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APRIL 2002

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# Poptronics®

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*The ALP can sample and loop audio, as well as remote-key a transmitter.*

**THE VISIE-TALKIE** .....Grego Banshuk 24  
*A classic re-printed from April 1945's **Radio-Craft**. Take note of the author's name.*

**BUILD THIS HOME APPLIANCE WATT METER/WATT-HOUR METER** .....Fernando Garcia 32  
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*Here are some quick and basic projects to inspire even the most jaded inventors.*

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# Hide and Hugo Seek!

We decided to have some fun this month by playing a game with our readers. The name of the game is Hide and Hugo Seek, and it's easy to play and win. Three images of Hugo Gernsback's head have been hidden within the pages of this issue. All you need do is find the three heads, write the page numbers where they were found on a postcard, and mail the postcard to: **Hide & Hugo Seek, 275-G Marcus Blvd., Hauppauge, NY, 11788.** There will be twenty contestants randomly chosen from all the correct entries that have been postmarked no later than April 30, 2002. Winners shall receive a prize package of various goodies from Uncle Hugo's Voltage Vault. No purchase is necessary, so if you cozy up with a copy of **Poptronics** at your local bookseller or library, you can play too! So, what are you waiting for? Go find Hugo's head.

In other news...the latest boom in technology is sure to be focused around fuel cells. Readers may remember the fuel-cell series that appeared in "Amazing Science" during February, May, and June of 2001. Author John Iovine told our readers about the various versions of these alternative fuel sources, and then he even showed us how to make our own energy-yielding cells. Now, everywhere from Texas to Tokyo, investors are backing ventures that are researching and developing alternative forms of energy that would incorporate fuel cells. Japan's National Space Development Agency (NASDA) and Tokyo's Institute for Laser Technology are working together to develop one such project, "New Sunshine." Mashiro Mori of NASDA told members of the Associated Press about this program, and how it would employ *Low Earth Orbit (LEO)* satellites that would collect solar energy to be fed to a *solar pump*. The solar pump transfers photons of sunlight into a solid-state laser. The laser amplifies the sunlight into approximately ten megawatts of energy. Finally, the laser is aimed at a tank of seawater that has been treated with a breakdown catalyst (titanium dioxide). The tank also has an optic array mounted above it for concentrating the incoming beam fired from the LEO satellite. The resulting blast of energy would be used to rip apart water molecules. This is only one of several alternatives to ordinary electrolysis. Opponents have argued over the fact that it takes electricity to create electricity in the case of electrolysis. Another popular alternative is the so-called "bug-batteries," which use living microbes to break down various hydrogen-yielding compounds. What's this mean to us? Well, experts don't foresee a widespread availability of fuel-cell cars until at least 2010, but there is no doubt in my mind that fuel-cell companies, cooperatives, and ventures will be popping up like prairie dogs. By the way, this is April's issue and we've included our traditional April Fool's feature. This time we relied on an old pro of the goof genre. The joke's on us though, because as absurd as this story scudded over fifty years ago, fantasy became reality.

Happy Reading,



Chris La Morte  
Managing Editor

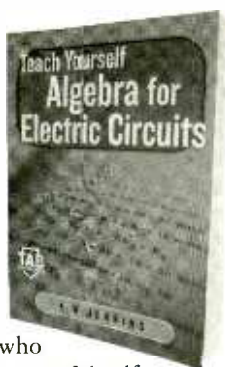
# NEW LITERATURE

## Teach Yourself Algebra For Electric Circuits

by *K. W. Jenkins*  
 McGraw-Hill  
 Two Penn Plaza  
 New York, NY 10121-2298  
 800-2MCGRAW  
 www.books.mcgraw-hill.com

**\$34.95**  
 This self-tutoring guide, specially geared for those who work with electric circuits, is a useful self-enrichment tool for upgrading math skills and learning the methods that support today's technological growth. It contains hundreds of practical problems with detailed solutions as well as over 300 illustrations for easier comprehension. Also included are circuit-focused applications and special

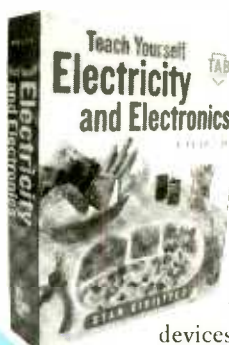
help with the algebra of logic and matrices.



## Teach Yourself Electricity and Electronics, Third Edition

by *Stan Gibilisco*  
 McGraw-Hill  
 Two Penn Plaza  
 New York, NY 10121-2298  
 800-2MCGRAW  
 www.books.mcgraw-hill.com

**\$34.95**  
 Learn the fundamentals of computing, communications, robotics, and entertainment devices through this introductory course in electronics. The text offers a user-friendly, independent-study approach, complete with practical examples, learning-enhancing illustrations, and test-yourself questions. Perfect for both hobbyists and students, this edition presents simple circuit design, new information on wireless technologies, advanced applications in artificial intelligence, and more.



## Digital Electronics Guidebook

by *Myke Predko*  
 McGraw-Hill  
 Two Penn Plaza  
 New York, NY 10121-2298  
 800-2MCGRAW  
 www.books.mcgraw-hill.com

**\$34.95**

Intended for electronics hobbyists and students who want to understand digital logic, this book features more than 20 projects for designing, constructing, and interfacing TTL (Transistor-Transistor Logic) circuits. From constructing your own simple 8-bit computer to creating and debugging applications, the author explores the art of digital electronics through

step-by-step instructions and demonstrations of project-assembly techniques.



## The Audiophile's Project Sourcebook

by *G. Randy Slone*  
 McGraw-Hill  
 Two Penn Plaza  
 New York, NY 10121-2298  
 800-2MCGRAW  
 www.books.mcgraw-hill.com

**\$29.95**  
 The clear, illustrated schematics and instructions provided in this book allow audio enthusiasts to build high-quality, high-power electronic audio components and testing equipment. The author gives easily comprehensible explanations of the electronics at work, as well as a practical foundation needed for experimentation and modification of existing audio equipment. Other projects include voltage amplifiers, balanced input driver/receiver circuits, graphic equalizers, and effects circuits.



## Robots, Androids, And Animatrons, Second Edition

by *John Iovine*  
 McGraw-Hill  
 Two Penn Plaza  
 New York, NY 10121-2298  
 800-2MCGRAW  
 www.books.mcgraw-hill.com

**\$19.95**

Build your own walking, talking, thinking robot with the projects covered in this book on amateur robotics. Providing you with the building blocks of electronics and motion control, the book enables you to construct a robotic arm that responds to your spoken command, put together basic modules to create sophisticated robot designs of your own, and more. First-time robot builders and advanced hobbyists can complete these projects without programming or assembly language skills.







# YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES



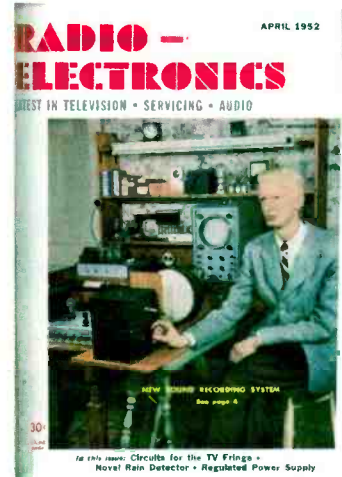
1900

1910

1930

1940

1952



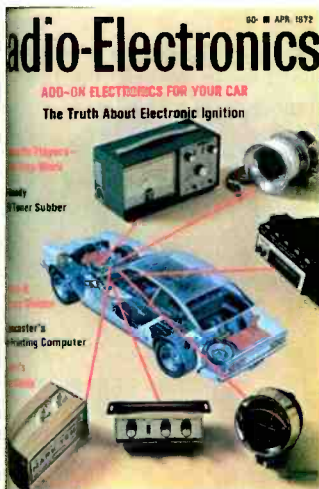
## Dateline: April 1952 (50 years ago)

In this issue, a **Radio-Electronics** editorial on collision-proof cars begins to explore the possibility of electronically-controlled cars. Brakes programmed to activate when a car comes within two or three feet of another object would be installed on the front fender, therefore limiting collisions. In the "Theory and Engineering" section, Mohammed U. Fips humorously shows how sound can be neutralized by a dead-beat heterodyne. Readers also learn how to make a rain detector that sounds an alarm with a single drop and how to construct a voltage-regulated power supply.

1960

## Dateline: April 1972 (30 years ago)

Summer months usually mean more time in the car. In this issue, **Radio-Electronics** gears up readers with add-on electronics for a more comfortable ride. Articles explain how to soup-up your car in time for vacation with ignition systems, RPM limiters, Dwell stretchers, or cassette players. For those who prefer to stay indoors during the hot months, other articles explore the difference between amplitude and tilt controls for the television, how to tell if the tuner is bad, or a way to develop a new surround sound system, from any direction, using omnisonics.



1972

1980

## Dateline: April 1992 (10 years ago)

This issue of **Popular Electronics** is devoted to improving the quality of at-home technology, without spending a fortune. For \$25 or less, readers learn how to construct an enlarging light-meter for more professional darkroom print developing. The quality of low-budget audio projects is enriched with bass and treble booster controls, and guidelines are presented for choosing the best all-around audio equipment. In addition, combining an agitator with an imbalanced motor and a heat lamp makes it easier and quicker to etch printed circuit boards.



1992

2000

# NEW GEAR

For more information go to page 80A

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## Illuminating Measurements

AEMC introduces two new lightmeters, *Models CA811* (\$119) and *CA813* (\$165), that measure illumination on four ranges in either footcandles or lux, from .1–20 kfc/klux. The CA813 also features a fifth range of 200 klux for higher sensitivity and responds better to common light sources. The two meters have a removable, optical sensor designed to match the response of the human eye. They include a 3½-digit back-lit LCD, as well as PEAK, HOLD, and MAX functions.

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## Hand-Held Radiation Detector

Taking a versatile and durable hand-held radiation monitor into the field is essential for measuring alpha, beta, and gamma rays. The *Gamma-Scout Radiation Detector* (\$330) measures all three at 4-, .2-, and .02-MeV, respectively. Field applications and data logging are simplified with the on-board memory and serial port, along with an extra-large, easy-to-read LCD display mounted on the face of the Novodour housing. The Gamma-Scout also features a Geiger-Muller tube detector and comes with an ultra-long-life 10-year battery.



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## Generating A Pulse

Expanding on its already extensive Model 500 series of digital delay/pulse generators, BNC has added the *555 4-Channel Digital Delay Generator* (\$2270) to the list. The 555 Generator provides pulses of 2, 4, or 8 with a 1-ns resolution. Each output can be individually adjusted by programming the controls from the front panel or via the GPIB or RS232 interface. Other adjustments, such as setting the delay from 0–100 seconds, are made this way, too.

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## Then There Was Color

It took 25 years for color to be added to televisions to enhance the viewer's experience. It took only two years after the launch of the ScopeMeter 190 Series of handheld oscilloscopes for Fluke to add two full on-screen color test tools. The *196C* (MSRP \$2695—without software) and *199C* (MSRP \$2995—without software) help make identification and differentiation of individual waveforms considerably easier while maintaining and improving the capabilities previously featured within the series, from a faster update rate to a new triggering mode.

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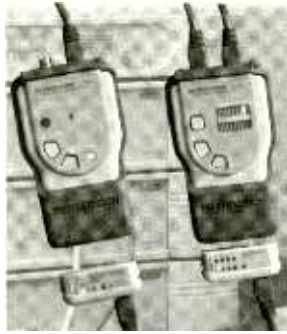
## Network Cable Testers

The *Model 230A Multi-Network Cable Tester* (\$69) and the *Model 231A Deluxe Multi-Network Cable Tester* (\$79) are portable, lightweight, and battery-powered. They can be used for testing cables such as 10Base T, 100Base Tx, 356A, Token Ring, and more. Both models feature a protective rubber boot, belt clip, and a built-in remote terminator-storage compartment. The accompanying remote unit allows the user to test installed cable either from the wall plate or patch panel.

### B&K PRECISION CORP.

1031 Segovia Circle  
Placentia, CA 92870-7137  
714-237-9220  
www.bkprecision.com

**CIRCLE 65 ON FREE  
INFORMATION CARD**



## High-Temp Wire Connectors

Designed for applications in high-temperature conditions up to 150° C (302° F), these *Hi-Temp Wire Connectors* (from \$5.50-\$10.50 per bag of 100) are fire-retardant and heat-resistant. The high-dielectric, thermoplastic shell provides superior flash-over protection and prevents exposure of bare wire. Available in four sizes, these connectors are perfect for HVAC, automotive, consumer, electrical, and industrial applications.

### GARDNER BENDER

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

**CIRCLE 67 ON FREE INFORMATION CARD**

## Sound-Off

A two-scale, direct-reading decibel meter allows the *Sound Level Meter* (#30387-32) (\$160) to be used in home, at school, or for industry. The low-scale indication ranges from 40-80 dB, while the high scale ranges from 80-120 dB. This lightweight and compact test tool features a battery check and calibration settings, along with a 1- X 2-inch window.



### SCIENTIFICS

#### Edmund Scientific

Dept. A021-C999  
60 Pearce Ave.

Tonawanda, NY 14150  
716-874-9091 or 800-728-6999  
www.scientificsonline.com

**CIRCLE 66 ON FREE  
INFORMATION CARD**

## AC Multitester

The open-jaw clamp-on feature of *Model 38393 AC Multitester* (\$79) enables the user to test one wire after another in a circuit box or control panel without opening and closing the jaws. It measures AC current to 200 A, resistance, frequency, capacitance, and duty cycle. Unique twin LCDs (2000-count ammeter and 4000-count multimeter) display AC current and test-lead function simultaneously. Other specs include data hold, continuity beeper, diode, and relative for non-current function.

### EXTECH INSTRUMENTS

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



**CIRCLE 68 ON FREE INFORMATION CARD**

## Bit Driver

Featuring an extra-strong magnet for safe bit retention, this ¼-inch hex *Bit Driver* (\$25) meets safety standards and has been tested for use up to 1000 V. The tool comes with six ¼-inch hex bits—one 0.31 slotted, one 0.47 slotted, two Phillips #1, and two Phillips #2. It may be used with most 1-inch long ¼-inch hex drive bits, and the six-bit storage compartment with the rotating window in the handle allows easy bit selection.

### JENSEN TOOLS

7815 S. 46 Street.  
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](mailto:requests@berkshire-is.com)

## Mobile XM Antenna

XM Satellite Radio provides a huge selection of digital, commercial-free music and talk radio channels. The *TRK-SR1* antenna (\$99.95) helps you listen to XM radio in your car. It attaches to a rear or side window using a special acrylic adhesive for a simple, "no-drill" installation. The antenna passes DC power and RF signals through the glass surface to an interior coupler that is then hard-wired to the XM receiver. Everything required for installation is included, as is a protective sleeve for use in car washes.

Terk Technologies Corp., 63 Mall Dr., Commack, NY 11725; 631-543-1900; [www.terk.com](http://www.terk.com).

CIRCLE 50 ON FREE INFORMATION CARD

## Hands-Free Car Talk

There are no tangled cords with the *EarBoom Winder* (\$34.95), compatible with any mobile phone with 2.5mm jacks and with Nokia 8000/3000 series phones. It lets you talk hands-free and then retract the cord and stow the EarBoom at the touch of a button. The device can be clipped to a belt, purse, or pocket to keep it in easy reach. It includes six EarGels—a pair each in small, medium, and large. EarGels fit comfortably inside the ear, boosting and channeling sound directly into your ear canal.

JABRA Corporation, 9171 Towne Center Dr., #500, San Diego, CA 92122; 800-327-2230 or 858-622-9955; [www.jabra.com](http://www.jabra.com).

CIRCLE 53 ON FREE INFORMATION CARD



## Medicine Reminder

How do you keep track of the pills and vitamins you take on a daily basis? If your hit-or-miss method results in more misses than hits, look into the *Automatic Vitamin & Pill Organizer* (\$69.95). Delivering the proper dosage at the press of a button, it can be programmed for a week's worth of four doses per day or 28 days of single doses. An alarm clock beeps, a light blinks, and a message flashes on the LCD when a dose is due; and the scheduled pills rotate into position to be released into the handy cup.

The Sharper Image, P.O. Box 7031, San Francisco, CA 94120-9703; 800-344-4444; [www.sharperimage.com](http://www.sharperimage.com).

CIRCLE 52 ON FREE INFORMATION CARD

## In-Wall Speakers

Get room-filling sound without filling the room with large speakers, with the *CAS Series Model 3.1* in-wall loudspeaker (\$1500 each). The Baffle Isolation System prevents the speaker from transferring vibrations to the surrounding wall, reducing resonance and providing superior clarity. The three-way speaker uses Ceramic Metal Matrix Diaphragm technology in its 9-inch woofer, 3½-inch midrange, and 1-inch tweeter. This technology is said to deliver unmatched clarity and tonal accuracy throughout its frequency range. This easy-to install



unit's Listening Window Selector lets you tailor its performance for smooth frequency response throughout the listening area.

Infinity Systems, Inc., 250 Crossways Park Dr., Woodbury, NY 11797; 800-553-3332;

[www.infinitysystems.com](http://www.infinitysystems.com).

CIRCLE 51 ON FREE INFORMATION CARD

## Progressive-Scan Video Processor

Designed for use with 31.5-kHz display devices, progressive-scan monitors/receivers, flat-panel display systems, DTV monitors, and front- or rear-projection systems, the *TB-6001 TrueScan Progressive Scan Display Interface* (\$800) accepts any NTSC S-video, composite-video, or component-video source. With reversed 3-2 pull-down processing for any film source, the device corrects for the different frame rates used in film and video for performance that is free of motion artifacts, jagged edges, and redundant or wrong fields. Special 2-2 pull-down processing offers crisp video images, and 4:4:4 video-processing technology doubles the horizontal resolution for greater picture detail.



Proton U.S.A., 13855 Struikman Rd., Cerritos, CA 90703-1031; 562-404-2222; [www.proton-usa.com](http://www.proton-usa.com).

CIRCLE 54 ON FREE INFORMATION CARD

## HDTV Monitor

The handsome 34PW9847 34-inch direct-view HDTV monitor (\$4499) has a black high-gloss finish and features a matching stand with an integrated analog clock. Its flat picture tube creates a distortion-free, crisp image. Digital Natural Motion, progressive scan, line doubling, and Active Control features enhance the image; and the Pronto universal touchscreen remote rounds out the home-theater experience.

Philips Consumer Electronics; 64 Perimeter Center East, Atlanta, GA 30346; 770-821-2400; [www.philips.com](http://www.philips.com).

CIRCLE 55 ON FREE INFORMATION CARD



## Powered Up

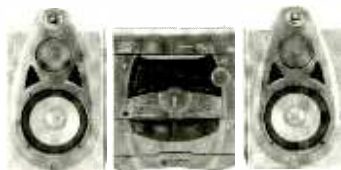
Providing big sound in small spaces, the RL-28W (\$499) powered subwoofer features unique, stacked dual 8-inch woofers in a slim-profile cabinet. Powered by a robust 200-watt rms discrete amplifier, the subwoofer delivers dramatic bass response measured from 35 to 120 Hz ( $\pm 2$  dB). It offers continuously variable output and crossover controls, allowing its sound to be precisely matched to other components.

Cerwin-Vega, 555 East Easy St., Simi Valley, CA 93065-1805; 805-584-9332; [www.cerwin-vega.com](http://www.cerwin-vega.com).

CIRCLE 57 ON FREE INFORMATION CARD

## Big-Sounding Mini-System

The Soundgear SG-3030 high-performance mini-system (\$399) is equipped with a three-disc CD changer and a full-logic dual-well cassette deck. The distinctively styled system boasts 200 watts of power and three-way loudspeakers. Patented VMAx digital signal processing produces realistic, three-dimensional surround-sound audio using just two speakers. The system includes an AM/FM tuner, clock with sleep timer



and dual wake-up alarms, and three-position EQ and Bass Boost controls.

JBL, Inc.; 250 Crossways Park Drive, Woodbury, NY 11797; 800-336-4525 or 516-496-3400; [www.jbl.com](http://www.jbl.com).

CIRCLE 56 ON FREE INFORMATION CARD

## Mobile Amp

Get your car rocking with the XA4300 (\$229.95) four-channel mobile amplifier, which provides 100 watts  $\times$  2 and 50 watts  $\times$  2 into a 4-ohm load (150 watts  $\times$  2 and 75 watts  $\times$  2 into 2 ohms). The amp can be bridged to provide 300 watts to one channel, while still providing 50 watts  $\times$  2 rms—ideal for powering both subwoofers and satellites from the same amp. Other features include a remote bass control, a selectable crossover, and variable bass boost.

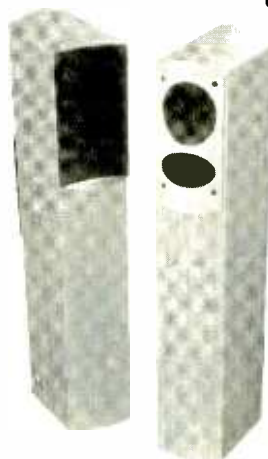
JENSEN Car Audio, 2950 Lake Emma Rd, Lake Mary, FL 32756; 407-333-8900; [www.jensenaudio.com](http://www.jensenaudio.com).

CIRCLE 58 ON FREE INFORMATION CARD



## Taking the Floor

Bose might be known for tiny, inconspicuous speakers and components, but it's no slouch when it comes to floor-standing speakers, either. The 701 Series II (\$998) speaker system features patented Direct/Reflecting speaker technology for balanced stereo sound. The speakers deliver deep, powerful bass without the port noise or compression often found with conventional speakers, and dedicated amplification gives low frequencies even more impact. The 701 is compatible with amplifiers up to 300 watts per channel, rated 4 to 8 ohms.



Bose Corporation, The Mountain, Framingham, MA 01701-9168; 800-444-BOSE; [www.bose.com](http://www.bose.com).

CIRCLE 59 ON FREE INFORMATION CARD



## 1-GB CompactFlash Card

The world's highest capacity standard CF Type I CompactFlash card to date, with an amazing 1-gigabyte of memory, is able to store more than 1000 digital images, more than 20 hours of digital music, or several hours of video. The 1-gigabyte CompactFlash Card can be used in digital cameras, music players, and other portable electronic devices. Priced at "less than \$800," you might expect it to come with one or more of those items, but huge storage capacity doesn't come cheap!

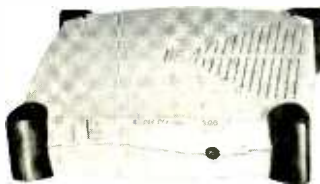
SanDisk Corporation; 408-542-0500; [www.sandisk.com](http://www.sandisk.com).



## Jack of All Trades

Combining the most often used office equipment into one space-saving unit, the *KX-FLM551* (\$419.95) serves as a plain-paper fax, a copier, a PC scanner, a telephone, and a 10-page-per-minute 600-dpi laser printer. The fax portion, with 14.4-kbps modem, has a 100-station auto dialer for sequential broadcasting. The scanner includes *OCR-Read-Iris 5.5 PRO* software, which recognizes text in up to 55 different languages.

Panasonic Consumer Electronics Company; 201-348-7000; [www.panasonic.com](http://www.panasonic.com).



## Compact Power Protection

Aimed at SoHo computer systems, the *Ellipse Premium* uninterrupted power supplies (UPS) (starting at \$220) are only three inches deep, yet pack enough battery power to keep a Windows NT server running for an hour (depending on configuration). An advanced voltage regulator allows the UPS to ride through deviations in input voltage without discharging the battery during momentary brownouts. The 650, 800, and 1200-VA models each include *Solution-Pac* power-management software for Windows 95/98/2000, NT Novell Netware, SCO Unix v.3.0 and Openserver 5.0, and Linux.

MGE UPS Systems; 800-523-0142; [www.mgeups.com](http://www.mgeups.com).



## PC Phone Home

The *Maestro Pocket PC* (\$649) connects easily with an Audiovox CM-9100 cell to provide complete Internet access without the need for an add-on modem or an additional wireless ISP. The small, lightweight unit features both 32 MB of SDRAM and 32 MB Flash ROM, as well as built-in CompactFlash and SD card slots. It's equipped with an Intel Strong ARM 206-MHz processor and Windows-powered *Pocket PC 2002* software. Packaged with the cell phone, *Maestro* is being offered through wireless carriers.

Audiovox Corporation; 800-229-1235; [www.audiovox.com](http://www.audiovox.com).



## Home Networker

Home computer users can now access the Internet from two different computers at the same time without running any cables, using the *Hewlett Packard/RCA H950 SystemLink* (\$249.95) and existing electrical wires and outlets. The external USB-to-powerline network adapter allows shared Internet access, remote printing, multi-user game playing, and transferring and sharing files. It sends digital signals over existing wires at rates of up to 2Mbps. The expandable system can handle up to 20 computers with add-on SystemLink nodes. The basic package includes two plug-in nodes, two parallel cables, two USB cables, and software.

Thomson Consumer Electronics; 317-587-4450; [www.rca.com](http://www.rca.com).

## Business Buzz

### ROOT TRACER

Genealogy enthusiasts can make sure their family trees are accurate at [www.FamilyTreeDNA.com](http://www.FamilyTreeDNA.com), which now offers 21-marker Y-chromosome DNA testing to analyze for genetic matches between males, and mitochondria (mtDNA) testing for females. A perfect match in the 21-marker DNA test indicates that the two subjects share a Most Recent Common Ancestor (MRCA) within 8.3 generations. The tests help people connect with relatives when the conventional paper trail ends, allow individuals to determine if they have a common ancestor, and help verify the accuracy of surname-based family tree projects. When two test subjects show identical markers, they are notified of the results (provided both parties have signed a release form).

### ONE-Gbit NAND FLASH CHIP

Toshiba and SanDisk have introduced the first commercial one gigabit NAND flash memory chip, effectively doubling the amount of storage that the companies can put in their flash memory cards. The new chip will be manufactured with the same multi-level cell (MLC) technology currently used to produce the 516-Mbit NAND, which allows two bits of data to be stored in one memory cell. Two 1-Gbit dies also can be stacked in a single TSOP (thin small outline package) to produce 2 Gbits of memory. Use of MLC technology in embedded chips or removable cards is expected to greatly expand the storage capacities of cell phones, digital cameras, MP3 players, and streaming audio and video.

### FLEX-FUEL PICK-UP

General Motors is offering the first full-size pick-up truck with the option to operate on ethanol (E85) fuel. Ethanol, a renewable fuel made from starch crops including corn, produces less air pollution than gasoline. E85 vehicles meet the U.S. Department of Energy's stringent mandates for alternative fuel-powered vehicles. The E85 compatibility feature will be available in 2002 as a special equipment option on select 1500 series Chevrolet Silverados and GMC Sierras equipped with the 5300 Vortec engine. Monsanto Company, a global provider of technology based solutions and agricultural products, already has ordered 50 E85 Silverados.

## Building a Better Bandage



Research Team Leader Professor F. Joseph Schork holds a bottle of biocompatible skin barrier that, when applied like a bandage over an infected wound, lets in air and water while guarding against germs.

**H**ow can you keep an infected wound clean and treat it in harsh battlefield conditions? Researchers at the Georgia Institute of Technology are developing a gel designed to treat soldiers suffering from infected burns or abrasions in isolated areas where no other medical equipment is available.

### A Second Skin

When the new liquid emulsion—called biocompatible skin barrier—is applied to a wound, it acts as a sort of second skin, forming a protective layer that is permeable to air and water, but keeps out dangerous microorganisms. The gel also contains control-released antimicrobial agents to actively treat the wound. The gel can be either sprayed or rolled on to create a translucent, durable layer that allows the wound to be examined as it heals, without removing the barrier. The gel layer could endure rain, mud, and other conditions for as long as two weeks.

### Stepped-Up Testing

Developed at Georgia Tech's School

of Chemical Engineering under the leadership of Professors Jan W. Gooch and F. Joseph Schork, the gel is undergoing clinical trials at the U.S. Army Institute of Surgical Research at Fort Sam Houston in San Antonio, TX. The recent military action in Afghanistan has changed the original timetable for completion, and human clinical trials were moved up to early 2002.

"It is imperative that the most advanced, life-saving innovations accompany the troops," Gooch said. "We must



Professor Schork injects a polymer sample into a gel permeation chromatograph to determine its molecular weight and quality.



# TYPE

recognize the unique needs of our armed forces for as many advances as possible in the area of trauma medicine and treatment delivery." FDA approval could come in less than a year.

The gel is expected to have benefits for civilian disaster victims or burn victims, as well.

**PT**

## Who's Using the Net?

It's a rainy Sunday, and you've just crossed off the last item on your wife's "Honey, do" list. With the afternoon looming ahead, do you grab the remote and make a beeline for the easy chair and some channel surfing or head into the den toward the PC and some Net surfing?

Chances are, the TV will come out the winner (especially if you're a sports fan). Yet, according to the UCLA 2001 Internet Report, the Internet is making inroads into America's TV-viewing time. Internet users—and more than 72% of Americans had Internet access in 2001—watch 4½ hours less television each week than those who are not Web surfers. If an anti-social, geeky image arises in your mind, banish it. The study also found that Internet users get more exercise and spend more time with their families than do non-users.

### Charting The Net Results

The last time a new technology with the potential to change the way our society interacted, learned, shopped, and was entertained—namely, television—was introduced, not many people viewed it as an instrument that would change the very fabric of our culture. No one bothered to embark on a comprehensive study of the impact it would have on our lives and our society.

Researchers at the University of California Los Angeles (UCLA) are making sure the early years of Internet use do not go unexamined. Beginning on June 8, 1999, UCLA launched an in-depth exploration of how computers, information technology, and their users

are shaping and changing society. "The UCLA study will provide the first long-term exploration of how life is being transformed by computers and the Internet, with year-to-year comparisons of the social and cultural changes produced as people use this extraordinary technology," said Jeffrey Cole, director of the UCLA Center for Communication policy and principal investigator of the study. Dubbed "Surveying the Digital Future," this study is also the first to analyze these broad questions about the Internet on a global scale.

Funded by the National Science Foundation, AOL, Microsoft, Disney, Sony, GTE, Pacific Bell, and the National Cable Television Association, the study will survey Internet use in over 2000 American households and, in conjunction with international partners, in Europe, Asia, Latin America, and Africa, as well. UCLA's Center for Communication Policy will conduct the U.S. survey and will coordinate the global partner projects to be directed by teams in each country.

### "Surveying The Digital Future"

In the U.S. study, the same 2000 households will be surveyed each year, tracking changes in Internet use as the technology evolves and noting both direct and indirect effects of the Internet on life and society. "For example, the automobile initially made it easier to visit grandma on Sunday afternoons; before long, it contributed directly to the suburbanization of America. The Internet will have direct effects on the behavior of individuals, but will also inspire a host of other changes, many of which are unimaginable today." Of special interest are those households currently unconnected, which will provide "before-and-after" scenarios once they begin using the Internet.

Although the overall study was designed as a long-term project, annual reports will analyze current findings and trends. The 2001 UCLA Internet Report, titled "Surveying the Digital Future," compares the responses of Internet users and non-users, and new-

## Research Notes

### SETI AWARDS

The SETI (Search for Extraterrestrial Intelligence) League received Technology Achievement Awards from the Central PA Chambers of Commerce for two engineering projects: The Lunar Reflective Calibration Beacon for Radio Astronomy won second place in the "Best Application of Technology" category, and the Array2k: Phasing Multiple Antennas for a Next-Generation Radio Telescope placed second in "New Technology Projects." The "Moonbounce" Beacon reflects microwave signals off the surface of the moon. The earth-moon-earth beacon allows amateur and professional radio astronomers to calibrate their receiving systems by providing a stable reference signal emanating from a known point in the sky. The Array2k design combines 16 or more standard satellite TV antennas into a single, powerful radio telescope.

### LIFE IN THE NANO-FAST LANE

When molecules move through liquid—just like when you try to move through traffic—it's easier and quicker in the fast lane. Scientists at Pacific Northwest National Laboratories (PNNL) have shown that liquids have a nanoscale "fast lane," a discovery that could be crucial to future nanoscale devices. Using a "soft landing ion system," PNNL researchers measured motion at the molecular level in organic solvent films and found that the solvent's outer surfaces were considerably less viscous than their interior.

### VACUUM CLEAN-UP

The U.S. Department of Energy's Los Alamos National Laboratory is using a giant vacuum to clean up contaminated sediments from the south fork of Acid Canyon in New Mexico, where treated and untreated radioactive liquid waste was discharged for 20 years, beginning in 1944. Despite previous attempts to clean up the most highly contaminated areas, the Los Alamos County-owned property, home to hiking trails and a skateboard park, still contains several isolated "hot spots" along the streambed. The \$1.2-million cleanup project will remove between 200 and 300 yards of contaminated soil and sediment, depositing it, and any dust generated, in specially designed containers for disposal at the Laboratory's low-level radioactive waste-disposal area.

bies (less than one year online), experienced, and "very experienced" (five or more years) users. It also compares 2001 results with those from the previous year's report. Five major areas were covered: who is online and who is not, media use and trust, consumer behavior, communication patterns, and social and psychological effects.

## So, Where Do We Stand?

Internet use is widespread and growing—72.3% of Americans have access to the Internet (up from 66.9% in 2000), and users spend an average of 9.8 hours a week online (up from 9.4 hours). On a scale of 1 (not at all satisfied) to 5 (completely satisfied), the Net rated an overall score of 4. The most satisfying feature of the Internet is users' ability to communicate with others. Teenagers, in particular, find the Internet an easy way to interact with friends and strangers. Users in every age group said that e-mail made it easier to keep in touch with people they don't usually speak to otherwise. In addition, the 18.8% of users who said that they had met someone in person whom they had originally met online averaged six new friends met in person in 2001, up slightly from 2000.

Of those households that are not online, most cited "no computer" or "lack of access to a computer" as the reason—and 44% of non-users expect to be online within the next year. Only 21.4% said they had no interest in using the Internet (down from 33.3% in 2000).

## Money Matters

Of course, the dot-com crash could not be ignored. "The broad issue we considered in 2001 was: How did a back-drop of economic meltdown affect users and non-users of the Internet? Would Internet users lose faith in online technology? Would Internet use decline? Did the collapse of the Internet boom affect online purchasing and other use?"

Internet shopping remains strong, despite the atmosphere of economic turmoil. In 2001, 48.9% of Internet users made a purchase online, down slightly from 50.7% in 2000. Shifts away from traditional retail buying were substantially lower in 2001, with 52.8% saying that online purchasing has "somewhat reduced" or "reduced a lot" their pur-

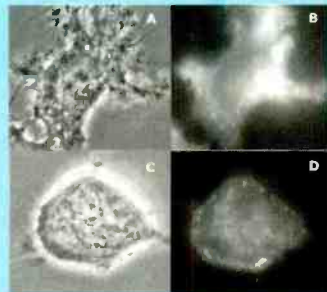
## ► Quantum Dots

**A new process developed by researchers at The University of Texas at Austin could lead to advances in biomedical products ranging from hearing-aid implants to robotic prosthetics. They were able to bond tiny semiconductor crystals known as nanocrystals or "quantum dots" to nerve cells. Cadmium sulfide quantum dots, measuring about one four-thousandth the width of a human hair in diameter, stick one-on-one to human brain neurons, tethered by a short protein chain called a peptide.**

**Professor of Biomedical Engineering Christine Schmidt and Brian Korgel, a chemical engineering professor whose specialty is growing nanocrystals, collaborated on the project, with key research performed by doctoral candidate Jessica Winter. Schmidt described the process as a modification of a "standard chemistry recipe," substituting the single peptide for two much longer protein antibodies. While most work in the realm of biological-electronic interfaces has involved comparatively large silicon-based electrodes and larger tissue areas, Schmidt said, "Our goal was to gain more molecular specificity, to target specific receptors on the cell surface."**

**Next, the team will attempt to establish communication between the biological and non-biological systems. Previous efforts by other groups to attach quantum dots to human cells have concentrated solely on silicon-based dots intended for use as inert dyes. "But we're working toward putting these quantum dots on nerve cells and then generating local electrical fields that will influence the cells to 'talk' to the dots," said Korgel. Because the dots are semiconductors, they become active in the presence of an electrical field.**

**Once the cells and dots are able to communicate, quantum dots one day could work as the interface between a wide array of new microelectronic biomedical applications, such as prosthetic limbs that could "communicate" with the neural cells of the people using them.**



This magnified image shows quantum dot attachment to neurons using antibody- (A, B) and peptide- (C, D) binding techniques. In B and D, the self-fluorescence of the cell's cytoplasm is visible as one color and the quantum dot luminescence is another color.

PT

chases from retail stores (compared to 65.2% in 2000). Fewer Internet shoppers said they expect to eventually make many more purchases online (43% compared to 54.5 in 2000). Not surprisingly, 43.3% agree or strongly agree that adding sales tax for online purchases would reduce their Internet shopping.

"Several trends about online buying continue to develop—especially regarding credit card security—that could have major effects on the evolution of Internet commerce," Cole noted. In both 2000 and 2001, users expressed deep concerns about credit-card security. Nearly all new users (98.6%) had some worries about credit-card safety when shopping online. Very experienced users are somewhat more comfortable, but not much—89.1% express some concern, and 57.2% remain very or extremely concerned.

"Americans have widely divergent views about credit-card security when used in traditional purchasing compared to online shopping," Cole said. "Restaurant patrons who think nothing of leaving a signed credit card receipt on a table in a busy café are nevertheless extremely concerned about online security. Without question, broad shifts in perceptions about Internet security must occur before online purchasing can truly flourish."

## Privacy, Please

Privacy is an issue that transcends credit-card security. More than half of Internet users and close to three-quarters of non-users agree or strongly agree with the statement that "people who go online put their privacy at risk." When or if they purchase goods online, 94.5% of all surveyed express some concern about the privacy of their personal infor-



mation. Worry about fraud and deception rank among the top reason that users cite for putting off their first online purchase, and 10% of ex-users say that they stopped using the Internet entirely due to privacy concerns.

### Wired Kids

When the researchers asked adults for their opinions on their children's use of the Internet, the results were largely favorable. For example, 88.2% said the kids were spending the right amount of time, or too little time online; 96.5% said that their children's grades had stayed the same or improved since using the Net; and 91.8% said the children spend the same amount of time, or more time, with friends. However, both users and non-users agreed that children could gain access to inappropriate material online.

In most cases, family time has not been adversely affected by Internet use. Only the "more experienced" users reported spending less time with family than before they went online. New users, very experienced users, and non-users all reported about the same amount of time spent in family activities such as eating dinner and playing games or sports together. In fact, the only "family" activity that appears to suffer from Internet use is television viewing. In 2001, 23% of the adults reported that their kids now watch less TV than before they began using the Internet. Non-users watch the most TV (10 hours a week). Newbies clock 9.4 hours, and very experienced users watch only 6.7 hours of TV a week. **PT**

## Spin Doctoring

One of the fundamental questions pondered by physicists is: Where do protons get their spin? Spin is a property of elementary particles as basic as mass and electrical charge. Researchers at the U.S. Department of Energy's Brookhaven National Laboratory (BNL) are using the facility's largest particle accelerator to investigate that question. The Relativistic Heavy Ion Collider (RHIC) has accelerated beams of polarized protons to the highest energy ever and is experimenting with colliding the beams.

"These will be the first-ever experiments where the protons in two colliding beams are all spinning in a controlled direction," said Thomas Roser, head of the Brookhaven



Thomas Roser, Naohito Saito, and Gerry Bunce with a quadrupole magnet once used in the Alternating Gradient Synchrotron (AGS), which feeds beams of polarized protons into the RHIC.

accelerator group running the project. The program was jointly initiated by BNL and Japan's RIKEN-BNL Research Center. Collaborators from other national and international laboratories have worked to develop the RHIC spin program. They hope to learn more about the structure of matter and the strong force that holds together the components of protons.

A lot is already known about protons. They are made of smaller particles called quarks, which are held together by emitting and absorbing particles called gluons, the carriers of the "strong" force. Gluons can be likened to strong springs that connect the quarks. All of these particles have an intrinsic property known as spin, which is some-



A specialized set of magnets called Siberian snakes were built. Their corkscrew-like design causes the direction of the magnetic field to spiral along the direction of the beam.

what similar to the Earth spinning on its axis.

Questions still exist. Although physicists have long believed that a proton's spin was simply the sum of the spins of its three component quarks, the quarks account for only about 20% of the proton's spin. So what accounts for the other 80%?

The most likely scenario is that the gluons also somehow contribute to the spin. "Unlike any previous experiments, collisions of spin-aligned (polarized) protons at RHIC will allow us to tease apart the individual contributions of both the quarks and the gluons," said Gerry Bunce, the Brookhaven physicist leading the spin program. Beams of polarized protons allow scientists to use the quarks in one beam to probe the properties of the gluons in the other beam. The products resulting from a very-high-energy collision between a quark in one beam and a gluon in the other beam—subatomic particles and energy—can reveal the properties of the colliding pair, including the gluon's spin. RHIC's PHENIX and STAR detectors will analyze the collision products to produce this information in complementary but overlapping ways. Another detector will explore the force between the colliding protons and analyze how the force is affected by spin.

One difficulty is keeping the beams polarized. After initial polarization, the beam moves through five accelerators, all composed of magnets that can interfere with the polarization because spinning protons are like tiny magnets. The solution to this problem is a specialized set of magnets called Siberian snakes, whose corkscrew-like design causes the direction of the magnetic field to spiral along the direction of the beam. In each of RHIC's two 2.4-mile-circumference rings, two snakes are located at opposite sides. As the beam moves through the snakes, the magnetic field flips the polarization, or direction of the spin, and simultaneously averages out many smaller effects of the accelerator magnets. This allows the team to maintain stable polarization. In addition, spin rotators, which allow scientists to select the spin direction at the collision points, and polarimeters that measure the exact degree of polarization were used. **PT**

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## CREATING YOUR OWN Web Site

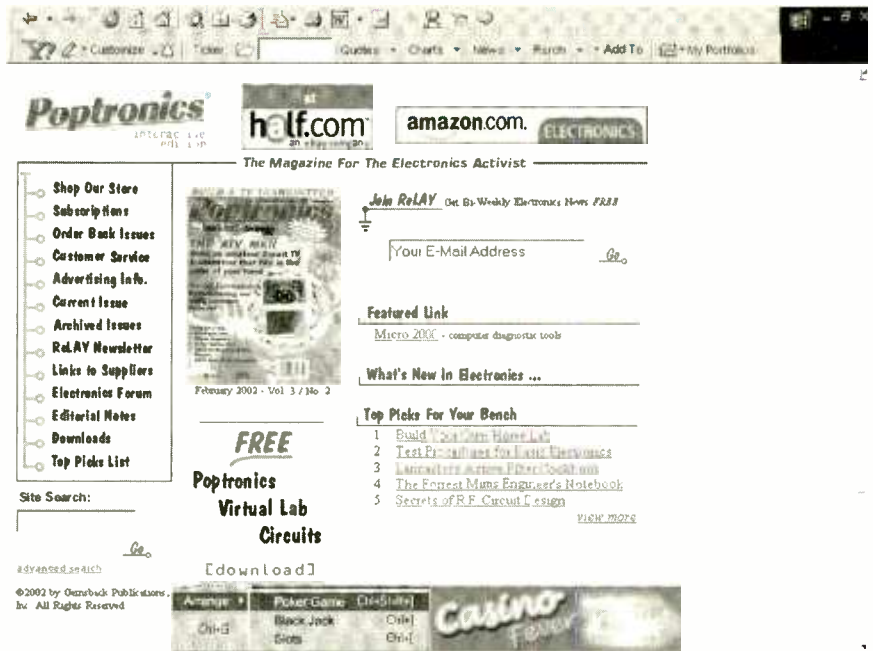
Looking to jump on the Dot Com bandwagon? The world of e-business is hopping with new opportunities, improved services, and easier applications and procedures. Anyone at any level of computer comprehension can start his or her own Web site. From finding an appropriate domain name to designing and running your site, the process has become much simpler and more straightforward over the past couple of years.

We will cover almost everything you need to know about starting your own Web site, from the initial steps of establishing your domain name to creating and setting up your site on the Internet. Whether or not you are a computer genius is practically irrelevant. That's like saying you should be a skilled superintendent in order to run a business out of an office building. There are experts in the field just waiting for you to give them the go-ahead. They will take your hand and guide you through the details, assisting you every step of the way, ready to answer all of your many, many questions.

### THE PROCESS

Where, exactly, do you begin? First, you need to outline your objectives. What is it that you want to do or accomplish? What are your goals? This article will focus mainly on those individuals who are interested in running some kind of online business, although those of you who simply want a Web site for personal use or public service will benefit as well.

After you have a plan in mind, such as what it is you want to sell, how much of it you plan to sell, and how you see your business progressing in the future, then you can begin to think of a name for your site.



Above is a screen capture of the Poptronics Web site. Whether you are developing a site for commerce or simply to share your views with the entire World Wide Web, there are plenty of resources available that can give you the inspiration and knowledge needed to create a successful site.

### THE DOMAIN-NAME GAME

The domain name, or Web site name, is actually an integral part of your site's success. From Internet searches to ease of remembrance, the name you choose is vital to your business. There are literally hundreds of domain-name registration sites that will search available Web site names for you, and then register the one you finally decide on—providing it isn't already taken. Some of these companies are listed in the "Source Information" section at the end of the article.

This part of the process can be fun, challenging, and truly exhausting. Since the name you give your Web site is so crucial, you should devote some time and thought to finding the perfect one. Beware, however, since there will

most likely be some complications along the way.

Let's say you have discovered a state-of-the-art weight loss plan, and you plan to market and sell it through a Web site. At first, you'll be extremely excited to register your "jellybelly" exercise program. You can picture the graphics, the logo, the packaging. Then you find out that "jellybelly" is taken. Dismayed, but not yet hopeless, you think of another neat name: "chunkymonkey." Again, you are let down—that name is also not available. So after hours of brain-strain, you muster up other names, names that are not so thrilling, but acceptable. At the end of it all, you settle for "flabbybabs," a far cry from what you originally envisioned.

The lesson here is this: Think of a couple of dozen names before you log on to the registration Web site. The process of typing each name on the screen and searching for its availability is tedious and grueling enough; but if you don't have back-up names on hand, you will begin to feel frustrated and disgusted, as well. It is remarkable that so many millions of names are taken. Don't take the registration process for granted. You may think that your name is so unique that no one else in this entire world would ever think of it—but think again.

The cost of a domain name should run in the ballpark of \$3 a month (plus the \$20 or so for the hosting company, which we will get into a little later.) The most common extension, and most familiar to the general public, is “.com.” There are other extensions including “.net,” “.org,” and other up-and-coming ones such as “.biz,” “.info,” and “.name.” Though they are less popular at the present time, these may prove to be appropriate choices in certain instances. It would be a good idea to look into the benefits and disadvantages of all of them. A wise decision, though a bit more costly, would be to scoop up all of the extensions. Just because your Web site is called “chicchefs.com”, doesn't mean there won't be a “chicchefs.biz” popping up in the near future.

Also, try to pick a domain name that is easy to spell and pronounce. You also want to refrain from using words that can be spelled or understood two different ways, such as: “tail” and “tale,” “buy” and “bye,” and “sent” and “scent.”

One last rule of the name game is to make sure the name is right for your business. There is a fine line between limiting yourself too much and not being clear about what it is your Web Site does or sells. For example, Yahoo, Monster, and Amazon all cleverly picked names that were catchy, yet potentially limitless in flexibility. Remember, though, that these megagiants have a tremendous marketing budget and have spread their name through the Web like wildfire.

You want to pick a name that will not stifle your ability to expand your business—like naming your site *niftysocks.com*—as you might decide to sell hats, scarves, and slippers in the future. Don't be too vague, however, as this could work against you. Picking a name like “Google” just wouldn't have

the same desired effect for most of us.

## AND YOUR HOST IS...

A Web host places your Web site onto the Internet through an outside server. Only in very rare instances would you attempt hosting the site yourself. Self-hosting a site requires a high-grade computer with lots of memory and disk space, and a technical person to oversee the server 24/7—it's just not practical for most people.

Your best bet is to find a company—and there are hundreds out there—who will host your site for you. These out-sourced servers have extensive memory and disk space, 24-hour monitoring to limit downtime (host's servers are almost never down), customer support, and security features to protect you from hackers.

There are many desirable features to bear in mind when choosing a Web host. Though many of them offer very similar packages, you want to narrow down one that is right for you. Here are some conditions to guide you through the selection process:

- **Customer Support**—There is nothing more frustrating than running into a technical glitch, or needing an answer to a question pronto, and there is no one around to ask. Most of the more established sites offer ongoing support at all hours of the day and night, and they are usually staffed with knowledgeable, helpful representatives.
- **E-commerce Capabilities**—Many hosting companies can also provide a shopping cart and secure online payment system. If you plan to engage in monetary transactions through your Web site—if customers are paying for items with credit cards—then both of these features are essential.
- **Disk Space**—Most small e-business Web sites take up less than 10MB of file space. Actually, most use between 1 and 3MB. Just be sure that your Web host can provide you with the 10MB to be safe, as you don't know what the future holds for your site.
- **Data Transfer Allowance**—This refers to the amount of traffic passing through your Web site, or the

amount of files that are viewed each month. Typically, Web hosts allow for a certain amount of traffic (1 or 3GB of data allowance per month, for example) with overages subjected to additional charges. Similar to deciding on a telephone-calling package for your home phone to complement your calling habits, you should use a host who will fit your traffic needs.

## LET'S CREATE A WEB SITE!

Now for the fun part—creating your Web site. If you have some basic computer skills and you are up for a small challenge, you may want to consider building your Web site yourself. One of the most popular Web design software packages, *FrontPage 2002*, is a very affordable (around \$100), user-friendly program that has everything you need to build your own site. *FrontPage* is so commonly used that most hosting companies even provide special customer support for *FrontPage* users to assist them in uploading their site to the Internet.

Although *FrontPage* comes with a basic manual, you will need the book *FrontPage 2002: The Complete Reference*, which provides detailed instructions and guidance through the program's more complex components.

If you think you'd like to become an expert Web site designer and have some extra time on your hands to learn more advanced capabilities, then HTML may be a valuable tool. Do understand, however, that HTML is not at all necessary. *FrontPage* is a comprehensive and more than adequate

## SOURCE INFORMATION

Here is a sample of companies who provide Web services:

### Domain Name Registration

[www.domain.com](http://www.domain.com)  
[www.domaindirect.com](http://www.domaindirect.com)  
[www.networksolutions.com](http://www.networksolutions.com)  
[www.register.com](http://www.register.com)

### Hosting Companies

[www.hosting.com](http://www.hosting.com)  
[www.hostindex.com](http://www.hostindex.com)  
[www.hostsearch.com](http://www.hostsearch.com)  
[www.interland.com](http://www.interland.com)  
[www.verio.com](http://www.verio.com)

### Web Designers

[www.bizbuyer.com](http://www.bizbuyer.com)



program and can provide most of the "bells and whistles" you'd be looking for in a professional Web Site.

Once your Web site is a completed work of art, you still have to publish it onto the Web. It doesn't just magically appear on the World Wide Web once you have designed it. You should contact the company you registered your domain name with, and they will instruct you in connecting your site to the Web.

## CALLING ON OUTSIDE HELP

There are some good reasons why you may consider calling upon the experts to design your Web site for you. Maybe you need a higher level of sophistication, like customized functions, high-end graphics, database integration, and more. Maybe you just don't want to tackle the construction of a Web site—there's a good chance you are just too busy.

On average, Web designers charge around \$1000 to create a typical 5–10 page site. The real dilemma is finding one you want to work with. You can start by asking around. A personal reference is usually a good bet, since you can find out all the details about your prospective creator.

If you dare to type in "Web designer" on a search engine, expect to scroll through hundreds, maybe thousands, of listings. That is why it is important to keep certain criteria in mind during your search.



Take a look at their portfolio. I don't mean the big black leather art case you see artist's lugging about on interviews. I mean visit some of the sites they have created. Have them give you a sample list of Web sites that they consider is their best work. Do they appeal to you? Is that what you are looking for in a Web site?

Ask for a list of previous customers. Ask the following questions of their clients: Did they stick to the schedule? Were they easy to get a hold of? Did they provide the service you expected? How pleased are you with the outcome?

Of course, compare services and

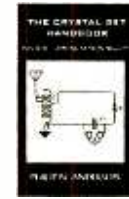
prices when you finally narrow down your search. Cheaper isn't necessarily better. Make sure that you are being offered quality work, and that the prices are fair. Remember that your Web site is going to be on view for the entire Internet world.

## AND OFF YOU GO!

You should now have some vague understanding of this whole Web site creation business. At first, as with anything you are unfamiliar with, it seems like a dense cloud of confusion. With a little bit of insight and a whole lot of

motivation and patience, you could be well on your way to owning a piece of the World Wide Web! P

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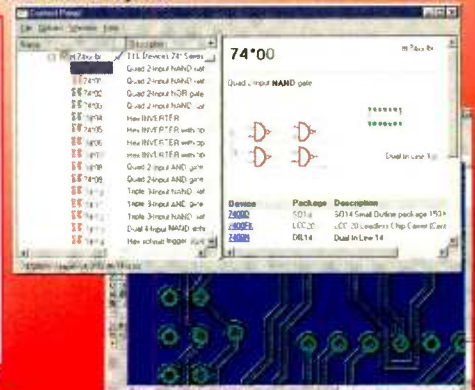
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## MONSTER WORKSTATION: PART 2

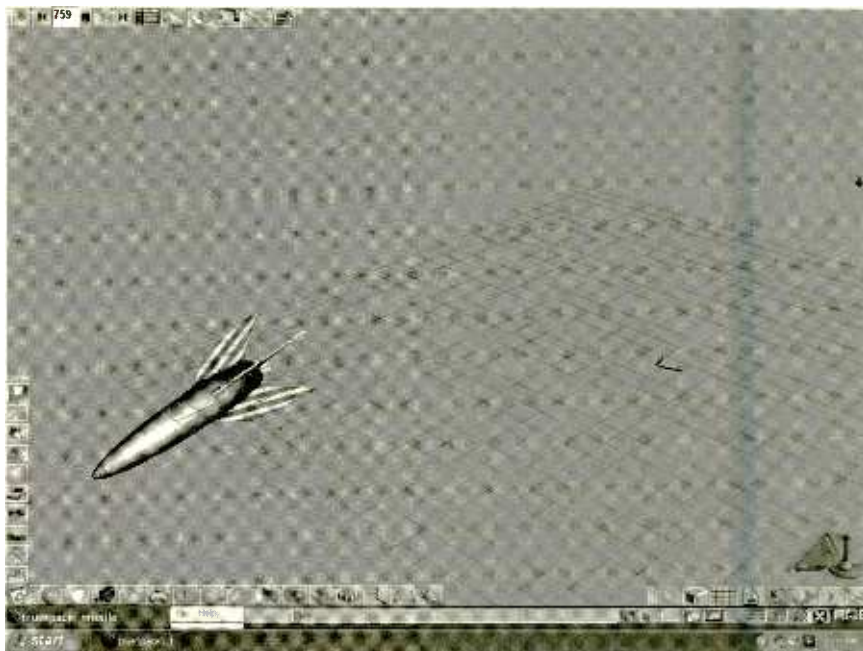
In the last column, we started discussing how to assemble your own monster workstation. If you missed this column, we defined a workstation as a PC that has been designed especially to handle very graphic or compute-intensive tasks.

We also described how we assembled our own "Monster" workstation around a Thunder 860 motherboard from Tyan Computers. This motherboard accommodates two Intel Xeon CPUs, which are specifically designed for use in a multiprocessor environment. The motherboard requires a special power supply, which was included with the tower case from Evercase Technologies that we used. Kingston Technology provided us with four 256MB RDRAM RIMMs; Maxtor sent us two of its newest 80GB ATA/133 hard disk drives; and we installed two different types of DVD burners, one from Pioneer and the other from Hewlett Packard.

When constructing a multiprocessor system, you need to be careful, as only some versions of the Windows operating system actually provide support for more than a single CPU. Windows NT 4.0, 2000 and XP Professional all provide this support; and we used Windows XP Professional on the "Monster."

### APPROPRIATE BENCHMARKING

Strangely enough, building the "Monster" wasn't the most difficult part of the project. Once we had the components in hand, the system went together in a matter of about 90 minutes. The most difficult parts of assembly were routing the drive cables around the plastic wind-tunnels that are part of the Xeon processors, heat



Eventually, we decided to base our benchmark on TrueSpace 5.1 from Caligari Corporation ([www.caligari.com](http://www.caligari.com)). TrueSpace 5.1 is an affordable modeling and animation system, just the sort of application many *Poptronics* readers might actually use.

sink design, and bringing up the ATA/133 controller that Maxtor included with the pair of drives they provided. Originally, we were going to use a RAID controller, which is why we requested two identical hard disk drives. When Maxtor sent their new ATA/133 drives and controller, we changed our minds.

The problem with just plugging in the ATA/133 controller is that Windows XP Professional doesn't recognize the new disk controller on the initial install. We plugged the Maxtor drives into the IDE controller on the Tyan motherboard to install Windows XP Professional. When the "Monster" was set up, we simply plugged in the new ATA/133 IDE controller that Maxtor provided with its drives and moved the hard disk

data cable to that controller.

More of a challenge was coming up with an appropriate benchmark. There are SMP (symmetric multiprocessing) benchmarks available as shareware and freeware, but that doesn't really help compare a dual 2-GHz Xeon system to a 1.7-GHz Pentium 4 PC, which doesn't perform SMP.

More germane is the output of most available benchmarks, which give scores in units that won't mean much to the average *Poptronics* reader. Utilities such as *Dr. Hardware* and *SANDRA* do include benchmarks for multiprocessor systems. However, *Dhrystones* and *Whetstones* don't intuitively transmit the actual benefits of going for a system like the "Monster."

Since our initial intent in building



**TABLE 1**

Component	From Where	URL	Aprox. Cost
Two 2-GHz Xeon CPUs	Intel	<a href="http://www.intel.com">www.intel.com</a>	\$800 (for both)
Tyan i860 Motherboard	Tyan	<a href="http://www.tyan.com">www.tyan.com</a>	\$800
1GB RDRAM	Kingston	<a href="http://www.valueram.com">www.valueram.com</a>	\$300
Case and 460-watt power supply	Evercase	<a href="http://www.evercase.com">www.evercase.com</a>	\$280
2 80GB ATA/133 Hard Disk Drives	Maxtor	<a href="http://www.maxtor.com">www.maxtor.com</a>	\$520
DVD-RW Drive	Pioneer	<a href="http://www.pioneer.com">www.pioneer.com</a>	\$550
DVD+RW Drive	Hewlett Packard	<a href="http://www.hp.com">www.hp.com</a>	\$500
Verto Geforce3 Ti500 Video Card	PNY	<a href="http://www.pny.com">www.pny.com</a>	\$399
Windows XP Professional	Microsoft	<a href="http://www.microsoft.com">www.microsoft.com</a>	\$199

the system was to create the ultimate system for performing DVD transcoding (the process of turning AVI video into MPEG-2), we anticipated creating a benchmark using one of the many DVD authoring packages we use. Unfortunately, none of them actually take advantage of having dual CPUs available. Some applications, such as Adobe Premiere, have plug-ins that use multiple processors when available. However, we decided against basing our benchmark on these.

Eventually, we decided to base our benchmark on *TrueSpace 5.1* from Caligari Corporation ([www.caligari.com](http://www.caligari.com)). *TrueSpace 5.1* is an affordable modeling and animation system, just the sort of application many **Poptronics** readers might actually use. The process of rendering a model, especially animated in a virtual 3D space, is extremely compute-intensive and provides a perfect type of benchmark. Best of all, *TrueSpace 5.1* is multi-threaded and takes advantage of multiple CPUs where available. You can download a trial copy of TrueSpace from Caligari's Web site if you'd like to play with it.

Caligari graciously offered us the use of a benchmark script it developed with AMD, which AMD uses internally for benchmarking its own processors and system designs. After playing with the software for a short time, we were able to develop our own benchmark, which uses a small missile flying an elaborate path around the screen. This missile is shaded and lit from a constant point source, so each frame rendered needs to take this into account

when constructing the image. The total sequence takes 759 frames. If enough readers request it, I will make available a copy of our benchmark so that you can compare your own PC to our "Monster" system.

**AND THE WINNER IS!**

Using an appropriate benchmark like the one we constructed easily demonstrates the benefit of a multi-processor system like the "Monster." The 1.7-GHz Pentium 4 PC we use for most tasks around here took just about 2 seconds to render each of the 759 frames of animation. Rendering the complete animation took 25 minutes and 43 seconds.

The Xeon-based "Monster" was almost exactly twice as fast, taking 12 minutes and 35 seconds to accomplish the same task.

When assembled, our workstation cost just under \$4300 to put together, not counting a keyboard, mouse, monitor, or any application software. That's a pretty hefty price tag for a personal computer. It is not, however, all that expensive for a workstation.

There aren't a lot of vendors that sell workstation-level computers directly to an individual end-user. Most of these sales are made to companies through a VAR (value added reseller) network. So making direct-cost comparisons between a do-it-yourself approach and commercial purchase isn't easy.

We did find a similar workstation available from Polywell Computers, a vendor whose PCs we've tested in the past and generally like very much. This

well-known vendor of PCs has a dual Xeon workstation model available that you can order from its Web site. They don't, as of this writing, offer the dual DVD-RW option we incorporated into our "Monster." You can, however, use the vendor's custom configuration option on the PolyStation 930X4 Dual Xeon workstation to get pretty close to what we put together. If we added a second DVD-RW drive to the configuration, the price at this writing would come out just under \$6000. That's a terrific price for a workstation this highly configured.

That makes our \$4300 workstation an even better bargain. There are a few differences between "theirs" and "ours." We could not get the Polywell configurator to eliminate the keyboard and mouse, and the PolyStation required a sound card, while our motherboard provided onboard audio. On the other hand, we configured the PolyStation with two 80GB Maxtor ATA/100 drives, while our "Monster" uses two of Maxtor's newest ATA/133 drives with a second IDE controller. The ATA/133 drives are a lot more expensive than the ATA/100 models, but provide better performance as well. An upcoming "Peak Computing" column will test these and several other hard disk upgrade options.

**WHY BOTHER?**

Now that we have it up and running, we are actively experimenting to see what applications we get better results with when we run them on the "Monster." Predictably, while the "Monster"

(Continued on page 58)

## Basic Op-Amps

The operational-amplifier (op-amp) is a staple item in electronic circuits and is a building block that is often one of the main components in linear, audio, and video circuitry. This device is basically a high-gain amplifier that is used in conjunction with feedback networks to make up a circuit whose properties are determined by linear-passive components, such as resistors, capacitors, inductors, as well as nonlinear components (diodes, varistors, thermistors, etc). The term “operational-amplifier” comes from the use of these devices in analog computers that were used decades ago to perform mathematical operations (addition, multiplication, differentiation, integration, summation, etc) on input quantities. The term has stuck and is still used, even though analog computers have largely departed the scene, having been replaced by digital computers long ago. Today’s operational-amplifier is a sophisticated device, composed of many transistors, diodes, and resistors, all in a chip and packaged in various configurations.

There are thousands of types of op-amps available, from flea-powered microwatt units to units capable of handling a few hundred watts of power—from a few cents to many dollars in cost. As you may imagine, the specs and performance requirements, as well as reliability, temperature range, and packaging, all affect cost. Op-amps that can do many ordinary jobs very well are available for under 50 cents, owing to low-cost plastic packages, large-scale integration, and high-volume production. Technologies commonly used are bipolar, FET, CMOS, and combinations. Some large or high-power op-amps are made using monolithic fabrication methods.

### An Ideal Amplifier

From a circuit viewpoint, for the purposes of explanation, an ideal amplifier is

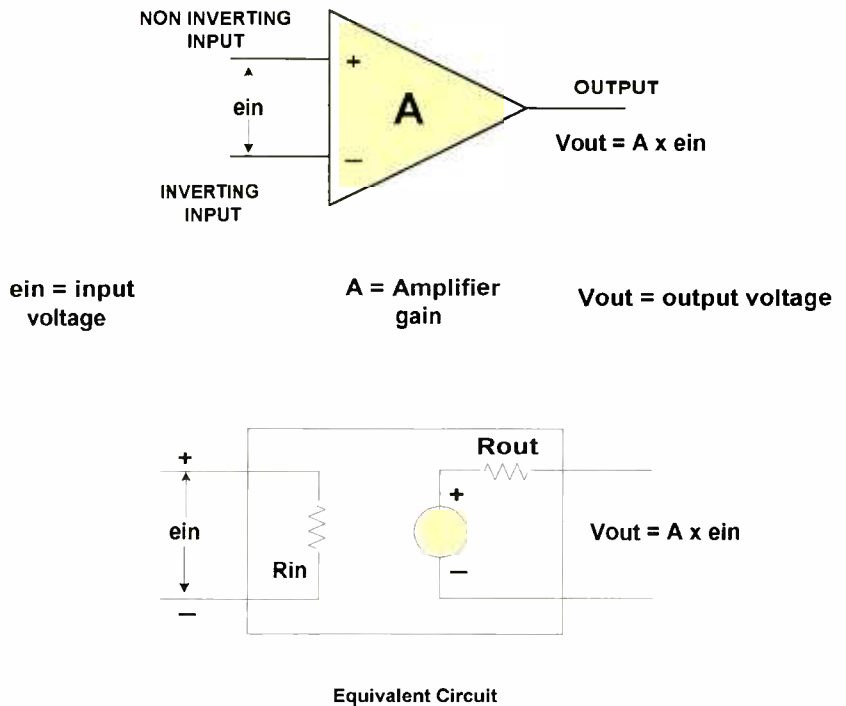


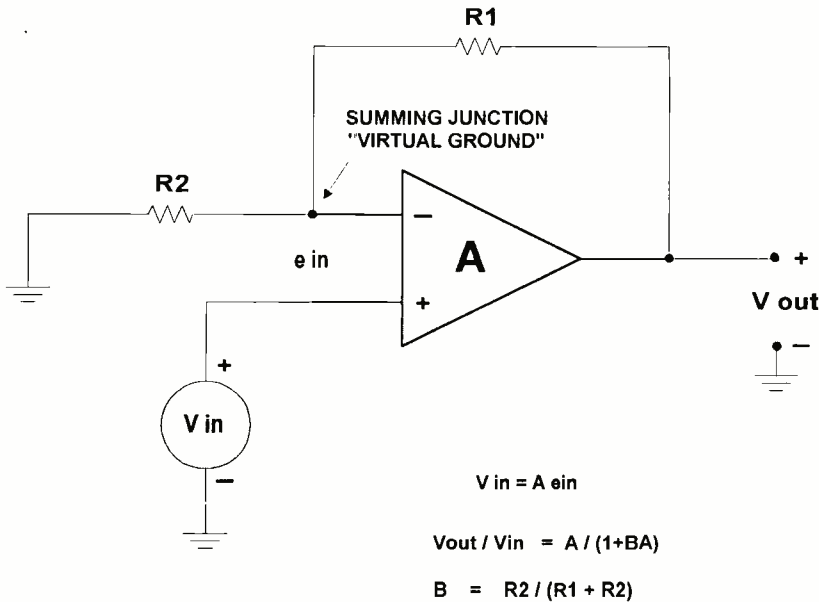
Fig. 1  
BASIC OPERATIONAL AMPLIFIER

used to represent an op-amp. An ideal amplifier has the following properties: infinite forward gain, bandwidth and input impedance with zero output impedance, noise voltage, DC offset, bias currents, and reverse gain. (See Fig. 1.) In practice, all op-amps have some bias current that flows in the inputs—almost negligible for JFET and CMOS types, but more significant in bipolar types. This current must be considered in high-impedance circuits, in DC and instrumentation amplifiers, and in circuits that must operate over a wide temperature range. In addition, even if you were to short the op-amp inputs together, you may not get zero output voltage, but some random DC level.

This DC voltage can be considered as

an equivalent DC input offset voltage present at the input. DC offset can also be produced from equal input bias currents flowing through unequal resistance in the inverting and non-inverting input circuits. This will produce a DC input voltage differential at the input. Some op-amps have external pins to which a potentiometer can be connected to balance out or otherwise cancel this voltage, bringing the DC output to zero under zero-signal input conditions. These are widely used in instrumentation amplifiers and related applications where nulling or zero adjustments are required. All amplifiers generate some noise, which is due to thermal and semiconductor junction effects, and can be considered as an equivalent input noise





**FIG 2**  
**BASIC OP AMP VOLTAGE AMPLIFIER**  
**NONINVERTING CONFIGURATION**

voltage. Amplifiers are available with low-noise characteristics for those applications where noise must be kept to a minimum.

A real-world op-amp has a lot of gain (>1000X voltage gain) and a fairly high input impedance (>100K). Generally there are two inputs shown, an inverting and a non-inverting input, and one output referenced to ground (but not always, differential outputs are sometimes used in certain applications). One of the inputs may be grounded in many common applications where a single-ended signal source is present. This is a common situation. There are limitations on the DC levels allowable on the inputs and limitations on the available output voltage swing.

Op-amps are available that allow a full output voltage swing between the positive ( $V_{cc}$ ) supply and negative ( $V_{dd}$ ) supply. These are sometimes referred to as rail-to-rail capable. In addition, if the exact same voltage is present on the inverting and non-inverting inputs, ideally the output voltage should be zero. This is not always so, and the degree of imperfection is called the common-mode rejection ratio. This is usually 60 dB or better, with 70–80 dB as a minimum. Note that this may vary with input voltage levels to some degree. Also, variations of power supply voltage

may show up as equivalent input signals. The degree to which the op-amp rejects this is called the supply-voltage rejection ratio. It is usually better than 60 dB and typically 70–80 dB or better. After all, nothing is perfect in life.

**What's To Gain?**

Op-amp power supply connections are sometimes shown in diagrams, especially if decoupling capacitors and resistors are necessary, but more often shown elsewhere in the schematic, as they play no part in the primary circuit function

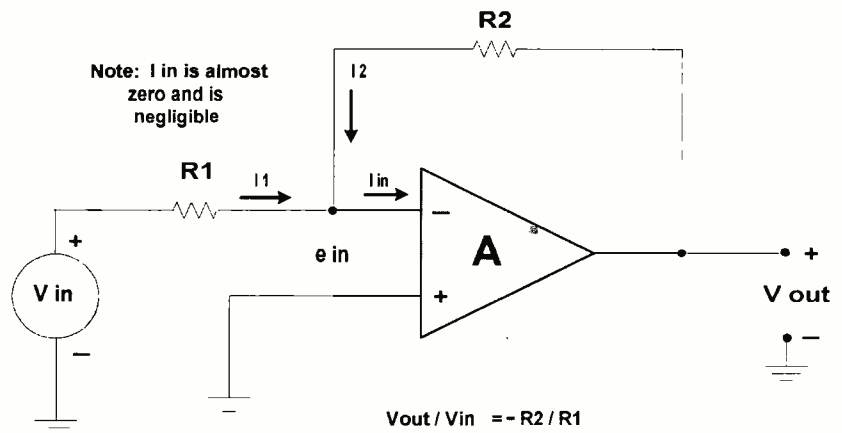
other than to power the amplifier. Many general-purpose op-amp chips have two or four separate operational-amplifiers in one package, with common power-supply connections. In practice the ideal amplifier criteria requirements are met only approximately, but as will be shown, close enough for most purposes.

Practically, an op-amp will have a gain of 10,000 or more, an input impedance of megohms, and a 3 dB bandwidth of several tens of hertz or more. If an amplifier has a 3 dB bandwidth of 40 Hz and a gain of 100,000 times, this is a gain bandwidth product of 4 million hertz, or 4 MHz. ( $40 \times 100,000$ ). It is advantageous in many feedback applications to have the gain falling at 6 dB per octave or 20 dB per decade at frequencies beyond the corner frequency (that frequency at which the amplifier gain has fallen 3 dB or 70.7 percent of its DC value).

Since the op-amp is used mainly in feedback circuits having much lower closed-loop gain, these performance figures are good enough in many cases. In fact, even a single high-gain (100X) common emitter transistor amplifier stage can be treated as an op-amp if feedback is employed, with surprisingly little error. In many cases, a single transistor will work almost as well as a more expensive op-amp device. One example is a simple audio amplifier stage from which a moderate gain (5–20X) is required. This will be shown in an example later.

**Op-Amp Families**

One of the most popular op-amps of all time is the venerable LM741, its dual



**FIG 3**  
**BASIC OP AMP VOLTAGE AMPLIFIER**  
**INVERTING CONFIGURATION**

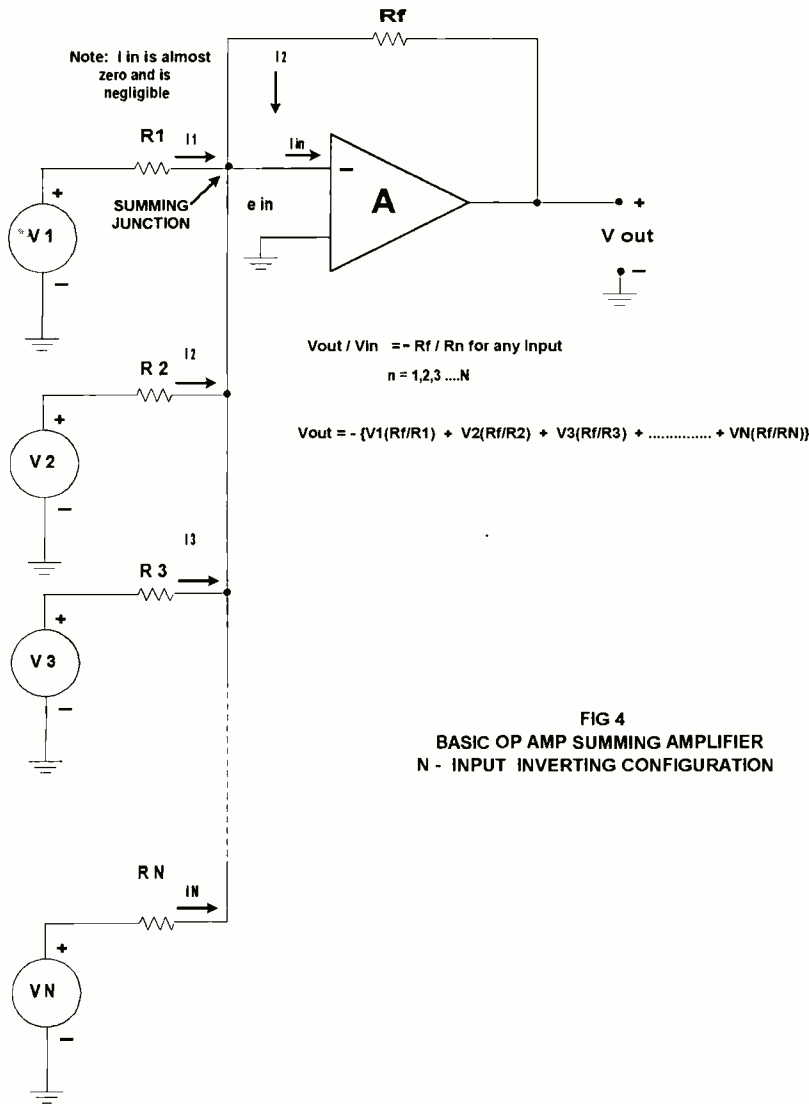


FIG 4  
BASIC OP AMP SUMMING AMPLIFIER  
N - INPUT INVERTING CONFIGURATION

that, while not difficult, can contain several terms and fractional expressions, leading to rather messy algebraic manipulation of these terms. This can confuse, intimidate, and scare away many readers. It is easy to get wrapped up in the math and then spend way too much time trying to figure out what is being done or what is meant. If you have ever studied algebra or calculus, you will surely have been through this. You also lose sight of the intended goal and the subject being discussed. What was to be a discussion of circuits turns into a time-wasting digression, usually a tedious and frustrating algebra exercise. This proves little except that you might be a complete bonehead because you do not immediately see the "obvious" meaning of these complex expressions. (Often the authors needed several hours correctly deriving them the first time or else just copied them from elsewhere so as to impress readers and look like geniuses). This will be avoided. We are going to make some simplifying approximations to get rid of the second and higher order stuff, which can be studied later after some basics are covered. Simplified approximations will still yield results accurate to a percent or so and avoid confusing trivial details which, while interesting, have dubious practical consequences for things the experimenter will get involved with. Even five or ten percent accuracy is good enough in many cases, if you are not doing instrumentation work.

### Feedback And Formulas

Figure 2 is a basic op-amp application, a simple gain stage. Amplifier A is a basic op-amp with a very high-input resistance. Resistors R1 and R2 make up a feedback network, a simple voltage divider. The voltage at the junction of R1 and R2 is  $R2/(R1 + R2)$ . In feedback amplifier work, the gain of the feedback network is commonly designated by the Greek letter  $\beta$  (beta). This gain is the ratio of output voltage to input voltage and is usually less than one—in many cases, much smaller than one. It may often be a complex number, having both real and imaginary components. Since practical feedback networks consist of resistors, capacitors, and sometimes inductors, they therefore have defined magnitude and phase characteristics. It may also be nonlinear, using diodes, varistors, and other nonlinear devices.

For the following discussions we will limit  $\beta$  to being linear and a purely real

version LM747 and their many descendants. The JFET input TLO8X series is also very popular, coming in single (TLO81), double (TLO82), and quadruple (TLO84) units. The TLO81 and TLO82 come in 8-pin DIP packages, while the TLO84 comes in a 14-pin DIP package. These op-amps operate well from 5–12-volt experimenter supplies and require both a plus and minus supply. These are also cheap and widely available. Other general-purpose types are the LM324, LM1458 (bipolar), and LM3900, along with all their variations and flavors. There are many others, but those mentioned are easily obtained by the hobbyist wishing to experiment with them, cheap, and in plentiful supply. Many manufacturers make them, so obsolescence should not be a problem for a long time.

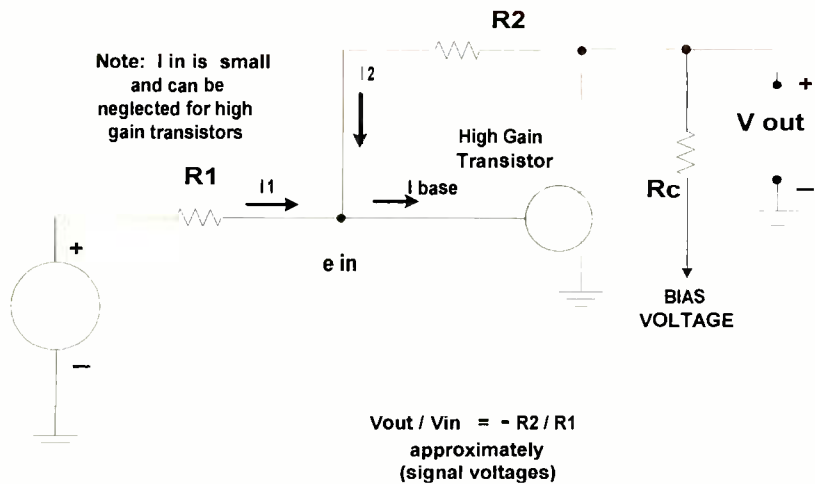
We will use the TLO8X series for circuit examples, as they are general-pur-

pose JFET types. The TLO8X series allows the use of higher resistance values and therefore smaller capacitor values, which is often more convenient from a design standpoint. The TLO8X series has an open-loop (no feedback used, the full gain the amp can deliver) voltage gain of over 10,000 and having JFET inputs, an input impedance of a million megohms. The gain bandwidth product (obtained by measuring frequency where gain falls to unity) is rated at 4 MHz for the TLO8X series. Op-amps are available with gain bandwidth products to several hundred MHz and even higher, and these are used in video and RF applications.

### Keeping It Simple

A word first to the nitpickers. (You know who you are). The exact explanation of op-amp and feedback principles requires the use of network equations





Note: DC Biasing for transistor not shown

FIG 5  
BASIC TRANSISTOR VOLTAGE AMPLIFIER  
INVERTING CONFIGURATION

number, as this simplifies the math. Most experimenter circuits will not involve complex feedback networks, but the reader should be made aware that this is not always the case.

In Fig. 2, the output voltage from the op-amp is  $V_{out} = A \times e_{in}$ .  $A$  is the gain of the amplifier (generally 10,000X or more). In a practical op-amp circuit powered by 5–15 volt supplies,  $V_{out}$  will be at most  $\pm 5$  to  $\pm 15$  volts. Therefore,  $e_{in}$  will be this voltage,  $V_{out}$  divided by the gain of the op-amp (10,000 or more). This says that  $e_{in}$  is very, very small, in the millivolt or microvolt range. However,  $V_{in}$  from the outside world is the input voltage we are applying to the circuit and could be a volt or more, such as a line-level audio signal, etc., while  $e_{in}$  is very much smaller. The circuit adjusts itself so that the ratio of  $V_{out}$  to  $e_{in}$  equals the gain of the amplifier, which we will take as 10,000. This requires  $V_{out}$  to be such that the portion of  $V_{out}$  at the junction of feedback network  $R_1$  and  $R_2$  exactly equals  $V_{in}$  minus  $e_{in}$ , so the total voltage difference across the inverting and non-inverting outputs is  $e_{in}$ . This occurs when:

$$V_{out} \{R_2 / (R_1 + R_2)\} = V_{in} - e_{in}$$

But,  $V_{out} = A \times e_{in}$ , where  $A$  is the gain of the amplifier. Define  $R_2 / (R_1 + R_2)$  as  $\beta$ , the feedback factor equal to the ratio of  $R_2$  to  $R_1$  and  $R_2$ . For example, if  $R_1 = 9K$  and  $R_2 = 1K$  then  $\beta$  equals

$1 / (9 + 1)$  or  $1 / 10$ , or 0.1. This means that one tenth the output voltage is being fed back via the feedback network. By substituting the previously mentioned equalities in the first equation:

$$A \times e_{in} \{\beta\} = V_{in} - e_{in}$$

If you add like quantities to both sides of the equation, it still is valid. Therefore, if you add  $e_{in}$  to both sides of the equation:

$$A \times e_{in} \{\beta\} + e_{in} = V_{in}$$

Noting that  $e_{in}$  is common to both terms in the left side of the equation, it can be factored out:

$$e_{in} \times [A \times \beta + 1] = V_{in}$$

But  $e_{in}$  must equal  $V_{out}$  divided by  $A$ , the gain of the op-amp, so that:

$$(V_{out} / A) \{A \times \beta + 1\} = V_{in}$$

The effective circuit gain is what we want, i.e. the ratio of  $V_{out}$  to  $V_{in}$ . We are inputting a signal represented by  $V_{in}$  and would like to know the magnitude of  $V_{out}$  that will result. If both sides of the equation are first multiplied by  $A$ , then divided by  $V_{in}$ , and then finally by the entire quantity in brackets  $\{A \times \beta + 1\}$ , we get an equation that expresses the ratio of  $V_{out}$  to  $V_{in}$  as a function of  $A$ , the op-amp gain, and  $\beta$ , the feedback factor:

$$\text{Gain} = (V_{out} / V_{in}) = A / (A \times \beta + 1)$$

$A \times \beta$  means the product of these two quantities. Since the order of multiplication does not change the product,  $A \times \beta = \beta \times A = \beta A$  (realizing the  $\times$  stands for multiplication we can get rid of it). Also, the order of addition of two quantities does not affect the sum. Then the equation appears as:

$$\text{Gain} = A / (1 + \beta A)$$

This is a very important equation when working with op-amps or most any feedback amplifier. It applies to a lot of things. The ratio of  $A$  to  $(1 + \beta A)$  yields not only the gain, but affects other circuit-performance factors, as well. In a real-world case, if  $A$  is 10,000 and if  $\beta$  is 0.01 or more (it generally is), note that the product of  $\beta$  and  $A$  will be greater than 100. Then, a very nice simplifying approximation can be made. It is true that for any quantity  $X$  much larger than 1 (10 times or more would qualify),  $1$  plus  $X$  approximately equals  $X$  with an error of around  $1/X$  times 100 percent. As an example if  $X$  were 10 then  $10 \approx 11$  approximately with an error of  $1/10 \times 100$  percent, or ten percent, which is obviously true. If  $X$  were 100, then  $(1 + 100) \approx 100$  with an error of  $1/100 \times 100$  percent, or 1 percent. Note that in our case where  $A$  is 10,000 and  $\beta$  is 0.01, the product  $\beta A$  is 100 and  $1 + \beta A \approx \beta A$  within one percent. Therefore, if in any case  $\beta A > 1$ , we can rewrite the equation as:

$$\text{Gain} = A / (1 + \beta A) \approx A / (\beta A) = 1/\beta$$

(Note that  $A$  is common to numerator and denominator and can be cancelled out.)

In other words, if the product of the op-amp gain ( $A$ ) and the feedback factor ( $\beta$ ) is much larger than one, the value of  $\beta$  determines the overall gain of the op-amp circuit. The product of  $\beta A$  is called the open-loop gain. The overall circuit gain with the feedback loop in place is called the closed-loop gain. The beauty of this concept is that, given a large enough value of  $A$ , the gain and other parameters of a feedback amplifier or any other system employing feedback can be closely controlled by a network of components that can be specified to any degree of accuracy needed. The value of  $A$ , component tolerances, drift, noise, temperature effects, and all things

(Continued on page 41)

# THE VISIE-TALKIE

By GREGO BANSHUK, I.R.A.; R.S.V.P.\*

**WE PRESENT** what is undoubtedly the biggest development in television up to now—the *Visie-Talkie*. As its name implies, it is a portable television handset over which you can also talk at a distance. A counter-part of the Walkie-Talkie and the Handie-Talkie, now something new—vision—has been added. Of importance is the development of *non-scanning television* which will simplify television to a greater extent than has been possible up to the present. The *Visie-Talkie* is described exclusively in this issue of *Radio-Craft*.

It was a memorable morning on February 1, 1945 that the Editor-in-Chief of *Radio-Craft* called me into his sanctum. The air seem electrified and there was a notable tension in the office. The Chief asked me to sit down and much



Keystone Photo

The *Visie-Talkie* is extremely simple to operate. Merely by opening the little door, the set begins functioning. Ordinary dry cells are used for power.

to my surprise handed me a cigar, which I immediately took with suspicion, because usually he doesn't hand out cigars, at least not during wartime. The Boss glared at me without a word for several long seconds as if he were searching my soul and then he delivered the following ultimatum in a high-pitched voice, eyeing me fiercely, now and then pounding the desk in front of him in great animation.

"Look here, Grego" he began in high strident tones, "this television business has exasperated me no end. The road the radio and television engineers are now pursuing is all triple-plated nonsense. The present television apparatus is no more television than Leonardo da Vinci's airplane was in the middle ages. Sure enough, we transmit and receive impulses which we later translate into light, but at what a cost! We have to scan at the transmitter and scan at the receiver. The correct word should not be scan but *scat*. I have talked myself hoarse for thirty years trying to get engineers to forget all about the silly scanning and I have vainly pointed out to them that animal vision,—far better than present-day television,—gets along very nicely without any scanning. Two billion years ago when the first creatures began roaming this earth, equipped with the animal eye—that was television and so far none of your engineers have been able to duplicate the

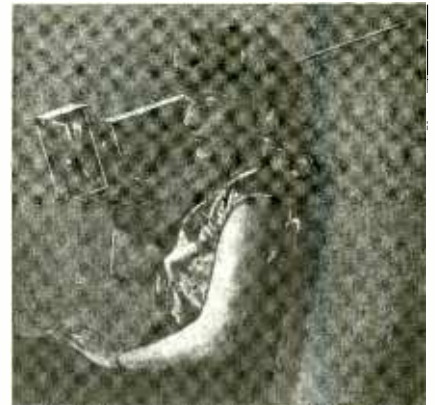
\*International Radio Association; Radio Society Veteran Physicists.

animal or human eye. Take your own eye and what do we find? The eye is equipped with a lens the same as your television transmitter, *but where is the scanning apparatus?* There isn't any. The light impulses fall on the retina which has the so-called *visual purple*, then there are a number of so-called rods and cones. These are connected by means of nerve conductors through the optical nerve with the human brain. Scientists now know that we see by electro-chemical means.

"Now then, it should be possible to duplicate, or at least approach the optical elements of the animal eye and translate all this into a modern up-to-date non-scanning televisor.

"But damn it all, your engineers will have nothing to do with it, so it is about time that *Radio-Craft* did something to show the television people what really can be done. I have here a number of sketches illustrating how the problem can be solved. I have slaved long and laboriously on it and I have worked out all the theoretical elements as you will see when you inspect

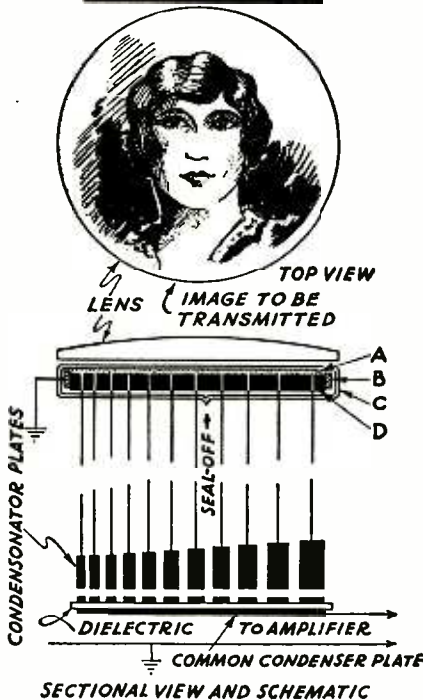
the sketches for which a Potent has been applied, to safeguard this revolutionary invention. You will notice that I am using as the transmitter an electro-chemical layer spread over a special disk of plastic into which thousands of fine wires have been



Keystone Photo

The *Visie-Talkie* can be used by anyone—no radio knowledge is required. It works on centimeter wavelengths, and has a range of about 5 miles.

## TRANSMITTER



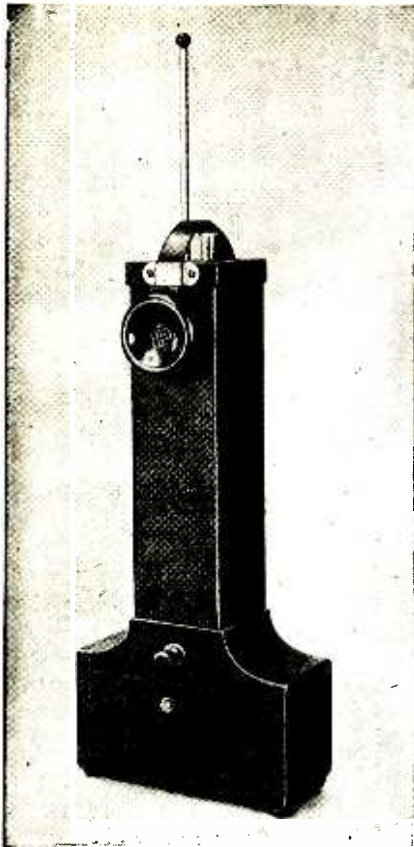
Simplified view of transmitter tube. A—Electro-chemical (photo-electric) layer; B—Ends of collector ring; C—Glass tube envelope; D—Plastic block in which wires are imbedded. Below, the Condensator.

embedded, leaving only the ends of the wires projecting.

"The end of each wire in turn goes to a new instrument which I call the *condensator*. This condensator is made up of different sizes of tinfoil or other material and in this manner each wire connects with a sort of condenser, *each having a different capacity from that of the next one*. There is a common return for the opposite plate as shown in the diagrams. Thus each wire has a different potential charge from the other. By a simple special means shown in my plans, each electrical impulse therefore is preserved and transmitted, because *each wire end modulates the condenser circuit in its own way*.

"This is made possible by development of a new plastic, which has a minus dielectric constant of very high absolute value. Thus the thousands of fine wires can be bunched very close together with no more effect on each other than if they were an inch or more apart. You will note that the lines are of different lengths, and that they are further end-loaded with special ceramic condenser-type units. These have the effect of tuning each wire to a slightly different natural frequency. In the Condensator a variable-frequency oscillator sweeps the gamut of the frequencies of these tuned leads, and is modulated in amplitude according to the strength of the light falling on the part of the chemical layer connected to the wire tuned to each



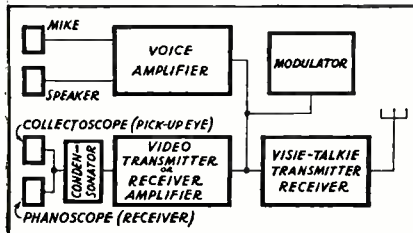


Helmich Photo

Left—The Visie-Talkie closed for carrying. Right—Chief elements of the Visie-Talkie are: A—Television receiver. Recessed Shadow-box and ground-glass screen is visible. B—Television transmitter with lens. C—Microphone. D—Sound control. E—Visual control. F—Power switch. G—Telephone Receiver. H—Extension Antenna.

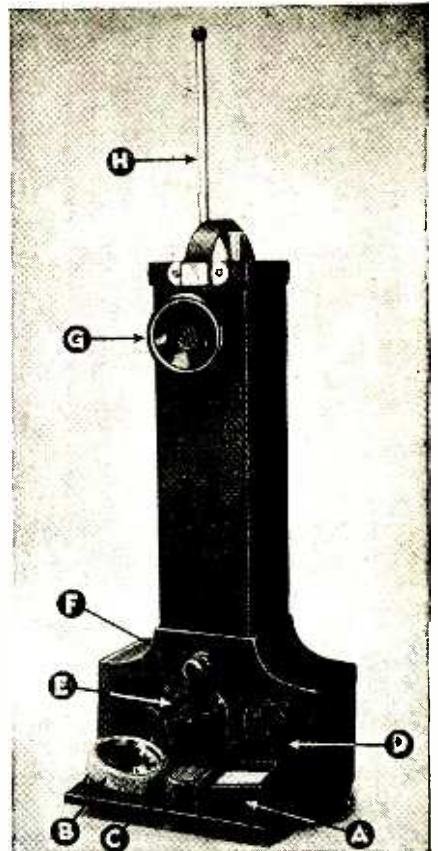
Here I draw a merciful curtain over what transpired during those eventful 60 days that followed.

I need not tell you how difficult the work was, but once I got the hang of the Chief's Visie-Talkie I picked up enthusiasm as my assistant and I went on with the work. Sure enough, the scheme worked out just as imagined by the big Boss. In about 40 days we actually had results and could see each other in the crude laboratory model. By this time the Old Man had produced the general mechanical design of the Visie-Talkie also and we galloped nicely along on the home stretch.



Simplified block diagram of the Visie-Talkie.

On account of the great importance of the invention we worked behind locked doors all the time. We had been admonished never to leave the plans out in the open and we had a big burglar-proof safe in the laboratory where the drawings were always safely cached whenever we had to be absent. This was not often, because most



Helmich Photo

part of its cycle. The condensation units are also discharged as the beat frequency oscillator passes their frequency, by an adaption of fairly conventional means.

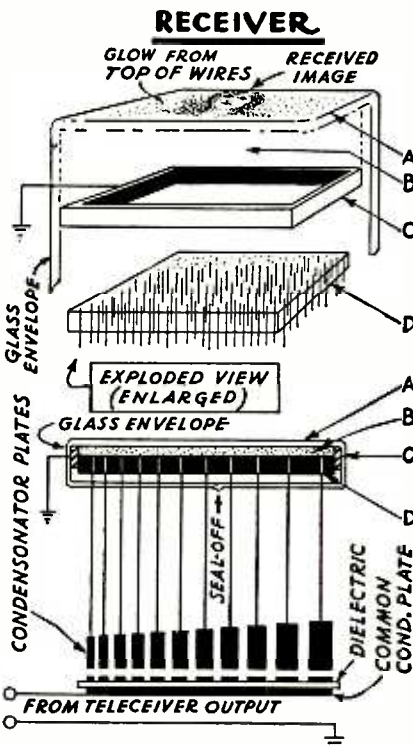
"The complex wave thus produced is both amplitude and frequency modulated. The frequency modulation sets the position of the exciting area in the image—the amplitude modulation, the strength of light falling on that area. Thus without scanning, we are able to transmit in a single super-complex wave the necessary impulses, fixing both position and strength of light to permit us to transmit an image.

"At the receiver we have a similar means, only reversed. Here we have a fluorescent gas in a special tube so that each wire end has a different potential; therefore it gives rise to a varying luminosity—either intense or weak, with all the other light intensities in between. As each condensation plate at the receiver works on a different frequency we therefore reproduce the same mosaic, or pattern, from the original light impulses transmitted at the transmitter. This gives us a complete television image at the receiver, without any scanning whatsoever. The amplifier circuits making all this possible are shown in a diagram in my drawings.

"Now then," bellowed the Chief while pounding the desk in front of him, "I have worked out all of the theoretical considerations for you. Take the drawings along, study them carefully, and if there is anything you don't understand don't hesitate to call on me for further illumination of the problem."

Here there was an ominous pause. Then the big Boss, lighting a huge black cigar, scowled fiercely at me, took a deep breath and said:

"And I want a complete set of models in exactly 60 days—or else." With that he threw the sheaf of drawings and instructions at me and I scampered out.



Exploded and cross-section views of Visie-Talkie receiver. A—Fluorescent screen. B—Fluorescent gas layer. C—Collector ring. D—Plastic block with imbedded wires.

of the time we slept in the laboratory and took turns on the cot provided for the purpose. During the last few remaining days we put the finishing touches to the Visie-Talkie and we even found a way to project the received image on its ground-glass screen in full natural colors, just as is done by the human eye. This was a little wrinkle which my assistant and I threw in for good measure.

There was also the little matter of static which we had to take care of so that the image would not flicker from static bursts from nearby automobiles and other man-made static annoyances. This problem we finally licked on the very last day.

Came the big moment when I marched triumphantly into the Big Chief's office and placed the now completed Visie-Talkie on his desk. My assistant stayed in the outer office and when the Old Man picked up the set (which automatically turns on the current when you open its little door) my assistant started to talk and his image and voice came over perfectly, much to the Chief's delight.

"I knew it was easy to do it," said he, "and now we have something that we can show these half-baked television engineers and teach them a non-scanning television lesson. As I figured it, the Visie-Talkie can be marketed for \$29.85 a pair, in the post-war period. There'll be millions in it!"

The big Boss beamed his full satisfaction and he must have been particularly happy, because he gave me two cigars, one for myself and one for my assistant. This was indeed mighty praise from the Great One. He insisted on keeping the two instruments on his desk and his parting statement was that he was much pleased that I came through exactly on the dot of the 60th day. As I backed my way out of his office I could not help noticing the historic date on his big wall calendar. It read:

APRIL 1st.

# Introducing The ALP

WILLIAM SHEETS, K2MQJ AND RUDOLF F. GRAF, KA2CWL

Often there is a requirement for a simple voice record-playback unit for use with a transmitter. This unit should be able to record a message and then play it back. These messages are usually of short duration (one minute or less) and often continuously repeat. Applications include warning and safety messages, announcements, talking signs used in real estate sales, transmitter identification, or any other similar application. Another use for such a device is in ham radio, for automatically controlling a transceiver, repetitively calling CQ, and switching to receive between calls to listen for an answer. This is a very repetitious and tedious task, especially when conditions are poor or band occupancy is very light. This situation also arises often in VHF-UHF weak signal work. When a response to the CQ is finally received, the identifier is then overridden and the operator takes over control. This can really save one's voice. Any radio amateur that has operated in contests, field day, or enjoys working DX will appreciate this.

There are many ways to implement this function. The traditional solution has been a tape deck using a short tape, often a continuous loop or a cassette, and, more recently, a solid-state memory chip. Inexpensive tape decks and memory modules can be pressed into service, but often there is really no adequate control method to set the frequency of the repeating message. Often, it is necessary to control an associated device, such as

an audio system, or radio transmitter such as the MPX2000, the MPX96, or the AM88 that are available from North Country Radio. As a result, an auxiliary device or circuit often has to be constructed and interfaced to accomplish this. This complicates a seemingly simple task. The ALP (Audio Loop Player) to

be described offers a solution to these problems.

Basically, the ALP performs the following functions:

- Recording a voice message up to one minute in duration.
- Playing that message back on demand once or repetitively.
- Providing a keying function for a transmitter or other device.
- Providing adjustable delay between message repeats.



**Circuit Operation.** The circuit (see Fig. 1) consists of a voice chip, ISD2532P or ISD2560P (32- or 60-second recording time, respectively), and a variable-delay circuit to generate reset and delay timing pulses. A mode switch that has three positions (record, single or play once, and loop) is included, as well as a keying circuit that provides a switch closure to ground. The keying circuit can switch a positive level up to 30 volts and sink up to 200 mA to ground, which should be adequate for many transmitter or transceiver T-R control applications. The circuit operates from a 9-volt to 12-volt supply, negative ground, and draws about 25 mA during playback and about 3 mA on standby.

*Sample/loop audio, and remote keying for your transmitter rig.*





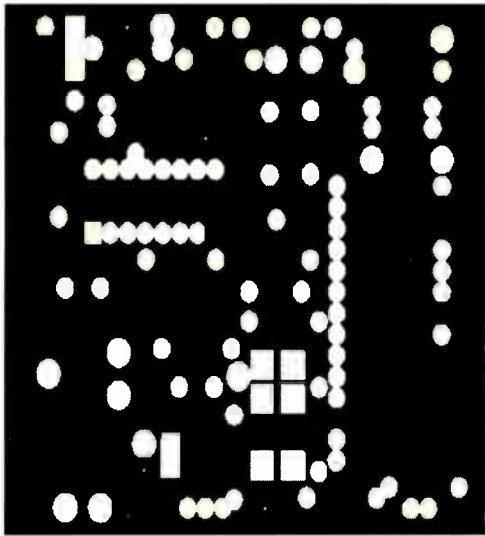


Fig. 2. This is the topside foil pattern for the ALP Transmitter. This pattern can be used as a guide for making your own PC board or a board can be purchased from the authors.

mike, and DC power is supplied through filter network R15 and C12. Coupling capacitors C10 and C11 couple mike audio into the internal mike preamplifier pins 17 and 18. Components R12 and C8 connected to pin 19 determine the automatic gain control (AGC) characteristics of the audio amplifier. Mike audio appears at pin 21 and is capacitively coupled via C9 and R11 to the analog audio input pin 20. The antialiasing filters are internal and are part of the chip, and they cut off at 3400 Hz. Pin 11 is an auxiliary audio input and can be used to feed the output amplifier when in the playback mode but not actively playing a message. It has about 10K ohm input impedance and unity gain. It is not used in this application.

Audio output from the playback amplifier appears at pins 14 and 15, which is a differential output and can drive a 16-ohm load with up to 50 mW of audio. From the memory array, it will provide 12.5 mW of

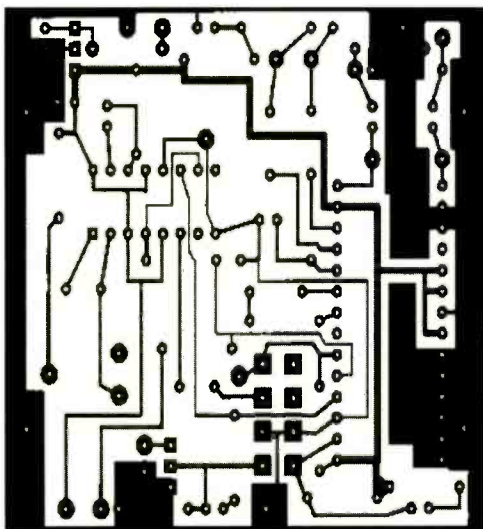


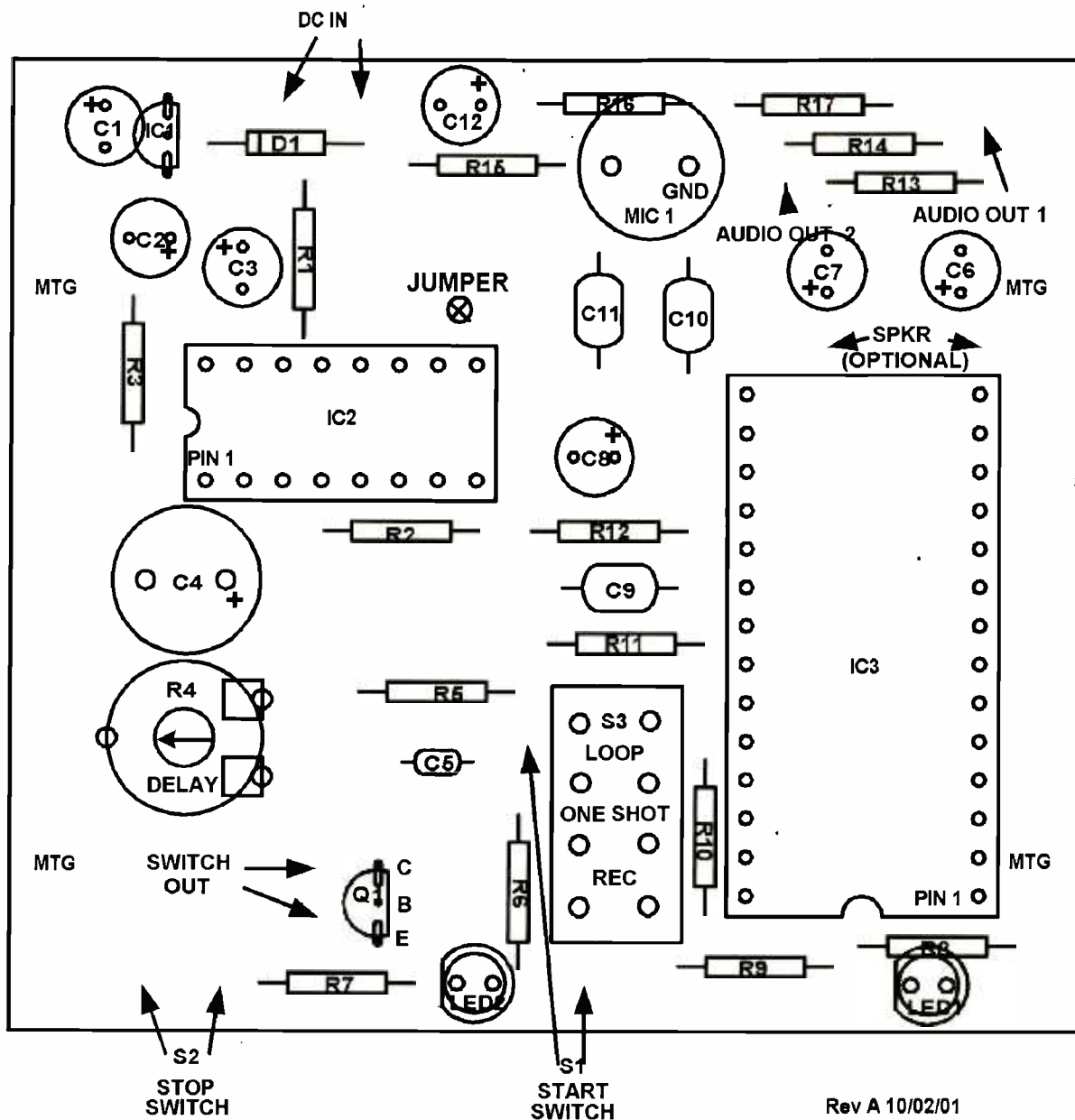
Fig. 3. This is the bottom-side foil pattern for the ALP Transmitter. This pattern can be used as a guide for making your own PC board or a board can be purchased from the authors.

audio. The signals at pins 14 and 15 are 180 degrees out of phase. Audio can be taken through a capacitor from either pin to ground as long as there is no DC path to ground from either pin 14 or 15. It is not recommended to use an impedance speaker or headset lower than 16 ohms to ground either pin 14 or 15 or to short them together. Audio is taken in this application through C6 and C7, with R13 and R14 providing a DC return for the audio output. These capacitors are connected to the output jacks for both monitoring and audio to the transmitter. Again, audio can be taken from one side to ground, or between the two audio output leads, as the signals are 180 degrees out of phase.

Pushing button S1 (start button) starts the cycle and grounds pin 23 of the voice chip, which starts a playback cycle. Pull-up resistor R10 holds pin 23 normally high. The state of pin 27 determines whether the cycle is record or play. If pin 27 is low when pin 23 is taken low, a record cycle is initiated. Pin 27 is held low when mode switch S3 is in the record position. R9 is a pull-up resistor, while LED1 and R8 serve as a record indicator, as LED1 will light when pin 27 IC3 is low. The chip will start in the 000 memory location, Pin 25 will go high and run until an end of message signal appears at EOM pin 25. Depending on the length of the previously recorded message, it is zero to 60 seconds after the cycle is started. If stop button S2 is pressed, this will bring pin 24 high, which stops and resets the cycle, irrespective of the particular point in the cycle. Useful for stopping a message, it can also stop the recording cycle after a message has finished being recorded. It is not necessary to use the full storage capability of the chip and any length from 0–60 seconds (32 seconds with the ISD2532 chip) can be recorded and played back.

When pin 25 goes low at the end of the cycle, several things happen. In the mode that we are using in this circuit, pin 25 is high when the cycle is running and low when it is not. This is used to drive LED 2, which serves as an activity indicator. When LED2 is lit, transistor Q1 is biased on. Its collector is brought out to the switch-out lead and is used as an external control device. Q1 and LED2 are off during inactive periods between cycles. When pin 25 goes low, IC2B, a monostable multivibrator, generates a short low-going pulse. This pulse length is determined by R1 and C3 and resets the voice chip via R2 and pin 24. It also triggers a variable delay monostable circuit consisting of IC2A and associated components R3, potentiometer R4, and C4. R4 is used to set the delay, which is one to about 12 seconds. This circuit is used only in the loop mode and at the end of the delay as set by R4, re-triggers IC3 by momentarily bringing pin 23 of IC3 low via C5, as long as S3 is in the loop position. If S3 is in the one-shot position, IC3 is not re-triggered and must be retriggered by pushing S1. In the record mode, S3 grounds the base of Q1, preventing activation of the device controlled by Q1 (if used) and lighting LED2 during periods when pin 25 is high (during cycle). Pin 27 is also grounded, lighting record LED1, and enabling the record mode.





Rev A 10/02/01

Fig. 4. Here is the component-side Parts Layout diagram. Be sure to carefully note those components that are not directly mounted to the board. Soldering the parts should be done carefully and systematically.

The circuit operates from 5 volts provided by IC regulator IC1, an LM78L05.

Diode D1 provides reverse-polarity protection for the circuit. Capacitors C1 and C2 are noise-filtering and bypass capacitors. Except for external-audio and control jacks, push button and power switches, and battery, all parts mount on the circuit board.

**Construction.** The construction of this project involves stuffing a small PC board with a number of parts and carefully checking your work. You can use the foil patterns in Figs. 2 and 3 as references when etching your own boards. There are no set-up adjustments. The board can be mounted in a small plastic housing. A plastic case with a battery compartment that takes a common 9-volt alkaline radio battery was used. The

board may be mounted in the case as shown in the lead photo, or you can use the board as part of another system or piece of equipment. There are no high frequencies or low-level signals that require special precautions, nothing being critical. The PC layout as shown is strongly suggested. The voice chip IC3 may produce noisy audio with a poor layout and inadequate ground plane.

Install all parts in the PC board. See the parts layout diagram (Fig. 4) for the location of the PC board parts. Note that there are several points that are soldered on top of the PC board—these must be soldered for proper operation. Figure 5 is a wiring diagram for use during the construction process.

Do not forget the jumper shown in the parts layout. Use a small scrap of bare wire passed through this hole

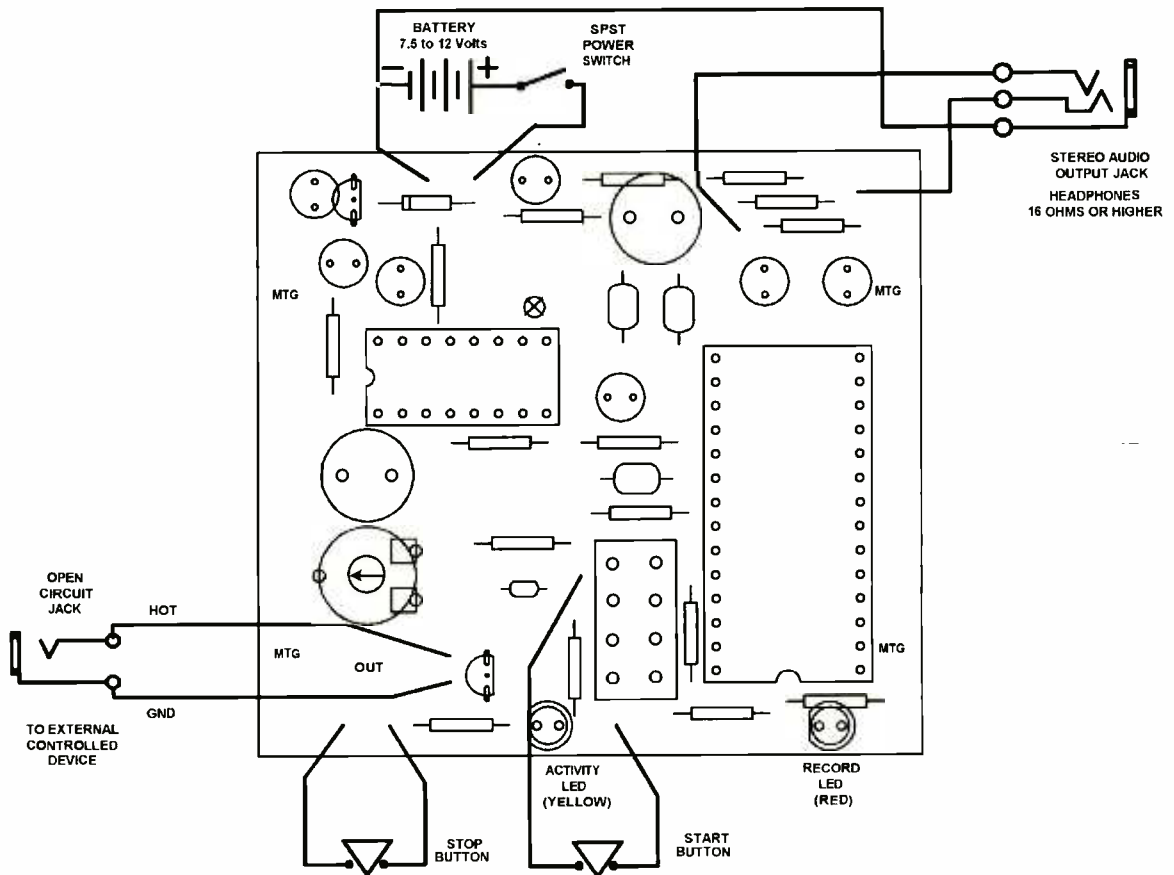
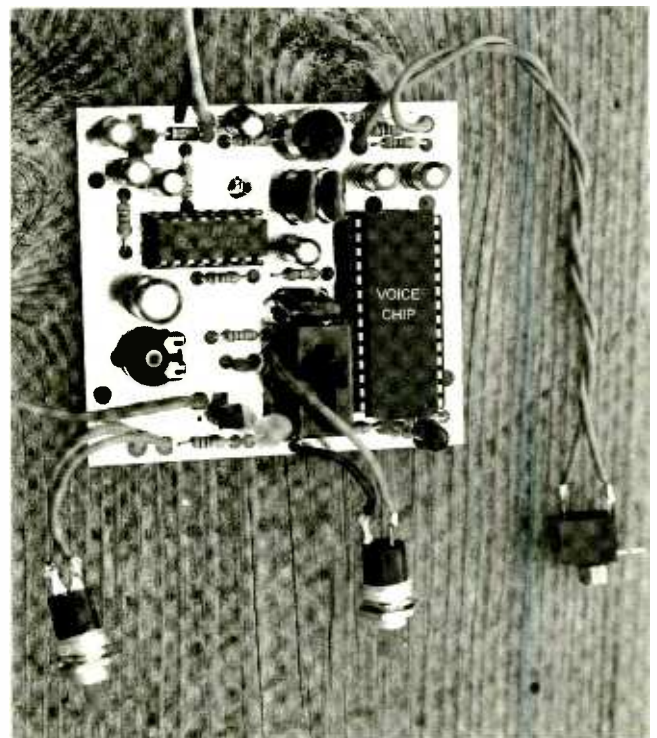


Fig. 5. This Wiring Diagram will come in handy when the time comes to make all the necessary wiring connections. Be sure to follow along with this guide in order to avoid frustrating faulty wiring.

and solder to both sides of the PC board. This provides ground for a number of connections throughout the circuit, and the PC board will not work without it. Check your work and carefully inspect for solder bridges and proper component polarities and orientation. Sockets may be used for IC2 and IC3 if desired (they're not included in the kit so purchase them separately). If everything is OK, connect small (16 ohms or higher) impedance earphones or a small speaker to C6-R13 and C7-R14 output terminals. Actually, a 1/8-inch jack and a pair of 32-ohm headphones (FM stereo pocket radio type) is usable and recommended. Connect a 9-volt battery to D1 (positive) and ground (negative). Reversal of battery connections will cause the circuit to not operate, but no damage should occur (assuming D1 is correctly installed!). Figures 6 and 7 can be used to construct a case for the project. A drill template is shown in Fig. 6 and a label is shown in Fig. 7.

**Checkout.** Place S3 in the record position. LED1 should light. Now press S1 (start button). LED2 should light. Speak into the microphone in a normal voice and when you are done, press S2 stop button. LED2 should go out. Now place S3 in the middle (one shot) position and press S1. You should hear the message and LED2 should light. Also, Q1 (switch output transistor) should turn on. You can check this with a small 12-volt bulb or an LED-1K resistor series combination connected between the collector of Q1 and the



This is the finished prototype prior to being fitted into the drilled case. The various off-board components can be seen, as well as the ISD253P Voice Chip.



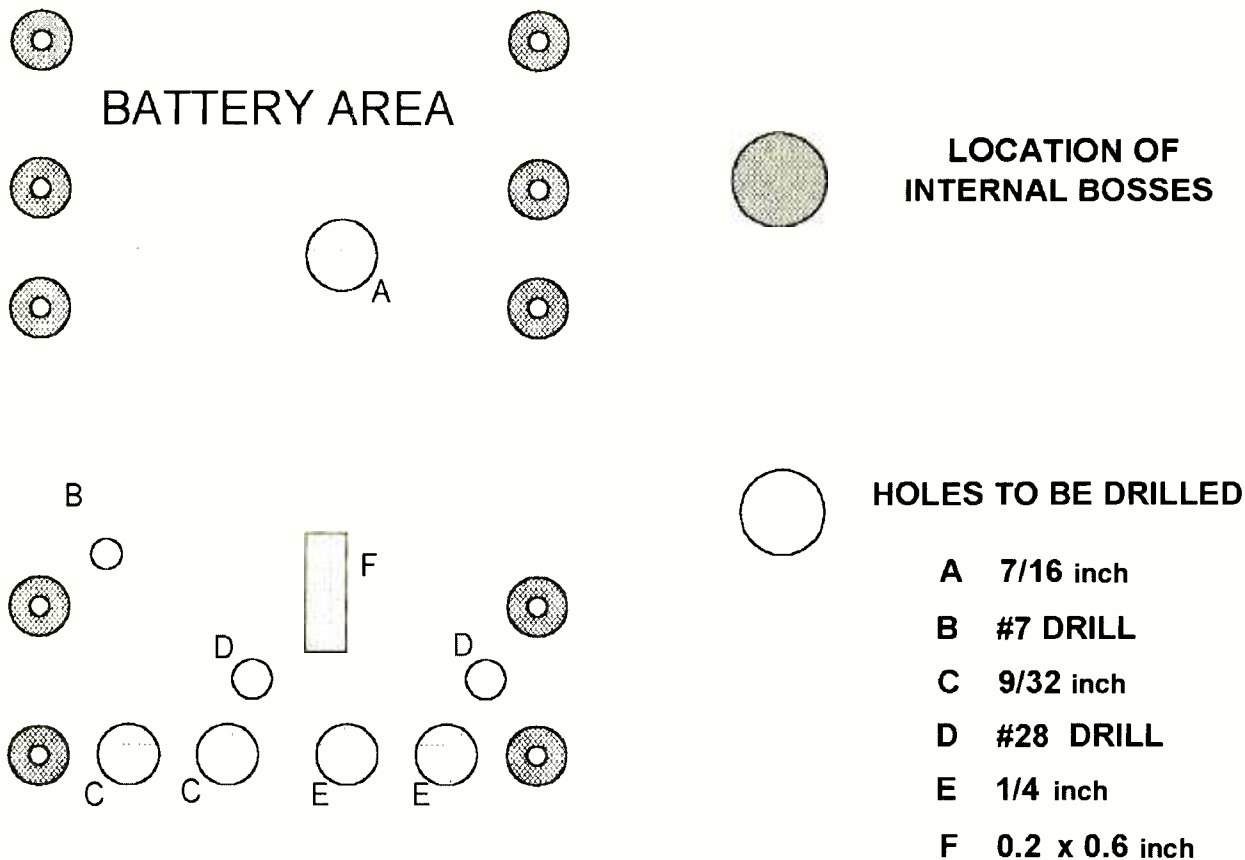


Fig. 6. Using the template above you can drill the required holes into the case. All of the components should fit easily into the unit and holes must be cut for the switches and LED indicators.

positive battery lead—it should light up. The message should complete and LED2 should extinguish. Also, Q1 should stop conducting as indicated by the bulb or test LED. Press S1 again, and the message should start up again. S2 should stop it and reset the

chip if pressed.

Set R4 delay control fully counterclockwise. Now place S3 in the loop position and press S1 again. The cycle should start up. Let it finish and it should almost

(Continued on page 40)

### PARTS LIST FOR THE ALP

#### SEMICONDUCTORS

- IC1—78L05, voltage regulator, 5 volts/100mA
- IC2—CD4528, dual retriggerable/resettable monostable-multivibrator
- IC3—ISD2532P (32s) or ISD2560P (60s), voice chip
- LED1—Light-emitting diode, red
- LED2—Light-emitting diode, yellow
- D1—1N4007, general-purpose rectifier
- Q1—2N3569, NPN-Si, audio frequency pre-amp

#### RESISTORS

- (All resistors are 1/4-watt, 5% units unless otherwise noted.)
- R1, R9, R10—100,000-ohm
  - R2, R16, R17—10,000-ohm
  - R3—3300-ohm
  - R4—100,000-ohm, potentiometer (PT10YH)
  - R5, R7, R8, R13, R14, R15—1000-ohm
  - R6—470-ohm
  - R11—4700-ohm
  - R12—470,000-ohm

#### CAPACITORS

- C1, C2, C6, C7—10- $\mu$ F, 16-volt electrolytic

- C3—1- $\mu$ F, 50-volt electrolytic
- C4—470- $\mu$ F, 6.3-volt electrolytic
- C5—.01- $\mu$ F, ceramic
- C8—4.7- $\mu$ F, 25-volt electrolytic
- C9, C10, C11—.1- $\mu$ F, Mylar
- C12—100- $\mu$ F, 16-volt electrolytic

#### ADDITIONAL PARTS AND MATERIALS

- S1, S2—NO push-button switch
- S3—Two-pole, three-position slide switch
- J1—Audio jack, 3.5-mm stereo
- J2—Keying jack, 3.5-mm open circuit
- MIC1—Electret microphone

**NOTE:** The following parts are available from: North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053: Complete kit consisting of a drilled and etched circuit board, all parts that mount on it, and complete documentation—\$32.50 plus \$5 postage and handling (within US). A suitable case is available from the same source—\$17.25. New York State residents add sales tax for purchases. Call 914-235-6611 or check Web site [www.northcountryradio.com](http://www.northcountryradio.com) for latest prices.

# BUILD THIS HOME APPLIANCE WATT METER/ WATT-HOUR METER

FERNANDO GARCIA

## IMPORTANT WARNING NOTICE:

The device described in this article involves the use of materials and substances that are hazardous to health and life. Unless you are experienced in the construction and safety considerations that apply to high-voltage devices of this nature **DO NOT** attempt to implement or use this information contained in this article. Although all possible measures have been taken to ensure the accuracy of the information presented, Gernsback Publications Inc. and the author are not liable for damages or injuries, misinterpretation of directions, or the misapplications of information.

**W**hy do I need a watt meter? A very valid question to ask.

As the West Coast energy shortages have shown, we are tremendously dependent on electrical energy. Unfortunately, new power-generating plants are not welcome in most communities, as all of them—whether fossil fuel, nuclear, hydro, or even wind-powered—have some environmental impact. Mix the environmental concerns with politics, and one can glimpse the mess electrical utilities have become.

The purpose of this article is not to discuss the messy details of energy, but what the average person can do to alleviate the problem. The answer is, quite a lot, by energy conservation measures. No, I'm not advocating that you set your thermostat at 85° F in the summertime. The key is smart conservation measures, the type that still allow you to maintain comfort and productivity, while reducing energy consumption. You know a few basic tricks, for instance, replacing incandescent bulbs with compact fluorescent lamps. Those are the obvious ones, but how about the not-so-obvious energy wasters?

Your house is full of them, from battery chargers to electronic appliances that, when turned-off, in reality only go into a standby mode. The power consumption



in that mode can be surprisingly high. There they sit, day in and day out, consuming more than their fair share of watts, just doing nothing but waiting for somebody to turn them on.

By far, the worst offenders are TVs and VCRs, if only by the sheer number of appliances installed. There have been many studies related to energy waste in home appliances that you can read about on <http://eetd.lbl.gov/ea/stand>

[by/Articles/Purdue.html](http://Articles/Purdue.html) and other similar Web sites. Some studies claim that standby power comprises 5% of total energy consumption in the US and about 13% in Japan! That is quite a lot of energy!

Fortunately, most newer appliances that are Energy-Star compliant are designed to consume 1 or 2 watts at most in the standby mode. How do you know if it is worthwhile to replace your old TV with a new one? The *Watt-Hour Meter* described in this article can help in your decision.

Even if you do not plan on replacing household appliances, being a power-hound is actually enlightening and a lot of fun. You can actually see how setting your fridge just a little cooler can jump its energy consumption dramatically. Attach the meter to your computer, and you can see how much it costs you to

*Keep track of your  
home-energy expenditure.*



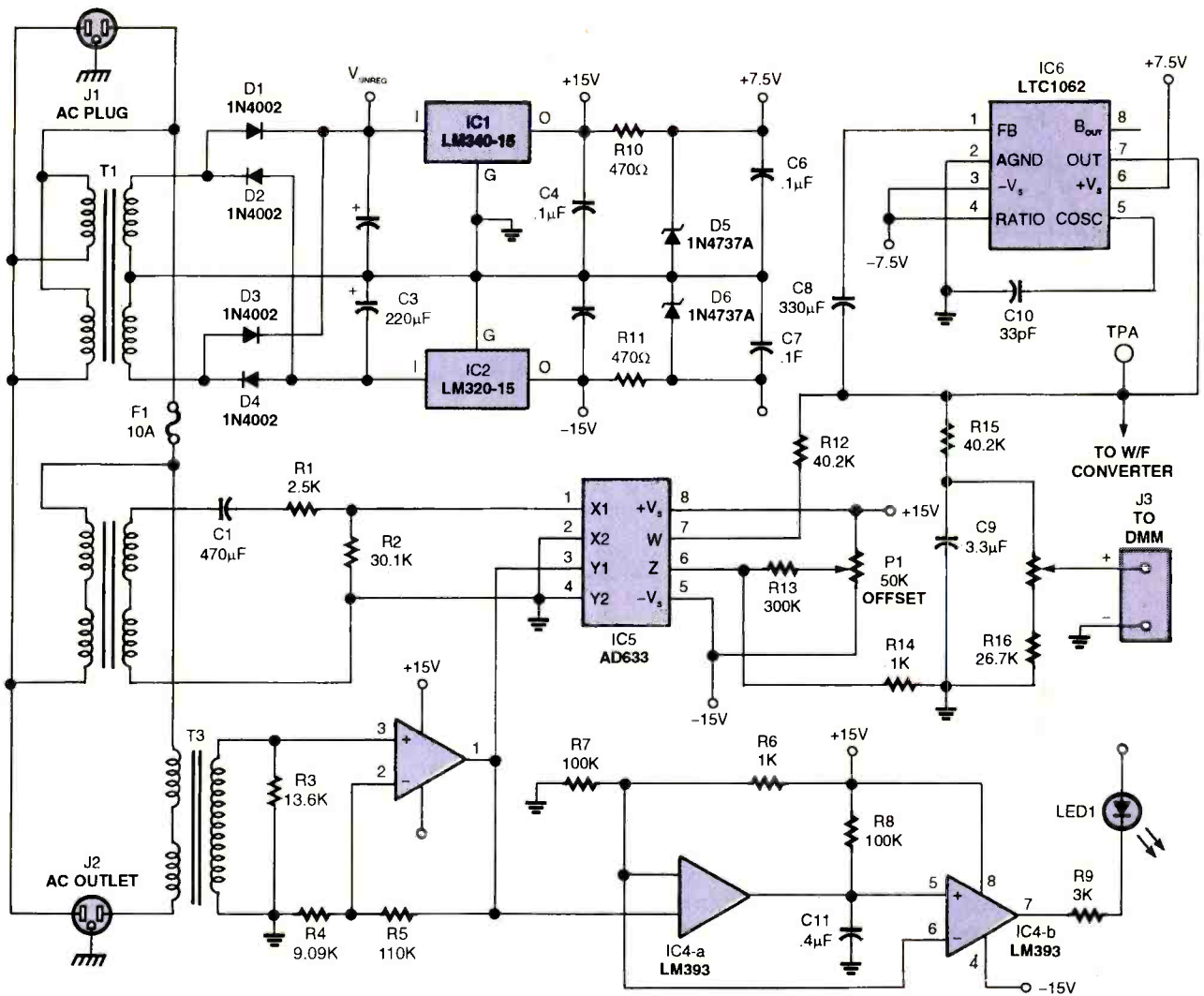


Fig. 1. Here is the schematic for the Watt Meter/Watt-Hour Meter.

leave the monitor on while you download that large file. Investigate how much it takes to mow your lawn with that rechargeable lawnmower.

The bottom line is that energy awareness actually saves you money. You can feel better knowing that you are doing your share to improve the environment.

**Watt Meter Circuit Description.** The electronic watt-hour meter is divided into two sections; the first measures the actual power and the second integrates this power consumption to obtain energy (watt-hours). If you only use a watt meter, this second section could be left off.

The inspiration for this article is an old National Semiconductor application note, AN-265, which was first published in 1984 and can still be found at their Web site. The note was written for seasoned engineers, and it suffers from a drawback that would preclude it from being published on a hobbyist magazine: a substantial portion of the circuit is connected without isolation to the "live" AC voltage. The app note does warn about using an isolation transformer to prevent electric shock, but I decided this project should be intrinsically safe.

Therefore, as shown in the schematic of Fig. 1, for safety's sake this design employs both a voltage and a current transformer (T2 and T3 respectively) in addition to its own power-supply transformer, T1. One may ask if the power-supply transformer could not be used as the voltage-sampling transformer. The answer is absolutely not; the supply current substantially reduces and distorts the output voltage. In addition, the transformer's magnetizing current, when operating close to its rated voltage, is quite large, which further distorts the voltage waveform. The key here is to employ a fully unloaded transformer operating at a voltage far below its primary ratings. Therefore, the dedicated voltage-sense transformer only sees a high impedance load and its primaries are connected in series to provide a 230-volt rating. When operated at normal 120-volt household voltage, the waveform distortion is kept at a minimum. You will later understand why distortion is a key parameter.

The current sample from T3 is converted into a voltage by resistor R3 and amplified by op-amp IC3a and gain set by R4 and R5. The voltage sample from T2 is divided down R1 and R2, and the inevitable phase shift equalized by C1. In both instances, this condition-

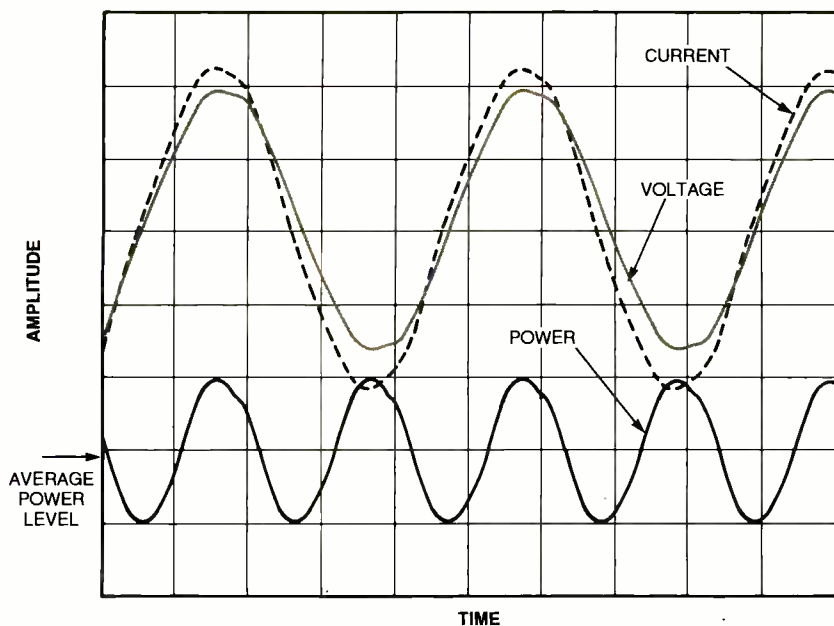


Fig. 2. Shown here are some waveforms that provide insight to the circuit operation. In this instance, the load was a room heater that had a small fan.

ing is necessary to obtain the proper values of  $\pm 10$  volt peak-to-peak at the circuit's maximum input range (130-volt rms and 10-amp rms). These are fed to the analog multiplier's X1 and Y1 inputs, where the circuit magic resides.

To design and build a multiplier using discrete components and op-amps is a tricky and difficult matter; fortunately, Analog Devices has in its catalog several monolithic analog multipliers. The low-cost device AD633 is used (IC5) in this project.

It can be shown that if two periodic waveforms are multiplied, the result is a waveform which contains an AC component at twice the original frequency, plus a DC component. How large is the DC component? One-half the product of the two values times the cosine of the phase angle. In equation form (and I promise this is the only equation I will show)

$$\text{DC level} = \frac{1}{2} * V * I * \cos(a).$$

Every student of electrical engineering will immediately recognize this as the equation used to compute AC true power.

We can measure this DC voltage in a properly calibrated scale and read true power. We must first get rid of the AC component, which

will be twice the power line frequency, or 120 Hz for American utilities. This can be done with a low-pass filter, which will attenuate this AC signal while allowing the DC information to pass through. This is a lot simpler said than done, as to obtain maximum accuracy, the 120-Hz component must be attenuated at least 60 dB. For a simple RC filter, it would mean a cut-off frequency so low that its settling time

would be measured in seconds. This is clearly an undesirable situation; the instrument would be unable to measure the power peaks that most equipment draws briefly during start-up. Therefore, to achieve the desired attenuation and fast transient response, a high-order filter is a must. Unfortunately, filter orders higher than three are pretty tricky to build and require all sorts of nonstandard component values.

Again, a semiconductor vendor comes to the rescue. Linear Technologies offers a variety of monolithic switched capacitor filters. These types of filters are tunable by varying the clock frequency, usually require very few external passive components, and high-order filter configurations are easily achieved. Filter IC6, an LTC1062 device, goes a little further. It is a DC-accurate topology, which is important if we plan to recover the DC-component precisely. Capacitor C10, along with the ratio pin 4 tied to the proper logic level, sets the internal clock frequency and thus its cutoff frequency. This frequency is set to 30 Hz. The device is a fifth-order filter; therefore, the desired 60-dB attenuation to the AC component is achieved. Capacitor C8, along with the equivalent resistance presented by R12, R15, R16,

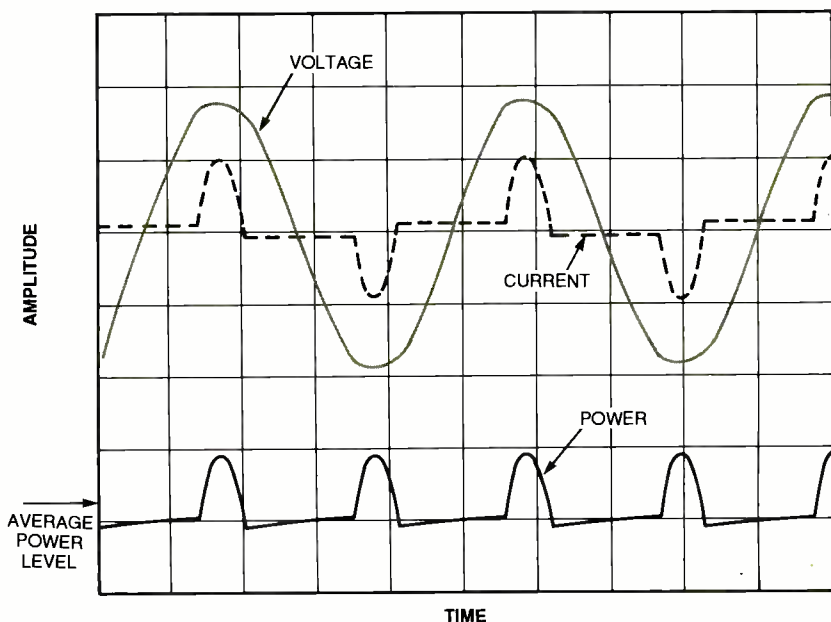


Fig. 3. These are pulses from an "electronic load," which in this case was a computer and monitor. Electronic loads are characterized by the fact that the current waveform is not sinusoidal but pulsed.



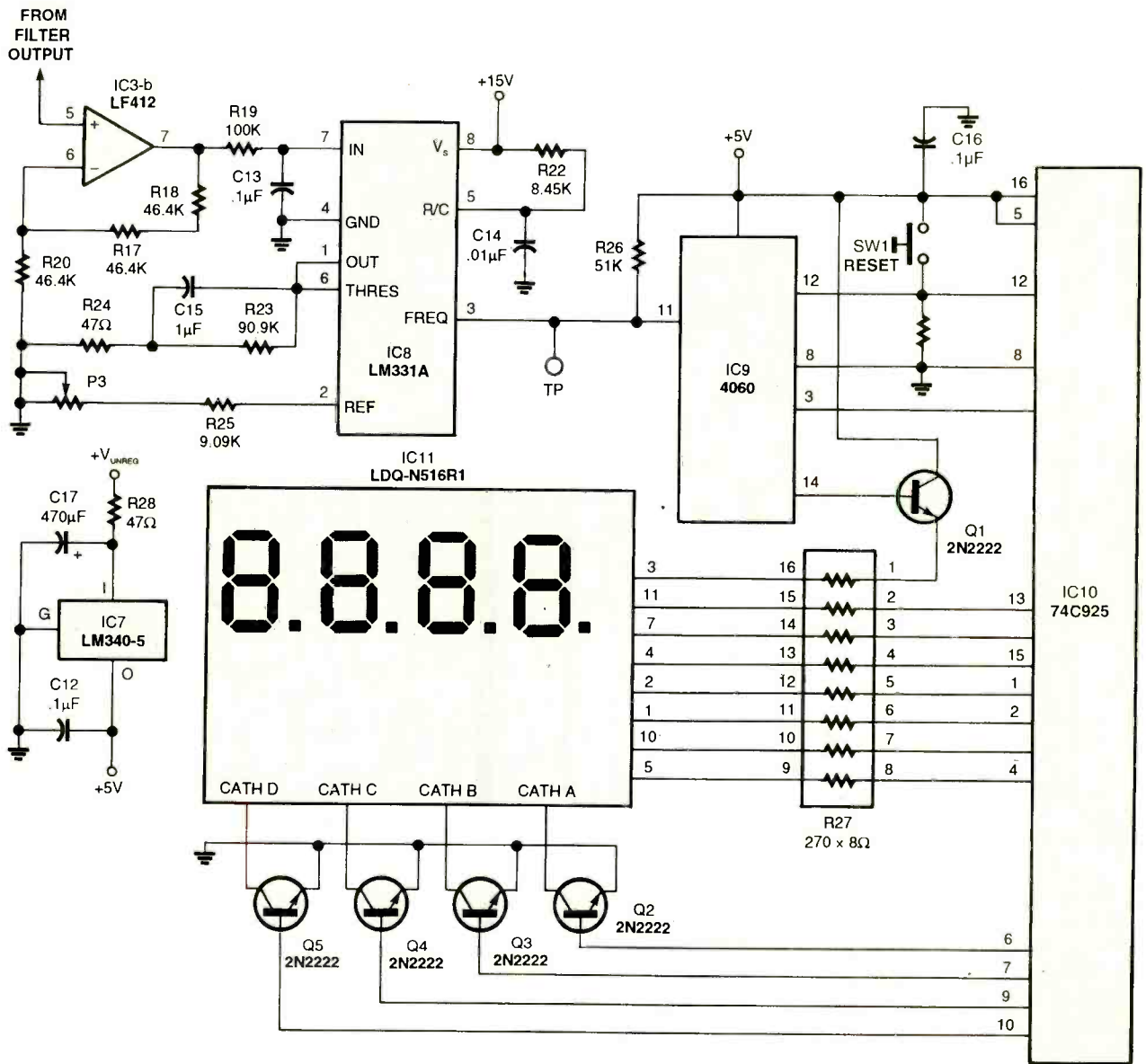


Fig. 4 This is the schematic for the digital integrator. The DC component from the low-pass filter is buffered and amplified by IC3b. This is fed to a voltage-to-frequency converter IC8.

and P2, sets the proper transient response for the filter. They also divide down the DC component such that the voltage present at J3 (adjustable by pot P2) is exactly one volt per kilowatt. This setting allows a digital multimeter or high-impedance analog meter (set to the 2-volt scale) to directly read the true power.

At the project's maximum rating (1300 watts), this would mean 1.3  $V_{DC}$ . Capacitor C9 eliminates any clock feedthrough from IC6. Although all devices are quite accurate, some small DC offset is inevitable. Thus P1, along with R13 and R14, injects a small trimmable offset to ensure that the output reads as close to zero volts DC when no load is applied.

Comparator IC4a and b, along with resistors R6 through R9, capacitor C11, and LED D7, is a current-overload indicator. One would think that by monitoring the power, one would be aware of impending current overload. This is not always the case, as described in the sidebar, "Power

Factor, Crest Factor, and No Power." Although a continuous overload will eventually blow the line-protection fuse F1, a milder overload due to a high-crest factor may yield completely erroneous results if the maximum range to the multiplier is exceeded.

Figure 2 shows some waveforms that provide insight to the circuit operation. In this instance, the load was a room heater that had a small fan. The power pulses, with a frequency twice that of the mains voltage, may be seen at the bottom trace.

Figure 3 shows the pulses from an "electronic load," which in this case was a computer and monitor. Electronic loads are characterized by the fact that the current waveform is not sinusoidal but pulsed. You can see that the analog multiplier still performs its job properly.

**Watt-Hour Meter Description.** A bipolar  $\pm 15$ -volt supply is provided by transformer T1, diodes D1-D4, fil-

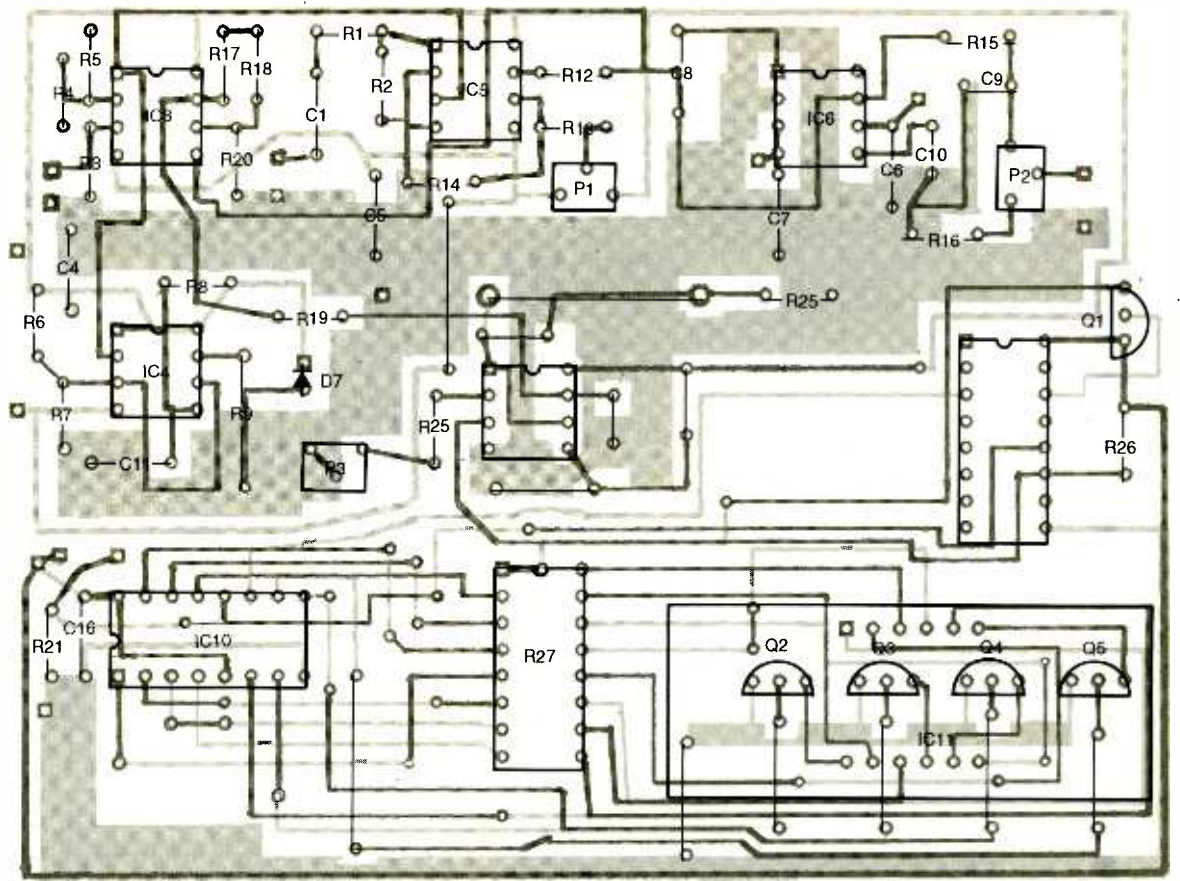


Fig. 5. Here is the Parts Placement diagram for the Home Appliance Watt-Meter.

ter capacitors C2 and C3, and three-terminal regulators IC1 and IC2. The 15 volts are required to maximize the front end's dynamic range; however, the monolithic filter cannot withstand and does not require such a high voltage. The voltage is thus regulated down to  $\pm 7.5$  volt by zeners D5 and D6. An unregulated positive supply is also provided for the logic voltage regulator IC7, which is shown in the next section.

Male plug J1 connects to a suitable wall outlet, and the device under test is connected to receptacle J2. The connection of T1 is "upstream" of the voltage and current sensors, so that none of the power it consumes is measured.

The above paragraphs describe the power-measuring section, but you may want to build the energy-measuring section. Energy, as you may recall, is power integrated over time, which is what your local utility bills you.

Figure 4 shows the digital integrator. The DC component from the low-pass filter is buffered and amplified by IC3b. This is fed to a voltage-to-frequency converter IC8. Voltage-to-frequency conversion is a straightforward analog-to-digital conversion, which easily lends itself to time integration by simply counting its pulses. Altogether, P3, R22-R25, and C14 form the timing components, while C15 is the capacitor for the internal sample-and-hold function. The exact frequency is adjusted via P3. These all are critical components, as explained later.

Resistor R19 cancels the input bias current offset. Resistor R26 is a pull-up resistor to +5 volts, which is used to feed the pulses to the logic circuits.

The variable frequency pulses are applied to IC9, a 14-stage counter, which divides the frequency down. The net result is that at its Q14 output, there will be a pulse every 3.6 seconds for a properly calibrated circuit when measuring a 1-kilowatt load. Thus, in an hour (3600 seconds), there will be 1000 pulses, meaning a one kilowatt-hour energy measurement. Of course, the pulse-repetition frequency will proportionately increase/decrease with a load increase/decrease.

The pulses are counted and displayed by 4-digit counter/display driver IC10. The digit drive is multiplexed; therefore, the driver scans, with the assistance of Q2-Q5, the display's four digits. The display (IC11) should be of the common cathode type.

Individual segments and the decimal point are fed via a current-limiter-resistor network, R27. All four decimal points are used to monitor watt-hour activity; they flash at a repetition rate much faster than that of the least significant digit change. This is useful when measuring low-power loads where a single digit increment may require tens of seconds. Thus a signal far down the divider chain (Q8) is taken and applied to an emitter follower, Q1, to drive the points.

Momentary pushbutton switch S1 is used to reset all counters to zero, which starts a measuring period.



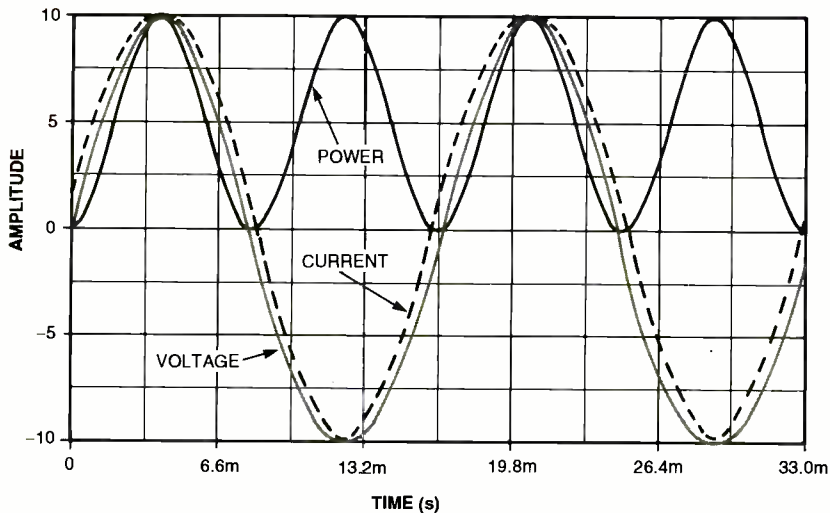


Fig. 6. Most loads will have small phase angles, and the power pulses are for the most part positive. On the other hand, as the phase angle increases to 90 degrees, the cosine value declines steadily to zero.

**Constructing And Calibrating The Project. WARNING: Before you attempt to build this project, remember that hazardous voltages and substantial currents are present in the primary side of the circuit.** Use at least 16-AWG wire for the line cord and the internal wiring, which is shown bold solid on the schematic. If you plan to use a metal enclosure, ground it via the line cord's green wire. Insulate exposed metal surfaces.

Since the hazardous voltage section is all confined to the transformer's primaries, either point-to-point wiring or a dedicated printed board may be used for the rest of the project.

A suitable board layout is shown in Fig. 5. There is no silkscreen on the bottom layer; it is shown only for guidance purposes (Figs. 9 and 10 show foil patterns for the PCB). In this particular board layout, I decided to mount all heavy, heat-producing, and high voltage-carrying components outside it. Therefore, all transformers, bulk capacitors, and voltage regulators are located out. These bulky devices are better suited to be wired point-to-point on a separate pressboard. Please also note that all components are mounted on the top board layer, like any normal assembly. The exceptions are the overload LED and the four-digit, seven-segment display. Therefore, you may mount the board on the wall of an enclosure, where the

appropriate holes for the indicator and the display may be cut out.

If you use the transformers specified in the parts list, follow the connections to the pin numbers exactly. Since a transformer is AC in, AC out, one may think that the actual phasing of the pin connections is of no consequence. Well, for this project it is. The transformers must be wired in the proper phase for the project to work. The silkscreen on the board has a square on the hole where the transformer's dotted terminal should be wired.

The project's display is used to measure watt-hours only. As previously mentioned, there are a pair of female banana jacks where you may connect a DMM to measure

power. As an option, you may wish to have a watt readout all the time and use a dedicated panel meter instead. There are many types available, but ensure that the meter is set to read  $2 V_{DC}$ , and that its input can measure a voltage referenced to its supply common. Beware of this last constraint; some panel meters require a floating power supply from the voltage you are attempting to measure.

You will require access to some test equipment to properly calibrate the project. You will need two DMMs to simultaneously monitor the AC line's voltage and current. One of the meters should have a 10-amp AC measurement capability. Of course, if a wattmeter is available, that's even better. A third DMM to measure DC voltage is required to make life easy; however, if none is available, you can swap the meter you are using to measure AC voltage. You will need some means of measuring frequency, either with a dedicated counter, a multimeter equipped with that function, or a scope. Be aware that if a scope is used the accuracy may be  $\pm 3\%$ , unless it has cursors or an automated frequency measurement capability. You will need a purely resistive high-power load, between 1000 and 1300 watts. I used a fanless room heater, but a bank of incandescent lamps will also do the job. A variable auto-transformer (variac) is also very useful, but not absolutely necessary.

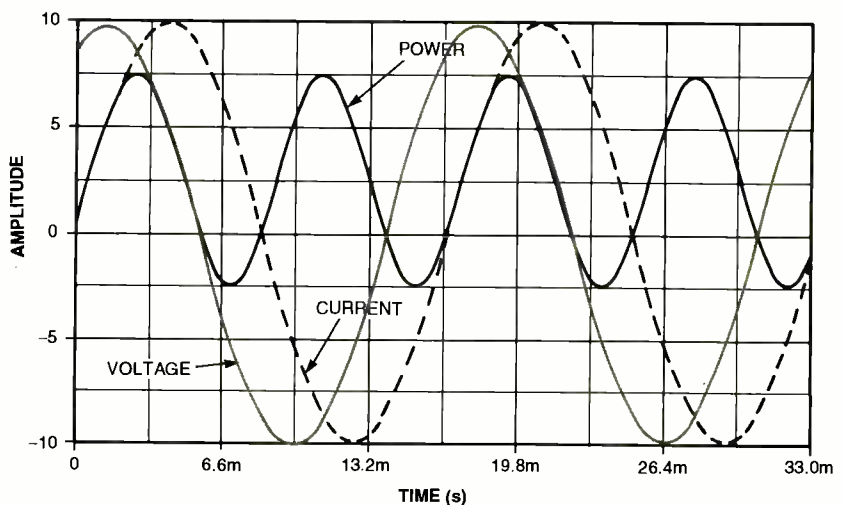


Fig. 7. The larger phase displacement of about 60 degrees causes the power pulses to spend a substantial time below zero. The average power thus decreases, although the peak-to-peak power is identical.

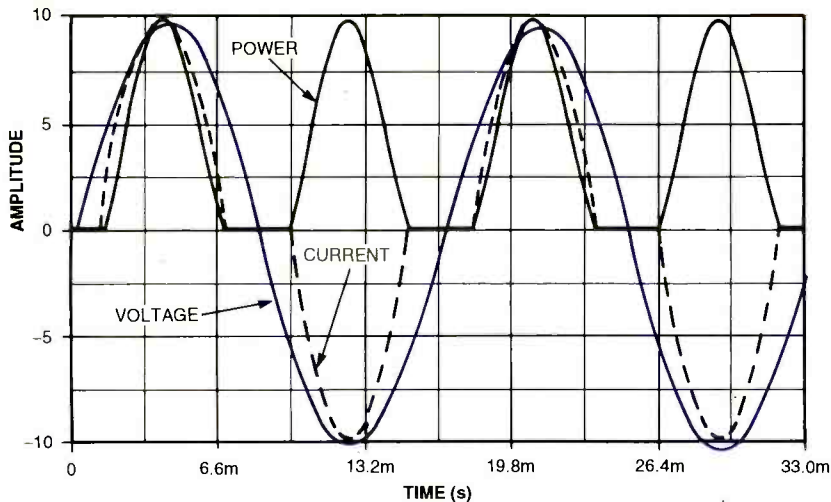


Fig. 8. Electronic loads receive their current in brief intervals of the total 60 Hz period and sit idle the rest of the time.

After you have built and thoroughly checked your assembly, remove fuse F1. Apply power to the unit and measure that all of your internal supply voltages are present and within  $\pm 5\%$ . Then with a DMM in the 200-mV DC range, adjust P1 such that the voltage between Test Point A and common is as close to zero as possible.

Remove power, connect the DMM that will measure current in series with the load (the empty fuse holder is a good place to attach

the ammeter), and the other DMM in parallel to the load. Connect the load and reapply power. If you have access to the variac, start all the way from zero volts and slowly increase to the rated voltage, usually 120 volts. At this time, your load will be fully on, and you will have a reading on both the current and voltage DMMs. Multiply those readings to obtain your wattage and adjust P2 to obtain that same reading for a DMM (or dedicated panel meter) set in the 2-volt DC range

## POWER FACTOR, CREST FACTOR, AND NO POWER

Unlike the simple task of calculating DC power which you obtain by just multiplying voltage and current, the calculation of AC power is a little more complex. For most instances, there will be a phase difference between the voltage and current. This phase displacement causes the true power to be a fraction of the product of voltage and current. This fraction is called the *power factor* and in mathematical terms it is the cosine of the phase angle between voltage and current.

When the load is purely resistive, the phase angle is zero and you know that the value for the cosine of zero degrees is one. Only in this instance can one calculate power by simply multiplying voltage and current readings. Most loads will have small phase angles (or in electrical terms, a high-power factor), and, as seen on Fig. 6, the

power pulses are for the most part positive. On the other hand, as the phase angle increases to 90 degrees, the cosine value declines steadily to zero. This is seen in Fig. 7, where the larger phase displacement of about 60 degrees causes the power pulses to spend a substantial time below zero. The average power thus decreases, although the peak-to-peak power is identical. You may reach a point with very low-power factor loads where you may have very substantial values of voltage and current, but the actual average power value is very low. These computer simulations agree with the actual measured waveforms of Fig. 2 and 3.

You could be overloading the circuit unknowingly. Although no damage is done, the power readings will be erroneous. The overload LED will alert you of this condition.

Another problem occurs with so-

and connected across J3.

Lastly, set your frequency counter or oscilloscope at Test Point B and adjust the frequency according to the following formula:

Frequency =  $4.551 \cdot \text{Power reading}$   
where the frequency is in Hertz and the power reading is in watts.

Push switch S1 momentarily to reset the counter to zero. The decimal points will be flashing and moments later the counter will increment. Reinstall the fuse. This completes the calibration and verification of the instrument.

## A Word About The Project's Accuracy.

Remember that the accuracy of your finished project depends on the accuracy of the instrumentation you used to calibrate it. I performed the initial calibration and troubleshooting with the limited equipment I have at home and then went to my local college where I could borrow the electrical lab and some equipment for a short period of time to perform the final calibration.

To retain the accuracy of the calibration, you must be aware of the sources of drift and what can

called "electronic loads." As its name implies, it is a load consisting of an electronic appliance, whether a computer, TV set, or audio amplifier. Electronic loads receive their current in brief intervals of the total 60 Hz period and sit idle the rest of the time. This is shown in Fig. 8. Although the rms current value may be moderate, these peaks may be quite high. This is a waveform with a high *crest factor*. Crest factors are the ratio of peak to rms values, and for a sine wave its value is 1.414. Electronic loads present crest factors from 2-3 and even higher. Therefore, you could possibly be measuring a load drawing moderate amounts of power with a very high peak current value. Again, no damage will be done, but the power readings will be all wrong. Again the overload LED will lit to alert you of this condition.



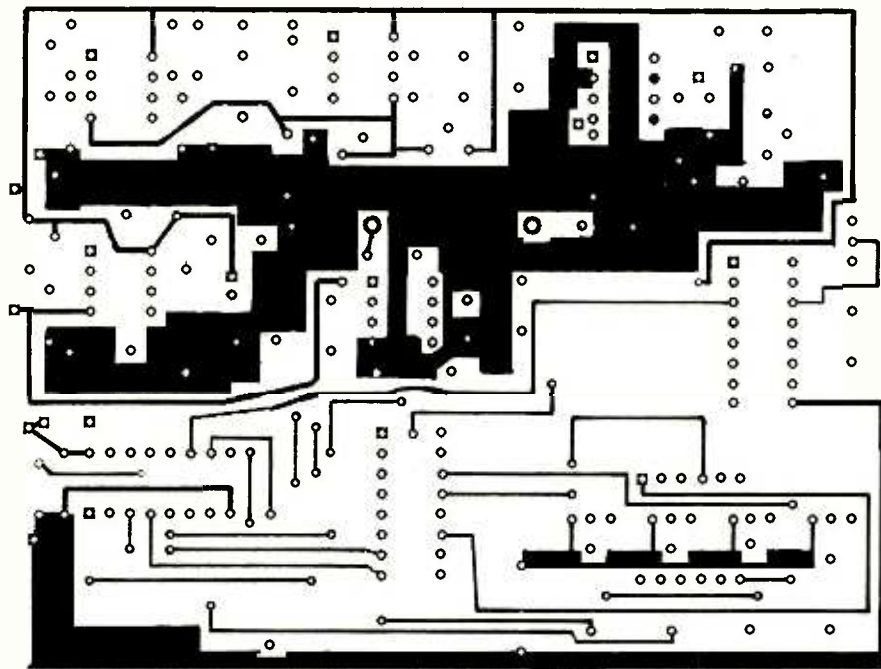


Fig. 9. Here is the foil pattern for the bottom of the PCB.

be done to avoid them. In short, four words: careful selection of components.

In particular, capacitors C14 and C15 should be polystyrene or polypropylene. Avoid ceramic, Mylar, polyester, or electrolytic caps in those positions. The trimmer potentiometers should be cermet, not carbon films. Maintain the use of metal film, 1% resistors in the areas where I specified them. Lastly, if you can get the "A" suffix versions of IC3 and IC8 (LF412A and LM331A), their offset will be much lower.

Although sense-transformer errors have been minimized by the techniques described above, there is still some residual phase offset, which is clearly seen in Fig. 2. In this instance, the load was purely resistive, and the voltage and current waveform's zero crossing should have matched. As previously described,

## PARTS LIST FOR THE WATT-HOUR METER

### SEMICONDUCTORS

IC1—LM340-15, positive-voltage regulator  
 IC2—LM320-15, negative voltage regulator  
 IC3—LF412A, dual BiFet op-amp  
 IC4—LM393, dual comparator  
 IC5—AD633 Analog Multiplier  
 IC6—LT1062, 5<sup>th</sup>-order switched-capacitor filter  
 IC7—LM340-5, positive-voltage regulator  
 IC8—LM331A, voltage/frequency converter  
 IC9—CD4060, 14-stage binary counter  
 IC10—74C925, counter/4-digit driver  
 IC11—LDQ-N516RI, 4-digit, 7-segment common cathode red display  
 D1—D4—1N4002 diode  
 D5, D6—1N4737A Zener  
 D7—Red LED  
 Q1—Q5—2N2222 NPN transistor

### RESISTORS

R1—21,500 ohms, 1%, 1/8-watt  
 R2—30,100 ohms, 1%, 1/8-watt  
 R3—13,600 ohms, 1%, 1/8-watt  
 R4, R25—9090 ohms, 1%, 1/8-watt  
 R5—110,000 ohms, 1%, 1/8-watt  
 R6, R21, R26—51,000 ohms, 5%, 1/8-watt  
 R7, R8, R19—100,000 ohms, 5%, 1/8-watt  
 R9—3000 ohms, 5%, 1/2-watt  
 R10, R11—470 ohms, 5%, 1/2-watt  
 R12, R15—40,200 ohms, 1%, 1/8-watt  
 R13—300,000 ohms, 5%, 1/8-watt  
 R14—1000 ohms, 5%, 1/8-watt  
 R16, R17, R18, R20—26,700 ohms, 1%, 1/8-watt  
 R22—8450 ohms, 1%, 1/8-watt  
 R23—90,900 ohms, 1%, 1/8-watt  
 R24, R28—47 ohms, 5%, 1/2-watt  
 R27—270 ohms × 8 dip network  
 P1—50,000 ohms, single-turn potentiometer  
 P2—5000 ohms, multi-turn potentiometer

P3—2000 ohms, multi-turn potentiometer

### CAPACITORS

Use 10%, lowest available voltage (usually 100 volts) for film and ceramic capacitors, unless noted.

C1—0.47  $\mu$ F, Mylar (see text)  
 C2, C17—470  $\mu$ F, 25-volt, electrolytic  
 C3—220  $\mu$ F, 25-volt, electrolytic  
 C4—C7, C12, C16—0.1  $\mu$ F, ceramic  
 C8—0.33  $\mu$ F, Mylar  
 C9—3.3 nF, Mylar  
 C10—330 pf, 5%, polypropylene  
 C11, C13—0.1  $\mu$ F, Mylar  
 C14—0.01  $\mu$ F, 2%, polystyrene or polypropylene (see text)  
 C15—1  $\mu$ F, polypropylene (see text)

### ADDITIONAL PARTS AND MATERIALS

T1—6 VA-size, 115+115 primary, 14+14 secondary, Tamura 3FD-428  
 T2—1.1 VA-size 115+115 primary, 8+8 secondary, Tamura 3FD-216  
 T3—10-amp, 250:1 current transformer, Coilcraft CS2106 or similar  
 F1—12-amp, 250-volt, slo-blo fuse and fuse holder  
 J1—Male AC plug  
 J2—Female AC receptacle  
 J3—Red and Black banana plugs  
 SW1—N.O. Momentary switch.

### PARTS AVAILABILITY

Digi-Key, [www.digi-key.com](http://www.digi-key.com) or Mouser Electronics, [www.mouser.com](http://www.mouser.com).

The Analog Devices AD633 is available from Newark Electronics, [www.newark.com](http://www.newark.com).

If there is enough interest, a PC board for the project may be offered for sale. Contact the author at [fernando.v.garcia@worldnet.att.net](mailto:fernando.v.garcia@worldnet.att.net).

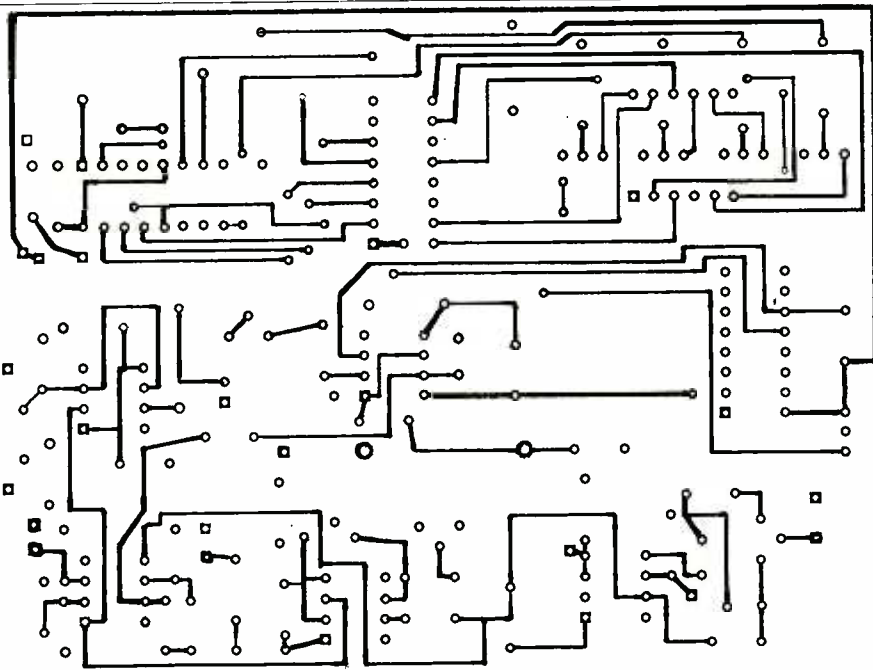


Fig. 10 Here is the foil pattern for the top of the PCB.

capacitor C1 compensates for this. If you have access to a dual-trace oscilloscope, you may wish to tweak the capacitor value to accomplish this. In my case, I required an additional 0.1  $\mu$ F in parallel with C1. If you have no oscilloscope to adjust the project, the phase error will still be quite small

### THE ALP (continued from page 31)

immediately repeat. The delay between finishing and restarting should be controllable with R4. If a longer maximum delay is desired, proportionally increase the value of C4 as needed. Note that pressing S2 will stop and reset the cycle, but it will start up again later as determined by the setting of R4. In the loop mode, complete stopping is obtained by moving S3 to the one-shot position.

See the figures for suggested package layout and a suitable label for the front panel.



"I don't think needing baby food jars to put spare parts in is a good reason to have another child."

and constant, and its effect on accuracy is less than 0.5%.

If you substitute the current transformer specified in the parts list, you may need to adjust R3 to provide the voltage-level ratio indicated in the schematic. You may notice that this is usually lower than the manufacturer's suggested resistance value. This is another trick to increase accuracy.

### Final Words On Using The Watt-Hour Meter.

I distinctly recall when reading National Semiconductor's app note being puzzled about the substantial increase in a refrigerator's electrical consumption as the thermostat was set just 2° C (3.6° F) cooler. This is very true. You may monitor the amount of energy you can save by turning off your computer's monitor when downloading a large file. Perhaps the biggest surprise came from the amount of power the bedroom TV and VCR

consume when they are off! These consumed as much as 23 watts while idling, while the newer TV and VCR in the living room, both Energy Star compliant, consume well below 3 watts.

# VOICE

MIC

# ID

DELAY

LOOP  
SINGLE  
REC

STOP START PWR OUTPUT

Fig. 7. This label can be copied and used for your unit. All of the indicators and switches are clearly labeled for ease of use.



## ALL ABOUT

(continued from page 23)

affecting  $A$  become less and less relevant to the circuit performance as the value of  $\beta A$  increases.

We do not mean to pull a snow job here, but you should spend whatever time is needed to understand these concepts, as they are the heart of the theory. Once understood, op-amp circuits will be a breeze to work with.

### Virtual Ground

In a practical op-amp circuit  $e_{in}$  is very small, since the value of  $A$  is at least several thousand. Since  $e_{in}$  is that voltage appearing across the input of the op-amp (see Fig. 3), if one input terminal of the op-amp is connected to ground or has zero signal on it, the other input will also be very close to ground. Note again that  $e_{in}$  is at most a few millivolts in practical circuits. Under all signal levels this will be true, provided the op-amp is not driven into saturation or another region where the gain falls to a low value. This gives rise to the term virtual ground, since the op-amp input is always very close in voltage to ground. The input terminal in many applications is the inverting input, with the non-inverting input grounded or connected to a source of zero signal. Additionally, the amplifier itself has a high-input impedance, often measured in megohms. The input current to the op-amp itself is negligible and zero for all practical purposes. Therefore, in Fig. 3, the input current  $I$  in  $R_1$ , equal to  $V_{in}/R_1$ , has to equal the feedback current in  $R_2$ , equaling  $V_{out}/R_2$ . Since these currents entering and leaving any junction must equal

Graf and Sheets are no strangers to the pages of Gernsback. Their educational projects, such as the *RF-Field Strength Meter* and the *MPX2000 FM Transmitter*, can be found at **North Country Radio**. Established in 1986, this company offers projects related to amateur TV transmitters/receivers, AM and FM transmitters/ receivers, video cameras, and numerous other subjects. Visit the Web site at [www.northcountryradio.com](http://www.northcountryradio.com) for more information.

**Ordering Information:** PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053; Voice: 914-235-6611; Fax: 914-576-6051; e-mail: [Rgraf30832@aol.com](mailto:Rgraf30832@aol.com).

### Engineering and Technical Support

PO Box 200, Hartford, NY 12838  
Voice/Fax: 518-854-9280  
e-mail: [support@northcountryradio.com](mailto:support@northcountryradio.com)

zero (Kirchoff's current law, the law of continuity—and plain common sense), it follows that the positive current flowing in  $R_1$  must be cancelled by a current flowing in  $R_2$ , except for a tiny current flowing into the op-amp, which is zero for all practical purposes. The only way this can happen is if  $V_{out}$  equals  $-V_{in}$  in  $(R_2/R_1)$ .

Note that there is an inversion in phase, since the currents must cancel. The voltage gain is simply the ratio of  $R_2$  to  $R_1$ . The two resistors set the gain. If multiple inputs are desired, extra input resistors and input sources can be added as in Fig. 4. The output voltage is given as:

$$V_{out} = -[V_{in1} \times R_f / R_1 + V_{in2} \times R_f / R_2 + V_{in3} \times R_f / R_3 + V_{inN} \times R_f / R_N]$$

This is called a summing amplifier (see Fig. 4) and the junction of all the resistors at the input is called the summing junction. Since the input of the amplifier is a virtual ground, there is almost complete isolation

between all the input sources. This circuit makes an excellent audio mixer with virtually no cross-talk effects. By varying the values of the input resistors,  $R_1$ – $R_N$ , different gains can be obtained for the various inputs.

As far as AC signals are concerned, a high-gain single-transistor amplifier circuit can approximate the behavior of an op-amp in these circuits if the collector is considered the output, the base the inverting input, and the emitter the non-inverting input. Naturally DC biasing arrangements are needed and there are DC level considerations, but the principles of feedback still apply. (see Fig. 5).

Several op-amp circuits will be discussed in the next part of this article. **P**



## Robotic Arm & IBM PC Interface

This month we are building a PC interface (IBM compatible) for OWI's popular Robotic Arm Trainer. The PC interface, see Fig. 1, allows one to control the Robotic Arm either interactively in real time or allows the computer to control the arm autonomously by replaying a script file.

Robotic arms, I believe, are the most widely used industrial robots. They are versatile and can be retrofitted for various tasks by changing the end manipulator. For instance, welding manipulators for spot welding robots, spray nozzles for spray painters and cleaners, grippers for pick and place, and routers for material cutting, just to name a few.

Designing and building a robotic arm from scratch is a difficult project. It is far easier to assemble a pre-fabricated robotic arm from a kit, and OWI Company offers such a kit. It is an inexpensive robotic arm kit that is suitable for interfacing to a computer.

### Gross Anatomy

The robotic arm is primarily made of lightweight injection molded plastic. The DC motors used in the robotic arm are small, high rpm, low-torque motors. To increase torque, each motor is integrally connected to a gearbox assembly. While the gearboxes increase the motor's torque, the robotic arm is not capable of lifting or moving a great amount of weight. The maximum recommended lifting capacity is 4.6 ounces (130grams). Here is a quick rundown of the arm's specifications:

- Five axes of motion.
- Base can rotate left and right—350 degrees.
- Shoulder moving range—120 degrees.
- Elbow moving range—135 degrees.
- Wrist rotate CW and CCW—340 degrees.

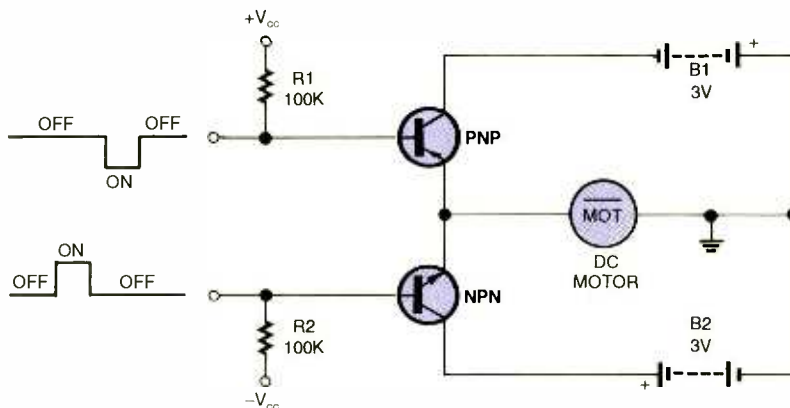


Fig. 1. The PC interface, see Fig. 1, allows one to control the Robotic Arm either interactively in real time or allows the computer to control the arm autonomously by replaying a script file.

- Gripper open and close—55 mm (2.2 inches)—0.
- Product Dimensions-Maximum length outwards—360 mm (14.2 inches).
- Maximum height upwards—510 mm (20.1 inches).
- Lifting Capacity-Maximum—130g (4.6 oz.) Power.
- Power Source: 4 "D" batteries (not included).

What makes the arm suitable for

computer control is the fact that it uses five small DC motors to produce motion in the base, shoulder, elbow, wrist, and gripper. The motors are controlled via a "wire" that we can tap into, meaning that each robotic motor (and its associated function) is controlled by wire supplying electrical power.

### Basic Motor Control

To understand the basic function of wire control as we are using it in this project, let's look at how two digital signals can control a single DC motor, see Fig. 2. Controlling a motor for clockwise (CW) and counter-clockwise (CCW) directions requires two complementary PNP and NPN transistors. Each transistor functions like a switch, controlling the current to the DC motor. The direction of the current controls which way the motor spins; clockwise (CW) or counter-clockwise (CCW)—each transistor controls the opposite direction.

Notice when both transistors are turned off, the motor is off. Only one transistor (per motor) should be turned on at a time. If both transistors are accidentally turned on, it will



Here is the OWI Robotic Arm Trainer that is controlled via a PC interface. What makes the arm suitable for computer control is the fact that it uses five small DC motors to produce motion in the base, shoulder, elbow, wrist, and gripper.



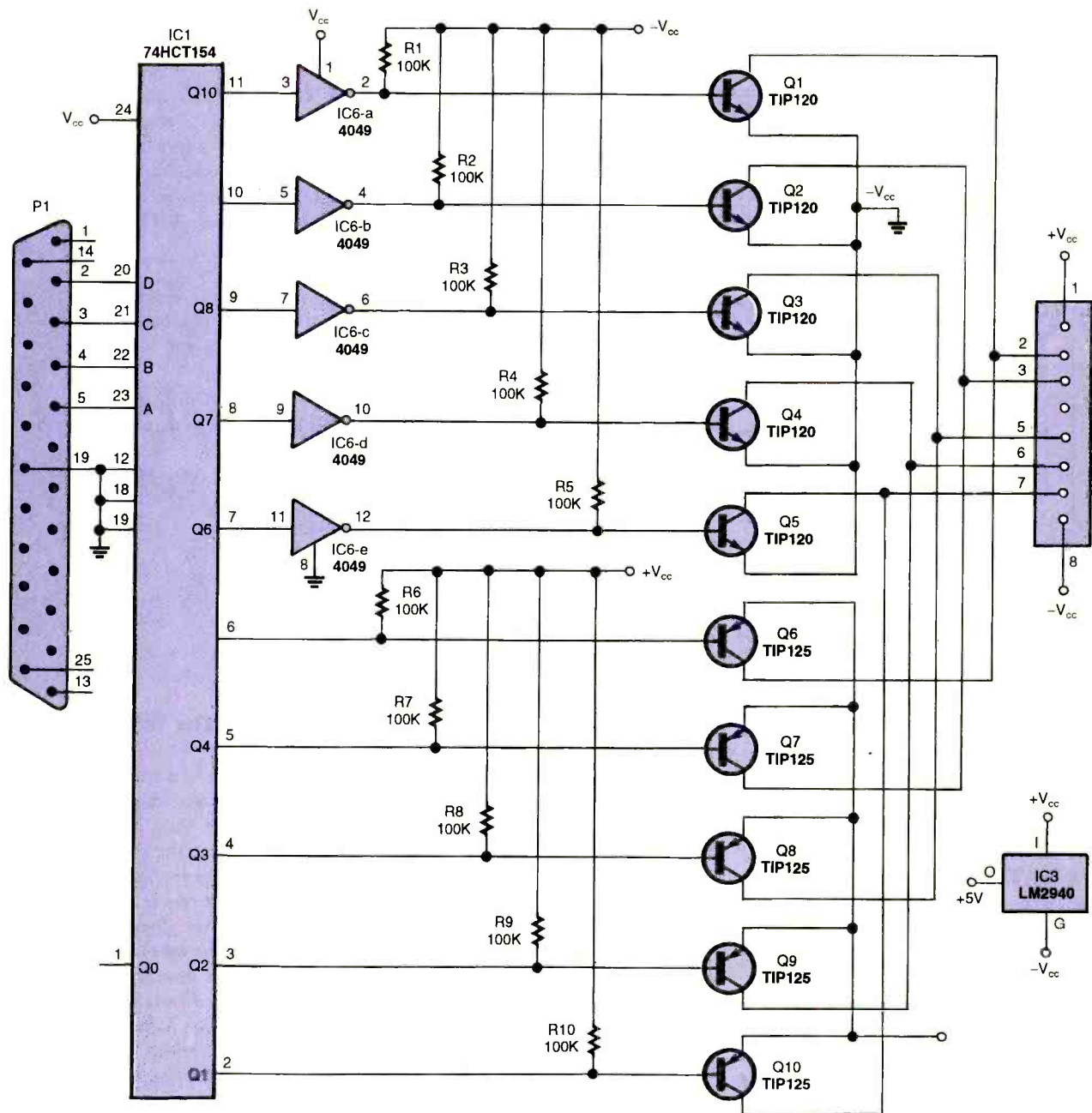


Fig. 2. Controlling a motor for clockwise (CW) and counter-clockwise (CCW) directions requires two complementary PNP and NPN transistors. Each transistor functions like a switch, controlling the current to the DC motor.

be the equivalent of creating a short circuit. Similarly, each DC motor in the robotic arm is controlled by two complementary transistors on the interface.

### PC Interface Construction

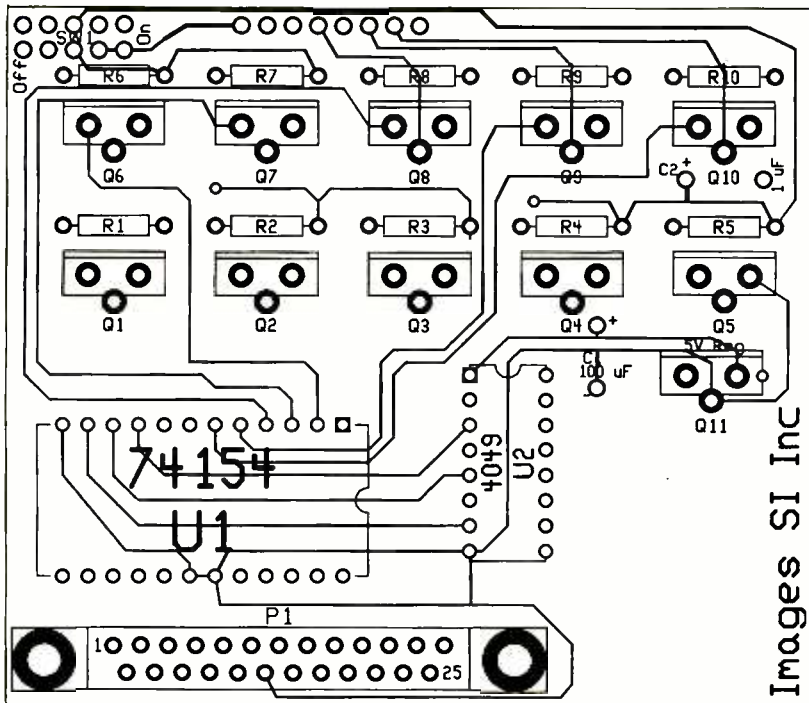
The PC interface schematic is shown in Fig. 2. There is nothing critical about the circuit, and it may be built on a breadboard. For those who purchase the kit, the parts placement on the PC board is shown in Fig. 3.

Begin construction by first identify-

ing the component side of the PCB. The component side has the white line drawings of the resistors, transistors, ICs, and DB25 connector. All components are mounted on the component side.

In general, after soldering a component to the board, clip away any excess wire from the under side of the PCB. It's a good idea to follow the sequence for mounting the components. Begin by mounting the 100K resistors (color bands brown, black, yellow, gold, or silver) labeled R1 through R10. Next mount the 14- and 20-pin sockets in the

U1 and U2 position. Mount and solder the DB-25 right-angle connector. Do not force the DB-25 pins through the board; it is a precision fit. If necessary, gently rock the connector in, making sure not to bend any pins. Mount the slide switch and the LM2940 voltage regulator. Mount and solder the TIP120 and TIP125 transistors. Finish the project by mounting the eight-position three-inch connection cable. Insert the two ICs, the 74HCT154 and 4049, into their respective IC sockets. Be sure to orient the chip indentation on the top-



## PARTS LIST FOR THE ROBOTIC ARM

- 5 TIP 120 NPN transistors
- 5 TIP 125 PNP transistors
- 1 74HCT154 ¼-inch decoder
- 1 8-position, 3-inch long Molex cable
- 1 DPDT PC-mounted switch
- 1 DB25 right-angled PC-mounted connector
- 1 PC board
- 10 100K, ¼-watt, resistors
- 1 LM2940 voltage regulator
- 2 program diskettes

The Robotic Arm Interface Kit (\$44.95) contains all of the above parts.  
OWI Robotic Arm Trainer (\$ 84.95)

Available from:  
Images Company  
39 Seneca Loop  
Staten Island, NY 10314  
718-698-8305

All Major credit cards accepted

Fig. 3. This is the Parts Placement diagram. Begin construction by first identifying the component side of the PCB. The component side has the white line drawings of the resistors, transistors, ICs, and DB25 connector. All components are mounted on the component side.

side of the chip with the indentation on the white line drawing.

### How The Interface Works

We need two complementary transistors to control each of the five DC motors. That works out to ten output lines to control the five motors. The PC

parallel port has eight available I/O lines. To increase the number of output lines, the robotic arm interface incorporates a 74HCT154 (4-16 decoder) IC. By using just four lines off the parallel port (lines D0-D3), we can add up to sixteen output lines, although we only need and use ten output lines.

### Connecting The Interface To The Robotic Arm

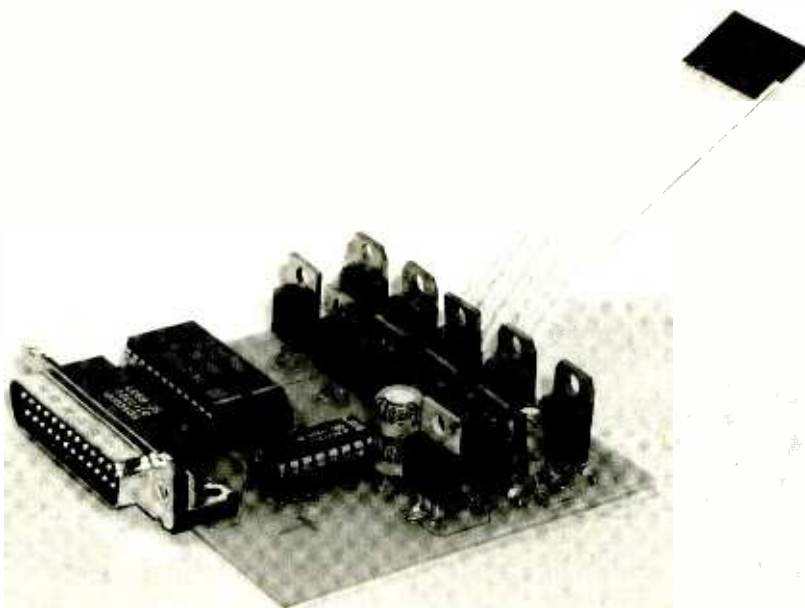
The robotic arm uses a single 6-volt power supply consisting of four "D" cell batteries in the base. The PC interface takes power from the arm's 6-volt power supply. The power supply is used like a bipolar  $\pm 3$ -volt power supply. Power is tapped from the 8-conductor Molex connector to the arm base.

Connect the interface to the robotic arm, using the 3-inch long 8-conductor Molex cable. The Molex cable connects to the connector on the base of the robotic arm. Make sure the Molex connector is firmly and properly seated.

Connect the interface to the computer's printer port. Keep the interface turned off until the Windows program is running. If the interface is turned on before the program is run, the existing (left-over) information (status) left on the printer port may activate the robotic arm.

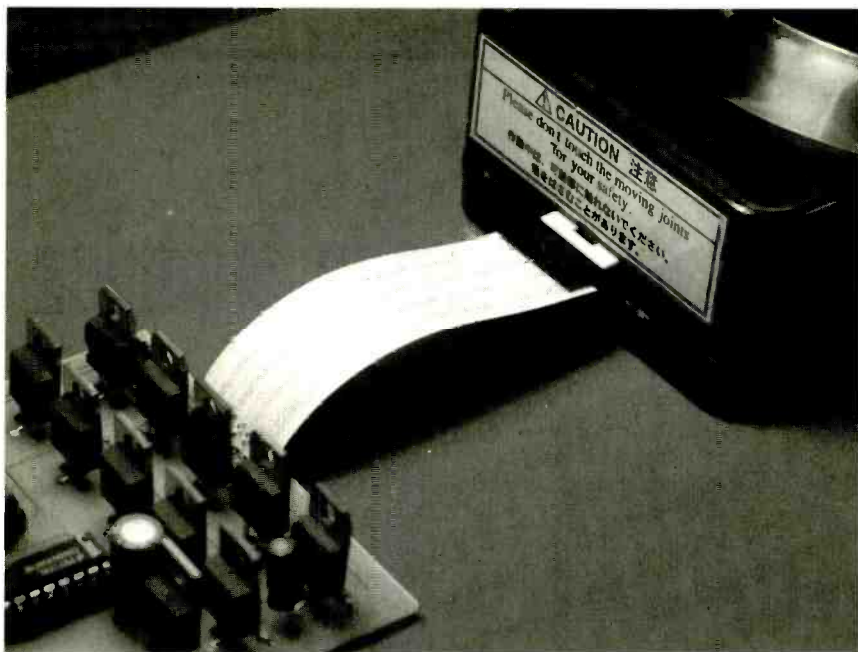
### Installing the WIN 95/98 Program

The program for the interface may be downloaded freely from the Internet. Go to [www.imagesco.com/catalog/RoboticArm/RoboticArm01.html](http://www.imagesco.com/catalog/RoboticArm/RoboticArm01.html). Download and unzip the file. Install the program by running Setup.exe. For those who purchase the kit, insert the 3.5-inch diskette labeled "Disk 1" into the computer's floppy drive and run the set-up program



This is the PC interface that is used to control the robotic arm. The PC parallel port has eight available I/O lines. To increase the number of output lines, the robotic arm interface incorporates a 74HCT154 (4-16 decoder) IC.





Connect the interface to the robotic arm, using the 3-inch long 8-conductor Molex cable. The Molex cable connects to the connector on the base of the robotic arm. Make sure the Molex connector is firmly and properly seated.

(setup.exe). The set-up program creates a directory named "Robotic Arm" on the computer's hard drive and the needed files are copied into this directory. A "Robotic Arm" icon is created on the "Start Menu." To run the program, click on this icon in the start menu.

### Using the Windows Program

Start the program. The program's opening screen is shown in the photo

below. Operating the robotic arm interactively is easy. Simply click on any function button to command the robotic arm to perform that function. When the function is active, its button color changes to green. Click on the button a second time to end (deactivate) the function (button color turns back to red).

### Creating Script Files

To program motion and automation,

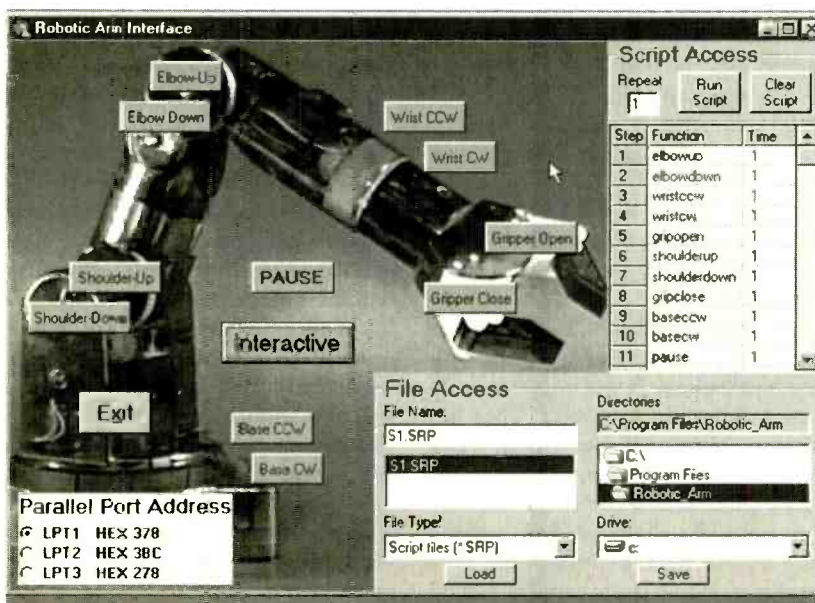
use script files. A script file is a list of timed instructions that control the robotic arm. Creating script files is simple. To create a script file, click on the "Interactive" button. The button label changes to "Program" and puts you into the "programming" script-writing mode. Clicking on a function button will activate the robotic arm function as before, but, in addition, the function information is entered into the yellow script table on the right side of the screen. The step number is placed in the left-most column, starting with one and increments with each new function. The function name is entered in the middle column. When the function button is clicked the second time, the function stops as before and the elapsed time from starting to stopping the function is entered into the third column. The time elapse is incremented in quarter seconds.

Continuing in this manner, a user may program up to 99 functions, including timed pauses, into a script file. Script files may be saved to and loaded from the local directory. Script files may be set to replay up to 99 times by typing a number in the Repeat box and hitting start.

To stop writing into a script file, click on the interactive button. This puts the computer back into the interactive mode.

### Animatronics


Script files may be used for computer automation or animatronics. With animatronics the underlying mechanical robotic system is usually covered and hidden from sight. For instance, if you covered the robotic arm with a child's sock puppet and programmed a small show, you would be programming an animatronic or electronic puppet. Animatronics is the entertainment side of automation. **P**



The program for the interface may be downloaded freely from the Internet. Go to [www.imagesco.com/catalog/RoboticArm/RoboticArm01.html](http://www.imagesco.com/catalog/RoboticArm/RoboticArm01.html). Download and unzip the file. Install the program by running Setup.exe.

9 out of 10 mice  
prefer the Consumer  
Information Catalog  
online. Catch it at  
**[www.pueblo.gsa.gov](http://www.pueblo.gsa.gov)**

U.S. General  
Services  
Administration



## Laser Pointers and Diode Laser Modules

This month I am inaugurating a somewhat new direction for "Service Clinic." Over the past several years, this series has covered many areas of consumer-electronics repair—most of which I can discuss above the level of an informed carrot. While some areas like television sets haven't been dealt with, computer monitors have—and these share about 90 percent of the same problems and solutions. Rather than repeating topics, which seems wasteful of space, or treating TVs or other major topics in depth (which puts people to sleep), this series will now cover a variety of mostly shorter topics, some involving repair, some involving general electronics, and some involving lasers and related areas. In other words, although the name of the series is still "Service Clinic," it may actually deal with almost anything. I may still cover a few other major areas of repair, but the era of the never-ending repair saga is over!

### Laser Pointers

Even if you haven't used one or don't own one, it's hard to avoid having seen them. How do they get an entire laser inside a gadget that fits in your pocket? What's the real story on the safety of these things? Why is the green variety so much more costly than red ones? For that matter, how can the red ones be so inexpensive? Can the output power of a laser pointer be increased safely (to you and the pointer)? What other modifications are possible? In this and the next "Service Clinic," we'll cover these fascinating topics and more.

Even if you don't do presentations and don't own a cat, a red laser pointer represents by far the least expensive real laser readily available and can have all sorts of other applications—so the following material may still be of interest.

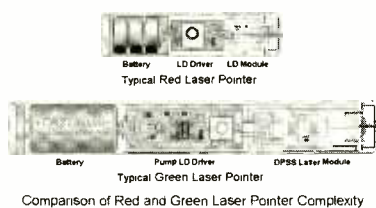


Fig. 1. In comparison, a red laser contains less parts than a green laser. The green laser requires a separate optics-module, called a DPSS, to produce the proper wavelength.

### History

In the old days, before CD players, and before the laser was invented, you used a stick to point out something on a screen or blackboard (this was even before whiteboards!). The earliest optical pointers used tiny incandescent bulbs, a lens, and mask or transparency to project a dot or arrow. Such devices were about as big as a full-size (D-cell) flashlight, required a separate power pack attached by wires, and probably plugged into the wall. Performance was not all that great since the beam could not be collimated as well as a laser, but, nonetheless was a major advance over the stick. However, since they used an incandescent lamp, any color was possible using optical filters. Given the brightness or lack thereof, white was most common.

The first laser-based laser pointers used helium-neon (HeNe) lasers with their high-voltage power supplies packaged as compactly as possible. They still required a separate power pack or bulky case, which included heavy batteries.

Being true lasers, the beam was very clean and well collimated. Both red and green HeNe laser pointers were produced (yes, HeNe lasers come in green). The real laser pointer revolution came about as a result of the development of inexpensive visible laser diodes. Laser

diodes are only slightly larger than a grain of sand and run on low-voltage low current. They can also be mass-produced—originally driven by the CD player/CDROM revolution, barcode scanners, and other applications where a compact low-cost laser source is needed. Now manufactured by the millions, these laser diodes cost well under \$1.

### Safety

There have been some recent articles (mainly in the UK) about eye injuries resulting from careless or malicious use of common laser pointers. In the U.S., there have been numerous news reports that would lead the average person to believe that the absolute end of civilization as we know it will result from the proliferation of these devices. Although the potential for eye injury is typically what comes to mind when one thinks of a laser, the possible side effects—or collateral damage—that may result from aiming one at somebody is at least as likely a cause for the current wave of hysteria.

Keep in mind that what gets reported in the popular press is not exactly rigorously reviewed for scientific accuracy. If it turns out that the outcome wasn't quite as originally reported, any correction for a front-page story is usually to be found in fine print buried on page 17!

Actual substantiated instances of long-term or permanent effects on vision resulting from momentary or unintentional exposure to a laser pointer's beam—or even from prolonged intentional misuse—appear to be all but non-existent. Flash blindness IS possible, but this is temporary and will clear up on its own.

The above applies where the laser pointer has been manufactured and tested to meet CDRH (Center for Devices

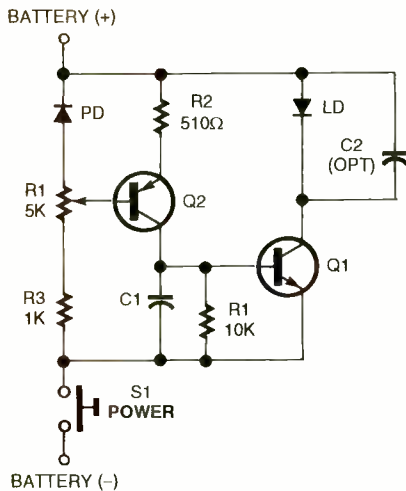


Fig. 2. This schematic shows a simple driver for a laser. People have successfully modulated this module at a reasonable frequency (upper limit not determined) by removing or greatly reducing the value of the filter capacitor, C1. However, do this at your own risk!

and Radiological Health, part of the FDA) Class IIIa safety limits or below. Note possible eye damage increases where these devices originate from countries with less rigorous quality control, where an internal current adjust pot can be twiddled, where laser-diode output power is greater, or where there is intentional abuse.

With respect to direct personal danger, potential damage to vision is the only real consideration—there is no risk from radiation, and there isn't enough power in a beam of less than 5mW to burn anything. However, from a public policy and regulatory perspective, there are actually three areas of concern:

1. Flash blindness from momentary exposure or permanent damage to vision from prolonged intentional misuse. Laser pointers are usually rated Class IIIa or less, which means that the power is low enough that the eye should be protected from permanent damage by natural pupil contraction, blink, and aversion reflexes.



Here's what you get when you crack open one of those bargain laser pointers. As you can see, the parts are minimal—power source, driver, laser.

2. Distraction and collateral damage—you wreck your car because someone directed a laser pointer at you while you were driving.

3. Misinterpretation of intent—you get blown away by someone with a BIG gun who thinks you are targeting them with a laser sight. Or, you are arrested and thrown in the slammer for aiming a laser pointer at a cop (this happened recently).

I am in favor of tough laws to make (2) and (3) crimes with appropriate punishments. Such behavior should not be tolerated. However, in the remainder of this section, I only really want to address the vision issues (1).

While I absolutely agree that intentionally aiming a laser of any kind into someone's eye is basically stupid (unless you are having laser eye surgery), one must be careful in interpreting the meaning of press reports that describe momentary exposure to the beam from a laser pointer waved around an auditorium resulting in instant total loss of vision in all three eyes! One would have to direct the beam into the pupil of the eye from a close distance for a few seconds or more without either the eye or pointer moving, twitching, or blinking. Distance is significant for two reasons. Laser pointer beams diverge (especially cheap ones), so less energy is able to enter the pupil of the eye as the source moves further away; and it is harder/less likely for it to remain stationary and centered on such a target a few millimeters across.

In fact, despite the great amount of press coverage lately—and such reports resulting in the passage of laws in some places banning laser pointer sales to minors (or to anyone), there are very few if any confirmed reports of permanent vision damage attributable to these things. The irresponsible aiming of a laser pointer at a person that might result in tragic consequences, whether from distraction or misinterpretation of intent, is far more likely to be a problem in today's world—and justifiably so.

### Specifications

Here are some of the things that manufacturers use to rate and promote both red and green laser pointers (see Table 1). However, given the quality control (or lack thereof) and constant shifting suppliers, none of this can be taken too seriously.

- **Wavelength**—This may be specified but don't trust it too much. Usually, lower (e.g., 640 nm versus 660 nm) is better since visibility is a strong function of wavelength.

- **Relative and Factor**—The term "relative" refers to the visibility compared to the 555nm peak of human vision; while the "factor" compares the brightness to that of an older 670 nm pointer. Note that visual perception of brightness is not linear. Thus, a 1 mW 532 nm green laser pointer isn't actually going to appear 28 times brighter than a 1 mW 670 nm red model. What it means is that a 1 mW green pointer will appear similar in brightness to a 28 mW 670 nm red one (if such a thing existed, but anything above 5 mW true power isn't legal).

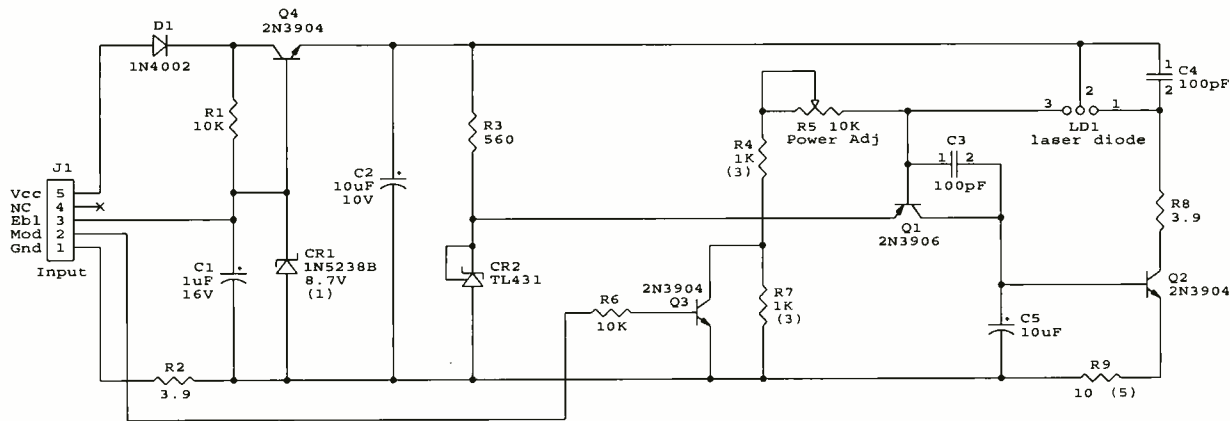
- **Output power**—Power ratings are often made deliberately confusing like "<5 mW," which could mean almost anything! Even among identical models, there can be significant variation, especially for green laser pointers.

- **Distance/range**—By itself, this is basically a totally useless number. Do they mean on a moonless night under smog-free conditions? Light doesn't travel a specific distance and stop or suddenly become too dim to be seen.

- **Beam shape/quality**—Without significant effort, the output of a red diode laser pointer is not a nice round spot like that of a HeNe laser. More expensive pointers may have the necessary optics to do a decent job of beam shaping but most do not. Sometimes, the beam shape will be shown in the catalog or Web site listing, probably to convince you to upgrade to the model with the rounder spot.

- **CW or pulsed**—As far as I know, all red laser pointers produce a continuous (CW) beam. However, due to the way modern green laser pointers work, there are significant advantages in terms of efficiency and thus battery to use a pulsed system. As a practical matter, it doesn't much matter to the user unless the pointer is moved rapidly in which case the pulsed beam will show up as discrete





**Notes:**

1. Preregulator zener value is not critical.
  2. TL431 set for 2.5 V - a zener diode may also be used.
  3. R6 and R7 should be selected for the desired power levels.
  4. C5 uF value must be reduced for high speed modulation.
  5. Laser diode current may be monitored as 100 mA/V across R9.
  6. Circuit can be debugged and tweaked safely by substituting 3 or 4 LEDs in parallel for the laser diode and using a discrete photodiode instead of the one built into the laser assembly.
- Once the circuit is working, replace with the laser diode assembly.

**Laser diode connector (LD1):**

- Pin 1: Laser diode cathode
- Pin 2: Common
- Pin 3: Photodiode anode

**Input Connector (J1):**

- Pin 1: Gnd
- Pin 2: Power Select (Modulation)
- Pin 3: Enable (high)
- Pin 4: NC
- Pin 5: Vcc (+6 to +12 V)

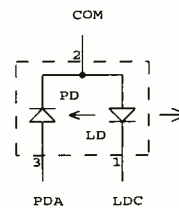


Fig. 3. While basically similar to the one in Fig. 2, this circuit includes soft start circuitry, reverse polarity protection, a reference to maintain output power constant regardless of power supply input voltage, and a modulation input.

spots rather than a continuous line.

- **Adjustable focusing lens**—While this may at first appear to be highly desirable, in the end it may turn out to be a nuisance—going out of focus on its own and prone to constant fiddling. (Of course, a piece of adhesive tape or dab of glue can cure this malady.) However, make sure that the pointer you acquire has had its focus properly set at the factory!
- **Multiple pattern-generating optics**—This type of thing appears really neat and cute. In my opinion, it has limited value, at most. Pattern generating reduces the overall brightness of the projected spot and, except for a basic arrow, just detracts from a presentation.
- **Battery**—The amount of time claimed for a set of batteries may tend to be optimistic. Some/many/most may assume something about the usage pattern in a pointing application (as opposed to cat teasing) like “25 percent on, 75 percent off.” The brightness of some pointers decreases significantly as the batteries are drained while others remain exactly

the same and then poop out without warning.

- **Life expectancy and warranty**—Sometimes there will be a spec like “2000 hour lifetime.” This is probably mostly relevant for the expensive green DPSS laser pointers and may be reasonable. Certainly, anything over 1000 hours is adequate for a pointer used as a pointer within one’s (human) lifetime (or until it becomes obsolete). However, any lifetime claim isn’t of much value unless there is an enforceable warranty!

By now, you’re probably totally confused. My advice: Use the specs for guidance, but if you really care about the quality of your laser pointer, try a few out which come with money back no-questions-asked warranties and keep the one you like. If, on the other hand, you just want to use the pointer for presentations (what a concept!) and not to stroke your ego, the cheapest red one will probably be just fine.

**What’s Inside a Laser Pointer?**

The description below applies to most red laser pointers sold today (pen or key-chain type). We’ll discuss green

laser pointers next time. A common red laser pointer contains the following components (see Fig. 1):

- **Laser diode**—This will have a 3- to 5- mW maximum output. Better or older ones will be in a can package like that in the diagram; newer cheaper ones will just be a bare chip mounted on a heatsink. See the photos for some typical packaged laser diodes, as well as a laser diode without the cover. The actual laser is the chip mounted on the fat vertical post.
- **Power source**—These are typical AAA Alkaline cells or watch-style button cells. Depending on design, the battery must produce 1.5 V to 4.5 V or more.
- **Power regulator**—Many of the visible laser diodes used in laser pointers have very precise current requirements. Too little and they don’t last; too much and they turn into poor imitations of Leeds or die entirely. The cheapest pointers today apparently use laser diodes that have a somewhat wider tolerance and just

(Continued on page 53)

## Boo! Lean is Scary

**Q** I have a Boolean equation as follows:

$$\bar{C}(\bar{B} + \bar{D}) + \bar{A}(\bar{B} + D) + ABC = W$$

I need to convert this into NAND format using DeMorgan's. I have a basic understanding and know the two DeMorgan laws, but am struggling to apply them to this length of the equation. If you could give me some direction, it would be much appreciated.—A.W., United Kingdom

**A** The key to NAND conversion is to get the equation into the “sum-of-products” form where it looks like a conventional algebra equation of multiplied terms that are added. To do that, we can distribute the “c” and “a” of the first two terms out just as we would in conventional algebra. At this point, I should warn readers that the rules of conventional algebra don't often carry across into Boolean algebra. This is one exception. The equation now becomes:

$$\bar{C}\bar{B} + \bar{C}\bar{D} + \bar{A}\bar{B} + AD + ABC = W$$

Now, we're in the “sum-of-products” form. The quick DeMorgan move on this equation is to invert the entire thing and then invert it back, resulting in a double vinculum over the entire equation. Double inversion has the same logic as no inversion. The equation becomes:

$$\overline{\bar{C}\bar{B} + \bar{C}\bar{D} + \bar{A}\bar{B} + AD + ABC} = \bar{W}$$

Now, over each “OR” sign, we can break the lower vinculum and change the “OR” sign to an “AND” sign. This ends up converting the ORed ANDs to Nanded NANDs. The equation transforms into:

$$\overline{\bar{C}\bar{B}} \overline{\bar{C}\bar{D}} \overline{\bar{A}\bar{B}} \overline{AD} \overline{ABC} = \bar{W}$$

Notice that  $\overline{\bar{C}\bar{B}}$  is simply  $\bar{C}$  and  $\bar{B}$  Nanded together. So is  $\overline{\bar{C}\bar{D}}$ ; and  $\overline{\bar{A}\bar{B}}$ ; and  $\overline{AD}$ ; and  $\overline{ABC}$ .

At this point, it may appear that you're

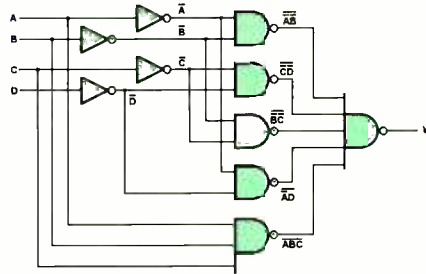


Fig. 1. This NAND circuit uses four integrated circuits to implement the Boolean equation presented in the text. Large combinational logic circuits like this are difficult to implement.

in deeper manure than where you started, but you've just ended up with your circuit in all-NAND form. The output of each of these five NANDs is Nanded together. The

D	C	B	A	W
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	1
1	1	1	1	1

Fig. 2. The truth table for the Boolean equation presented in the text shows all possible states of the four inputs and the resulting output.

circuit looks like that of Fig. 1.

Combinational logic can be very messy at times. That final 5-input NAND is an ugly thing to behold. You'd have to use an 8-input 7430 with the three extra inputs enabled by tying them off to a logical HIGH. It takes four different ICs to implement this circuit.

One cute trick to cut down on a lot of IC connections is to use a multiplexer such as the 74150 to mimic this logic. Beginning with a truth table of the original equation as shown in Fig. 2, we connect the 16 data inputs to HIGHs and LOWs depending upon the desired output with that particular DCBA input, as illustrated in Fig. 3. For instance, with a binary 0111 (decimal 7) input, the output should be a HIGH. Since the 74150 has an inverted output, we connect the D7 input to a LOW. When selected, it will be inverted to a HIGH at the output.

Using a 74150 like this won't work well if it's driving high-speed logic—for that matter, neither will the NAND circuit of Fig. 1. Combinational logic, whether individual gates or a multiplexer like the 74150, is “glitchy” logic. Propagation delays through individual gates can create “glitches” or unwanted narrow logic pulses between state changes. If the circuit is used to drive a human-observed display, there should be no problem; but high-speed clocked logic can be falsely-triggered by these glitches.

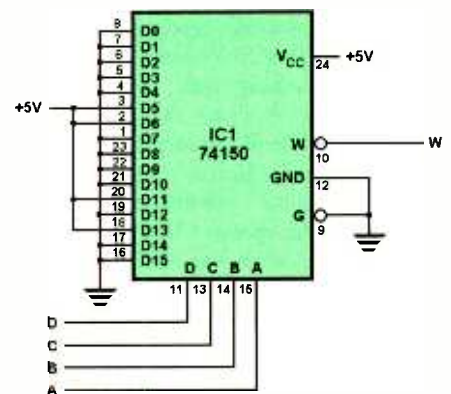


Fig. 3. A multiplexer can be used to mimic a large combinational logic circuit. Although the 74150 is a large 24-pin chip, it still saves space and a lot of complex wiring over the original 4-chip circuit of Fig. 1.

# Kelvin Revisited

**Q** Your description of 4-wire resistance measurement is good. I have a few additional comments. I wrote about the "Low-Ohms Tester," an add-on device for a DMM in "Expanded Resistance Ranges for your DMM" (*Popular Electronics*, December 1995) and about a separate meter, "Low-Ohms Meter" in "Using Digital Panel Meters" (*Popular Electronics*, October 1996).

When you are making repeated measurements, it's convenient to only use two clips, with two wires from each clip going to the meter or adapter. As I wrote, this can be a problem because of the resistance along the length of the clip. Steel alligator clips can't be used, but solid copper clips can be used for a 3- or 3½-digit readout. For a 4- or 4½ digit readout, the resistance of copper clips is too high. You can buy "Kelvin clips," which have the two jaws insulated from each other, with one wire going to each jaw. At that time, and still today, I only know of one source for these clips. They are made by Mueller, but the only supplier I know of is Hosfelt Electronics, Steubenville, OH 43952-1158; 800-264-6464. They are high, \$7.50 each, but when there's only one source ....

You can get 0.1% resistors from Mouser Electronics, but I think if I were building a 4- or 4½-digit device today, I would use a 15-turn pot to set the current and a good 4½-digit DMM to measure the current for calibration.—Bill Stiles, via e-mail

**A** Bill, I had forgotten all about mentioning Kelvin clips. I had actually bought a couple of pair of them for use at the school when I was in Oklahoma, and I believe it was from Hosfelt. It was one of those things that I instantly ordered, because I'd never seen them offered by anyone before. I've made some specialized "tweezer" style test leads for working with surface-mount resistors, so I don't see that it would be that difficult for the enterprising experimenter to make Kelvin clips for repetitive 4-terminal resistance measurements. A little epoxy and file work while sacrificing another pair of alligator clips could produce a primitive, but functional set of Kelvin clips.

You have to be very careful of your ammeter method of setting the current as you mentioned at the last. Between voltage and current measurements, current measurements present the most error because of the extra resistance the ammeter inserts into the circuit. If you

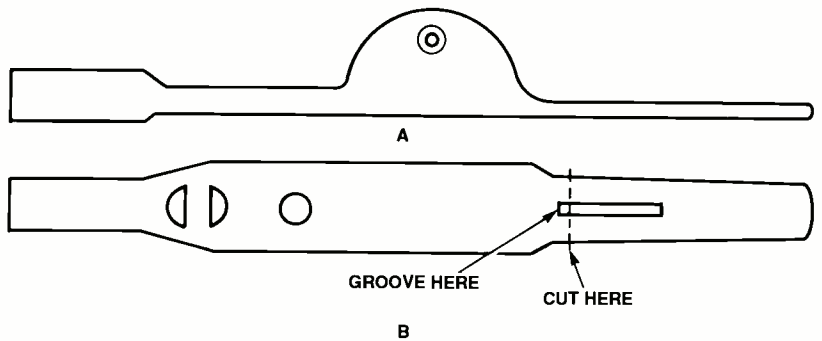


Fig. 4. The initial preparation for making a Kelvin clip (a) consists of grinding off the teeth of the lower jaw and (b) cutting a groove in the underside of a second alligator clip, as described in the text. The upper jaw is still attached in (a), but not shown for clarity.

set the current with the DMM and then pull the DMM out of the circuit, depending upon the range of the ammeter, you'll pull anywhere from 0.1 to 10 ohms out of that series circuit. The current will increase enough to blow your subsequent voltage measurement out of the water.

That's why I prefer to find a very accurate, low-value resistance that will drop around 0.1–0.2 volts at design current and just leave it in the circuit where I want to measure the current. I can then use the voltmeter to measure the voltage drop and calculate the current from that. Next, I use the same DMM to measure the voltage across the "unknown" resistance, giving me far greater accuracy. If the DMM happens to be a little off, it probably won't matter because it's likely that you'll be using the same voltage range for both measurements. The

Ohm's Law calculation of resistance will not be hurt because this meter error will divide out in the calculation.

As long as the reference resistance for setting the current is accurate, the DMM is stable and repeatable, and the number of significant figures on the DMM reading back-up is the precision you're trying to achieve, using the same meter for both voltage measurements should yield final results that are comparable to the accuracy of the reference resistor.

Now, back to the Kelvin clips. You can make your own if you have the time and the patience, and if getting a root canal doesn't sound more appealing at the moment. The root canal will start to look better as you get into this project.

Begin with four new alligator clips and a small piece of 0.007-inch- (0.19-mm) thick double-sided glass-epoxy cir-

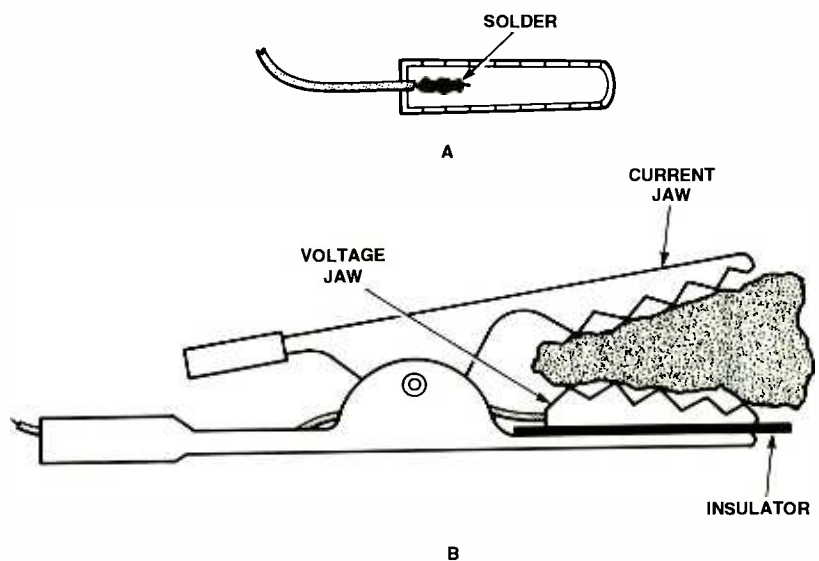


Fig. 5. A wire is soldered into the groove (a) made in the jaw section that was removed, and (b) these transplanted teeth are soldered to the insulating double-sided circuit board previously installed. The completed Kelvin clips are identical and have the lower jaw insulated from the upper jaw. Current is supplied to the upper jaw while a voltage reading is taken from the lower jaw.



cuit-board material. This is really thin stuff. I have a lot of it. If you need some, send me an SASE (I stress the "AS" in the middle) and I'll slip you enough so that you can make two clips and several mistakes.

Remove the wire-securing screw, if any. Hold the clip open with pliers (wind a few turns of rubber band around the plier handles so they're self-closing) and use a Dremel tool or file to grind down and deburr the lower jaw of the clip, as shown in Fig. 4a. On the underside of a second clip, make a deep groove along the length of the jaw toward the middle,

as shown in Fig. 4b. This groove should be deep and wide enough to lay in and solder a small-gauge stranded wire. Now cut off the lower jaw where marked with the dashed line in Fig. 4b and deburr the cuts you've made.

Clean up both sides of a 1/4- × 1-inch strip of the circuit-board material. Sandwich the board and a 1/4-inch-thick piece of cork between the jaws of the first clip so that the cork is pressing the board against the detooped lower jaw. Solder the board in place onto the lower jaw. You want the solder to wick under the board so that you can later grind it

off flush with the side of the clip.

Solder a six-inch-long, 24- or 26-gauge stranded wire into the groove you cut into the jaw section, as shown in Fig. 5a. Use the grinder or a file to make the surface of the jaw and the wire flat again. Try not to nick the wire where it exits the end of the jaw.

Sandwich the jaw section and the piece of cork between the jaws of the first clip, as shown in Fig. 5b. You'll have to run the wire under the spring of the first clip so that it pokes out the "handle." At this point, if the light has not yet dawned, you're about to find out why Kelvin clips are expensive. Position the jaw section directly over the lower jaw of the first clip, with the piece of cork and the spring tension of the upper jaw holding things in place. Sight down the throat of the clip, making sure that the transplant jaw is exactly over and aligned with the lower jaw, checking both sides for symmetry. Now, you get to solder this jaw section to the circuit-board material. Be careful that the wire doesn't pull out as you solder. Again, make sure you use enough solder and get things hot enough that the solder wicks under the jaw. However, don't get the clip hot enough that you melt the insulation on the wire. Teflon-insulated wire would be a nice touch here. See your nearest electronics surplus store for that.

Now use some shop scissors to trim away the extra board material from around the clip. Then use the grinder or a file to make the board material flush with the sides of the clip. I recommend that the direction of grinding/filing be along the length of the clip so that the burrs don't short the two sides of the board together.

Time for an ohmmeter check. Put the cork back between the jaws to keep them open. On a high-resistance range, check the resistance between the upper jaw and the teeth of the lower jaw. It should be "infinite," showing an open. If it doesn't, get a really strong magnifying lens and check along the edge of the circuit board, looking for stray burrs that may be shorting the two sides together. The wire may be shorting to the spring or the main part of the clip if the insulation isn't snug against the board. In that case, go back up to the paragraph that starts, "Begin with four new alligator clips."

If the meter shows an open, you're almost done. Solder a heavier-gauge stranded wire to the wire hole (or the

## HOW TO GET INFORMATION ABOUT ELECTRONICS

**On the Internet:** See our Web site at [www.poptronics.com](http://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.elec.tronics.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/](http://www.hitex.com/chipdir/), or try addresses such as [www.ti.com](http://www.ti.com) and [www.motorola.com](http://www.motorola.com) (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online: [www.questlink.com](http://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](http://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.repairfaq.org](http://www.repairfaq.org)

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

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 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 Clagck, 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](http://www.arrl.org)). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

vacant screw hole) in the clip, taking care that you don't melt the insulation of the first wire. Run both wires out the back of the clip and use two layers of heat-shrinkable tubing to hold everything in place. Then apply a daub of epoxy in the channel of the clip as a strain relief to hold the wires in place, especially the one going to the isolated jaw.

That's one clip done. Repeat for the second clip. If all went well, you should have a pair of Kelvin clips and a pair of clips in need of dental transplants that you can give to a "friend." In use, the larger wires will connect to the current source, and the smaller wires will connect to the voltmeter.

## And Revisited...

**Q** *In reference to the 4-terminal resistance measurement, your answer was correct and well-written, but to me is incomplete. I really would like to know how to make a constant current source of 2-, 3- or 5- significant-digit accuracy. A 10-milliamp source would have to be accurate to 1 microamp to get that accuracy.—W.A.*

**A** That's a tough one. I may play around with that idea, but 0.1% (or better) accuracy is a little tough to achieve with off-the-shelf parts. I'm one of those guys who appreciates having accurate test equipment on my bench, but at home I just have to make do with what I can cobble together. The digital multimeter that most hobbyists own is probably their most accurate item of test equipment, so is a good foundation upon which we can build our test circuits. My solution to the 4-terminal problem was designed to work without using exotic circuits and was intended for the occasional need to make low-resistance measurements.

A good regulated power supply and a stable, low-value resistor work very well as a "pseudo-constant current" source. Once set up, they will remain relatively stable long enough to make a decent measurement of the unknown resistance. I'll take your request into consideration and try to come up with a simple design that will work for this application. Meanwhile, take a look at Chapter 4 of Walt Jung's *IC Op-Amp Cookbook* (Sams 0-672-22453-4) where he discusses all kinds of Howland voltage-controlled current sources. That happens to be an excellent text on op-amps that every hobbyist should have on the bookshelf.

## Batteries on Vacation

**Q** *I want to add an extra "house" battery for my "Class B" van. I've been told by one person to just add the second battery positive to positive, negative to negative. Another told me to hook them up like that and then run the positive from the charger to the positive of battery #1 and the negative from the charger to the negative of battery #2. What's right here?—V.G., via e-mail*

**A** Adding an extra battery involves nothing more than simply putting the second battery in parallel with the first, the two positive posts of both connected together and the two negative posts connected together. They should be connected together by wiring that is the same size or larger than what was connected to the original battery. The original charger wires can connect to the posts of either battery, as long as you connect positive to positive and negative to negative. All of that is the easy part. Now for the precautions.

Don't forget that lead-acid automotive batteries liberate all kinds of hydrogen gas. Hydrogen (starts with the same letter as Hindenberg) is explosive, and batteries must be vented to outside air so that hydrogen doesn't accumulate in a confined space.

**Never** install a brand-new battery in parallel with an older battery. Although it may seem a waste, get rid of the original battery and put two new, identical-twin batteries in the coach. Use the original battery on your trolling motor or something else that needs a single deep-cycle battery. Connecting a new battery alongside an old battery would be like hitching a Clydesdale draft horse alongside a Shetland pony. The unmatched batteries could set up a current loop between them where the new battery would discharge into the older battery. If the water level in the older battery had ever been allowed to fall below the tops of the plates, it will begin to increase its rate of self-discharge and pull the charge down on the new battery, as well. Parallel-connected batteries are not unusual in trucks and busses. The general rule-of-thumb should be this: If you have to replace one, replace them all.

Don't forget to use deep-discharge marine/RV or golf-cart batteries in RV applications. Conventional car and truck batteries are designed for short, very heavy bursts of current for starting an engine and will have shortened lives if

allowed to go dead too many times. A deep-discharge battery is designed for lower discharge currents rather than high "cold-cranking amps" and is able to be deeply discharged and recharged with no harm. Although the amp-hour rating of similar-sized batteries of both types might be the same, the starting battery will be capable of high current for a short period of time while the marine/RV battery will be capable of lower currents for a long period of time.

The negative-battery clamp, which is connected to chassis ground, is always the first battery connector to be removed (both of them) and always the last one(s) to be connected. This keeps inadvertent slips of the wrench to the chassis from causing a short circuit when removing the positive connections.

## National Radio Institute

Reader Malcolm Leonard sent me a few copies of the *National Radio-TV News* and the *NRI Journal* from the early 50s and late 60s, respectively. These bimonthly publications from the National Radio Institute are really fun to read. One issue indicated that the starting salary for a new technician in 1951 was around \$280/month. Some of the test equipment that was built as part of the course is used for theory lessons in these little magazines and sometimes whole schematics are shown. They'll be a great resource in my quest to be able to supply schematics for these "orphaned" items of equipment. Malcolm, thank you for your generosity. Readers, scour your attics and basements for these old correspondence course schematics. I'm still on the hunt and a long way from my goal.

## Heathkit Help Hotline

**Q** *I've subscribed to your magazine for several years and have found it to be a great source for electronics information. During the 70s, I put together several Heathkit projects with nearly all of them still working. The one not working is the Heathkit clock model GC-1107. I need the clock IC—the original part number was 443-848. If anybody can point me to a source, it would be greatly appreciated. Thank you.—D. A., Warner Robins, GA*

**A** There were true tears shed by electronics hobbyists around the world  
(Continued on page 58)

## SERVICE CLINIC

(continued from page 48)

have a resistor to limit current.

- **Collimating/correcting optics**—At the very least, there must be a lens to convert the highly divergent beam from the bare laser diode to one that is roughly parallel.
- **Some means of generating multiple patterns (optional)**—These permit the projected shape to be selected to be something other than a formless spot either by a built-in thumb-wheel type thingie or by replacing end-caps.

### Power Regulators in Laser Pointers

Figure 2 shows an example of a discrete driver from a cheap laser pointer. (Laser diode driver ICs may also be found in better units; but since these still cost more than discrete parts, they are probably still less common.)

Since there is no absolute reference, output power depends somewhat on battery voltage. People have successfully modulated this module at a reasonable frequency (upper limit not determined) by removing or greatly reducing the value of the filter capacitor, C1. However, do this at your own risk!

### Difference Between Diode Laser Modules and Laser Pointers

Collimated diode-laser modules and pocket-laser pointers both produce a spot of light. So why the typical huge difference in price? There can be variability in any type of product. While the desired output of a laser pointer and collimated diode-laser module is similar, how fussy the end-user is and how one gets there may not be.

Laser pointers are mass-produced, so

this helps reduce costs. They generally have less complex and less robust drive electronics since the power source is supposedly well defined—a set of batteries. There may be no corrective optics for the astigmatism and elliptical aberrations of the typical laser diode—at a distance, your spot isn't a nice round Gaussian profile. There is probably just a single cheap plastic lens glued in place, though some models do have adjustable focus.

Diode laser modules are more of a specialty item used inside other equipment and for optics research and development. Production volumes are not as high. They usually (but not always) have high quality driver circuits designed to protect the sensitive laser diode from moderate abuse—noisy power, for example. Many have high quality optics including additional elements for correction of the laser diode aberrations. They usually have adjustable focus.

Figure 3 shows the typical circuit that might be used in a high-quality diode-laser module. While basically similar to the one in Fig. 2, it includes soft-start circuitry, reverse-polarity protection, a reference to maintain output power constant regardless of power supply input voltage, and a modulation input.

In the end, it is probably the mass production that is the most significant factor in keeping costs down. There is also another difference between the two that relates to output power.

For a laser pointer, the power rating is the maximum you might see with fresh batteries, under the right conditions, on a very good day, or possibly just the 5 mW maximum for Class IIIa (which is the most that is legal in the U.S.A. for a laser pointer). Obviously, the seller wants to impress you with the specs for their product and not all are being entirely honest or forthcoming. The actual power could be much less and may decrease rapidly as the batter-

ies are drained.

For a diode laser module (from a reputable manufacturer at least), the power rating is likely to either be what they actually measured for that sample or a guaranteed minimum value, and the actual output power could be greater. The CDRH safety sticker will still list an upper boundary, but it will likely be much higher than the module's power rating.

### Can I Boost the Power Output of a Laser Pointer or Diode Laser Module?

The quick answer is probably not, or at least, not by much. I know that in your fantasies, you have dreamed about the possibility of creating a burning laser or Star Wars style light saber from a laser pointer. Unfortunately, neither of these is even possible theoretically. The best you could ever hope for would be to obtain 5 mW from a device currently outputting 2 or 3 mW.

While it might be feasible to increase the current to the laser diode, unless you know its specifications AND have an accurate laser power meter (mucho \$\$\$), there is no way of knowing when to quit. Above their rated maximum optical power, laser diodes turn into DELDs (Dark Emitting Laser Diodes) or expensive LEDs. Exceed this rating for even a microsecond and your wimpy 3 mW output may be boosted to precisely 0.0 mW. This is called Catastrophic Optical Damage (COD) to the microscopic end-facets of the laser diode. There can also be thermal runaway problems or a combination of both of these depending on design—or lack thereof. However, if you have a bag of these gadgets and are willing to blow a few, feel free to experiment.

### Wrap-up

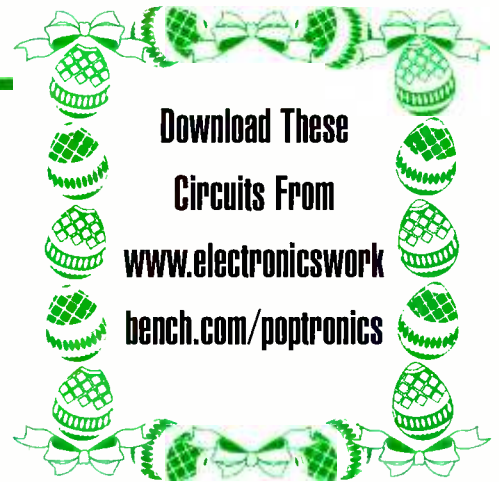
Next time, we'll continue with some of the more technical aspects of red laser pointers, as well as the much more complex green ones. There is much more information on laser pointers and almost anything else laser related on my Web site [www.repairfaq.org](http://www.repairfaq.org) under "Sam's Laser FAQ." P

**To learn how to talk with your kids about tough issues, like sex, AIDS/HIV and violence, call 1-800-CHILD-44 and get your free guidebook.**

TABLE 1

Wavelength	Relative	Factor	Color	Type
555 nm	1.000	33	Green	Reference peak
543.5 nm	.974	30	Green	HeNe laser
532 nm	.885	28	Green	DPSS laser
632.8 nm	.237	8	Orange-red	Red HeNe laser
635 nm	.217	7	Orange-red	Red diode laser
640 nm	.175	5	Orange-red	Red diode laser
650 nm	.107	3	Red	Red diode laser
660 nm	.061	2	Red	Red diode laser
670 nm	.032	1	Red	Red diode laser





Download These  
Circuits From  
[www.electronicworkbench.com/poptronics](http://www.electronicworkbench.com/poptronics)

## More Fun With Magnets And Motion

**B**uilt anything lately? Feel a need to make electrons flow? Need a fix of solder flux? If your answer to any of these is yes, stick around and take a dose of our electronic "BC" elixir. This month we're going to continue with more magnet and motion circuits for your enjoyment. As I mentioned in last month's visit, these are not offered as step-by-step construction projects, but as a guide to hopefully encourage creative construction of your very own motion machine.

### Horizontal Rotating Wheel

Last month we finished up with a vertical-rotating wheel utilizing a Hall-Effect device as the timing sensor. This visit we're going to start off with a dual-driver coil circuit with the rotating wheel in the horizontal position and an IR-LED timing sensor. The electronics and mechanics of this whirling wheel are

very basic in design and can be easily modified. As long as the basic concept is followed, the rotating wheel can take just about any shape or form—let the process of metamorphosis take over.

### The Circuit

One common feature of our motion projects is the simplicity of the electron-

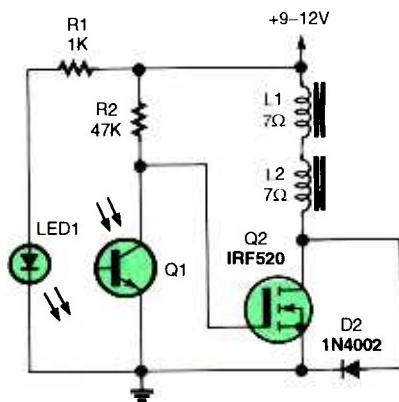


Fig. 1. The complete circuit is shown above. A combination of an IR-LED emitter and phototransistor operate in unison as the timing sensor.

### PARTS LIST FOR THE HORIZONTAL WHEEL CIRCUIT (FIG. 1)

- LED1/Q1—IR LED and phototransistor package, RadioShack #276-142, or similar combination
- Q1—IRF520 power HEXFET
- D2—1N4002 1-amp silicon diode
- R1—1000-ohm, ¼-watt, 5% resistor
- R2—47,000-ohm, ¼-watt, 5% resistor
- L1, L2—See text.

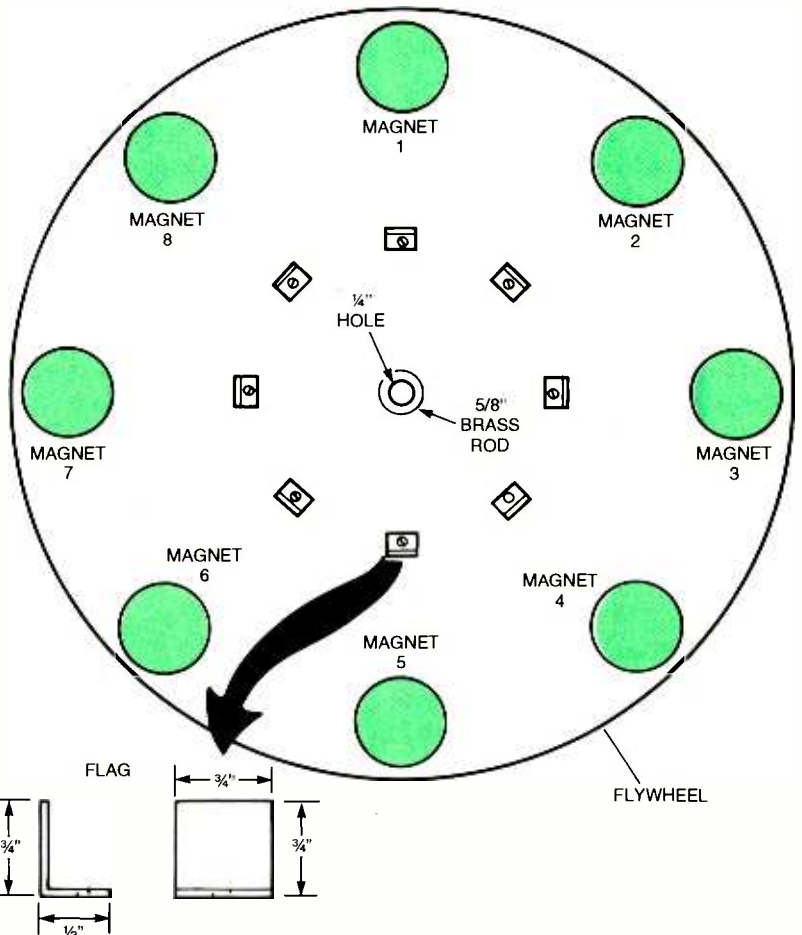


Fig. 2. This rotating wheel is a 9-inch circle cut from a 1/8-inch thick piece of fiberboard material. Any non-metal material can be used for the wheel.

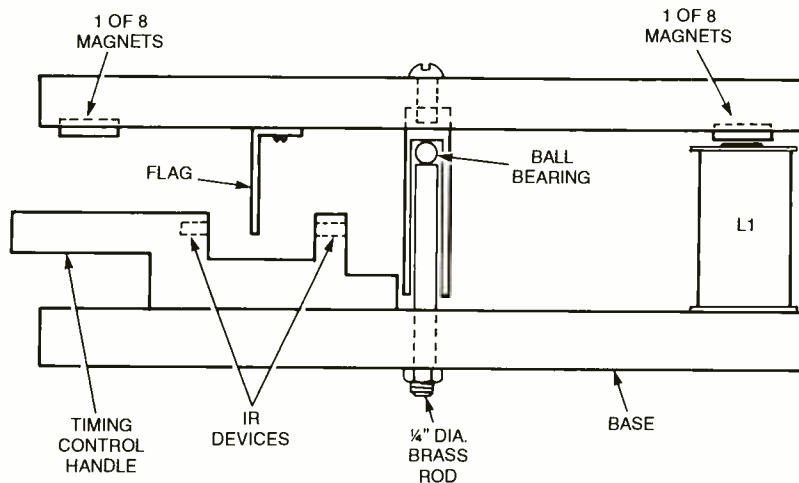


Fig. 3. The bearing support that mounts to the turning wheel was made from a piece of  $\frac{1}{8}$ -inch brass rod. Drilled and tap the top for a  $\frac{1}{8}$ -inch bolt to attach the support to the rotating wheel.

ic circuitry—this one is no exception. The complete circuit is shown in Fig. 1. A combination of an IR-LED emitter and phototransistor operate in unison as the timing sensor. The output of the sensor is directly coupled to the gate of an IRF520 power HEXFET. The HEXFET's output supplies drive current to the dual-drive coil combination during the time that the IR light source is blocked from the phototransistor. When the IR light source is not blocked, the voltage at the collector of Q1 is near ground level, keeping the HEXFET turned off. A 1-amp silicon diode, D2, helps protect the HEXFET from the reverse voltage developed across L1 and L2 when the drive current ceases to flow.

The rotating wheel, Fig. 2, is a 9-inch circle cut from a  $\frac{1}{2}$ -inch thick piece of fiberboard material. Any non-metal material can be used for the wheel. Eight donut-style magnets are mounted in an equally spaced arrangement around the bottom side of the wheel.

The eight magnets are mounted with the same magnetic poles facing out. It really doesn't matter which pole, north or south, as long as they are arranged in the

### PARTS LIST FOR THE FLYWHEEL AND ASSEMBLY (FIGS. 2-5)

Non-metal material for flywheel and for timing control, eight donut magnets, thin metal material for eight flags,  $\frac{1}{4}$ -inch diameter brass rod,  $\frac{3}{8}$ -inch brass rod misc. hardware, etc. See text for details.

same manner. The two coils are connected to produce a magnetic field at their top to repel the magnets on the wheel. This arrangement produces a push each time a magnet passes over a coil. Also, this scheme reduces the down pressure on the single-support bearing and allows the wheel to nearly float as it turns.

Interrupting the IR light source between the IR emitter and phototransistor generates the timing pulse that sends the signal to the HEXFET, telling it to turn on. Eight metal flags are mounted to the bottom of the wheel in alignment with the eight magnets that break the IR light path to send a turn "on" signal to the HEXFET. The location of the flags and the timing control can be seen in Figs. 2 and 3. Greater details of the timing control unit are shown in Fig. 4. This assembly is attached to the motor's baseboard with a single 8-32 screw, washer, and nut. This arrangement allows the assembly to move back and forth to control the direction of

rotation and operating speed.

The turning wheel and the base are of the same dimension, cut from fiberboard, wood, or any non-metal material. The wheel contains the eight magnets, eight timing flags, and the single bearing support. I made the simple, but very efficient, bearing assembly from scrap brass stock; however, other similar material will suffice. I used a piece of brass rod  $\frac{1}{4}$ -inch in diameter and threaded one end to mount to the baseboard (see Fig. 3). The bearing support that mounts to the turning wheel was made from a piece of  $\frac{3}{8}$ -inch brass rod. I drilled and tapped the top for a  $\frac{1}{8}$ -inch bolt to attach the support to the rotating wheel (see Fig. 3). The opposite end was drilled to a diameter slightly larger than the  $\frac{1}{4}$ -inch diameter support rod. The actual depth of the hole is drilled to allow a distance of about  $\frac{1}{16}$ - to  $\frac{1}{8}$ -inch spacing between the magnets and the top of the two drive coils. Also the secret of the efficient bearing arrangement is the small ball bearing that sets on the top of the  $\frac{1}{4}$ -inch support rod. This allows the wheel to ride on the very smooth top of the ball, reducing the bearing friction to a very low level.

The two drive coils were wound on old relay-coil cores with about 110 feet of number 28 enamel-covered copper wire. Each coil measured about 7 ohms. The coil locations are shown in Fig. 5, along with the location of the timing unit.

As previously mentioned, these drawings were taken from my rotating wheel and are only provided to give enough general information so you too can build your very own version.

### New Toy

Our next project is a modern day ver-

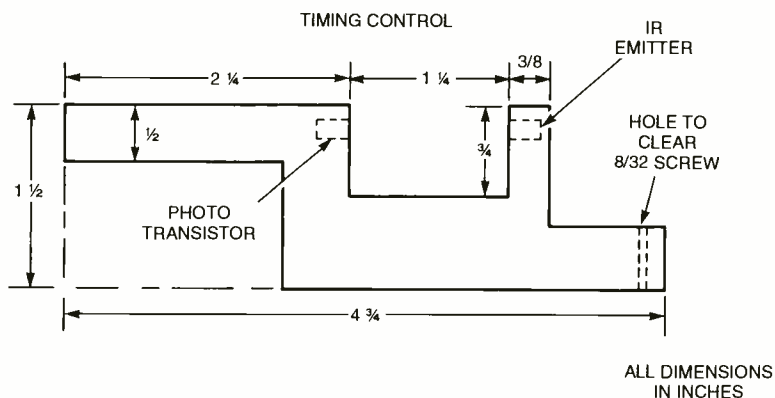
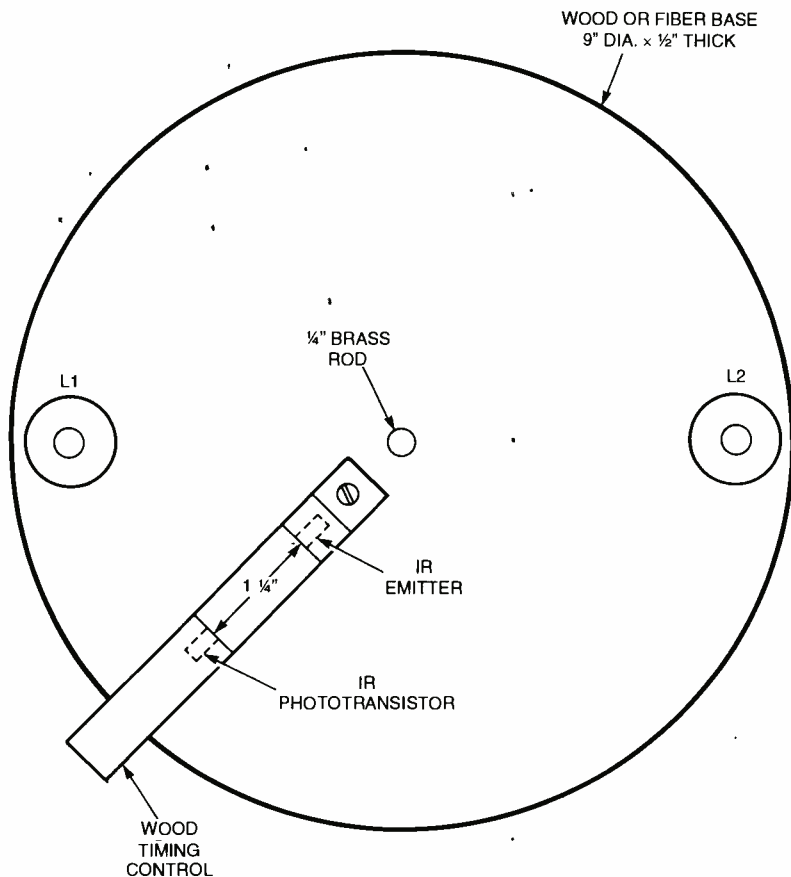


Fig. 4. Greater details of the timing control unit are shown here. This assembly is attached to the motor's baseboard with a single 8-32 screw, washer, and nut.



made of cast iron and will still run when connected to a 3-volt DC source.

The circuit for this model spinning wheel, shown in Fig. 6, is very similar to the circuit in our last project. The timing is based on the interruption of an IR light source, and the drive coils are powered by a power HEXFET. On the previous model, the blocking of the IR light source sent a power pulse to the coils; however, in this circuit the opposite takes place. A power-output pulse is sent each time that the phototransistor is exposed to the IR light source. In our last circuit, the gate of the HEXFET was connected to the collector of the phototransistor, and on this circuit the gate is connected to the emitter. This simple change inverts the HEXFET's output that drives the drive coils. In this circuit, when the IR source is blocked from the phototransistor, the voltage at its emitter is zero and the HEXFET remains off. The phototransistor only draws current when an IR light source is detected.

The timing wheel is made of thin metal with four openings to allow the IR light to pass through when in position for an output drive pulse.

A side view of the spinning wheel is shown in Fig. 7. The base and side sup-

Fig. 5. The coil locations are shown here, along with the location of the timing unit.

sion of an old toy motor that was popular in the early years of the last century. Many of these toy motors were built from good materials before the days of plastic, and for that reason some are available at a price today. The toy motor that my version is based on was patented in March 1908 and has a 3-inch diameter vertical flywheel. This robust toy was

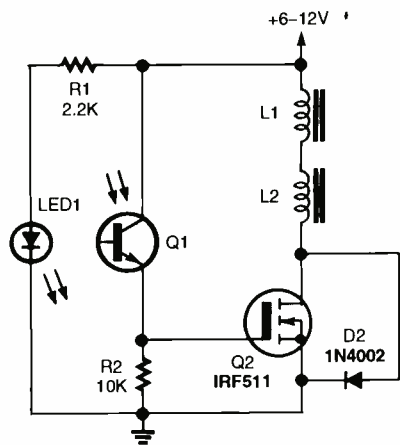


Fig. 6. The circuit for this spinning wheel is very similar to the circuit in our last project. The timing is based on the interruption of an IR light source, and the drive coils are powered by a power HEXFET.

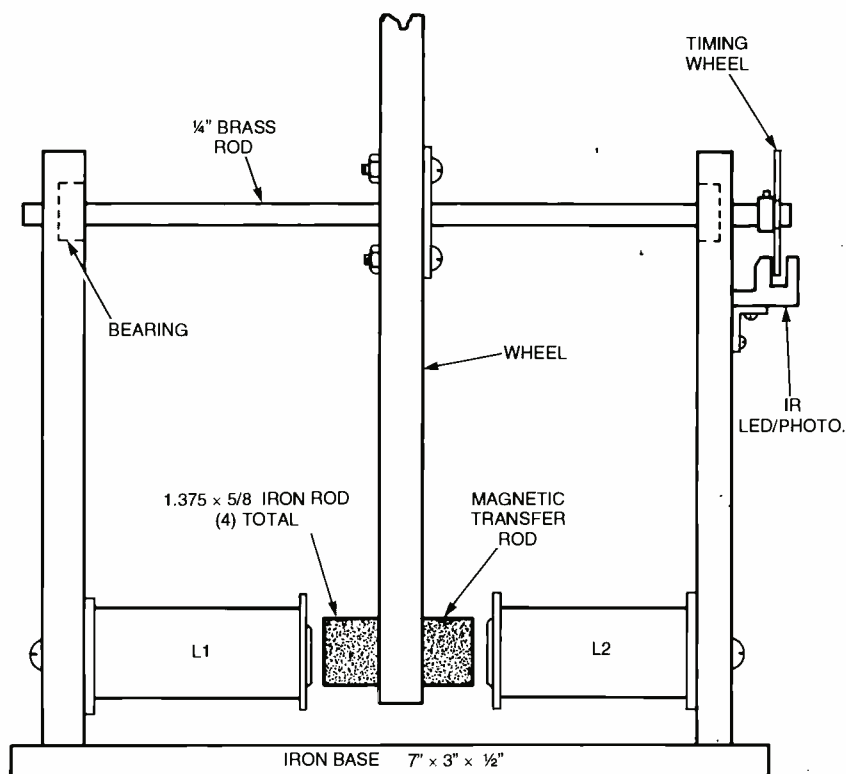


Fig. 7. A side view of the spinning wheel is shown here. The base and side supports are made of cast iron. The four magnetic transfer rods are cut from 3/8-inch soft iron-rod material.



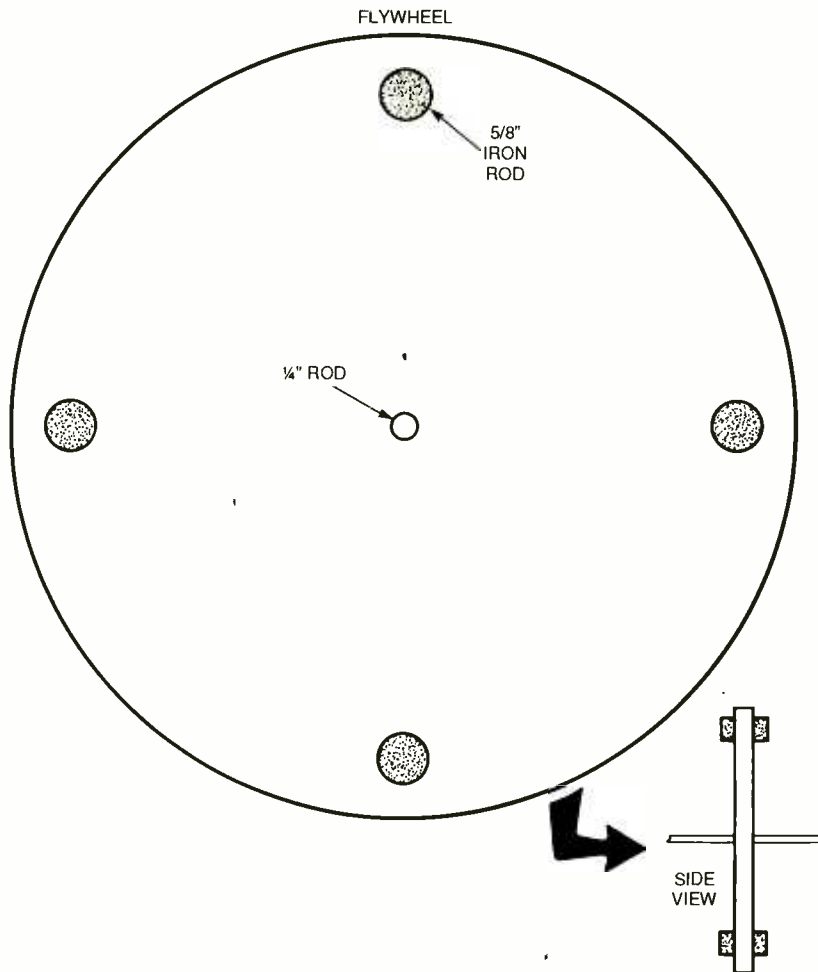


Fig. 8. The four magnetic transfer rods are cut from 1/8-inch soft iron-rod material. The diagram above can be used as a placement guide for the iron rods.

ports are made of soft iron. The four magnetic transfer rods are cut from 1/8-inch soft iron-rod material (see Fig. 8). The timing wheel, see Fig. 9, may be made out of metal or any opaque mater-

ial that will not allow IR light to pass through.

The spinning wheel (flywheel) is made from fiber or any similar non-metal material and is cut to the same size as our previous horizontal wheel. The

size of the spinning wheel is not important as long as all other components are sized accordingly. The reason that the 9-inch diameter size was chosen is because I had a number of surplus fiberboard wheels on hand for project use. The four 1/8-inch diameter magnetic transfer rods are equally spaced around and within 1/2-inch of the wheel's edge. These rods may be press fit in place or by a keeper screw through the rim of the wheel. They must all be of the same length and mounted with equal lengths extending on each side of the spinning wheel.

The flywheel is attached to the 1/4-inch brass rod with a bushing that bolts in place in the center of the flywheel. The 1/4-inch rod that supports the flywheel passes through both end supports, which are equipped with small ball bearings. The optical timing wheel is mounted on the 1/4-inch shaft, see Fig. 7, and the IR assembly is connected to the support as shown.

The two drive coils were taken from old telephone exchange equipment and measure about 30 ohms each; however, the coils may be hand wound on soft iron rods or may be old relay coil cores. A core of 1/2-inch diameter by 1 1/4-inch long wound with about 350 ft. of number 30 enameled covered copper wire will do just fine, or any similar winding that offers a coil resistance of 20 to 36 ohms. Higher resistance coils will work but will require operating at a higher supply voltage and lower operating voltage for lower ohm coils.

The spacing between the magnetic transfer rods and the two coils should be somewhere between 1/16 and 1/8 inches. Actually, the spacing between the coils

**PARTS LIST FOR THE  
NEW TOY CIRCUIT  
AND ASSEMBLY  
(FIGS. 6-9)**

- LED1/Q1—Mouser part #512-H21A1.  
or build using RadioShack part#276-142.
- Q2—IRF511 Power HEXFET
- D2—1N4002 1-amp silicon diode
- R1—2,200-ohm, 1/4-watt, 5% resistor
- R2—10,000-ohm, 1/4-watt, 5% resistor
- L1, L2—See text for details.

**ADDITIONAL PARTS  
AND MATERIALS**

1/2-inch iron material, 1/4-inch brass rod, 1/8-inch iron rod material, misc. materials. See text for details.

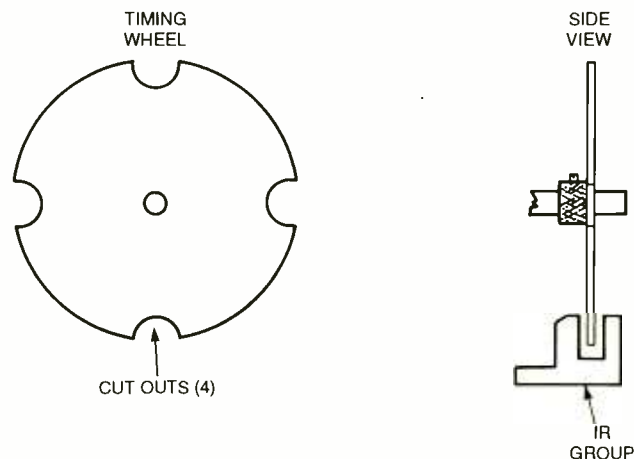


Fig. 9. The timing wheel may be made out of metal or any opaque material that will not allow IR light to pass through. The spinning wheel (flywheel) is made from fiber or any similar non-metal material and is cut to the same size as our previous horizontal wheel.

and magnetic transfer rods should be as close as possible for the most efficient operation.

### Phasing The Coils

There are two methods of operating the spinning wheel. One is to have the two coils connected in a way that each end facing the magnetic transfer rod is of the same magnetic pole. This method will spin the wheel by repelling the transfer rods when the coils are activated. The other method is by connecting the two coils so one produces a "N" pole

field and the other a "S" pole field. This method will spin the wheel by attracting the transfer rod to the two coils. Either method will work, but I prefer using the repelling arrangement.

### Setting The Timing Wheel

Start with the cut-outs in the timing wheel aligned with the four magnetic transfer rods in the flywheel. Position any one of the transfer rods so it centers between the two coils. Then adjust the timing wheel so one of the cut-outs just barely allows the IR light to reach the

phototransistor. This should get the wheel ready to run. Connect a power source and give the wheel a spin. If it slows and does not take off, stop and spin it in the other direction. Once you have it running, fine-tune the location of the timing wheel for maximum speed.

Hopefully, I've been successful in sharing enough information for one or both of these fun and relaxing projects to become one of your next endeavors. If you do take the challenge, please send me a photo and details of your spinning project. **P**

## PEAK COMPUTING

*(continued from page 19)*

makes a good game machine, most games don't take advantage of the dual processors and run almost as well on the standard 1.7-GHz P4 we used for comparison.

The "Monster" would earn its keep

if you had extensive mathematical analysis to perform. Applications such as SPSS are available in multiprocessor versions and would really zoom on the dual Xeon platform. So would many CAD or printed circuit board layout applications.

Be careful, though, if you are thinking of duplicating our project for your own

use. Check with the vendor and make sure that their application actually does support dual processors. If it doesn't, you might as well run it on a standard high performance single-CPU P4.

With applications that do support dual-CPU systems, you'll find that a personal workstation like the "Monster" truly does provide Peak Computing! **P**

## Q & A

*(continued from page 52)*

when Heathkit ceased the mainline production of kits. For years, they were our main source for reasonably-priced test and ham equipment and a variety of household electronic kits. They almost immediately ceased support for the kits they had already sold.

You do have a couple of resources available to help out. Don Peterson has a Web site devoted to Heathkit parts and manuals at [www.d8apro.com/heath1.htm](http://www.d8apro.com/heath1.htm), where you'll also find links to other Heathkit sites. One of those links is Tom's board at <http://pluto.beseen.com/boardroom/q/51675/>, where you can post questions to a Heathkit-targeted audience. There you'll also find a link at the top to Tom's manual archive in the U.K. where Heathkit schematics can be freely

downloaded. One or more of the links that you'll find on these two sites are operated by former Heathkit technicians who have squirreled away a ton of inside information that may be helpful to you.

Check the number on the top of the chip and any references in the manual. It was aggravating whenever Heathkit "house numbered" chips, for most of the integrated circuits they used were otherwise off-the-shelf items that could be purchased anywhere if you only knew the "real" type number. Kits such as their "Most Accurate Clock" did use two or three custom-programmed chips that can no longer be obtained except through the salvage of a hangar queen. The on-line auctions may be another source for an identical clock that may have a good clock chip, while the remainder of the unit is junk.

Good luck in your search and repair

mission, and if you find a really nifty Heathkit resource that wasn't picked up directly from one of the sites listed above, let me know here at "Q & A."

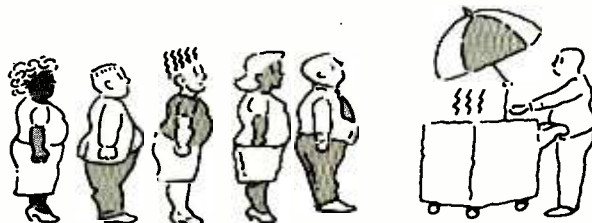
## Writing to Q&A

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](mailto:q&a@gernsback.com), but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K. **P**

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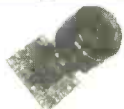
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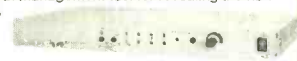


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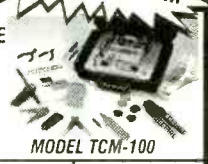


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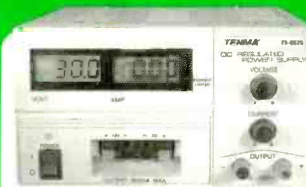
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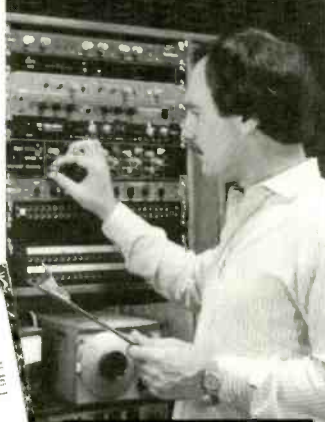
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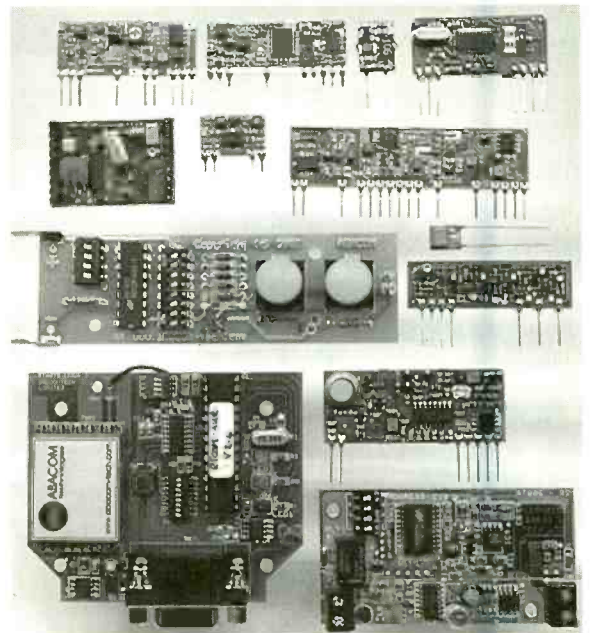
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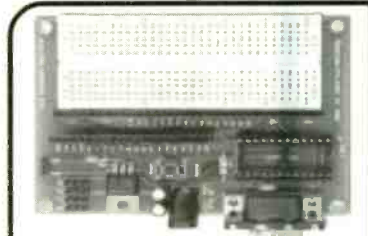
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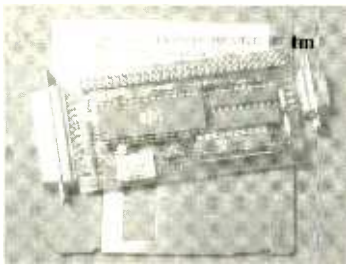
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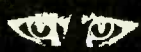
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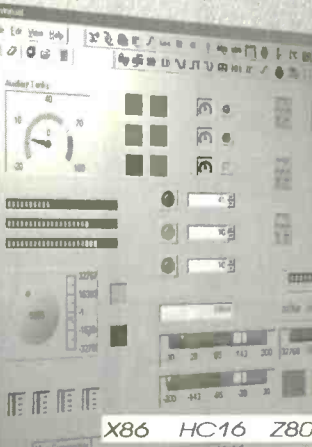
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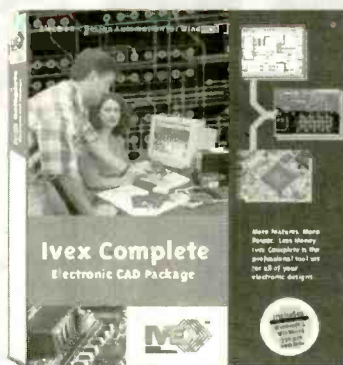
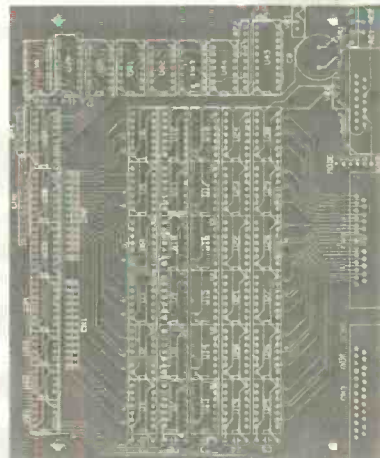
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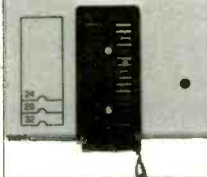
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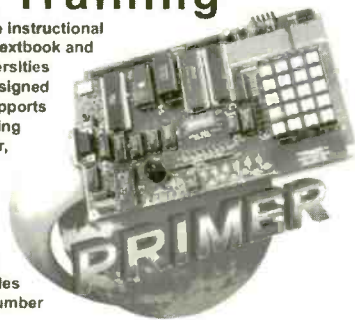
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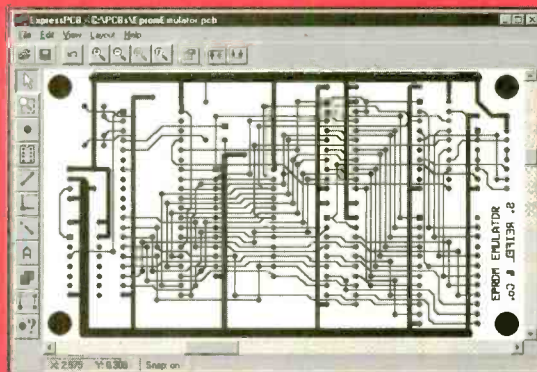
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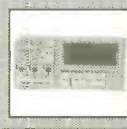
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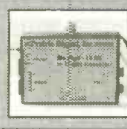
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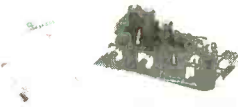
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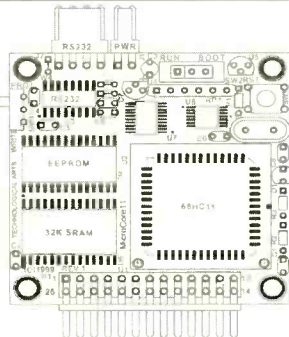
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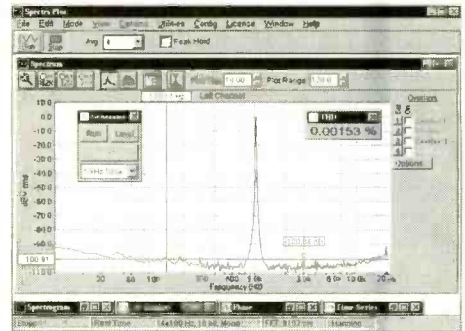
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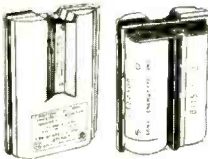


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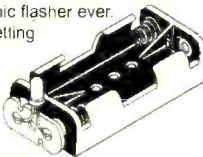
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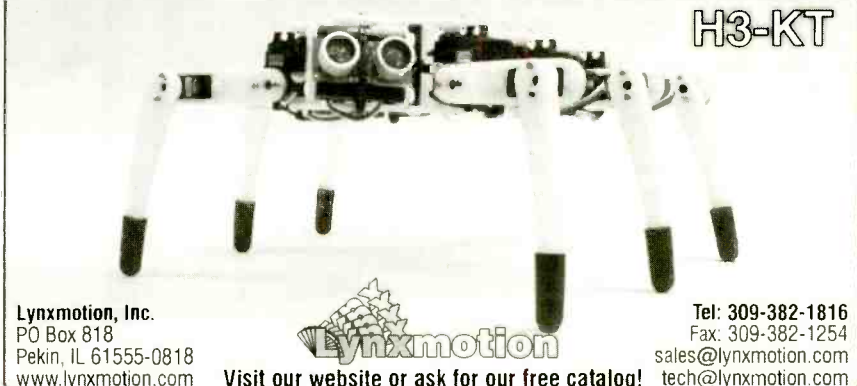
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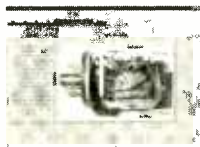
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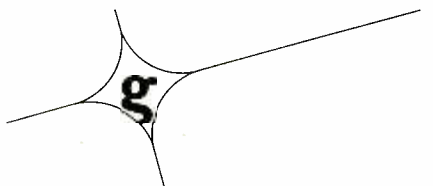
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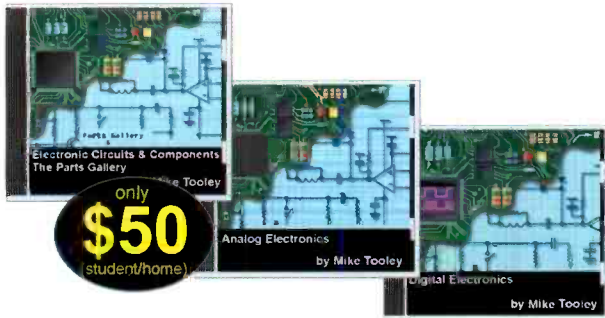
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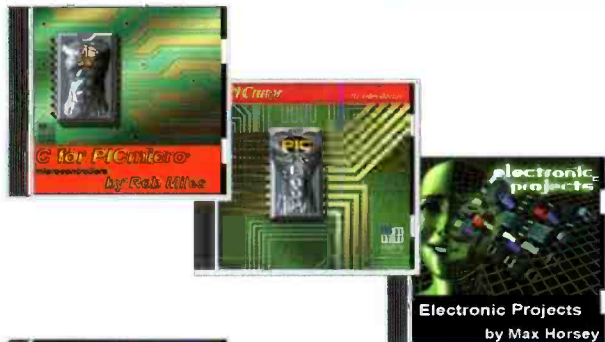


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**Digital Electronics** details the principles and practice of digital electronics, including logic gates, combinational and sequential logic circuits, clocks, counters, shift registers, and displays. The CD ROM also provides an introduction to microprocessor based systems.



**Analog Electronics** is a complete learning resource for this most difficult subject. The CD ROM includes the usual wealth of virtual laboratories as well as an electronic circuit simulator with over 50 pre-designed analog circuits which gives you the ultimate learning tool. The CD provides comprehensive coverage of analog fundamentals, transistor circuit design, op-amps, filters, oscillators, and other analog systems.

**Electronic Projects** is just that: a series of ten projects for students to build with all support information. The CD is designed to provide a set of projects which will complement students' work on the other 3 CDs in the Electronics Education Series. Each project on the CD is supplied with schematic diagrams, circuit and PCB layout files, component lists and comprehensive circuit explanations.



**PICtutor and C for PICmicro microcontrollers** both contain complete sets of tutorials for programming the PICmicro series of microcontrollers in assembly language and C respectively. Both CD ROMs contain programs that allow you to convert your code into hex and then download it (via printer port) into a PIC16F84. The accompanying development board provides an unrivaled platform for learning about PIC microcontrollers and for further development work.

**Digital Works** is a highly interactive scalable digital logic simulator designed to allow electronics and computer science students to build complex digital logic circuits incorporating circuit macros, 4000 and 74 series logic.

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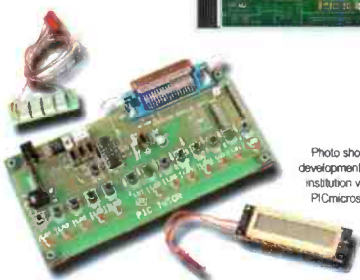


Photo shows PICmicro development kit supplied with installation versions of C for PICmicros and PICtutor

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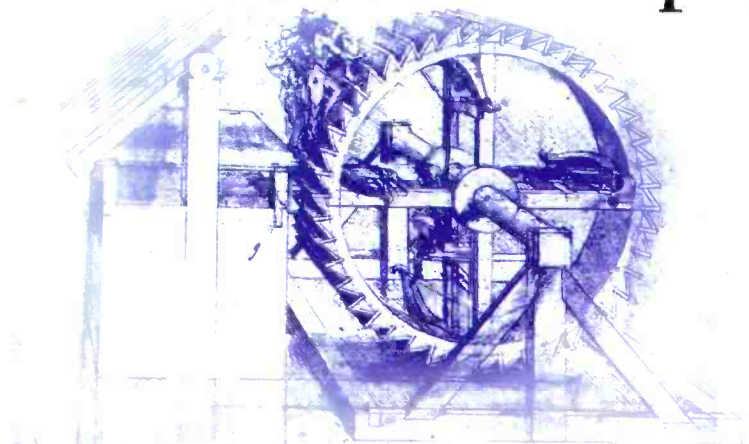
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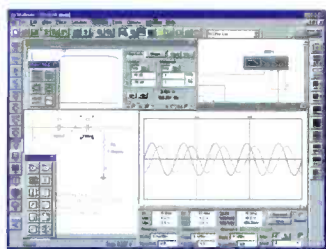
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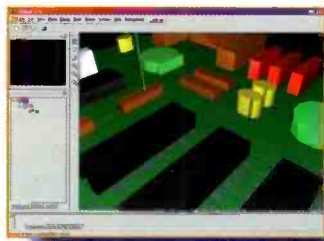
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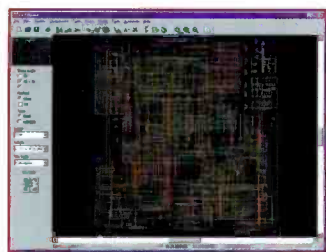


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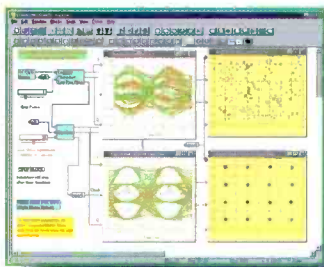
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