won't write you can use this approach with the monitor memory dumps to verify almost every signal until you are finally able to download firmware into the flash ROM.

Many of the firmware revisions contain a simple memory tester that will write several byte patterns to various locations within the SIMM and attempt to read them back. Usually this is installed as a monitor command, so you can press the T key to run the test. This test will verify most of the connections between IC4 and J11. If there is a bad connection between the FPGA and SIMM, checking which addresses failed and which data bits were incorrect will oftentimes help pinpoint which line is bad.

There is also a utility included in most firmware revisions that can test the IDE interface. Great care should be observed while running this utility, as pressing W will write directly to a sector on the disk drive, without any regard to the file system, directories, and files on the drive. Usually this utility is installed as a normal program, so press R at the monitor prompt, and then select the IDE test utility from the list. It will attempt to read the drive's model number, serial number and cylinders, and heads and sector information from the drive. These should match either the information printed on the drive or the message that a PC BIOS prints as it detects the drive in a PC. If they differ, checking which bit positions are different from the correct values can sometimes lead you to which pin may be connected incorrectly. Fortunately, this is rarely a problem when the SIMM memory test has passed, because most of the signals are shared between the SIMM and IDE interface.

Once you've successfully downloaded the firmware, you may run

(Continued on page 44)

OTHER COMPONENT SOURCES

All American
www.allamerican.com

Arrow Electronics
www.arrow.com

Digi-Key
www.digikey.com

Earth Computer Tech
www.earthlcd.com

Future Electronics
www.futureelectronics.com

Insight Electronics
www.insight-electronics.com

TTI Electronics
www.ttiinc.com

PENTIUM 4

(continued from page 26)

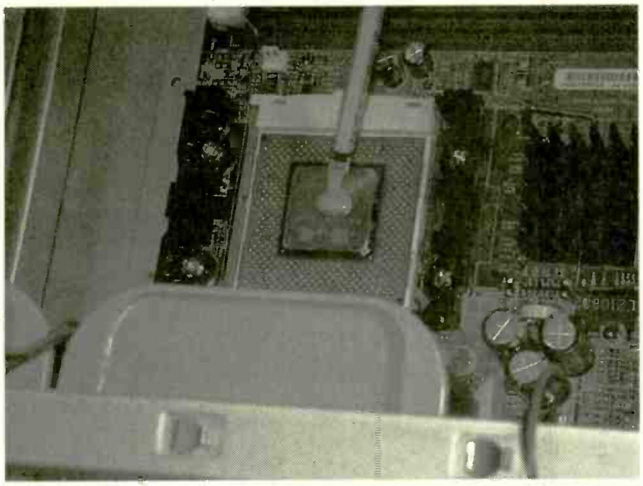


Photo 5. *Use the syringe to squeeze thermal paste onto the CPU, as shown here.*

That's simply not true with the D850GB motherboard. This motherboard requires a power supply that's compatible with the ATX12V Power Supply Design Guide V1.1 specification. These power supplies have two more motherboard connections in addition to the standard motherboard connector. There's a new 4-pin, +12-volt power connector to enable the delivery of more 12-volt power to the motherboard. There's also a 6-pin auxiliary power connector that delivers extra current to meet the heavier +3.3-volt and +5-volt needs.

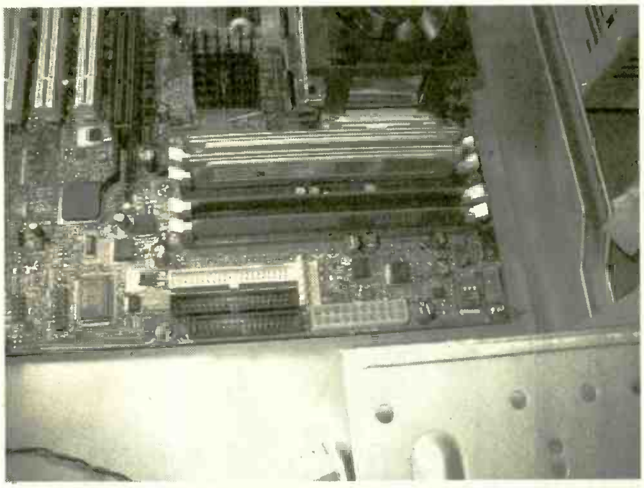


Photo 6. *Mount the two RDRAMM RIMMS and their terminators in position. You can see the CPU heat sink in the background.*

Intel's specifications for the D850GB motherboard require a power supply rating of at least 250 watts and suggest a 300-watt supply. To be on the safe side, we selected an SX840 case from Antec, Inc. This beauty of a case is a full-size tower, with three external 5.25-inch and two external 3.5-inch drive bays, a pull-out cage for mounting up to three hard drives, and almost enough interior space to park an SUV. As delivered, Antec provides three fans on the rear panel (one of which is in the power supply), so there's plenty of air movement. We also mounted a third fan on the front panel and a fourth to the cage with our hard-disk drive. The heavy steel case keeps the noise level down, while there's lots of air movement to keep our heavily loaded P4 system nice and cool.

Best of all, the SX840 comes with a P4-compatible power supply, rated at an impressive 400 watts. If you want to save a few bucks and don't plan on quite as

Photo 7. *A pair of pliers is used to remove knockouts where the two optical drives will go, as shown here.*

hefty a system as we built, Antec also offers an identical case (SX830), with a 300-watt power supply, for about $50 less. We used this SX830 model to house the 1-GHz Pentium III we built for running RAM tests for a "Peak Computing " column in an earlier issue.

Making Your Mark. Once you've gotten all of the components that you'll need for putting your system together, the first thing to do is mark the Antec case to show where the motherboard supports should be mounted. The case itself has numerous holes and can support pretty much any type of motherboard form factor, including the ATX-style D850GB. We took the motherboard, carefully placed it in the case, and used a marking pen to put arrows where the holes on the motherboard lay.

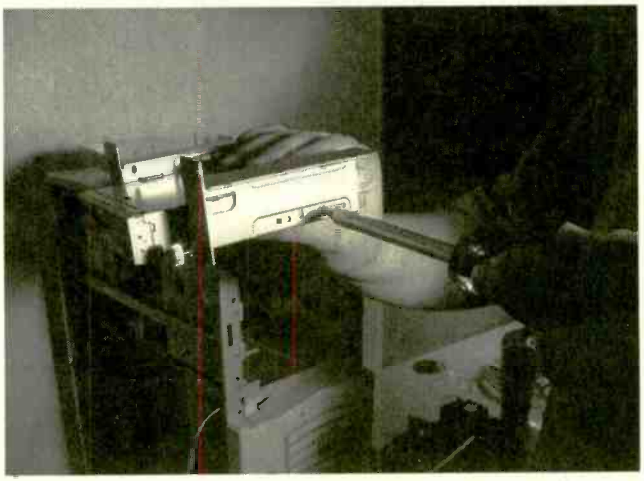


Photo 8. *The Antec case provides a slide-out cage for mounting the drives.*

Photo 9. The case has a stick-on mounting to store the unneeded third set of rails.

Note: It's a good idea to use a wrist-grounding strap whenever you handle the motherboard or any other electronic component that's delivered in a conductive bag, including the CPU and RAM. You can purchase one of these straps for about a dollar in many electronics stores or make one yourself from a piece of copper wire, wound around your wrist, and attached on the other end to a ground. This drains off any static charge before it can damage a sensitive piece of electronics.

In mounting the D850GB motherboard, the one place you need to be extra careful is around the CPU socket. The Pentium 4 CPU itself is just a bit larger that the Pentium III. What's considerably larger, however, is the heat sink included with our "boxed" CPU. It weighs

Photo 10. Slide the drives into the case, as shown here.

close to a pound, and if not correctly mounted, it can pull the CPU right out of the motherboard socket when you turn the case vertical!

If you look at the CPU socket in Photo 1, you'll notice that the socket is surrounded by four plated-through holes. You need to mark the area under these holes on the case for mounting stand-offs. These stand-offs allow you to fasten the heat sink directly into the case, making sure that no excessive force is applied to the processor socket. The heat sink also thermally conducts a bit of the heat produced down the screws into the stand-offs and into the case.

Once you've made your marks (Photo 2), tightly screw in the metal stand-offs supplied with the Antec case using a pair of pliers. Make sure there's a stand-off placed wherever the motherboard has a hole for mounting. The more stand-offs you use, the more rigidly the motherboard will be held.

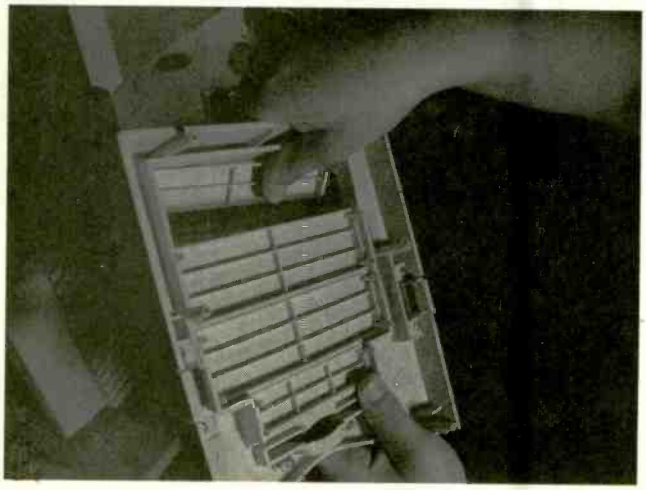


Photo 11. Push out the appropriate plastic plate on the case's front panel.

Next, mount the motherboard to the stand-offs, using the screws provided with the Antec case (Photo 3). Do NOT mount the four screws around the CPU socket yet!

As mentioned previously, the heat sink for the P4 CPU needs some special mounting to distribute its weight. The boxed 1.7-GHz P4 we used was supplied with the heat sink, a fan, and a special set of mounting clips. A screw goes through these clips into the stand-offs that surround the CPU socket (Photo 4). Once these clips are secured, there's also an extra plastic clip that attaches to the video card AGP slot, providing an extra measure of security. Just slide it on and push into place.

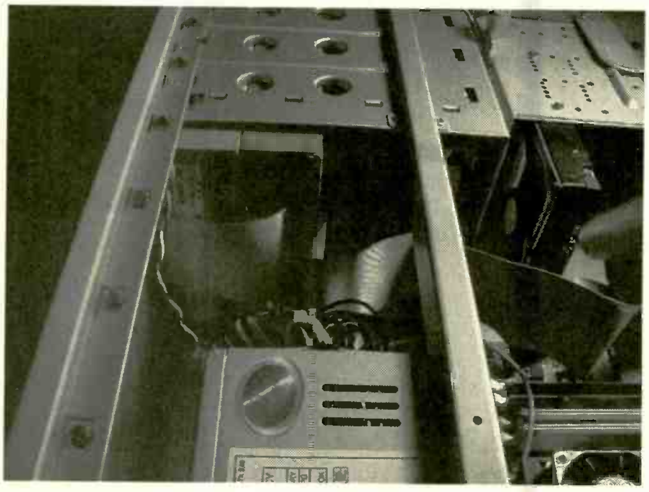


Photo 12. Run the cable from the drives to the sockets on the motherboard, as shown here.

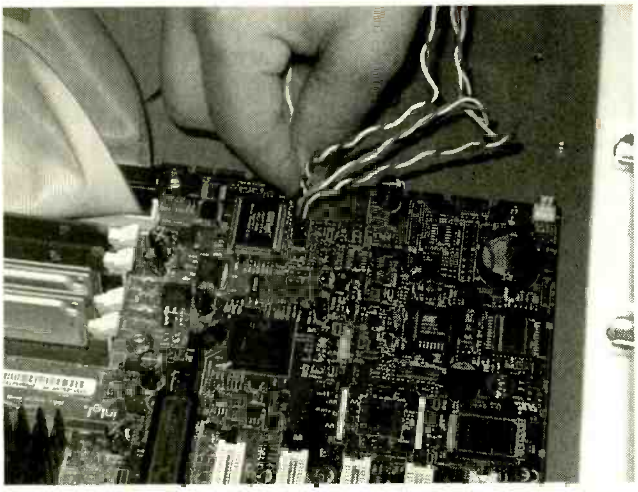


Photo 13. Seen here is the way to attach the cables from the case's power switch, LEDs, and speaker to the motherboard.

Getting Down To Business. The next task is to install the Pentium 4 CPU's heat sink and fan. The CPU socket on the motherboard is a ZIF (zero-insertion force) model. There's a locking lever that must be lifted up before the CPU will fit. Carefully align the CPU—it only fits one way—and let it drop down into the socket. Lightly press it with your finger to make sure it's fully seated, and then close the lever. The CPU comes with a syringe of gray goop. This is thermal paste, which helps transfer heat from the CPU into the large heat sink. Use the syringe to squeeze a good dollop of this goop onto the CPU (Photo 5). Then fit the heat sink onto the CPU socket, pressing it until it clicks into place in the clips that you've previously mounted. The fan included with the heat sink simply snaps in place and gets plugged into a small set of pins on the motherboard labeled CPU Fan.

Next, mount the two RDRAM RIMMs and their terminators (Photo 6). You can see the CPU heat sink in the background of this photo.

With the motherboard mounted and CPU and memory in place, much of the rest is simple assembly work. The case has knockouts where we'll have to mount the two optical drives, so a pair of pliers is used to remove them (Photo 7).

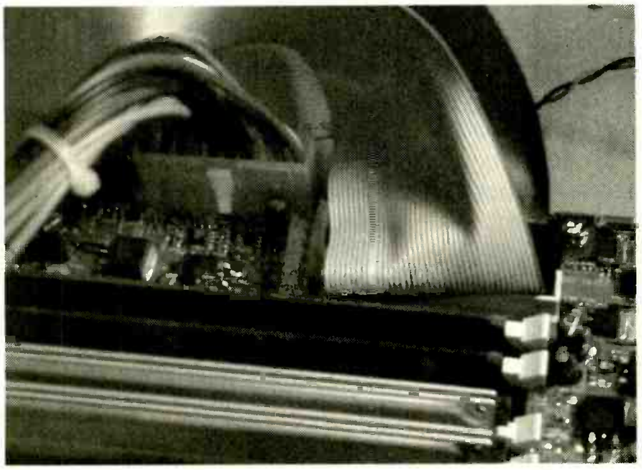


Photo 14. Pictured above, the main and other power connectors are plugged in to the system.

Mounting The Drives. After you've prepared the case, you have to mount the drives. We really loaded up our system here. The Antec case has room for two 3.5-inch drives, so we added an internal 250-MB Iomega Zip drive as a supplement to a standard 3.5-inch floppy disk drive. We've found the 250-MB Zip disks to be an effective way to send files to some of our clients who have standardized on the Iomega drives. The Antec case provides a slide-out cage for mounting these 3.5-inch drives (Photo 8).

The two optical drives are mounted on rails, supplied with the case. (The case also has a stick-on mounting to store the unneeded third set of rails for future use, so they won't get misplaced.) (See Photo 9.) We decided to use both a DVD drive and a separate CD-RW drive. The DVD was a 16X model from I/OMagic, which provides excellent performance, but is value priced. The CD-RW drive, one of TEAC's latest models, is also a super performer—with 16X on CD-Rs and 10X on CD-RWs, a fast 40X audio rip rate, and Version 5 of Roxio's *Easy CD Creator and Direct CD*.

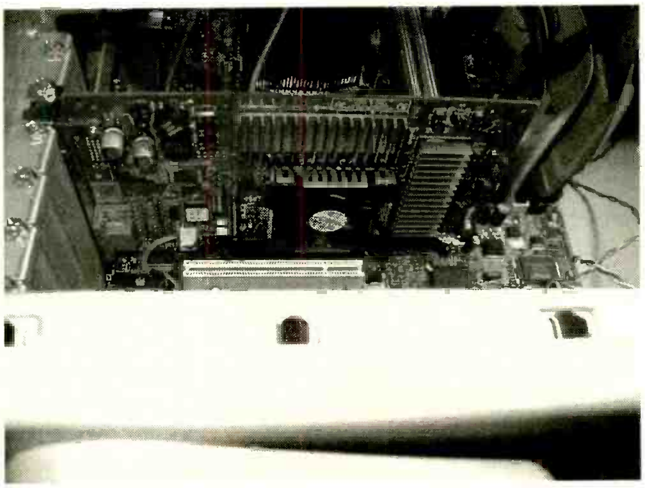


Photo 15. The last assembly step is to plug the Hercules 3D Prophet Ultra video card into the AGP socket and secure the mounting screw.

As you finish mounting the drives, make sure that the drive jumpers on each drive are set correctly. Since the DVD and CD-RW drives will be on the same cable, set the CD-RW as the master drive and DVD as the slave. This setup will insure that you get the fastest burn speeds the CD-RW drive can render. Once you've set these jumpers, slide the drives into the case (Photo 10) and push out the appropriate plastic plate on the case's front panel (Photo 11).

Finally, the Western Digital 40-MB ATA/100 hard-disk drive was mounted in the drive cage. This drive slides out of the Antec case with a simple lever movement, which also makes it easy to mount a fan at the case-side of the cage to improve airflow over the drive. The fan isn't absolutely necessary, but since the drive spins at a fast 7200 RPM, we figured it wouldn't hurt to keep it as cool as possible.

TAKING IT A NOTCH HIGHER

Introduced last year, the Pentium 4 is actually the sixth generation of Intel processor. It is based on 0.18 micron manufacturing technology, which allows 42 million transistors to be used on the CPU die. At the time this is being written, clock speeds on the Pentium 4 range from 1.3 GHz to the 1.7-GHz processor used in our P4 project. It is possible that by the time this article appears, Intel may have announced even faster P4s.

One big difference in the P4 architecture is the system, or front-side bus. Intel has bumped up the bus speed and bandwidth. Where the Pentium III front-side bus runs at a maximum of 133-MHz, the P4 runs at 400 MHz, tripling the bandwidth from 1.06 Gb (gigabits)/sec to 3.2 Gb/sec With the release of the Pentium 4, Intel has enhanced the design to support even more robust graphic capabilities. These design enhancements take place in several areas of the CPU. One immediate improvement over the Pentium III is in the amount of memory that can be directly addressed by the CPU—up to 64 GB of physical RAM.

Intel lumps several of the new design features under a single label, "NetBurst Micro-Architecture." Bundled under this fragment of techno-speak are a number of new features like Hyper-Pipelined Technology, a 400-MHz front-side system bus, Execution Trace Cache, and a Rapid Execution Engine. Enhancements include an Advanced Level 2 Transfer Cache, enhanced floating point and multimedia unit, and Streaming SIMD Extensions 2 (SSE2.)

Hyper Pipelined Technology doubles the number of pipeline stages. Pipeline allows the processor to "predict" which instructions it will need to execute next, and the P6 (Pentium III) design used 10-stage pipelines. The Pentium 4 Hyper Pipelined Technology increases the number of pipeline stages to 20.

Intel has also changed the cache geometry in the Pentium 4. The P4 adds an Execution Trace Cache, which stores decoded micro-ops, removing the micro-op decoder from the main execution loop. The Pentium 4's Level 2 Cache has also had its bandwidth boosted. Where the 1-GHz Pentium III's L2 Cache has a data transfer rate of 16 GB/sec, the Pentium 4's L2 Cache maxes out at 48 GB/sec.

Also new in the Pentium 4 design is a Rapid Execution Engine. Two ALU (arithmetic logic units) on the P4 are clocked at twice the core frequency. These units allow basic integer instructions such as Add, Subtract, Logical AND, Logical OR, etc., to execute in half a clock cycle.

The floating-point and multimedia unit has also been enhanced in the P4 by the expansion of the floating-point registers to 128-bits, as well as the addition of another register for data movement.

Finally, the SSE technology that was initiated with the introduction of the first Pentium MMX has been extended. SSE2 adds 144 new instructions that will help accelerate graphics applications such as photo-image processing and video. As with the original MMX technology, it will be a while before software developers take advantage of these new SSE2 instructions.

Now For The Big Finish! Once all of the drives are installed, carefully run the cables from the drives to the proper sockets on the motherboard (Photo 12). If you add the Iomega Zip 250 drive, as we did, you'll find that you are a connector short on the motherboard. The floppy drive plugs into the floppy connector on the motherboard, the hard-disk drive plugs into IDE channel 1, and the chained pair of optical-disc drives plugs into the secondary IDE channel. The Iomega Zip 250 drive also needs an IDE interface, but since it is so much slower than the hard-disk, you don't want to plug it into the same channel and cable. The answer is to add a second IDE controller. I/OMagic offers one for about $30. Plug it into one of the empty PCI slots and run a cable between the new controller card and the Zip 250 drive. There's also a second IDE connector on the controller card, which lets you add an additional pair of ATA/100 hard disk drives at a future time.

Now is also the time to attach the cables from the case's power switch, LEDs, and speaker to the motherboard (Photo 13). These locations are clearly marked on the motherboard. Plug in the main and other power connectors at this time, as well (Photo 14).

Finally, plug the Hercules 3D Prophet Ultra video card in the AGP socket and snug down the mounting screw (Photo 15). Route the wires so that they are neat—we used nylon cable ties for this—and get ready to run the system.

Attach a monitor to the video card, a power cord to the power supply, and a keyboard and mouse. We used Logitech's Freedom keyboard and mouse, which are wireless, and a small RF transceiver that's plugged into the keyboard and mouse ports.

System Check. Our system powered up on the first try. If yours doesn't, turn it off and check to see that all of the connectors are snuggled in, that the RAM is correctly mounted in the socket, and that all of the add-in cards are correctly inserted in the PCI slots. One common cause of a no-boot is that the cables to the hard-disk and/or floppy and/or optical drives are not properly connected.

When the system boots, you will have to install an operating system (OS). This particular PC got Windows 98SE, simply because we're pretty happy with the way it runs. You could also install Windows Me, which costs about the same, or Windows 2000 Professional, which is a bit more expensive. Installing the OS is simply a matter of placing the CD-ROM in one of the optical drives. You may have to set the BIOS to permit a boot from a CD-ROM before the operating system setup autoloads.

As Windows installs, it will ask you for various drivers. Some of them—like those for the embedded audio and network adapters—are on the CD-ROM that was included with the D850GB motherboard. Others, such as the driver for the I/OMagic ATA/100 controller card and the Hercules 3D Prophet Ultra, will be asked for after the operating system installs and re-boots. We found that the installation of the operating system, along with the format-

TABLE 1

COMPONENTS AND SOURCES

COMPONENT	VENDOR	STREET PRICE
SX840 Case and Power Supply	Antec, Inc.	$149
850 Chipset Motherboard	Intel	$149
1.7-GHz Pentium 4 CPU	Intel	$329
128-MB 800-MHz RDRAM RIMMs (two)	Kingston ValueRAM	$118
ATA/100 IDE Controller Card	I/OMagic	$ 29
56-Kbps Modem Card	US Robotics	$ 98
40-GB 7200 RMP ATA/100 Hard Disk	Western Digital	$129
16X10X40X CD-RW Drive	TEAC	$199
16X DVD Drive	I/OMagic	$119
250-MB Zip Drive	Iomega	$129
1.44-MB Floppy-Disk-Drive	CompUSA	$ 19
3D Prophet Ultra	Hercules	$410
Wireless Keyboard and Mouse	Logitech	$ 87
Windows 98SE Operating System	Microsoft	$189
	Total System Cost	$2153

SOURCE INFORMATION

Antec, Inc.
510-770-1200
www.antec-inc.com

Hercules, Inc.
514-279-9960
www.hercules.com

Intel Corp.
408-765-8080
www.developer.intel.com

I/OMagic Corp.
714-953-3000
www.iomagic.com

Iomega Corp.
888-4-IOMEGA
www.iomega.com

Kingston Technology Corp.
877- KINGSTON
www.kingston.com

Logitech Corp.
800-231-7717
www.logitech.com

Microsoft Corp.
425-882-8080
www.microsoft.com

TEAC America, Inc.
323-726-0303
www.shopteac.com

US Robotics Corp.
888-904-2243 or 866-2-USR-NOW
www.usrobotics.com

Western Digital
877-934-6972 or 949-672-7000
www.westerndigital.com

ting of the 40-GB hard-disk drive, took about an extra hour. Once completed, however, we installed our applications and the system was up and running!

Saving More Money. Basically, we went all out when building our P4 Project system, using the highest-performance components that were available when we assembled our P4. We wanted to see what we could save against the equivalent, commercially available, high-end P4s being offered by major vendors such as Compaq and Dell.

If you are working with a tight budget, you can get much the same performance but save hundreds of dollars more by going for several less expensive components. If you substitute a GeForce2 MX card, such as the $99 MagicVideo 3DMX from I/OMagic for the Hercules 3D Prophet Ultra, you'll save $300 right there. Eliminate the Zip drive, choose a less capable (and less expensive) CD-RW drive, and there's another couple of hundred dollars off of the bottom line. If you want, you can even substitute a combo DVD/CD-RW drive for the two optical drives we used. These budget moves bring our P4 project down into the price realm of store-bought 1-GHz Pentium III systems, but make it easy to pump up the system with a few inexpensive peripheral upgrades in the future.

We don't, however, recommend skimping on the CPU—buy the fastest version that's available at the time that you build your system. This is a much more expensive upgrade to perform in the future. Consider memory an investment as well. While several vendors were, at the time this was being written, working to bring out motherboards that used less expensive DDRRAM rather than RDRAM, these motherboards won't offer the same level of performance that RDRAM allows. At the same time, if you need a lot of RAM for your applications, DDR-RAM may be an important consideration in assembling your PC.

Plug It In, Plug It In. When you have all the components arrayed in front of you, all in their original boxes, your first impulse may be to cut and run. If you've looked through the photos and have read the text, you'll find that putting together your own high-powered P4 is really just a matter of attaching components into the case and onto the motherboard. Scott and Bryan, 14-year-old brothers, put together our P4 project system in about two hours, taking time for photos. The system immediately powered up, and was ready to go once the Windows 98SE operating system was installed.

In fact, the hard part is collecting all the components you'll need. That can take several weeks if you use various mail-order suppliers, but we greatly recommend that you have everything you need on hand before starting. That way, the process goes as smoothly as possible.

One last word of caution—be careful where you purchase the CPU. Make sure that you are getting a "boxed" version of the P4, with the proper heat sink. It may cost you a few dollars more, but Intel does stand behind the retail version of its CPUs if you have a problem.

Have fun with your new P4 system. Don't forget to fasten your seat belt before booting it up! **P**

MP3 PLAYER

(continued from page 38)

it using the R command, or by simply rebooting. As the firmware runs, it will print messages about each step as it initializes the hardware, detects and scans your hard drive, and then plays the files. If something is wrong, the firmware will usually print a message about what was wrong before it returns to the monitor. Hopefully, everything will go well; and your MP3 files will be playing before you know it. **P**

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Form 3526, October 1994

Q & A

mailto: q&a@gernsback.com

Readers' Questions, Editors' Answers
Conducted by Dean Huster

Living Errors

Q *In the October 2001 column, at least you didn't use the phrase "Last month, errors crept into the column." I hate that! Errors aren't alive; it's people that screw up!—M.S., via e-mail*

A Ah, but it's much more tasteful to blame those non-sentient errors rather than finding a scapegoat in an individual. Besides, I'd have to blame myself too much of the time. Still, I'd rather be known as a person who readily admits a mistake as opposed to putting on a false front as being perfect and omniscient.

Meter or Motor?

An open-collector output could drive a meter movement, but it would be a little pointless, wouldn't it? For some reason, in the bottom circuit of Fig. 6 in the October "Q & A," my little circle with brushes and an "M" in the center was translated as a meter movement by the layout folks. That's supposed to be a motor in that spot. I suppose the diode would still be necessary if it was a meter, but I doubt that a meter movement would have much of an inductive kick-back!

Marine Transceiver

Q *I would appreciate your assistance in finding a copy of the circuit diagram for a Ray Jefferson model 987 handheld marine transceiver. It appears that the manufacturer has fallen by the wayside, and no information is available on the Web or from Sam's. The Ray Jeff handhelds are sufficiently similar, so that any one of their diagrams should provide the insight I need.—B.E., via e-mail*

A Neither I nor the readers want this column to become a manual resource "Dear Abby," but I think it can be helpful to other folks when the answer can point out some other resources that might be helpful for less-common types of equipment. When Google only sends back a few items on a search, that's bad. When the commercial and Internet sources are dry, you have to depend upon the benevolence of others for your help. The search did pop up with a few Ray Jefferson hits, and they were embedded within a nautical forum. I think that if you post your request on that nautical forum and on the scanner/receiver forum that I've mentioned in a previous column, you might find someone who has the resources you need. Try the Strong Signals forum at *www.strongsignals.net/msgboard/index.html* and for the nautical forum, try *www.yachtingnet.com/forums/electronics.html*. While you're at it, it never hurts to post on the Resource Bin on the Gernsback site at *www.gernsback.com*. There may be some readers who have access to this documentation. If anyone does, let me know; and I'll forward that information on to B.E.

Trailer Light Wiring

Q *I'm adding a trailer hitch to my new 2001 Saturn LS2 (I must be crazy!). I have many applications for a trailer hitch with small loads under 1000 pounds. I'll be using a universal converter (5 to 4), but I'm still worried about shorting out my auto lights or computer. How do these converters operate? Any suggestions? Any protective circuitry I can add?—B. K., via e-mail*

A B.K. is referring to converting a car that has separate turn signals and brake lights to a trailer electrical connector that is compatible with standard trailer lights that share brake and turn signal lamps. If you're using a commercial adaptor designed for this task, you shouldn't have any worries. In the industry, they only refer to the actual lamp lines, so they call it a 3-wire to 2-wire adaptor. Reese, the venerable hitch manufacturer, has such an adaptor as their part number 85210. You can contact them online at *www.reeseprod.com*. These adapters advertise "no voltage drop" to the lights, so I'm reasonably sure that modern versions use power MOSFETs for the power-controlling element, as do modern electronic brake controllers.

Fig. 1 shows what would be the simplest implementation that should work in this application. To minimize voltage drops to the lamps, use hot-carrier (Schottky) diodes in the circuit that are capable of handling at least 2 to 3 amps of current. The diodes serve to isolate the brake line from the turn-signal lines, so that application of the brakes won't turn on all the lights in the world on the back of your car and trailer. You could build a clunkier version using relays for no voltage drop and a lot of potential reliability problems. Of course, if you want a guarantee of no damage, stick with a tried-and-true commercial unit.

If you do any wiring for the trailer yourself, remember that automotive and marine environments are second only to aeronautical and astronautical environments for harshness. I suggest that you use uninsulated crimp connectors so that you can solder the crimps. Then double-insulate the connections with at least two layers of heat-shrinkable tubing. Use lots of cable ties to firmly keep the wiring out of harm's way and to keep it from flopping and vibrating. I realize that you're dealing with relatively small towing loads, but if you do a lot of mountain driving with a trailer, I recommend trailers with brakes and adding a

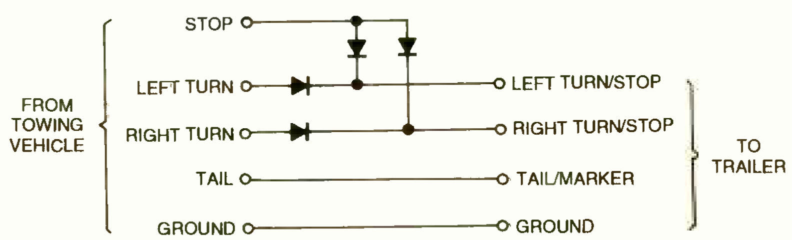

Fig. 1. A simple four-diode isolation circuit for tail and brake lights can adapt a three-light automotive system to a two-light trailer system with minimum voltage loss.

brake controller to the car. They're easy to install and decent ones are only around $60. There's no need to give your car brakes an extra half-ton to deal with while negotiating switchbacks, especially on slick roads where the trailer can push you into a jackknife or an exciting trip down the mountainside.

There's an active RV forum on the Internet that may be useful for you, especially if you decided to snap a tent camper or inky (REALLY dinky) travel trailer to the back of the Saturn. It has "towing" and other categories that may be of interest to you no matter what you pull. The forum is a spur off *www.rv.net*.

Open Collector Caboose

Q *I have been trying to understand the advantage of an "open collector" vs. one without such a collector. Please explain to me in plain layman's language what it is and what it can do. What are its uses? Applications?—R.P., via e-mail*

A In the October 2001 installment of "Q & A," I covered the various applications, advantages, and limitations of open-collector (OC) TTL logic. I thought I'd add something here about the logic of tying various open-collector outputs together.

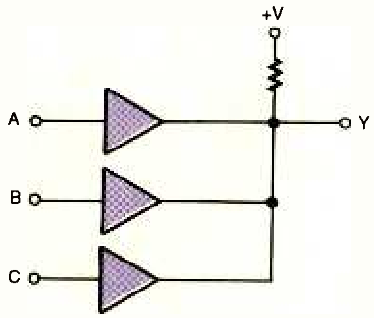

Fig. 2. Open-collector non-inverting buffers with their outputs tied together create AND gates.

If you tie OC non-inverting buffer outputs together, you will end up with an AND truth table. All it takes is one buffer per AND input, as shown in Fig. 2. If you tie OC inverter outputs together, you have a circuit with a NOR truth table as shown in Fig. 3; again, each inverter input becomes one of the NOR inputs.

Multiple OC NOR gate outputs can be connected together and the result is just a wider NOR gate. Interestingly, you can connect either NOR gate or invertor outputs together, as shown in Fig. 4. The whole circuit operates as a wide

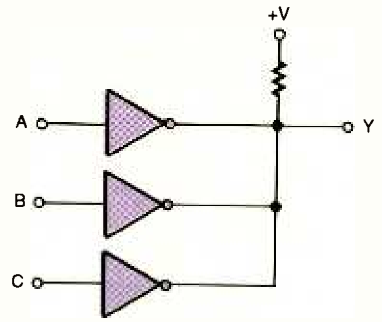

Fig. 3. Open-collector invertors with their outputs tied together create NOR gates.

NOR gate, no matter the combination of invertors or individual NOR gates.

Like the NORs, multiple OC AND gate outputs can be connected together. The result is a wider AND gate, as illustrated

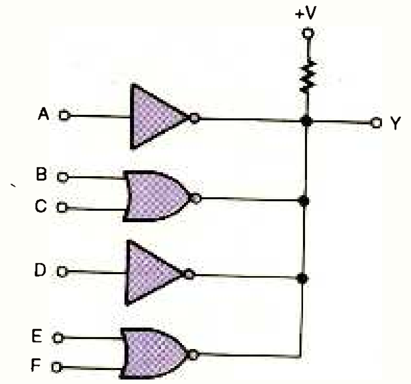

Fig. 4. Multiple NOR gates make wider NOR gates, while invertors added to the circuit add more NOR gate inputs.

in Fig. 5. In a similar fashion, you can connect non-inverting buffers with the AND gates, and the whole circuit will operate as a huge AND gate no matter how many buffers and/or AND gates are in the circuit.

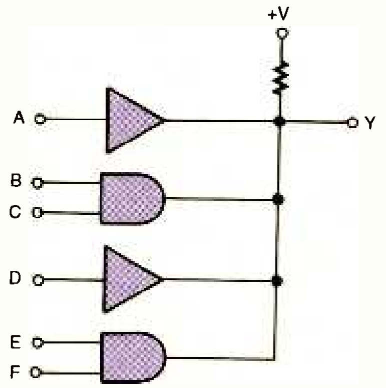

Fig. 5. Multiple AND gates make wider AND gates, while non-inverting buffers added to the circuit add more AND gate inputs.

If you try to connect OC NAND gates or OC OR gates together, you'll end up with some weird truth tables. The same will be true if you connect an OC NAND with an OC inverter or a non-inverting OC buffer. An OC OR connected with OC inverter or non-inverting buffer will also produce an odd truth table.

DMM Diode Test Function

Q *I was reading the August 2002 issue and got to your "Q & A" section where you answer a reader's inquiry on testing transistors with a DMM's (digital multimeter) diode-test function. Could you tell me what brand and model DMM you were using? Your DMM seems to either be designed peculiarly or have a problem on its diode-test function if it reads "3.00" volts across a reverse-biased junction! In over 20 years as a professional electronics service tech, I've never run across a DMM that gave a voltage reading with a good silicon reverse-biased junction. Also, you might mention that most DMM diode-test ranges read about 0.4 to 0.5 volts for a forward-biased power transistor junction like that of a 2SC3856 and about 0.6 to 0.7 volts for a small-signal device like a 2N2222.—D.H., via e-mail*

A I guess that was a little confusing. Most DMMs are 3½- or 4½-digit models with a maximum reading of 1999 or 19999. With a 3-volt internal source, they would indicate "OL" vs. the actual voltage on a reverse-biased junction. I happened to be using an inexpensive Elenco LCM-1950 3¾-digit DMM with a maximum reading of 3999, which doesn't produce an "OL" at the 3-volt level. I'd been using this particular model so long that I didn't even consider the fact that most other DMMs would operate differently. Of course, any DMM manufacturer could design their box so that it used a less-precise range for indicating a higher bias voltage, but most don't.

Your observation is certainly valid, and your point is well taken. Since I was working with a "less-normal" DMM, readers should be aware that most DMMs will not indicate a reverse voltage over 1.99 volts and will instead indicate "over range" with the typical "OL" display.

It should be noted that any forward-biased semiconductor junction does not always adhere to the textbook 0.7 volts. Larger, clunkier junctions of power transistors tend to read lower for a given current than a small-signal transistor. For instance, a 1N4001 rectifier diode may indicate 0.6 volts on a DMM diode-test function, but in operation can have as much as a 0.9-volt forward drop when running at its full one-amp rating.

Since 1972, I've always had some form of a Tektronix semiconductor curve tracer at my disposal, and something like that can spoil you rotten. For the last four years, I've not had a working curve tracer at all, no time to get one of the two I have repaired; and it's really hard for me. The transistor test function of a DMM just doesn't get it. The weekly meetings don't help much either. "Hello. My name is Dean. And I can't work without a curve tracer."

Inductive Audio Loop

Q *I would like to see a schematic of a constant current amplifier with at least 20 watts output! I wish to construct such an amplifier to drive an inductive audio loop for hard of hearing people. —via e-mail*

A Back when I was a teenager, I used an inductive loop so that my headphones didn't have me leashed to the shortwave receiver. I could listen late at night without bothering the rest of the family while I continued to work on other projects. For the uninitiated reader, an inductive-loop system is nothing more than a giant audio transformer. It worked very well for me with about four turns of wire as the primary around the perimeter of my 150-square-foot shop area, and driven directly by the 3-watt output of the receiver in place of the speaker. I used the little amplifier from a small portable reel-to-reel tape recorder with a couple of hundred turns of wire around a ferrite rod as the transformer secondary. It was connected to the former tape head input of the amplifier. The amplifier and ferrite bar were attached to one earpiece of the headphones, which were connected to the amplifier output. The system was a great monophonic wireless headphone system that had no "dead spots" as a more modern infrared system might have.

I don't understand why you would need a constant-current source. Normally those are used for instrumentation loops where an off-the-shelf transmitter might be connected to any length of signal line to the receiver and must have a range of compensation to keep the output at an accurate level at the receiver. It appears that your inductive audio loop would be installed permanently in one location, so you would not have to deal with any resistance changes.

I would decide what loop impedance I needed by determining the minimum wire gauge I want to use. For instance, if you settle on 18-gauge wire with 6.51 milliohms of resistance per foot, you can calculate that 4 ohms would have a length of about 614 feet. If the room you're working with has a perimeter of 100 feet, you would run six turns of the wire around the room. An 8-ohm impedance would require 1200 feet of wire and 12 turns around the room. A lower impedance is the better choice for maximizing the output capabilities of a typical solid-state amplifier.

Connecting the wire ends to the output of an amplifier rated for your 20 or 30 watts should do the trick. You can adjust the loop impedance by increasing or reducing the number of turns or by changing the wire gauge. The larger the room, the higher the power you might have to run in the primary turns around the room for good pickup by the

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

Many electronic component manufacturers have Web pages; see the directory at *www.hitex.com/chipdir/*, or try addresses such as *www.ti.com* and *www.motorola.com* (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online: *www.questlink.com* features IC data sheets and gives you the ability to buy many of the ICs in small quantities using a credit card. You can also get detailed IC information from *www.icmaster.com*, which is now free of charge although it formerly required a subscription. Extensive information about how to repair consumer electronic devices and computers can be found at *www.repair faq.org*

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

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

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

Back issues: Copies of back issues of and past articles in **Electronics Now, Popular Electronics**, and **Poptronics** can be ordered on an "as available basis" from Claggk, Inc., Reprint Department, P.O. Box 12162, Hauppauge, NY 11788; Tel: 631-592-6721. To ensure receipt of the correct material, readers must supply complete information on the article or issue that they wish to buy.

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

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

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, 130 N. Cutler Dr., N. Salt Lake, UT 84054.

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

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

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

receivers. Nothing says that you can't drive it from a 70.7-volt system along with the rest of the speakers using the right transformer, providing your power amplifier has enough headroom for the larger-than-normal speaker load.

For a more reliable system, I'd recommend going the wireless RF (*r*adio *f*requency) route. Commercial units have no "dead spots," have a range outside of the auditorium (great for "cry rooms"), and are much easier to install.

Reflections

When I was living in Oklahoma City, I lost two good friends in the Alfred Murrah Federal Building bombing. We heard and felt the explosion and Honda, my wife who is a registered nurse, was with some of the first groups at the site providing help at the rescue workers' first aid tent. Devastating as that was, it is but a small fraction of what our many friends in New York are experiencing at this time in September as I finish this month's column. My prayers are for those families and their tragic losses, for the injured, for the rescue workers, for the families of the rescue workers who died that others might live, for our leaders as they work through the issues that must be confronted, and for our nation and its citizens. "Let there be peace on Earth, and let it begin with me."

Writing to Q&A

As always, we welcome your questions. Please be sure to include:

(1) plenty of background material,

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

(3) and a complete diagram, if asking about a circuit; and

(4) type your letter or write neatly.

Send questions to Q&A, **Poptronics**, 275-G Marcus Blvd., Hauppauge, NY 11788 or to *q&a@gernsback.com*, but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K. **P**

Poptronics® SHOPPER begins on page 63

mailto: roboticsworkshop@gernsback.com

SCOTT M. SAVAGE

Robot Simulation

Last month, my article dealt with creating a formula that would correct a robot's course while it was traveling down a hallway.

The robot described in that article is shown in Fig. 1. It used two drive wheels, each with its own motor. One drive wheel is placed on each side of the robot, and a coaster is in the back with the weight of the batteries holding it down. Given this configuration, the robot makes turns by slowing down the wheel on one side, while speeding up the wheel on the other side.

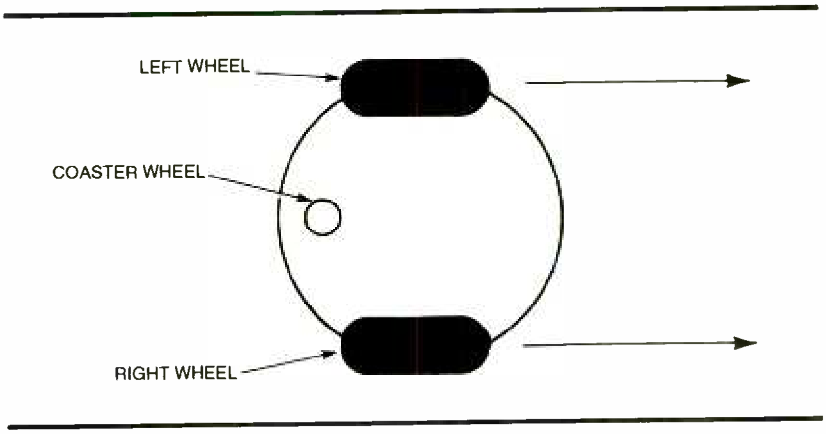


Fig. 1. If both wheels are turning at the same speed, the robot travels straight down the hall.

Correction Angle

The course correction formula took the input values from two infrared distance rangers and, using a little trigonometry, calculated the speed needed for each drive wheel of the robot.

As shown in Fig. 2, if the robot is not in the middle of the hall, then the correction angle for turning to return to the middle can be derived by taking the ratio of the robot's offset from center (Y) and the distance to a point out in front of the robot (X) in an Arctangent calculation.

[CorrectionAngle = Arctangent(Y/X)]

The Y value was easy. It was calculated from the Infrared Distance rangers on the robot. (discussed in detail last month). The X value in the formula, however, is an unspecified point in front of the robot. Any distance, within certain limits, can be used. If the distance is too small, then the robot will overcompensate for being out of center and will wind up weaving back and forth around the center of the hall. If the distance is too large, then the second angle of correction will not adequately overcome any mechanical error. The correct distance really depends on the mechanics of your robot and needs to be tuned.

The question now is: How to tune the value for X? The most mathematically correct answer would be to take the RPM rating for the motors, the gearbox reduction, the total voltage supplied from the batteries, the distance between the wheels, the diameters of the wheels, the total weight of the robot, and the total friction of the robot's drive train all together in a complex formula. After evaluating that course of action for a very short period of time (a very short period of time), I decided it would be much faster to just make an educated guess and make up a number to try. I figured this should be easy.

After a little more contemplation, I started thinking that the guessing game could turn into an extraordinarily tedious chore. Just imagine how many times one would need to pick a number, code it into the robot's program, put the robot in a test area, test the robot, and then based on how the robot failed, guess a new number, and repeat the process.

An easier and more enjoyable solution was found in an unusual source, Cognitoy's *MindRover*. This computer-based robot simulation allowed me to

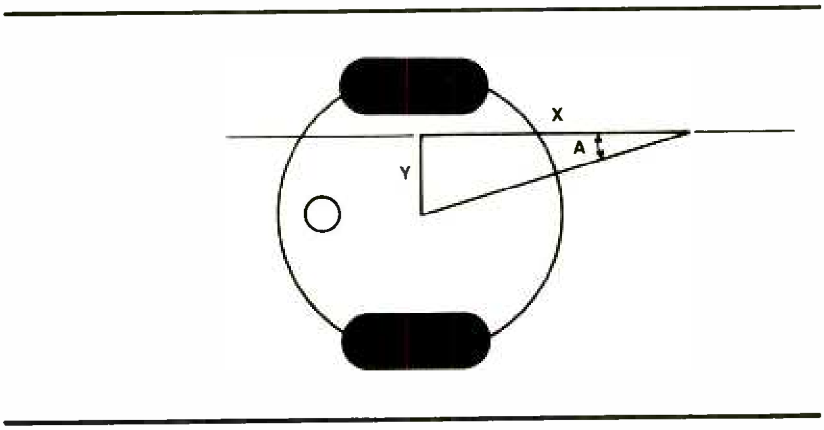


Fig. 2. When the robot is not in the middle of the hall, a second angle of correction can be calculated.

Fig. 3. Cognitoy's MindRover *is a robotic simulation program.*

build and test a prototype in a virtual environment, which saved hours of time. The code used to control the virtual robot could be sent to an OOPic in order to control the actual physical robot.

Let's examine *MindRover* closely.

Cognitoy's MindRover

Cognitoy's *MindRover* (as seen in Fig. 3) is a PC game, and, as such, has found a large following in the PC gaming group. Now, I am not much of a gamer, but I found that *MindRover* worked, for me, more like an unusually fun utility for robotic simulation and testing.

From a gamer's point of view, *MindRover* takes you to a whole new level of participation within the game. You are actually required to wire the robot's functionality. By this, I don't just mean wiring a power supply to the drive system; I mean actually creating the wiring for the robot's brain. CogniToy calls it "3D strategy/programming." This process all takes place with a 3D environment and graphical wiring system. *MindRover's* slogan prompts the gamer to "think more and twitch less."

The players construct small virtual-reality robotic "rovers" that compete with one another in a variety of challenges. What's particularly different from other games on the market is that in the end, it's not just a matter of choosing a weapon from the keyboard and driving around with the joystick, frantically pressing the fire button. The player actually programs the robot's behavior before the testing and competition begins, just as a real robot would require. This makes MindRover robots autonomous. CogniToy took that a step further even by giving their virtual-reality autonomous robots the ability to become real robots by downloading the robot's program to an OOPic or to a LEGO RCX pack—effectively taking the robots off the screen and putting them on the floor.

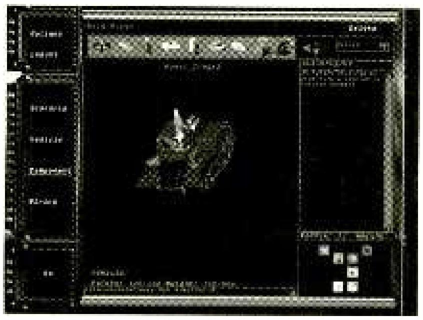


Fig. 4. With the construction lab's "Component" page, players choose bodies, drivetrains, sensors, weapons, and manipulators for their robots.

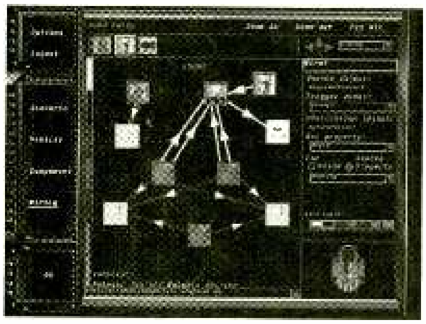


Fig. 5. Using the construction lab's "Wiring" page, players wire the components together.

In the construction lab portion of the game, players choose bodies, drivetrains, sensors, weapons, and manipulators for their robots from a large array of possibilities (Fig. 4); and then they visually wire these components together to give each rover a unique set of behaviors (Fig. 5). The rover is then moved to the competitive arena and set free (Fig. 6). In the arena, the robot's design is tested in a real-time 3D simulation, where it can compete with other robots, or, in my case, tune the formula for tracking the wall—a nice, neat solution.

MindRover has three types of robotic vehicle chassis: wheeled, treaded, or hovercraft, and each comes in varying sizes. *MindRover* also supports three major categories of competition: Race, Sport, and Battle, as well as a miscellaneous category and tutorials. In the Miscellaneous category, players find puzzles, mazes, hunts, and other unique problem-solving tasks.

I am sure that some of you out there are already imagining what kind of Battle-Bot to build with this.

Underlying the game is an accurate physics simulation system and a complete object-oriented programming language, ICE, which CogniToy developed for this game. ICE forms the foundation of the entire game and is used for every-

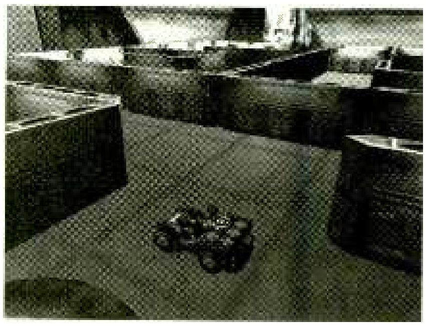


Fig. 6. The arena is used to test the robot's design in a real-time 3D simulation.

thing. The arenas, the goals, and all the intelligence in the game—even parts of the user interface—are all coded in ICE.

MindRover and OOPics

By chance, I met Kent Quirk, the CEO of CogniToy and designer of *MindRover* at the Trinity College Fire Fighting Robot Contest in 2000. At that time, he was looking for a method of taking *MindRover's* virtual-reality autonomous robots off the screen and putting them on the floor. What he needed was a microprocessor that used an Object-Oriented programming model. After some discussion, we both quickly realized that not only did both the OOPic and *MindRover* use an Object-Oriented programming model, but both products also used a method of wiring the Objects together that allowed the Objects to exchange data in a multi-tasking environment.

One major difference between the OOPic's wiring method and *MindRover's* method that had to be overcome was that when a connection was made between the Objects in the OOPic, the Object's data was continually updated between the Objects. In *MindRover*, when a connection was made between the Objects, the data was updated only when an event occurred. It might also be noted that in *MindRover* the Objects are referred to as "components" and that in the OOPic components are referred to as "Objects."

With this in mind, Kent and I set out to create updates that would allow *MindRover* to simulate a robot in virtual reality and download its program directly into an OOPic, which would control a robot in reality.

For the OOPic, the changes that were required for this alliance can be found in the OOPic *II* in the form of Clocked Objects. These Objects work like *MindRover* counterparts that transfer data when an event occurs.

For *MindRover*, the changes are available as a software add-on that is installed after the *MindRover* program is installed. This add-on creates an OOPic program that is the function equivalent of the *MindRover* ICE program.

A chart showing the similar Objects/components can be found at *www.oopic.com/mrc.htm*.

Using *MindRover*

To help the players get started, using *MindRover*, the game comes with a programming tutorial scenario that guides players through building and wiring your first robotic rover. The robotic rover built in the tutorial is a hovercraft with two thrusters that uses a set of components called "MediumRadar" to detect other robotic rovers and objects in the scenario. You can set the properties of the radar to define a cone-shaped area where the radar is looking. When a vehicle or other object comes into the cone of the radar, the radar triggers a "TurnOn" event. When an object leaves the cone, the radar triggers a "TurnOff" event. The information that was gathered from the "MediumRadar" component is then used to hunt down and tag an opponent. To keep the tutorial from getting too complicated, the opponent in the tutorial doesn't move.

While creating and wiring your robotic rover, a display box is shown at the top of the screen that lists icons for all the available components. Clicking on the icons will give a name and description of the component. The components are placed on the robotic rover by dragging them to the rover and dropping them in place. When they are placed on the robotic vehicle, they appear as small icons in the lower right corner.

A feature of the design environment that I really like is that by clicking on the body of the vehicle with the right mouse button, you can drag it around and it will rotate in place. This feature allows you to preview what it will look like from all angles.

Component Properties

Once the components are placed, the robotic rover needs to be programmed. This is done in the "Wiring" section of the construction lab. In this screen, you configure and connect the components you have just placed on the robotic rover, making them work together to accomplish the goals of the scenario. The tutorial guides you through configuring the components with a collection of input boxes, slide bars, and wheels. Each component requires configuration, and the tutorial gives recommended values for each of these. After you try the recommended values in the real-time simulation, different values can be experimented with to see how they affect your robotic rover's behavior.

Wiring Components Together

When something passes in front of either radar, the radar will send out a signal. The wires are used to instruct the robotic rover what to do when it sees that signal. In order to create a wire, you click and drag from the component's icon. This will cause a drag box to appear. When the drag box reaches another component, a wire will appear. Releasing the mouse button will create a wire. This also brings up a property box with information on that wire on the right side of the screen. The properties that are shown in that box describe the function of that wire.

As seen in Fig. 7, the tutorial wires are created between the "Medium-Radar" components and the "Thruster" components in such a way that if the one of the radars spot the opponent rover, it will steer the hovercraft towards it by firing the thruster on the opposite side of the robotic rover. Lastly, a set of wires is added that tell the radars to turn off the thrusters that aren't being used.

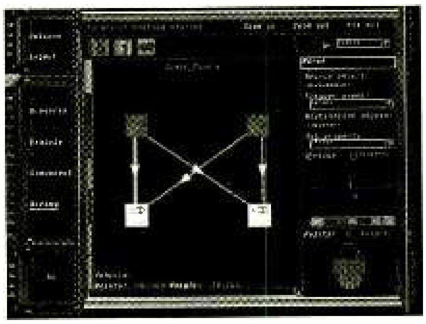


Fig. 7. Wires are formed between radars and thrusters, creating the program for this robotic rover.

Testing It Out

Clicking on the "GO" button in the lower left of the console starts the simulation. When you do this, you just sit back to watch your robotic rover go to work. When the robotic rover reaches the opponent, a message saying so appears and asks you if you want to see a replay, restart this scenario, continue, or go back to the console. "Return to console" will give you the ability to tweak your robot, add components, and start the competition again, or even start a new scenario.

Next Month

Next month, I will discuss how to create a virtual-reality robotic rover. After testing it in virtual reality, I will explore how to move it off of the screen and on to the floor.

On The Web

More information on Cognitoy's *MindRover* can be found at *www.mindrover.com*. More information on the OOPic can be found at *www.oopic.com*. **P**

JOHN IOVINE

UFO Detector, Part 1

Do *Unidentified Flying Objects* (UFO's) exist? Of course, they exist! UFO sightings are reported all over the world by thousands of people. The real question is whether UFO's are interstellar travelers visiting Earth. Most UFO sightings can be classified as misidentified aircraft, planets, or other aerial phenomena, but not all of them. There is that small percentage of UFO reports that can't be explained by any known aircraft or natural phenomena. It is these reports that create an exciting possibility.

Granted, the open possibility attracts fringe personalities and UFO groups that should not be taken seriously. But one should not discount the entire UFO subject based upon the ramblings of a few individuals or groups. Real UFO enthusiasts know the odds are stacked against their credibility and try to root out lunatics and hucksters as best they can.

The UFO issue can be intelligently debated on both sides of the fence. This article will not join into the debate. However, if UFOs arouse your curiosity you may be interested in building this month's project: a UFO Detector.

The first question is how do we detect something we don't even know really exists? Well, to do so we must rely on information gathered from past UFO sightings. According to many reports, some UFO's cause major electrical and magnetic disturbances and anomalies. For instance, a running car engine will start to stumble, cough, and then eventually stall dead. Magnetic compasses swing wildly, around and around. If this information is accurate, we can use these UFO side effects to make a UFO detector.

By using the magnetic anomaly side effect, we can make a simple UFO detector from a standard magnetic compass. You place the compass down, away from any magnetic fields, electrical fields, and ferrous materials. Let the compass needle settle down and point to Earth's magnetic north. The compass-detector is now set; you sit and watch the compass needle. If the needle starts jumping around and swinging wildly, you may have detected a UFO. However, just because the needle started jumping around doesn't always mean it's detecting a UFO. There can be other (more common) reasons that the compass needle started to act erratically.

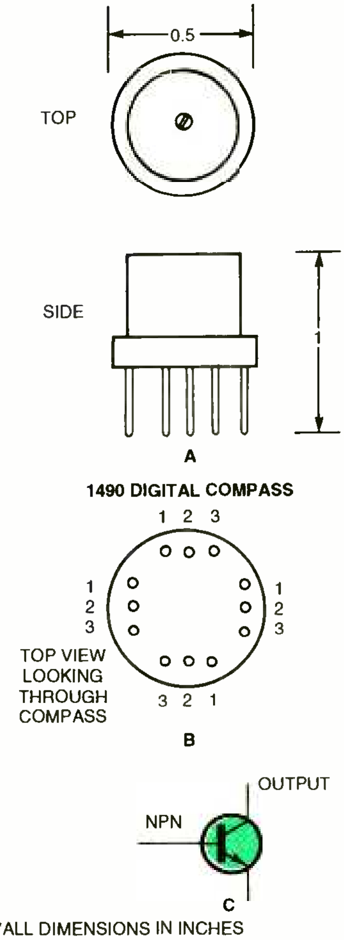


Fig. 1. Shown here is the schematic for the 1490 Digital compass from Dinsmore Instrument Co.

For instance, somebody passing the compass holding a strong permanent magnet or carrying a quantity of ferrous materials could cause the needle to move. If the compass is lying close to an electrical line and someone switches electrical power on or off through the line, this action can also cause the compass to react. Placing the compass close to any electrical device may also cause the compass to react erratically. After eliminating these possible terrestrial triggers, you may be left with a legitimate event to investigate.

Typically, UFO sightings are rare events. Therefore, you may have to keep looking at that compass for days, weeks, months, or years at a time before you detect an event. Obviously that is not practical, and that is where our UFO Detector comes in. The UFO Detector described operates 24 hours a day, seven days a week, for over six months on one 9-volt battery.

Circuit Function

The UFO Detector works in a similar way to the method described earlier that used a magnetic compass. Since this is an electronic circuit, we are using an electronic compass. The electronic compass for our detector is a 1490 digital compass sold by Dinsmore Instruments Company. A pre-programmed 16F84 continuously monitors and checks the status of the compass for any anomalies. When it detects a magnetic anomaly, it signals by flashing an LED and beeping.

The Digital-Compass Sensor

The 1490 compass contains four solid-state Hall-effect devices. Each device corresponds to a position of the four cardinal points on a standard compass, North (N), South (S), East (E), and West (W). When used as a compass, it can detect the four cardinal points as well as the intermediate directions North East (NE), North West (NW),

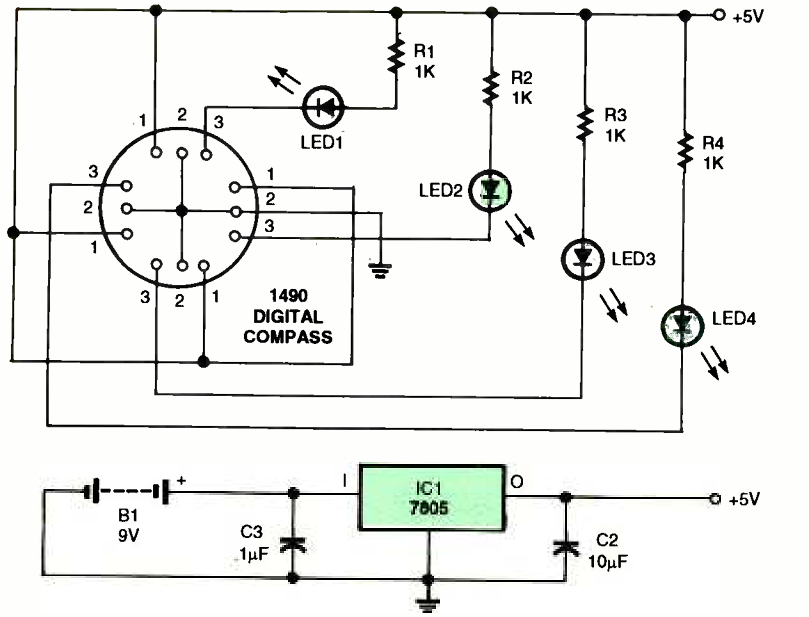


Fig. 2. This basic digital compass circuit allows the user to test the operation of the compass.

South East (SE), and South West (SW).

The bottom of the device has a total of twelve leads, arranged in four groups of three leads. Looking down at the device from the top, you can see that each group of leads is labeled 1, 2, and 3 (see Fig. 1). The group of leads labeled 1 is connected to V_{CC} (+5V). Those labeled 2 are connected to ground, and those labeled 3 are our output leads. The output leads of the device are equivalent to an open collector of an NPN transistor (see Fig. 1). Each output is capable of sinking 20 mA continuously or 25 mA intermittently.

Figure 2 is a basic compass circuit. I am presenting this circuit to clearly illustrate how the Dinsmore sensor works; it isn't necessary to construct this circuit for the UFO Detector. The circuit uses four LEDs for directional display. Each cardinal position on the compass lights one of the four LEDs. Intermediate directions light two LEDs.

To use the circuit in Fig. 2 as a digital compass, we need to calibrate the circuit. First, find the direction of magnetic north with a standard compass. Rotate the circuit so that just one LED is lit. Use that LED as North. I used the LED furthest away from the sensor for North (see Fig. 1). If you also follow the wiring in the schematic exactly, the other three LEDs will fall into the sequence shown in Table 1. (1 = on, 0 = off)

The 1490 Digital Compass sensor is sensitive to tilt. Any tilt greater than 12 degrees will create errors and reduce sensitivity.

Under Control

The UFO-Detector (see Fig. 3) uses a pre-programmed 16F84 microcontroller from Images SI Inc. (see Parts List). The microcontroller is responsible for monitoring the four outputs from the digital compass and sounding an alarm when a potential UFO event has occurred.

When power is applied to the circuit (or reset), the microcontroller waits about seven seconds before beginning active scanning of the digital compass sensor. These seven seconds allow the user to place the UFO detector down wherever the user wants and

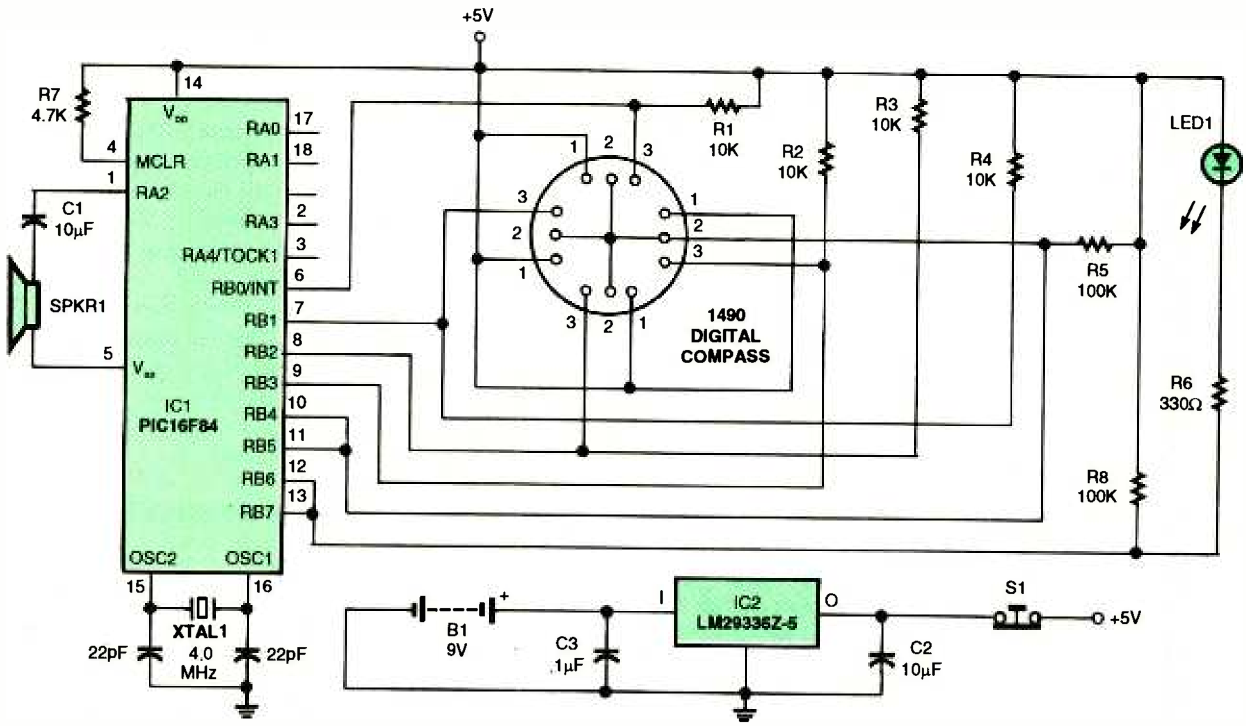


Fig. 3. The UFO-Detector circuit schematic is shown above. A PIC microcontroller is used to monitor and control the compass.

TABLE 1

DIRECTION	LEDs	DECIMAL NUMBER EQUIVALENT
North	0001	1
North East	0011	3
East	0010	2
South East	0110	6
South	0100	4
South West	1100	12
West	1000	8
North West	1001	9

PARTS LIST FOR THE UFO DETECTOR

SEMICONDUCTORS

IC1—PIC16F84, pre-programmed microcontroller
IC2—5-volt voltage regulator
LED1—Green, super-bright LED

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1–R5—10,000-ohm,
R8—100,000-ohm
R7—4.7K-ohm
R6—330-ohm

CAPACITORS

C1, C2—10-µF capacitor, 12 volts
C3—.1-µF capacitor, 12 volts

ADDITIONAL PARTS AND MATERIALS

Dinsmore 1490 Digital Compass
X1—4.0-MHz crystal
(2)—22-pF capacitors, 12 volts (for crystal)
9-volt battery clip; mercury tilt switch; miniature speaker (approx 1-inch diameter, 8 ohms); UFO-detector housing; 9-volt lithium battery.

NOTE: UFO Detector Kit containing two printed circuit boards, and all the components listed above, ($ 39.95) can be ordered from Images SI, Inc, 39 Seneca Loop, Staten Island, NY 10314; 718-698-8305; *www.imagesco.com.*

The following components are sold separately from the same supplier: Dinsmore 1490 Digital Compass, $14.95; PIC16F84 pre-programmed microcontroller, $8.95; 9-volt lithium battery, $8; Area 51 UFO Model (separate delivery charge), $25; alien-head sculpture (separate delivery charge), $99.95.

gives sufficient time for the digital compass to come to a complete rest before it begins scanning. After the initial seven seconds have elapsed, the microcontroller flashes the LED and beeps once signaling it's in detector mode. It reads the positional information from the digital compass and stores that value in memory.

The microcontroller then begins active scanning of the digital compass sensor for any changes in its output. However, it does its scanning in an economical way. In order to conserve electrical power, the microcontroller goes into a low-power mode for approximately 2 seconds. It wakes up for approximately 4 milliseconds (.004 seconds), applies power to the main circuit, and checks the digital compass sensor. If the output of the compass is the same as the stored value, it goes back into low power mode for another two seconds and repeats the cycle. If the new reading from the sensor is different then the stored valued, the microcontroller sounds an alarm by blinking a super-bright LED and beeping. The alarm will continue until the circuit is reset or the battery runs down.

Since the circuit is only active and drawing full power for .004 seconds every 2.0 seconds, considerable power savings are realized. This allows a 9-volt lithium battery to last longer than six months while in the search or detector mode 24 hours a day. When the alarm is active, full power is applied to the circuit continuously; and the battery life runs down much more quickly.

Battery Power

Although the 9-volt lithium battery looks identical to a standard 9-volt transistor battery, the lithium battery has up to three times the power density of the standard battery. However, that IS NOT the primary reason we use a lithium battery in the UFO detector. The primary reason is the battery's non-metallic,

The Area 51 UFO Model from the Testor Company can be used as a housing for the project.

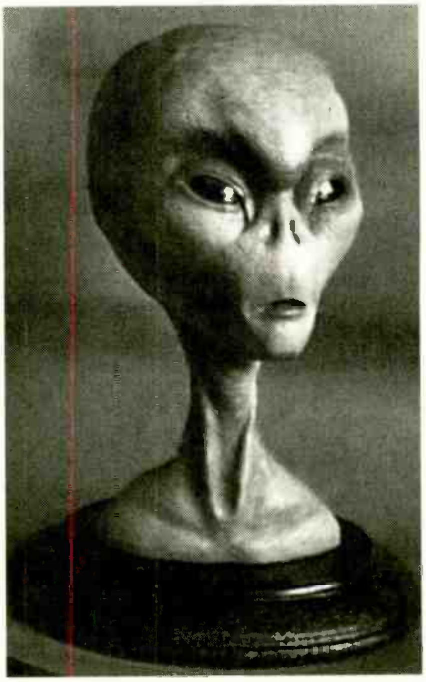
non-ferrous case. Standard carbon and alkaline 9-volt batteries use a metallic ferrous material that will adversely affect the sensitivity of the digital compass sensor.

There is a small amount of ferrous material used in the construction of a lithium battery—the terminal clips on top of the battery. If the terminal clips are placed away from the sensor, they do not affect the sensitivity of the digital compass to any great extent.

While we are on the subject of keeping any ferrous material away from the sensor, the small 8-ohm speaker should also be placed away from the sensor for the same reason.

Get It Mounted

It may appear odd to discuss housings for and mounting of the finished circuit board before we actually begin the circuit construction, but there is a good reason for it. The finished UFO Detector board will occupy a space of 1 × 1.5 × 2.5 inches. There will be



This "Grey" alien-head sculpture, said to be "life sized," can also be used as an appropriate housing for the UFO-detector circuit.

three sets of leads coming out of the circuit board: one pair of leads for the super-bright LED, one for the speaker, and one for the 9-volt battery clip. Before construction, decide whether the finished circuit is to be mounted vertically or horizontally, because the digital compass cannot be tilted greater than 12 degrees without degrading its performance. Keeping this in mind, we have two ways to mount the compass with reference to the main circuit board—vertically and horizontally.

Housing Needs

The decision to build a vertical or horizontal circuit will depend on the housing you choose. You can pretty much choose any non-ferrous housing that's large enough to hold the circuit board and battery. Suitable non-ferrous housing materials include the following: plastic, wood, brass, foam board, and aluminum. If the housing is large enough, you can mount the UFO detector either way.

If you would like an almost ready-made housing I can offer a few suggestions. The Testor Model company sells a plastic AREA 51 UFO model. The model is large enough to hold the detector inside and makes a suitable enclosure. If I were mounting the UFO detector circuit inside this model, I would build the circuit horizontally. I would mount the super-bright LED in the upper portion of the UFO model so that its light would glow through the transparent plastic. The speaker may be mounted inside the model, with a suitable speaker hole drilled into the case at an appropriate position. There are other model spacecraft and rockets that offer an interesting housing as well.

The Grey Alien head shown in the photo is another possibility. This is an exquisitely sculptured (supposedly) life-sized model (based on reports). The finished UFO detector could be mounted behind the head, or the black base may be hollowed out to fit the circuit.

Next Month

We will continue with the construction of the UFO Detector next month. For those who wish to get a head start, you can purchase the components or the kit and begin looking for a suitable housing for your UFO Detector. ■

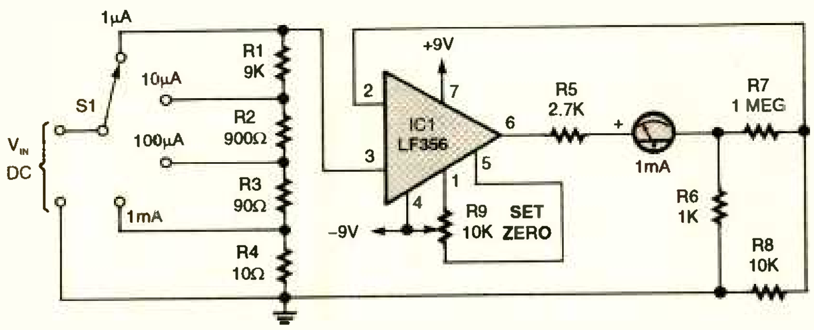
SHORT CIRCUITS

mailto: shortcircuits@gernsback.com

CHRIS LA MORTE

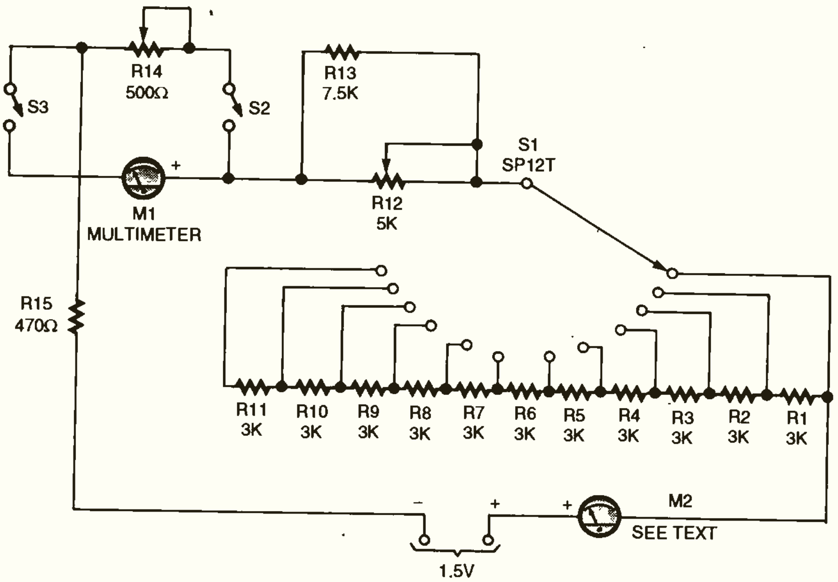
Meters, And Testers, And Detectors. . .Oh My!

This month we have meters, testers, and testers to test you meters. An electronic workbench should always have a multitude of test equipment, and nothing is more fun than building your own. Here are schematics of some popular test equipment. Break out the "junkbox" and pref-board, folks.



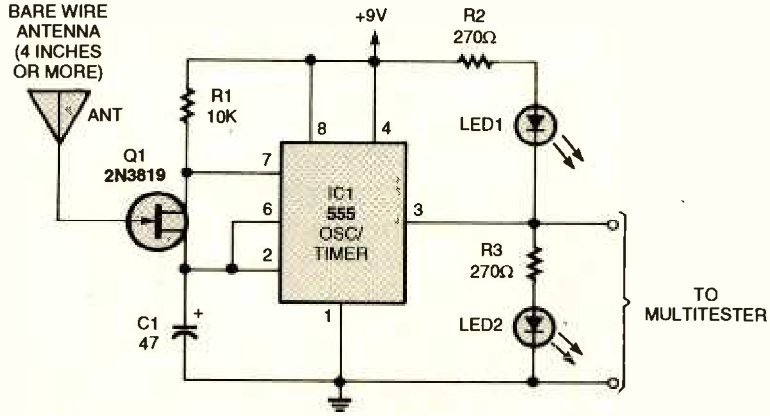
MICROAMMETER

This circuit is for a 4-range microammeter that reads between 1 μA and 1 mA. The circuit is powered by a 9-volt power supply and is designed for use within DC circuits. Probes can easily be attached to the DC inputs in order to use this device as a pocket-sized tester.



METER TESTER

In this schematic M1 is a multimeter set to measure current and M2 is the meter under test. Start by setting S1 to the maximum resistance and S2 open. Slowly decrease the resistance with S1 and fine-tune the current by adjusting R12. When M2 reads full scale observe the reading on M1. This reading is the full-scale current for the meter under test. After this test, close S2 and adjust R14 and R15 until M2 reades mid-scale. The sum of the resistance of R14 and R15 is the same as the internal resistance of M2. If the internal resistance to be measured is known to be less than 470 ohms, then close S2 and adjust R14 until M2 is mid-scale.



STATIC DETECTOR

This circuit can be used to detect the presence of static fields. A bare-wire antenna feeds a Field-Effect Transistor at the heart of the circuit. The FET has a direct effect on the flashing of the two LEDs. This device can be used to sniff out potentially dangerous environments that might harbor electrostatic voltages, which could zap fragile semiconductors with lethal voltages.

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES

SUDDEN IMPACT TRANSDUCERS

In my opinion, electronics is the world's best hobby. Just about any mainstream high-tech hobby you can think of today is filled with electronic circuitry. Model airplanes, boats, trains, cars, and other remote-controlled devices would be dead in the water without electronics. Some of these devices use complex electronic circuitry to get the job done, where others use more basic circuits. However, as we all know, most complex circuitry is made up of numerous simple basic circuits. This month we're going to play with impact transducers, which have a number of applications—including the one I enjoy: shooting air guns.

Building Transducers

Another great attribute we all share in the electronics hobby is the ability to build most anything we need much more cheaply than it can be purchased ready made. With that said, all of the impact transducers we'll discuss should be inexpensive to duplicate, especially if a well-filled junk box is available.

Our first impact transducer, see Fig. 1, uses a 2.25-inch diameter speaker attached to a .125-inch-thick metal plate. This simple combination produces a super high output signal. Hitting the face of the transducer with about 2- to 4-foot-pounds of energy from a small .177 lead pellet produces an output signal that is several hundred millivolts peak to peak. This signal level is more than ample for most output applications. The output signal can be used to drive audio and visual circuitry, which we'll get into later on.

In putting together the speaker transducer, be aware that the metal plate that the speaker attaches to is the place the pellets impact. This material should be durable and thick enough to stand up to the pounding of the pellets without penetrating or denting. The plate's overall size should be slightly larger than the speaker and can be either round or square. The speaker is attached to the metal plate with a thin layer of silicon rubber. The transducer assembly will be positioned behind a target front with a hole of suitable diameter to allow the pellet to travel through and hit the metal plate.

The drawing in Fig. 2 shows one method of using the transducer with a

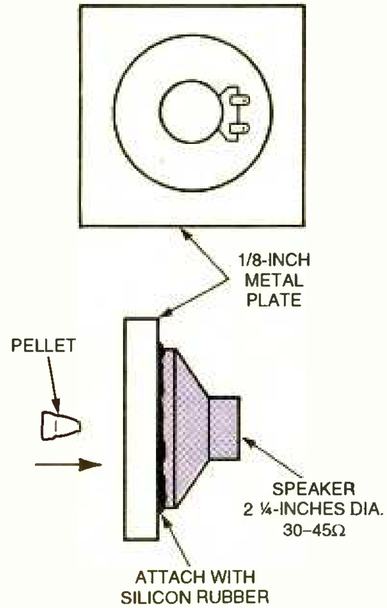


Fig. 1. Our first impact transducer uses a 2.25-inch diameter speaker, attached to a .125-inch thick metal plate.

PARTS LIST FOR THE SPEAKER TRANSDUCER (FIG. 1)

Small 1½–2¼-inch diameter magnetic speaker, output impedance of 16 to 45 ohms.

One ⅛-inch metal plate, slightly larger than speaker used. Silicon rubber, etc. See text.

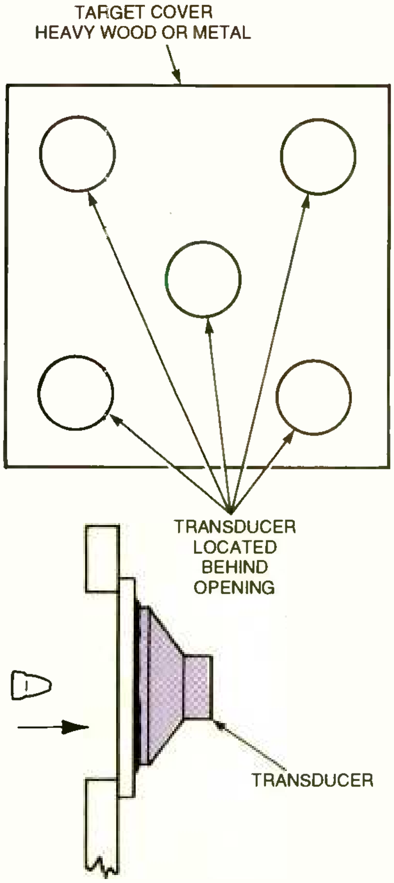


Fig. 2. The transducer is centered about ¼-inch behind the hole in the target cover, without actually touching the cover

PARTS LIST FOR THE TARGET COVER (FIG. 2)

Heavy wood or metal cover for transducers, see text.

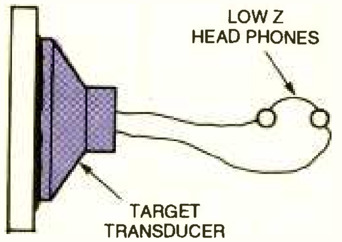


Fig. 3. The speaker transducer produces an output level that can easily be monitored with a pair of low-impedance headphones.

PARTS LIST FOR THE SIMPLE HIT MONITOR (FIG. 3)

Pair of low-impedance headphones.

target cover. The actual target area can be any size hole, from the pellet size to 2 inches in diameter. The transducer is centered about ¼-inch behind the hole in the target cover without actually touching the cover. The transducer can be supported by any convenient means that restricts contact with the target cover. Also, the opening in front of the transducer does not have to be round. Any desired target figure can be cut out of the target cover to produce a hit-output signal anywhere within the target area.

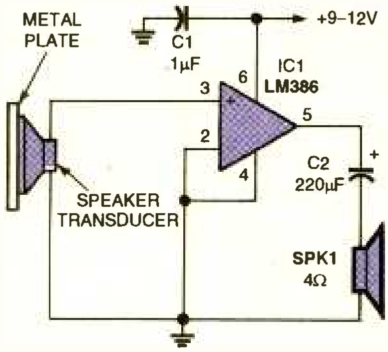


Fig. 4. The circuit shown in the schematic above adds a power-audio amplifier to the transducer's output, allowing monitoring without using headphones.

PARTS LIST FOR JACKING UP THE OUTPUT (FIG. 4)

IC-1—LM386 audio power amplifier IC
C1—.1-µF, ceramic-disc capacitor
C2—220-µF, 35-WVDC, electrolytic capacitor
Spk.—Small 2- to 4-inch 4-ohm speaker

Simple Hit Monitor

The speaker transducer produces an output level that can easily be monitored with a pair of low-impedance headphones, as illustrated in Fig. 3. The output sound will depend on many factors including the type and hardness of the transducer's metal plate, the area that the pellet hits, and the energy on impact. With a little practice, it's possible to tell when the target is hit in the center or on the outer edge.

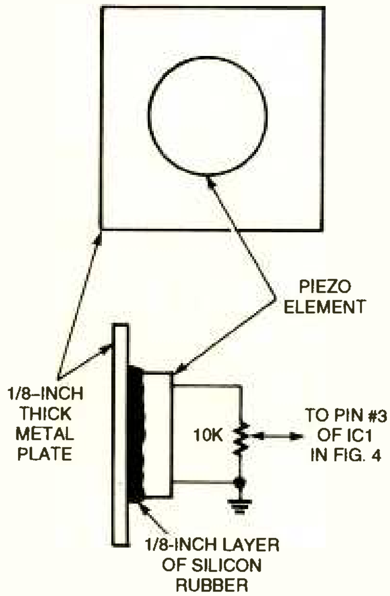


Fig. 5. The basic construction of the piezo impact transducer closely follows our first one in Fig. 1, with a minor, but important change—the use of a piezo device.

PARTS LIST FOR THE PIEZO TRANSDUCER (FIG. 5)

Piezo element, any size from .75- to 1.-inch in diameter, and without an internal sound generator.
One ⅛-inch target plate, silicon rubber, 10K pot, etc.

Now is a good time to add a couple of cautions in using the transducers. Firstly, **never** shoot without safety glasses. Secondly, **only use soft lead pellets and never ever BBs**, as they can fly right back and hit you. Just use your common sense as you would in flying model planes or any other hobby that has moving objects that might hurt you if they were to hit you.

Jacking Up The Output

The sounds coming from the transducer can be very interesting and informative. The circuit in Fig. 4 adds a power-audio amplifier to the transducer's output, allowing monitoring without using headphones. A single LM386 low-voltage audio-power amplifier IC raises the transducer's output to drive a small 4-ohm speaker. The LM386's circuitry is connected for a minimum voltage gain of 20. Pins 1, 7, and 8 are not used in this configuration. The amplifier circuit may be operated from any solid DC source with 6 to 15- volts and a minimum output of 100mA.

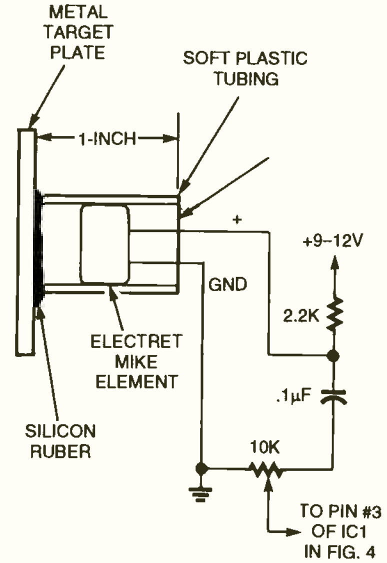


Fig. 6. The figure above illustrates the mounting of the mike element in a 1-inch length of ⅜-inch (inner dimension) by ½-inch (outer dimension) vinyl tubing.

PARTS LIST FOR THE ELECTRET-MIKE-ELEMENT TRANSDUCER (FIG. 6)

Electret-mike element, Radio Shack #270-090.
Metal target plate, 1-inch length of ⅜-inch (inner dimension) by ½-inch (outer dimension) vinyl tubing; silicon rubber; 2200-ohm, ¼-watt, 5% resistor; 10K pot; .1-uF, ceramic-disc capacitor; wire; etc.

Piezo Transducer

Another great pick-up sensor for impact detection is the piezo transducer, which is available for less than two bucks at your local electronic-supply house. Only the plain Jane piezo element is required for our use; therefore, the more expensive devices that have built-in tone generators are not required and will not work anyway. Just about any size piezo element will fit; however, I'd recommend one that's about .75 to 1.0 inches in diameter.

The basic construction, see Fig. 5, of the piezo impact transducer closely follows our first one in Fig. 1—with a minor, but important, change. The piezo elements are hardy little fellows, but they can be cracked or broken if handled carelessly. To reduce that chance, the piezo element is mounted to the metal plate with a ⅛-inch layer of silicon rubber to serve as a buffer between the impact area and the piezo element. The silicon rubber should be applied in a circle slightly smaller than the diameter of the piezo element.

Take care in attaching the piezo element to the plate so that no silicon rubber gets into the element. The piezo transducer may be connected to the same amplifier circuit shown in Fig. 4, with the addition of the 10K pot.

Electret-Mike-Element Transducer

The electret-mike element is another great inexpensive device that makes a good impact transducer. The micro-

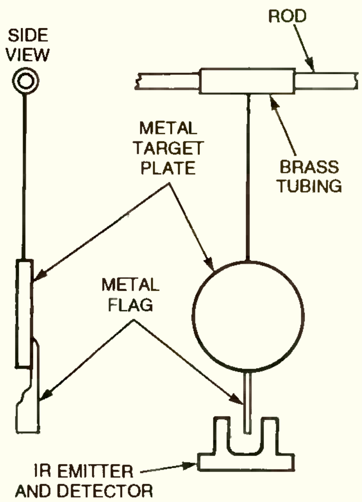


Fig. 7. The circuit above is for a swinging target. An IR detector and emitter are used to monitor the swinging target.

PARTS LIST FOR THE SWINGING TARGET (FIG. 7)

Round metal target plate, brass tubing, metal rod that goes through the brass tubing, metal for flag, IR interrupter switch—Mouser part #512-H21A1 or similar device.

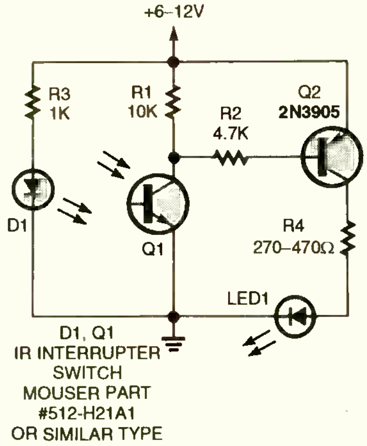


Fig. 8. The circuit above adds a flashing LED to the swinging transducer in Fig. 7. The IR emitter and detector are in the same package and are available from Mouser Electronics, listed as an IR interrupter switch.

PARTS LIST FOR THE SIGNAL LIGHT (FIG. 8)

SEMICONDUCTORS

D1, Q1—IR interrupter switch, Mouser part #512-H21A1
LED1—Any color or size
Q2—2N3905 PNP general-purpose transistor

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—10,000-ohm
R2—4700-ohm
R3—1000-ohm
R4—270-ohm to 470-ohm

phone element is very sensitive and must be mounted in such a way that only the pellet impact sound is detected. This is easily done by mounting the mike element in a 1-inch length of ¼-inch (inner-dimension) by ½-inch (outer dimension) vinyl tubing, as shown in Fig. 6. The vinyl tubing is mounted to the center of the metal plate with silicon rubber. After you push the mike element about halfway into the tubing, seal the open end with silicon rubber. Any outside noise or sound reaching the mike element will be greatly reduced by the vinyl tubing and silicon rubber.

The electric-mike transducer can also be connected to the amplifier circuit shown in Fig. 4, by following the drawing in Fig. 6.

Swinging Targets

Many sporting goods and large discount stores offer at least one type of swinging target for pellet guns. Some of these are easily modified to work with our next impact transducer, shown in Fig. 7. If a suitable one cannot be found, it's no big chore to build your own. The metal target is usually round in shape and anywhere from ½- to 2-inches in diameter; however, any shape or size will work. The idea is for the target plate to move back and forth when hit by a pellet. This movement allows the IR detector to see the IR source when the target is swinging back and forth. At rest, the metal flag is centered between the IR emitter and detector, allowing no IR source to reach the detector. The IR transducer should, like the others, be located behind the target cover, as

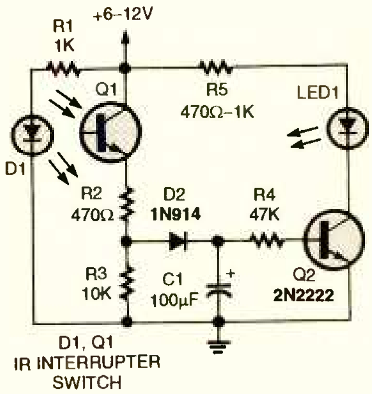


Fig. 9. This circuit adds a turn-off delay function keeping the LED on for a short time period without flashing on and off.

PARTS LIST FOR THE DELAYED TURN-OFF CIRCUIT (FIG. 9)

SEMICONDUCTORS

D1, Q1—IR interrupter switch (same as in Fig. 8)
D2—1N914 silicon diode
LED1—Any color or size
Q2—2N2222 NPN general-purpose transistor

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—1000-ohm
R2—470-ohm
R3—10,000-ohm
R4—47,000-ohm
R5—470-ohm to 1000-ohm

CAPACITORS

C1—100-µF, 35WVDC, electrolytic capacitor

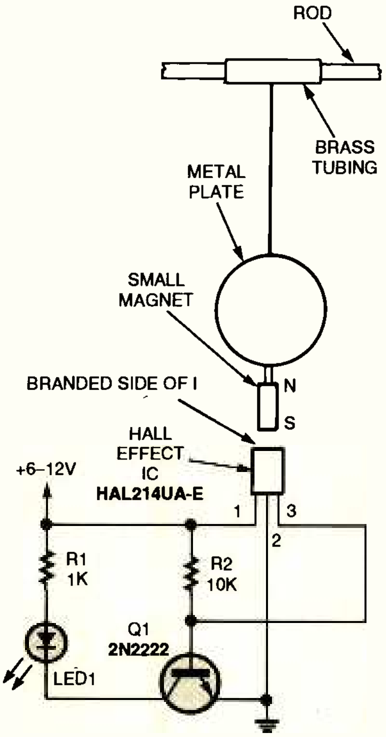


Fig. 10. Our last impact transducer incorporates a Hall-effect circuit into its design.

shown in Fig. 2. This arrangement protects the detector and allows for a selected target area.

Signal Light

The circuit in Fig. 8 adds a flashing LED to the swinging transducer in Fig. 7. The IR emitter and detector are in the same package and are available from Mouser Electronics, listed as an IR interrupter switch.

Transistor Q1 is turned off, and its collector is at positive supply, keeping Q2 turned off as well. When the target swings away from the IR interrupter switch, Q1's collector goes from positive supply to near ground level. This action switches Q2 on and off at the same rate, causing the LED to flash on and off. The LED lights each time the swinging flag is out of the gap between the IR emitter and detector.

A similar circuit, see Fig. 9, adds a turn-off delay function keeping the LED on for a short time period without flashing on and off. The same IR interrupter switch is used as in our previous circuit, with the detector transistor, Q1, connected as an emitter follower. When the metal flag moves from between D1 and Q1, the voltage at the emitter of Q1 rises to near battery voltage, charging C1 through R2 and D2 and supplying base current for Q2. Then Q2 turns on, lighting the LED. The on time can be as much as five seconds with the 100-µF capacitor, and longer when C1 is increased in value. Resistor R2's purpose is to limit Q1's maximum current flow when charging C1.

PARTS LIST FOR THE HALL-EFFECT CIRCUIT (FIG. 10)

Same metal parts as in Fig. 7, with a small magnet replacing the metal flag.
IC1—Hall-effect IC # HA214UA-E, sensor available from Digi-Key
LED1—Any color and size
Q1—2N2222 NPN, general-purpose transistor
R1—1000-ohm, ¼-watt, 5% resistor
R2—10,000-ohm, ¼-watt, 5% resistor

Hall-Effect Circuit

Our last impact transducer this time around is the Hall-effect circuit shown in Fig. 10. The swinging metal plate is arranged like our previous target, with a small magnet replacing the metal flag. The south pole of the magnet is facing the branded side of the Hall-effect IC, which causes the output of the IC, pin #3, to go and stay low as long as the magnet remains still. Hitting the target plate causes the magnet to swing back and forth allowing the Hall-effect to turn off and on at the same rate. The LED flashes following the swinging target. The Hall-effect's output can also be used to supply clock pulses to a simple counter to display the number of swings the target makes.

I still have a few more impact transducers to share along with a number of display circuits that can be driven with the transducers. These combinations can turn out to be interesting targets and loads of fun to boot. Come around again next month same time, same station. ■

DIGITAL DOMAIN

(continued from page 15)

excels at person-to-person journalism," says Trayes. The flip side to the Net's personal nature is the high incidence of misinformation. Without the filter of experience and editing, rumors and hoaxes proliferate. In one Internet discussion group I follow, it was reported that the planes that slammed into the World Trade Center had biological weapons on board.

The misinformation can be visual as well as verbal. In the days after September 11th, a doctored photo circulated around the Internet of a tourist on top of World Trade Center smiling for a camera while a plane in the background was just about to slam into the building. Anti-hoax Web sites such as the Urban Legends Reference Pages at *www.snopes.com* can help ferret out the truth.

Television wasn't immune to reporting false rumor as news, including the car bomb outside the U.S. State Department, the three other missing airliners that were presumably heading for Virginia, and the van on the New Jersey Parkway loaded with explosives.

Maybe what's most valuable about the personal nature of the Net is its ability to bring the community together. During a disaster, it's a natural human impulse to reach out to others; and the Net is unparalleled in bridging the distance that often separates us. "In the midst of horror, we need to know that we're not alone," says Steven J. Vaughan-Nichols, chairman of the Internet Press Guild. "Ultimately, we're family, and like all families we're drawn together when terror's night threatens us."

The Net can also bring together those who otherwise might not think of themselves as family. "The Internet can facilitate discussion among people who otherwise might be belligerent," says Outing. This won't guarantee peace, of course. We've already seen that. "There is a time for everything ... a time for war and a time for peace," according to both Ecclesiastes and the Byrds.

Reid Goldsborough is a syndicated columnist and author of the book *Straight Talk About the Information Superhighway*. He can be reached at reidgold@netaxs.com or *http://members.home.net/reidgold.* ■

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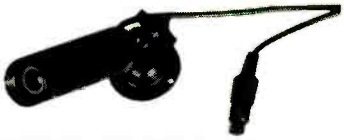

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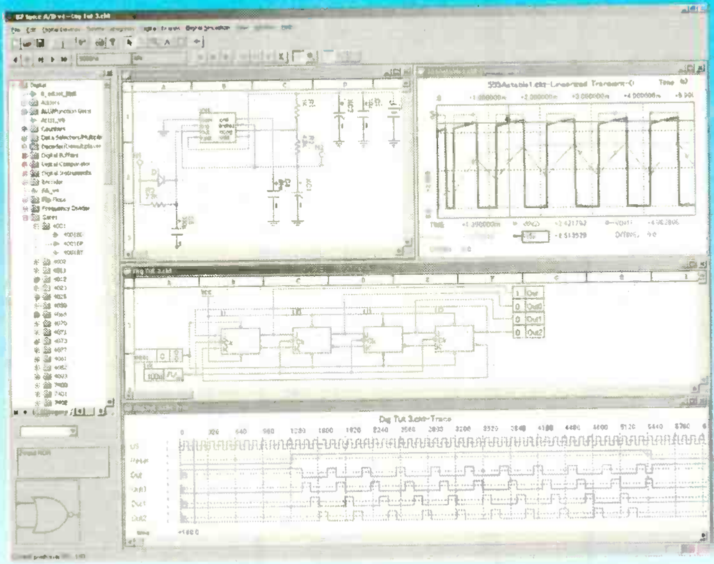

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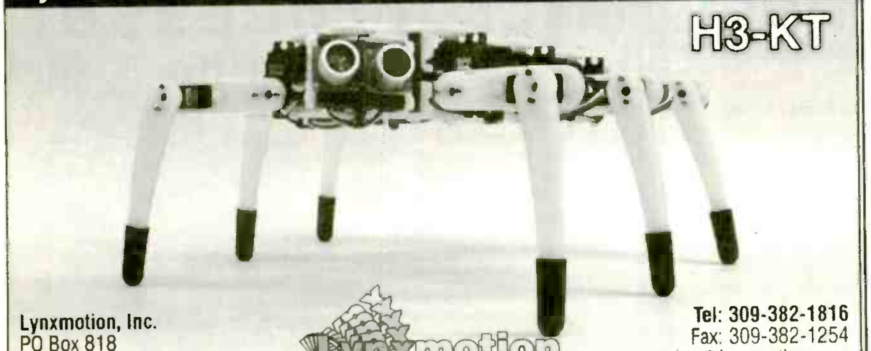

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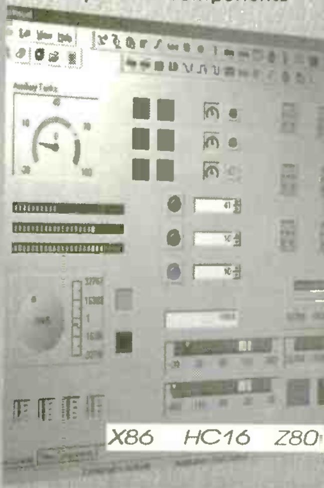

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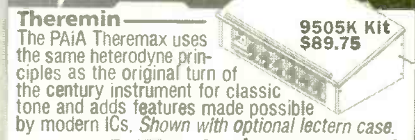

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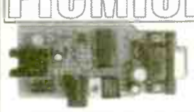

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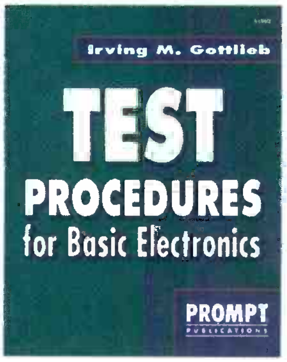

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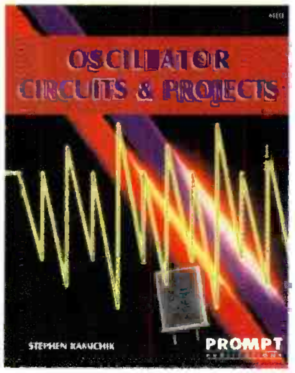

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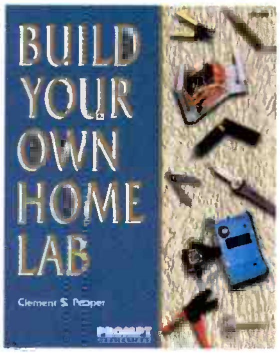

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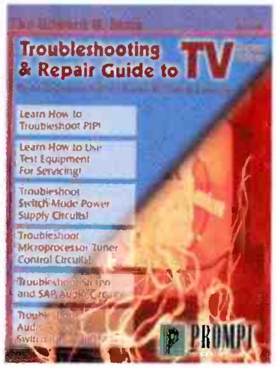

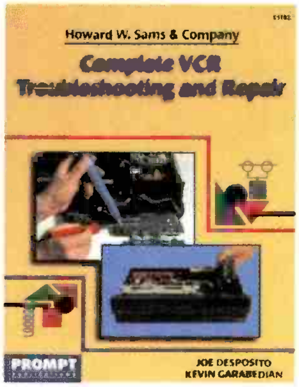

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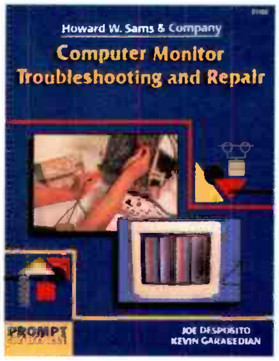

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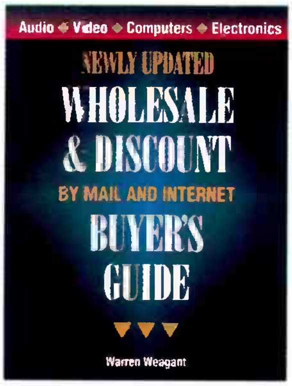

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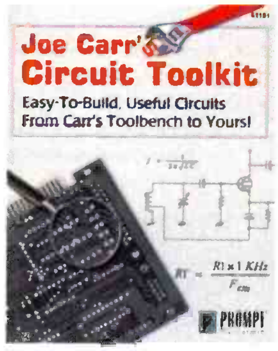

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