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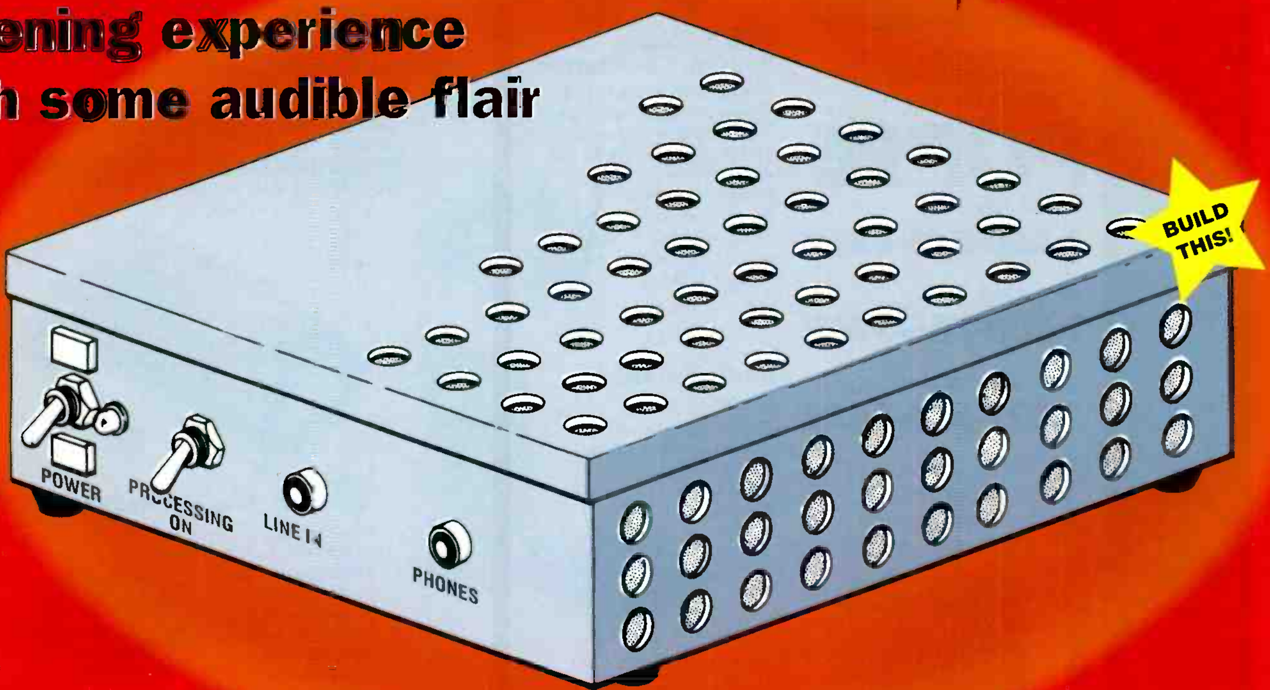

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COLUMBIA MD 21046-2073

May 2002, Vol. 3, No. 5

Electronics Now Popular Electronics

Poptronics®

Poptronics (ISSN 1526-3681) Published monthly by Gernsback Publications, Inc. 275-G Marcus Blvd., Hauppauge, NY 11788. Second-Class postage paid at Hauppauge, NY and at additional mailing offices. One-year, twelve issues, subscription rate U.S. and possessions $24.99, Canada $33.15 (includes G.S.T. Canadian Goods and Services Tax Registration No. R125166280), all other countries $33.99. Subscription orders payable in U.S. funds only, International Postal Money Order or check drawn on a U.S. bank. U.S. single copy price $4.99.

Postmaster: Please send address changes to Poptronics, Subscription Dept., P.O. Box 459, Mount Morris, IL 61054-7629

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WARNING

In March 2002's Issue we featured an article entitled *Artificial Muscles*. The article explained in great detail how Electroactive Polymers are created. One of the key ingredients in the chemical recipe was a lethal poison called HYDRAZINE HYDRATE. Having read the MSDS, we do not see any possibly legal way that the general public could procure this chemical. We implore you DO NOT ATTEMPT TO HANDLE THIS CHEMICAL IN ANY FASHION! This hazardous recipe is intended for professional chemists and therefore was shown for purely educational purposes.

TECHNOCRAZY

"If you can't measure it, then surely your ruler must be broken."—anon.

I had the pleasure of browsing the World Wide Web of Conspiracy this morning. Each day I pick a random word, plug it into the search engine, and reap the results. Today's word was *Technocracy*. To paraphrase a 1971 dictionary, a Technocracy is a government and social system controlled by scientific technicians. According to *www.technocracyinc.org* it is an organization that was founded by Howard Scott in the early thirties in order to study, measure, and troubleshoot the productivity of the North American Continent. It appears that even back then, scientists were predicting an enormous energy crisis. A chart presented by the members of the Technocracy predicted a dire inverse proportion of time verses energy production. According to their statistics our planet's population was increasing at an alarming rate, due, in part to technology. Yet, production was on a diving trend. Seeing things from an engineer's point of view, this was due to an inefficient system.

Now, here is where it gets cold and impersonal...Technologists like to refer to humans as *units*. Using advanced laws of thermodynamics, these techs can measure the units' output in common terms, such as BTU. The goal of the Technocracy is to tap the energy of each unit in the most efficient way. The technicians must attempt to predict the "next most probable energy state" of their (whoops, I mean the) units. Prior to setting off on this task though, the Technologists must first succeed in toppling the pesky *Price System*, or more affectionately known as Uncle Sugar's Fiat Currency Debacle. Let's assume (you, me, and the donkey) a dollar is only worth about three calories of heat when converted to energy via a blue-tipped wooden match, as opposed to the nearly 9,000 BTUs put out by an average fleshy unit over an eight-hour period. So, then it is safe to say that units are more efficient than money when it comes to energy production. Are you following this? Of course you aren't, because I am talking double-talk.

Needless to say I was amused by the anti-capitalist rhetoric and bizarre anti-European twist that the original Technocracy possessed. After all, Technocracy Inc. is a Washington State-based organization that happily invites American housewives of all fonts and hues to join their ranks, but shuns any and all Aliens and politicians. Well, isn't that a weird charter. Hmmm, I must not be gifted enough to understand the higher purpose of such groups. Personally I am still trying to organize a movement among warm-weathered penguins and emus. Those are two highly productive populations. The other day I had my penguin up to 10,000 BTUs. Little bugger had my whole second floor lit up until his flippers blew. Now that's science at work for humanity.

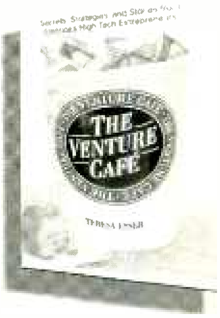
We Can All Afford To Pay Attention,

Chris La Morte,
Managing Editor

NEW LITERATURE

The Venture Café

by Teresa Esser
Warner Books
1271 Avenue of the Americas
New York, NY 10020
800-759-0190
www.twbookmark.com
$24.95

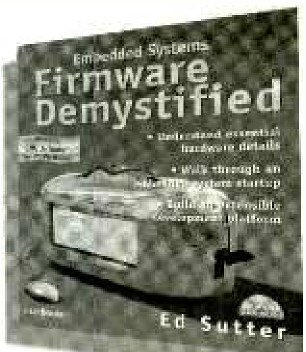


On the campus of MIT, the most creative minds of high technology get together at the Muddy Charles Pub and talk shop—from lessons they have learned and their fights in the trenches to their accomplishments and moments they're most proud of. The entrepreneurs share their invaluable insights and provide personal anecdotes, insider information, and practical advice vital to success in today's fast-paced business environment.

Embedded Systems Firmware Demystified

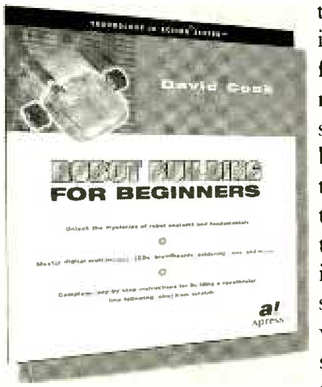
by Ed Sutter
CMP Books
6600 Silacci Way
Gilroy, CA 95020
800-500-6875
www.cmpbooks.com
$49.95

Useful for both novice and experienced developers alike, this guide demonstrates how to build a network-bootable embedded system application from start to finish. Readers get hands-on experience with the fundamentals of starting an embedded system, including the basic boot in assembly language, exception handling, flash drivers and a flash file system, and serial and ethernet connections. The companion CD-ROM contains source code, user documentation for the boot platform, and full, unrestricted GPL distribution of Microcross GNU X-Tools.



Robot Building For Beginners

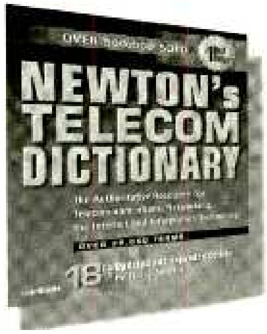
by David Cook
Springer-Verlag
175 Fifth Ave.
New York, NY 10010
800-777-4643
www.springer-ny.com
$29.95



Complete with step-by-step instructions and hands-on experiments, including a line-following robot that the reader can build out of a sandwich container, the book provides basic, practical knowledge on amateur robotics. Also featured is a consolidated listing of sources of necessary tools and parts, as well as an in-depth analysis of digital multimeters. Basic safety and numbering systems are also covered.

Newton's Telecom Dictionary, 18th Edition

by Harry Newton
CMP Books
6600 Silacci Way
Gilroy, CA 95020
800-500-6875
www.cmpbooks.com
$34.95



A useful resource for anyone involved in the telecommunications, networking, or Internet industries, the latest edition has a comprehensive technical dictionary, with over 21,000 terms. This updated version features current standards, vendor-specific terminology, and the latest technical jargon and phraseology.

Kit-Building Catalog

from Ramsey Electronics
793 Canning Parkway
Victor, NY 14564
800-446-2295 or 716-9244560
www.ramseykits.com
Free

Offering the latest electronic kits, this catalog features amateur radio gear—one highlight is the LPFM transmitter and camera, tools and test equipment, and more. It also includes high-performance CCTV cameras, an electrocardiogram heart monitor, a lead-acid battery charger, and the CompuTemp binary LED thermometer.

YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

1900

1910

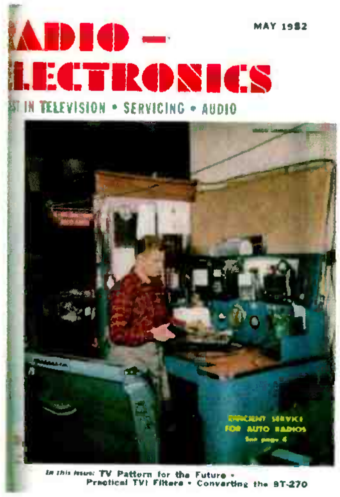
1930

1940

1952

Dateline: May 1952 (50 years ago)

Amateurs and hobbyists can always find practical ideas and projects in the pages of **Radio Electronics.** This month features a low-pass TVI filter for transmitter operation. There are explanations on how to prevent interference and what the FCC regulations are—especially since the country is on the brink of a new nationwide television system. There is also a way to convert the RCA 9T-270 receiver. A continuing series combining electronics with music focuses on the circuitry of the Hammond Solovox electric piano and how to construct your own.



1960

1972

Dateline: May 1972 (30 years ago)

Home installations are fun projects that serve a purpose. This month's **Radio Electronics** makes installing burglar alarms, various wires, and intercom systems easy with simple solutions, explanations of electrical codes, and lists of the necessary tools. There are also useful tips on how to repair personal appliances, such as a hair dryer. Once the home is taken care of, treat yourself by building a new 8-digit pocket calculator or learning about amplified car radio antennas for AM and FM.

1980

Dateline: May 1992 (10 years ago)

This month's **Popular Electronics** is not your typical science project manual. While most parents help their children build paper-mache volcanoes that spew tomato sauce lava, you can now create a high-voltage mini-tornado using a clay flowerpot and a metal conductor. You can also add stormy sounds after reading up on audio indicators and acoustics. This issue also introduces the high-tech electronics age, with reviews of new equipment such as wide-screen televisions and shock-proof CD players.

1992

2000

NEW GEAR

For more information go to page 80A

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

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

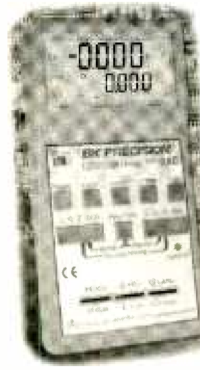
Cable Stripper

Used for cutting and stripping RG-59 and RG-6 coaxial cable, the *Coaxial Cable Stripper* ($14.99) is ideal for consumers as well as those in data communications, telecommunications, and utility applications. The hexagon-shaped stripping station easily strips the outer jacket of the cable, while the 18-gauge stripping station strips the center conductor. The curved cutting blade ensures the wire will not slip while cutting, and the spring return action reduces hand fatigue.

GARDNER BENDER
P.O. Box 3241
Milwaukee, WI 53201-3241
800-624-4320
www.gardnerbender.com

CIRCLE 60 ON FREE INFORMATION CARD

Synthesized In-Circuit Meter



Able to test components at frequencies up to 100 kHz, the *Model 886 Synthesized In-Circuit LCR/ESR Meter* ($769) is lightweight, battery-powered, and handheld. Designed for both production-line and bench-top testing, this meter offers a wide range of measurement parameters and test conditions. It features DC resistance measurement, a rechargeable battery, 0.5% basic accuracy, a large, dual LCD display, fully auto/manual selection, and quick response.

B&K PRECISION CORP.
1031 Segovia Circle
Placentia, CA 92870-7137
714-237-9220
www.bkprecision.com

CIRCLE 62 ON FREE INFORMATION CARD

Network Tester

An ideal tool for installing and maintaining Local Area Networks (LAN) running the TCP/IP protocol, the *Pinger Network IP Tester* ($349) quickly tests proper LAN operation after a move, add, or change. This handheld tester uses the Ping function to verify connectivity, to check transmitted and received data integrity, and to measure round-trip time. It also notifies users of duplicate IP address responses and when the default gateway cannot be located.

JENSEN TOOLS
7815 S. 46th St.
Phoenix, AZ 85044-5399
602-453-3169
www.jensentools.com

CIRCLE 61 ON FREE INFORMATION CARD

Resistance Meter

The *IR800 Portable Tester* ($395), a handheld insulation-resistance meter, adapts to a wide variety of applications from field installations to preventive maintenance and diagnostic testing of wiring and other electronic products. It offers resistance and continuity testing, as well as providing accurate insulation-resistance measurements up to 2000 ohms. Voltage measurements, AC or DC, are possible up to 1000 volts. A zero-offset adjustment provides automatic removal of lead resistance for optimum accuracy at low resistance.

QUADTECH, INC.
5 Clock Tower Place
210 East
Maynard, MA 01754
978-461-2100
www.quadtech.com

CIRCLE 63 ON FREE INFORMATION CARD

Impact Socket Sets

Offering great versatility, both the *10 Piece Fractional ⅜-inch Drive Semi-Deep Impact Socket Set* ($69.99 MSRP) and the *12-Piece Metric ⅜-inch Drive Semi-Deep Impact Socket Set* ($72.89) provide access in work spaces where conventional sockets are too big. The two sets feature the patented SureGrip design that drives the side of the fastener hex, not the corner, increasing its strength and making it effective on partially rounded fasteners. For improved fastener contact, the sockets incorporate a deeper than standard broach depth and a fully tapered nose-down design.

S•K HAND TOOL
9500 West 55th St., Suite B
McCook, IL 60525-3605
708-485-4574
www.skhandtool.com

CIRCLE 64 ON FREE INFORMATION CARD

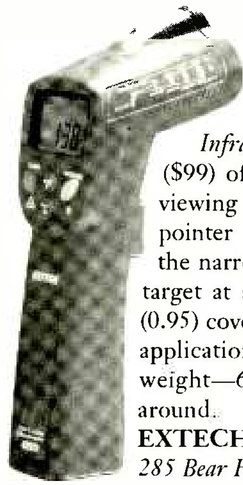
Soldering Systems

Maximizing heat delivery at low, safe temperatures, the *ST35* ($139) and *ST55* ($189) *Soldering Systems* also eliminate the need for calibration. The ST35 is an analog system, while the ST55 is a fully programmable digital system. An included mounting bracket allows mounting under a workbench or shelf. Systems are available with either the PS-70 soldering iron for micro-applications or the PS-90 for medium- and heavy-duty applications.

PACE
9893 Brewers Court
Laurel, MD 20723-1990
301-498-3252
www.paceworldwide.com

CIRCLE 65 ON FREE INFORMATION CARD

Infra-Red Thermometer



Measuring surface temperature without contact in ranges from 0° to 600° F with 1° resolution, the *Infra-Red Thermometer, Model 42529* ($99) offers a large, backlit LCD for easy viewing in dim light. The built-in laser pointer targets the area to be measured—the narrow field-of-view measures a 1-inch target at a 6-inch distance. Fixed emissivity (0.95) covers 90% of the surface-temperature applications. The compact size and light weight—6.4 oz.—make it easy to carry around.

EXTECH
285 Bear Hill Road
Waltham, MA 02451-1064
781-890-7440
www.extech.com

CIRCLE 67 ON FREE INFORMATION CARD

Digital Light Meter

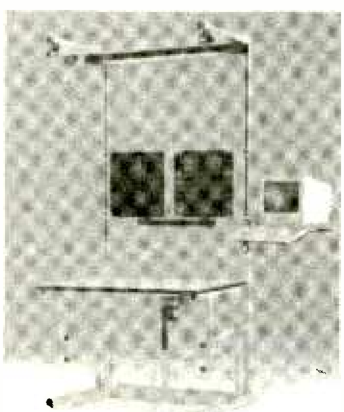
Designed for hard-to-measure locations with a detachable 45-inch sensor flex-cord, the *LM631 Digital Light Meter* ($99.95) is perfect for verifying workplace illumination standards and OSHA requirements. It accurately measures light in lux as well as foot-candles, features a large 3.5-digit display, uses a CIE spectrum curve for accurate human eye response, and sports "peak-hold" and "data-hold" functions.

WAVETEK METERMAN
P.O. Box 9090
Everett, WA 98206-9090
877-596-2680 or 425-446-5070
www.metermantesttools.com

CIRCLE 66 ON FREE INFORMATION CARD

Workstations

Theses ergonomic, electrically-driven *Workstations* (starting at $799) provide dynamic lifting capacities of up to 2500 pounds. They come in five different styles and over 50 different models. Powered by quiet linear actuators, these units offer push-button adjustability for virtually any need. The units also offer customizing capabilities and are backed by a one-year limited warranty.



ALL METAL DESIGNS, INC.
700 Windcrest Drive
Holland, MI 49423
616-392-3696
www.allmetal.com

CIRCLE 68 ON FREE INFORMATION CARD

Pelican Micro Cases

Crushproof, watertight, and corrosion proof, these *Pelican Micro Cases* ($11.95–$21.95) provide protection for small electronic equipment like multimeters, cell phones, palm pilots, and pagers. The cases come equipped with an automatic pressure purge valve that compensates for changes in temperature and altitude, plus a shock-absorbing rubberized tub in the bottom and convoluted foam in the lid. They are available in a variety of sizes.

JENSEN TOOLS
7815 S. 46th St.
Phoenix, AZ 85044-5399
602-453-3169
www.jensentools.com

CIRCLE 69 ON FREE INFORMATION CARD

GIZMO®

For more information go to page 80A
or e-mail: requests@berkshire-is.com

Do You Know Where Your Children Are?

Combining Global Positioning System (GPS) and digital wireless technologies, the *GPS Personal Locator* ($399 plus a monthly service charge of $29.95 to $39.95) is a miniaturized, watch-like device that allows parents to check their children's whereabouts 24 hours a day. Parents can use the Internet or any phone to pinpoint their child's location to within several feet within 60 seconds. In an emergency, either the child or the parent can request a 911 response; and police will be dispatched to the site.

Wherify Wireless, Inc., 2000 Bridge Pkwy., Suite 201, Redwood Shores, CA 94065; 877-LOCATE1 or 650-551-5200; *www.wherifywireless.com*.

CIRCLE 50 ON FREE INFORMATION CARD

Ultra-High-End Loudspeaker

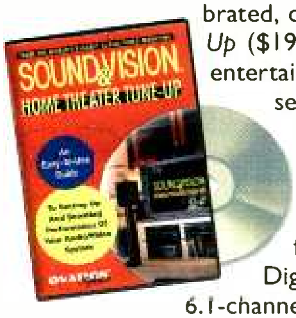
Designed to provide "the ultimate in sonic performance," the *K2 S9800* ($25,000/pair) uses a heavy-duty, almost distortion-free woofer. It includes a massive 5.7-pound magnet, 1.6-inch voice coil gap, and 0.8-inch-long voice coil. The 3-inch voice coil in the mid-range compression driver feeds into a rapid-flare horn shape designed to dramatically reduce second-harmonic distortion. The ultrahigh-frequency compression driver is mated to a specially designed high-frequency horn, extending its response to beyond 50 kHz. Sophisticated adjustment capabilities that include a bi-amp switch, an LF-damping switch, and an HF level selector assure optimum frequency response.

JBL Consumer Products, 250 Crossways Park Dr., Woodbury, NY 11797; 516-496-3400; *www.jbl.com*.

CIRCLE 52 ON FREE INFORMATION CARD

Home-Theater Help

You've got all the gear—so how did *Five Easy Pieces* suddenly turn into *Mission Impossible?* If you're having trouble getting your home theater properly set up and calibrated, check out *Home Theater Tune-Up* ($19.95). This DVD is designed to entertain while teaching you about the set-up and operation of your DVD player and surround-sound system. Various test patterns and audio signals help you get peak performance from your gear, including Dolby Digital Surround EX and DTS ES 6.1-channel systems. A DVD-ROM section allows computer users to access a glossary of technical terms and extensive manufacturer and resource directories with hotlinks to Web sites.

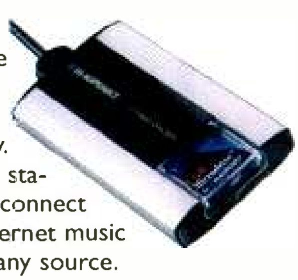


Sound & Vision, 1633 Broadway, New York, NY 10019; 212-767-6758; *www.soundandvisionmag.com*.

CIRCLE 51 ON FREE INFORMATION CARD

Mobile MP3 Hard Drive

The portable *MDP-01 Microdrive* ($849) MP3 record and playback system provides up to 18 hours of music storage on its 1-GB mini hard drive. It also adds MP3 playback to Blaupunkt's Skyline and Funline series car stereos. With the MDP-01 drive, users can easily retrieve and take along home PC MP3 files—files compressed to about one-tenth size with no audible loss in quality. The included USB reader/writer station and software make it easy to connect the unit to a PC to download Internet music files or to create MP3 files from any source.



Blaupunkt, 2800 South 25th Ave., Broadview, IL 60153; 800-950-2528; *www.blaupunktUSA.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Telemarketer Turn-Off

Sick of having your dinner (favorite TV show, new novel, conversation, *life*) interrupted by sales calls? Most such calls are computer-dialed; a live salesperson comes on the line only after you answer the call. The *TeleZapper* ($49.95) is a small black box that attaches to your telephone. It emits a special tone that tells the computer your number is disconnected, and the number is dropped from the call list. As your number is removed from more and more lists, the calls should be virtually eliminated.

Privacy Technologies Inc., 7005 Cochran Rd., Glenwillow, OH 44139; 888-217-9732; *www.privacytechnologies.com*.

CIRCLE 54 ON FREE INFORMATION CARD

Home PDA

Let the *Home Digital Assistant*, or *HDA* ($99.95), juggle your family's diverse tasks and busy schedules. This family-oriented PDA is designed to be kept in the kitchen, where everyone can have easy access to memo and voice memo reminders, "to do" lists, shopping lists, and schedules. Its phone book stores contacts for the whole family. The handheld device also contains 500 recipes and allows you to store your own favorites, as well.

Aurora Corporation of America, 3500 Challenger St., Torrance, CA 90503-1640; 800-327-8508 or 310-793-5650; *www.auroracorp.com.*

CIRCLE 55 ON FREE INFORMATION CARD

SmartMute Radar Detector

While a vehicle is stopped or moving slowly, radar detectors are subject to false alarms triggered by automatic door openers, microwave links, and other non-police radar/laser signals. *The ESD-9860* ($209.95) virtually eliminates such false alarms. SmartMute technology senses the relative vehicle speed and the engine's RPM via an activation point that's set by the user. Once it's set, the unit mutes all audible incoming radar/laser alerts when the engine revs below that point and reactivates them when the engine is above that point. The detector also features an electronic compass, a DigiView data display, and Voice Alert, which provides specific band and mode messages.

Cobra Electronics Corp., 6500 West Cortland St., Chicago, IL 60707; 773-889-8870; *www.cobra.com.*

CIRCLE 57 ON FREE INFORMATION CARD

Speed and Distance Clocker

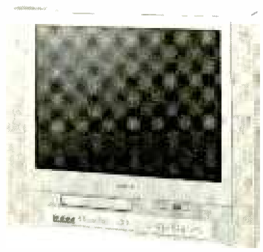
It's easy to know how far you've run if you're doing laps around a track. Take to the country—or even to the streets—and it's difficult to gage your distance and speed. The *Ironman Speed & Distance System* sports watch comes with a GPS re-ceiver, about the size of a cell phone, that transmits precise speed, distance, and pace readings in real time. The Ironman GPS system is available with 100-lap or 50-lap memory, priced at $225 and $250, respectively.

Timex Corp., 555 Christian Rd., P.O. Box 310, Middlebury, CT 06762-0310; 800-367-8463 or 203-346-5000; *www.timex.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Triple Play

The *MW24FM1* ($699.99) combines a television, a full-function DVD player, and a four-head hi-fi VCR in one stylish, stream-lined unit. The TV features an FST Pure flat-screen picture tube for greater edge detail and sharpness and a wider viewing angle. The TV/DVD/VCR features built-in side-firing stereo speakers, as well as digital audio outputs for connecting to a full home-theater surround-sound system. The unified remote control, front-panel inputs with a game/TV switch, one-touch recording, and a 360-minute on/off timer make the unit convenient to use.



Toshiba America Consumer Products, 82 Totowa Rd. Wayne, NJ 07470-3191; *www.toshiba.com.*

CIRCLE 58 ON FREE INFORMATION CARD

Portable Jukebox

With a 10-GB hard-disc drive, the tiny *RCA LYRA Personal Jukebox, Model RD2800,* ($299) is big enough to hold thousands of songs as well as computer files and digital images. When updated to play MP3PRO files (via a software download slated to be available by press time), the 11-ounce device will store 300 hours of music—the equivalent of most consumers' entire CD library. It also provides complete hard drive capability, allowing you to store and transport PC or Mac files, including digital images and documents, and to download and store information from the Internet.

Thomson Consumer Electronics, 10330 North Meridian St., Indianapolis, IN 46290; 317-587-4450; *www.rca.com.*

CIRCLE 59 ON FREE INFORMATION CARD

PC GIZMO®

Cruzin' Along

The first portable storage device with removable and upgradeable flash memory cards is the *Cruzer*, a pocket-sized unit that provides for easy transport of computer data and image files and digital audio and video. It accommodates both SD cards and MultiMedia cards and is fully compatible with PCs and consumer-electronic products. Cruzer features Mass Storage Class (MSC) compliance for true plug-and-play operation when used with Windows 2000, Millennium Edition, and XP. First-generation Cruzers will be available in 32-, 64-, 128-, and 256-MB versions, with prices ranging from $59.95 to $199.95.

SanDisk Corp.; 408-542-0500; *www.sandisk.com.*

Glowing Discs

Your CD recordings will stand out from the crowd if you use *Glow Discs* glow-in-the-dark CD-Rs. With 80-minute, 700-MB capacity and 1X to 32X write speeds, they offer an eye-catching alternative to storing your favorite MP3 tunes or digital photos. They come in packages of 10 for $9.99.

Fuji Photo Film U.S.A., Inc.; 800-800-FUJI; *www.fujifilm.com.*

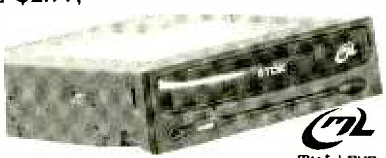
Give 'em a Hand

Now you can control your Mac, PC, PlayStation 2, or XBox with a wave of your hand—as long as that hand is sheathed in the *P5 Controller* ($129). Sensors on the glove-like device track the relative position of the hand and allow you to shoot a gun by moving your trigger finger, throw a football, or swing a baseball bat. The P5 offers six degrees of tracking (X, Y, and Z axis, yaw, roll, and pitch)—a big step up from trackball, joystick, and mouse controllers that currently offer a maximum of 3 degrees of movement. It comes with a desk-mounted docking station and two USB interfaces.

Essential Reality, 212-244-3200; www.essentialreality.com.

2-GB CD/ML Burner

Ideal for PC backup and multimedia archiving, the *2GB ML CD-RW Burner* ($199) incorporates a *MultiLevel* (ML) read/write chip. This chip adds a 2-GB mode to its standard CD-R/RW recording capability when used with *ML-R* (write once) *or ML-RW* (rewritable) discs, priced at $1.99 and $2.99, respectively. The drive is rated at 36X/24X/40X in ML mode, allowing you to archive 2GB of data in less than six minutes. The internal drive with ATAPI connectivity is Windows XP-compatible.



TDK Electronics Corp.; 516-535-2646; *www.tdk.com.*

Laser Digital Copier

Aimed at the SOHO market, the *DCP-1400* ($499) is a laser printer that also offers digital-copier and color-scanning functions. Compatible with both Windows and Mac, the device is equipped with parallel and USB ports. It prints up to 15 copies-per-minute in printer or copier mode and has a 50-page auto document feeder. Scanner resolution is 9600 dpi, while the laser printer offers 600- × 600- dpi resolution.

Brother; 908-704-1700; *www.brother.com.*

G

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

A LOOK AT
TOMORROW'S TECHNOLOGY

PROTO

Business Buzz

ROSE-COLORED WINDSHIELDS

For decades, automotive manufacturers have been matching interior detailing to a vehicle's exterior paint. Now they are gong a step further, with color-tinted windows. Ford recently displayed a Mighty F-350 Tonka truck and a GT40, both equipped with Vanceva Color—a glass interlayer product from Solutia Inc.; while GM's concept Chevrolet Bel Air and Pontiac Solstice featured bluish-purple and light gray glass, respectively. In addition to aesthetics, the laminated glass Vanceva Color windows filter road noise, provide ten times the intrusion resistance of tempered glass, and block 95% of UV rays.

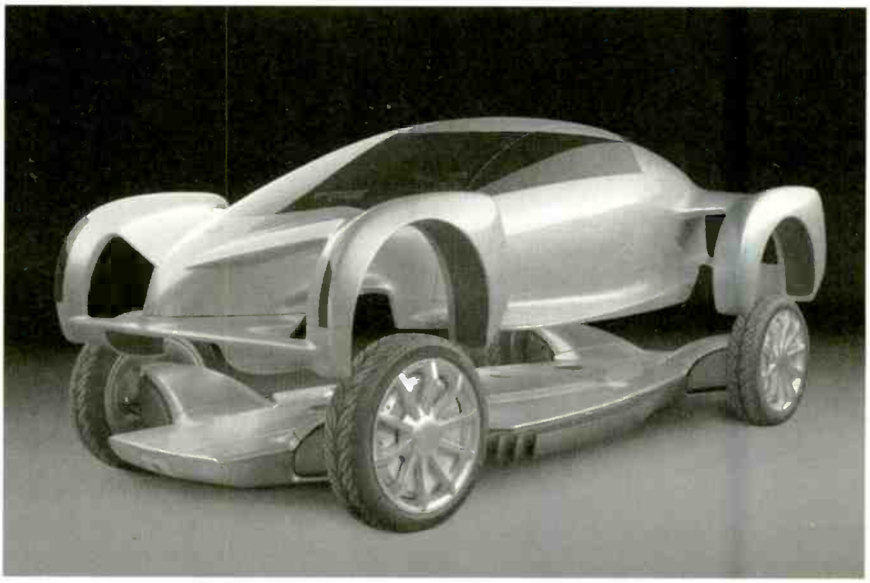
SURROUND IN MOTION

You've got surround sound in your living room. Now, Dolby Laboratories has introduced Surround in Motion that allows licensed manufacturers to create everything from high-end concert-hall experiences to affordable surround-sound for in-car entertainment systems. At the Consumer Electronics Show, Dolby's demo vehicle was a 2001 BMW X5 SUV outfitted with 5.1-channel Dolby Digital, Dolby Surround Pro Logic II, Dolby Headphones (which simulate a 5.1-channel system), and MPL Lossless (the core audio technology behind DVD-Audio). The vehicle featured a 5.1-channel surround processor from Alpine and MB Quart loudspeakers.

MONEY TRACKER

Wherify Wireless's currency-tracking pack uses patented location service technology for speedy return of stolen cash and capture of the bank robber. The tracking pack, to be marketed by Global Pursuit Systems, blends GPS, RF beacon, and wireless technologies into a miniaturized locator. The currency-tracking packs will communicate over a network covering 4000 U.S. cities and metro areas, rapidly pinpointing the bank robber's location. Local police will be dispatched via Wherify's Location Service Center.

The Skateboard Car



GM's concept car, dubbed the AUTOnomy, features a skateboard-like chassis and a removable body. Shown here is a sporty two-seater.

What does a car have in common with a skateboard (besides four wheels)? Well, if the car happens to be GM's AUTOnomy concept vehicle, the answer is its chassis design. All of its propulsion and control systems are contained within a six-inch-thick, skateboard-like chassis, freeing the body shape to be virtually anything its designers can envision. The unique design lends itself to customized bodies—and even the possibility of leasing multiple bodies and swapping them to suit your changing moods or transportation needs.

"We've chosen this unique two-seater," said Wayne Cherry, GM Vice President of Design, referring to the concept car unveiled at the North American International Auto Show in January, "but it doesn't have to be that way at all. Next, we might do a mobility body that allows a wheelchair user to roll right into the driving position or a 10-seat transit bus. We've even talked about a seating position that puts the driver right up front, like a helicopter pilot."

Skateboard Schematics

All of AUTOnomy's essential systems—which include an innovative fuel cell stack and on-board hydrogen storage system—are packaged in the six-inch-thick chassis. The universal skateboard chassis design would simplify manufacturing and service and speed up product development cycles by allowing a wide variety of vehicles to be built on a small number of platforms.

At the heart of the electrical system is a centrally located universal docking port that creates a quick and reliable way to connect all of the body systems—controls, power, and heating—to the rolling chassis. That design makes the body lightweight and uncomplicated.

Power By Hydrogen

The body design is only one of the AUTOnomy's innovations. The vehicle is the first to be engineered from the ground up around a fuel-cell propulsion system. Fuel cells remove electrons from hydrogen atoms and use them as an electrical current. The hydrogen atoms are then combined with oxygen to form water vapor. Powered by fuel cells rather than gasoline, such vehicles, ideally, would emit only water and heat.

It's also the first to combine fuel cells with x-by-wire (or drive-by-wire) technology, which allows steering, braking, and other systems to be controlled electronically rather than mechanically. With computers and software controlling the x-by-wire systems, upgrades to improve vehicle performance or to tailor handling characteristics can be downloaded easily.

Larry Burns, GM Vice President, Research & Development and Planning, says of the AUTOnomy, "It has electric motors at all four wheels; and the fuel cell stack, hydrogen-storage system, controls and heat exchangers are embedded within. There is no IC engine; no transmission; no drivetrain; no axles; no exhaust system; no radiator; and no mechanical steering, braking and accelerating linkages. In fact, the only things moving other than electrons, protons, water and air, are the wheels and suspension!"

Reality Check

Of course, a "concept vehicle" has a long road to travel before it's ready to hit the real-life highway. Although GM President and CEO Rick Wagoner touts the AUTOnomy as "more than a new concept car, it's potentially the start of a revolution in how automobiles are designed, built, and used"—the first working prototypes are expected to look, and perform, a bit differently. Measuring 11 inches, the chassis will be almost double the thickness to be able to accommodate hydrogen tanks large enough for trips of just 100 to 150 miles.

It's a starting point, however, for GM's future vision, summed up by Burns: "The 20th century way the century of the internal combustion engine. The 21st century will be the century of the fuel cell." PT

Molecular Chip Patent

A patent was awarded to researchers at HP Labs and the University of California in Los Angeles for their collaboration on a technology that could make it possible to make very complex logic chips at the molecular scale. The patent, issued to James R. Heath of UCLA and Philip J. Kuekes and R. Stanley Williams of HP Labs, builds on their previous patents and research. It is funded by a grant from the U.S. Defense Advanced Research Projects Agency, matched by Hewlett-Packard.

The team views molecular electronics as an entirely new technology that could augment silicon-based integrated circuits within the next ten years—and eventually replace them entirely. Unlike today's chip-manufacturing process, which requires many expensive precision steps to create the complex patterns of wires that define the computer circuit, the molecular electronics technology proposes the use of a simple grid of atomic-scale wires connected by electronic switches a single molecule thick.

HP Labs had previously demonstrated how some rare earth metals naturally form themselves into nanoscopic parallel wires when they react chemically with a silicon substrate. Two sets of facing parallel wires, arranged roughly perpendicular to each other—think of a street map, could then be fashioned into a grid.

In a related experiment, the researchers crossed wires the size of those used in today's computer chips and sandwiched them around a one-molecule-thick layer of electrically switchable molecules called rotaxanes. By downloading signals to molecules trapped between the cross wires, they created simple logic gates.

"That work demonstrated for the first time that molecules could be used as electronic devices to perform computer logic," said Heath, UCLA chemistry professor and director of the California Nanosystems Institute.

The team has also patented a memory chip based on molecular switches. "In the future, programming could replace today's complex, high-precision method of fabricating computer chips," said Kuekes, a senior scientist and computer architect

Research Notes

WATER-RESOURCES MODEL

Researchers at Sandia National Laboratories have created software models that calculate tomorrow's water resources given today's policy choices. The software tool could help avert water crises and quell geopolitical tensions. It's important not only in regions and nations with critical water shortages, but also in areas such as the southwestern U.S., where sound water-management policies might avert a future crisis. The models are based on commercially available simulation software, which provides immediate extrapolation and visualization of results. Each model is a complex representation of the subtle interrelationships among ground and surface water sources, recharge rates, groundwater pumping, irrigation, climate, evapotranspiration, and demographics. Future models will include other factors, such as environmental impacts, water quality, economic productivity, and an area's social and cultural foundations.

"DIET" FOR GLASS

The 150 pounds of glass sported by today's average car translates to reduced gas mileage and higher emissions—two undesirable conditions. Researchers at *P*acific *N*orthwest *N*ational *L*aboratory (*PNNL*) and their partners in the automotive and glass manufacturing industries have developed a prototype windshield that is 30 percent lighter, yet it retains key optical, thermal, and safety properties. Related PNNL projects have focused on testing the strength of various lightweight glass designs and of high-speed impact windshields. In addition, the researchers are involved in understanding how temperature, humidity, and flaws impact glass strength. Reducing windshield thickness by as much as half may result in only small decreases in a vehicle's "torsional rigidity—an important consideration."

at HP Labs. "Once a basic grid has been assembled, programming could be used to implement a very complex logic design by electronically setting the appropriate configuration switches in the molecular-scale structure."

However, the researchers faced a conceptual barrier to taking full advantage of the technology and creating practical, more complex chips. "The problem is that on a single large grid all the electrical signals would interfere with each other," said Williams, HP Fellow and director of quantum science research at HP Labs. "It would be like removing all the traffic signals from Manhattan and demanding a minimum speed of 30 mph — the result would be total gridlock. Signal lights, or cut wires, regulate the flow of traffic and make it possible to carry passengers, or information, between any two points on the grid.

Thus, the patented invention cuts the wires into smaller lengths by turning some "intersections" into insulators. The insulators are created by "cutter wires," which are chemically distinct from the others. A voltage difference between the cutter wire and the target wire creates the insulator. Controlling those voltages and charges involves a special demultiplexing technique using a chemical process to connect lithographically formed wires to the nanometer-scale wires. Williams and Kuekes also hold a patent on that control technique, which also provides a method to connect the molecular-scale devices to current technology.

"Essentially," said Williams," you subdivide the city into smaller neighborhoods, with smaller streets within each neighborhood and larger streets connecting the neighborhoods." PT

➤Irradiation Warning

The CompactFlash Association (CFA) has issued a warning that semiconductors used in electronic systems, including CompactFlash and CF I/O cards, would be irreparably damaged if they were subjected to the irradiation process that is being used by the U.S. Postal Service in the wake of anthrax attacks. Not only will data stored on the cards be lost, but the cards themselves will be rendered inoperable.

In October, the USPS began using electron-beam irradiation systems to sanitize certain mail streams against anthrax and other possible biological contaminants. The systems, which operate in the range of 55 kGy, damage not only semiconductors, but also pharmaceuticals, contact lenses, biological samples, and photographic film. According to the USPS Web site, "Sanitization technology is currently being tested on a wide range of film products, digital and magnetic storage devices, laboratory samples, food and plant products, and 'smart' credit cards with embedded chips to ensure that all business mail can be safely processed through the postal system." PT

Cancer Catcher

University of Texas scientist Josef Käs has developed a technology to help doctors detect cancer and determine whether cancer cells are capable of spreading to other parts of the body. Evacyte Corporation, an Austin biotechnology firm created to commercialize the diagnostic process, is developing the technology—known as the Optical Cell Stretcher.

Käs, associate professor of physics and researcher in the Center for Nonlinear Dynamics, became interested in cancer diagnosis and treatment when, over several years, he watched a series of friends and family members battle the disease unsuccessfully. "Being a physicist and something of a geek, I did what I always do when confronted by a problem," said Käs. "I read."

His research revealed that, despite advances in cancer therapy, the death rate has not changed significantly—mainly because many cancers are detected too late to respond to treatment. Early detection has been elusive; on a molecular level, cancer actually is more than 100 diseases. Finding techniques to detect all those diseases is extremely complex and expensive.

A single characteristic shared by all cancer cells inspired Käs to come up with an idea which, though simple, can be very effective in detecting a cancer cell's ability to metastasize. As cancer progresses, cells become increasingly malleable due to the breakdown of their internal polymer support network, called the cytoskeleton. Käs compares the cytoskeleton to bits of "half-cooked spaghetti" that give the cells their stability and shape.

"It's documented that cancer cells have much less 'half-cooked spaghetti' than normal cells, and this decrease in cytoskeletal strength is common to all cancer cells," he explained. Cells with less "half-cooked spaghetti" become more elastic and better able to move into the bloodstream and invade other parts of the body.

According to the American Cancer Society, 90 percent of cancer deaths are caused by cancer that spreads. Cancer patients can be placed in three roughly even groups: one with cancer that has already spread when they are diagnosed, one with cancer that is spreading but hasn't yet been detected, and the rest with localized tumors. Patients in the third group are often treated as if their cancer had spread, as a precaution.

Käs's Optical Cell Stretcher technology addresses both the under-treatment and over-treatment of cancer patients due to a lack a diagnostics capability. The test uses small tissue samples, obtained through fine needle aspiration or cytobrush. Both procedures are much less invasive than a typical biopsy. One cell at a time is stretched using lasers. The amount of stretching tells doctors whether a cell is normal or cancerous and whether cancer cells are elastic enough to spread to other parts of the body. This earlier detection and better understanding of a cancer's ability to metastasize can help doctors provide more appropriate treatments. Patients with localized cancer might be spared the aggressive therapy needed by patients with spreading cancer.

Evacyte's initial efforts will be focused on detecting spreading cancer cells in breast and melanoma tumors, both of which are highly treatable in their early stages. "We anticipate that this technology can reduce the overall cost of treatment and mortality of metastatic cancer that is now diagnosed as local cancer," said Evactye co-founder Christian Walker. "In addition, it could potentially lessen medical liability costs by providing more accurate diagnoses." PT

Second Time's a Charm

In 12 years of studying six trillion subatomic particle decays—processing enough data to fill 50 million CD-ROMs, an international team of physicists has spotted one of the rarest occurrences in the subatomic world—not once, but twice!

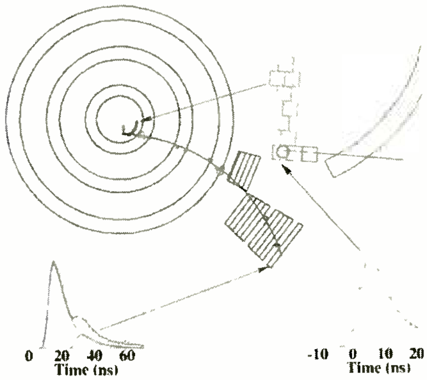
In a collaboration called "E787" for its experiment number, the 50 American, Canadian, and Japanese researchers first noted the rare decay four years ago. An unstable particle called a kaon can decay, or break apart, in various ways. One decay mode, in which the kaon turns into a positively charged pion, a neutrino, and an antineutrino is so rare that, in theory, it occurs only a few times in every 100 billion kaon decays. Making matters worse, it's difficult to distinguish this type of decay from many others that look like it. So, the physicists had to search through many times that number of events to have a chance of finding one.

Before the search could begin, the scientists needed six trillion kaons. For this, they used Brookhaven National Laboratory's Alternating Gradient Synchrotron, a particle accelerator that's capable of producing the world's most intense beam of kaons.

Because kaons exist only for about 12 billionths of a second, the team built a state-of-the-art particle detector—the size of a small house, which could examine one million decays per second. Promising decays were "short-listed" to magnetic tape (the "short" list contained thousands of gigabytes of data), where they could be examined in detail as the physicists reconstructed what really happened inside the detector.

The Experiment 787 detector magnet

The Experiment 787 detector magnet can examine 1,000,000 decays a second.



This photo shows the path the kaon takes as it decays. In the upper left, a K+ enters near the center of the concentric circles representing a cylindrical tracking chamber. It loses energy, stops, and then decays to a pi+ that leaves the target.

"Out of all that data, we've now found two events explicable only by the rare kaon decay we were searching for," said Brookhaven physicist Laurence Littenberg.

According to Doug Bryman, of the University of British Columbia, this rare decay is one of the keys to understanding the universe's most elemental forces and building blocks. "This is a decay that physicists have been looking for since the 1960s, but nobody knew for sure if we would see it," said Bryman.

The decay is important to physicists because it involves some of the more exotic aspects of the Standard Model, the theory that describes the subatomic world. Primarily because of the kaon's "strange" quark—a heavy relative of the quarks that comprise ordinary matter such as atomic nuclei, kaon decays have been an important source of information on fundamental questions in particle physics.

The photo above shows the path the kaon takes as it decays. In the upper left, a K+ enters near the center of the concentric circles representing a cylindrical tracking chamber. It loses energy and stops in a segmented target of scintillating plastic counters; and then decays to a pi+, which leaves the target and is tracked through the chambers (small circles indicate the path) into an array of large scintillation counters surrounding the chamber. The counters in the path of the pi+ are shown.

On the upper right is a blowup of the stopping target region. The filled squares indicate target elements hit by the K+; the outlines are those hit by the pi+ leaving the target. The curved element indicates a trigger scintillation counter adjacent to the target, which the pi+ also hit on its way out. The curve on the lower right is the pulse of energy left by the K+ when it stopped. The curve on the lower left shows the pattern of energy deposition in the last counter on the pi+ trajectory. The pulse of energy left by the stopping pion is shown by the muon to which it decayed after about 15 billionths of a second.

"Understanding such complex forms of decay is especially important to physicists attempting to learn how matter behaves at the most fundamental level," said Bryman. PT

Seizure Control

Georgia Tech researchers are using the same technology that senses an impending electrical failure in an airplane to detect the onset of an epileptic seizure. A collaboration between Georgia Tech's School of Electrical and Computer Engineering and neurologists at the University of Pennsylvania and Emory University revealed that the brain displays a series of electrical "blips and burps" up to seven hours before a seizure. The team hopes that the onset of seizures can be predicted—and even stopped—in those patients for whom standard pharmaceutical or surgical treatments are not effective. The next goal is to develop a miniature pulse-generating device that could be implanted in the brain where it would monitor brain-wave activity and detect and abort any seizures. PT

A Hands-on Electronics® REPORT

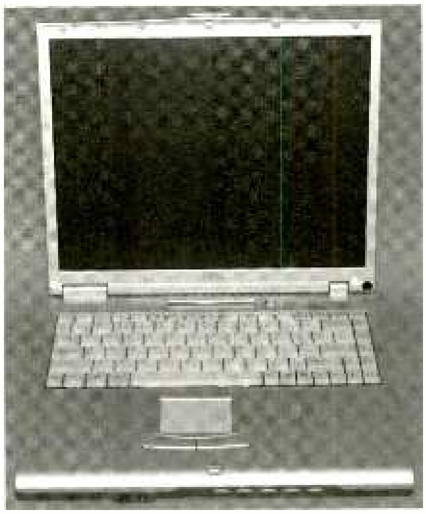
Today's Notebook Computers

Notebook computers take a lot of abuse. Let's look at some key features essential to their long life.

The most important thing to consider when purchasing a notebook computer is its durability and feature set. Durability is important because notebooks are inherently fragile.

Two notebook horror stories come to mind where durability helped prevent complete disaster. A friend once flipped his car over on the expressway. Fortunately, both he and the notebook were okay. Unfortunately, the tow truck driver accidentally ran over the notebook bag when he arrived at the scene, cracking the screen in half. The notebook still worked and does to this day, with the aid of an external monitor. Another friend of mine inadvertently dropped a spackle bucket on to his notebook. The screen didn't crack, but it never lit up again, either. Luckily, the computer still booted, and we were able to transfer his important files onto floppy disks. Minutes later the notebook expelled a puff of smoke and ended its life.

In both stories, the durability of the notebooks played a major role in allowing them to boot at all after the accidents, also allowing important files to be copied while it was still running. Accidents aside, notebooks still lead a hard life; display hinges fatigue, buttons wear out, port covers break off, the keyboards wear out, and so on. This means that the most important thing to look for in a notebook computer is quality.



A two-spindle notebook, the Fujitsu Lifebook E Series has a wireless mouse option that's really slick.

The Compaq EVO N180 looks and feels expensive, and its "rubberized" finish is easy to get a grip on.

Let's take a look at six of the best notebook computers available today. All of them run at speeds of at least 1 GHz, so performance is no longer a big concern. I'll go over the highlights of each one, and you can refer to the Feature Chart for individual specifications.

Compaq Evo N180

Of all the notebooks covered here, my personal pick is Compaq's Evo N180. Nothing else matches it in terms of quality, and it features a beautiful 15-inch screen. Compaq protects the screen with a rigid magnesium lid. Housed in a black, gray, and silver enclosure with chrome accents, the Evo N180 looks and feels expensive. Its "rubberized" finish is easy to get a grip on, as well.

The three-spindle Evo N180 weighs 7.6 pounds and supports both DVD-ROM and CD-RW drives simultaneously, allowing the direct copying of discs. The notebook also supports dual batteries for extra runtime. If you're looking for an affordable, well-made, versatile notebook computer, look no further than Compaq's Evo N180.

Fujitsu LifeBook E Series

The Fujitsu LifeBook E Series is housed in an eye-catching silver enclosure, but its magnesium alloy lid could be more rigid. The LifeBook is a two-spindle notebook; both an external USB floppy drive and a modular floppy drive that swaps with the DVD-ROM drive are available as options. An optional wireless mouse is really slick—it works beautifully when placed anywhere near the notebook.

The LifeBook can be ordered with a built-in modem and NIC or with a modem and FireWire port, but not all three. Four programmable buttons along the front edge of the unit let

Hewlett-Packard's Omnibook 6100 is a full-size two-spindle notebook with a 15-inch screen. Features include both a touch pad and a pointing stick.

The Jetbook 9200 lets you play music CDs and MP3 discs without turning on the computer; It also has a built-in SmartMedia memory card slot.

you set up your own shortcut keys. Nothing stands out about this unit, except perhaps the wireless mouse. However, if you like the way it looks and find it for a good price, there's no reason not to buy one.

Hewlett-Packard Omnibook 6100

Hewlett-Packard's Omnibook 6100 is a full-size two-spindle notebook with a 15-inch screen. A combo DVD/CD-RW drive provides disc-reading and -writing functions in a single-drive bay. This notebook's native resolutions is a not so standard 1400 × 1050, making things appear smaller than usual, but at higher resolution. The Omnibook features built-in 802.11b wireless networking, which works great provided you've already set up an 802.11b wireless hub. The Omnibook 6100 features both a touch pad and a pointing stick, so you can use whichever pointing device you prefer.

The Omnibook 6100 is well made, and it's about 1.5 pounds lighter than Compaq's three-spindle unit. This is another great choice for any mobile computing needs.

Jetta Jetbook 9200

Jetta builds notebook computers for other vendors, but you can also get a Jetbook directly from Jetta or one of its distributors. The Jetbook 9200 is a sleek-looking unit finished in gunmetal and black, with silver accents. Controls let you play music CDs and MP3 discs without having to turn on the computer.

General	Compaq	Fujitsu	Hewlett-Packard	Jetta	KDS	Toshiba
Full Model Name	Compaq Evo N180	LifeBook E Series	Omnibook 6100	Jetbook 9200	Valiant 6000G	Tecra 9000 Series
Price as tested	$1,999 (street)	$2,649 (street)	$2,500 (street)	$1,980 (street)	$1,499 (street)	$2,900 (street)
Physical						
Dimensions W x D x H (inches)	10.99 x 1.63 x 12.91	12.13 x 10.39 x 1.52	12.8 × 10.38 × 1.36	12.28 x 10.48 x 1.30	12.2 x 10.2 x 1.5	12.2 x 10.6 x 1.2
Weight (with battery--pounds)	7.7	6.5	6	5.7	6.8	5.3
Processor						
Type, Speed	Intel Pentium III, 1.0 GHz	Intel Pentium III, 1.2 GHz	Intel Pentium III, 1.13 GHz	Intel Pentium III, 1.13 GHz	Intel Pentium III, 1.0 GHz	Intel Pentium III, 1.2 GHz
Memory/BIOS						
RAM standard/maximum (Mbytes)	256/1024	256/1024	256/1024	256/512	256/1024	256/1024
BIOS manufacturer	Compaq	Phoenix	Phoenix	Phoenix	Phoenix	VESA V2.0
System Bus Speed (MHz)	133	133	133	133	100	133
Display						
Type	TFT Active Matrix	TFT Active Matrix	TFT Active Matrix	TFT Active Matrix	TFT Active Matrix	TFT Active Matrix
Size (diagonal--Inches)	15	14.1	15.0	14.1	14.1	14.1
Native resolution	1024 x 768	1024 x 768	1400 x 1050	1024 x 768	1024 x 768	1024 x 768
Graphics Accelerator (type/model)	ATI Mobility Radeon M6	ATI Mobility Radeon-D	ATI Mobile Radeon-D	Nvidia	Trident CyberBLADE Ai1	S3 Super Savage
Graphics Memory (Mbytes)	32	16	16	16	8	16
Pointing device						
Type (touchpad/stick/trackball)	Touchpad	Touchpad / IR mouse	Touchpad and stick	Touchpad	Touchpad	Stick
Hard Drive						
Manufacturer	Varies	Varies	IBM	Toshiba	IBM, Toshiba	Toshiba
Capacity (Gbytes)	30	30	30	40	20	30
Disc Drive						
CD-ROM or DVD-ROM	CDRW and DVD-ROM	DVD-ROM	CDRW/DVD Combo	CD-ROM	DVD-ROM	CDRW/DVD Combo
Manufacturer	Varies	Various	Toshiba	Teac	Toshiba, LG	Toshiba
Power						
Battery type	Lithium-Ion	Lithium-Ion	Lithium-ion	Lithium-ion	Li-Ion	Lithium-ion
Average run time (hours)	4	3.5	3.5	3	3	3
Accepts second battery	No	Yes	Yes	No	No	Yes
Ports						
Parallel	1	1	1	1	1	1
Serial	0	1	1	0	1	1
PC Card	1	2	2	2	1	2
SCSI	No	No	No	0	NO	No
Built-in modem (56K)	Yes	Yes	Yes	Yes	Yes	Yes
Built-in NIC (10/100)	Yes	Yes	Yes	Yes	Yes	Yes
Wireless NIC (802.11b)	No	No	Yes	Yes	No	Yes
USB (number or ports)	2	2	2	3	2	2
FireWire (IEEE 1394, number of ports)	1	0	0	1	0	1
Infrared (IrDA)	Yes	Yes	Yes	Yes	Yes	Yes
Docking station	No	Yes	Yes	No	No	Yes
Headphone jack	Yes	Yes	Yes	Yes	Yes	Yes
MIDI/joystick	No	No	No	No	No	No
External mouse/keyboard	Yes	Yes	Yes	No	Yes	Yes
Microphone input	Yes	Yes	Yes	Yes	Yes	Yes
Built-in microphone	Yes	Yes	Yes	Yes	Yes	Yes
Audio line in	Yes	No	Yes	Yes	Yes	No
Audio line out	Yes	No	Yes	Yes	Yes	No
Video input	Yes	No	No	No	No	No
Video output	Yes	Yes	Yes	Yes	Yes	Yes
Warranty						
Years	1	3	3	1	1	3

Unique to the Jetbook is its built-in SmartMedia memory card slot, which allows these cards to be read quickly and simply without requiring an external reader.

SmartMedia is commonly used in digital cameras and other multimedia devices, such as portable MP3 players. If you do a lot of digital photography with such a camera or have this type of MP3 player,

(Continued on page 48)

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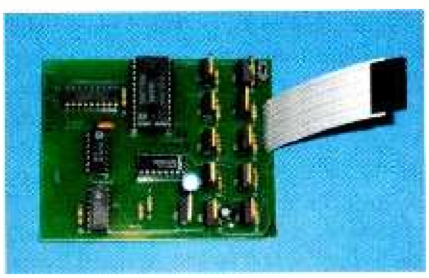
JOHN IOVINE

Speech-Controlled Robotic Arm

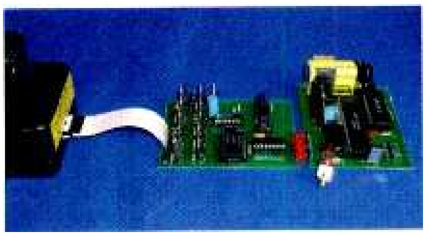
Last month we built a PC interface for the OWI robotic arm. This month we will do one more project for the robotic arm, a speech-recognition interface. The interface uses the speech-recognition kit covered in my column in the December 1999 and January 2000 issues. While the speech-recognition kit has been revised since then, the older version is still usable for this interface. This interface fits in between the speech-recognition circuit and the robotic arm. It allows one to control all the robotic arm functions using verbal commands.

If you compare last month's PC interface to this month's schematic (see Fig. 1), you will see a similarity in the back end portion of the circuit that connects to the robotic arm. The robotic arm, as we discussed last month, has ten wired movement functions. We require one verbal command for each function, plus one additional command for stopping all functions (movement). In total, we need 11 verbal commands.

The speech-recognition kit (rev 1) can recognize up to 40 words. The second revision of the speech-recognition kit allows the user to choose, via a jumper setting, between recognizing 40 one-second words, or 20 two-second words. Since we only need 11 commands, it is better to set the board jumper to 20 two-second words; that setting improves the word recognition accuracy.



This is the finished speech-interface board.



Here is a close-up of the connection to the robotic arm base.

The speech interface needs to perform a couple of jobs. It first needs to determine when a spoken word has been detected. After a word has been detected, it must distinguish whether it is a recognized or an unrecognized word. If the word is a recognized "command word," the interface passes the binary information to the output to initiate the robotic arm function. If the detected word is not a command word, it must block any change to the robotic arm.

How The Circuit Works

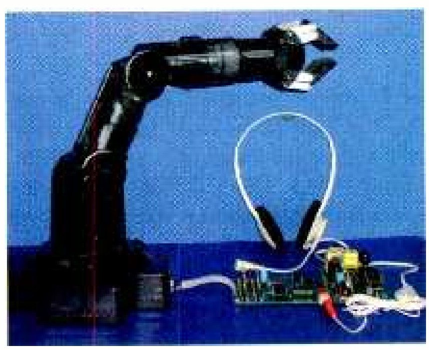
Before we can examine how the circuit functions, we must look at the output information we receive from the speech-recognition circuit. The speech-recognition circuit outputs two four-bit binary coded decimal (BCD) numbers. This binary information is shown on the speech circuit's two-digit digital display. Whenever a word is detected, the circuit uses the digital display to output the word number it has recognized or an unrecognized/error code. If the word detected is not recognized, the circuit will display one of the following codes:

55 = word too long
66 = word too short
77 = didn't find a suitable match

In contrast to previous interface designs, this design incorporates a PIC microcontroller. A pre-programmed microcontroller (16F84) simplifies the circuit design. The first thing to determine is if a word has been spoken, and to do this we use an LM339 comparator. A reference voltage for the comparator is generated using a voltage divider made up of resistors R4 and R5. The reference voltage is placed on pin 5 of the comparator. Pin 4 of the comparator is connected to the LED lead on the speech-recognition circuit. Whenever a word is detected, the LED blinks off momentarily. The output of the comparator (pin 2) is connected to pin 10 (RB4) of the 16F84 microcontroller, which monitors the line. The output of the comparator (pin 2) is usually high (+5V). When a word is detected, the output (pin 2) drops to ground momentarily.

Once a word has been detected, it is necessary for the interface to read the BCD output from the speech-recognition circuit. Using the high- and low-digit BCD nibbles, it's possible to recognize trained target words. To do so, the interface must distinguish the error codes 55, 66, and 77 from trained words numbers 5, 6, and 7.

Four NAND gates off the 4011 integrated circuit are connected to the high-digit nibble. If the high-digit BCD nibble has the equivalent numbers of 5, 6,



The complete speech-controlled robotic arm is shown in the photo above.

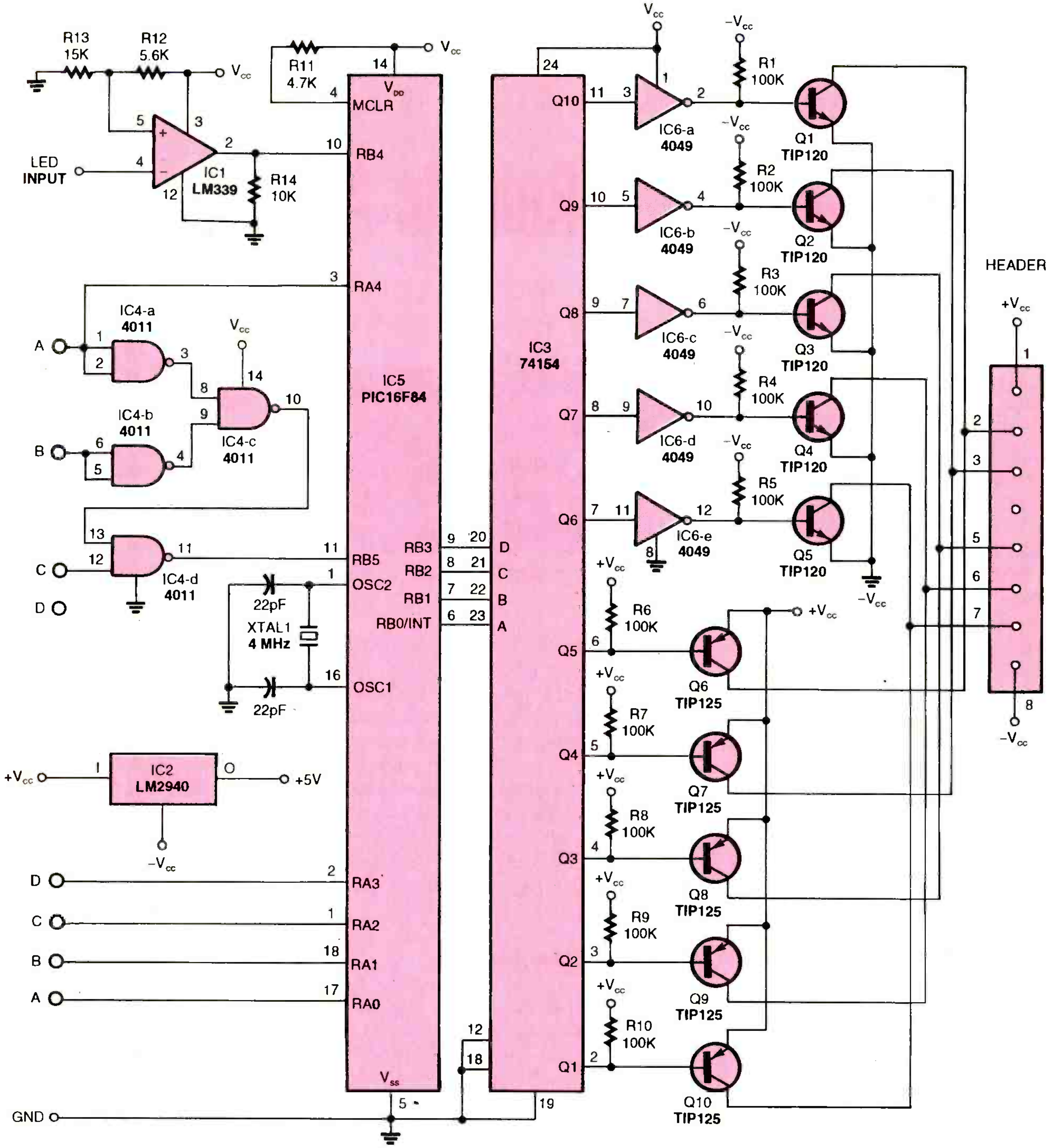


Fig. 1. The speech-interface schematic above uses the PIC16F84 microcontroller in order to simplify the circuit.

or 7, the output from the four NAND gates is low. The output from the four NAND gates is connected to pin 11 (RB5) of the 16F84. The 16F84 reads this pin to see if the high-digit nibble is a 5, 6, or 7 (0V or ground). If these numbers are not displayed, the output of the NAND gates is high (+5v).

So far, our circuit can tell when a word has been detected and if the resulting word is an error code. If the output of the speech-recognition circuit is an error code, nothing else happens—the microcontroller loops back to the beginning of the program waiting for another word detection. On the other hand, if a word is detected and it's not an error code, the microcontroller passes the number through to the 74HC154 (4- to 16-line decoder) IC. The 74HCT154 decoder reads the binary number passed to it and brings the corresponding pin equivalent to that number low.

The low-output pin from the 74HCT154 connects to one of the ten complementary transistors controlling the robotic arm motors and turns it on. For the five TIP125 transistors, the output(s) pin(s) from the 74HCT connect directly to the base(s) of the TIP125 transistors. For the TIP120 transistors, the output signal is first inverted by an inverting gate off a 4049 hex gate.

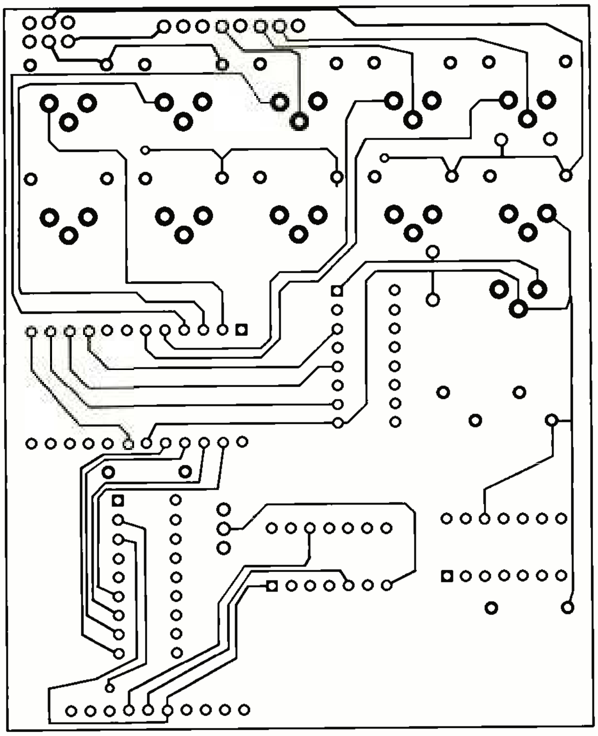


Fig. 2. Here is the top foil pattern PCB for the speech-recognition board.

Power for the circuit is taken from the robotic arm. The robotic arm uses a single 6-volt power supply consisting of four "D" cell batteries in the base. The power supply is used like a bi-polar ±3-volt power supply. Power is tapped from the 8-conductor Molex connector at the robotic arm.

Circuit Construction

There is nothing critical about the circuit construction. The circuit may be wired point to point on a breadboard, if you like. Printed circuit boards make the construction easier. Top and bottom foil patterns are shown in Figs. 2 and 3. Component parts placement is shown in Fig. 4.

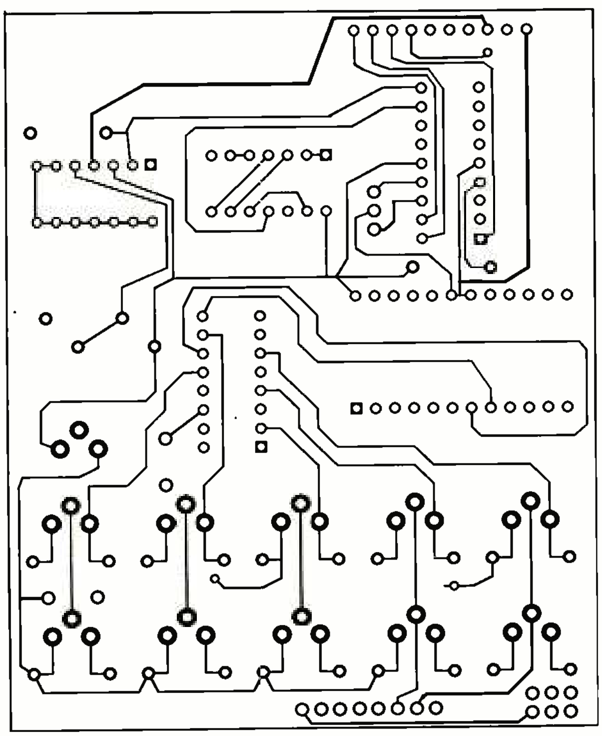


Fig. 3. This bottom foil pattern for the PCB can be used as guide to produce your own board.

PARTS LIST FOR THE SPEECH-RECOGNITION INTERFACE

SEMICONDUCTORS

IC1—LM339, Quad-comparator
IC2—LM2940, 5-V voltage regulator
IC3—74HCT154, 4- to 16-line decoder
IC4—4011, Quad-NAND gate
IC5—Pre-programmed 16F84 *
IC6—4049, Hex-inverting buffer
Q1—Q5—Tip120 Transistors
Q6—Q10—Tip125 Transistors

RESISTORS

All resistors are ¼-watt, 5% units.
R1-R10—100,000-ohm
R11—4700-ohm
R12—5600-ohm
R13—15,000-ohm
R14—10,000-ohm

CAPACITORS

C1—100-µF
C2—1-µF

ADDITIONAL PARTS AND MATERIALS

4.0-MHz ceramic resonator
DPST PC-mounted switch
(1) 8-pin ribbon cable
(1) 10-pin female header

* Pre-programmed 16F84 available separately for $10 from Images SI Inc.

Entire speech-recognition interface kit (all components, including pre-programmed 16F84 and PCB), $49.95.

Images SI Inc.
39 Seneca Loop
Staten Island, NY 10314
718-698-8305

The only component that needs special notice is the 10-pin female header. If you have the latest speech-recognition circuit (rev 2), plug the speech-interface board into the display header on the main PCB of the speech-recognition circuit.

If you are constructing this interface to be used with the rev 1 version on the speech-recognition kit, leave the female header off. You need to solder nine wires from the speech-recognition PCB to the interface board, using a length of wire approximately eight inches long. Begin by soldering the ABCD wires of the lower digit and the ABC of the upper

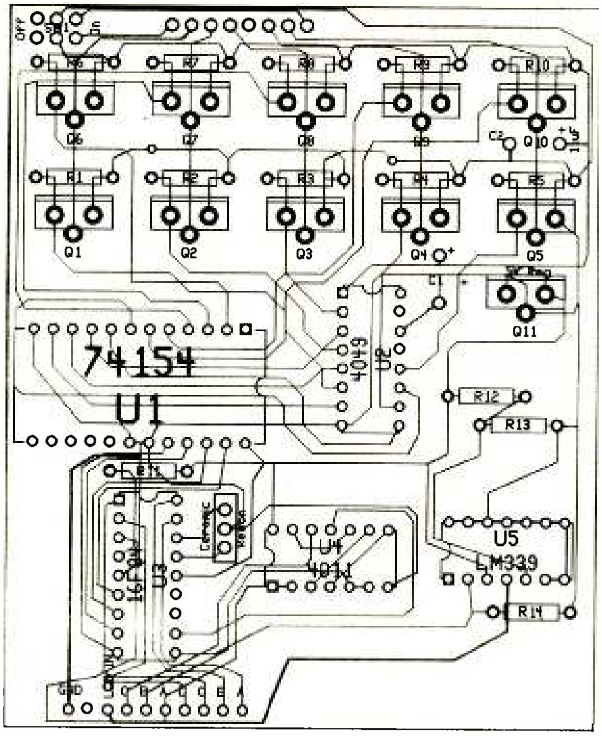


Fig. 4. This is the author's original part layout. Take note that the parts list uses "IC" in place of "U" for integrated circuits.

digit of the speech-recognition kit to the ABCD (lower digit) and ABC (upper digit) of the speech-interface board. Solder a wire from the ground terminal of the speech-recognition circuit to the ground terminal of the interface. Finally, solder a wire from the LED output from the speech-recognition kit to the LED input of the interface kit.

Programming The Speech-Recognition Circuit

Program the speech-recognition circuit as per the directions in the previous article or the instruction that came with the kit. Choose the words you want to use to control the robotic arm. Table 1 shows some suggested words. You can change any one of them.

Testing And Retraining

Before connecting the interface to the robotic arm, test the circuit. Start by repeating all the trained words into the microphone. The corresponding word number will be displayed on the digital display. You should achieve a word accuracy better than 95%. If the circuit continually confuses two training words, try retraining one of the words. To retrain a word, press the word number using the keypad; the word number will be displayed on the digital display. Press the "T" (training) key and say the word into the microphone. If the circuit still confuses the two words, you may have to change one of them.

Connection To The OWI Robotic Arm

Once the recognition kit has been trained and tested, it's time to connect it to the robotic arm. The interface is connected to the base of the robotic arm using the 3-inch ribbon cable (see photo on page 17). The entire system—robotic arm, interface, and speech-recognition circuit (rev 2)—is shown in the photo on page 17. **P**

TABLE 1

Word Number	Function	Word Suggestion
1	Grip	Close
2	Elbow Down	Down
3	Base CCW	Left
4	Shoulder Up	Raise
5	Wrist CCW	Count
6	Wrist CW	Turn
7	Shoulder Down	Fall
8	Base CW	Right
9	Elbow Up	E-Up
10	Grip Open	Release
11	Stop	Stop

WILLIAM SHEETS, K2MQJ, and RUDOLF F. GRAF, KA2CWL

Basic Op-Amps, Part 2

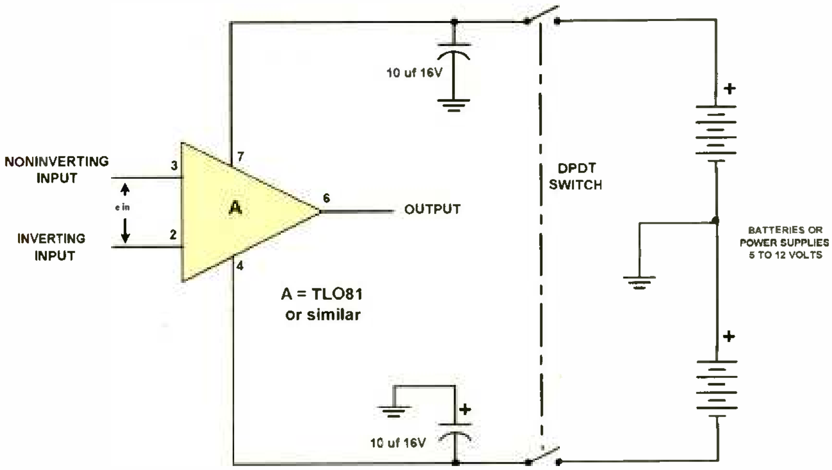


FIG 1
BASIC OP AMP BREADBOARD

The operational-amplifier (op-amp) is useful for a wide variety of applications. Last month, we discussed basic theory and a few elementary circuits. For further understanding of how op-amps, (or most anything else), work, some hands-on experience is essential. So let's get working.

We suggest that a simple breadboard circuit, as shown in Fig. 1, be constructed, as a basic functioning op-amp circuit for experimentation. An 8-pin DIP op-amp can be used, such as a 741 or TLO81, as only one amplifier section will be needed. The TLO81 is cheap and readily available, and it's a JFET type that is an excellent general-purpose amplifier for experimentation and hobby circuits. Of course, other types can be used if you have them handy, but JFET types are probably preferable since they allow the use of more reasonable component values (capacitors, especially).

Supply Voltages

The op-amp should be rated to work with the supply voltages you will use. Anything from 5 to 12 volts will be okay. You will need two supplies of equal voltage, one delivering a positive (plus) voltage and one delivering a negative (minus) voltage. Ideally a laboratory-type AC-powered adjustable DC supply delivering plus and minus voltages would be desirable. However, several AA batteries with two suitable battery holders, two 9-volt transistor radio batteries, or two 6-volt lantern batteries will work just as well.

AA-battery holders that hold four to eight AA cells are widely available, and two such holders can be used to make up a suitable supply. The batteries should last a very long time in this application. Dedicated "universal" experimenter breadboard setups are available (approx. $20 to $40) that feature connectors and sockets suitable for plugging in most components and jumpers to configure almost any circuit. These breadboard setups will prove to be time-savers and will eliminate much, if not all, soldering.

Some source of signal should be handy—a function generator, an audio oscillator, or even audio from a CD or tape player. Access to an oscilloscope is desirable, but not necessary.

A few op-amp circuits will be discussed. These circuits are for demonstration and teaching purposes to illustrate the principles of op-amps, and they are not claimed to be optimized for any specific application. There are refinements that can be added in some cases, but were omitted for simplicity. There are literally millions of op-amp circuits, and in a short column we cannot cover very much.

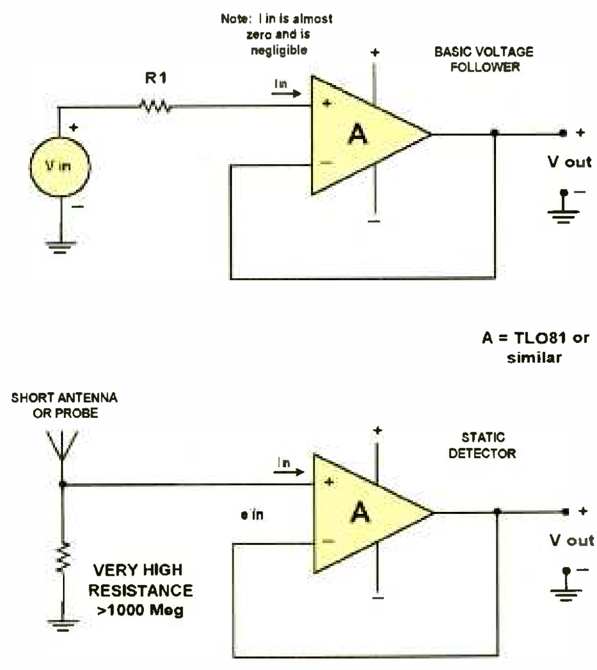


FIG 2
VOLTAGE FOLLOWER

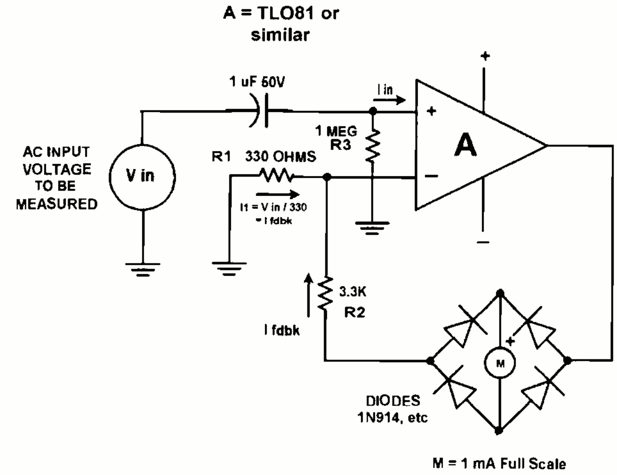


FIG 3
LINEAR AC VOLTMETER CIRCUIT

The reader is strongly advised to consult the literature and manufacturer's application notes. Several years ago National Semiconductor offered a publication titled "Linear Applications Handbook" (our copy is dated 1994), which is an excellent reference text, full of ideas and applications, using op-amps. The devices referenced in older literature may be out of production and no longer available, but the circuit principles and ideas are relatively timeless and can be applied to currently available devices.

The Voltage Follower

The circuit in Fig. 2 is s voltage follower. This unity-gain amplifier uses a TLO81 or similar JFET op-amp as a buffer and driver. A very high-impedance source (microphone, sample-and-hold circuit, transducer, etc.) can be interfaced to a lower impedance load with no loss in voltage. The gain here is all current gain. Since the feedback factor is unity, the output voltage will equal the input voltage minus e_{in} Since e_{in} is very small and the gain of the amplifier is high (10,000), the output voltage will equal the input voltage within 0.01 percent.

This circuit can be used as a simple, high-impedance meter amplifier. If a DVM is connected to the op-amp output and a single 1.5-volt AA cell is connected to the input through a 22-meg resistor (highest commonly available resistor value), the resistor will have practically no effect on the voltage reading of the battery. This demonstrates the high-input impedance—in

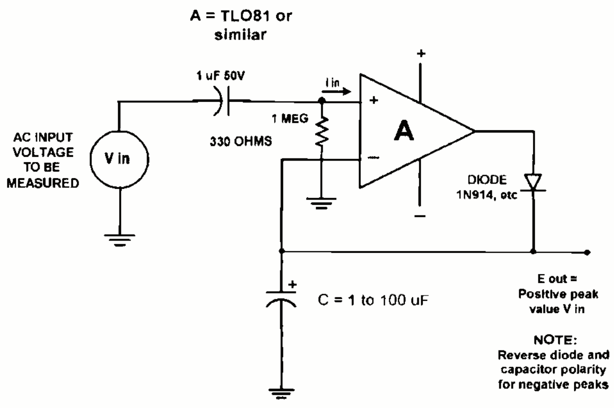


FIG 4
PEAK DETECTOR CIRCUIT

the thousands of megohms—available with this circuit. By using a voltage-divider network and appropriate switching, you can make a high-impedance voltmeter that will have input impedance of hundreds of megohms or more. By using CMOS type op-amps, you can construct a simple electrometer able to read currents as low as 1 trillionth of an ampere (or 1 picoampere, if you prefer).

If the input of the amplifier is connected to a short (3-inch) wire, a body charged with electricity (hard rubber comb rubbed on flannel, or a glass rod rubbed with silk, etc.) brought near this wire will produce a change in the op-amp output voltage. Now we have a static-charge detector circuit. However, practically, a high resistance should be connected between the noninverting input and ground to establish a stable operating point. This resistor could be several thousand megohms in practice.

Overcoming Diode Drops

Another useful circuit (Fig. 3) is an AC-voltmeter. The meter rectifier is in the feedback circuit, compensating for the diode forward drop. A conventional meter rectifier using a diode-bridge rectifier is compressed at the low end of the meter scale since small AC voltages may not overcome the diode forward voltage drop of 0.6 volt. This causes nonlinearity at the low end of the scale. When the bridge is placed in the feedback loop, the AC-signal current in the feedback loop

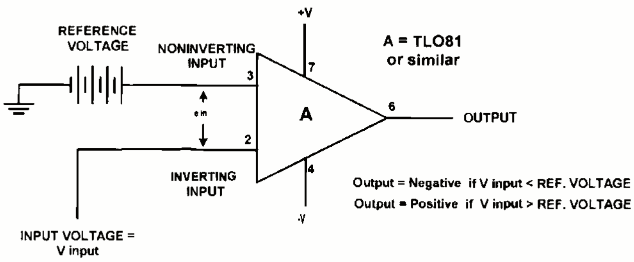


FIG 5
BASIC OP AMP COMPARATOR

must equal the input current through R1. This equilibrium forces the op-amp to produce sufficient voltage to overcome the 0.6-volt diode drop, irrespective of the input level. Therefore, the meter will read linearly. It is easy to make an AC voltmeter with a full-scale deflection of 100 millivolts or less with this circuit with a perfectly linear scale. This AC-voltmeter circuit works well and will be fairly accurate in the audio-frequency range and into the low-frequency RF range (100 kHz) or higher with fast diodes and a wideband op-amp.

A voltage follower can be used as a peak detector (Fig. 4) to give the peak voltage of a waveform. The signal is applied to the noninverting input as shown. Capacitor C1 will charge to the peak voltage of the input signal. Since the diode is in series with the amplifier output, it will compensate for the diode drop. The output voltage will equal the peak value of the input voltage.

Op-Amps Make Waves

Op-amps can also be used as comparators to compare two voltages. Figure 5 shows a typical circuit. The reference voltage is applied to the inverting input. Any voltage greater than this reference voltage will drive the op-amp output in a positive direction. Since the gain of the op-amp is several thou-

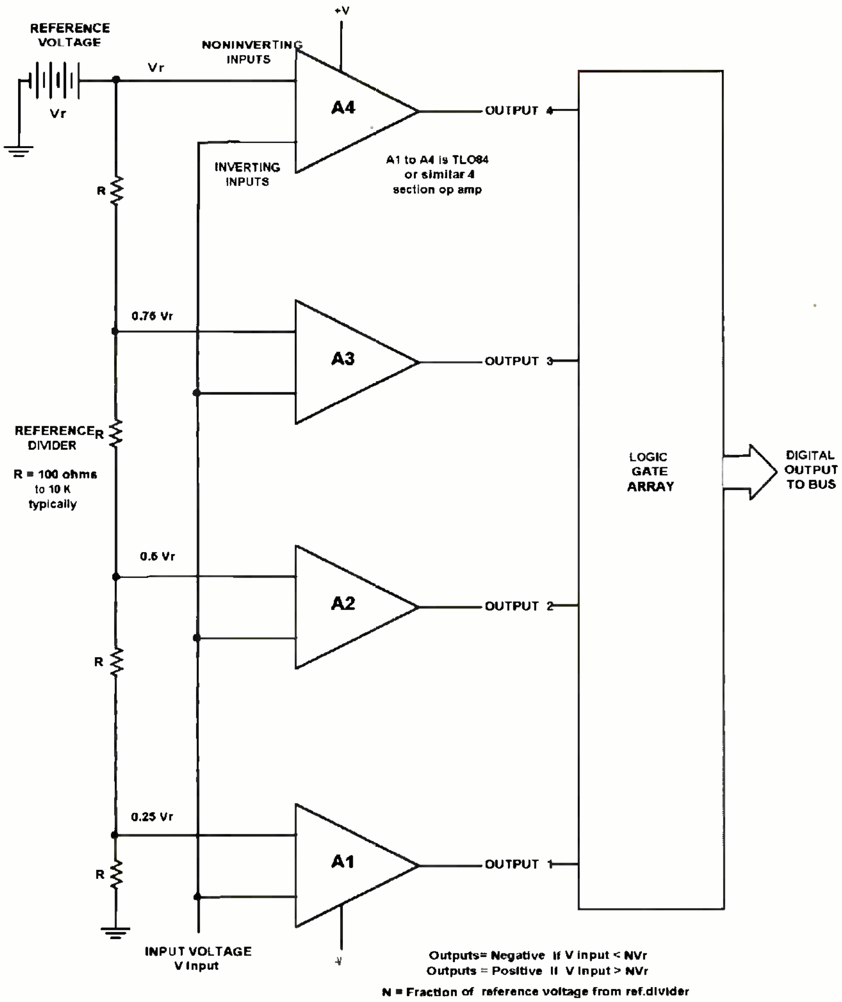


FIG 6
BASIC FLASH A-D CONVERTER

sand, this transition is very sharp. Voltages less than this amount will cause the output to go in a negative direction. Output can be fed to an LED indicator or logic circuit as an indicator or used to drive another circuit.

Several op-amps can be connected to a resistive divider and can have their inputs connected to a common input. (See Fig. 6). The outputs can be fed to a system of logic gates that will produce a binary pattern that is a function of how many comparators are ON or OFF. The output can be made to be a binary value representing the number of ON or OFF comparators. The idea is to make a "flash" *a*nalog to *d*igital (A-D) converter, since the output is an instantaneous function of input. The flash A-D converter is useful for digitizing fast waveforms and is widely used in digitization of video signals. By summing the comparator outputs, a staircase wave can be generated from a ramp-waveform input.

By using both positive and negative feedback, it is possible to make oscillators with different output waveforms. Figure 7 shows a square-wave oscillator. Capacitor C1 charges toward the positive supply rail through R1. After it reaches the reference voltage derived from R2 and R3, the comparator output goes low. This result also changes the reference voltage to a lower (more negative) level, which forces the comparator to a negative output.

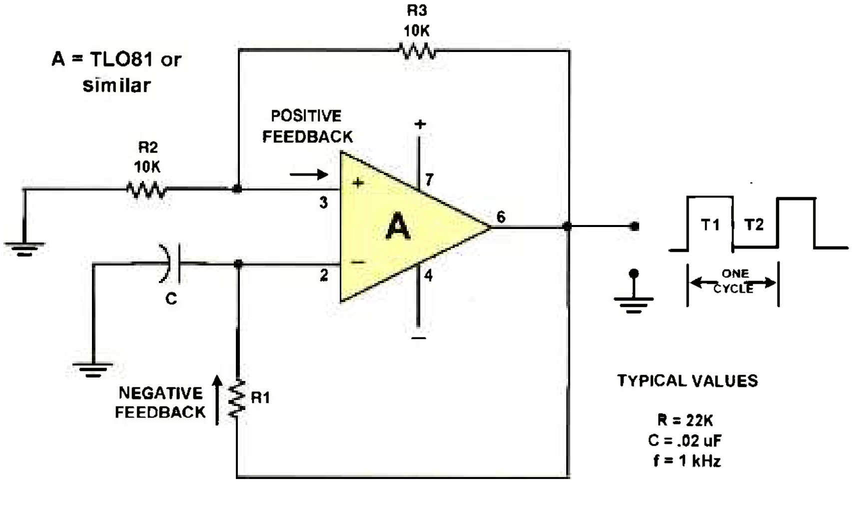
Now the capacitor discharges towards the negative supply rail. This sequence will continue until the voltage at the inverting input reaches the new reference voltage. At this point the comparator switches to high (positive) output. The cycle is repeated. A square-wave output results. By using diodes and two separate feedback resistors, you can make dissimilar charge and discharge paths, allowing two different time constants. This setup allows generation of a variable duty-cycle waveform. A potentiometer can be used along with, or in place of, R1 and R2 to adjust this duty cycle, as shown in Fig. 8.

Generating A Sine Wave

It is possible to generate a sine wave using a circuit known as a Wein Bridge. At a frequency $f = 1/(2\pi RC)$, the network shown in Fig. 9 will have a transfer function of 1/3 with zero phaseshift between input and output—permitting its use as a frequency-determining network. The Wein bridge is connected between the output and noninverting input as shown in Fig. 9, allowing positive feedback and oscillation.

However, the amplifier would generate a poor waveform, since limiting the output can only be accomplished by driving the amplifier to its positive and negative limits, resulting in severe clipping of any generated sine wave. Another feedback network is used to introduce negative feedback. A resistive divider with a division ratio of slightly more than 1/3 is used. This ratio reduces the gain to a little over 3, which is enough to sustain oscillation. Limiting would still be obtained by clipping in the output, although the waveform would be somewhat improved.

Using a voltage-dependent resistor for R4 allows automatic gain control. Resistor R4 is selected to have a resistance that increases with applied voltage. A thermistor can be used for this purpose, but a more common approach is to use an ordinary tungsten-filament lamp. This kind of lamp has the exact characteristic we need. As more voltage is applied across the lamp, the filament heats up, its resistance increases, and the negative feedback increases, and lowers the gain of the op-amp. This sequence tends to reduce the amplitude of oscillation to a level that will not drive the op-amp into limiting. Very pure sine waves can be generated in this manner, and less than 1 percent distortion is easy to achieve. By making R1 and R2 a ganged potentiometer, you can obtain variable frequency operation. This circuit was widely used in the vacuum-tube days, and a 120-volt, 3-watt tungsten lamp was used for R4. For an op-amp version, one of the 5-volt, 10 mA subminiature lamps will work well. The lamp is typically operated at 10 to 20 percent of rated voltage, and the filament should barely glow. Resistor R3 is a pot to adjust the amplitude of oscillation at that level that yields satisfactory operation.



FOR THIS CIRCUIT:

T1 = T2 = 1.1 RC APPROX
T1 + T2 = ONE CYCLE
F = 1 / 2.2 RC APPROX

FIG 7
SQUARE WAVE OSCILLATOR CIRCUIT

Creating A Tuned Amplifier

Finally, the use of both positive and negative feedback enables one to make a tuned amplifier having the desired given center frequency and bandwidth. A simple bandpass stage is shown in Fig. 10. We will not go into the design details except to present the design equations for one simple type of stage. Combining several of these stages allows one to derive a filter network of desired characteristics. These are called active filter networks. There are a number of circuit configurations, yielding low-pass, bandpass, and high-pass types of filters. Refer to a book on active filters for more detailed information. In addition, software programs are available from manufacturers that allow a PC to be used for the design of almost any active filter.

For the filter shown (suitable for bandpass audio use) with bandwidth B and center frequency f and gain A:

$$\omega = 2\pi f \quad Q = f/B \quad a = 1/Q \quad H = \alpha|A| \quad \text{and } Q > \sqrt{(A/2)}$$

$$R1 = 1 / (H \times \omega \times C1)$$

$$Req = 1/Q\ (C1 + C2)\omega$$

$$R2 = R1 \times Req / (R1 - Req)$$

$$R3 = A \times R1(1 + C1/C2)$$

In practice, suitable values are chosen for C1 and C2 (generally, they are equal) and the resistors calculated. At audio frequencies, a suitable range of values may be around .001 to 0. 1 µF. Note that the exact type of op-amp is not specified; an ideal op-amp is assumed. The TL081 comes close enough.

As an example, design a filter for 1 kHz with a bandwidth of 100 Hz. We will try to use capacitors of 0. 01 µf at C1 and C2. The filter should have a gain A of 10X (or 20 dB).

First check:

$$Q \text{ required} = f/B = 1000/100 = 10$$

$$a = 1 / Q = 0.1 \text{ and } H = 1$$

$$\omega = 2pf = 6.28 \times 1000 = 6280$$

Then check to see if $Q > \sqrt{A/2} \quad 10 > \sqrt{10/2} \quad \sqrt{10/2} = \sqrt{5} = 2.23$

Since 10 > 2.23, this condition is satisfied. Then:

$$R1 = 1 / (1)(6280)(10 \exp -8) = 15.9\ K\ (16K)$$

$$Req = 1/10\ (2 \times 10 \exp -8)6280 = 796\ \Omega\ (820\Omega)$$

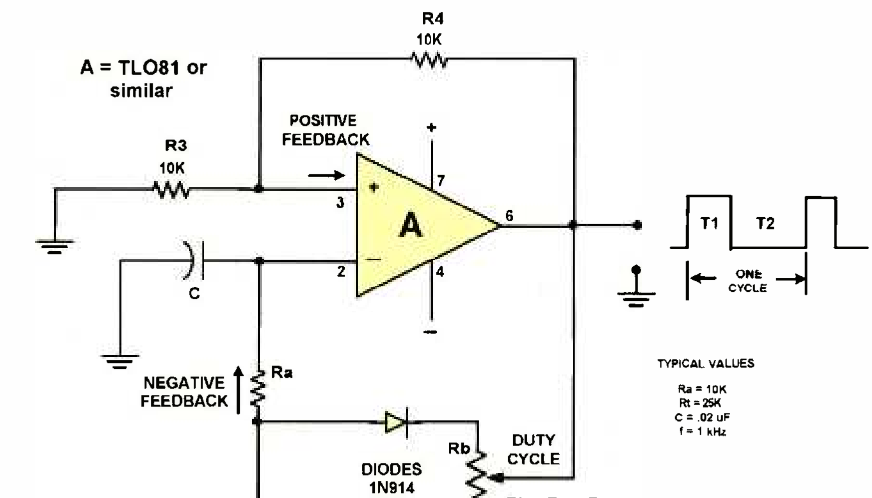
$$R2 = 15.9 \times 796 / 15.9 - 7.96 = 838\ \Omega\ (820\ \Omega)$$

$$R3 = 10 \times 15.9\ (2) = 318\ K\ (330\ K)$$

Values in parentheses are nearest standard 5% resistor values.

This circuit was built and tested, and results agreed with theory, as did a SPICE simulation. This circuit in itself is useful, as a 1-kHz tuned amplifier is useful for testing and in ham radio work as a CW filter. The design of this filter is rather simple, and the reader should try other frequencies and bandwidths as an exercise.

We have presented a number of circuits that should give a novice some



FOR THIS CIRCUIT

T1 = 1.1 (Ra + Rb) C APPROX
T2 = 1.1 (Ra + Rc) C APPROX
T1 + T2 = ONE CYCLE
T1 + T2 = 1 / (2.2 Ra + 1.1 Rt) C) APPROX

FIG 8
SQUARE WAVE OSCILLATOR CIRCUIT
VARIABLE DUTY CYCLE

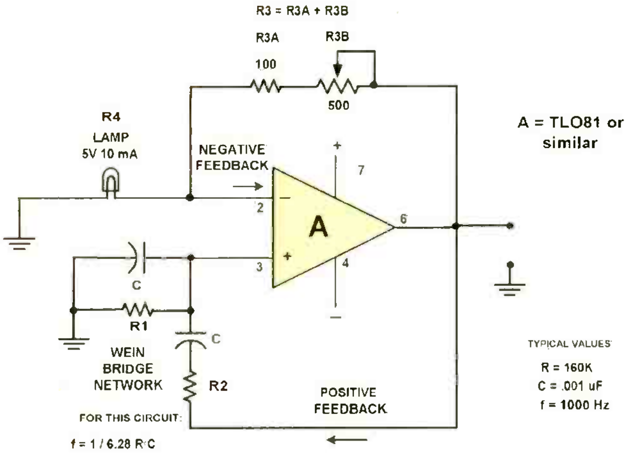
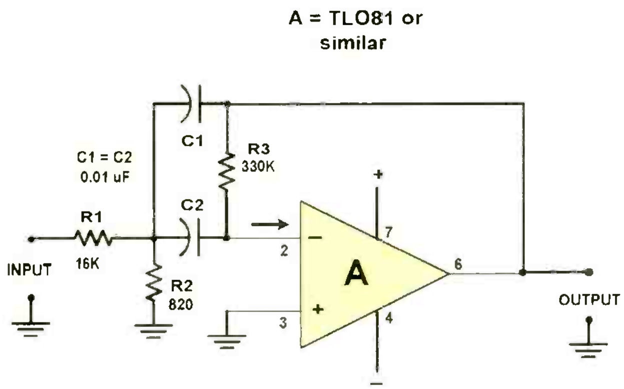


FIG 9
WIEN BRIDGE OSCILLATOR CIRCUIT
SINE WAVE OUTPUT



Values Shown for: Freq = 1000 Hz
Gain = 10X
BW = 100 Hz
Q = 10

FIG 10
BANDPASS ACTIVE FILTER

starting experience with op-amps. It would be a good idea to try some of these circuits and others that you can find, as well. There is no substitute for experience, and undoubtedly you will come up with some circuits of your own that can be tailored for your applications. P

Raymond Scott
A Pioneer of Electronic Music

MARIA ORLANDO

An electronics engineer with a creative spark, Robert Scott had the right combination of artistry and scientific ability. He was a composer with unique musical taste and a thirst for cutting-edge technology that at times made him seem eccentric. Genius is sometimes synonymous with crazy, but maybe only to those of us who aren't on that level.

Scott liked highly produced sounds and electronically sophisticated melodies. The quality and flexibility of the sound he envisioned was not available—he had to invent the technology to create the music he dreamed of.

Nearly all "serious" musicians of that era snubbed him, chastising his electronic music because it was so different and discouraged improvisation. He created music with machines instead of instrumentalists, and it's likely that many musicians felt they were left out. Practically all of his work was done while tucked away in a secluded laboratory and recording studio.

His name is not familiar to the public, though the majority of us have heard his tunes dozens of times in popular animations and various Hollywood productions. His contributions to the world of electronic music are only recently being discovered and appreciated. Many of his compositions are now being released with various artists recording and performing his music.

While his contributions to electronic music have been widely overlooked, a newfound interest in Raymond Scott has arisen in recent years.

A musician and a scientist ahead of his time, Scott invented the electronics he needed to get the sound he wanted.

A Born Musician. Raymond Scott was born Harry Warnow in 1908, in Brooklyn, NY, to Russian immigrants Sarah and Joseph Warnow. Joseph owned a music shop, where young Harry and older brother Mark spent much of their early years. Both showed signs of musical talent as tots—Mark picked up the violin, while two-year old Harry favored the piano. Harry, however, also demonstrated interest in the mechanics behind the music, as he kept busy tampering with the turntables while he played his records.

As the two brothers grew up, Mark took a musical career path, while younger Harry planned on pursuing his love for engineering. Mark, however, persuaded his younger brother to attend the Juilliard School of Music. Seeing his brother's musical potential, he told Harry that he would pay the Juilliard tuition. Harry accepted, and his musical career began.

After Harry graduated, the CBS Radio house band, conducted by his brother Mark, took him on as the staff pianist. To shield himself from accusations of nepotism, Harry changed his name—after flipping through the phone book, he decided on Raymond Scott.

Scott stayed at CBS for several years, temporarily ignoring his true calling. For the most part his creativity was stifled; but, on occasion, he did attempt to share his strange compositions with the orchestra, who were not overly enthused.

Scott wanted more, and he convinced CBS producer Herb Rosenthal to let him create his own ensemble—the "Raymond Scott Quintet."

At this point, his perfectionism and relentlessness affected everyone around him. A tyrant in the music studio, Scott expected only the finest from his singers and musicians. He wanted them to behave as mechanical robots would; he didn't like to be challenged or argued with. This trait proved to be a catalyst for his fervent work in technology in later years—machines were non-confrontational and could be managed more easily than people.

Scott was never good with people. His colleagues and friends soon distanced themselves from him. His personal life didn't fare too well, either—he married three times and was not very close to his four children.

The Man And The Music. Despite his difficult character, he did have a knack for creating unique

Raymond Scott in 1938, at work in his lab.

melodies and composing music that sold well. In the late 1930's Hollywood called on him to compose the music for numerous productions, including *Rebecca of Sunnybrook Farm*, *Happy Landing*, and *Nothing Sacred*.

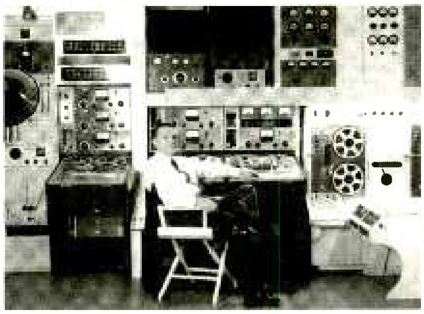
With the success of the Quintet, Scott's musical career soared. In 1938 he became music director for CBS. Warner Brothers bought his recordings, and used them in dozens of *Looney Tunes* and *Merrie Melodies* cartoons. He also composed jingles for radio and television, cut records, started his own record label, and much more. A list of some his more noted musical contributions can be found at the end of this article.

Scott with his 1950's keyboard synthesizer invention, the Clavivox.

His Passion For Technology. Despite his musical abilities, his roots were still in electronics and engineering. His science lab was disguised as a recording studio, and he regarded his music sessions more as experiments, testing his theories, and developing his inventions.

He immersed himself in his work, a common trait of most distinguished scientists and visionaries. He spent his time within walls that were covered with controls and switches. It was where he felt most at home.

Robert Moog, inventor of the Moog Synthesizer and one of Scott's few and closest friends, visited his home on Long Island for the first time in the 1950s. He described what he saw:



Electronics recording studio designed and built by Scott.

"It was a beautiful, big, four-story mansion.... First, he showed us the recording studio... a large room with a cutting lathe, and all sorts of monitoring and mixing equipment....amplifiers that drove the cutting head of the disc lathe were behind a screen....There was an elevator going from one floor to another....The entire downstairs of the house was a dream workshop...it consisted of several rooms....A large room with nothing in it but machine tools of the highest quality. ..It looked like heaven to me."

A Mastermind of Electronic Music. Scott discovered and mastered the circuitry concept for the "automatic sequential performance of musical pitches," commonly known as the sequencer. Robert Moog said that Scott had a brilliant intuition and that he was influenced by the future. "Scott was definitely in the forefront of developing electronic music technology... he had built a sequencer with relays, motors, steppers, and electronic circuits. I had never seen anything like it...He foresaw the use of sequencers and the use of electronic oscillators to make sounds."

His long line of inventions began in 1946, when he patented an electromechanical synthesizer called the Orchestra Machine. This machine featured a keyboard that could simulate the musical instruments in an orchestra, with multiple soundtrack units. Also in that year he founded the Manhattan

TAKING CREDIT

In an unaddressed letter written in the late 1970s, Scott wrote:

"It is not widely known who invented the circuitry concept for the automatic sequential performance of musical pitches—now well known as a sequencer.

I, however, do know who the inventor was—for it was I who first conceived and built the sequencer....I was so secretive about my development activities—perhaps neurotically so.... Now, with the passing of years, I guess I regret my secrecy and would like for people to know of what I accomplished."

THE MUSIC BEHIND THE MAN

Scott's music was featured on numerous television, radio, movie, and animated productions. For more information go to *www.raymondscott.com.*

Good Morning, America
Hard Copy
The David Letterman Show
Looney Tunes
Macy's Thanksgiving Day Parade
Merrie Melodies
Moonlighting
Morning Edition
MTV News
The Odd Couple
Saturday Night Live
The Simpsons
Spin Radio
The Howard Stern Show

Research Company, a science lab/recording studio where he would conduct research and work on his inventions.

In 1948, Scott invented an effects generator he called the "Karloff" that could imitate common household noises, as well as swishing, honking, beeping, etc. It could produce almost limitless variations of these sounds, giving it flexibility for musical composition.

One of his more remarkable inventions was the Clavivox, which he patented in 1956. This synthesizer "allowed a player to glide smoothly from one note to another without a break over a 3-octave keyboard." It also simulated many traditional instruments, had vibrato capability, and had many technologically advanced effects and features.

Impressed with his work, Motown Records contacted Scott in 1971, inviting him out to California. In 1972 Scott started directing Motown's electronic music research and development.

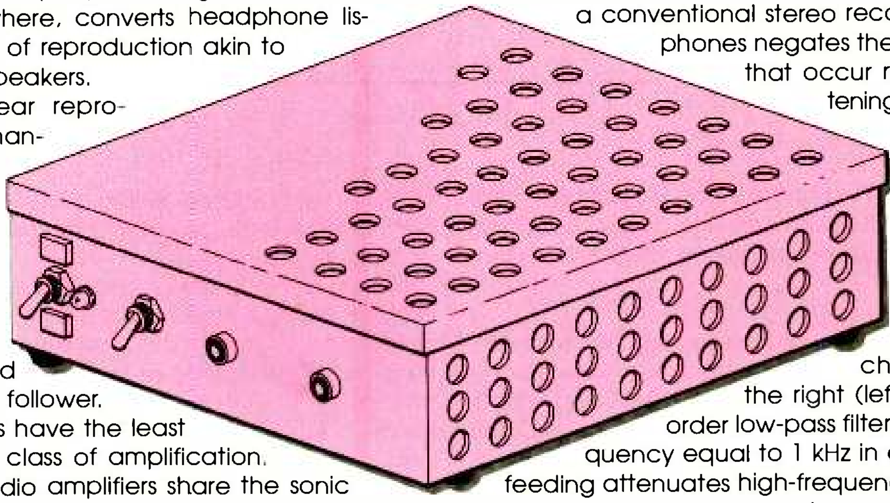
In 1987 Scott's health began to decline, and he suffered several crippling strokes. He died February 8, 1994, at the age of 85.

This article should serve as a tribute to the remarkable inventor who remained in the shadows of popular music for most of his life. A caption In a 1937 issue of *Billboard* magazine read: "Scott's music evolved as something more substantial than mere jazz. Its ultimate worth can only be judged by the future." P

HEADPHONE AMBIENCE PROCESSOR

PETER H. LEHMANN

The vast majority of stereo recordings are produced for reproduction by a pair of loudspeaker systems. Listening to these unaltered recordings with headphones is like trying to walk an elephant into a telephone booth. The result is a flat-type of reproduction with the performance apparently taking place on a virtual plank of a stage supported by your left and right ear lobes. My cross-feed processor, including some unique processing circuitry that you won't find elsewhere, converts headphone listening to a type of reproduction akin to listening to loudspeakers.



For crystal clear reproduction, each channel output stage of my processor is a power MOSFET (*metal oxide semiconductor field effect transistor*) configured as a single-ended Class A voltage follower. Class A amplifiers have the least distortion of any class of amplification. FET and tube audio amplifiers share the sonic characteristics of producing "warm" and "smooth" reproduction.

The cost of parts and materials for the *Headphone Ambience Processor* approaches, but does not exceed, $100. All of the PCBs and the power transformer fit comfortably in what is a rather large chassis compared to present day micro-miniaturization manufacturing practices. (See Photo 1.) The trade-offs to the cost and bulk of the project are excellent listening quality and no need to replace batteries. (The processor is powered by 115 VAC.)

Liven up your headphones with this audible delight!

Speakers Vs. Phones. With stereo loudspeakers, sound from each of the pair of speakers reaches both ears of the listener. The listener's head casts a sound shadow that attenuates the high frequency content of sounds that must travel around his/her head before reaching an ear in the shadow. Also, the listener can turn his/her head, thereby altering the pattern of reception of sounds. These effects are some of the ways the listener localizes the sounds as originating at the speakers.

For a stereo recording heard through headphones, reproduction of the left channel is heard at the left ear only and that of the right channel is heard at the right ear only. Head movement does not alter the relation of sounds heard at each ear. Therefore, listening to a conventional stereo recording with headphones negates the localization cues that occur naturally when listening to a pair of stereo loudspeakers.

This processor electronically mimics the sound shadow by cross-feeding a low-frequency band of the left (right) channel signal to the right (left) channel. A first order low-pass filter with a cut-off frequency equal to 1 kHz in each leg of cross-feeding attenuates high-frequency content.

To mimic head movement, processing of my unit includes an alternating increase of the cut-off frequency of low-pass filtering of one leg of cross-feeding at a time. This increase, alternating in the left and right cross-feeding channels, is randomly initiated electronically. Increasing the cut-off frequency of cross- feeding from the left (right) channel to the right (left) channel corresponds with head movement to the left (right) resulting in moving the right (left) ear out from the sound shadow to a greater extent.

The processor can only accidentally correspond to an actual change of position of the listener's head. For that reason, the increase factor of the cut-off frequency (equal to about 2 or an octave) was experimentally determined not to produce an apparently large disruption of the sound field of reproduction. This random increasing of the cut-off frequency gives presence to

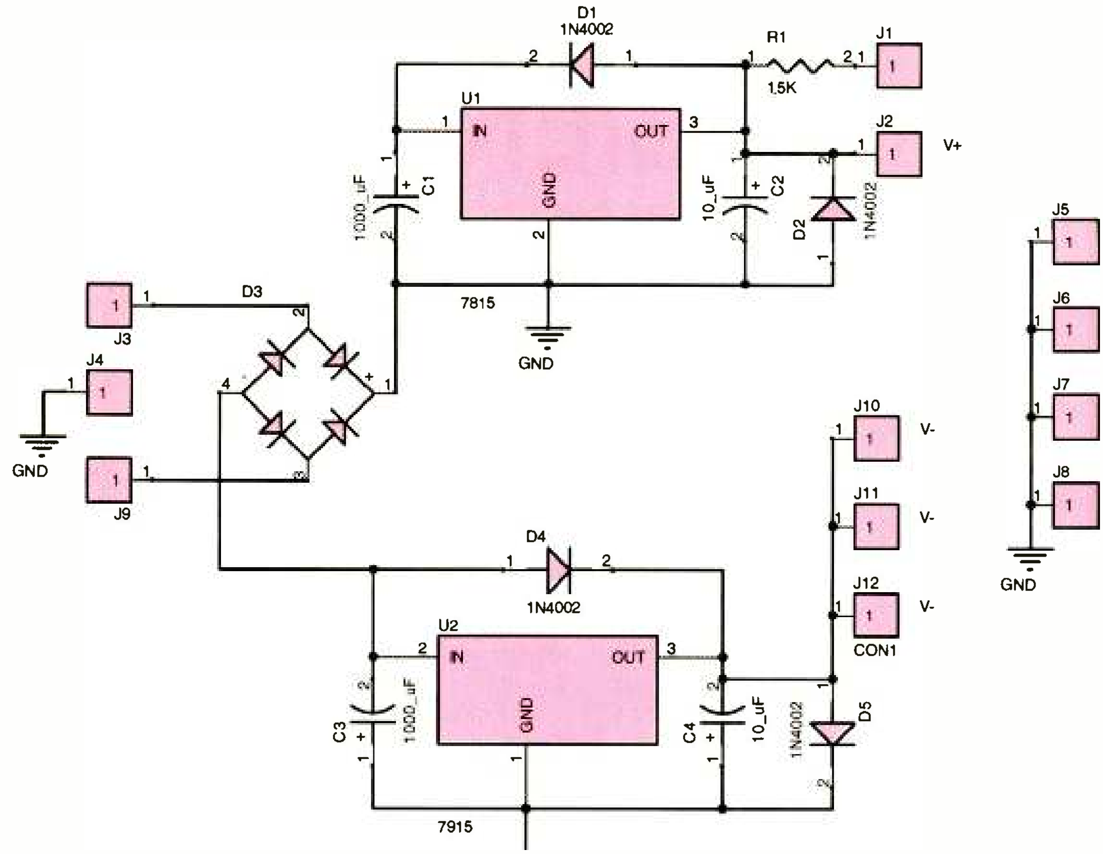


Fig. 1. Schematic diagram of the power supply.

sound reproduction via headphones in a similar manner as a motion picture film shot with a jittery handheld camera imparts a sense of presence at the scenes portrayed.

Circuitry Overview. The ambience processor is composed of three PCBs and some chassis-mounted components. The three PCBs are a power supply, a controlling board, and a signal-processing board. The schematic diagrams of these three boards are shown at Figs. 1, 2, and 3, respectively. In these diagrams, the square outline designated as a "J" component (jack) is a soldering pad for point-to-point wiring to another pad or to a terminal of a chassis-mounted component.

Jacks J3 and J9 of the power supply at Fig. 1 are connected to the secondary winding of a chassis-mounted power transformer. Jack J4 is connected to the center tap of the secondary winding of the transformer. With respect to the center tap of the secondary winding or ground, the power supply board produces a regulated –15 volts taken at jacks J10 and J11 for the controlling and signal-processing boards, respectively, and +15 volts taken at jack J2 for the signal-processing board only.

The controlling board of Fig. 2 randomly determines which of two legs of cross-feeding per stereo channel at any given time are mixed with the channel source signal. Both U1A and B are 555 timers configured as astable multivibrators, while U2A and B are NAND gates configured for signal inversion and ICs U3 and U4 are bilateral switches performing a logic function. The four controlling signals generated by the board are taken at jacks J3–J6.

Shown at Fig. 3, the schematic diagram of the signal-processing board includes U1A and C configured as low-pass filters with a cut-off frequency of 1 kHz and U1 B and D configured as low-pass filters with a cut-off frequency of 1.9 kHz. ICs U2 and U3 and power MOSFETs Q5 and Q6 are configured as audio mixers and channel-output stages for connection to a pair of

PARTS LIST FOR THE POWER SUPPLY (FIG. 1)

SEMICONDUCTORS

D1, D2, D4, D5—1N4002 1-amp, 100-volt
D3—Full-wave bridge rectifier, 2-amp, 100PIV
U1—7815 +15 volt, 1.5-amp, voltage regulator
U2—7915 -15-volt, 1.5-amp, voltage regulator

RESISTORS

R1—1500-ohm, ¼-watt, 5% metal film

CAPACITORS

C1, C3—Radial 1000-µF, 50-volt, polarized electrolytic, 20%
C2, C4—Radial 10-µF, 50-volt, polarized electrolytic, 20%

ADDITIONAL PARTS AND MATERIAL

Two heat sinks, (Mouser Stock No. 532-551002B00), four A1 hex standoffs, ¼ × .375 (Mouser Stock No. 534-2202)

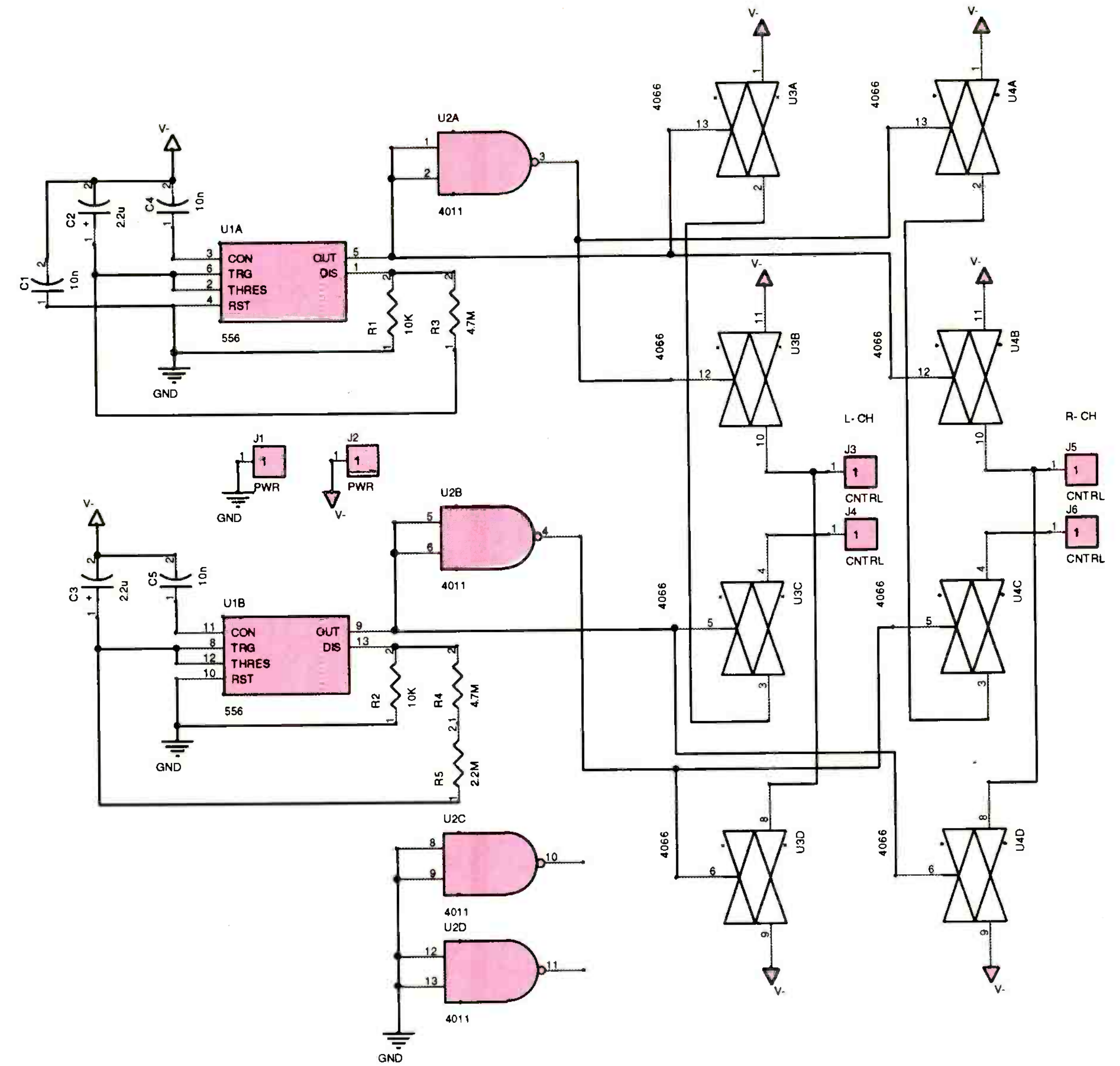


Fig. 2. Schematic diagram of the controlling circuitry.

PARTS LIST FOR THE CONTROLLING CIRCUITRY (FIG. 2)

SEMICONDUCTORS
U1—TS556CN dual CMOS timer
U2—4011 Quad 2-input NAND gate
U3, U4—4066 Quad bilateral switch

RESISTORS
(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2—10,000-ohm
R3, R4—4.7-megohm
R5—2.2-megohm

CAPACITORS
C1, C4, C5—10-nF polyester film 50-volt, 10%
C2, C3—2.2-μF axial polarized electrolytic

ADDITIONAL PARTS AND MATERIAL
Four of 14 pin DIP socket, four of hex A1 standoffs, ¼ × .375 (Mouser Stock No. 534-2202)

headphones, respectively.

Power Supply. Returning to the drawing of the power supply shown at Fig. 1, recall that jacks J3 and J9 are connected to the end terminations of the secondary winding of the power transformer (not shown). Full-wave bridge rectifier D3 converts the AC voltage of the secondary winding to pulsating DC with a frequency of 120 Hz taken at its output terminations 1 and 4. Where current drawn from the secondary winding is equal to the rated current of 1.5 amps, the peak voltage occurring across terminations 1 and 4 equals 35 volts—the rated voltage of the secondary winding—times 1.414 equals 50 volts. The absolute value of the peak voltages taken at terminations 1 and 4 of rectifier D3, with respect to the center tap of the secondary winding or ground, equals 25 volts. Including smoothing of the input voltages to regulators U1 and

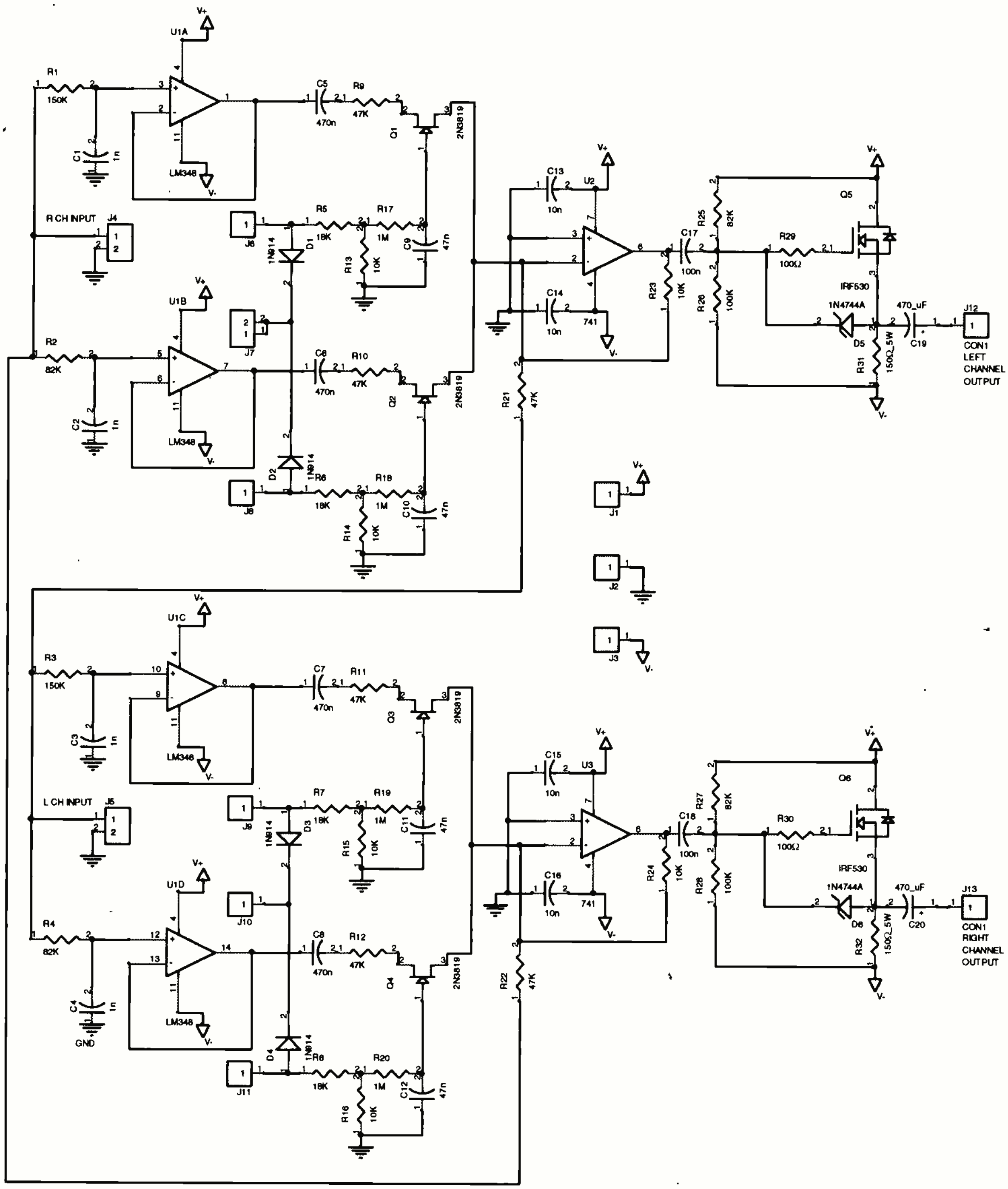


Fig. 3. Schematic diagram of the signal-processing circuitry.

PARTS LIST FOR THE SIGNAL-PROCESSING CIRCUITRY (FIG. 3)

SEMICONDUCTORS
D1–D4—1N914 silicon signal
D5, D6—1N4744A Zener, 15-volt, 1-watt
Q1–Q4—2N3819N-channel JFET
Q5, Q6—IRF530N-channel MOSFET
U1—LM348N DIP-14 Quad bipolar op-amp
U2, U3—LM741CN DIP-8 single bipolar op-amp

RESISTORS
(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R3—150,000-ohm
R2, R4, R25, R27—82,000-ohm
R5–R8—18,000-ohm
R9–R12, R21, R22—47,000-ohm
R13–R16, R23, R24—10,000-ohm
R17–R20—1-megohm
R26, R28—100,000-ohm
R29, R30—100-ohm
R31, R32—150-ohm, 5-watt Cement Power

CAPACITORS
C1–C4—1-nF, 50-volt polyester film, 10%
C5–C8—470-nF, 50-volt polyester film, 10%
C9–C12—47-nF, 50-volt polyester film, 10%
C13–C16—10-nF, 50-volt polyester film, 10%
C17, C18—100-nF, 50-volt polyester film, 10%
C19, C20—470-nF axial polarized electrolytic, 50-volt

ADDITIONAL PARTS AND MATERIAL
Two of heat sinks, (Mouser Electronics Stock No. 532-551002B00), Four of hex A1 standoffs, ¼ × .375 (Mouser Electronics Stock No. 534-2202), one 14-pin DIP socket, two 8-pin DIP sockets

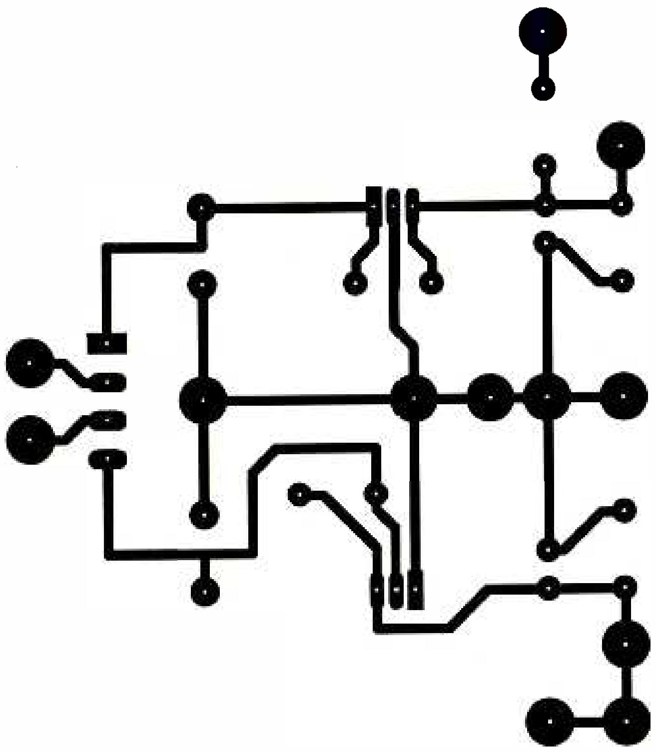


Fig. 4. Full-sized foil pattern of the PCB for the power supply shown from component side of board.

U2 by capacitors C1 and C2, headroom of 3 volts or greater occurs for both regulators for current consumption by the power supply and connected components of 1.5 amps or less.

Diodes D1 and D4 protect regulators U1 and U2 from the inadvertent state where the absolute value of the input voltage to the regulator is less than the absolute value of the output voltage. Such a state without a protective diode in place will destroy the regulator IC. For example, if capacitor C1 were to be shorted, then input terminal 1 of regulator U1 is placed at ground. Capacitor C2 maintains the voltage at the output terminal of regulator U1, terminal 3, at about +15 volts. Under these conditions, the anode of diode D1 is positive with respect to its cathode, and the diode safely shunts current around regulator IC U1.

Diodes D2 and D5 are included for protection of the devices connected to the power supply. If the polarities of the out-terminations of regulators U1 and U2 were to accidentally reverse polarity with respect to ground, then diodes D2 and D5 reduce the absolute value of those reverse polarities to 0.6-volt-protecting circuitry connected to the power supply. Capacitors C2 and C4 of the same figure, connected from the out-termination 3 of regulators U1 and U2 to ground, greatly improve AC ripple voltage rejection. Resistor R1, shown connected between the out-termination 3 of regulator U1 and jack J1, limits current to an indicator LED (not shown) connected across jack J1 and ground.

Controlling Board. The power-supply voltages of the controlling board shown at Fig. 2 are V- and ground for the purpose that will become clear later when the joint operation of the controlling and signal-processing boards (Fig. 3) is discussed.

ICs U1A and B are CMOS 555- type timers in a 14-pin package. As ground is positive with respect to V-, V_{CC} equals ground for U1. Not shown at Fig. 2, pins 7 and 14 of U1 are connected to V- and ground, respectively. Timers A and B of U1 are configured as independently free-running multivibrators or square-wave generators.

The period of oscillation of timer A of U1 equals 0.695 times the summation of the value of resistance of R1 plus twice the value of resistance of R3 times the value of capacitance of C2 equals 14 seconds. The period of oscillation of timer B of U1 equals 0.695 times the summation of the value of resistance of R2 plus twice the values of resistance of R4 and R5 times the value of capacitance of C3 equals 21 seconds.

Given that timers A and B of U1 operate independently at somewhat different periods of oscillation, the state of the output terminal pin 5 with respect to that of output terminal pin 9 can be considered to be a random relationship or repetitive after a long time interval. Capacitor C1, connected from ground at pin 4 of U1 to V-, functions to

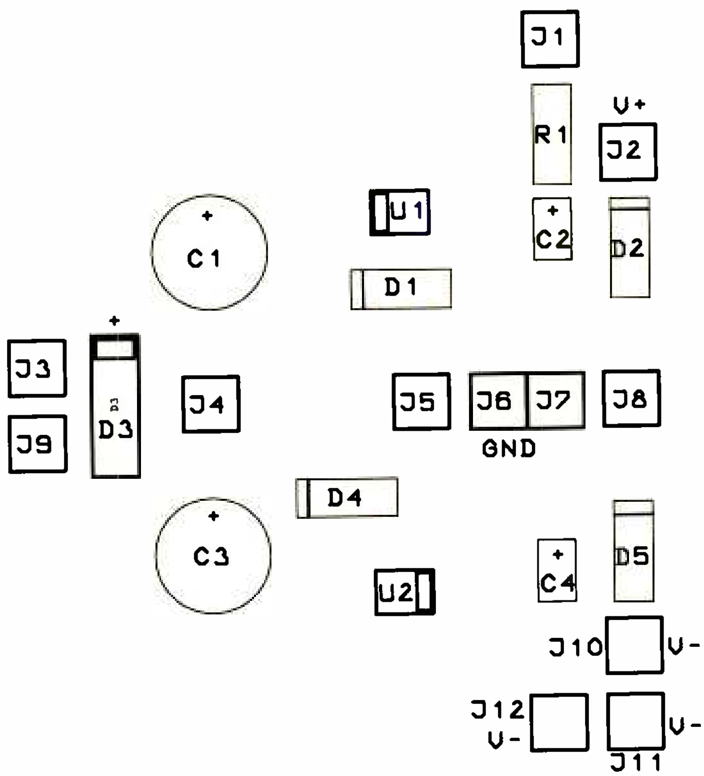


Fig. 5. Parts placement on power-supply PCB.

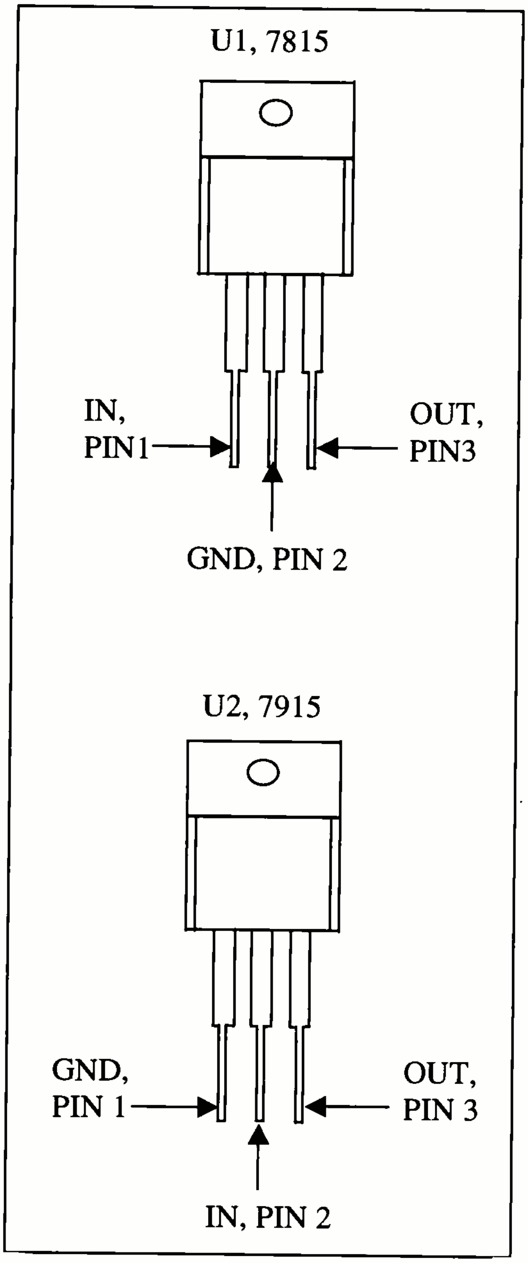


Fig. 6. Pin-outs of the voltage regulator ICs of the power supply.

bypass signals from the power-supply line for isolation of the operation of timers A and B.

IC U2 is a 4011 Quad NAND gate. Not shown at Fig. 2, V_{SS} connected to pin 7 of U2 is the V- voltage, and V_{DD} connected to pin 14 of U2 is ground. A NAND gate functions according to its truth table such that if both of its inputs are high, then its output is low and vice versa. So applying an input voltage to both input terminals of a NAND gate causes the voltage taken at the output terminal of that gate to be the inverse of the applied voltage. Gates A and B of U2 function as inverters of the output states of the two multivibrators. Note that pins 1 and 2 of gate A of U2 are connected to out-pin 5 of timer A of U1, and pins 5 and 6 of gate B of U2 are connected to out-pin 9 of timer B of U1. Gates C and D of U2 are not used, so output pins 10 and 11 are open; and input pins 8, 9, 12, and 13 are tied to ground since they are located next to pin14 of the same IC, also connected to ground.

ICs U3 and U4 are type 4066 Quad bilateral switches in a 14-pin package. Not shown are the power connections to U3 and U4, V_{SS} at pin 7 connected to V-, and V_{DD} at pin 14 connected to ground.

First and second pairs of switches of U3 and U4 in Fig. 2 are connected, respectively, in series and in parallel between an output jack, J3–J6, and V-. Switches A and C of U3 are connected in series between jack J4 and V-. Switches A and C of U4 are connected in series between jack J6 and V-. Switches B and D of U3 are connected in parallel between jack J3 and V-. Switches B and D of U4 are connected in parallel between jack J5 and V-. Control terminals of U3 and U4 are connected to either pin 5 or 9 of U1 or pin 3 or 4 of U2.

For example, series connecting of switches A and C of U3 is as follows. A first termination of switch A, pin 1, is connected to V-. The second termination of switch A, pin 2, is connected to a first termination of switch C, pin 3. The second termination of switch C, pin 4, is connected to jack J4. The control terminal corresponding to switch A, pin 13, is connected to pin 5 of IC U1. The control terminal corresponding to switch C, pin 5, is connected to pin 9 of IC U1.The presence or absence of V- at jacks J3 and J4 controls cross-feeding of the right-channel signal to the left-channel output, and at jacks J5 and J6 it controls cross-feeding of the left-channel signal to the right-channel output.

Signal-Processing Board. Processing for the left-channel output is described here. Processing for the right-channel output has the identical elements of the left channel and complementary controlling voltages and signals. (See Fig. 3.)

Left-channel processing includes two legs of passive low-pass filtering of the right-channel input signal. A first leg is the connection of the first pad of jack J4 to a first termination of resistor R1 and the connection of the second termination of resistor R1 to a first termination of capacitor C1, the second termination of C1 being connected to ground. The filtered output voltage is taken at the junction of R1 and C1, which is connected to the non-inverting input terminal of op-amp U1A. The second leg of filtering is composed of jack J4, resistor R2, capacitor C2, and op-amp U1B, configured in the identical way as the first leg. The cut-off frequency of the first leg equals the inverse of the product of 2pi times R1 times C1, or 1 kHz. The cut-off frequency of the second leg, calculated in the same manner as that of the first leg, equals 1.9 kHz.

Op-amps U1A and B buffer the outputs of the filters for connection to the following circuitry.

Audio mixing of the frequency-filtered right-channel signal and the unfiltered left-channel signal is accomplished by op-amp U2, configured as an inverting amplifier. A first input leg is the connection of the inverting input terminal of op-amp U2, pin 2, to the drain termination of JFET Q1. The source termination of JFET Q1 is connected to a first termination of input resistor R9. The second termination of resistor R9 is con-

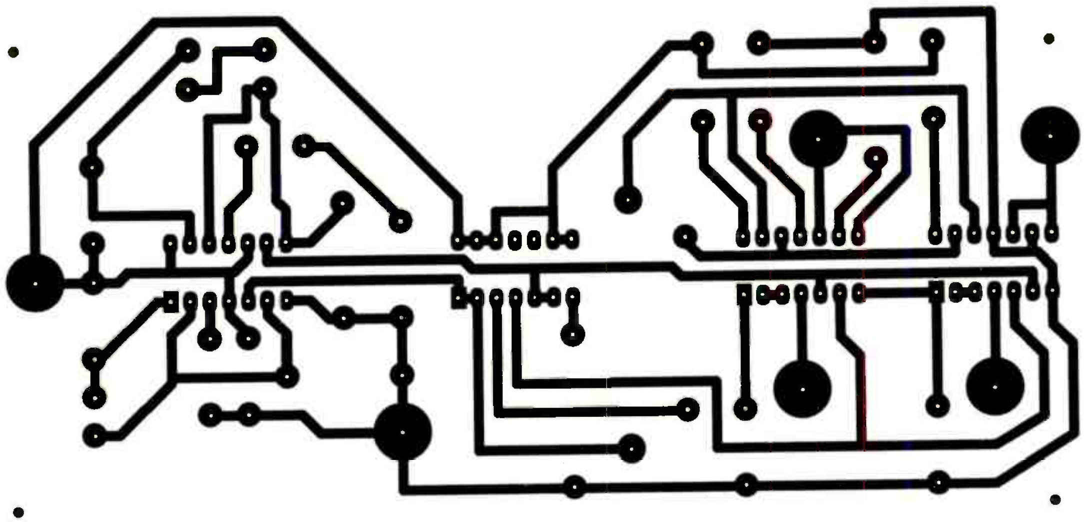


Fig. 7. Full-sized foil pattern of the PCB for the controlling circuitry shown from component side of board.

nected to a first termination of AC coupling capacitor C5, the second termination of which connects to output pin 1 of buffering op-amp U1A. A second input leg is JFET Q2, resistor R10, and capacitor C6 connected from the inverting input terminal of op-amp U2 to the output pin 7 of buffering op-amp U1B in the same manner as the first leg. A third input leg is resistor R21 connected between pad 1 of jack J5 and the inverting input terminal, pin 2, of op-amp U2.

Switching of the two frequency-filtered right-channel signals, simultaneously one in and one out, is effected by rendering the channels of the JFET's Q1 and Q2 conductive and non-conductive, respectively, or vice versa. If no connection is made to jacks J6 and J7, then any charge on capacitor C9 connected between ground and the gate of JFET Q1 is discharged to ground by resistors R17 and R13. As a result, the gate of the depletion-type JFET, Q1, finishes at ground potential, and the channel of Q1 is conductive. If either jack J6 or J7 is connected to V- or negative15 volts, then, due to voltage division by the series connection of resistors R5 and R13 between jack J6 and ground, the voltage taken at the junction of resistors R5, R13, and R17 equals about negative 5.4 volts. Capacitor C9 charges to that voltage. When the voltage taken at the gate of JFET Q1 is less than negative 4 volts, then the channel of Q1 is rendered non-conductive. The voltage divider consisting of series-connected resistors R5 and R13 reduces switching noise by JFET Q1 since the rate of charging of capacitor C9 when it approaches negative 4 volts is much slower than if it were charging to negative 15 volts.

The channel of JFET Q2 is rendered conductive or non-conductive in the same manner as JFET Q1.

With jack J7 disconnected from V-, signal diodes D1 and D2 isolate V- taken at one of the two jacks J6 or J8 from rendering the channels of both JFETs Q1 and Q2 non-conductive. If jack J7 is manually connected to V-, then the channels of both JFETs Q1 and Q2 are rendered non-conductive defeating cross-feeding.

The value of resistance of input resistors R9, R10, and R21 equals 47,000 ohms. The value of resistance of the

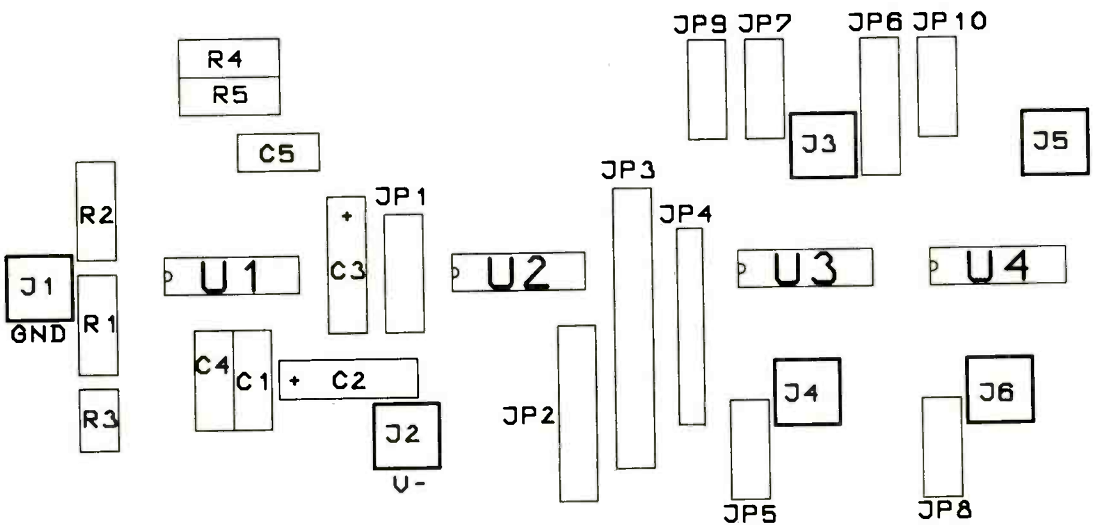


Fig. 8. Parts placement on the PCB for the controlling circuitry.

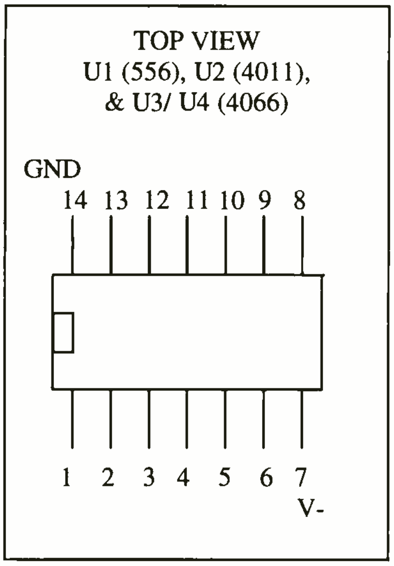


Fig. 9. Pin-outs and power-supply connections to the IC pins of the controlling circuitry.

channels of JFETs Q1 and Q2 rendered fully conductive with respect to that value of resistance is negligible. The value of the feedback resistor connected between pins 6 and 2 of op-amp U2, R23, is 10,000 ohms. ACL of the inverting amplifier U2 therefore is equal to 0.2. Audio mixer U2 was configured with this value of ACL for the purpose of allowing for an adequate number of degrees of rotation of the volume control of an integrated amplifier. This rotation corresponds to low volume to the maximum listening level when the stereo source signals are taken at the speaker terminals of the amplifier.

Finally, capacitor C17 and resistor R29 connected in series connect output pin 6 of op-amp U2 to the gate of the N-channel MOSFET Q5 configured as a source follower. FET Q5 matches the high impedance of the preceding signal-processing circuitry to the low impedance of the left phone connected between ground and jack J12. Capacitor C17 provides AC coupling, and resistor R29 stabilizes FET Q5. The voltage divider bias stick consisting of the series connection of resistors R25 and R26 from V+ to V- biases the gate of FET Q5 at about +16.5 volts with respect to V-. As a result, with respect to ground, the quiescent source voltage equals about –2 volts so that output-coupling capacitor C19 can be polarized. V_Z of Zener diode D5 equals 15 volts and protects the gate of FET Q5 from voltage transients greater than V_{GS} max, which equals ±20 volts. The resistance value of R31 causes bias current to be equal to about 90 mA for linear Class A operation of FET Q5. The value of capacitance of C19 limits the minimum impedance of the headphones connected to the processor to about 32 ohms. If headphones with a nominal impedance lower than 32 ohms are to be used with the processor, then the value of capacitance of C19 must be proportionately increased so as not to limit bass response.

Electronically Shifted F_C. Table 1B shows the interconnection of jacks J3–J6 of the controlling circuitry of Fig. 2 to jacks J6, J8, J9, and J11 of the signal-processing circuitry of Fig. 3. These connections produce an automatic and random shifting of the cut-off frequencies of channel cross-feeding. The logic of this automatic shifting is tabulated at Table 2. Note that a precondition of the tabulation of Table 2 is disabling of the connection of jacks J7 and J10 of Fig. 3 to V- with a toggle switch not shown at Fig. 3.

In Fig. 2, where the voltages taken at pins 5 and 9 of U1 are both at ground, the connection from jack J3 to V- is open as the control terminals of switches U3B and D are connected to the output terminals of inverters U2A and B, respectively. Jack J4 is connected to V- as the control terminals of switches U3A and C are connected respectively to pins 5 and 9 of U1. Like jack J3, jack J5 is parallel connected to V- but oppositely controlled, so jack J5 is connected to V-. Like jack J4, jack J6 is series connected to V- but oppositely controlled, so jack J6 is disconnected from V-.

The state of switching of the left-channel processing of Fig. 3 corresponding to the state of the controlling circuitry of the above paragraph is as follows. The open connection from V- to jack J3 of Fig. 2, which is connected to jack J8, means that the voltage taken at jack J8 is at ground because of the connection of resistor R14 to ground. This causes capacitor C10 to be discharged to ground and the channel of JFET Q2 is made conductive. Jack J4 of Fig. 2 not isolated from V- and connected to jack J6 causes capacitor C9 to be charged to V- and the channel of JFET Q1 is made non-conductive. Therefore, the upper leg of low-pass filtering with a cut-off frequency

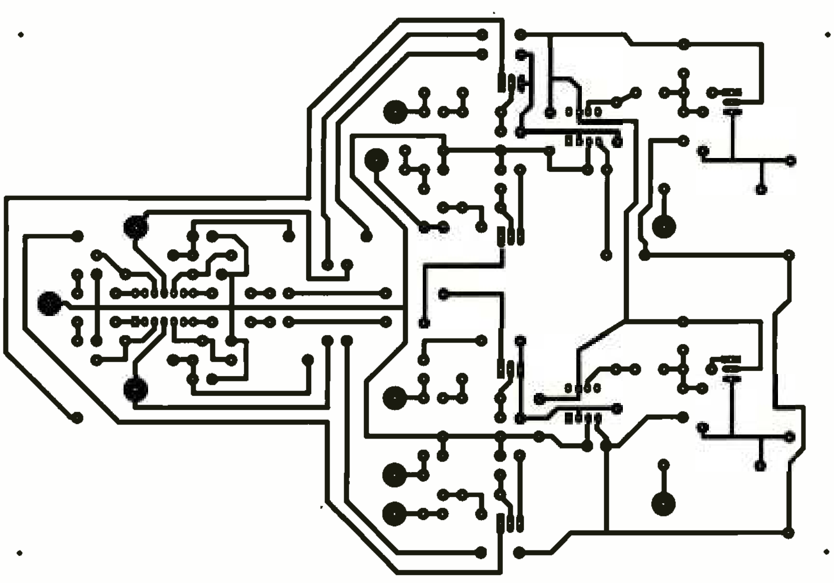


Fig. 10. Fifty-percent-sized foil pattern of PCB for the signal-processing circuitry shown from the component side of board.

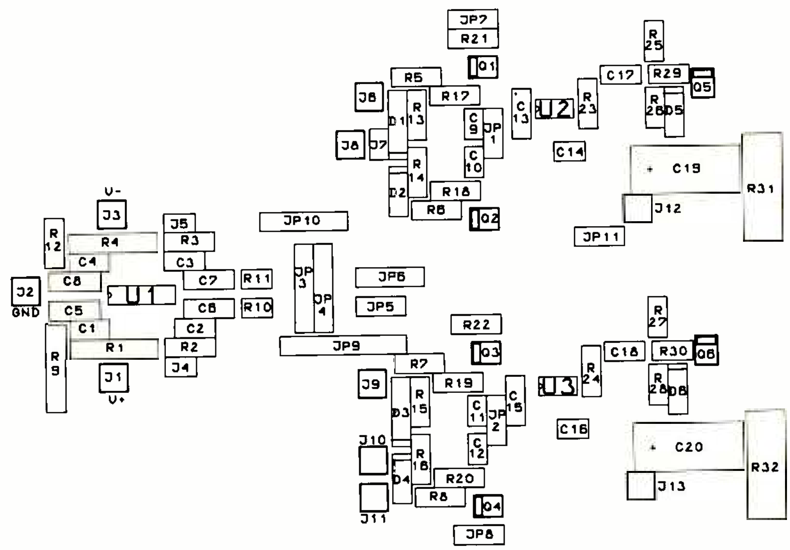


Fig. 11. Parts placement on the PCB of the signal-processing circuitry.

equal to 1 kHz is disconnected from input to op-amp U2 and associated components configured as an audio mixer, while the lower leg of low-pass filtering with a cut-off frequency of 1.9 kHz is connected from the same. Shown at Table 2, the value of F_C of low-pass filtering of the right-channel source signal (XR-CH) mixed with the unfiltered left-channel source signal equals 1.9 kHz.

Continuing to consider the voltages taken at pins 5 and 9 of U1 of Fig. 2 to be both at ground, the state of switching of the right-channel processing of Fig. 3 follows. Jack J5 of Fig. 2, not isolated from V- and connected to jack J11, causes capacitor C12 to charge to V-, making the channel of JFET Q4 non-conductive. The open connection from V- to jack J6 of Fig. 2 connected to jack J9 means that the voltage taken at jack J9 is at ground because of the connection of resistor R15 to ground. This in turn causes capacitor C11 to be discharged to ground, and the channel of JFET Q3 is made conductive. The result is that the upper leg of low-pass filtering with a cut-off frequency equal to 1 kHz is connected to the input of op-amp U3 and associated components configured as an audio mixer, while the lower leg of low-pass filtering with a cut-off frequency equal to 1.9 kHz is disconnected from the same. That is, at Table 2, the value of F_C of low-pass filtering of the left-channel source signal (XL-CH) mixed with the unfiltered right-channel source signal equals 1 kHz.

The remainder of the values of Table 2 can be understood by repeating the method of analysis taken above. If the voltage taken at jack J11 of Fig. 3 is considered to be the output state and the voltages taken at pins 5 and 9 of U1 of Fig. 2 are considered to be the input states, then this circuitry functions according to the logic of a NOR gate. Jack J8, which is parallel-connected to V- in the same manner as jack J11, also functions according to the logic of a NOR gate with respect to the voltages taken at pins 3 and 4 of inverters U2A and U2B. Jacks J6 and J9 of Fig. 3 are each separately connected to V- by a pair of switches in series circuit. The resulting logic of the voltages taken at these jacks with respect to the corresponding switch-controlling voltages is therefore that of a NAND gate.

Shown at Table 2, on the average, half of the time the cut-off frequencies of cross-feeding are equal while for the remainder of the time the cut-off frequency of cross-feeding is alternately higher in one channel of cross-feeding than that of the other. This scheme of cross-feeding simulates a listener facing directly forward towards a musical performance half of the time and turning slightly to the left or right for the remainder of the time. The cut-off frequency of cross-feeding of the right-channel source signal by my processor increasing to 1.9 kHz while that of the other leg of cross-feeding remains at 1 kHz simulates the listener shifting his head to the right. Shifting of the listener's head to the left is simulated by my processor by the cut-off frequency of the left-channel source signal increasing to 1.9 kHz while that of the other leg of cross-feeding remains at 1 kHz.

Building It. Information for contacting the recommended suppliers appears as a side bar. If a RadioShack is located near you, then that would also be a possible source. All of the required parts and supplies for this project are commonly available from many other sources.

The circuitry of each of Figs. 1–3 is constructed on a separate PCB allowing you to easily test the correct functioning of sections of the processor before final assembly. If you can construct PCBs of good quality, then you have won half the battle of building my processor.

The use of sockets for the ICs is recommended as this allows you to easily check for solder bridges with an ohmmeter, avoid heat damage, check for the presence of power-supply voltages, and easily replace the IC if damaged.

Construction. The PCBs of my processor were etched from pre-sensitized (pre-coated), positive acting board stock of 1/16-inch glass epoxy (FR-4) with one ounce of copper cladding on one side. The three required PCBs of this project are of standard size with the exception of the board for the power supply measuring one inch shorter lengthwise than standard size. The boards of the power supply, controlling circuitry, and signal-processing circuitry measure, respectively, 4 × 5 inches, 3 × 6 inches, and 6 × 9 inches.

The trace patterns of foil from the component-side of each board (X-ray view) are shown at Figs. 4, 7, and 10. Printing these trace patterns from a computer file to my laser printer on a sheet of transparent laser film, I found that the opacity of the traces and pads was not adequate. Exposing the etch-resistant coating of the PCBs for an adequate period of time to allow removing of the etch-resistant coating in the exposed areas resulted in a weak resistance to etching of the

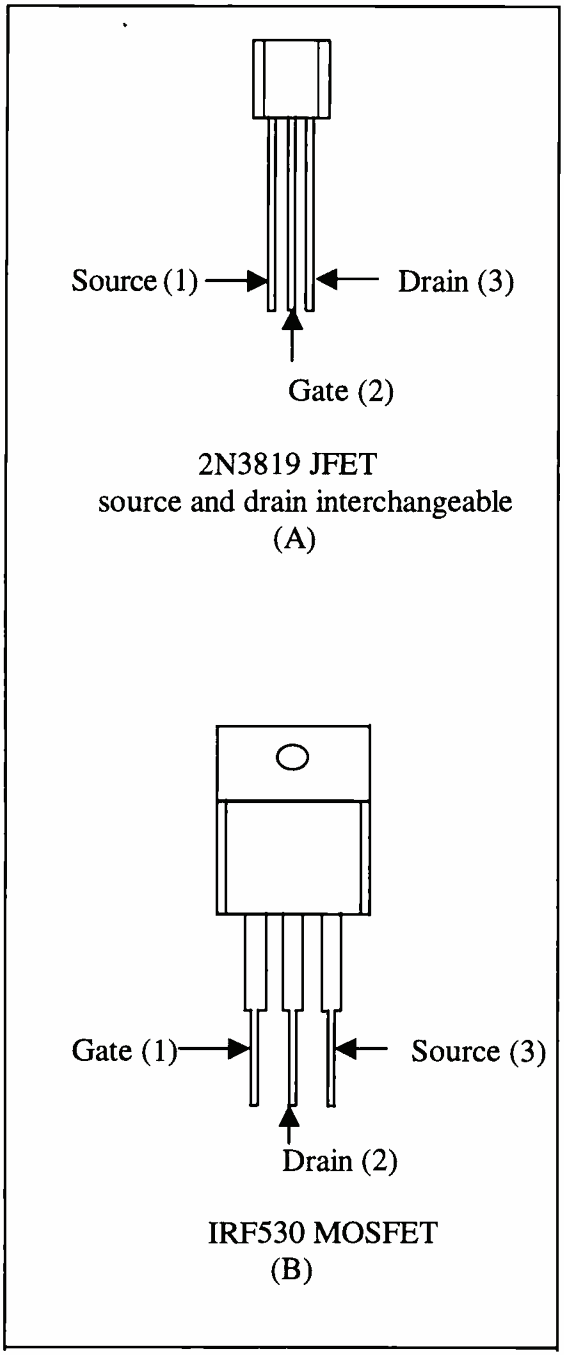


Fig. 12. Pin-outs of the transistors of the signal-processing circuitry.

trace pattern. My solution to getting the required amount of opacity of the trace patterns was to print out two transparencies of each trace pattern and then to glue the two transparencies together, precisely matching patterns. Glue that is excellent for doing this is Avery's "Glue Stic" intended for gluing paper, Avery # 00226. The glue is placed outside the perimeter of the trace pattern of one transparency and sets slowly enough that the transparencies can be repositioned somewhat after pasting them together. This technique of obtaining the required opacity of trace patterns probably also works making transparencies with a photocopying machine. I found that a single transparency-copy of a trace pattern on white paper produced by the type of photocopy machine normally used at printing shops lacked the required opacity. The question is to what extent the spacing and dimensions of a second photocopy is identical to that of the first.

The centers of the mounting holes of the PCBs of Figs. 4, 7, and 10 are shown by the small dots located near each of four corners of the rectangle, indicating the perimeter of the board at each figure. The diameter of these holes for mounting with 4–40 machine screws should be $\frac{1}{8}$ inch. The diameter of the holes for making point-to-point power connections with insulated and stranded 18 AWG wire is $\frac{1}{16}$ inch. The power-line output jacks of the PCB of the power supply shown at Fig. 5 are jacks J2, J5, J6, J10, and J11. The power-line input jacks of the board of the controlling circuitry shown at Fig. 8 are jacks J1 and J2. Jacks J1, J2, and J3 are the power-line input jacks of the signal-processing board of Fig. 11.

The diameter of all of the other holes of the PCB of the power supply, shown at Fig. 4, equals .042 inches or wire size 58.

The diameter of the holes of jacks J3–J6 of the PCB of the controlling circuitry, shown at Fig. 8, equals $\frac{1}{16}$ inch for accepting 18 AWG stranded and insulated wire. Jacks J3–J6 are the output terminations for con-

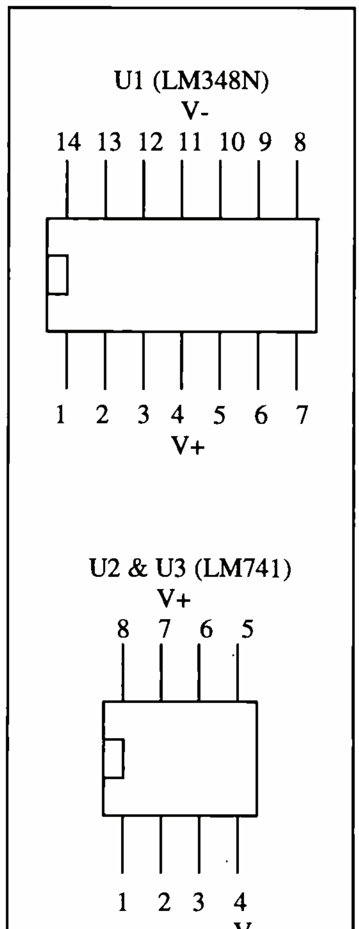


Fig. 13. Pin-outs and power supply connections to the IC pins of the signal-processing circuitry.

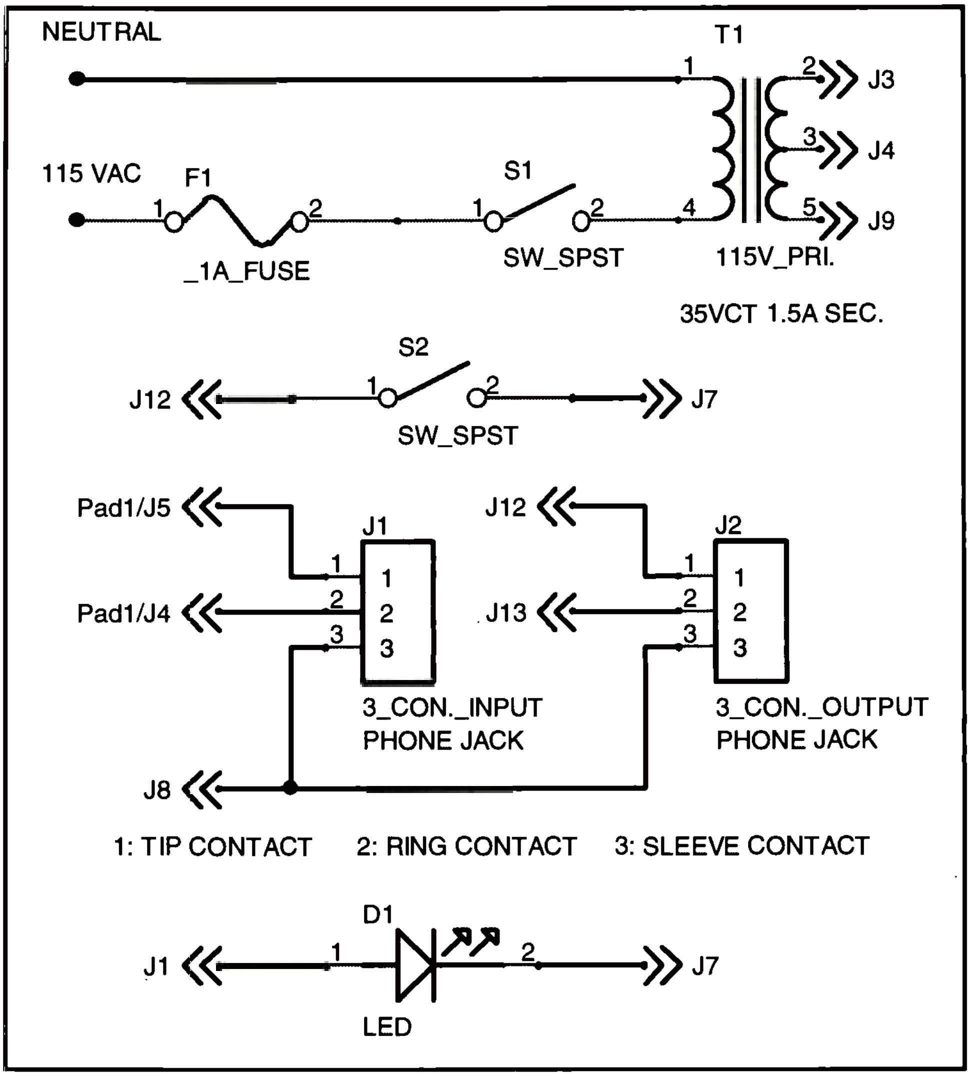


Fig. 14. Schematic of the connections to the chassis-mounted components. Tip and ring contacts of phone jacks carry respectively left- and right-channel signals.

PARTS LIST FOR THE CHASSIS-MOUNTED COMPONENTS (FIG. 14)

F1—1A fast-acting fuse and fuse holder
S1—Standard SPST toggle switch
S2—Miniature SPST toggle switch
T1—115-volt primary, 35 VCT/1.5-amp secondary power transformer (Mouser Electronice Stock No. 553-F54X or equivalent)
J1, J2—3 con. ¼-inch phone jack
D1—Panel-mounted LED indicator, such as RadioShack Stock No. 276-069B

trolling signals. All of the other holes of the PCB for the controlling circuitry, shown at Fig. 7, are of the diameter equal to wire size 58.

Shown at Fig. 11, the jacks J6, J8, J9, and J11 accept control signals from the controlling circuitry by 18 AWG stranded and insulated wire; and, therefore, the pads of these jacks have a hole-size diameter equal to 1⁄16 inch. Jacks J12 and J13 of the same figure connect to an output phone jack with 18 AWG stranded and insulated wire; therefore, the hole-diameter size of these jacks also equals 1⁄16 inch. The diameter of all of the other holes of the PCB of Fig. 10 is wire size 58.

Photo 2 shows the placement of the PCBs and the power transformer in the chassis, LMB #10123, Mouser Stock Nr. 537-10123. Also visible in this photo are the fuse holder and power cord with attached strain relief mounted on the rear panel and the power switch, processing defeating switch and input/output phone jacks mounted on the front panel.

A photocopy of Fig. 7 glued to the rear panel and photocopies of Fig. 4 and 10 glued to the bottom of the chassis provide templates for drilling the holes for mounting the PCBs. A rectangular template of paper for drilling the mounting holes for the power transformer, also glued to the bottom of the chassis, has a length equal to the distance from edge to edge of its mounting tabs and a width equal to the outside diameter of its windings. When placing the template for drilling the mounting holes for the PCB of the control-

TABLE 1

(A) INTERCONNECTIONS FROM POWER SUPPLY TO CONTROLLING & SIGNAL-PROCESSING BOARDS		
PWR BD, FIG. 5	CNTRL BD, FIG. 8	SP BD, FIG. 11
J5 (GND)	J1	/
J6 (GND)	/	J2
J10 (V-)	J2	/
J11 (V-)	/	J3
J2 (V+)	/	J1

(B) INTERCONNECTIONS BETWEEN CONTROLLING & SIGNAL-PROCESSING BOARDS	
CNTRL BD, FIG. 2 & 8	SP BD, FIG. 3 & 11
J3	J8
J4	J6
J5	J11
J6	J9

(C) INTERCONNECT BY POINT TO POINT WIRING ON SIGNAL-PROCESSING BOARD	
SP BD, FIG. 11	SP BD, FIG. 11
J7, PAD 1	J10

Table 1. Wiring between PCBs (A and B) and a single point-to-point wiring on the signal processing board (C).

ling circuitry on the rear panel, be certain that the edge of the board nearest the corner of the chassis is 1¼-inches distant from the corner to clear the corner brace. To accept 4–40 machine screws, the diameter of the holes for mounting the PCBs equals ⅛ inch. To accept 6–32 machine screws, the diameter of the holes for mounting the transformer equals 5/32 inch.

If you use an Avery "Glue Stic" for attaching the above templates, then after drilling the holes, the templates and glue can be removed with warm soapy water.

Ventilating holes are drilled in the right-hand side of the chassis (visible at Photo 2) and in the cap of the chassis (visible at Photo 1), LMB #10123C and Mouser Stock Nr. 537-10123C. I drilled ¼-inch diameter holes with the drilling centers spaced at ¾-inch apart. Slots must be cut into the flange of the cap cover overlapping the rear panel where two 4–40 machine screws are to be inserted near the top edge of the rear panel of the chassis for mounting the PCB of the controlling circuitry.

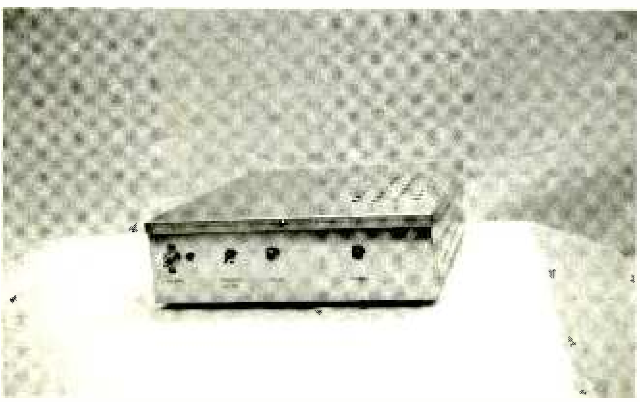


Photo 1. The aluminum chassis of the processor measures 10 × 12 × 3 inches.

Building The PCB Circuitry. The parts placement diagrams for the power supply, controlling circuitry, and signal-processing circuitry are, respectively, Figs. 5, 8, and 11. The components shown at these diagrams as a "JP"-type of part are jumpers; these jumpers are *not* shown at the corresponding schematic drawings and are constructed from 24 AWG solid tinned bus wire. A 50-foot spool of this wire is available at RadioShack as Stock Nr. 278-1341.

Markings and indicators of orientation shown at Figs. 5, 8, and 11 are a (+) symbol indicating the lead of a polarized electrolytic capacitor that is the positive one, a line at one end of the outline of diodes indicating the cathode termination and the position of the notch of an IC socket, and the IC to be inserted in the socket always to the left. Viewed from the component-side of each board as shown at the parts placement diagrams, pin 1 of all of the ICs is the first pin on the left of the bottom row of pins.

As previously mentioned, installing IC sockets is highly recommended for several good reasons. Also, ease of removal and replacement of U1 of the controlling circuitry, Fig. 2, is helpful in a procedure, to be described in a later section, for comparing cross-feeding with and without the electronically controlled variation of the cut-off frequencies.

The pin-outs of the voltage regulators U1 and U2 of Fig. 5 are shown at Fig. 6. The pins of each regulator are bent at a 90° angle relative to the TO220-type case of the regulator. The regulator is then bolted to the PCB with the heat sink placed between the case of the regulator and the board surface. Fix the position of each heat sink on the board with hot glue so that it doesn't contact the pins of the regulator IC or other components on the board. (See Photo 3.) At Fig. 5, pin 1 of each regulator is indicated by a rectangle at one end of and inside the part outline of the regulator. At the same figure, pin 1 of the bridge rectifier D3 is also indicated by a rectangle within the outline of the rectifier and is the positive terminal of the rectifier.

The parts placement diagram for the controlling circuitry is given at Fig. 8. Figure 9 shows the identical numbering of pins of the four ICs of the controlling circuitry. For all four ICs, the power supply connections are pin 7 to V- and pin 14 to ground. The completed circuitry is shown in Photo 3.

Figure 11 shows the parts placement diagram for the signal-processing circuitry. The pin-outs of transistors Q1–Q4 and Q5 and Q6 of Fig. 11 are shown at Fig. 12. Pin 1 of transistors Q1–Q4, indicated by a rectangle within the outline of each transistor, can be either the source or drain termination of the 2N3819-type transistor. For transistors Q5 and Q6, the pins of each transistor line up vertically at Fig. 11 with pin 1 (the gate termination) at the top. The pins of Q5 and Q6 are bent at a 90° angle relative to the case of the transistor and are bolted horizontally to the board with a heat sink between the case of each transistor and the board. Again, fix the position of each heat sink on the board with hot glue so that it does not contact the pins of the MOSFET or other components on the board. (See Photo 3.)

Testing The PCBs. Some testing of the filled boards is in order before installing the PCBs in the chassis, wiring them together, and connecting to the chassis-mounted components. If you fully assemble the processor and then discover that something isn't functioning properly, fixing the problem could be a royal pain in the neck.

Starting with the power supply, you want to connect it to AC power and then check the DC output voltage readings with no load and with a moderate load. (See Fig. 5.) Connect the end terminations and the center tap of the secondary winding of the transformer to, respectively, jacks J3, J9, and J4. The type of transformer required is listed in the Parts List for The Chassis-Mounted Components, Fig. 14. When you are ready to power up, connect the primary leads of the transformer to $115V_{AC}$. Be careful in handling the connections to the primary winding as the voltage of the primary winding can give you an unhealthy shock.

Continuing at Fig. 5, where the outputs of the power supply are unloaded, the voltages of V+ taken at jack J2 and V- taken at jacks J10–J12 should be about equal to, respectively, +15 volts and −19 volts. Connecting a first load resistance of 150 ohms from jack J2 to ground and a second load resistance of the same value from jacks J10–J12 to ground, the voltages of V+ and V- should equal, respectively, very nearly +15 volts and slightly less than −15 volts or about −14.8 volts.

Next, check the controlling circuitry, see Fig. 8. After making the connections from the power supply to the controlling circuitry (ground to jack J1 and V- to jack J2), pins 7 and 14 of each of the ICs, U1–U4, should be at the power supply voltages of, respectively, V- and ground. Connecting a voltmeter in turn to jacks J3–J6, over about a one minute interval, the DC voltage taken at each jack should change after an interval of several seconds from an open connection to connected to V- and vice versa.

Table 2 can be "converted" to tell you whether or not the logic of the controlling circuitry is correct or not. First substitute jacks J3–J6 of the controlling circuitry for the jacks of the signal-processing circuitry given at Table 2, by referring to Table 1B which indicates the controlling jacks of the two boards that are connected. Second, wherever Table 2 indicates "GND" (ground), substitute "OPEN." Looking at Fig. 8, remove U1 from its socket and insert ½-inch lengths of buss wire into the insertion locations of the socket for pins 5 and 9 of the IC. With a pair of leads terminated with IC test clips, connect the two short lengths of buss wire to ground and V- according to "converted" Table 2 and check that the voltages taken at jacks J3–J6 correctly correspond to the simulated output voltages of pins 5 and 9 of U1.

Looking at Fig. 11, the power supply voltages V+ and V- are connected respectively to jacks J1 and J3. Ground of the power supply is connected to jack J2. The voltages taken at pins 4 and 11 of U1 should equal,

TABLE 2

U1A	U1B	U2A	U2B	J8	J6	X R-CH	J11	J9	X L-CH
Pin 5	Pin 9	Pin 3	Pin 4			Fc, kHz			Fc, kHz
GND	GND	V-	V-	GND	V-	1.9	V-	GND	1.0
(high)	(high)	(low)	(low)						
V-	GND	GND	V-	V-	GND	1.0	V-	GND	1.0
(low)	(high)	(high)	(low)						
GND	V-	V-	GND	V-	GND	1.0	V-	GND	1.0
(high)	(low)	(low)	(high)						
V-	V-	GND	GND	V-	GND	1.0	GND	V-	1.9
(low)	(low)	(high)	(high)						
At Fig 2: U1A & B, Astable multivibrators; U2A & B, Inverters.									
At Fig. 3, jacks J6, J8, J9 & J11: control voltage junctions. X= cross-feed signal.									
Connection from V- to J7 and J10 at Fig. 3 is open.									

Table 2. Logic of selecting the cut-off frequencies of cross-feeding.

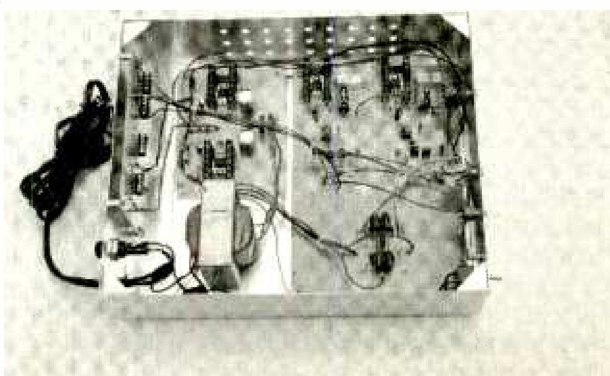


Photo 2. Placement of the PCBs and power transformer in the chassis.

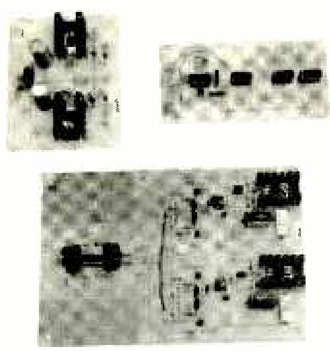


Photo 3. PCBs of the processor, power supply at top left, controlling circuitry at top right, and signal-processing circuitry at the bottom.

respectively, V+ and V-. The voltages taken at pins 4 and 7 of U1 and U2 should equal, respectively, V- and V+.

To test filtering by the signal-processing circuitry of Fig. 11, connect the tip and ring contacts of the phone plug of a pair of headphones to, respectively, jacks J12 and J13. The sleeve of the phone plug is connected to ground. With no connections made to jacks J6–J11, apply a sine wave signal initially with a frequency equal to 500 Hz to right-channel input jack J4 only. The applied AF signal should be heard at an equal level in both headphones. Advancing the frequency of the AF signal to above 1 kHz should result in a gradual dropping of the level of the signal heard at the left ear. Returning the frequency of the AF input signal to 500 Hz and then connecting jack J7 to V- should cut out the input signal heard at the left ear. This procedure should be repeated applying the sine wave signal to left-channel input jack J5 only and connecting jack J10 to V- to cut out the input signal heard at the right ear.

Final Assembly. The filled printed circuit boards are attached to the bottom and rear panel of the chassis with ⅜-inch long hex aluminum standoffs. Apply self-adhesive feet to the bottom of the chassis that are of sufficient height to protect surfaces from the heads of the 4–40 machine screws protruding below the bottom panel of the chassis such as RadioShack Stock Nr. 64-2342.

Table 1 indicates the required point-to-point wiring between the PCBs and on the signal-processing board. For this wiring, use 18 AWG stranded and insulated hook-up wire. Figure 14 indicates the connections to be made between the chassis-mounted components and the PCBs. The chassis-mounted components are listed in the Parts List for the Chassis-Mounted Components, Fig. 14. Wiring from the input phone jack J1 of Fig. 14 to jacks J4 and J5 of the signal-processing circuitry, Fig. 11, is made with shielded two-conductor audio cable. One end of the shield conductors of these cables is connected to pad 2 of jacks J4 and J5 of Fig. 3. The opposite ends of the shield conductors are connected to the sleeve contact of input jack J1 of Fig. 14. The indicator LED and switch S2 of Fig. 14 are connected to the PCBs with 22 AWG stranded and insulated hook-up wire. All of the other point-to-point wiring of Fig. 14 is done with 18 AWG stranded and insulated wire.

SOURCE INFORMATION

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Operating It. The capacitance of C19 and C20 of Fig. 3 limits the minimum nominal impedance of the headphones driven by my ambience processor to 32 ohms. Driving headphones with nominal impedance less than 32 ohms is possible if this value is correspondingly increased. A 1000-µF axial polarized electrolytic capacitor rated at 25 volts will fit on the PCB of Fig. 11 where capacitors C19 and C20 are located.

The signal-input jack of the processor that I built is connected to the speaker-output terminals of my integrated amplifier rather than to the headphone jack of my amplifier so as to avoid the poorer quality of the circuitry of the headphone amplifier compared to that of the circuitry for driving speakers. The resistance of R23 and R24 of Fig. 3 is based on the range of voltage taken at the speaker output terminals. If greater voltage gain of my processor is required, then the value of resistance of those resistors can be increased.

Switch S2 of Fig. 14 allows you to compare reproduction with and without processing. When this switch is closed, then cross-feeding is defeated. The total effect on reproduction by my processor is not immediately apparent as changing of the cut-off frequency of the legs of cross-feeding occurs over several minutes. To best judge the improvement of reproduction, listen to a selection for a few minutes and then defeat processing.

Comparing the effect of cross-feeding with and without the variation of the cut-off frequency of low-pass filtering of cross-feeding can be done as follows. First, for several minutes listen to a selection with switch S2 of Fig. 14 open. Second, remove U1 of Fig. 8 from its socket and connect two short lengths of buss wire to the contacts of its socket accepting pins 5 and 9. Finally, connect one length of buss wire to ground and the other length of buss wire to V- with a pair of test leads terminated with IC clips. Looking at Table 2, this arrangement causes the cut-off frequency of low-pass filtering of both legs of cross-feeding to remain constant and equal to 1 kHz. With switch S2 of Fig. 14 remaining open, you can now listen to the same selection without the variation of cross-feeding ■

Stereo Phone Plugs

Q *I am building a pair of interconnects from scratch and am new to electronics. On one end of each interconnect, there will be a left and right RCA plug and on the other a 3-conductor, 3.5-mm phone plug. When soldering, can I solder the ground of the left and right RCA's directly to the same ground connector on the 3.5-mm, or will this cause the two outputs to drive each other? Do I need a resistor? Also, how can I tell which lead connector is left/right on the 3.5-mm?—S.N., via e-mail*

A You won't need any resistors in your cables. The hardest part is using two shielded cables, one from each RCA plug, and trying to get them to both fit into the tiny 3.5-mm connector shell. My suggestion is to use RG-135/U coax or other miniature coax that has a smaller diameter of about 3/32-inch. Standard audio or *r*adio *f*requency (RF) coax is too large and clunky for this application. The shield of the cable goes to the outside part of the RCA plug, while the center conductor goes to the male pin. You may have to use a taper reamer, file, or knife to enlarge the cable opening in the phone plug's shell.

You can connect both of the shields of the other end of the cables together to the common or ground connection of the 3.5-mm phone plug. The standard for both 3.5-mm and ¼-inch stereo (two-circuit) phone plugs has the tip carrying the left channel and the ring carrying the right channel, while the sleeve is ground or common. Figure 1 illustrates a typical male phone plug and the tip, ring, and sleeve portions.

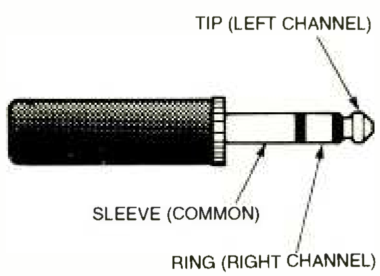


Fig. 1. Two-circuit, stereo, 3.5-mm or ¼-inch phone plugs have standardized wiring for the left and right channels.

Soldering to some of these connectors, especially the RCA plugs, can get a little irritating. Most of them are Asian imports; and I'd swear that they all have a thin coating of oil, or maybe they're plated with chromium. Begin by tinning the connectors before you even think about attaching a wire to them. You may have to use a knife, file, or emery cloth to shine them up, sometimes getting down to the brass-base metal on really trying cases.

Line-Level Inputs

Q *Most PC sound cards have a line-in jack. I believe that "line levels" are about one volt. How do you input other audio into the sound card at that level from, say, a radio earphone jack? Is the line also balanced? Do you have a circuit that would handle this?—V.B., via e-mail*

A Inputs and outputs from sound cards are unbalanced, single-ended circuits. A balanced input is a differential input and is usually expected to have two signals that are identical but 180 degrees out-of-phase, although there are ways around that. In the audio world, about the only place you'll see balanced inputs is in professional sound reinforcement systems, as used on the mixer microphone inputs.

However, the sound card is a little more complicated than just a simple unbalanced input, for those little 3.5-mm line-input jacks are actually stereo jacks and require a 2-circuit plug for proper mating. They are two unbalanced inputs, one for the left channel and the other for the right channel. Those types of plugs were illustrated in Fig. 1. All of the soundboards at my disposal have stereo jacks for line in, line out, microphone in and/or speaker out.

Line-level inputs don't have a hard and fast standard and can range anywhere from around 100-mV rms to 2-volt rms and are typically a high-impedance circuit of around 47,000 ohms, a figure that also will vary from equipment to equipment. The earphone output of a simple radio is monophonic, and the tip of the radio's plug must be connected to both the tip and ring of the sound card's input plug. This connection insures that the monophonic signal will be distributed to both channels of the card if you want to use both channels. If the earphone jack is from a stereo source such as an FM radio, CD, or cassette player, a cable with a 2-circuit stereo plug on either end will suffice to connect the two together. Although the radio will have a low-source impedance, the output voltages should be near line-level voltages and should drive the sound card just fine. You can adjust the radio's volume control for the highest output without clipping to keep the signal-to-noise ratio high.

Doggie Doors

Q *While visiting my son over the Christmas holidays, I saw an electronic pet door installed at his home that I liked, but needs modifications to make it practical.*

The door works great with the exception of the sending and receiving system. The door goes up and down smoothly and doesn't put any pressure on the animal if it's somehow caught by the door's descent. If the door touches anything, it opens back up automatically. The collar that the pet needs to wear in order to activate the door is another matter. It contains a circuit board with a speaker continually emitting an ultrasonic sound that can be picked up when the animal approaches the door. Aside from the need to periodically change batteries, the immediate problem is that his cat and my dog both dunk the TX collar in their water bowl while getting a drink, rendering the device useless until it's been dried out and the battery changed. Not too practical!

I'm wondering how the systems used at retail stores work that sense magnetic strips/sending units if you leave the area without first having the device deactivated? Could you make any suggestions as to how I could adapt something like that to one of their electronic pet doors?

A An ultrasonic emitter hanging around the neck of an animal whose ears perk up at the sound of a "silent" dog whistle? Does the ASPCA know about this?

The anti-shoplifting tags typically are resonant circuits. The pedestals on either side of the exit are a low-power transmitter and a receiver. When the resonant tag passes between the pedestals, some power is robbed from the space between transmitter and receiver. When the receiver sees the resulting signal-drop, the alarm is triggered. I know this because we had the rep from one of those companies at our school when we were considering such a system. He explained it all and left me some adhesive-backed sample stickers. I attached one to the back of my business card and gave it to a lawyer friend of mine who promptly shoved it deep into her purse and forgot about it. After her trip to Wal-Mart a month later, and ten attempts to get out the exit with the security folks in attendance, I had a new enemy.

Anyway, the tags are deactivated by holding them near a high-power signal source that blows a link in the circuit, rendering it non-resonant.

Since the tags are passive, they would make an excellent, potable (in this case, that's pot-able, not pote-able) collar tag for a pet that would be impervious to moisture and other environmental concerns. However, the cost of the commercial transmitter/receiver set will take your breath away. I'm not sure how easy it would be to duplicate a similar system that would be stable enough to eliminate false triggers, yet sensitive enough to reliably open the door. Any readers care to take a stab at it?

My Wires Are Crossed

Readers Dave Marzetti and Gary Modrell noticed that I tend to do too much of the work on this column late at night when I should be sleeping and not coming up with "wonderful" ideas. My simple diode-steering 3-to-2-wire trailer turn signal and brake-light converter circuit in the January 2002 column works fine until you apply the brakes, and then the turn signals will disappear. I knew that, but blithely designed right on past that concept anyway. My suggestion to just buy a commercial converter is still the best idea, because overall you'll get better reliability and proven circuitry. It will also end up being cheaper, especially if you count the cost of all the labor of construction and the magazine. Most importantly, I won't get sued if you build our lamebrain circuits and then get rear-ended or sideswiped while trying to make a turn.

I was down to the column deadline

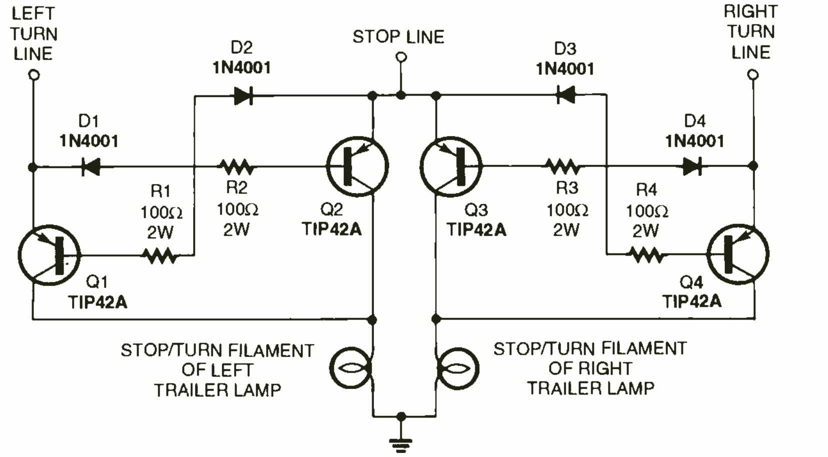


Fig. 2. A turn-signal isolator circuit using PNP bipolar transistors is similar to a commercial 3-to-2-wire converter for trailer lights.

last month on the "Wig-Wag" design. I had the circuit working just great when it dawned on me that the two headlights are tied together on the car, and I'd end up with the headlights doing nothing but flash on and off together. It's the reverse of the turn signal problem. So that item had to be scooted off to this month's column so that I could test out my modification. At the rate that I'm going with these automotive projects,

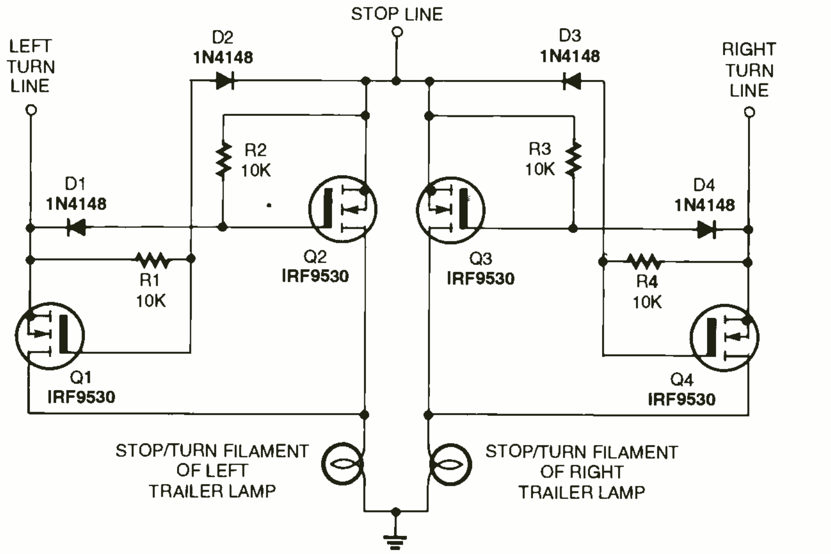


Fig. 3. Another signal isolator using N-channel MOSFETs is a design option for such a converter.

I'm going to have to build a mock-up of an automobile electrical system that I can use to test circuits. My electronics program is right next door to the automotive technology program. You'd think I'd have sense enough to walk over there and try these circuits out on their cars!

Anyway, Gary, who's a design engineer, sent along a couple of circuits, one using bipolar transistors and the other using N-channel MOSFETs. He says that both circuits end up with the same voltage drop across the transistors and could probably be lowered by using a different design with P-channel MOSFETs or a more complicated N-channel design. I'm printing both circuits for your experimenting pleasure, depending on what components you have available. Dave indicates that he's tested and used the bipolar transistor version (some of us are smarter than others) and that the MOSFET circuit is a quick, untested offering.

Wig-Waggin' the Wagon

Q *I am a volunteer firefighter and recently started a course in basic electronics. I am looking for help on a circuit to operate the headlights on my truck. We use a device called a "wig-wag" that lets the headlights flash alternately.*

I would like to build a circuit to do that except I want my lights to flash in a different sequence: the left headlight flashes two times, the right two times, both two times, and then the sequence repeats. I know this is a strange request, but ever since I saw a truck do this I've wanted the same thing. And what better way to practice in my new electronics fascination than to build something I could really show off?—R.S., Amory, MS

A Texas Ranger Walker's Dodge and most other professional vehicles usually flash xenon strobes mounted within the headlight and brake-light housings for a more intense effect that overrides the normal intensity of those lamps. Add to that the fact that some serious stress is placed on the filaments, and this will shorten their lives severely when you flash the headlamps like that. Finally, Illinois and many other states only allow flashing white lights on the front of "professional" vehicles such as fire trucks, ambulances, police cars and coroners' vehicles. (I just report 'em, I don't explain 'em—I guess they want them while they're still warm). They specifically prohibit flashing headlights on a volunteer fireman's personal vehicle—they are only allowed to have flashing blue lights. I don't know what the Mississippi laws say on this subject, but you'd better check first. In Paragould, Arkansas, I did see a volunteer firefighter's personal vehicle with wig-wag lights.

As another warning, note that for safety reasons I don't particularly like messing around with a vehicle's lights. In this case, we're just modifying the high beams, and the low beams will be unaffected. All that aside, it sounds like a great project!

Back in the July 1996 issue of **Popular Electronics**, Anthony Caristi had an article titled "Add Daytime Running Lights To Your Car." I used his HEXFET output circuit for driving the headlights. That way, normal headlight operation will override the wig-wag. I know that there has to be many ways to implement this circuit, and I'd love for readers to submit some of their proven ideas for such a circuit.

I wrestled with a couple of different ideas and settled on the one shown in Fig. 4. A 555 timer drives a Johnson counter and enables the NAND gates. The counter sets up which lights will flash, while the NAND gates determine when they will flash. The gates then drive the gates of a pair of MOSFETs, each controlling a headlamp.

You'll have to break the connection from the original wire going to the high-beam switch so that you can install D3 and D4 to isolate the left and right headlamps from each other while D1 and D2 isolate the MOSFETs from the headlamps when the circuit is off. Those are 7.5-amp Schottky (aka hot carrier) rectifiers to minimize voltage drops to the headlights and are available from Newark or Allied Electronics. You can use regular silicon rectifiers in their place with a correspondingly higher voltage drop. Just make sure that they're rated for the headlamp current. Capacitors C2 and C3 are placed across the supply and pins of IC2 and IC3, respectively.

I used open-collector NAND gates so that I could combine their outputs and change the logic level to a +12-volt HIGH for driving the MOSFETs. This is a good example of the use of open-collector logic discussed in previous columns. Note that I used a 74LS01 since that's what I had on hand and that it has an "odd" pinout. A 74LS03 will work just as well, but be aware that its connections are different, with the same

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

Many electronic component manufacturers have Web pages; see the directory at *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.

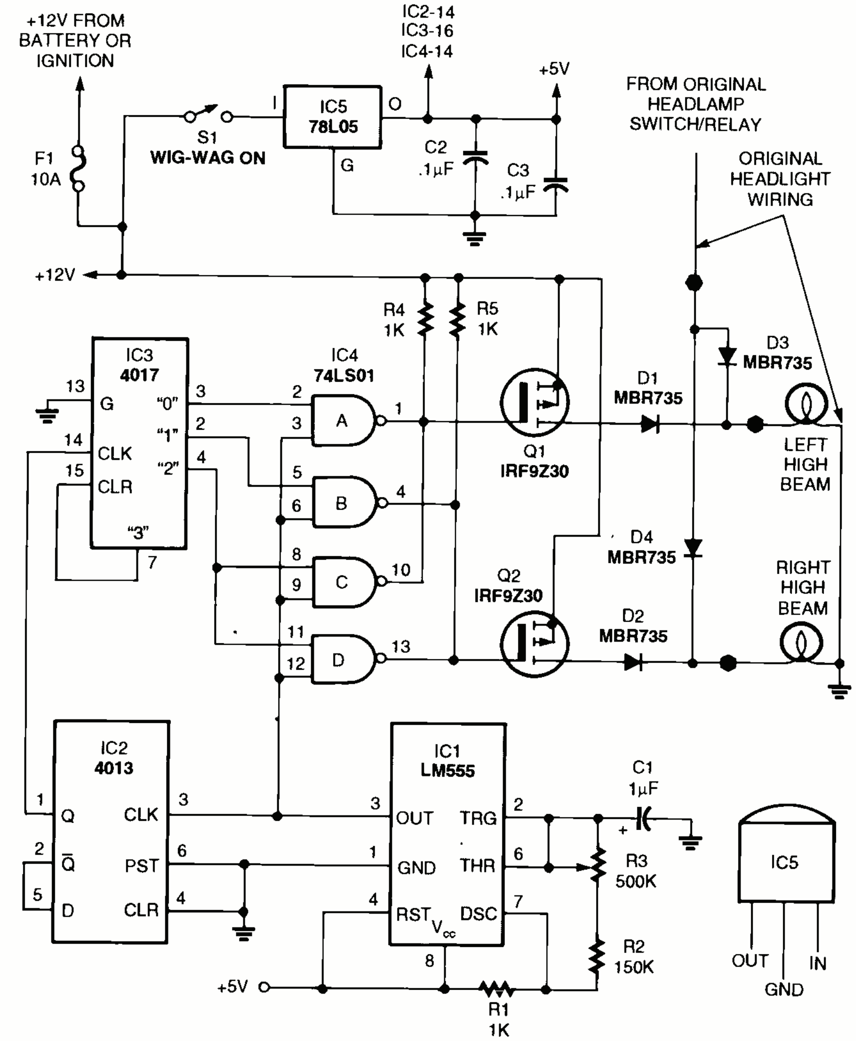


Fig. 4. This "Wig-Wag" circuit will alternately flash the high-beam headlamps of an emergency vehicle while still retaining normal low- and high-beam operation of the lights.

pinout as a standard 74LS00 quad NAND gate. Because of needing that single TTL chip, I added a 78L05 regulator to derive +5 volts for all the ICs.

In operation, the circuit will work with the headlights on or off. If you have the high beams on, the wig-wag will be overridden, which is not a bad thing. The power switch turns off the logic but not the +12 volts being fed to the pull-up resistors on the NAND gates. This way, when the wig-wag circuit is off, those NAND outputs will be pulled HIGH, keeping the MOSFETs off.

Working Without A Map

Q *How do I approach troubleshooting when I have a piece of equipment in front of me with no documentation and no chance of getting any? I can make reasonably accurate checks on most components, but is this my only option—randomly checking parts? Your advice is welcome.—R.W., via e-mail*

A While you're working on the equipment without documentation, keep a line in the water by haunting several of the Internet forums where you might be able to find help in that area. Specialty forums for specific brands (Heathkit, Knight-Kit, Tektronix) or for specific types (antique radios, communications, amateur radio) can be of great assistance in finding obscure schematics and manuals.

I hate being in the situation of not having documentation, and the more complex the equipment, the worse it is. Assuming that it is impossible to get any documentation, you'll be left just a few avenues for repair. An experienced TV repairman can often work on a television with no documentation simply because he or she has a tremendous knowledge base of typical problems and likely culprits. Finding things like the horizontal or vertical output transistors and other common parts is easy, and 90% of the repairs may be obvious. If it's a nasty problem in another area, the lack of docs may bring progress to a screeching halt.

The random checking of parts can be a waste of time since 99.978% of the parts are likely not prone to catastrophic failure. You need to zero in on likely failures. Fuses, filter capacitors, power transistors, cables that are routinely flexed and other parts that take a heavier beating ought to be checked first. If you have a stereo amplifier that has no output on the left channel only, don't mess with the right channel or parts that are shared by both channels, such as most of the power supply. Concentrate on the left-channel components. Watch out for obvious problems: missing jumpers, unplugged power cords, mis-set switches and controls, unconnected or broken wires, missing parts, broken parts, cracked circuit boards, loose components and other mechanical problems. Larger components, especially those that are not otherwise mounted to the chassis or circuit board, are prone to cracked solder joints that need to be carefully checked.

The nice thing about a stereo amplifier is that you have an identical twin nearby to compare things with, so at least you can look for suspect voltage changes.

There are some things that you can take a stab at. Sometimes checking supply voltages is easy, especially if marked in the equipment. Smoldering resistors indicate a problem, but don't forget that burned resistors and blown fuses are usually secondary failures caused by something more radical such as a shorted transistor. You're limited by the human senses on this one. Whatever you see that's not right, a smell that's not pleasant, or something that's too hot, is a potential problem, but may only be the surface of something deeper. Don't forget that the human probes are somewhat conductive—keep your fingers away from dangerous line and power supply voltages.

If working on older equipment, you can sometimes fall back on the fact that there are lots of similar models out there. For instance, one vacuum-tube voltmeter was pretty much like another as far as the general circuitry and tube complement were concerned. Radios were very similar. Sometimes the schematic for one old radio would be close enough to get an idea of the schematic of another.

If the item is simple enough, I've been known to reverse-engineer a schematic.

About the most complex thing I've done this with is a digital "Jeopardy" game controller whose manufacturer refused to supply docs. After working through ten chips and a bottle of ibuprofen, I finally had a working schematic that I used for several years to repair a dozen of those little boxes. You have to determine your own level of patience for this route.

Finally, don't let your pride get in the way. Find someone who's experienced in this sort of thing to give you some pointers and help you over rough spots. You can both learn from the experience.

Help On The Way

Reader Barry McMahon contacted me, offering to copy his marine transceiver manual to satisfy a reader request in the January 2002 column. Thanks, Barry, for your kind response!

Aaron Colson Taylor Is Here!

A couple of the days that I normally spend right before deadline, cleaning up the column copy, were wonderfully taken from me as I attended the birth of our first grandchild on January 14th. There is no doubt in my mind that the cute little tyke will take an instant liking to electronics as a hobby. Unfortunately, by the time he's really into it, the technology will probably have changed so much (or I'll have gotten so senile) that I'll look at his projects with the same unknowing wonder and amazement that my grandmother showed mine. Besides playing with the little guy, all I want to do is take apart the little stuffed dog he has that says, "Weeeee!," "Oh-oh!," or laughs whenever he's jostled.

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. ■

HANDS-ON-REPORT

(continued from page 16)

Weighing slightly less than seven pounds, KDS' Valiant 6000G is a very affordable three-spindle notebook.

then the Jetbook's built-in SmartMedia slot might be enough to sell you on the product.

KDS Valiant 6000G

KDS used to make inexpensive peripherals, monitors in particular. KDS still makes inexpensive peripherals, but the quality is now right up there. The new Valiant 6000G notebook is one of only two three-spindle units examined here. Finished in silver and navy blue, the Valiant weighs slightly less than 7 pounds.

Though the Valiant 6000G does not offer many frills such as FireWire or a wireless NIC, its quality is good and its price is the lowest in the roundup. That alone may be its best selling point.

Toshiba's TECRA 9000 is the lightest notebook covered here, just over five pounds. Both integrated 802.11b wireless networking and support for Bluetooth wireless technology are featured.

Toshiba Tecra 9000

Toshiba Tecra 9000 is housed in a black and silver enclosure, with some parts made of plastic and other parts made of metal alloys. Toshiba notebooks have always sported unusual mouse buttons. You become accustomed to the buttons with regular use, but they are awkward if you use the notebook only once in a while. Also, the pointing stick works best if the motion is slowed down a bit. The front corners of the notebook should be more rounded, as they dig into your hand when grasping the unit.

The Tecra 9000 is the lightest notebook in the group, weighing just over 5 pounds. It's also the only notebook tested that includes both integrated 802.11b wireless networking and support for Bluetooth wireless technology. Bluetooth is becoming a popular way to link peripherals, such as printers and scanners that support Bluetooth.

Marc Spiwac is the Technical Editor of CRN.

SOURCE INFORMATION

Compaq Evo N180 Notebook
Price: $1999 (street)
Warranty: 1 year
800-345-1518
www.compaq.com

Fujitsu LifeBook E Series
Price: $2649 (street)
Warranty: 3 years
408-982-9500 or 877-372-3473
www.fujitsupc.com

Hewlett-Packard Omnibook 6100
Price: $2500 (street)
Warranty: 3 years
970-635-1000 or 800-752-900
www.hp.com

Jetta Jetbook 9200
Price: $1980 (street)
Warranty: 1 year
732-329-9651 or 800-445-3882
www.jetta.com

KDS Valiant 6000
Price: $1499 (street)
Warranty: 1 year, parts and labor
713-379-5599 or 800-237-9988
www.kdsusa.com

Toshiba Tecra 9000
Price: $2900 (street)
Warranty: 3 years
949-583-3000 or 800-867-4422
www.csd.toshiba.com

TED NEEDLEMAN

Sound Cards: The Next Generation

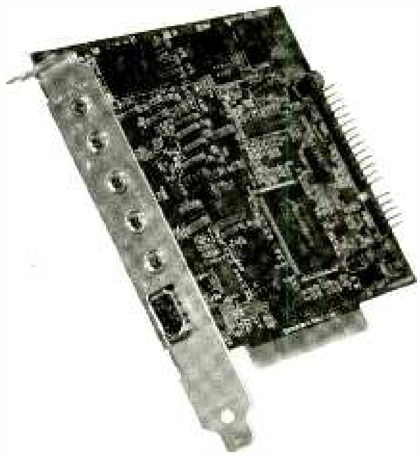
If you stop to think about it, different type of peripherals and PC subsystems get refreshed at different intervals. Processor speed gets bumped up every couple of months, though CPU design proceeds at a much slower rate. The same thing is true about hard disks. We'll be looking at some of the newest hard drive offerings in a later column. Aside from drive capacity, which continues to improve, actual changes in technology such as the ATA interface come very slowly.

That's not true about some subsystems, however. For example, video-controller technology is one of the most frequently changing areas in the industry. With many users still running on video cards from vendors that have gone out of business, such as Diamond or 3Dfx, nVidia has introduced the GeForce, GeForce2, GeForce3, and Titanium versions of the GeForce2 and GeForce3, all in the past two years. As this is being written, the vendor has again upped the ante with the introduction of the GeForce4.

Sound cards fall somewhere in the middle of the upgrade cycle. As long as users are happy with the way their PC sounds, they don't generally bother with an audio upgrade. If they do upgrade, the part of the audio subsystem that's most likely to be upgraded are the speakers, not the sound card.

NEW AND IMPROVED

There are exceptions to this, however. When a new generation of audio technology becomes available, it's time to consider whether or not you should embrace it. That's the case right now, with the introduction of the Audigy and Extigy products from Creative Labs.



There are two Audigy models with extensive patch bays. The Audigy Platinum has an internally mounted patch bay that fits into an empty drive bay. The Audigy Platinum EX has the patch bays contained in an external box that's attached to the card.

Both of these product lines are based on the same new core chipset. Creative calls this the Audigy, and it has a number of improvements over the EMU10K1 chipset used in the Sound Blaster Live! models. The Sound Blaster Live! will continue to be sold for the immediate future.

The most important of these chipset features is the bandwidth and sampling rate. The new chipset uses 24-bit DACs (digital-to-analog converters) and runs at 96 kHz. This gives the Audigy/Extigy chipset a claimed four-time increase in processing power verses the older EMU chipset used in the previous generation of Sound Blaster models. In turn, Creative uses this additional processing power to implement its EAX Advanced HD technology. EAX is Creative Labs' own audio technology, which is used to clean up the signal as well as produce effects such as tailoring the playback to a virtual environment. With EAX Advanced HD, you can specify the playback "venue," such as a concert hall; and the processor will modify the acoustics to fit. EAX Advanced HD also lets you vary the speed of audio playback while maintaining accurate pitch.

The new chipset also provides a SNR (signal-to-noise ratio) of 100. That's considerably better than most audio cards in the consumer price range. The improved SNR is important when you listen to music with a wide dynamic range, as it allows you to keep the volume cranked up without being subjected to background noise such as a hiss.

The Audigy line currently has four models. Two of them, the Audigy Gamer and the Audigy MP3+, are identical except for the software collection each boasts. Each of these models is an internal card with a second bracket that contains the MIDI/game port. This means that the Audigy takes up two slots, rather than the single slot the previous Creative Labs cards required. This is necessary because the card now provides an IEEE 1394 Firewire port, called an SB1394 port, where the MIDI port connector used to be located. Both of these cards list at about $100

There are also two Audigy models with extensive patch bays. The Audigy Platinum costs just under $200 and has an internally mounted patch bay that fits into an empty drive bay. The

The external sound card, called Extigy, attaches to a PC or laptop via a USB cable. It, too, uses the Audigy chipset and provides the same EAX Advanced HD effects and processing, low SNR, IEEE-1394 port, and an extensive set of connectors.

$249 Audigy Platinum EX has the patch bays contained in an external box that's attached to the card. This box can be placed on the top of the PC or in any other place you find convenient.

The external sound card, called Extigy, attaches to a PC or laptop via a USB cable. It, too, uses the Audigy chipset and provides the same EAX Advanced HD effects and processing, low SNR, IEEE-1394 port, and an extensive set of connectors.

In fact, all three of these models (Platinum, Platinum EX, and Extigy) have I/O connectors for 5.1 Dolby Digital output, optical connectors, MIDI in and out connectors, IEEE-1394 connector, and connectors for a headset and microphone. Volume controls are provided, as is an infrared remote control.

SOURCE INFORMATION

Creative Labs
www.creative.com

IS THAT A YES, OR A NO?

It's really easy for an editor or reviewer to get excited about a product, no matter how expensive it might be. Vendors are very generous in providing equipment for review. As I've said before in this column, the bottom line for me is whether the product I'm looking at is compelling enough for me to spend my own money on it. Given that constraint, would I upgrade to one of the new Creative Labs sound offerings?

Unfortunately, the answer in this case isn't an unqualified one. After testing the Audigy Platinum EX and Extigy on a high-end Pentium 4 system, I probably would upgrade to an Audigy with the PCs that currently have one of the premium speaker systems attached. The Klipsch ProMedia 5.1s, Logitech Z-560s, and Altec Lansing 641s all have the output power and frequency response to benefit from the SNR and dynamic headroom that the Audigy provides. Most of the speakers attached to the other PCs on the network don't have this kind of response or capability. On those systems, the current sound cards, including a Sound Blaster Live!, Hercules Game Theater XP and Fortissimo II (and even embedded motherboard audio), are all sufficient and wouldn't be upgraded.

On the other hand, if all I had was a laptop, I would definitely consider the Extigy and a good set of 4.1 or 5.1 speakers. The Extigy is, at least for the moment, absolutely the best offering for getting truly excellent sound from a laptop.

Finally, musicians who use their PC for recording and arranging may want to consider either Creative Labs' offering for upgrading their systems. The array of patch options in the Audigy's extended patch bay and box or the Extigy's front and rear panels provide much greater functionality than that offered by the previous generations of soundcards.

For most other users, only the most demanding audiophiles will find the newest Creative Labs' offerings a compelling upgrade—at least for the moment. As prices drop, that will change, as it does with other PC upgrades. **P**

REID GOLDSBOROUGH

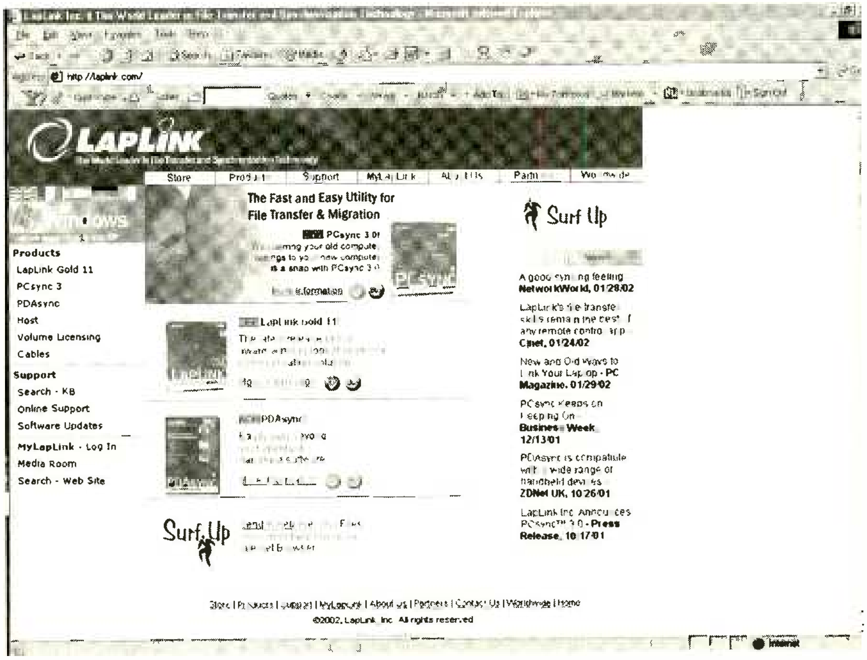
mailto: digitaldomain@gernsback.com

Overcoming Fear of PCs

Are you afraid of computers? Do you know someone who is? If you've grown up with personal computers or been around them for any length of time, you probably take them for granted. After all, PCs have become nearly as commonplace as dishwashers.

According to the U.S. Census Bureau's latest statistics, more than half of U.S. homes now have at least one PC; and 90 percent of school-age children have regular access to PCs, two-thirds from their homes. Despite the statistics, there's still a lot of fear and loathing about these machines. As many as 85 percent of us have at least some level of discomfort around technology, including PCs, says Larry Rosen, co-author of the book *Techno-Stress: Coping with Technology @Work @Home @Play*, who has a Web site at *www.technostress.com*.

In work settings, two-thirds are "hesitant" about technology, says Rosen, a psychology professor at California State University, Dominguez Hills. Fully 80 percent, according to Rosen's studies, feel that workplace technology has brought additional stresses to their lives.



PCsync from Laplink, at www.laplink.com, *comes with both a serial and USB cable. It supports 45 different programs and costs about $75.*

DEALING WITH TECHNOSTRESS

Although the design of PC hardware and software has improved over the years, there's still room for more intelligent simplicity here. In the meantime, what steps can you take to overcome "computerphobia?"

Rosen, who prefers the broader term "technostress" over the more common terms "technophobia" or "computerphobia," says the first step is to understand that "essentially everybody is feeling stressed out by technology," as borne out by his research. "You are not alone in your fears," he says.

Second, "Technology is frustrating," he says. Whether you're dealing with less complex technologies such as cellular phones, pagers, or voice mail or more complex technologies such as computers, e-mail, or the Internet, it's inevitable for it not always to work the way you want.

Don't make the complex more complex than it already is, says Rosen. "Just because technology can do many things at the same time, this doesn't mean you have to." Rosen has a name for this too: "multitasking madness." By doing too many tasks at once, you don't pay enough attention to any one task. Much here has to do with how time has become compressed in our increasingly frenzied lives.

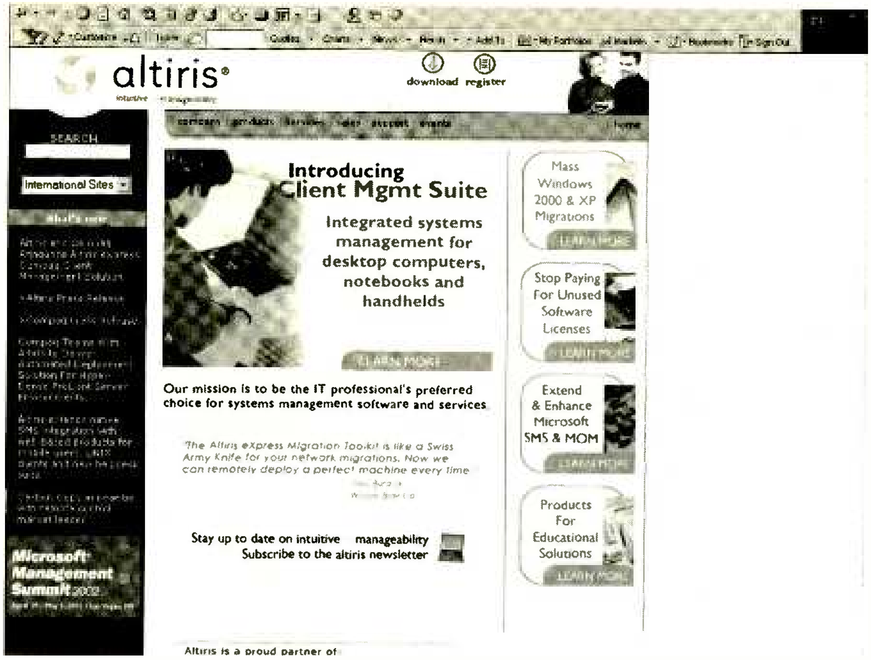
"Time is indelibly stamped on our routines," says Rosen. "This gives us an impossible yardstick to measure ourselves against. We find ourselves getting impatient for a fax to go through, which might take 30 seconds, or for computer to boot, which may take one minute."

THE POWER OF LEARNING

The irony here is that personal computers, while enabling us to get things done faster, also increase the expectation for speed. Such expectations can add pressure to an already pressure-filled situation and drive your anxiety level through the roof.

To overcome any anxiety, seek out help wherever you can, says Rosen, including your family. It may be a cliché in the information age that kids are computer mavens, but it's often true. This shifts power away from parents and toward children.

As a parent, turn this upended power structure in your family to your advantage. "Make it a positive, a way for you to be proud of your children's



If you're responsible for migrating many computers, an industrial-strength tool, such as the well-regarded PC Transplant Pro *from Altiris can automate the process.*

knowledge and for them to teach you what they know," says Rosen. "If they know how to search the Net, for instance, let them show you. Do it as a family."

In a work setting, help is crucial as well. You shouldn't be on your own here, though too often people are. A sixth of the workers Rosen surveyed received no computer training at all, while only one-third said they received excellent or very good training. Not surprisingly, people who receive good computer training have less computer stress. Rosen's work indicates that those business people who had "excellent to good" training had more positive reactions to technology. Those who received "fair to terrible" training had more negative reactions.

If you feel your training has been inadequate, find someone in your organization who knows the technology and who can speak about it in a down-to-earth fashion, recommends Rosen. Ask the person to show you one or two things the technology does. Then spend some time doing that. Don't worry about making mistakes. "If you get stuck, call your friend," says Rosen. "When you want to learn more, call your friend."

As Ralph Waldo Emerson once wrote, "Fear always springs from ignorance." Knowledge is a great antidote to fear. Once you know, you're no longer afraid.

JUST WHEN YOU THOUGHT YOU WERE SAFE...

Once you are finally in your computer comfort zone, guess what? Don't get too comfortable! The only constant with computer technology is change. No matter how at ease you are with your current PC, at some point you'll need to move on to a new one.

Perhaps you want to use programs that won't run on your old PC. Perhaps you've run out of hard disk space and memory. You can upgrade or replace these components, but with a computer more than three or four years old, it's often better to buy a new system. "Migrating" to a new PC can range from hellish to exhilarating, depending largely on how well you prepare, whether you're dealing with one PC or several hundred.

First, check if you can use your old programs and hardware peripherals with any new computer you're considering. One key is the new computer's operating system. Check the Web site of the operating system vendor. Microsoft, for instance, lets you search the "Windows Catalog" to see if programs and peripherals are compatible with its new Windows XP operating system. You can also check the Web sites of the software and peripheral vendors.

If a program or peripheral is incompatible, all is not lost. Though it will cost you, upgrading a program usually brings added benefits. With peripherals, sometimes you can overcome compatibility obstacles. In upgrading recently to a new HP Pavilion 2.0 gigahertz machine, I knew that my versatile 10-year-old Maxi Switch keyboard wouldn't work with it. It has an old keyboard-style plug, which I had been using on a newer computer with the help of a PS/2 adapter. So I bought a second adapter to let me plug the PS/2 adapter into the USB port of my brand new computer.

Belkin Components of Compton, CA, at *www.belkin.com*, sells a lot of adapters like this. You may be able to buy a Belkin adapter less expensively, as I did, from a third-party vendor such USB-Shop.com, at *www.usb-shop.com.*

POINT AND CLICK

Aloha Bob
www.alohabob.com

Altiris
www.altiris.com

Belkin
www.belkin.com

Detto Technologies
www.detto.com

Freebyte
www.freebyte.com

Laplink
www.laplink.com

Larry Rosen
www.technostress.com

USB-Shop
www.usb-shop.com

Xdrive
www.xdrive.com

FROM OLD TO NEW

Next, plan how you'll be transferring your data from the old system to the new one. You have many options. The simplest options, collectively dubbed "sneaker net," involve copying files onto floppy or Zip disks, Jazz portable hard disks, backup tapes, or writable CD or DVD discs, and then walking them from one PC to the next. With floppy disks, no single file can be larger than the 1.44-megabyte capacity of the disks unless you use a program to split up larger files into smaller pieces, such as Freebyte's free *HJ-Split*, at *www.freebyte.com.* The floppy route though is too slow unless you're moving only a few files.

With Zip and Jazz disks and backup tapes, both the old and new computer must be equipped with the same technology. With writable CD or DVD discs, the old computer must have a writable optical drive. Another option, if you're comfortable working inside a computer's case, is to remove the hard drive from the old PC and temporarily install it on the new PC. The new PC, though, has to use the same hard drive technology.

A third option is to transfer the files through the Internet using your Web space at your Internet service provider or an online storage service such as Xdrive, at *www.xdrive.com.* This method is slow, though, unless you have a cable, DSL, or other broadband connection.

One more option is to connect the two computers directly using a parallel, serial, USB, or network cable. Windows can help here. In Windows XP, the Files and Settings Transfer Wizard can transfer files and Microsoft Office settings, saving you time if you've customized these programs. You'll have to buy the appropriate cable unless you have an extra one around.

Third-party "system migration utilities" can do more, though you'll pay for the convenience. *PCsync* from Laplink, at *www.laplink.com*, comes with both a serial and USB cable. It supports 45 different programs and costs about $75. *IntelliMover* from Detto Technologies, at *www.detto. com*, supports 47 programs and costs less, about $40 for the parallel-cable version and $45 for the USB-cable version.

Aloha Bob PC Relocator from Eisenworld, at *www.alohabob.com*, costs about $40, comes with a parallel cable, and transfers entire programs. Unless you no longer have the installation discs, however, you're usually better off with fresh installations. All three programs are appropriate for home users as well as small businesses.

If you're responsible for migrating many computers, an industrial-strength tool, such as the well-regarded *PC Transplant Pro* from Altiris, at *www. altiris.com*, can automate the process. A 100-node license runs about $2000, with other license options available.

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mailto: serviceclinic@gernsback.com

SAM GOLDWASSER

Reaping Repair Resources

This and next month's articles deal with ways of locating general electronics and repair information, as well as problem-specific specifications, datasheets, manuals, and tech-tips. Since we first presented this set of topics several years ago, there have been two major trends that are worth noting—one good and one bad.

First, the Internet, specifically the World Wide Web, has become THE preferred avenue for obtaining device datasheets and related information. While it may still be possible to order printed databooks, the convenience of typing in the part number to a search engine like Google and having its datasheet link appear almost instantly as one of the top three results cannot be overemphasized. This outcome applies to virtually any widely used commercial discrete semiconductor or IC. Unfortunately, those with house numbers and more specialized ICs found in consumer electronics will probably not get the same results as easily. For those of you without Web access at home or work, libraries and other institutions are increasingly providing this service; and one can't hide from the future forever!

Note that I have attempted to confirm that all Web sites in this article are still in existence as of the writing date. However, the World Wide Web has a fundamental time constant that is on the order of 1 to 2 years. Thus, after several years, most links have decayed to below the background noise level of the Universe.

Second, the number and types of equipment that can be effectively and economically repaired are dwindling. VCRs, CD and DVD players, cell phones, pagers, and much other newer equipment is simply not designed to be repaired by anyone but the authorized service company—or not at all. Much A/V equipment is constructed so cheaply that it's lucky to last the warranty period. Compact high-tech devices are put together using surface-mount technology (SMT) and ICs that simply cannot be identified, so anything beyond an obvious bad connection probably means it is junk. Absolutely NO service information is available in any form; and the manufacturer, assuming they can be identified, couldn't care less about helping.

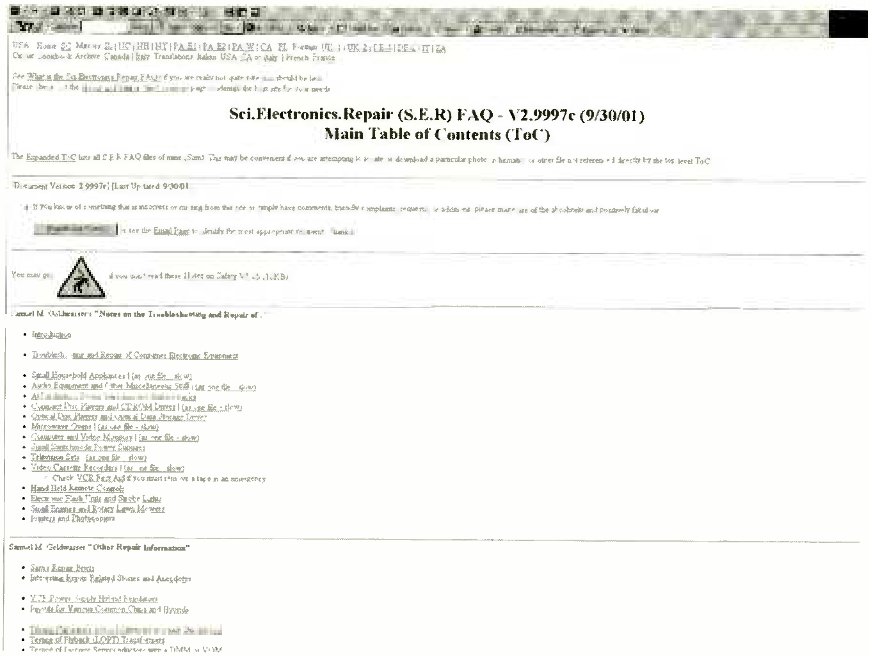

Fig. 1. Here is a snapshot of the main Repair Menu page from the Web site: www.repairfaq.org/REPAIR/.

PCs have been this way for many years, where anything beyond swapping modules is probably a futile exercise. Well, guess what? Devices like digital set-top boxes, digital video recorders, video game consoles, and digital flat-screen TVs can be added to this list. Even worse, they don't use anything resembling standard modules like PCs still do to some extent. So, forget about achieving any significant success rate repairing this and similar equipment.

The *Sci-Electronics Repair* (S.E.R) FAQ

You may have noticed that the material for the "Service Clinic" articles looks very similar to contents of the S.E.R Faq Web site, *www.repairfaq.org* (and its mirror sites). This site features my latest and greatest "Notes on the Troubleshooting and Repair of..." series of comprehensive repair guides for consumer electronics equipment and other household devices. There is also a great deal of other information of interest to the electronics hobbyist, experimenter, technician, engineer, and possibly even the dentist and poet. Included are the now quite comprehensive and massive "Sam's Laser FAQ," many new schematics, and links to over 1000 technology-related sites. In addition, there are a variety of documents from other sources on electronics troubleshooting, repair, and other related topics.

When dealing with anything more complex than a flashlight, the most important link on my repair page is the one to "Notes on Safety!" If you have easy Web access, one of the S.E.R FAQ sites should be your first stop. I try to maintain up-to-date links in the FAQs and my bookmark file (though this is often frustrating given the bit decay on the Net). Note that all S.E.R FAQ sites are totally non-commercial with no advertising or other fluff, and I do not benefit in any way from Web traffic. Come and take advantage of all the free information!

On-Line Tech-Tip Databases

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

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

In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general—this has nothing to do with any one in particular—is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem.

Therefore, an understanding of the hows and whys of the equipment along with some good old-fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

The other disadvantage—at least from one point of view—is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined or what may have caused the failure in the first place. Nor is there likely to be any list of other components that may have been affected by overstress and may fail in the future. Replacing Q701 and C725 may get your equipment going again, but this will not help you to repair a different model in the future.

One alternative to tech-tips databases is to search via Google Groups (*http://groups.google.com*) for postings with keywords matching your model and problem and the newsgroup *sci.electronics.repair*, as well.

The people who compile tech-tips databases assume you know what you are doing, at least to the extent of taking appropriate precautions to minimize the possibility of bodily harm and equipment damage. Before going inside any piece of electronic equipment, make sure you understand and follow the guidelines. If you are at all unsure of your understanding of this safety info, take the equipment to a professional for repair or buy a new one. Your life is more valuable than the few dollars you might save by doing it yourself!

Tech-Tip Web Sites

This list used to be much longer. Many of the non-commercial sites have disappeared in the last year or so.

Universal Sites.

From this site, you should be able to download a fully operational version of a database with over 115,000 tips for TVs, VCRs, camcorders monitors, microwave ovens, audio equipment, and more. It will work for 14 days and can be purchased and registered during this time. There are versions for both Windows (WinSTIPS) and DOS (SVCTIPS).

They also offer "ServiceTalk," an online discussion group for electronics repair professionals. This members-only forum has access to a subset of WinSTIPS (about 17,000 tips).

- *www.ServiceSoftware.com/prod01.htm*)—WinSTIPS and SVCTIPS Page from KDTV-Indiana Wholesale Electronics.

Another site also provides tech-tips for all sorts of equipment, but it's not very extensive.

- *www.members.aol.com/bcts1/ttt.htm*—Tech tips for technicians at the Bucks County Tech School Audio/Video Technology Web site.

Sites for Computer Monitors, TVs, and VCRs.

- *www.anatekcorp.com/techforum.htm*—Anatekcorp Tech Forum (Free)
- *www.repairworld.com/">Repair World*</A> (about $8/month)

Sites For VCRs Only.

These comprehensive tech-tips databases are currently free.

- *www.fixer.com/dbase*—Fixer. Quite extensive VCR repair instructions.
- *www.vidcam.com.au*—Vidcam. Australia, but has USA models as well.

Site For TVs.

This has quite a bit of info. Some may be free, but others require a relatively small charge (up to $25) or a monthly or other membership fee. However, this may include a personal reply from a technician experienced with your monitor, so it could be well worth it.

- *www.shophelper.net*—Shop Helper

Sites For Monitors.

- *www.members.tripod.com/~ADCC/tips.htm*—ADCC. Tech-tips of the month and 'ask a wizard' options.
- *www.metrosites.com/amr/monitor_repair_tips.htm*—AMR Monitor Repair Tips.
- *www.kmrtech.com*—KMR Technical Services Tech Support. ($19.95 charge).

Site For Microwave Ovens.

In addition to a large database of specific repairs, there is a great deal of useful information and links to other sites.

- *www.gallawa.com/microtech*—MicroTech Home Page. Everything you always wanted to know about microwave ovens.

These types of sites seem to come and go, so it is worth checking them out from time to time even if you don't have a pressing need. If possible, download and archive any useful information for use on a rainy day.

Some also include many useful links in addition to the tech-tips info, so are worth investigating even if you don't have a specific symptom to deal with! All the sites in this list were active as of the date this article was written. That's all I'll guarantee!

Manuals And FCC Numbers

Service manuals are still available for a great deal of consumer electronics. Once you have exhausted the obvious possibilities or mechanical problems, the cost may be well worth it. Depending on the type of equipment, these can range in price from $10 to $50 or more. Some are more useful than others. However, not all include the schematics so if you are hoping to repair an electronic problem try to check before buying.

ADDITIONAL SOURCES FOR SERVICE INFORMATION AND MANUALS

WEB SITES

- Bomarc Services (*www.bomarc.org*)—Reverse-engineered schematics.
- Consolidated Surplus (*www.usimperio.com/consolidated*)—Test equipment service, calibration, and manual sales and rentals.
- Cooke International (*www.cooke-int.com*)—Test equipment manuals.
- David DiGiacomo's Test Equipment Manuals Trading List (*www.spies.com/~dd/manuals.html*)—Many popular models.
- Diverse Devices (*homepages.tcp.co.uk/~diverse/man.htm*)—(UK) Manuals for test equipment, consumer electronics, etc.
- Eagan Technical Services (*www.eagantech.com*)—Reverse-engineered schematics.
- Electronix (*www.electronix.com*)—Some TV, VCR, monitor schematics.
- Marty Gasman (*www.tiac.net/users/mgasman*)—Many audio service manuals.
- Harman Kardon Service Manuals (*manuals.harman.com/hk/Service%20 Manual*)—Complete service manuals for most models.
- Infotronix (*www.infotronix.net*)—Hard-to-find and out-of-print manuals, schematics, and other information.
- K4XL's Boat Anchor Manual Archive (*bama.sbc.edu*)—Tube equipment manuals.
- Manual Merchant (*manualmerchant.com*)—Test equipment manuals.
- Manufacturer's Service Manuals (*www.acadia.net/michelle/manuals.htm*)
- Mauritron Technical Services (*dial space.dial.pipex.com/mauritron*)—(UK) Manuals, publications, CD-ROMs.
- Raymond Sarrio Co. (*www.sarrio.com/sarrio/rsfinal2.html*)—Amateur radio equipment manuals.
- SBC Manual and Schematics—(*ftp://bama.sbc.edu/downloads*).
- Treasure Chest Corporation (*www.treasurechestcorp.com*)—Owner's and service manuals for many brands.
- Triplanetary Diagrams (*www.triplanetary.freeserve.co.uk/diagrams*).
- W7FG Vintage Manuals (*www.w7fg.com*)—Manuals for ham radio and test equipment.
- Wizards Electronic Repair Center (*jc.kan.net/30.htm*)—Over 85,000 manuals.

OTHER SOURCES

- Mark Hughes (E-mail: MarkHugh@aol.com)—Copies of vintage manuals, schematics, and catalogs.
- William E. Miller (eagle@trader.com)—Used Sams' TV Repair Manuals.
- Ed Mosher, 921 Wisconsin Ave., St. Joseph, MI 49085.
- NAP, 800-851-8885—Alternative to Sams'.
- Pepper Systems, 214-353-0257.
- Synergetics Surplus, 520-428-4073.
- G. Tannenbaum, Electronic Service Data (E-mail: k2bn@agtannenbaum.com)—Parts and service data, 1920s to the present.
- Tech Systems, 800-435-1516.
- Michelle Troutman (E-mail: ai495@yfn.ysu.edu)—Reasonably priced and has many out-of-print manuals.
- US Surplus, 410-750-1083.

HEATHKIT MANUALS

- Heathkit Downloads (*ftp://bama.sbc.edu/downloads/heath*)
- The Heathkit Virtual Museum (*www.heathkit-museum.com*).

Manuals sometimes turn up at auctions—on-line (e.g., eBay and others), as well as at estate sales and the like, though hardly a way of finding exactly what you want.

Only a few manufacturers actually produce the vast majority of consumer electronic equipment. For example, RadioShack, Magnavox, and Emerson do not make their own VCRs (I can tell you are not really surprised!). House brands are nearly always the products of well-known manufacturers that are identical or very nearly identical to their standard models but repackaged or at least relabeled to reflect the store chain's name and logo. This is one reason why such lower cost products may be a good deal (but not always).

How do you determine the actual manufacturer? For most consumer electronic equipment, there is an FCC ID or FCC number. Any equipment that may produce RF interference or be affected by this is required to be registered with the FCC. This number can be used to identify the actual manufacturer of the equipment. A cross-reference and other links can be found at *www.repairfaq.org/REPAIR/F_FCC_ID.html* (FCC ID Numbers Cross Reference).

Sam's PHOTOFACTs

Sams' (no relation) is Sams Technical Publishing (formerly Howard Sams & Company), who publishes circuit diagrams and service info for just about every TV sold on this planet since the 1940s. *Sams' PHOTOFACTs* schematics and service literature are published by Sams Technical Publishing, 5436 W. 78th St., Indianapolis, IN 46268-3910; 800-428-SAMS; *www.samswebsite.com.*

You can search the Web site to determine if they have a folder for your model. Service info. (E:facts) for most models manufactured after 1992 is available in electronic form (currently for about $11). These are similar to the print *PHOTOFACTs* but may be ordered on-line and will arrive via e-mail within one business day.

These folders of service information have been published for over 45 years (I don't know for how long, but I have a set for a 1949 portable three-inch Pilot TV—about as portable as an office typewriter if you remember what one of those was like) and are generally the best, most consistent source of service info for TVs, radios, some VCRs, and other consumer electronics.

There are some *Computerfacts*, but the number of these is very limited. The *VCRfacts* are also somewhat limited, and the newer ones tend to have strictly mechanical information.

Sams' PHOTOFACTs are often available (for photocopy costs) from your local large public library, which may subscribe to the complete series. If not, a large electronic distributor can order the selected folder for you.

NOTE: I have heard that some of the *PHOTOFACTs* recently purchased directly from Sams Technical Publishing/ Howard Sams have been poor photocopies with illegible scope waveforms rather than original printings. If this is the case, it is truly the end of an era and too bad. In any case, try to confirm the quality before you buy or get your info from the library.

Inside Cover Of The Equipment

Television sets and even old radios often have some kind of circuit diagram pasted inside the back cover. In the old days, this was a complete schematic. Now, if one exists at all, it just shows part numbers and location for key components, occasionally some test points and voltages—still very useful. Some TVs—as recently as ten years ago, maybe even now—included a complete schematic with the product information and owner's manual. I have a 1984 Mitsubishi that came with a very nice, high-quality multi-page schematic.

However, it's the very occasional exception rather than the rule anymore for A/V equipment. Microwave ovens do almost always have a schematic diagram of the microwave power-generation circuitry pasted inside the sheet-metal cover. This diagram will generally include at least the high-voltage transformer, interlocks, rectifier, capacitor, and magnetron. Since most microwave oven problems are in these areas, it's all you are likely to need. The controller, especially for electronic units, is often omitted or only covered superficially.

Reverse Engineering Your Own Schematics

Of course, most of us have had the need to reverse engineer equipment. This is probably not realistic for a multilayer PC mainboard. Even for something as complex as a TV or computer monitor, it may not be that difficult; and, in some cases, it's the only option. I generally do this by going component by component and determining all the connections to each of them. The initial drawing will be a total mess—a spaghetti diagram. Once the wiring has been determined, I redraw the circuit (you've seen enough of them in these pages!). Everyone who does this more than once probably has their favorite technique to make the task easier.

There are a few companies who do this for resale such as Bomarc and Eagan. (See Sidebar). However, the cost and accuracy can vary greatly (and they may not be correlated!), so it may be better to do your own.

Wrap-Up

Next time, we'll look at other aspects of finding information about electronic components as well as other Internet resources. As always, I welcome inquiries via e-mail at sam@repairfaq.org or through the feedback form on my Web site *www.repairfaq.org*. **P**

TIPS FOR MAIL ORDER PURCHASE

It is impossible for us to verify the claims of advertisers, including but not limited to product availability, credibility, reliability and existence of warranties. The following information is provided as a service for your protection. It is not intended to constitute legal advice and readers are advised to obtain independent advice on how to best protect their own interests based upon their individual circumstances and jurisdictions.

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

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

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

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

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

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

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

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

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BASIC CIRCUITRY

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES

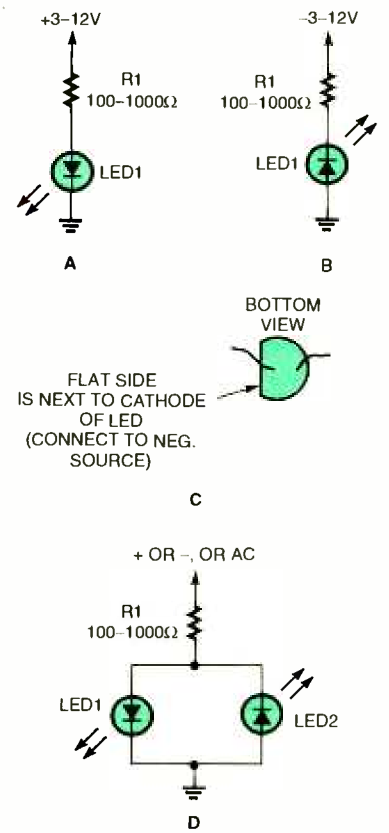
Protect Your LEDs —And Save The Tears

Download These Circuits From www.electronicsworkbench.com/poptronics

Put your seat belt on and get ready for a ride into the world of basic electronic circuitry. Hop aboard and see where it takes us this month—enjoy the journey.

Back To Basics

LEDs are found in almost everything that's electrically operated. They come in many colors, sizes, and shapes; and all are somewhat similar to the array of silicon diodes that have been around for decades. However, there are some notable differences.



PARTS LIST FOR THE BACK-TO-BASICS CIRCUITS (FIG. 1)

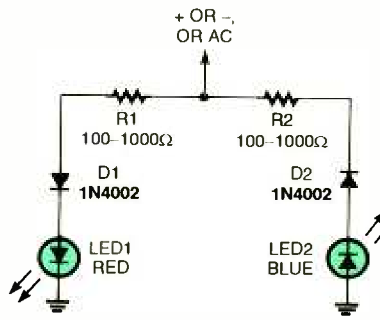
LED1, LED2—Light-emitting diode, any color
R1—100–1000-ohm ¼-watt, 5% resistor

Rectifier diodes are constructed to withstand relatively high reverse voltages, while LEDs are not and can be easily damaged by reverse voltage. Also, most silicon diodes that are rated with reverse voltages below 1000 volts have a forward voltage drop of about .6 volts when the diode is conducting. The average forward voltage drop of an LED is closer to 2 volts, and the actual voltage is determined by the LED's color. Interesting, isn't it?

The typical red LED's forward voltage drop is from 1.7 to 2.4 volts, while yellow, green, orange, and clear LEDs are between 2.1 and 2.8 volts. The blue color is the stepchild of LEDs, with a forward voltage rating of nearly 5 volts. Also, the blues are very sensitive to static electricity, and since they go for about $5 each—ouch!— they need to be protected. (See Fig. 1 for basic LED circuits.)

Figure 1D shows a safe circuit for all LED colors except blue. The blue's forward voltage drop can be as high as 5 volts, which is too great for the reverse voltage rating of most other LEDs. Generally, common LEDs can withstand a reverse voltage of about 4 volts; when used together as in Fig. 1D, no reverse voltage damage will occur. Replace one with a blue LED, and its 5-volt forward drop may possibly damage the remaining common LED.

A simple protection circuit is shown in Fig. 2. Each LED is powered through its own current-limiting resistor, allowing each to be individually protected from reverse-voltage damage by a series silicon diode.

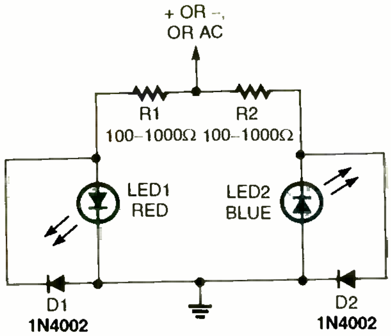


PARTS LIST FOR THE SIMPLE PROTECTION CIRCUIT (FIG. 2)

D1, D2—1N4002, or similar, silicon diode
LED1—Light-emitting diode, red
LED2—Light-emitting diode, blue
R1, R2—100–1000-ohm, ¼-watt, 5% resistor

The circuit in Fig. 2 may be used as a polarity indicator in a balance circuit or other circuitry requiring a simple method of indicating the type of input source. A positive source will light LED1, a negative source will light LED2, and an AC source will cause both to cycle on and off at the input frequency. At 60 Hz, both LEDs appear to be on at the same time.

Another circuit (see Fig. 3) uses shunt diodes to protect the LEDs from reverse voltage damage. A silicon-rectifier diode is connected across each of the LEDs in the reverse position. This setup restricts the maximum reverse voltage for each LED to only .6 volts, which is a very safe and inexpensive way to keep the LEDs



PARTS LIST FOR THE SHUNT-DIODE PROTECTION CIRCUIT (FIG. 3)

D1, D2—1N4002, or similar, silicon diode
LED1—Light-emitting diode, red
LED2—Light-emitting diode, blue
R1, R2—100–1000-ohm, ¼-watt, 5% resistor

healthy.

Orphan and junk-box LEDs generally will operate safely with a forward current of about 20 mills; however, unless you know the manufacturer's specifications, it's impossible to know the maximum power rating.

One method I use in determining a safe operating current for an unknown LED is to vary the input current until no increase in brilliance is observed; then, I reduce the current about 10% and use that value for the absolute maximum-operating current. This method may not be 100% foolproof, but it does allow the use of orphan LEDs.

Blow The Fuse And Save The Tears

While we're using a silicon rectifier to protect LEDs, let's look at a reverse-voltage protection circuit that could save big $$$$. Believe me, I've seen tears in the eyes of high dollar ham equipment owners who connected their rig up backwards to the DC power source. They would have saved themselves, if they had only added a single silicon-rectifier diode to their equipment (see Fig. 4). The diode's current rating should be greater than the fuse rating, and the reverse-voltage rating should be several times the supply source. As a general rule, I would use a 15-amp or higher rated diode for a circuit that is equipped with a 10-amp fast-blow fuse. For slow-blow fuses, I would double the current rating of the diode.

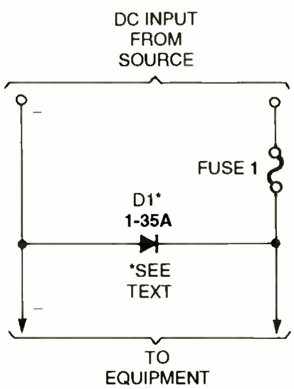


Fig. 4. This simple reverse-voltage protection circuit will save money and aggravation.

Before moving on, here's another simple method (see Fig. 5) of protecting DC-operated equipment. This method is only useful if the DC power-source output voltage is at least .6 volts greater than the connected equipment requirement. The diode's current rating should be at least 25–50% greater than the equipment's maximum current demand.

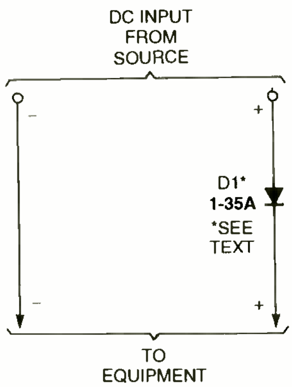
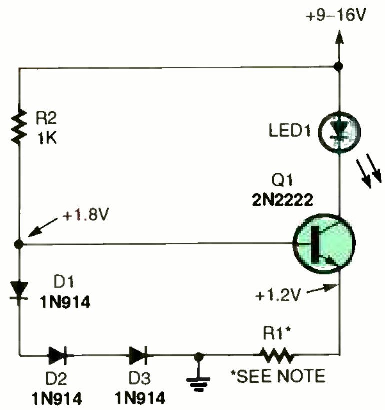


Fig. 5. The circuit shown here is designed to safeguard DC-operated equipment.

One item we did not cover in our previous LED discussion was a simple current-limiting circuit for operating LEDs with different input voltages. The simple constant-current circuit shown in Fig. 6 is an inexpensive way to add current-limit protection to an LED indicator circuit. The three series-connected diodes make up a reference voltage that maintains Q1's base at about 1.8 volts. The emitter maintains a constant voltage of about 1.2 volts. The emitter resistor, R1, determines the constant current level, R=1.2/I. The resistance value required for an LED current of 10 mA would be 1.2/.01 or 120 ohms. A 20-mA current would require a 60-ohm resistor for R1.



*NOTE: R1 = 120Ω FOR 10mA
R1 = 60Ω FOR 20mA
I = 1.2V/R1

PARTS LIST FOR THE CONSTANT-CURRENT CIRCUIT (FIG. 6)

D1–D3—1N914 silicon diode
LED1—Light-emitting diode, any color
R1—See text.
R2—1000-ohm, ¼-watt, 5% resistor

It Doesn't Add Up—Or Does It?

Take two like transistors and connect them as one and what do you have? Behemoth gain! The two-transistor configuration (see Fig. 7) is known as a Darlington pair with an hFE gain figure equal to the product of the two. If each transistor has an hFE gain figure of 150, then the Darlington pair has an hFE gain figure of 22,500—not too shabby for two general-purpose transistors. The Darlington transistor pair can be made up of two NPN or PNP transistors or ordered ready-made from most electronic supply houses. Darlington transistors come in various power levels, from signal to multi-amp switching types.

An application that the Darlington

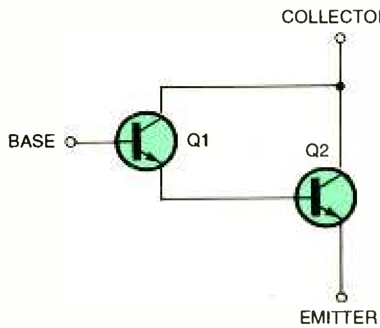
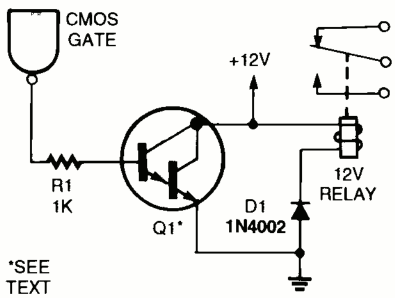


Fig. 7. The Darlington pair circuit can convert a micro-amp input signal into a hefty control output.



PARTS LIST FOR THE RELAY-DRIVER CIRCUIT (FIG. 8)

Q1—2N6043 or 2N6284, see text.
D1—1N4002 silicon diode
Relay—12-volt power relay, see text.
R1—1000-ohm, ¼-watt, 5% resistor

transistor can handle with ease is converting a micro-amp input signal into a hefty power-controlling output. The Darlington transistor can take the wimpy output of most any CMOS device and control relays, motors, and other high current DC loads with ease.

A relay-driver circuit is shown in Fig. 8, which uses a low-priced NPN 2N6043 Darlington transistor to supply operating current to the relay coil. DC motors operating at several amps can be controlled with a high-power Darlington, such as the 2N6284 in the T03 metal case. Reverse-voltage protection is handled by D1, which clamps any negative voltage spike that would likely damage the transistor. As in any circuit application, the semiconductor device used must be able to easily handle the circuit's voltage and current demands. Always select a device that is capable of doing at least 25 to 50% more than the job requires. Safety factors are either forgotten or pushed to their limits in many of today's products, resulting in premature failure. Murphy is always standing by, ready to smoke a circuit if given a chance. Outfox him with added safety factors in all of your circuits.

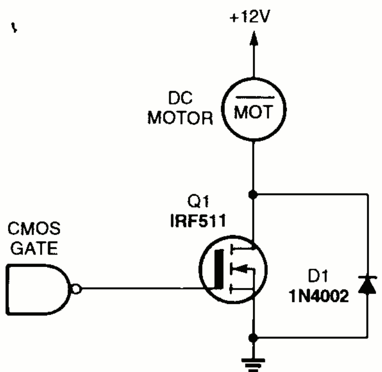


Fig. 9. The HEXFET transistor in this motor-control circuit can operate a 1-amp DC motor.

The power HEXFET is another wonderful semiconductor device that easily handles this type of job. The input-current requirement of a typical HEXFET, operating at DC or at a very low frequency, is zero—for all practical purposes. This situation allows a very low output device to easily drive a HEXFET.

A simple on/off motor control circuit is shown in Fig. 9. The IRF511 HEXFET is rated at 4 amps with a maximum reverse voltage rating of 60. This device can easily operate a 1-amp DC motor. A DC motor that normally operates at 1 amp often requires several times that amount to start turning, especially under a load condition. The diode, D1, protects the HEXFET from reverse-voltage damage when the motor is turned on and off.

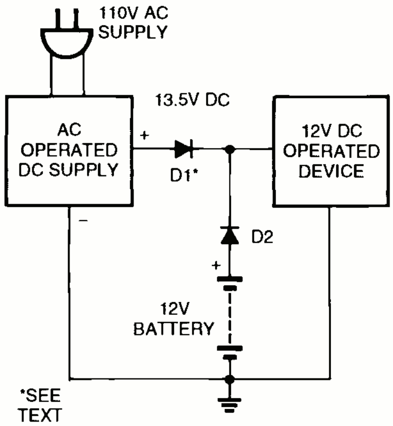


Fig. 10. Here is an example of using diodes in a standby-power circuit.

Another Diode Job

The diode stands tall among its semiconductor siblings, ready for duty in so many applications. Diodes make it easy to add a standby-power source to just about any AC-operated equipment that is internally designed for DC operation. Typical equipment would include computers, security systems, fire alarms, safety lights, and any other equipment that must function when the AC power fails.

A two-diode standby-power circuit is shown in Fig. 10. Without the standby circuit, the AC-operated DC power supply would be connected directly to the equipment and would operate normally from the AC source. Diode D1 blocks the positive battery voltage from getting into the AC-operated supply when the AC power has failed. Diode D2 blocks the positive power supply from reaching the battery during normal AC operation. However, when the AC power fails, D1 blocks the battery's output from entering the AC supply, and D2 allows the battery to supply power to the equipment. Be sure that both diodes are at least 1.5 times normal current flow.

When the AC power is restored, the reverse occurs—D1 passes power to the equipment, and D2 blocks the battery's output. Proper operation requires that the AC-operated supply outputs a slightly higher voltage than the battery. If not, the battery could end up supplying some of the equipment's power during normal operation, reducing its effectiveness during a power outage.

Hopefully, getting back to some very basic circuits didn't turn out to be a boring experience. Many of the problems we encounter in electronics can often be solved simply and easily. Maybe one of the circuits we shared today will do just that. In any case, hang in there, 'cause we'll be back next month with something entirely different to play with.

May your circuits never fail! **P**

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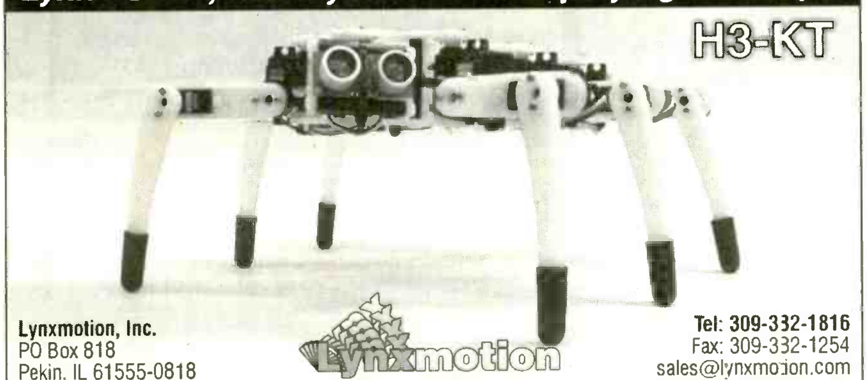

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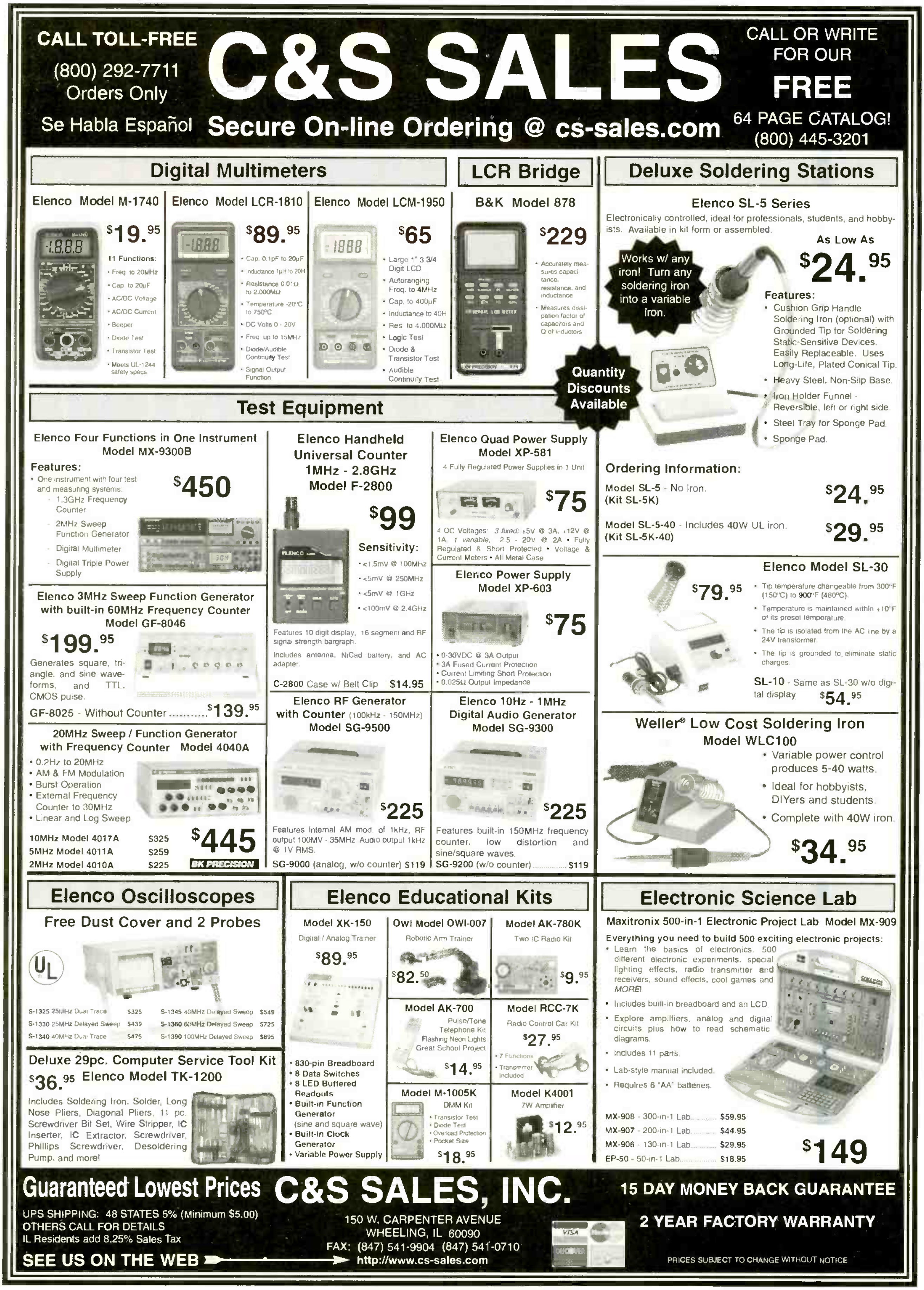
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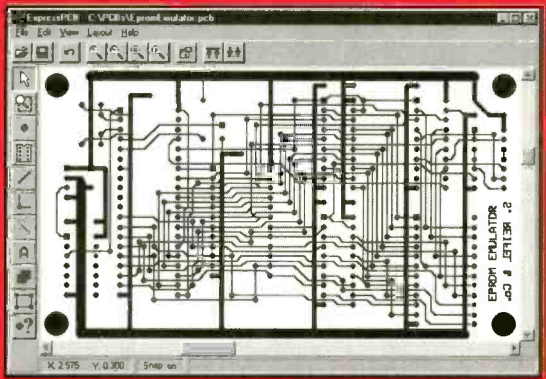

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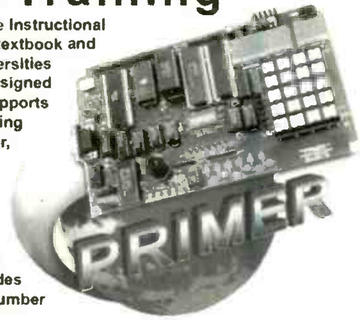

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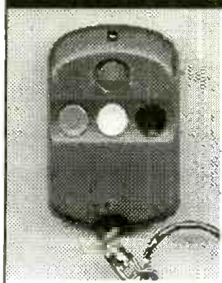

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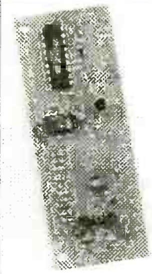

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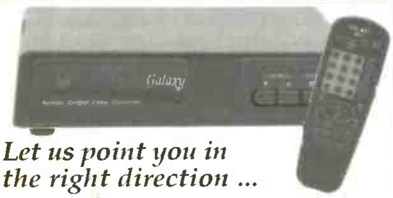

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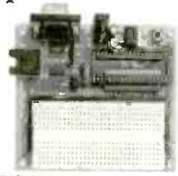

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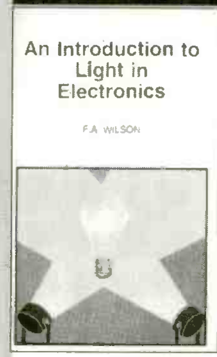

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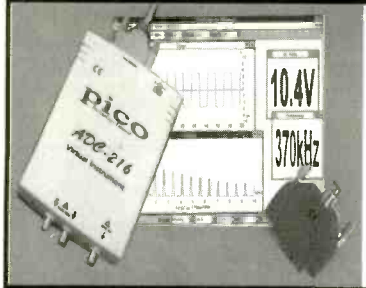

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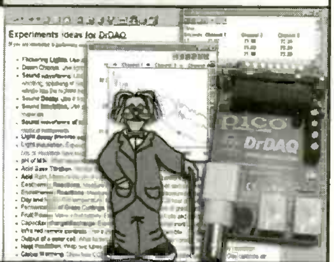

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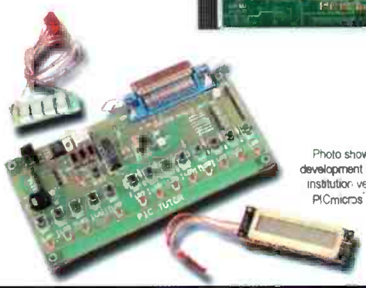

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