

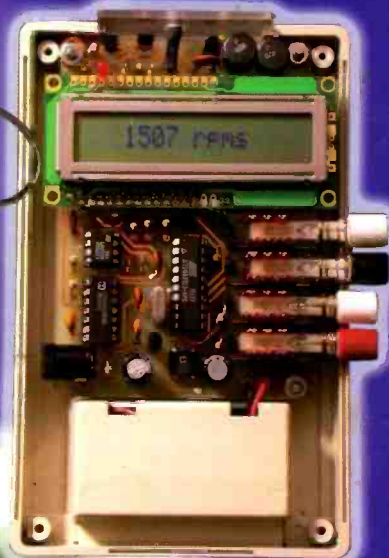
# Poptronics®

Formerly Popular Electronics® and **Electronics NOW**



## ULTRASONIC LISTENING DEVICE

Plans for this parabolic receiver



## The Tach-Plus Tachometer

Accurately measure RPMs



## Six-Volt Strobe

A powerful transformer that fits in your hand

### Also Inside:

- RC Timers
- Basic Circuits
- Bi-Pedal Robots
- Digital Photography
- IsoPod Microcontroller

\$4.99 U.S.  
\$6.50 CAN.

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 COLUMBIA MD 21046-2073



# FCC Course with Certificate

## A Powerful 19 Lesson Self-Study Program on one CD!

### FCC Exam Review Course

After completing this course you will be ready to take the FCC examination for a General Radiotelephone Operator License.

The General Radiotelephone Operator License is required to adjust, maintain or repair any FCC licensed radiotelephone transmitters in the aviation, maritime and international fixed public radio services. It is issued for the lifetime of the holder.

Through the years Cleveland Institute of Electronics (CIE) has been able to compile a great amount of information concerning the types of questions that the FCC include in their examinations.

Because of the extensive FCC sample questions in this course, you can look forward with confidence to passing the FCC exam particularly if you heed the hints given throughout the course.

### Here's what you'll get!

#### 19 FCC Lessons on CD ROM

Every lesson is presented in a clear and easy-to-understand format which makes learning this material fun and easy. After each lesson you'll take an exam. You can take it on-line or fill out one of the answer sheets we provide and mail it. After you finish the 19 lessons we'll send you a Certificate of Completion from CIE.

#### CIE Instructor Assistance:

Use our toll-free hot line to access our faculty and staff if you ever need assistance with your course work.

#### Priority Grading:

Your exams will be graded and sent back to you within 24 hrs.

#### Certificate of Completion:

Earn a Certificate of Completion that's suitable for framing.

#### Why is an FCC License so valuable?

An FCC license is an excellent credential for career advancement because it's proof of a certain level of electronics know-how. Because it is a federal examination, the FCC license with its implied knowledge is accepted by industry nationwide.



### Lesson Topics Include:

- Modern Modulation Methods
- Receiving Equipment
- Batteries, Control Motors & other Power Sources
- Digital & Data Commun.
- Frequency Modulation
- Transmission Lines & Wave Guides
- Transmitters
- Antennas & Wave Propagation
- Monochrome & Color TV
- Microwave Comm. Systems
- Tuned-Stage Operation
- Suppressed - Carrier Modulation and Single
- Detection & Frequency Conversion
- Lasers in Communications & Industry
- Communications by Fiber Optics
- FCC Review Lessons Pt 1
- FCC Review Lessons Pt 2
- Pointers & Practices for Passing FCC G.C. Exam Pt 1
- Pointers & Practices for Passing FCC G.C. Exam Pt 2

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- PC Diagnostic Video
- 200 + Page Training Manual
- PC Assembly & Configuration Video
- Micro-Scope Diagnostic Software (LE)
- CD-ROM - contains videos and manual 02-020 ..... \$99.95

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This CD ROM trainer uses pictures, sounds, animations & interactive circuits to teach you the basics of motor control. A Certificate of Completion may be printed on your printer if you achieve a passing score on the included test. 02-050 (not a CIE certificate) ..... \$99.95

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01-SD01 (1 graded lesson w/ cert) ..... \$65
- Digital Data Communications with Lab**  
01-DD01 (11 graded lessons w/ cert) .. \$245

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Shipping & Handling: \$0 - \$30 **\$2.75**, \$30.01 - \$50.00 **\$5.25**, \$50.01 - \$100.00 **\$11.75**, \$100+ **\$15.75** CA, HI & OH residents must add sales tax.

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# Poptronics<sup>®</sup>

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*Hear insects, electrical relays, and other sources of ultrasonic noise with this hand-held parabolic receiver.*

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*You'll find the plans for a palm-sized circuit with a transformer that steps up from six to 300 volts.*

**BUILD THE TACH-PLUS DIGITAL TACHOMETER** ..... Robert Nance Dee 31  
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editor-in-chief and publisher

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# On My Command... Energize, Scotty

Welcome to the dawn of teleportation. Reports have been confirmed that physicists at the Australian National University (ANU) successfully employed a technique known as quantum entanglement. This process broke a particle of laser light down and reconstructed it at a different location. Credit has been given to IBM Labs for its theories of teleportation established in 1993, but not until June of 2002 has anyone reported a successful experiment. Researchers say that quantum entanglement will be an important factor in quantum computing. Teleportation of light will be primarily used for the instantaneous transfer of data riding along light carriers. As far as teleporting humans, scientists warn that they have yet to perfect the transfer of a single atom, let alone the zillion or so it takes to make one fleshy unit (aka human). Well then, what was that about the *Philadelphia Experiment* being a hoax? Just teasing, gang. I've always said that science fiction is just reality with an unlimited budget.

What wonders wait for us, as smart alloys abound, organic chips shrink to microscopic proportions, and the properties of light are mastered? Chances are (if this planet doesn't melt by the time this Editorial hits the stands) we are all going to witness some mind-blowing advances in the next decade. There are already experiments being conducted in the field of cyborgenetics that aim to meld man and machine, and companies like Microsoft and Verizon are working to merge the fields of communications and entertainment all into one wall jack. The world of Stanley Clarke's *2001: A Space Odyssey* is right outside our door. Question is: do we really want to open it?

In our magazine...

This month we are happy to offer our readers three hands-on projects for their constructing pleasure. There are plans for a parabolic receiver capable of detecting ultrasonic noises, a strobe light that runs on four AA batteries, and a tachometer that has many practical uses around the lab. Along with these three projects, you'll also find circuits for timers, robotic ambulation, humidity sensors, and custom seven-segment displays.

Enjoy,



Chris La Morte  
Managing Editor

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

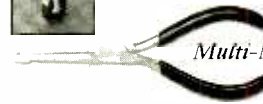
## Air Ion Counter

Useful for detecting radon, the *Air Ion Counter* (\$495) pulls air, or any other gas with ions present, through a parallel-plate assembly. The outer two plates are held at polarization potential, while the center is the linear detector plate. Accuracy is  $\pm 25\%$  for fast ions—the counter is less sensitive to slow ions such as charged pieces of dust. Ion collection efficiency is 65%.

**ALPHALAB, INC.**

Attn: David - PT  
1280 South Third West  
Salt Lake City, UT 84101-3049  
808-874-9126  
[www.trifieldmeter.com/AirIon.html](http://www.trifieldmeter.com/AirIon.html)

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## Multi-Nut Plier

Made of stainless steel with cushion PVC grips, this *Multi-Nut Plier* (\$14.95) is designed for home or professional use—mechanics, repairmen, electricians, and hobbyists. A companion tool that is invaluable for holding larger bolts and torquing down smaller ones, it is instantly ready to use with no adjustment necessary. Its V-shaped jaws also hold hard-to-reach heads when tightening bolts.

**JENSEN TOOLS**

7815 South 46<sup>th</sup> St.  
Phoenix, AZ 85044  
602-453-2542

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

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## Soldering Systems

The *HeatWise* (\$250) and *TempWise* (\$350) *Soldering Systems* feature the TC

100, a slim, ergonomically correct handpiece and the smallest footprint available. The *HeatWise* system has interchangeable power modules that allow the user to change performance levels without changing tips; while the *TempWise* system has a programmable digital display and InstaCal, which allows

for calibration in less than ten seconds using a highly accurate, platinum RTD sensor. Both can be mounted under a bench or shelf using the optional power-source mounting bracket.



**PACE**

9893 Brewers Court  
Laurel, MD 20723-1990  
301-490-9860

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

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## InfraRed Probe Meter

This pocket-size *Infrared Thermometer*, Model 403265 (\$159), features a built-in laser pointer to improve aim. Infrared readings range from  $-4^{\circ}$  to  $1022^{\circ}$  F with  $1^{\circ}$  resolution; and measurements are displayed on a large 3 $\frac{1}{2}$ -digit backlit LCD with data hold. An alarm sounds when temperature exceeds the programmable high and low set points, and emissivity is adjustable from 0.1 to 1.00 to cover just about any surface application. It comes complete with batteries and carrying case.

**EXTECH INSTRUMENTS**

285 Bear Hill Road  
Waltham, MA 02451-1064  
781-890-7440  
[www.extech.com](http://www.extech.com)

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## Power Supply Kit

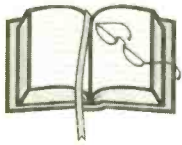
Combining safety and functionality with convenience and economy, the *Model TLPS Power Supply Accessory Kit* (\$39.95) provides an initial selection of accessories commonly used with popular power supplies. Ideal for use with power supplies in educational, service and maintenance, and manufacturing applications, the kit includes fully insulated and standard alligator clips, silicone leads, spade-lug adapters, and banana-plug adapters. The kit is enclosed in an easy-to-use package.

**B&K PRECISION CORP.**

22820 Savi Ranch Parkway  
Yorba Linda, CA 92887  
714-921-9095

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

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# YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES



1900

1910

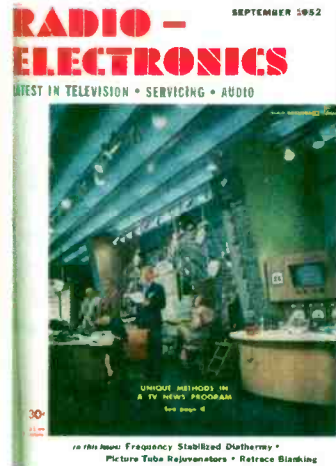
1930

1940

1952

## Dateline: September 1952 (50 years ago)

The *Today Show's* modern electronic communications center is a highlight in this issue of **Radio Electronics**. Equipment in the news hub included tape recorders, teletypes, and even facsimile machines! Also, a brief clip describes the U.S. President's new communications car on his train, designed by the Army Transportation Corps. The Chief could communicate with anyone in the country thanks to multiple antennas and then-sophisticated receiving and transmitting equipment.



1960

## Dateline: September 1972 (30 years ago)

This Special Color TV issue of **Radio Electronics** features automatic tint control, new circuits, Trinitron vs. Shadow Mask picture tubes, and plug-in modules. On the VCR movement, the race is on to see which manufacturer can produce a videocassette player that is cheap enough for widespread, household use. Motorola, Mitsubishi, Toshiba, and Sony are in the running. Prices are averaging \$1000 for playback only machines and even higher for those with recording capability.

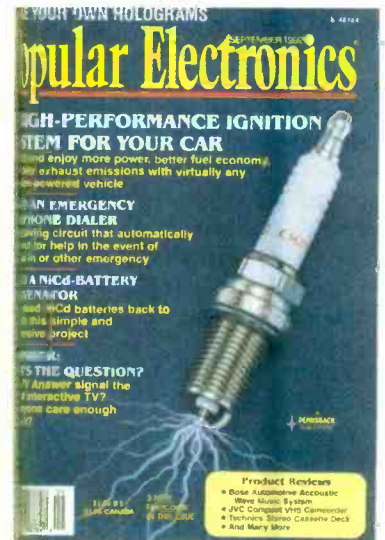


1972

1980

## Dateline: September 1992 (10 years ago)

Imagine ordering a pizza, taking part in a poll, or competing on a game show, by talking to your TV set from your living room couch! The dawning of interactive TV is explored a decade ago in **Popular Electronics**, with a black box called TV Answer supposedly coming on the market soon. Still no sign of it yet! "Computer Bits" discusses the recent strides in programs like *Microsoft Excel 4.0* and *Visual BASIC*, and the pressure on software designers to build multi-tool applications—programs that integrate data bases, word processors, and spreadsheets.



1992

2000

# NEW LITERATURE

## Robot Teams

by Tucker Balch and  
Lynne E. Parker  
AK Peters  
63 Sound Ave.  
Natick, MA 01760  
508-655-9933  
www.akpeters.com  
**\$49**

A comprehensive reference on multi-robot systems, this text explores the maturing field of robotics research and development and the important issue of cooperation among robots. Along with the essentials of multi-agent robotics theory, there are also descriptions of exemplary implemented systems demonstrating the key concepts of multi-robot research. In addition, detailed mathematical formulations, photos, diagrams, and source code examples are included.



## The ARRL Extra Class License Manual

by Larry D. Wolfgang, WR1B,  
Dana G. Reed, W1LC,  
and R. Jan Carman, K5MA  
ARRL  
225 Main St.  
Newington, CT 06111-1494  
888-277-5289  
www.arrl.org  
**\$24.95**

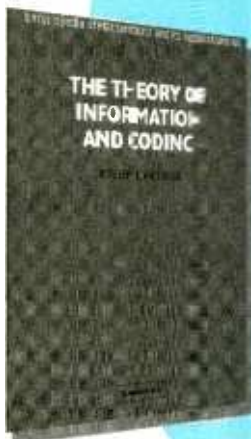


Providing complete license preparation materials, this book has detailed explanations, step-by-step math solutions, and helpful suggestions for passing the Amateur Extra Class License exam. There is a new Element 4 question pool with over 800 questions and all the FCC rules you'll need to know, as well as electronics theory and amateur operating practices.

## The Theory Of Information And Coding

by Robert J. McEliece  
Cambridge University Press  
40 West 20th St.  
New York, NY 10011-4211  
212-924-3900  
www.cambridge.org  
**\$60**

Useful for self-study or as a college text, this volume is a self-contained introduction to all basic results in the theory of information and coding. After a brief overview of the concept of coding, the author covers channel and source coding theorems and specific coding schemes. The book includes dozens of worked examples and several hundred problems to be solved. Some prior knowledge of probability and linear algebra is beneficial.



## Digital Signal Processing

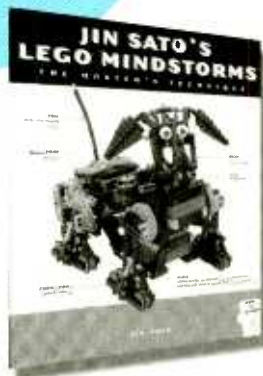
by Paulo S.R. Diniz, Eduardo  
A. B. da Silva,  
and Sergio L. Netto  
Cambridge University Press  
40 West 20th St.  
New York, NY 10011-4211  
212-924-3900  
www.cambridge.org  
**\$60**

This single, comprehensive volume covers all the major topics in digital-signal processing design and analysis. Taking a modern approach to the subject, it includes MATLAB examples and references to other computer-modeling tools. Though primarily intended as a college textbook, it is also useful for engineers working on the development of signal-processing systems.



## Jin Sato's LEGO Mindstorms: The Master's Technique

by Jin Sato  
No Starch Press  
555 De Haro St.  
Suite 250  
San Francisco, CA 94107  
415-863-9900  
www.nostarch.com  
**\$24.95**



Covering construction techniques in detail, the author, creator of the Robotic dog MIBO, illustrates how to assemble bricks, motors, gears, and sensors to create more balanced, stable structures. Also, learn how to combine sensors with the RCX controller to create robots that respond to the environment; program RCX with software like NQC, Robolab, and legOS; and design LEGO CAD drawings and assembly diagrams with MLCad, L3P, and POV-Ray.

## The ARRL Repeater Directory

by Brennan Price

ARRL

225 Main St.

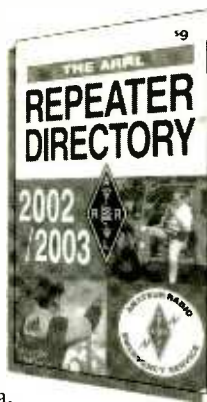
Newington, CT 06111-1494

888-277-5289

www.arrl.org

\$9

Containing information necessary to contact Frequency Coordinators and ARRL officers, this reference manual includes repeater locations, frequencies, and other pertinent data for the US, Canada, and US territories. There is also information on general repeater operating procedures, specialized emergency procedures, and locating and effectively overcoming jamming. In addition, there is a comprehensive listing of regional frequency coordinators and coordination bodies, with Web URLs and e-mail addresses, when available.



## Electronics Catalog

from Mouser Electronics

1000 N. Main St.

Mansfield, TX 76063-1514

800-346-6873

www.mouser.com

Free

This 600-page catalog offers a comprehensive line of products and parts from many various companies, including Texas Instruments, Pomona, Omron, Molex, AMP, Mallory, and others. Some featured items are semiconductors, optoelectronics, test connectors, terminals, sockets, capacitors, resistors, transformers, and inductors. Switches, hardware, batteries, and power supplies are also included.



## Digital and Microprocessor Fundamentals

by William Kleitz

Prentice Hall

One Lake St.

Upper Saddle River, NJ 07458

800-282-0693

www.prenhall.com

\$104

Using simple, easy-to-understand prose and many clearly explained examples, this text covers the fundamentals of both digital electronics and microprocessors. There are nearly 1000 illustrations that explain practical applications and problems using industry-standard ICs and circuits, and schematics that students will encounter on the job. The volume encompasses digital number systems and representations, logic-gate operation and specifications, logic circuits and reductions techniques, data-control devices, and more.



## Electronic Component Catalog

from Allied Electronics

7410 Pebble Drive

Fort Worth, TX 76118

800-433-5700

www.alliedelec.com

Free

Offering over 125,000 stocked products available for same day shipping, this catalog has a comprehensive product index, new product showcase, and complete manufacturer's part number index. Featured items include fans; heatsinks; motors; transformers; panel meters; and hardware, computer and security products. In addition, there is solder equipment, hand tools, lighting, test equipment, chemicals, cleaners, cable, wire, electrical cords, strips, and more.



## Smart Power ICs: Technologies and Applications

Edited by Bruno Murari & others

A.R.C.

Springer-Verlag

175 Fifth Ave.

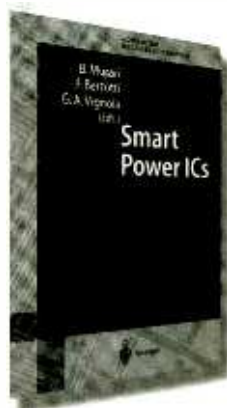
New York, NY 10010

800-777-4643

www.springer-ny.com

\$109

A valuable source of information and reference for both power IC design specialists and those concerned with applications and the development of digital circuits and systems architecture, this book provides a survey of the state-of-the-art technology and future trends in the new family of Smart Power ICs. It describes design, applications in a variety of fields ranging from automotive to telecommunications, reliability evaluation, and qualification procedures.





# GIZMO®

For more information go to page 80A

or e-mail: [requests@berkshire-is.com](mailto:requests@berkshire-is.com)

## More Music

Take your favorite music along with TDK's *MOJO 620 CD-MP3* digital jukebox (\$149) that can play up to ten hours of music from a single MP3-CD. This ultra-portable player features 8-minute ZeroSkip shock protection and high-quality headphones with a handy remote control on the cord itself. Its *Navitrak* software has a big, easy-to-read, four-line backlit display that provides song title, artist, album, and other information. Users can view song lyrics during playback with its *LyriSync* feature.

TDK Electronics Corp., 901 Franklin Ave., Garden City, NY 11530; 516-535-2600; [www.TDK.com](http://www.TDK.com).

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## Slim and Trim

A sleekly designed control module, a pair of high-quality speakers (each measuring less than 3½-inches deep), and a powered subwoofer can all be found in the *Prime Sound Series D-107 Compact Music System* (\$749). Brushed aluminum front panels are accented by a deep blue, illuminated, horizontally-displayed control section and CD window; and the subwoofer also boasts a curved, silver-finish front panel. The entire system can be wall mounted. In addition to CD, CD-R, and CD-RW playback, the D-107 plays back MP3-encoded CDs with text display. Not only a CD-player, it offers 30-station AM/FM random preset tuning and a clock display with an everyday/once/sleep timer, as well.

Denon Electronics, 19 Chapin Road, P.O. Box 867, Pine Brook, NJ 07058; 973-396-0810; [www.denon.com](http://www.denon.com).

CIRCLE 52 ON FREE INFORMATION CARD

## Single-Play Model

This single-play DVD 25 player (\$349) offers many advanced features, such as progressive-scan component-video outputs, built-in MP3 decoding, CD-R, and CD-RW playback. To deliver



maximum video quality, it has precision digital-video circuitry that reconstructs the 3/2 pull-down process and delivers full 60-frame playback. The intuitive on-screen menu system and the full-function, back-lit, ergonomically designed remote control combine to make it easy to use. The DVD 25 offers a wide variety of viewing and picture-search options, such as four-speed smooth scan; four-speed slow motion; frame-by-frame advance; and a choice of program-, random-, and repeat-play modes.

Harman Kardon, 250 Crossways Park Drive, Woodbury, NY, 11797; 516-496-3400;

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

CIRCLE 51 ON FREE INFORMATION CARD

## Portable Power

Need some power on the go? An ideal mobile-office companion, the *XPower Mobile Plug* (\$29.99) is designed for those who rely on mobile electronic devices. This universal AC-power adapter plugs into any vehicle's cigarette lighter socket and allows users to recharge and run cell phones, laptop computers, camcorders, and most palm pilots—without the need for multiple adapters. A typical car battery will power a laptop for about ten to twelve hours.

Xantrex Technology, 8999 Nelson Way, Burnaby, BC, Canada V5A 4B5; 604-422-8595; [www.xantrex.com](http://www.xantrex.com).

CIRCLE 53 ON FREE INFORMATION CARD



## For The Video Buff

Designed for the consumer who wants professional-level video, the *DCR-TRV950 Mini DV Handycam Camcorder* (\$2500) creates high-quality video with color clarity and detail. This three-CCD (charge-coupled device) camcorder uses one million pixels per CCD imager and advanced HAD technology. The built-in Optical Super SteadyShot picture-stabilization system, which includes motion sensors, compensates for camera shake. Optional manual controls allow for creativity and control; and the person filming can override automatic features with options such as manual focus, digital zoom, and spotlight compensation.

Sony Electronics, Inc., One Sony Place, San Antonio, TX 78245; 888-222-SONY; [www.sony.com](http://www.sony.com).

CIRCLE 54 ON FREE INFORMATION CARD



## Super Sonic

Promising to satisfy even the most demanding audiophiles, the SA8260 Multi-Channel Super Audio CD Player (\$1049.99)



offers high-performance design features to deliver maximum fidelity and sonic purity. These include copper-shielded HDAM (high-definition amplifier module) discrete output stages, premium components to produce the audio signal, and a heavy-duty power supply. Elegantly styled with a black, brushed metal front panel, the SA8260 has a window that displays SACD and CD text, with a full complement of program and play functions. It provides six-channel and two-channel analog audio outputs, as well as digital audio outputs and a headphone jack for private listening.

Marantz America, Inc., 1100 Maplewood Drive, Itasca, IL, 60143; 630-741-0300; [www.marantz.com](http://www.marantz.com).

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## Sound Sleep

Wouldn't you love to snooze to the sounds of the rainforest, the ocean, or even a crackling fire? The Travel Soother 20 Radio/Alarm Clock (\$99.95) masks disturbing noises with 20 innovative sound environments. The AM/FM digital PLL tuner has 12 presets; and the alarm can wake you to the sounds of soother, buzzer, church bells, or radio. Illuminated in calming blue, the backlit LCD shows 12/24 time, alarm or dual-time, temperature, month, and day. Other sounds include Summer Night, Wind Chimes, and the City.

The Sharper Image (stores in 28 states and Washington, DC); P.O. Box 7031, San Francisco, CA 94120-9703; 800-344-4444; [www.sharperimage.com](http://www.sharperimage.com).

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## Back Seat Fun

What better way to make the miles fly by for your back seat passenger than with a

movie, video game, or T.V. show? This 6.5-inch Widescreen Overhead LCD Color Display (\$800) has a tilt-down screen, wired or wireless headphone outputs, adjustable angles, five selectable viewing modes, accessible controls on the console face, and a

remote control. There are also two overhead lights; an anti-glare, low-reflection, coated LCD color screen; three A/V inputs; and one A/V output.

Pioneer Electronics, 2265 E. 220th St., Long Beach, CA, 90801; 310-952-2570; [www.pioneerelectronics.com](http://www.pioneerelectronics.com).

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## See and Speak

Dress your best for the latest in video communications. The Motion Media mm225 Videophone (\$2200) is designed for people who need low-cost videoconferencing. No larger than a standard office phone, the mm225 provides clear picture



quality with frame rates fast enough to keep up with sign language for the hearing impaired. Two-way data sharing is accomplished with support for Microsoft NetMeeting, which allows the mm225 to perform its own audio and video processing.

Motion Media Technology Inc., 6714 Netherlands Drive, Wilmington, NC, 28405; 910-395-6108; [www.motion-media.com](http://www.motion-media.com).

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## Cam Bag

Designed for compact digital camcorders, digital, or 35-mm cameras and accessories, the DS-3 Photo and Video Bag (\$24.95) is weather resistant and thickly padded to protect delicate equipment. Its adjustable interior offers a custom fit; and the front pocket holds spare batteries, digital memory cards, and more.



Case Logic, Inc., 6303 Dry Creek Parkway, Longmont, CO 80503; 800-925-8111; [www.case-logic.com](http://www.case-logic.com).

CIRCLE 59 ON FREE INFORMATION CARD

## 3-D Animation

Want to create scenic environments and realistic landscapes on your PC? The *Bryce 5 3D Landscaping and Animation Program* (\$299) lets you do just that, as well as Web animations, thumbnail images, organic shapes, virtual tours, and more. Powerful and easy to use, you can add natural-looking mountains, bodies of water, skies, fog, trees, and various terrain to your images with preset collections and image-editing tools. Images can be imported as 2D from a variety of formats, and then transformed into 3D and incorporated into your scenes. They can also be rendered on multiple computers simultaneously to save time.

Corel Corp., 1600 Carling Ave., Ottawa, Ontario, Canada, K1Z 8R7; 800-772-6735; [www.corel.com](http://www.corel.com).



## Vaio Desktop

Ready to dive into the world of customized DVD recording? Featuring DVD-RW drives that are ideal for video editing and data transfer to blank DVDs, the *Vaio Desktop PC Model PCV-RX780G* (\$2100) offers a



variety of configuration options with its novice-friendly *Simple DVD Maker* software. The included Giga Pocket personal video

recorder allows users to watch live TV on their PC while recording shows to the hard drive for later viewing. It also provides an easy way to capture video from analog camcorders for editing and DVD creation.

Sony Electronics, Inc., One Sony Place, San Antonio, TX 78245; 888-222-SONY; [www.sony.com](http://www.sony.com).

## P-Touch Label Printer

Perfect for creating address, file folder, CD jewel case, and other labels, the *PT-1500pc Label Printer* (\$129.95) includes a built-in photo frame that allows users to display their favorite pictures on their desks. It also features cyber-clipping software, a program that captures highlighted text from any Windows software application, automatically formats the data to fit the label, and then prints it out. The additional easy-to-use label design software imports graphics, bar codes, and works with database files, as well. The printer comes complete with software, printer cable, tape cassette, and AC power supply.



Brother International Corp., 100 Somerset Corporate Blvd., Bridgewater, NJ 08807-0911; 877-4PTOUCH or 908-704-1700; [www.brother.com](http://www.brother.com).

## Vacuum-Tube Motherboard

Back to the future—the return of the vacuum tube. Targeted to audiophiles and extreme gamers, the *AX4B 533 Tube Motherboard* (\$240) creates ultimate sound reproduction from a desktop

PC. The idea started out as a lark...combining the warmth and depth of vacuum-tube sound with a state-of-the-art motherboard. The tube output stage couples the two front digital stereo output channels with tube output, creating high-quality audio effects—making music come alive and the sound effects in games feel more immediate.

AOpen America, Inc., 1911 Lundy Ave., San Jose, CA 95131; 408-232-1251; [www.aopen.com](http://www.aopen.com).



## Hot Wheels

Want to relive your Hot Wheels days? The *Planet Hot Wheels* Web site allows players to race their car against others anywhere in the country. With the purchase of a Hot Wheels car (\$.99-3.99) or other Hot Wheels merchandise, buyers receive a special code to enter their car on to the virtual race track displayed on the Web. Players can continue to upgrade their cars by cashing in points earned by winning races or performing wild online stunts. This online race-track and multi-player gaming site will also fea-



ture a custom car show, four-player races, demolition derby, and more.

Mattel, Inc., 333 Continental Blvd., El Segundo, CA 90245; 310-252-2000; [www.planethotwheels.com](http://www.planethotwheels.com).



## Business Buzz

### BINOPLY?

Two giants of the Technology Domain—Microsoft and Verizon—have joined forces in order to launch a co-branded high-speed version of the MSN online service. The service is DSL-based and will officially launch in the spring of 2003, offering broadband content over filtered phone lines. This merger is only one of numerous mergers between Web services and phone companies. In early June, Yahoo! Inc. co-branded a service together with SBC Communications, Inc. All of these moves are setting up the inevitable, a foreseeable fusion of all communication devices in our homes, to include television, digital radio, phone service, and Internet access.

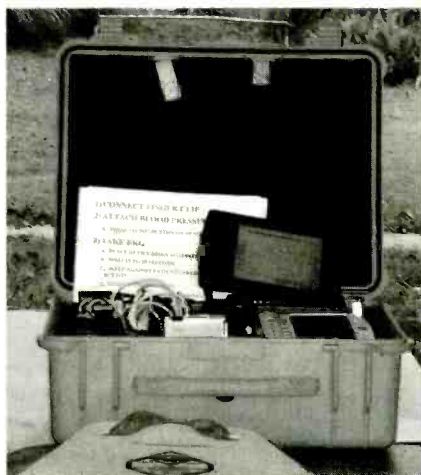
### SHARP'S ZAURUS SET FOR JAPAN

Japan's Sharp Corporation will offer its new Zaurus PDA to Japanese customers, in a direct assault to Sony Corporation, who has been slowly winning the battle of the PDAs in Asia. The new PDA from Sharp is only 4.45 inches by 2.73 inches in size, making it about the size of a business card holder. Open-source fans will rejoice at the choice of operating system for the new device. It is none other than Linux. Competitor, Sony, uses an OS developed by Palm, while other companies rely on the Windows Pocket PC platform. Plans are also being made to release Sharp's PDAs in China, where many Linux developers reside. No talk has been heard of a USA release.

### SMALLER AND FASTER

Chip champion, Intel, has introduced the latest and fastest lines of both Pentium and Celeron CPUs for PCs and laptops. Basing its venture on research that claims laptops will outsell desktops at a four-to-one ratio in the next four years, Intel has begun to flood the market with its latest wares. In addition to a 2-GHz chip, they also offer a Pentium 4 running at 1.90 GHz for mobile applications, as well as the Celeron brand chips, designed for lower-priced laptops. The Celerons will operate at 1.33, 1.40, and 1.50 Ghz.

## Technology Could Help First Responders



*The Medical Reachback System uses a secure wireless local area network to transmit vital patient information via the Internet from first responders to a command post. (Photo by Sheree Collins, GTRI.)*

In a chemical or biological attack, there are precious few minutes for emergency medical technicians to save someone's life. Researchers at the Center for Emergency Response Technology, Instruction and Policy (CERTIP) at the Georgia Tech Research Institute (GTRI) have developed technologies to help first responders during chemical and biological events when seconds count. Recently, several of these were demonstrated to President Bush and Homeland Security Director, Tom Ridge, during the Project Atlanta demonstration—a mock chlorine gas release. Here is a brief description of each system.

### BioSensors

Using sensor techniques originally developed for monitoring the environment and food safety, the CERTIP scientists designed a shoebox-sized integrated-optic sensor to detect the presence of chemical or biological

agents in seconds. The sensor consists of a laser light source, a planar waveguide, and a detector for monitoring light velocity changes produced by a chemical reaction occurring on the surface of the waveguide. The surface is treated to respond simultaneously to a number of specific biological and chemical agents. Changes are compared with a reference beam; then, signal-processing software interprets the results to identify the agents and their quantity. Currently, the sensor can detect chlorine gas and salmonella. With future enhancements, the sensor could detect airborne bacteria, viruses, anthrax and other dangerous substances.

### Wireless Life-LAN

First responders in the "hot zone"



*A first responder goes through an electronic checklist of symptoms using ChemBio Decision Aid software running on a PDA. (GTRI photo by Stanley Leary.)*

# TYPE



The Situation-Awareness Geographic Information System (GIS) tracks the location of people and biological or chemical agents. (CERTIP photo.)

could use the Medical Reachback System to transmit vital information about “victims” to a command post via the Internet, so emergency medical technicians on the scene could quickly get a doctor’s permission to administer antidotes. The physicians need information on victims’ symptoms and vital signs in real time to make decisions. Hospital emergency rooms doctors can view Web pages displaying victim’s symptoms and vital signs using an Internet browser without any special software. For security, data is transmitted over a private wireless local area network that requires both encryption and authentication. Only a number identifies patients, and there isn’t any specific information that would jeopardize a victim’s privacy. Security in the event of a cyber-terrorism attack is also being considered. The goal is to make the system affordable enough for smaller agencies and departments. Another goal is to reduce the size of the system to make it more portable than the two suitcases now needed for the equipment.

## Triage A la PDA

With the CERTIP-developed *ChemBio Decision Aid* software running on a personal digital assistant (PDA), initially a Windows CE-based Palm Top PC, EMTs can quickly determine the presence of specific chemical or biological agents from victims’ symptoms. *Decision Aid* asks a series of 14 questions (such as whether the patient is sweating, cough-

ing excessively, etc.) and prompts rescuers to gather and store basic information (such as whether the patient is conscious, male or female, adult or child, or perhaps pregnant). Later, rescuers can download this information at the command post or medical station. Eventually, the PDA would interface with the Reachback System to transmit the information via the Internet to the experts. *Decision Aid* software can also provide information on patient treatment and site decontamination. CERTIP plans to publish the software as a shareware program soon; it will be available for a nominal fee. The substance sensor will also be integrated with *Decision Aid* software.

In addition, the Situation-Awareness Geographic Information System tracks the location of people and biological or chemical agents. The system locates the airborne release plume, and then calculates its dispersion and shows evacuation routes. The information is used to create electronic maps that superimpose various types of information in layers over a common map. Using Reachback’s wireless communication link and *Decision Aid*’s Palm Top display, the system could transmit information like building blueprints and prediction of contaminant plume dispersion from command centers to Palm Tops carried by emergency responders

## Hand-Held RADAR

Developed originally by GTRI researchers to help police officers find suspect hiding in buildings, the RADAR Flashlight could also help first responders find unconscious victims of a chemical attack. The RADAR Flashlight can detect a human’s presence through doors and walls up to eight-inches thick. The device uses a narrow 16-degree radar beam and specialized signal processor to discern respiration and/or movement up to nine feet behind a wall. The device can penetrate even heavy clothing to detect respiration and movements of as little as a few millimeters.

## Research Notes

### COSMIC LATTE

Astronomers at John Hopkins University have determined the color of the cosmos as being similar to coffee—café latte to be precise. The official color is “Cosmic Latte” as announced by astronomers Karl Glazebrook and Ivan Baldry. Ironically, latte is similar to “latteo,” which means Milky Way in Galileo’s native Italian. The color was determined after light from numerous distant galaxies was collected, split by electronic means (similar to a prism), and then averaged. Readers can visit [www.pha.jhu.edu/~kqb/cosspec](http://www.pha.jhu.edu/~kqb/cosspec) for more information.

### DISGRUNTLED ROBOT ESCAPES

Gaak, one of twelve robots taking part in a “survival of the fittest” test at Magna Science Centre in Rotherham, South Yorkshire in the UK, was found in the company parking lot. Apparently the machine, which has been programmed to gradually learn, had left the building while a lab assistant’s back was turned. Gaak managed to force its way out of a makeshift paddock, out the front door, and down an access slope towards the compound’s perimeter. Luckily a visitor narrowly missed running the renegade robot over with his car. Professor Noel Sharkey of the Centre calmly stated, “...no need to worry, as although they can escape they are perfectly harmless and won’t be taking over just yet.”

### ROBOCUP 2002

RoboCup—a World Cup for robots and engineers—introduced its first hominid players in six years. This year marked the participation of quasi androids. The rules include yellow cards for aggressive behavior, but offside rules and hooligans are not a factor. Each droid is programmed to think for itself (there is no remote control), as well as react to the environment of an indoor soccer field. Using cameras to scan the goal, each robot attempts to calculate the perfect banana kick required for scoring. Kazuo Yoshida, a professor of System Design at Keio University, says these games will help develop robots capable of rational thought and a grasp at sense of purpose.



The RADAR Flashlight could help first responders find unconscious victims of a chemical attack. (GTRI photo by Sheree Collins.)

## A Bit About...

Georgia Tech research scientist, Tom Bevan, who saw the need for new technology to assist those who would respond first to a terrorist attack or major disaster, created the CERTIP three years ago. Bevan said a series of letter bomb and anthrax hoaxes in Atlanta several years ago got him thinking about the problem. The CERTIP is funded through a partnership with the Marine Corps Warfighting Laboratory and Marine Corps Systems Command.

—by Bill Siuru PT

## IsoPod Shows Promise

The IsoPod, a tiny 1.2- × 3-inch controller board, started shipping in June from New Micros, Inc, which has been designing and manufacturing chips, single-board computers, peripherals, and custom electronics for over 20 years. Made as small as possible, while still maintaining large enough connectors for easy human access, all connectors on the IsoPod have .1-inch spacing. About three fifths of the board is covered with connectors. The controller comes complete with a built in high-level-language and parallel-processing operating system, *IsoMax*.

The board features sixteen General Purpose Digital I/O lines, two serial channels, RS-232 and RS-422/485 connectors, a CAN BUS, an SPI Interface, eight channels of 12-bit A/D, eight General Purpose Timers, twelve Pulse Width Modulation (PWM) outputs which can be used individually to control R/C Servos control or grouped to

## ► NanoMuscles Hit Mainstream

NanoMuscle, Inc., a manufacturer of devices that displace small electromagnetic motors and solenoids, now offers developer's kits for their breakthrough miniature motion actuators. These kits are available for hobbyists, inventors and the robotics community through their partner, Mondo-tronics at a cost of \$179, see [www.RobotStore.com](http://www.RobotStore.com).

Unlike conventional electric motors that use electromagnetism for movement, NanoMuscle Actuators produce movement using a form of shape memory alloy (SMA), similar to those discovered in the 1960s by the US Navy. SMA can be fashioned into tiny wires (often called *muscle wires*) that produce movement whenever an electric current is passed through them. Several of these wires are packaged in a device about the size of a paper clip that can then perform the function of a motor or solenoid.

In addition to providing access to miniature motion, NanoMuscles deliver a number of other benefits to inventors and hobbyists including completely silent operation. They consume one-fifth the energy of a motor of comparable size making them ideal for mobile robotic applications that need to carry their own power source

Each developer's kit includes the following: a working example application, two model NM70 NanoMuscle actuators with digital interfaces, technical documentation, and a mounting/electrical hardware assortment making it possible for hobbyists to immediately start incorporating miniature motion within their prototypes.

PT

control up to two three-phase Brushless DC motors and a two-channel Quadrature Decoder to read motor position encoders.

*IsoMax* is the proprietary programming language that comes with the kit, and it is based on state machine programming concepts. Each real-time task is assigned a virtual machine that will sense conditions, take actions, and move to new states. Users will find that the language for creating machines is very "English" readable, more so than some of the standard languages. Data entry is accomplished through the RS-232 via a PC, laptop, PDA, or any serial device (even dynamically by another micro-processor). Simply put, programming in *IsoMax* occurs through interactively creating new processor tasks, assigning each a state machine, and testing that machine.

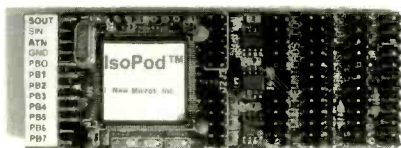
One of the most exciting features of the IsoPod is its *Virtually Parallel Machine Architecture* (VPMA), a new programming paradigm possible with

*IsoMax*. VPMA allows more than one of the state machines to be installed into background process. The installed machines run independently in a virtually parallel fashion. Tasks are handled on the same level, each running like a separate machine. Imagine running 20 stamp-like microcomputers, each with a single task, in parallel, and this is what VPMA would be like.

A useful single-state machine can be written with as little as three lines of code. When the programmers are satisfied with the performance of a new machine, they would install it into a chain of machines. The machines installed in the machine chain become background features of the IsoPod until removed or replaced.

Machines don't come and go, like tasks in a multitasking system. The *IsoMax* language is inherently "multitasking" without the overhead, complexity, and headaches of a multitasking operating system. The interactive foreground remains always available for both further interactive development and interactive checking on the running machines.

The combination of *IsoMax* software, VPMA structure, and diverse hardware makes IsoPod ideal for dedicated control of DC motors, BDCM, stepper motors, solenoids, and motion-control applications, in general. It also works



Made as small as possible, while still maintaining large enough connectors for easy human access, all connectors on the IsoPod, have .1-inch spacing.

well for data collection and many networked control applications. Not to mention that the CAN BUS opens the possibility of distributed processing networks, so parallel hardware can be combined with parallel software.

Developers expect the IsoPod to meet the needs of robots very well, with its many R/C servo outputs. In particular, promise is seen for robot walkers. Each joint can be treated as a separate task. Software would communicate between tasks to create higher-level architectural functions such as leg behavior. This is just one example of how VPMA lets many tasks work together. The VPMA structure may allow advances in Neural Net Processing simulation, and AI applications as well. Robots using this new paradigm may appear more "thinking" than their predecessors.

The IsoPod brings an amazing amount of computing and control function to a very small space at a very reasonable cost. A single unit is \$99. For more information, visit [www.newmicros.com](http://www.newmicros.com) or write to New Micros, Inc. 1601 Chalk Hill Road, Dallas, TX 75212. You might want to check out the user's manual at [www.newmicros.com/store/product\\_manu\\_al/isopod.zip](http://www.newmicros.com/store/product_manu_al/isopod.zip). **PT**



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# Books that Bridge Theory & Practice

Many electronics enthusiasts discovered that the bridge from classroom theory books to hands-on project building is difficult to span at times without a handy pocket guide. Even the equipment manual to operate a gadget often makes things murkier rather than clearer. A compact text authored by a seasoned expert with hands-on knowledge and a knack of writing in an easy-to-understand style is many times more valuable than the price of ponderous theory and equipment manuals or the parts for a project that could be damaged. Here's a sampler of some titles you may want to own!

**ELECTRONIC HOBBYIST DATA BOOK**—The info you need to transport you from the schematic diagram to project parts. Pin-outs, color codes, truth tables, parts parameters, etc. **Order BP396- \$10.99 Includes S & H**

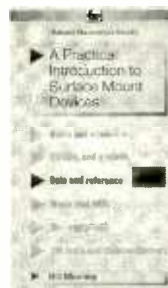
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## PC vs. MAC: THE WAR GOES ON

For those of you who may not be aware of it, the PC vs. Mac war rages on. It's amazing how adamant each platform can be about their system's supremacy. PC users will declare with confidence that Windows is ultimate and that their processor is faster. Mac users swear by the graphics capability and the friendly nature of its functions.

The truth of the matter is that neither one is a "better" computer. It is personal preference that should sway your opinion either way. I will introduce some of the myths and popular misconceptions about each, as well as some truths about their basic differences. Knowing some basic facts about the rivals, you will have the privilege of choosing the one that suits your needs.

### THE DAWNING OF THE COMPUTER AGE

Apple Computer Inc. and International Business Machines Corp. (IBM), as the innovators of personal computers, set the standards for today's market. The Apple I was introduced in 1976, eight years before the Macintosh. The Apple II, which followed in 1977, was the first personal computer capable of generating color graphics. It was available to the public for \$1298, and users had to use their TV sets as monitors and audio cassette recorders as storage devices.

#### SOURCE INFORMATION

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

[www.deil.uiuc.edu](http://www.deil.uiuc.edu)

[www.teach-nology.com](http://www.teach-nology.com)



*The Apple iMac's Desktop 800-MHz PowerPC G4, a popular Mac, is now on the market.*

In 1984 the Macintosh 128K entered the market at a price of \$2495, followed by the Macintosh 512K, which sold for \$3195. That was the beginning of the Mac era.

Designed with ease of use in mind, the Mac utilized the mouse—a handheld pointing device—and the graphical user interface (GUI). This interface contained icons—pictorial representations of complicated commands. Because of the user-friendly characteristics, the Mac became popular with household users.

IBM, a leader in office equipment, decided to hop into the mainstream market around the same time. In 1981 they introduced a small computer called the IBM Personal Computer, otherwise known as the PC (this came to mean any computer that was comparable to the IBM personal computer). Although the Macintosh is truly a personal computer, it is not referred to as a PC.

Though they look very similar, Macs and PCs have some notable differences. See the accompanying table for a comparison.

### THE CHOICE IS YOURS

As you can see from the table, it isn't that one computer is inferior or superior. You have to decide what exactly it is that you will be using your computer for, and then make a decision based on each computer's features and abilities.

It's like choosing between a Mercedes and a BMW. They are both classy cars; they handle the road well; and they offer high-quality performance and top-notch extras. Maybe the contour of one driver's seat fits your bottom better. Maybe one comes in pretty custom colors. Maybe one cup holder fits your mug more snugly. Who knows?

The point is that both computers have kept up with technology and offer powerful processors. Both have advanced graphic capabilities, access and surf the Web at similar speeds, and perform well while running appli-



*The Systemax Celeron Desktop is a competitively priced PC, with 1.0 GHz and 128 MB RAM.*



TABLE 1

FEATURE	PC	MAC
Software	There is much more software, including free software, available for the PC.	There is much less software available for the Mac.
Add-Ons	It is more difficult to add on devices and components.	Considered "plug and play." Pretty simple to add on components.
Choice	There are hundreds of brands of PCs available—more of a selection for the consumer, and a more competitive market.	There is only one company that makes the Mac—Apple Macintosh.
Price	PCs are relatively inexpensive.	Macs are still slightly higher priced.
Operating System	More complicated operating system.	Less complicated operating system.
Mouse	Dual-button mouse, which allows for shortcuts.	One button mouse—no shortcuts.
Training	Since system is more complex, it requires more training time.	Less complicated system calls for less training.
Viruses	Most viruses are targeted for the PC.	Hardly any viruses are targeted for the Mac.
Networking	Networking is more difficult and complex, and requires more maintenance.	Networking is less difficult. It is more stable and requires less maintenance.
New Products	Tendency to have more bugs on newly released products.	Pretty well tested before sold on the mass market.
Operating Software	Most systems running on Windows OS have parts made by 30 or 40 different manufacturers.	Mac Operating Software is specifically for the hardware it is running on.
Compatibility	PCs are the business industry standard.	Not the business industry standard. If you're not PC compatible, you may not be able to keep up in the business world.
Disk release	PCs allow you to release the disk while in use.	Cannot eject the disk while in use.
Parts and Service	Parts are widely available for the PC and relatively inexpensive, and there are plenty of knowledgeable techs out there to service your PC.	Parts can be hard to find as well as costly, and knowledgeable techs are scarce.
Tech Support	Tech support is abundant and readily available.	It is relatively hard to find tech support for the Mac, especially on short notice.

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education programs.

If you are in the market for a new computer, shop around, and really think about your needs and wants. Just because you have been a die-hard PC user all of your life doesn't mean you can't make the switch, and vice versa. Many a consumer has jumped to the other camp after careful consideration of the matter—only most have a hard time admitting it.

Talk to users of both, and see why they prefer one or the other. They may offer some guidance or shed some light on common misconceptions. I have personally used both, so I can be objective as well as diplomatic—I like both for different reasons.

For additional information on the PC vs. Mac debate, see the Source list in this article.

## You Ought To Be In Pictures

The hottest peripheral of the moment is probably the one that spends the least amount of time connected to the PC. If you haven't already guessed, I'm talking about the peripherals used for digital photography. While there are enough products in this category to easily write a monthly column on this subject alone, this month we'll take a look at a trio of brand new offerings. In fact, one of the products is so new that as of the time of this writing, it won't even be announced for another month.

### HANDY, BUT SIMPLE

One big problem with photography, both film and digital, is that most people simply don't carry a camera around with them unless they are consciously thinking of taking a snapshot or two. It's pretty much a certainty that everyone who is reading this column has, at least once, wished that they were carrying a camera.

That's the market Logitech is addressing with its newest Pocket Digital camera. There's nothing fancy about the Pocket Digital. It doesn't have a flash, and the lens is fixed focus, not autofocus. Maximum image resolution is 1.3 megapixels, or 1280 × 960. That's okay for snapshots, but you won't want to blow these up much past 4 × 6 inches. This resolution is interpolated, as the actual CMOS imaging sensor has only VGA, or 640 × 480 resolution.

So far, the Pocket Digital doesn't sound very exciting. What makes it so, however, is the form factor. The Pocket Digital is about the same size as a credit card, and about a quarter-inch thick. Its case is brushed aluminum, and you get it ready to take a picture by just sliding the left and right sides of the case apart, exposing the lens and



*The Pocket Digital camera is available only for Windows-based PCs at the moment and comes with a copy of MGI PhotoSuite 4 SE.*

the optical viewfinder. The shutter release button is on the top of the camera, easy to get to and use. The camera is small enough to always carry, and ready whenever you need to take a picture.

A lithium polymer rechargeable battery provides power for the camera, and the battery automatically recharges every time you use the included USB cable to download images into your PC. If the small, low-battery indicator shows that the battery is low, you can, of course, recharge the unit without having to download images.

The Pocket Digital camera is available only for Windows-based PCs at the moment and comes with a copy of *MGI PhotoSuite 4 SE*. At a suggested price of \$129, it's a great deal; and it's so small you'll never have to miss a great "photo op" again.

### A GREAT TEAM

A terrific partner for the Pocket Digital camera is the new Hewlett-Packard PhotoSmart 130 printer. Looking at the photo, you'll notice that it's resting on the output tray of an HP PhotoSmart 1315. Maybe Mike Myers will buy one for "Mini-Me" in the next Austin Powers movie.

The PhotoSmart 130 has one for-

mat—4 × 6 inches. It's a four-color printer that uses a single ink cartridge containing all four colors. That's a first for HP in a photo printer, though all of the previous and current PhotoSmart photo printers use only a four-color process, rather than the five colors or six colors of ink that many of the vendor's competitors use. Resolution is up to an incredible 4800 × 1200 dpi on glossy photo paper.

The PhotoSmart 130 shares one feature with other less diminutive PhotoSmart printers—integrated flash media readers. The slots at the top of the paper-feed opening accommodate SmartMedia, CompactFlash, Sony's MemoryStick, Secure Digital, and Multimedia cards. These make it easy to make prints directly from the media card, without first having to download the files to your PC.

The PhotoSmart 130 requires a USB interface and comes with drivers for both Windows and Macintosh PCs. The suggested list price will probably be around \$180, though you should be able to find the printer for less than that in the stores.

We've printed a couple of dozen prints from our PhotoSmart 130 and, most of them, depending upon the camera that was used to take the shot, are indistinguishable from standard film-based prints.

### SAVING THE BEST FOR LAST

The products mentioned so far are all pretty affordable. That's fine for day-to-day use. The digital imaging market, however, is segmented. There are the amateur products detailed here, more expensive serious amateur products (sometimes called "prosumer," a contraction of professional and consumer), and those very high-end prod-



The PhotoSmart 130 requires a USB interface and comes with drivers for both Windows and Macintosh PCs. The suggested list price should be around \$180.

ucts designed (and priced) for professional photographers.

We've had the distinct pleasure of using a prosumer camera from Olympus America, the E-20N. The list price of this camera is just a few dollars under \$2000, more than many readers have probably paid for their PCs. To be truthful, as much as we loved the E-20N, there's no way we would ever be able to justify buying one, even at the somewhat reduced price it sells for on the street.

If, however, you do photography for a living or even an income-producing side-line, the E-20N is very much worth a hard look.

The camera takes the popular SLR, or Single Lens Reflex, form factor. If you are not up on camera jargon, the E-20N is probably not going to be at the top of your want list, but an SLR camera, digital or film-based, focuses, performs, and sets exposure and shutter speed metering through the single lens at the front of the camera. Most cameras today, other than some of the more esoteric models used by professionals, are SLRs. The E-20N has a huge Olympus 4x optical zoom lens, and as with many more advanced camera models, the lens is removable so that you can use an optional lens. Easy-to-use controls are abundant for those times when you want to operate the camera in manual mode. There are seven user-selectable pre-set white balances, and they range from 300CK to 7500K.

Our E-20N review unit offered both an optical viewfinder and a color LCD panel that can also be used to frame the shot. The optical viewfinder carries the usual diopter adjustment a step further, with a focus ring that lets you quickly get a crisp image in the viewfinder. In fact, even the edges of the viewfinder are padded.

Even forgetting that the E-20N is a digital camera (at least for the moment), it's an impressive piece of equipment. As a camera, it gives you a choice of shooting in completely automatic mode using the E-20N's dual active autofocus (which uses both active Infrared and passive TTL, Through The Lens, focusing) or focus-

#### SOURCE INFORMATION

##### Hewlett-Packard Corporation

3000 Hanover St.  
Palo Alto, CA 94304  
800-552-8500  
[www.hp.com](http://www.hp.com)

##### Logitech Inc.

6505 Kaiser Drive  
Fremont, CA 94555  
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##### Olympus America

2 Corporate Center Dr.  
Melville, NY 11747-3157  
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ing the camera strictly manually. Modes include programmed Auto-Exposure (called AE) or aperture or shutter priority. Metering, as with all higher-end cameras, is TTL; and you can use center or spot metering, or one of the available metering patterns.

The digital side of the camera is just as impressive. When operating in standard interlaced mode, the camera yields an effective resolution of 5.0 megapixels. You can also operate the camera in progressive-scan mode, which drops the resolution down to 2.5 megapixels. Depending upon the file format you chose to save your images in, this can yield an image resolution of up to 2560 × 1920 in RAW or TIFF uncompressed format. Other file formats allow saving in JPEG with various degrees of compression.

Our review camera came with a set of lithium batteries and a 32-MB SmartMedia card. Pop open the media-card cavity, and you'll see slots for both SmartMedia and CompactFlash cards. You can have one of each in the E-20N. You can also use an IBM MicroDrive, which is a 320-MN or 1-GB tiny hard disk in the format of a CompactFlash card. To use this in the E-20N, however, requires a different and higher-capacity battery pack.

We could actually write several complete columns on the E-20N, it's that good a product. And now you know what you can get us for the upcoming holiday. **P**

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## Computer Excess

Joe, a computer programmer, was talking with his psychotherapist. "You've got to help me," he says. "I've fallen in love with my computer, but I know I can never marry her."

"Well, it's good you haven't totally lost touch with reality," says the therapist. "Oh, it could never work," says Joe. "She wants a career."

It's easy to make fun of computer nerds, as did this joke from *The Official Computer Freaks Joke Book*. Just as anything can be taken to an extreme, fascination with computers can be harmful. It's not difficult to see why computers can fascinate.

### THE POSITIVE SIDE

They allow you to communicate with far more people than a phone or letter. They help you write far more efficiently than a typewriter or pen and paper. They make it possible to keep track of people and things far more easily than a roster or list. They let you budget, forecast, and plan far more effectively than a calculator or table. And they make education far more compelling than words and pictures on paper.

Computers are indeed powerful, and their power can let people compensate for their own perceived lack of power. In today's world of huge corporate, educational, and government bureaucracies, it's easy for individuals to feel lost, like a tiny cog in a giant impersonal wheel that spins with no interest or concern about their welfare.

PCs also epitomize newness in a culture that places great importance in it. The PC market is able to rejuvenate itself with every new central processing unit and operating system that's released, creating well-deserved excitement as well as hype each time.

There has in fact been much progress. A run-of-the-mill personal computer today is ten times faster than



Site Mani

Even geeks must remain savvy. Visitors to Geek Culture's Web site can catch up on the latest fashions, trends, and peculiarities associated with the geek set.

it was five years ago. Despite this increase in raw power, PC hardware and most software have fallen in price in absolute terms as well as in dollars adjusted for inflation.

Finally, a personal computer never judges or rejects you (short of a glitch or crash), and it's always there for you. If you know what you're doing, it does what you want, which can't always be said about human relationships. In some ways, a computer mimics the human mind and can become an extension of yourself. It's no wonder people love these machines.

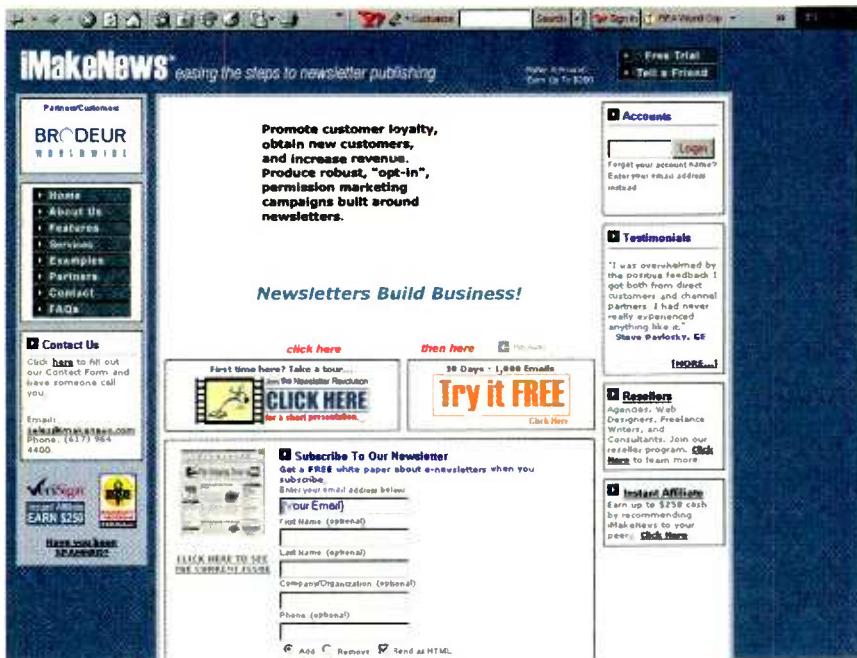
### COMPUTER ADDICTION

However, some people love them too much, says Richard Johnson, Ph.D., a psychologist from Fort Washington, PA, who works with people experiencing "computer addiction." Computers can be harmful if they isolate people

from other spheres of life and from other people, he says. If you forego important social, occupational, educational, or recreational activities in favor of time in front of your computer screen, you've taken things too far.

Men are more prone to this than women, says Johnson, but women can experience it, too. Excessive involvement with PCs, like any activity taken to an extreme, can be an attempt to fill a void caused by loneliness or to block out insecurity, shyness, or other shortcomings in a person's life. People can use a PC in a dysfunctional way to deal with guilt or shame or to avoid having to tackle difficult decisions or responsibilities. Because their lives aren't perfect, some people obsessively tweak and otherwise try to make their computers perfect.

On the flip side, while computers can isolate, they can also connect.



Newsletters have always been a useful tool for charities, business, and even families. The iMakeNews site will lead you step-by-step as you develop a newsletter of your own.

Many people have developed online friendships and romances that have blossomed into offline relationships. People use the Internet to find and reconnect to old friends and classmates. E-mail and instant messaging can be an easy, low-cost way for family and friends to stay in touch with one another over even great distances.

### FINDING A BALANCE

As with just about everything, much depends on striking a healthy balance. As long as you keep things in perspective, there's nothing wrong with being a nerd, a word coined by Dr. Seuss in his 1950 book *If I Ran the Zoo*. Or, for that matter, a geek, dweeb, wonk, or freak.

As Craig Jackson, a Web professional from Santa Cruz, CA, points out on his Geek Web page (<http://samsara.circus.com/~omni/geek.html>), a computer geek can be a person who simply enjoys being social with his (or her) computer.

If you're a computer nerd, why not revel in it? At the Web site Geek Culture (<http://www.geekculture.com>), you can discuss your geekhood with other geeks, send geeky e-cards, and even buy a sleek black propeller beanie.

If you're really into beanies, the site Broadway Costumes (<http://www.broadwaycostumes.com/sales/hats-novelty.htm>) sells an even nerdier-looking multicolored propeller beanie for less than half the price.

### MASS COMMUNICATION

E-mail is a hugely successful phenomenon, letting ordinary people communicate with far more people using far less effort than any previous communications medium. But this facility has its dark side—the incessant bombardment of e-mail in-boxes with ads for illegal “Make Money Fast” pyramid schemes, pornographic Web sites, quack healthcare remedies, and other come-ons.

As a result, some people misguidedly regard all bulk e-mail as “spam,” a derogatory term for untargeted, unsolicited bulk e-mail. But if you flip the spam concept on its head, you have a powerful tool you can use to reach a lot of people quickly and inexpensively, for business as well as personal purposes. To make it work, you keep the bulk part—sending many messages out. But instead of flinging out untargeted missives, you target your messages to the interests of your recipients. And instead of heaving them unsolicited—this is the crucial part—you ask your recipients' permission before encroaching upon their e-mail in-boxes. You make sure they “opt in.”

One of the best uses for opt-in bulk e-mail is e-mail newsletters. As with bulk e-mail in general, there are pitfalls here as well as promises. To sort out one from the other, I talked to the queen of e-newsletters, Debbie Weil. Along with running her own Washington,

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<http://samsara.circus.com/~omni/geek.html>

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D.C., consulting business that specializes in helping businesses set up e-newsletters, Weil publishes her own, *WordBiz Report*, at <http://www.wordbiz.com>.

“The biggest mistake business people make with e-newsletters is thinking like a promoter, not a publisher,” says Weil. “Hypey, direct-response writing doesn't work with e-mail newsletters,” she says. “It's a turn off.” Even if your objective is marketing, you need to provide information that's useful to your recipients, not to yourself. Put yourself in the shoes of typical recipients. Provide them with substantive, accurate, and comprehensive information that meets their needs and present it in a lively fashion.

“If you blast out gaudy graphics and promotional copy that shouts, ‘Check out the widget we have for sale this month!’ the response you'll receive is, ‘So what!’” says Weil. “People are tired of e-mail promotions jamming e-mail in-boxes.”

Whether you send your e-newsletter to customers or prospects, if you do it right by being truly useful, it will be time-consuming. That's why Weil doesn't recommend doing it more than once a month. She also recommends keeping e-newsletter issues short, no longer than 1000 words. With e-mail, people expect to get in and out quickly.

### E-MAIL CREATION

It's easier than ever to create e-mail messages using HTML, the language of the Web. Here Weil and I differ a bit. She recommends HTML as being easier to read. Whenever I see an HTML-

coded e-mail message, I think come on. But if recipients have opted in to receive an HTML newsletter, I can see how they would be receptive to it.

Concerning mechanics, Weil recommends two Web-based application service providers (ASPs) that specialize in helping people create e-newsletters and manage subscription lists for them. Constant Contact, at <http://www.constantcontact.com>, is the less expensive. It's free for up to 50 recipients, \$10 per month for up to 250 recipients, and \$25 per month for up to 2500 recipients, with prices continuing to rise incrementally from there.

IMakeNews, at <http://www.imake-news.com>, starts at \$200 per month, but has beefier content management features, including a companion Web site for your e-newsletter. Both services offer free trial periods. A simple alternative appropriate for low-volume personal or family e-newsletters is using your regular e-mail software.

Don't just paste a long block of e-mail addresses into the "To" (sometimes referred to as "Mail To") or "Cc" (carbon copy) address lines. This results in an e-mail message with a large header that not only looks ugly but can force recipients to scroll down repeatedly to get to your message.

Instead, if your e-mail program supports it, use the blind carbon copy line (typically identified as "Bcc" or "Blind Cc"). By sending an e-mail message to yourself and pasting recipients' e-mail addresses here, you can hide these addresses from the other recipients.

To build a subscriber base for a business e-newsletter, your best bet is to include an opt-in box at relevant pages of your Web site, including your check-out page if you have one. Don't assume that if someone visits your Web site or even purchases from you that they want to receive your e-newsletter. "As with spam, people regard that as an invasion of privacy, and they'll respond with anger," says Weil. P

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# Six-Volt Strobe Light

PAUL FLORIAN

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

## ***BUILD THIS PALM-SIZED STROBE THAT PACKS A HIGH-VOLTAGE PUNCH***

**A** strobe light is a useful gadget, both for recreational uses and for emergency situations. It's even better if the device is portable. This article details a *Six-Volt Strobe Light* that works great as an emergency flasher, and it's light enough to fly on board a model aircraft. The flash rate is variable from 1 to 3 flashes per second, though the rate slows down over time as the battery voltage decreases. Uses for this strobe light are many. It can be worn on a belt clip when jogging or riding a bike at night, used on a boat, on the highway if your car breaks down, and so on.

### **Circuit Description.**

Figure 1 shows the schematic for the flasher circuit. In this application, a switching power supply eliminates the need for a specially wound transformer to generate the required 300 volts for the flash tube, FT1. A 555 timer, U1, oscillates at about 14 kHz and drives the gate of a 400-volt MOSFET (Q1). When pin 3 of U1 goes high, Q1 turns on and current

flows through inductor L1, generating a strong magnetic field around the coil.

When U1 pin 3 goes low, current stops flowing through Q1 and the inductor. That sequence collapses the magnetic field and causes a high-voltage spike

that charges capacitor C2 through diode D1. At the same time, capacitor C3 charges through resistor R4. When the voltage on C3 reaches 300 volts, Sidactor SD1 conducts and dumps a charge on C3 into the trigger transformer T1. Transformer T1 then produces a 3- to 4-kilovolt pulse at its output, which ionizes the xenon gas in the flash tube causing it to become conductive. Capacitor C2 then discharges into the flash tube, resulting in a short, bright flash of light. Capacitor C2 then begins to charge again,

beginning the flash cycle over again. The charge rate, and hence the flash rate, are proportional to the duty cycle of U1 and the battery voltage. The duty cycle is varied by potentiometer R1.



**Construction.** The use of a PC board is highly recommended for this project because of the high voltages involved. Figure 2 shows the foil pattern for a PC board you can make yourself, and Fig. 3 is the parts-placement diagram. Be careful of the polarity when installing D1, D2, Q1, C2, and the socket for U1. Remember to cut the tab off SD1

before mounting. Make sure that transformer T1's fine wires do not short with its ground wire. The flash tube is installed last. Its pins are soldered to the 1/4-inch bare-wire loops 1 and 2 of transformer T1.

Figure 4 shows a diagram of the side view of the final assembly. The circuit board should be insulated with a sheet of lexan, cardboard,

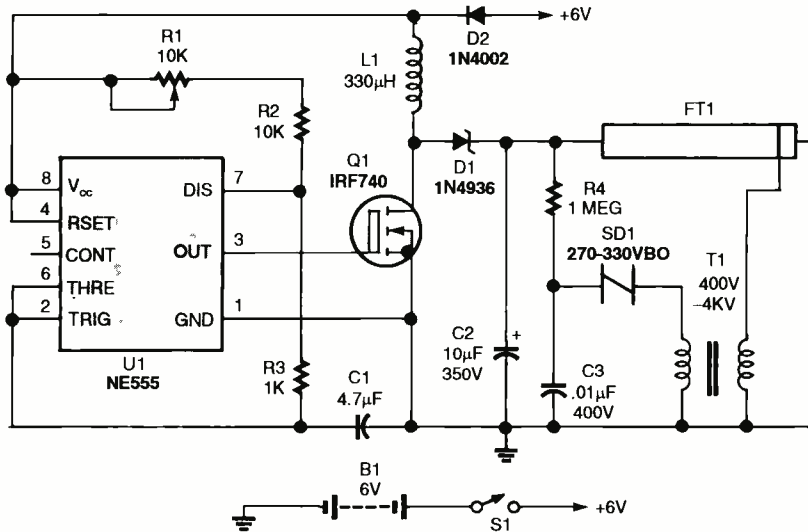


Fig. 1. This six-volt strobe light circuit uses a switching power supply instead of a specially wound transformer to generate 300 volts.

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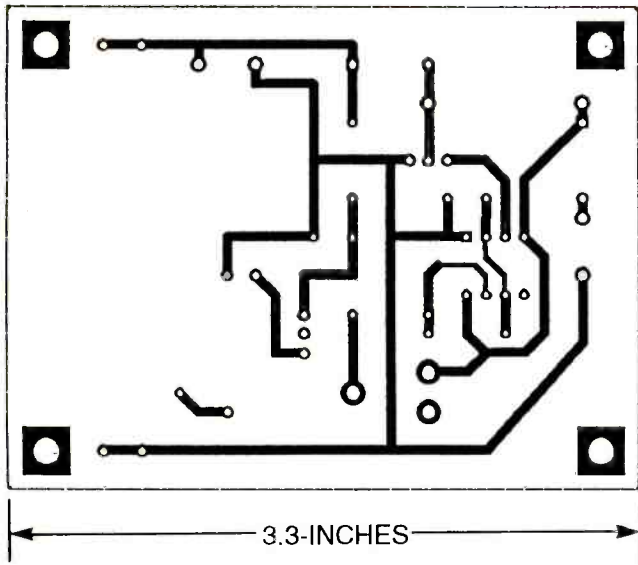


Fig. 2. Foil pattern for the strobe light PC board. A PC board is recommended because of the high voltages involved.

## PARTS LIST FOR THE SIX-VOLT STROBE LIGHT

### SEMICONDUCTORS

- U1—NE555 timer
- D1—1N4936 diode (Mouser Part Number 625-1N4936GP)
- D2—1N4002 diode
- SD1—270V to 330V Sidactor (Digi-Key Part Number K3000F1-ND)
- Q1—IRF740 transistor (Mouser Part Number 511-IRF740)

### RESISTORS

- (All resistors are 1/4-watt, 5% units unless otherwise noted.)
- R1—10,000-ohm potentiometer (Mouser Part Number 323-409H-10K)
  - R2—10,000-ohm
  - R3—1000-ohm
  - R4—1-megohm

### CAPACITORS

- C1—4.7-nF, ceramic
- C2—10- $\mu$ F, 350V, electrolytic (Mouser Part Number 140-XRL350V10)
- C3—0.01- $\mu$ F, 400V (Mouser Part Number 140-PF2G103K)

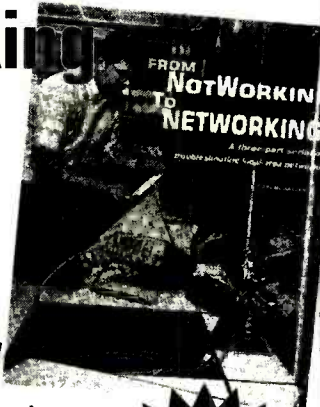
### ADDITIONAL PARTS AND MATERIALS

- L1—330- $\mu$ H (Mouser Part Number 542-5800-331)
- T1—400V to 4kV transformer (Mouser Part Number 422-1304)
- FT1—300V flash tube (Mouser Part Number 36FT050)
- S1—SPST switch
- B1—4 AA batteries (or equivalent)
- 4 AA battery holder, double-sided tape, 0.030-inch lexan, 0.060 ABS, 8-pin IC socket, cardboard, wire, solder, spacers, screws

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and ABS plastic as shown. Figure 5 shows a template for the lexan cover plate, and it can be used to size the cardboard and ABS as well. The 1/4-inch hole is for potentiometer R1 and the 3/8-inch hole is for switch S1. Be sure to drill a 1/8-inch hole at each corner for the spacers that will hold the assembly together.

Switch S1 should be small enough so that it does not interfere with the PC board once it's attached to the lexan cover plate. You might also have to bend Q1 down slightly to

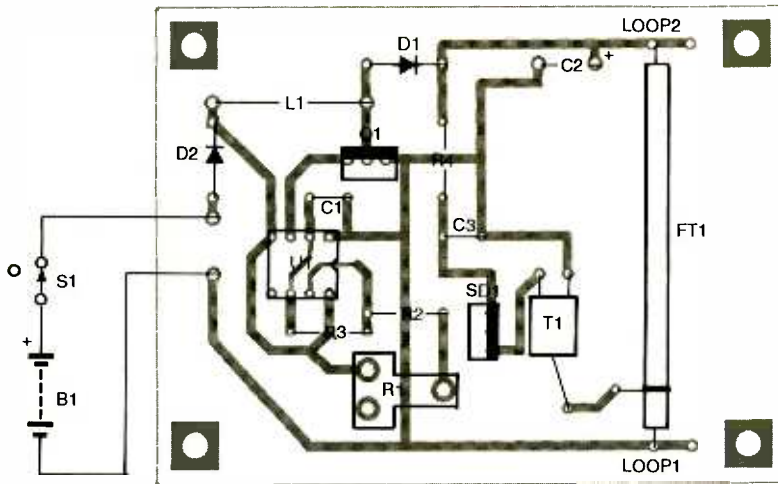


Fig. 3. Parts-placement diagram. Be careful of the polarity when installing D1, D2, Q1, C2, and the socket for U1. Remember to cut the tab off SD1 before mounting.

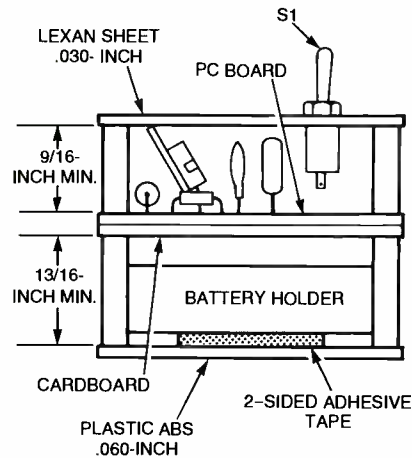


Fig. 4. Side view of the final assembly. The circuit board should be insulated with a sheet of lexan, cardboard, and ABS plastic as shown.

clear the cover. Switch S1 is connected in series with the positive 6-volt battery terminal, and the negative battery terminal is soldered directly to the circuit board at ground. The battery holder can be attached to the ABS back panel using a piece of double-sided tape.

When the circuit board is complete, install batteries in the holder and check for 6 volts at pins 4 and 8 of U1 before putting U1 in its

socket. To help prevent shock, place some electrical tape across the leads of C2 and insulate the pins of the strobe light with hot-

melt glue. Now install U1 in its socket and with the board placed on a non-conductive surface, turn on S1. With R1 turned fully clockwise, the flash rate should be about 3 Hz. Once you're sure everything is working properly, assemble the parts as shown in Fig. 4.

**Variations.** In cases where you would like the flasher to be a color other than white, you can place a piece of colored translucent tape over the lexan cover plate. Such tape is often used for the temporary repair of brake and turn signal lenses. If you would like to power the circuit from a 12-volt cigarette lighter socket, simply add a 6-volt regulator, such as an LM317 or LM7806 to the power supply. **P**

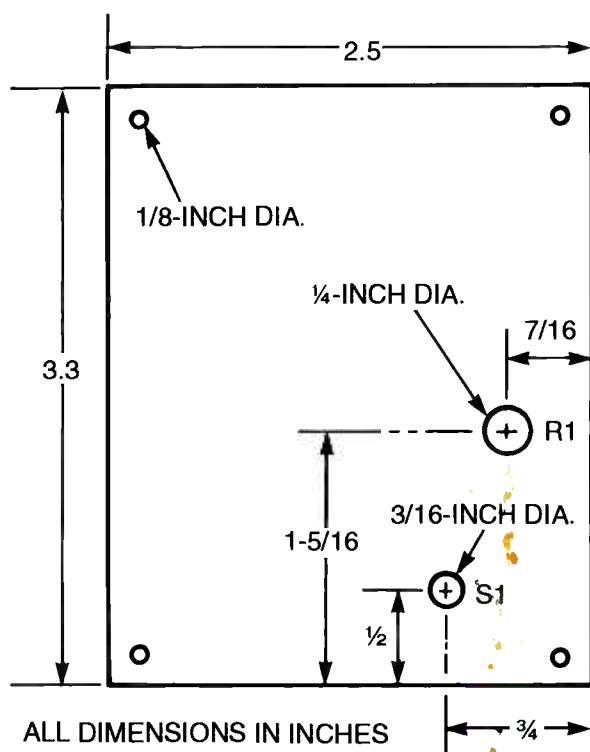


Fig. 5. Template for the lexan cover plate. Use this to size the cardboard and ABS pieces as well.

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# Ultrasonic Listening Device

MARC SPIWAK

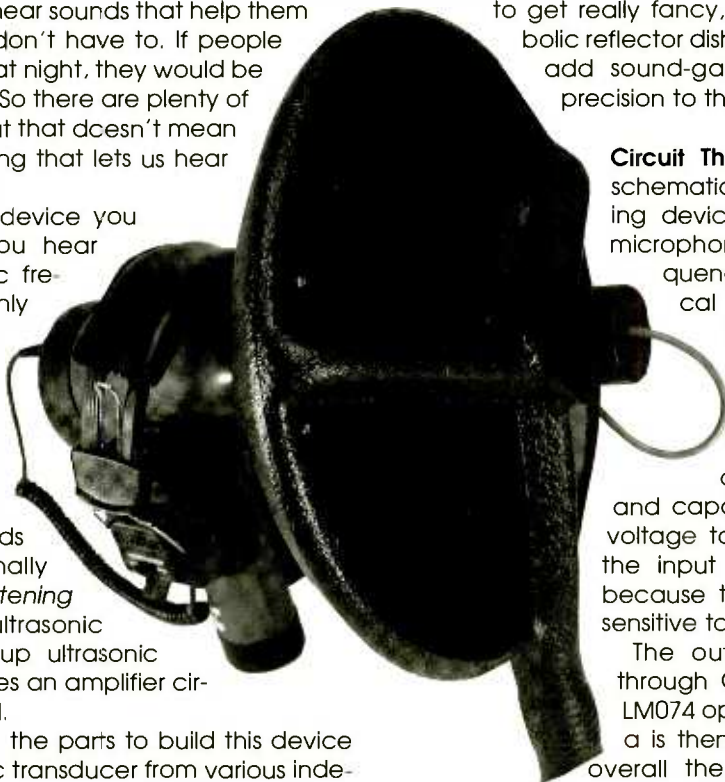
## *LISTEN TO BATS, INSECTS, AND OTHER HIGH-FREQUENCY NOISES*

**T**here are sounds that people can hear and there are sounds that people just can't hear. It has to do with the frequency response of the human ear or the sounds it is designed to hear. Certainly bats and various insects have to hear sounds that help them do things that people don't have to. If people had to fly around blind at night, they would be better off with bat ears. So there are plenty of things we can't hear, but that doesn't mean we can't build something that lets us hear these sounds.

This article details a device you can build that lets you hear sounds in the ultrasonic frequency range. Not only bats and insects make ultrasonic sounds. Things like leaking gases or rushing air, jingling keys and coins, electrical equipment, and people and animals walking in grass make sounds that you don't normally hear. The *Ultrasonic Listening Device* contains an ultrasonic transducer that picks up ultrasonic frequencies and provides an amplifier circuit with a proper signal.

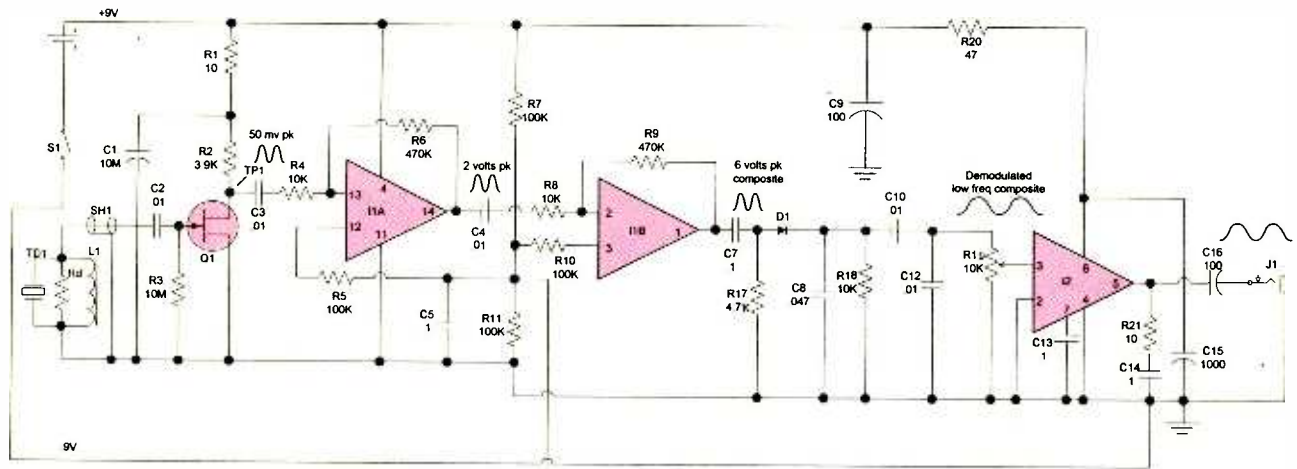
You can purchase all the parts to build this device except for the ultrasonic transducer from various independent sources. The transducer is a custom-made part available only from the source given in the Parts List. Basically, you need to build the circuit containing the transducer, isolate the transducer from vibrations with a rubber mounting scheme, and power up the circuit aiming the transducer in various directions.

With a bit more investment in time and cost, you can also make a slick gun-like housing for the device with your own parts or with the pre-cut and drilled parts also available from the parts source. If you want to get really fancy, a molded plastic parabolic reflector dish is also available. It helps add sound-gathering and directional precision to the device.



**Circuit Theory.** Figure 1 shows a schematic of the ultrasonic listening device. Ultrasonic transducer microphone TD1 converts high-frequency sounds into an electrical signal using the piezoelectric effect. Inductor L1 helps tune the transducer to 25 kHz. The signal is coupled to FET transistor Q1 through capacitor C2. Resistor R1 and capacitor C1 decouple bias voltage to the drain. Shielding of the input lead is very important because this part of the circuit is sensitive to noise and feedback.

The output of Q1 is coupled through C3 and R4 to IC1-a, an LM074 op-amp. The output of IC1-a is then coupled to IC1-b; and overall the signal is amplified by about 50, set by the ratio of resistors R6 and R4. The output of IC1-c is coupled back into the circuit simply by stray pickup, but you can experiment with this part of the circuit by adding a "gimmick" capacitor, which involves nothing more than soldering bits of wire leads to pins 2 and 8 of IC1 and twisting

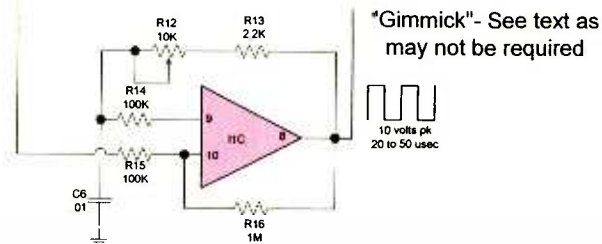


Proper routing of input power leads will improve noise figure.

Leads to J1 must be short and direct as possible

Leads to power must be routed direct to underside of mounting plate

Rd is chosen to dampen transducer response. Suggested value is around 10K



"Gimmick"- See text as may not be required



Fig. 1. Schematic of the ultrasonic listening device. Ultrasonic transducer microphone TD1 converts high-frequency sounds into an electrical signal using the piezoelectric effect

them together... but again, this is an optional step, as pin 2 tends to pick up the signal from pin 8 automatically.

With or without the gimmick, the oscillator now generates a signal that is mixed with the picked-up signals, creating sum and difference signals. Capacitor C7 and R17 form a filter that attenuates the higher frequency component of the mixed signals while allowing lower frequencies to pass by a factor of 20 dB. The resulting signal is the difference between the received signal and the oscillator frequency. This is similar to the super heterodyne effect. The resulting signal is rectified by 1N914 diode D1, transformed into a signal that produces sounds you can hear.

Potentiometer R12 tunes the circuit to cover a small

band of frequencies. Potentiometer R19 attached to LM386 amplifier IC2 controls volume or the level of the signal reaching headphone jack J1. The output is set to 8 ohms. While you're better off with headphones, you can substitute a small speaker. Suitable headphones are available from the source given in the Parts List.

**Construction.** You can build this circuit on perforated construction board, but you're much better off using a PC board. You can make one using the foil pattern provided here or buy one with the kit. Figure 2 shows the parts-placement diagram and Fig. 8 is the foil pattern. Note that the potentiometers supplied with the kit mount to the PC board using bits of scrap component leads so that the potentiometers stand vertically as shown in Fig. 3.

Twisted leads work fine for the headphone jack, but the transducer must be connected to the circuit using shielded cable. Figures 3-6 show details on how to assemble the device. Be sure to solder components L1 and Rd directly across the leads of transducer TD1 as shown in Fig. 4.

After you have assembled the board and checked for errors, connect either a 9-volt battery or 12 volts from 8 AA cells, turn on the circuit and listen for a rushing sound in the headphones. If the circuit seems to be working, proceed to the final assembly of the gun handle and reflector if you're adding them. If you're not, it helps to mount the PC board insulated from and directly above a metal plate of the same size.

The gun handle is easy and fast to build if you're doing it from the kit. Otherwise you're on your own from here. Assemble the handle parts as shown with

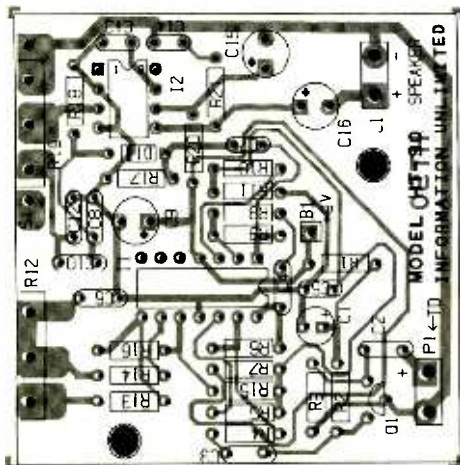


Fig. 2. Parts-placement diagram. You can build this circuit on perfboard, but you're much better off using a PC board.

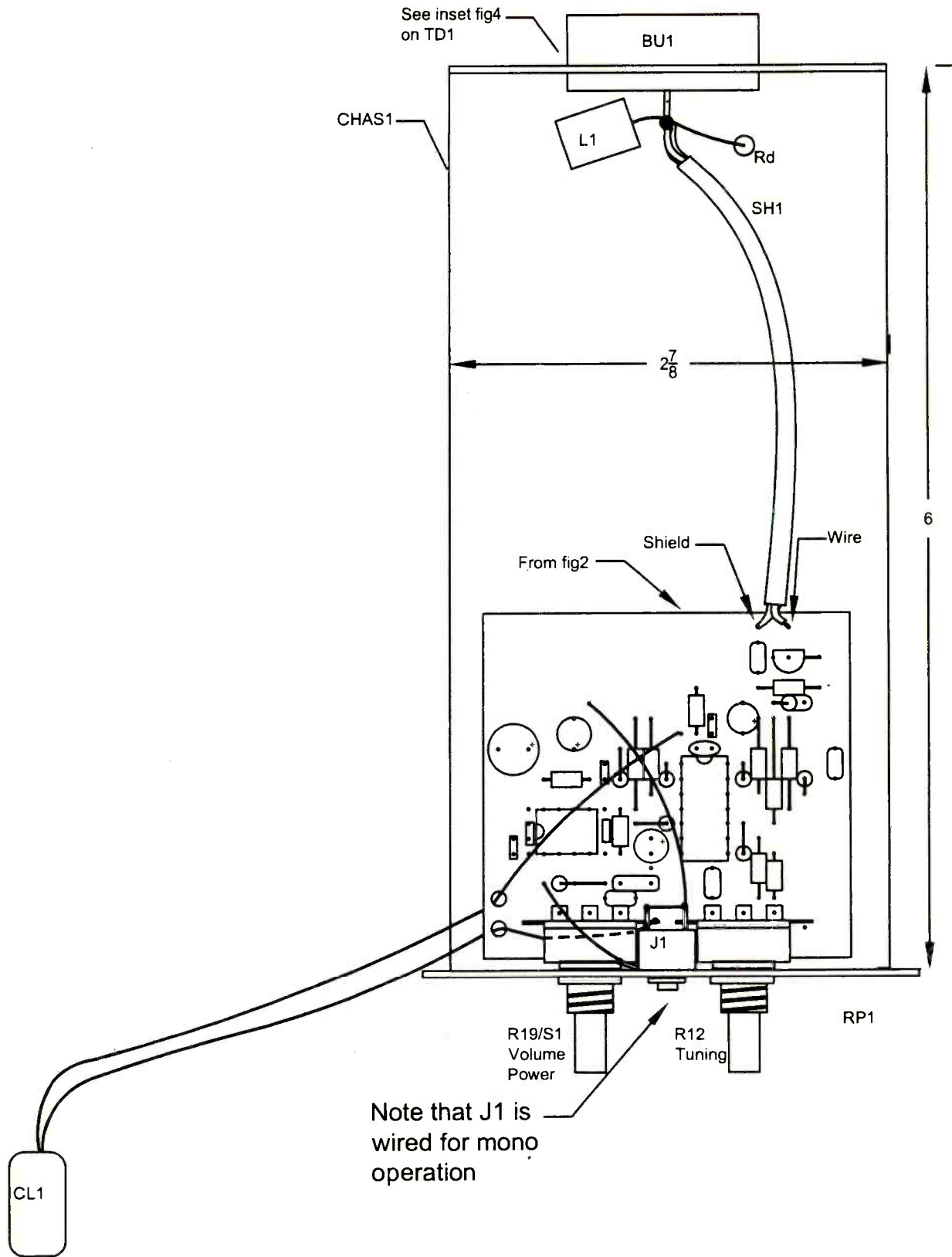


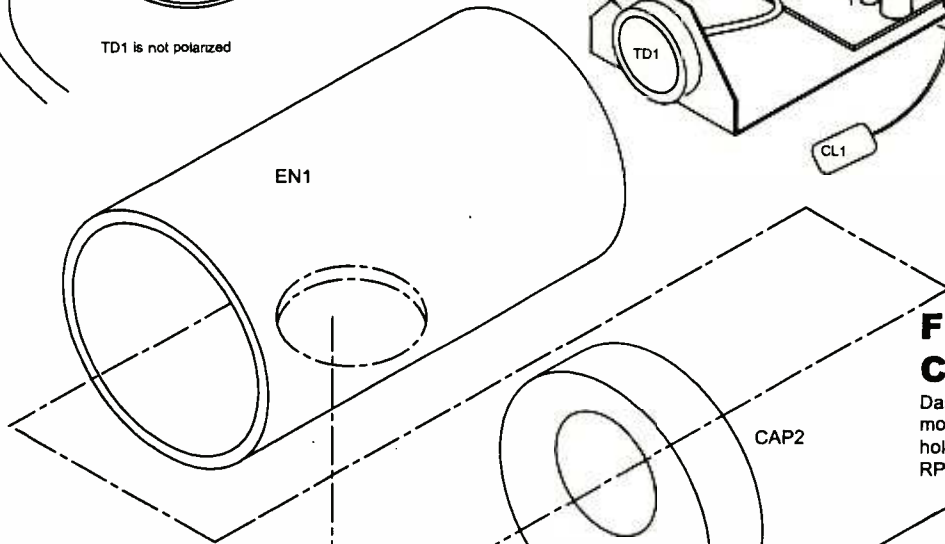
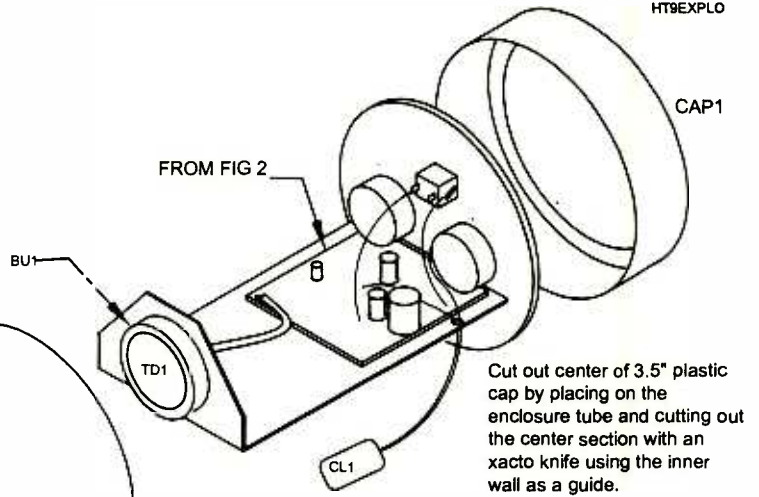
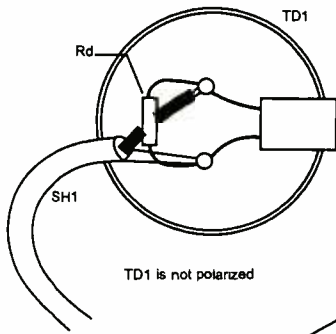
Fig. 3. Follow this mechanical layout if you're building the basic gun-handle type case.

the board mounted above the pre-formed metal plate that holds everything in place (see Fig. 5). Be sure to mount the transducer in the rubber grommet to prevent it from picking up stray bumps and taps from

the handle.

The parabolic dish assembly is shown in Fig. 7. Note that the assembly is designed to allow the transducer to slide toward and away from the center of the dish

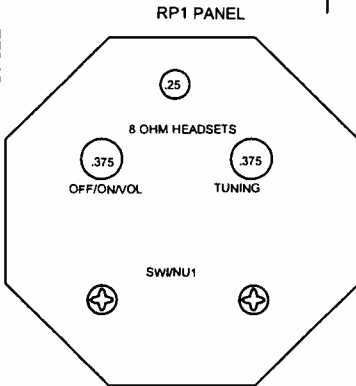
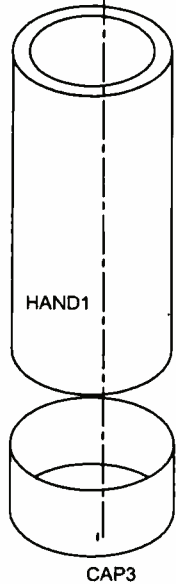
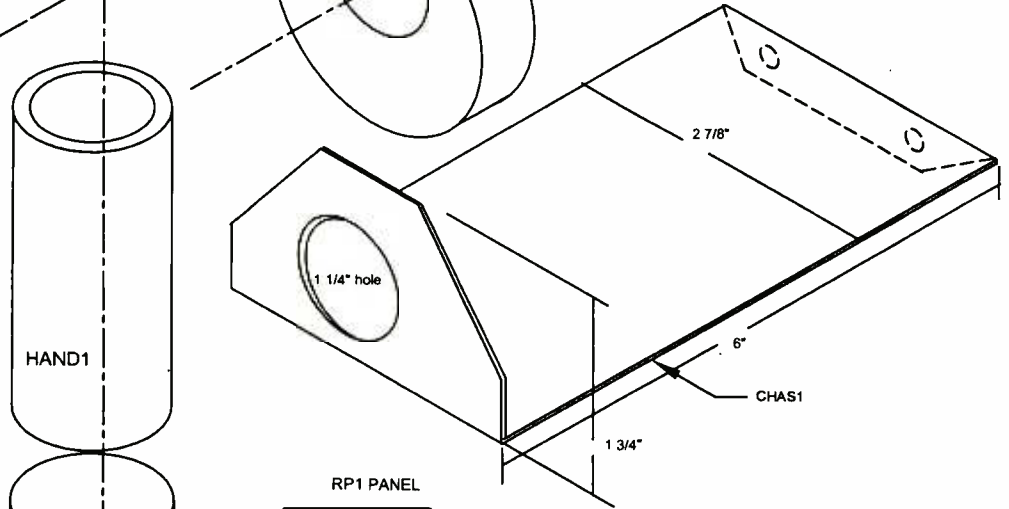
### Fig 4 Final Blow Up



### Fig 5 CHAS1 Chassis Fab

Dashed lines indicate 1/2" mounting lip. Note clearance holes for SW1 mating to holes in RP1 rear panel section

Note that hole in EN1 for handle is best cut with a 1 7/8" circle saw. Fit must be tight to properly secure handle in place. The handle serves as the housing for the single 9 volt or 8 aa cells.



### Fig 6 Front Panel Fab

Panel is cut from a 3 1/4 x 3 1/4" piece of .045 aluminum or .03 gal. Cut corners to approach a circular shape.

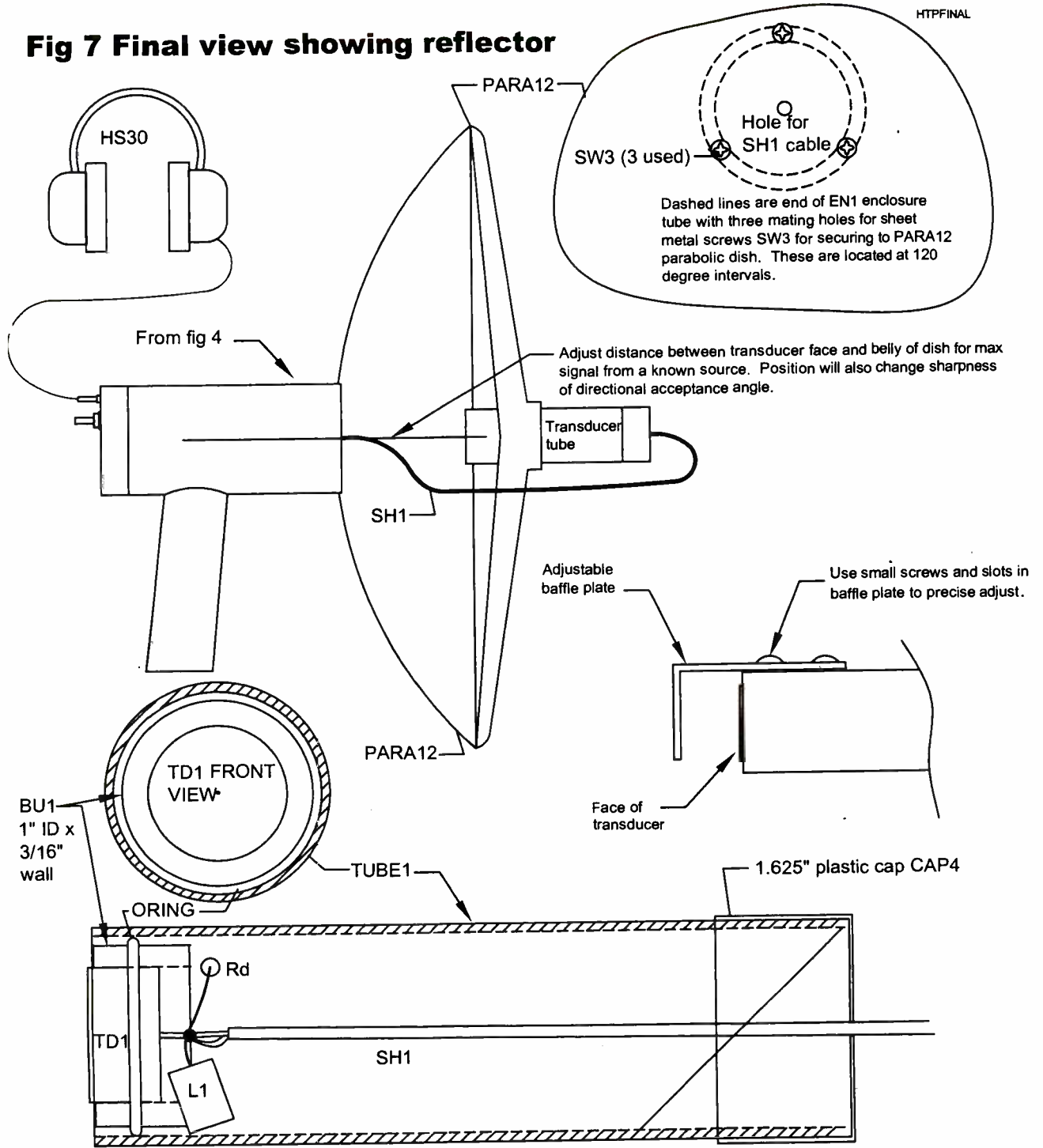
Note that holes must be accurately positioned for proper alignment to R12, R19 and J1 on the assembly or printed circuit board.

Fig. 4. Be sure to solder components L1 and Rd directly across the leads of transducer TD1 as shown here.

Fig. 5. The basic gun-handle type case is assembled from PVC pipes and plastic end caps.

28 Fig. 6. Front-panel fabrication. The potentiometers and jack for the headphones mount here.

# Fig 7 Final view showing reflector



## X-ray view of transducer tube showing mounting scheme

Note shielded cable is 18" and is routed through a small hole in the rear cap CAP3 and in PARA12 reflector

TD1 is fitted into bushing BU1. Assembly is then inserted into the 5.5" x 1.625 diameter enclosure TUBE and is spaced by the ORING. This scheme shock mounts the transducer and secures it in place.

Transducer is wired as shown in fig.4

Fig. 7. Parabolic dish assembly. The assembly is designed to allow the transducer to slide toward and away from the center of the dish for tuning adjustment, so it needs a good length of shielded cable to allow it to do so.

## PARTS LIST FOR THE ULTRASONIC LISTENING DEVICE

### SEMICONDUCTORS

IC1—LM074 op-amp  
IC2—LM386 audio amplifier  
D1—1N914 diode  
Q1—J202 N-channel FET

### RESISTORS

R1, R21—10-ohm, ¼-watt, 5%  
R2—3900-ohm  
R3—10-megohm  
R4, R8, R18—10,000-ohm  
R5, R7, R10, R11, R14, R15—100,000-ohm  
R6, R9—470,000-ohm  
R12—10,000-ohm potentiometer, 17mm  
R13—2200-ohm  
R16—1-megohm  
R17—4700-ohm  
R19—10,000-ohm potentiometer, 17mm, with switch (S1)  
R20—47-ohm  
Rd—10,000-ohm

### CAPACITORS

C1—10-µF, 25 volts, electrolytic  
C2, C3, C4, C6, C10, C12—0.01-µF, 25 volts, disk or plastic  
C5, C7, C13, C14—0.1 µF, 25 volts, disk or plastic  
C8—0.047-µF, 50 volts, plastic  
C9, C16—100 µF, 25 volts, electrolytic  
C11—Not used  
C15—1000-µF, 25 volts, electrolytic

### ADDITIONAL PARTS AND MATERIALS

L1—27-mH inductor (available from Mouser)  
J1—3.5-mm stereo audio jack wired for mono  
TD1—25-kHz acoustical receiving transducer  
Shielded mike cable, PC board or perfboard, insulating plastic, rubber mounting bushing for TD1, 9-volt battery holder with 12-inch leads (or 8-AA holder for 12-volt operation), two 3½-inch plastic caps, one 1¼-inch plastic cap, 6-inch long 3.5-inch diameter PVC pipe, 7-inch long 1¼-inch diameter PVC pipe, steel or aluminum shielding plate (see Fig. 4), headphones, one 1½-inch plastic cap, one 1⅝-inch × 1⅝-inch × ⅝-inch rubber o-ring, one 5½-inch × 1½-inch O.D. plastic tube, #6 × ⅝-inch sheet metal screws, 12-inch plastic parabolic reflector.

**Note:** The following items are available from Information Unlimited, PO Box 716, Amherst, NH 03031, 800-221-1705, 603-673-4730, [www.amazing1.com](http://www.amazing1.com), e-mail: [infol@xtdl.com](mailto:infol@xtdl.com). Complete kit (includes headphones, PC board, and all parts except parabolic reflector, PNT9K), \$99.50; Kit for PC board only (PNPCT9K), \$39.50; single PC board w/o parts (PNPCT9), \$7.50; custom-made ultrasonic transducer (single part only) (PNTDT9), \$24.50; fully assembled PC board (PNPCT90), \$59.50; parabolic reflector (PNPRT9), \$39.50; fully assembled and tested unit (PNHT90), \$149.50. Both PNPCT9K and PNPCT90 include a transducer.

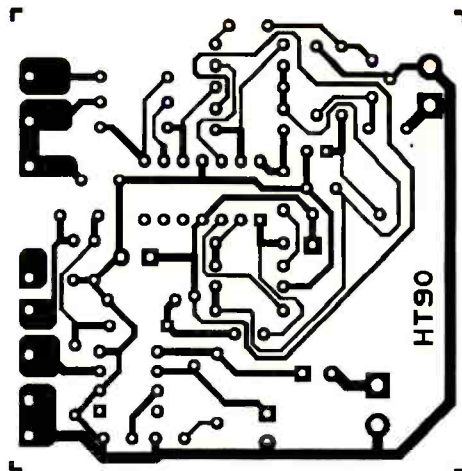


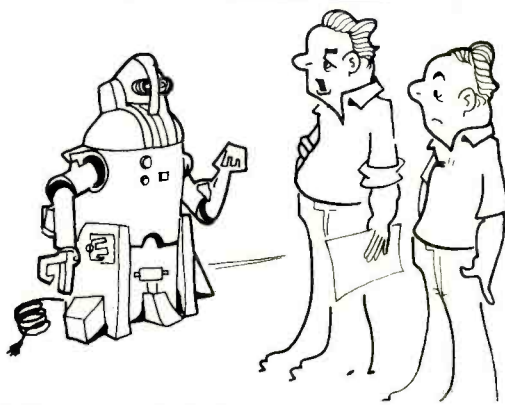
Fig. 8. You can make your own PC board using this foil pattern.

for tuning adjustment, so it does need a good length of shielded cable to allow it to do that.

**Using the Listener.** Once the unit is completely assembled in the form you have chosen, it's up to you to find interesting sounds to listen to. Of course you'll have no problem finding new sounds... but you might have trouble identifying what they are and where they are coming from. Regardless, and whatever you do hear, you will have opened up a whole new world of sounds to listen to.



"Oh, I get it now, you throw some stuff in a box and then it does something or other."



"It replaces ten men, but it takes twenty technicians to keep it going!"



Accurately measure  
RPMs when

# THE TACH-PLUS TACHOMETER

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to measure the rotation of other moving part. If it's once or twice a second, it's by eye. The *Tach-Plus* project author's need to accurately measure a small machine. After I completed and many other uses include checking propellers on model airplanes; set-erators to particular speeds; g turntables, machine tools, d mills; and more. To increase its versatility, a turn counter mode has been added to the device to count turns on coil-winding machines or lathes.

**Theory.** The Tach-Plus works by measuring the time it takes for a spinning shaft or object to make one complete revolution. It does this by "reading" a reflective strip of aluminum tape placed on a rotating surface. Once the time to make one revolution is known, we can determine how many revolutions occur in a given period of time.

The schematic of Tach-Plus is shown in Fig. 1. At the heart of the circuit is an Atmel AT90S2313 microchip (U2) running at 4 megahertz. It takes care of the math and coordinates the switches. The firmware, or program code, for U2 is available for download from the **Poptronics** Web site; and a preprogrammed chip is available from the source mentioned in the Parts List.

Components R1, C1, and U1-d form a 40-kHz oscillator. The signal is inverted by U1-e and U1-f to turn on transistor Q1 and connect D4 to ground. Emitter D4 obtains 5 volts through Q2, which is controlled by U2 pin 3 to save power. The effect is that the emitter diode turns on only when reading the reflective strip.

On the detection side of things, the 40-kHz pulse from the IR emitter is picked up by the IR detector (D2) and transferred to pin 3 of U4-a, an LM358 op-amp. Inductors L1 and L2 stop daylight from affecting the sensor. Op-amp U4-a amplifies the signal about twenty times, while C5 blocks any DC offset from the op-amp before reaching the rectifier circuit composed of D6, D5, C2, and R6. The rectified signal is amplified another twenty times by U4-b before reaching Schottky inverter U1-a, which cleans up the signal before presenting it to microchip U2 pin 6.

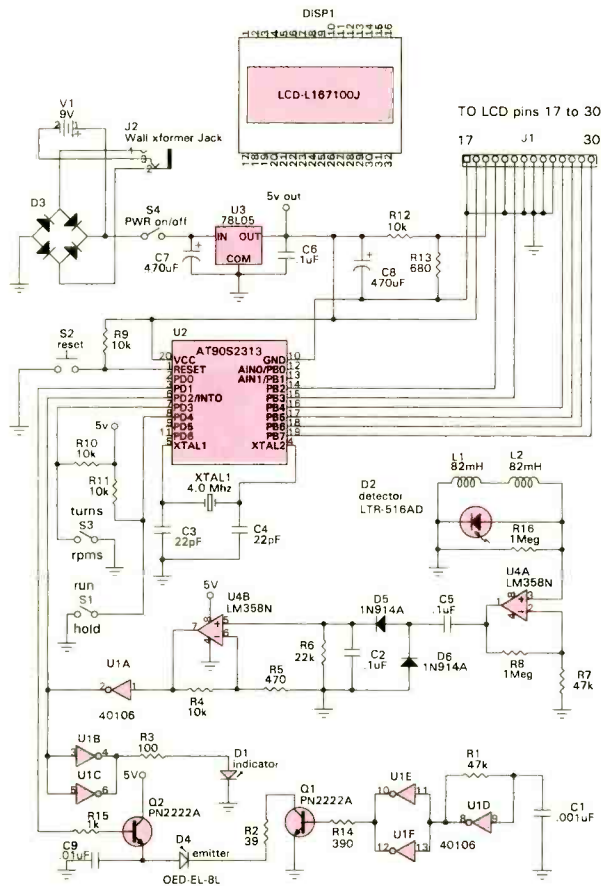
Power for the circuit is supplied from either a 9-volt battery or an AC-to-DC power adapter through jack J2. Bridge rectifier D3 allows the use of a wall transformer with a plug of either polarity, so it's not possible to connect the adapter backwards, although the 9-volt battery must have correct polarity. Power regulator U3 provides +5 volts.



**Construction.** Tach-Plus can be built on a PC board as shown in the parts-

placement diagram in Fig. 2 or point-to-point wired on perfboard. A PC board is available from the source given in the Parts List. If you want to make your own PC board, the upper and lower foil patterns for the double-sided board are provided in Figs. 3 and 4, respectively. The traces have been kept thick (.030-inch), and no traces run between IC pins. Be sure to solder short wires between both sides of the board at all through-hole locations where a component lead does not already do the job; and also make sure to solder leads on both sides wherever there's traces on both sides. Solder the IC sockets first and the display and switches last. Also examine Fig. 5 before soldering.

Note that switches S1 and S2 have the hold-in pins 31



L1 & L2 are metal encapsulated chokes

Fig. 1. The schematic of Tach-Plus is shown above. At the heart of the circuit is an Atmel AT90S2313 microchip (U2) running at 4 megahertz. It takes care of the math and coordinates the switches.

removed to make the the spring on the front remove the short wire, switch will no longer lock be replaced should the new, temporary push buttons. Pull the display forward and the display is higher than an can case.

Figure 5 will help in aligning the for best performance. Notice that the ed slightly above the circuit board to adjustments in position if necessary. Ma sor and the emitter are inserted with the ity (see Fig. 6). Also apply heat-shrink emitter as shown to block stray emitter reaching the sensor.

**Testing and Troubleshooting.** Before inserting their sockets, power up the unit and check for on pin 20 of U2. Insert the ICs and press the switch. The display should show either "RPMs" or "Counter," depending on the position of S3. An un play may mean U2 is not working. Check the oscill or the leads to the display for shorts or opens. With t HOLD/RUN switch released, move your hand up an down in front of the sensor. The red indicator D1 should light. If not, determine if the sensor side or the emitter side is not functioning.

Tach-Plus uses a 40-kHz oscillator, the same frequen-

### PARTS LIST FOR THE TACH-PLUS

#### SEMICONDUCTORS

- U1—40106 inverter
- U2—AT90S2313 AVR
- U3—78L05 voltage regulator (TO-92A)
- U4—LM358N op-amp
- Q1, Q2—PN2222A transistor (TO-92B)
- D1—LED indicator, any color
- D2—IR detector, LTR-516AD
- D3—Bridge rectifier, DB103
- D4—IR emitter. OED-EL-8L
- D5, D6—1N914A diode
- DISP1—LCD display, LCD-L167100J

#### RESISTORS

- (All resistors are 1/4-watt, 5% units.)
- R1, R7—47,000-ohm
  - R2—39-ohm
  - R3—100-ohm
  - R4, R9-R12—10,000-ohm
  - R5—470-ohm
  - R6—22,000-ohm
  - R8, R16—1-megohm
  - R13—680-ohm
  - R14—390-ohm
  - R15—1000-ohm

#### CAPACITORS

- C1—0.001-μF
- C2, C5, C6—0.1-μF
- C3, C4—22-pF
- C7, C8—470-μF
- C9—0.01-μF

#### ADDITIONAL PARTS AND MATERIALS

- L1, L2—82-mH, metal encapsulated choke
- V1—9-volt battery
- XTAL1—4.0-MHz crystal
- J1—SIP14 connector
- J2—Power adapter jack
- S1-S4—DPDT switch
- Hardware, solder, 9-volt battery, RadioShack case #270-213, heat-shrink tubing.

**Note:** The following items are available from Design Specialties, 4444 County Hwy 16, Delhi, NY 13753 or [www.dsgnspec.com](http://www.dsgnspec.com). Pre-programmed AT90S2313 chip, \$16; double-sided silk-screened PC board, \$11. Add \$4 for shipping and handling. NYS residents please add appropriate sales tax.

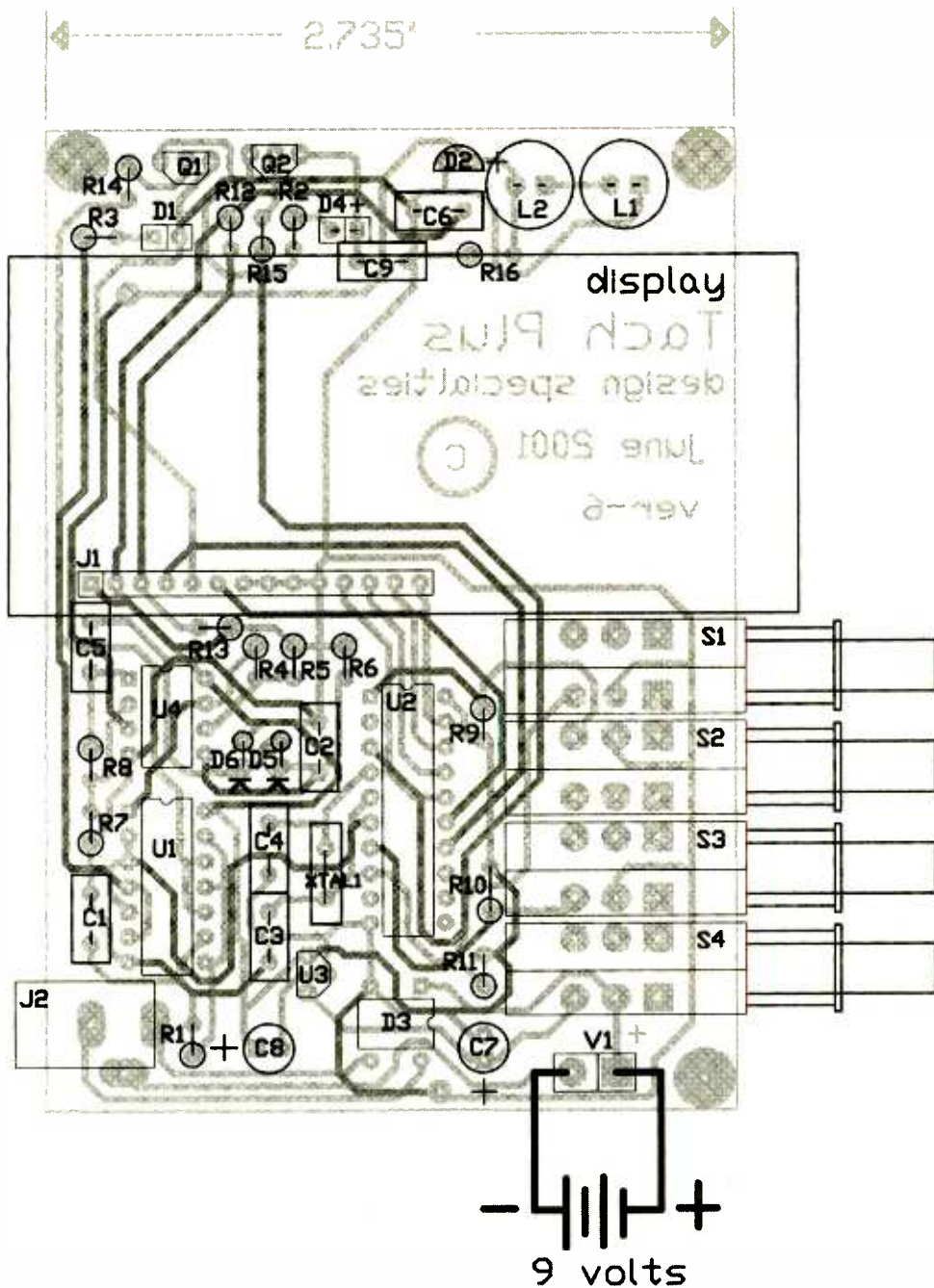


Fig. 2. Tach-Plus can be built on a PC board as shown in the parts-placement diagram or point-to-point wired on perfboard. A PC board is available from the source given in the Parts List.

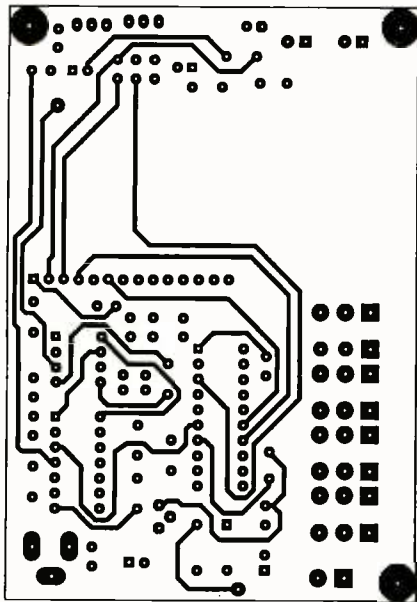
cy as most IR remote controls. Place a remote control in front of the sensor and press any button on it. (It's best to do this in the TURNS position.) The indicator light should flash. If it does, the trouble is in the emitter side of the circuit. Check the emitter of Q2 for +5 volts to see if U2 pin 3 is turning on the transistor. Make sure that the HOLD switch is in the RUN position, as U2 will turn off Q2 in the HOLD position. Check both oscillators if you have an oscilloscope or frequency counter. U2's clock frequency at pins 4 and 5 is 4 MHz, and the sensor circuitry is 40 kHz measured at pin 8 of U1.

You can check a malfunctioning sensor circuit by moving a piece of aluminum foil in front of the sensor

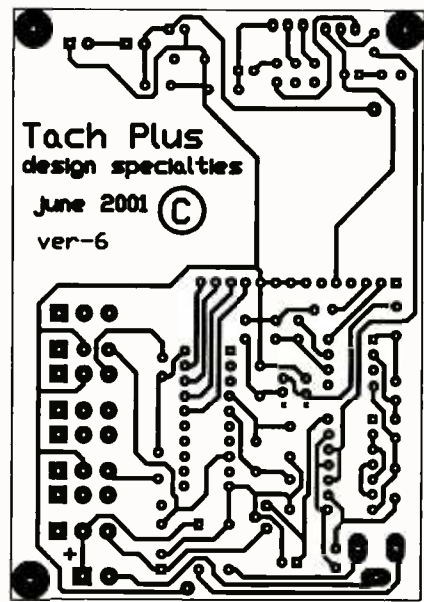
and emitter. Place a voltmeter on pin 5 of U4-b while doing this. The voltage should vary from 0 to about 3 volts. Pin 2 of U1-a should vary from 0 to 5 volts at the same time, and pin 6 of U2 should also vary from 0 to 5 volts.

Do not place both the emitter and the sensor behind clear plastic, as the sensor is quite sensitive and will pick up the slightest reflected light from the IR emitting diode. Don't use a dark plastic lens either, like one from an old remote control, because it will shorten the working distance of the instrument.

**Final Check.** Cut a two-inch round disk out of card-



TOP LAYER  
expose face down to copper



BOTTOM LAYER  
expose face down to copper

Fig. 3. Here is the component-side foil pattern for the Tach-Plus. You can use this template to etch your own board. The traces have been kept thick (.030-inch), and no traces run between IC pins.

board or index card and tape a strip of 1/4- or 3/8-inch aluminum foil to it, shiny side out, from the center to an outside edge as shown in Fig. 6 (you don't have to blacken the background). Attach the disk to a small hobby motor and connect the motor leads to a variable power supply.

Fig. 4. Here is the solder-side foil pattern for the Tach-Plus; and also make sure to solder leads on both sides wherever there's traces on both sides.

Vary the speed of the motor and point Tach-Plus toward the spinning disk until the indicator LED blinks on and off. A constant on indicates that you are too close to the disk and a constant off indicates that you are too far away; position Tach-Plus so that you get a consistent reading. A four- to eight-inch distance

TABLE 1

SWITCH FUNCTION:

POSITION	OUT	IN
HOLD / RUN:	RUN Reads or counts 20 ma. drain	HOLD Press momentarily (one to two read cycles). Holds last reading. About 12 ma. drain. Press RESET to restart run cycle
RESET:		RESET Resets Tach-Plus waits for next reflective pass. 50 ma. drain
RPMS / TURNS:	RPMS Reads rpms 20 ma. drain	TURNS Reads turns. Maximum speed is about 1000 rpms. 50 ma. drain
ON / OFF	OFF Power off	ON Power on. Waiting for Reflective reading. 50 ma. drain.

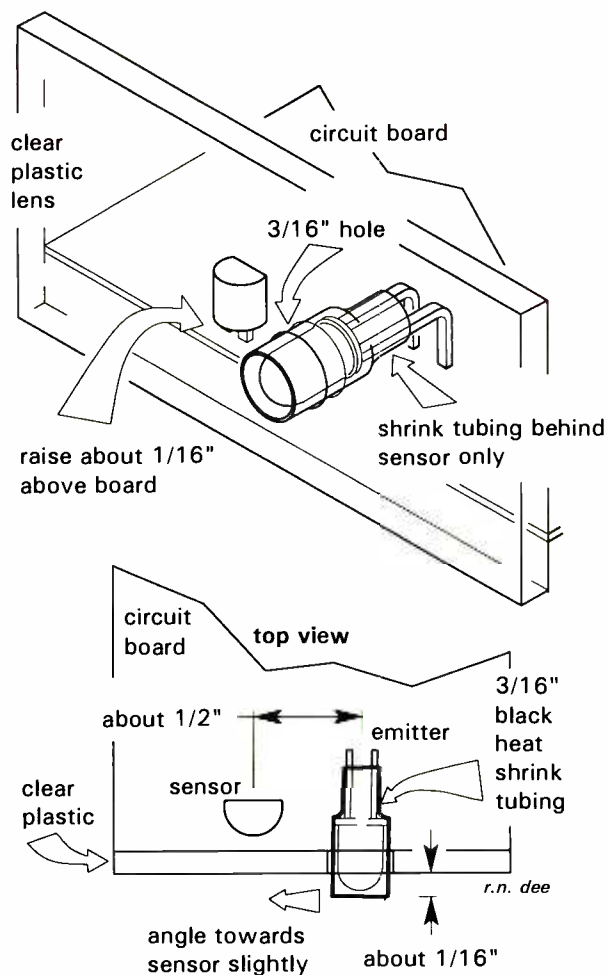


Fig. 5. This diagram will help in aligning the sensor and emitter for best performance. Notice that the sensor is mounted slightly above the circuit board to allow for slight adjustments in position if necessary.

should yield the best results. An inconsistent reading might be caused by not having enough of the emitter diode shielded by the shrink tubing or if some metallic object is reflecting D4's light into the sensor. Make any adjustments before installing the board in a case. The board fits nicely inside RadioShack case #270-213, but any case that fits will work. Just be sure to cut at least a 5/8-inch high by 1-inch wide window in front of the sensor D2.

**Using Tach-Plus.** Table 1 shows how to use Tach-Plus' switches. Whatever you want to measure the speed of must have a reflective surface attached. The best material to use is aluminum tape of the type used for ductwork. Place a strip of reflective tape, about 1/2-inch wide and 1 inch long, on the spinning shaft or object. Turn on the device, being careful not to catch your clothes, fingers, or limbs on any machinery, and hold Tach-Plus in position.

Readings are held in the display (latched) for half a second before being updated. Note that the faster the object rotates, the faster the display will update. Taking readings in strong daylight will shorten the maximum reading distance. Tach-Plus has been tested to work at over thirty five thousand rpm. The turn counter

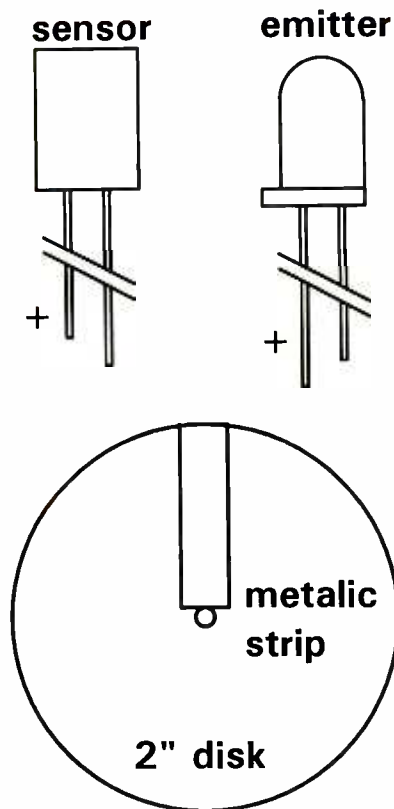
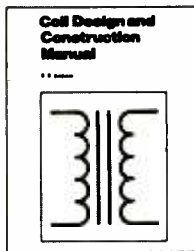


Fig. 6. Make sure the sensor and the emitter are inserted with the correct polarity (use the drawing above as a guide).

mode is most reliable if Tach-Plus is held stationary during use. This mode counts total turns rather than turns per minute. The turn counter will measure as many as one thousand turns per minute.



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ET06

## RC Timers and Timing Circuits

Timers and timing circuits are used in a wide variety of applications from short time delays of a few nanoseconds used in digital circuitry and computers to long periods of thousands of hours used to control daily, weekly, or yearly events. Electronic circuits can provide this function reliably, accurately, and repeatably, with no need for any user input or monitoring once the time has been set.

While most timers used for everyday applications in consumer goods are now implemented with or are part of a microcontroller system, for simple applications this is not always necessary. The use of a simple circuit based on a 555-type timer or a multivibrator may be more appropriate in these cases. Where high accuracy is needed, a crystal oscillator and a divider chain can be used.

There are a number of CMOS logic chips useful for this purpose. R-C (resistor-capacitor) or L-C circuits are useful where timing errors of a few percent are acceptable, but where accurate timing is a must crystal oscillators or other circuits with stable resonators should be used. The oscillator circuit is often

referred to as the clock, since it generates time intervals that are counted in some way to produce the desired timing interval.

However, the simplest timers are based on the charging and discharging of a capacitor through a resistor or current source. This approach has been around for a long time, even though its accuracy is somewhat limited (1–10 percent). We will confine this discussion to timers using RC components as timing elements. First, a few basic concepts.

### The Basics

The voltage across a capacitor is equal to the charge on it divided by the capacitance, in any consistent system of units. Charge is usually measured in Coulombs and capacitance in Farads. Current is defined as a flow of charge. The Ampere, or unit of current, is defined as that current produced by one coulomb of charge flowing across a given surface in one second. A one-ohm resistor will show a one-volt drop across it with one ampere (or one coulomb per second) flowing through it. In a practical situation, the presence of one ampere of current in a wire signifies that one coulomb

of charge flows past a given point in one second. A one-farad capacitor will have a charge of one coulomb when there is one volt of potential difference between the plates. If we connect a one-ampere current source across a one-farad capacitor, the voltage across it will rise at the rate of one volt per second, continuing to rise at this rate as long as the charging current remains constant. By knowing the current and the capacitance, we can accurately predict how long it will take to reach a certain voltage. This voltage may be that needed to produce some desired action. Conversely, if we know the capacitance, final voltage needed to produce that action, and the time delay desired, we can calculate the necessary charging current. This can be used as a basis for a timer circuit.

However, the problem in real life is that one-farad capacitors and ideal one-ampere current sources are not very practical to use. One-farad capacitors are usually of the memory-backup type limited to low voltages used in logic circuitry, and units rated at 15 volts or so are physically very large and expensive. One-ampere current sources involve extra electronic circuitry and are limited

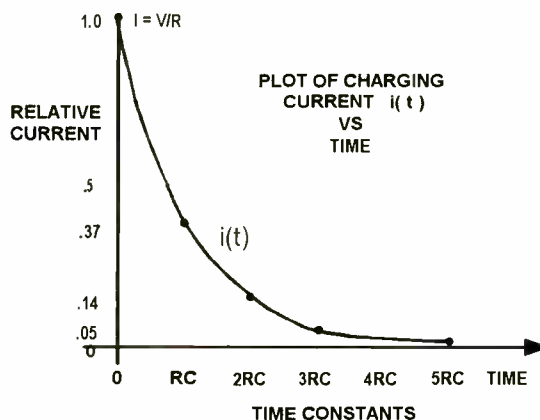
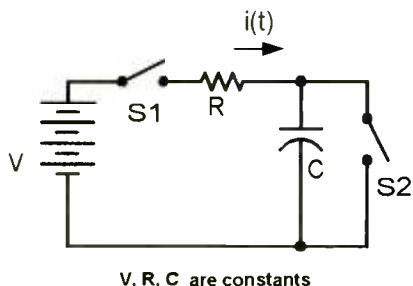
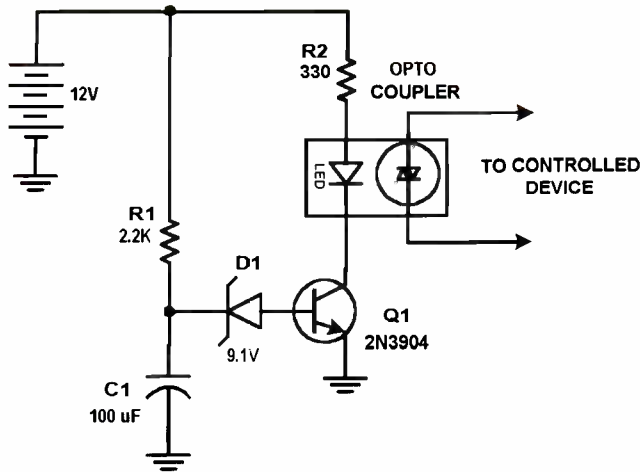


FIG 1 R-C CHARGING CIRCUIT



THIS CIRCUIT PRODUCES A DELAY IN TURNING ON THE OPTOCOUPLER USING COMPONENTS R1, C1, D1, AND Q1

FIG 2 SIMPLE TIMER CIRCUIT

as to output voltages they can achieve and still maintain one-ampere current flow. This, at best, would be a few hundred volts and, practically speaking, could be dangerous to work with. Much smaller capacitors of a few microfarads or less and much lower charging currents are used in practice. This allows use of standard-size electronic components. It is not necessary to use an ideal current source either. A voltage with a series resistance can be used instead.

**The Charging Circuit**

See Fig. 1, a basic R-C charging circuit. This circuit is generally well covered and "beat to death" in elementary electronics texts. When the switch S1 is closed and S2 is opened, voltage V is applied to the circuit. C1 has initially (and ideally) zero voltage across it and an initial current equaling V/R flows. However, the voltage across C1

starts to rise, and now the voltage across R1 is slightly less. This causes the charging current to drop. This process continues, the current dropping as the capacitor charges toward a final value equal to the voltage V. The exact waveform of the current is given by the mathematical plot of the function  $e^{-\alpha t}$  where  $\alpha = 1/RC$  and  $t =$  time.

If one writes the loop equations for this circuit as follows:

$$V = IR + Q/C$$

where  $I = i(t)$  a function of time;  $Q =$  charge on capacitor; and the quantities  $V =$  supply volts,  $C =$  Capacitance,  $R =$  resistance are all constant, then:

$$V - I(t)R = Q/C$$

If V (supply voltage) is constant and

the value of C is also constant, then remembering that the current I is defined as the rate of flow of charge per unit time:

$$\Delta V/\Delta T - [dI(t)/\Delta T] R = (dQ/\Delta T) / C$$

Remember,  $\Delta$  symbolizes "change of." This can be expressed mathematically using derivatives. A derivative of a mathematical function is the rate of change of one variable (current) with respect to another variable (time). If the rate of change is rapid, the derivative is large. If the function is a constant (no change), the derivative is zero. If two functions are identical, then their derivatives at a point are equal. Therefore:

$$dV/dt - [di(t)/dt] R = (dQ/dt) / C$$

Now remember that current is the rate of flow of charge with respect to time past a given point. Therefore:

$$i(t) = dQ/dt$$

We said that the supply voltage V is constant and does not change with time so

$$dV/dt \text{ is zero}$$

Therefore:

$$- [di(t)/dt] R = i(t) / C$$

or dividing both sides by R

$$di(t)/dt = - i(t) / RC$$

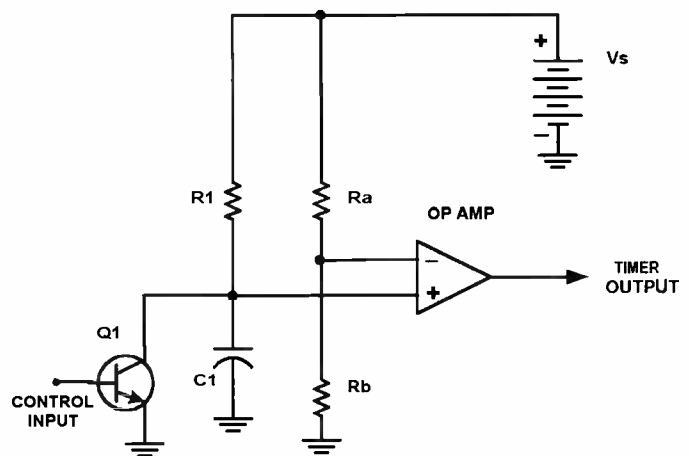


FIG 3 OP AMP TIMER

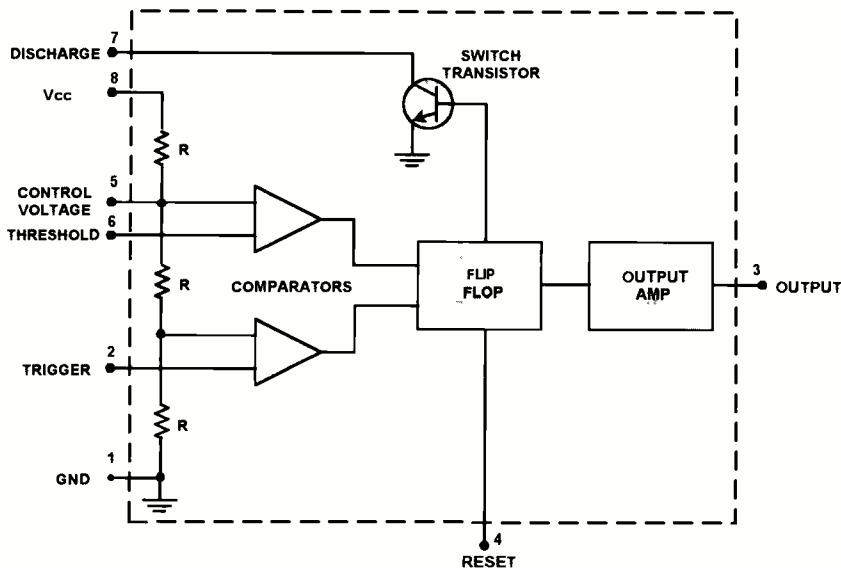


FIG 4 NE555 BLOCK DIAGRAM

than one percent of initial value. It never can equal the supply voltage, since this would require zero voltage across R; therefore, there would be zero current flow to get that "final step."

Mathematically we say that the function  $e^{-(t/RC)}$  approaches a limit of zero as time approaches infinity. Physically, it will never actually get there, but given enough time, it will approach as close as you like. The reason we mention this is to dispel a popular misconception that any RC timing circuit will have a time period equal to RC. The time period depends on both the RC product and the initial voltages across the capacitor or the resistor, as well as the final voltage needed to produce the required actions in the circuit. Therefore R-C timers can be severely affected by the circuit supply voltage, unless suitable precautions are taken to compensate them for voltage variation. The R-C circuit is usually reset by discharging the capacitor, preferably through some low resistance so as to limit the discharge current to a safe value. S2 is used for this function. As this was simply a demo circuit, no resistance was used. The discharge time constant would be RC, with R equaling the resistance of the switching circuit

Figure 2 shows a very simple timing circuit using a single transistor and an R-C timing circuit. This circuit was used to switch on a device via an LED-photocell arrangement (opto-coupler). It produces a delay on powering up to ensure correct sequencing of certain equipment. C1 charges toward the power-supply voltage (12 volts) through R1. When the voltage reaches 9.1 volts, zener diode D1

and therefore:

$$di(t)/dt + i(t) / RC = 0$$

This differential equation says that  $i(t)$  has a rate of change with respect to time that equals the original current  $I(t)$  divided by RC, or it is its own derivative divided by a constant, which is RC. The mathematical function that has this property is equal to e raised to the power  $(-t/RC)$ , written as  $e^{-(t/RC)}$ . "e" is the base of natural logarithms and is a natural constant, which is approximately equal to 2.7182 (See a math book, it has a lot more decimal places). If this function is plugged into the relationship above, the equation is satisfied, indicating that indeed this is a solution to the differential equation. This exponential waveform has the shape shown in Fig 1. Note that it starts at a maximum and decays to zero. This is called the exponential decay and is characteristic of many natural processes (cooling off of a hot object, radioactive decay, certain chemical reactions, etc.). We are not going any further here with the math; get out your high school advanced algebra books if you are lost.

As we said before, the voltage across the capacitor increases towards the supply voltage V.

As the current drops exponentially, the voltage drop across R drops in an identical fashion. The capacitor voltage is the voltage V (power supply voltage) minus the IR drop.

### The Time Constant

However, the capacitor voltage never quite reaches V. The product of R and C is called the time constant. It has the units of seconds. If R is in megohms, then C is in microfarads. Therefore a 1-megohm resistor and a 1-microfarad capacitor (very practical values) have a time constant of 1 second. In one time constant, the capacitor voltage will be 63 percent of the source voltage. The current in R will be 37 percent of initial value. In two time constants, it will reach a little more than 86 percent of the supply voltage, the current about 14 percent of initial. After three time constants, it will be 95 percent, with 5% current flow. After five time constants, it will be over 99 percent; and the current will be less

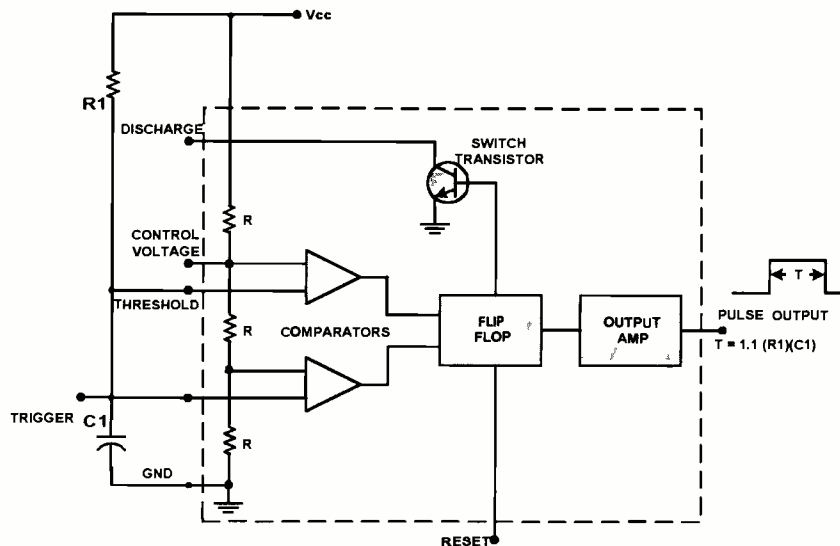


FIG 5 MONOSTABLE OPERATION OF NE555 TIMER



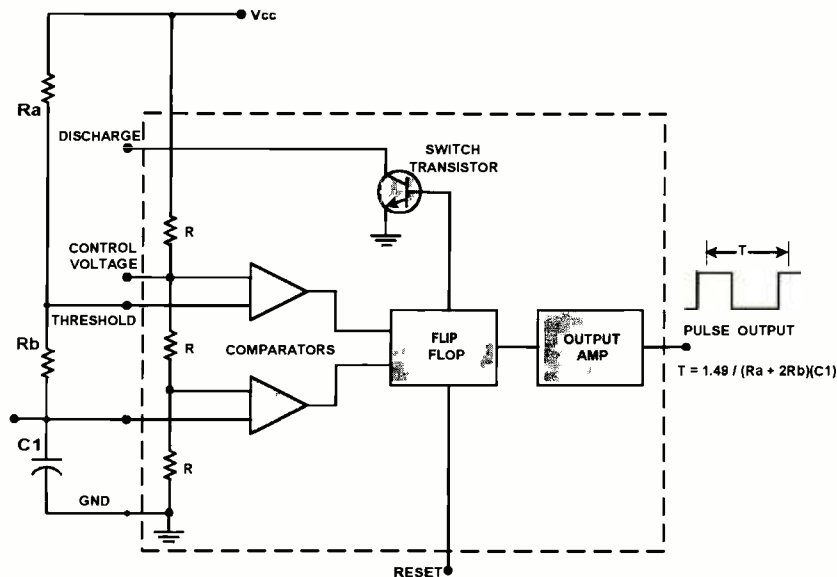


FIG 6 ASTABLE OPERATION OF NE555 TIMER

conducts, forward biasing the transistor Q1, turning it on. At about 9.8 volts, the zener diode and base of Q1 conduct heavily, taking the charging current from C1. C1 can charge no higher and ceases to draw current.

When power is turned off, the circuit is reset by C1 discharging through R1 into the now zero voltage supply. The time can be varied by changing R1 and C1, the zener voltage of D1, or the supply voltage. Note that the 2.2-K resistor and 100-µf capacitor have a time constant of 0.22 seconds. The actual delay time is about 0.37 seconds since the capacitor has to charge to about 82 percent of the supply voltage, which takes 1.7 time constants, and this is  $1.7 \times 0.22 = .374$  sec

If the 12-volt power supply malfunctioned and increased to 15 volts, the capacitor would have to charge to  $9.8/15$  or 64 percent of the supply voltage. This would take slightly more than 1 time constant, 1.015 to be exact; and this would decrease the delay time of this circuit to close to 0.22 seconds. Note the change in delay time with supply voltage. This change could cause premature turn on of the external controlled device with possible serious consequences. In practice, a critical function such as this would be handled by a microcontroller or other more sophisticated controller system, but the circuit shown demonstrates the principle.

### Op-Amps

Circuits using op-amps can also be used as timers. In these circuits, voltage

levels needed to set "trip points" can be derived from resistor-divider networks. The trip or reference voltages are determined by ratios of resistor values, rather than absolute voltage levels. This helps them to be independent of supply voltages. Now operating conditions are determined by percentages of power supply voltage, not fixed parameters. The reference voltages will directly track the power supply voltages, automatically compensating for variations.

A simple circuit is shown in Fig. 3. In this circuit an op-amp is used as a comparator. The reference voltage is derived from the power supply by the use of a resistive divider, Ra and Rb, and sets a level at the inverting input of the ampli-

fier. C1 normally would charge toward the power supply voltage Vcc, if not for the switching transistor Q1. For purposes of explanation, assume Ra = Rb. Then the reference level will be half the supply voltage. Initially the op-amp output voltage will be at its low limit, close to zero volts, since the capacitor voltage is held at zero by a switching transistor Q1 that is biased on.

When Q1 has its bias removed, it will cease conducting. Now C1 charges toward the supply voltage. When it reaches half of this voltage, its voltage will equal the voltage at the inverting input of the op-amp as set by Ra and Rb. When this voltage is passed, the op-amp, having very high gain, will switch; and its output will rise to nearly the supply voltage at this point. The time that this occurs will be at a time interval equaling 0.692 times the RC time constant, since at this point the voltage on the capacitor will reach half the supply voltage. The op-amp output voltage could be used to switch on Q1 by controlling the bias on it. This would either end the cycle or cause it to repeat; depending on the exact way it was done. A circuit called a flip-flop could be used to do this. A flip-flop is an elementary memory circuit having two stable states, much like a toggle switch, and is controlled by applying a level or pulse to its inputs. This principle is used in a very popular integrated circuit used as a timer, the NE555.

### The NE555 Timer

The NE555 timer and its various

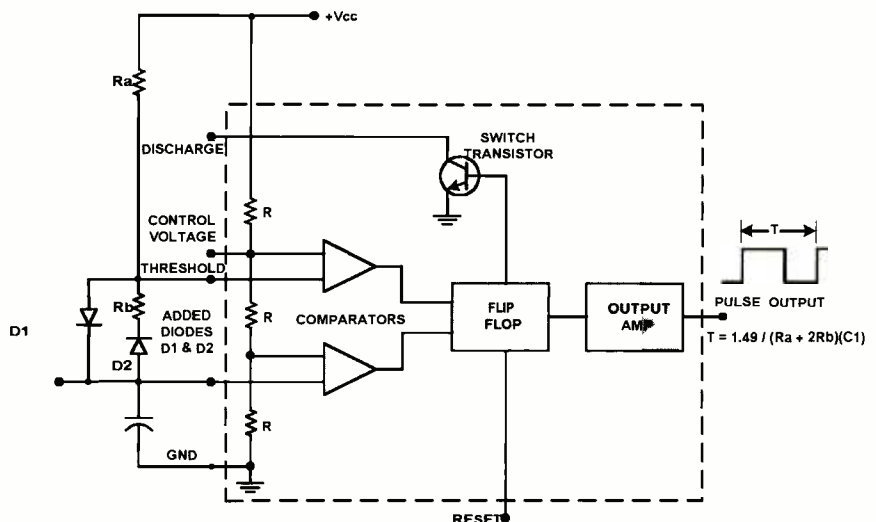


FIG 7 ASTABLE OPERATION OF NE555 TIMER WITH DUTY CYCLE CONTROL

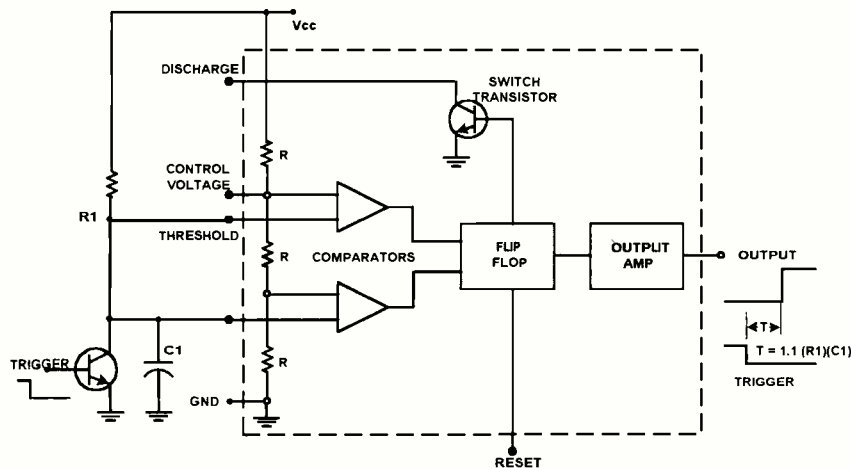


FIG 8 TIME DELAY OPERATION OF NE555 TIMER

related types are probably among the ten most popular and widely used IC devices of all time. The NE555 has existed for about thirty years and is a staple among experimenters. While the 555 is available in bipolar and CMOS types (7555), the CMOS versions may prove to be somewhat more useful for many experimenter applications. This is because the higher circuit impedances allow more reasonable values of R and C components, especially important where long time delays are required. These devices come in a DIP (dual inline) 8-pin package in thru-hole and surface-mount.

A dual timer, the NE556, is also available, as well as a quad version, the NE558. The NE555 is very versatile and can be used as an astable (free running) timer/oscillator or as a one-shot (monostable) triggered timer. Figure 4 is a block diagram of the 555 device. It consists of two comparator amplifiers, a flip-flop, an output driver and a discharge transistor. A single external resistor, R, and capacitor, C, determine the

time interval. The comparators are internally referenced by an internal resistive voltage divider at  $\frac{1}{3}$  and  $\frac{2}{3}$  of the supply voltage. The  $\frac{2}{3}$  voltage is brought out to a separate pin. This pin is often unconnected or bypassed to ground in many applications. The collector of the discharge transistor is also brought out to a separate pin. A reset input is provided to reset the flip-flop. The bipolar NE555 can output 200 mA with a 15-volt supply, enough to directly drive many small loads. The pulse width can be from about a half a microsecond up to around an hour, depending on external components. About 20 to 30 minutes is about the maximum practical limit. Beyond this limit, an external count-down scheme using a frequency divider can be implemented.

### Generating A Pulse

A circuit to generate a pulse is shown in Fig. 5. In this circuit, the flip-flop internal to the 555 is normally set so that the discharge transistor is conducting. A

negative going trigger or pulse is applied to the trigger input. This input is that of the lower comparator and is biased at  $\frac{1}{3} V_{cc}$ . The trigger must be negative going so as to drive the input below  $\frac{1}{3} V_{cc}$ . Generally an AC-coupling capacitor is used so as not to upset the DC level here. This causes the comparator to change the state of the flip-flop, cutting off the discharge transistor. External capacitor C1 starts to charge through R1 until it reaches  $\frac{2}{3} V_{cc}$ . This takes about 1.1 time constants. At this point, the upper comparator changes its state and resets the flip-flop. This causes the internal discharge switch transistor to turn on, discharging C1. Note that the trigger to the lower comparator must be removed by this time, or else erroneous operation will result. Since the discharge transistor is directly connected to the threshold input and across the capacitor, this action is very rapid.

The generated pulse appears at the device-output pin and has a period of close to 1.1 RC. This circuit can be used to trigger another timer circuit. Triggering in this mode occurs on the negative-going edge of the trigger pulse. Once the circuit is triggered, it will complete its cycle with no regard to extra triggers during this period. Resetting can be done via a pulse applied to the reset input. This resets the flip-flop and turns on the discharge transistor.

The 555 can be used as an oscillator, with one extra resistor needed to do this. Figure 6 shows this configuration. The trigger pin is tied to the threshold pin. R1 is split into two parts, Ra, and Rb, and the discharge transistor is connected to their junction. When power is applied, the capacitor, C1, charges toward Vcc until  $\frac{1}{3} V_{cc}$  is reached. At that point, the discharge transistor turns on, discharging C1 through Rb until  $\frac{2}{3} V_{cc}$  is reached. Then, the comparator trips; and the discharge transistor turns off. Now the capacitor, C1, charges again to  $\frac{2}{3} V_{cc}$  until this voltage is reached. The capacitor voltage will switch between  $\frac{2}{3} V_{cc}$  and  $\frac{1}{3} V_{cc}$ . Note that on startup the first cycle is longer, since the capacitor must charge between zero and  $\frac{2}{3} V_{cc}$ . On subsequent cycles, it starts from  $\frac{1}{3} V_{cc}$ , so the time for charging will be shorter. The formula for the frequency is given by:

$$F = 1.49 / (Ra + 2 Rb)C1$$

Note that by varying the ratio of Ra  
(Continued on page 56)

## NORTH COUNTRY RADIO: A HAVEN FOR WIRELESS BUFFS

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.

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## Wig-Wag Too

**Q** The Wig-Wag circuit in the May 2002 column is an interesting and compact solution to the problem; however, it can be made smaller. If a 74LS92 integrated circuit is used in place of the original IC3, the original IC2 can be eliminated. In the circuit I provided (see Fig. 1), the new IC2 is a divide by 6 counter that feeds a slightly different decode circuit. IC3a and IC3b decode for counts 1, 2, 5 and 6 for the left lamp. IC3c decodes for counts 3 and 4, and IC3d decodes for counts 5 and 6. The outputs of IC3c and IC3d are combined to drive the right lamp. This creates two pulses on the left, two pulses on the right, and then two pulses on both. Thanks for an interesting magazine filed with a variety of electronics subjects.—Glenn Bray

**A** Glenn taught this old dog a new trick. I had made the assumption that the 74LS92 was similar to the sister counters, 74LS90 and 74LS93, having an output that can be decoded in a binary fashion. When I worked out a timing

diagram, I found that the circuit would work fine for the first six pulses and then things would go haywire. I contacted Glenn who sent me a timing diagram that he had done and steered me to the data sheets. I quickly found my error.

This counter doesn't belong on the same pages of the data sheets as its cousins. It has a clean binary output for the first six states (up through count "5"), but when it hits count "6," the "binary" output jumps to "8" because the first three flip-flops in the counter reset to zero while the "D" output goes high. The chip does fine as a divide-by-6 counter with a shortened BCD output using only the A, B, and C outputs. The final D output is a true divide-by-12 output for frequency-division purposes with a symmetrical output, and that is probably why the first three flip-flops reset on a count of "6." A straight binary counter with a forced reset of all four flip-flops after a count of "11" was reached would produce a non-symmetrical output as does the 74LS90.

It's also interesting how different

approaches to a problem often produce different solutions. I started with a timing diagram that I knew I needed for the lamps and worked my way back. I would guess that Glenn saw that there were six distinct states to the solution and jumped on a divide-by-six counter as a start. For a hobbyist, either solution will work. If this were to be a production of 100,000 units, then consideration would have to be made as to how much money can be saved by killing off one chip. That could be considerable, in this case saving a few tens of thousands of dollars. However, the 74LS92 is a bit more difficult to find, and that could be another problem altogether. I had only three of those in stock compared to having upwards of 300 or more various versions of the 7490 and 7493.

## ESD Wrist Straps

It's interesting that I have yet to see a text on the CompTIA A+ Computer Technician Certification that has an accurate section on the electronics portion of the test. As far as I can tell, all of those books are written by "computer nerds" who have zero electronics experience. One such book states that the reason for the resistor in the ground strap is to protect circuits from electrostatic discharge (ESD). If that's all we wanted to do, we wouldn't have a resistor in there, would we? That resistor is there to protect the technician in case he or she contacts a live, higher-voltage circuit.

One unidentified reader e-mailed me to mention that most safety recommendations state that such straps should NOT be worn when working on high-voltage circuits. That is very true, and all of the A+ texts that I've seen do stress that point. If you get into the high voltage inside a computer monitor while wearing a wrist strap, that 1-megohm resistor will not limit current to a safe value for the technician. At least 10 milliamps of current will flow if you contact 10KV or more, so things can get lethal. Wear a wrist strap only while working on the computer proper or with items scattered on a static-free work mat and not while working inside a monitor that

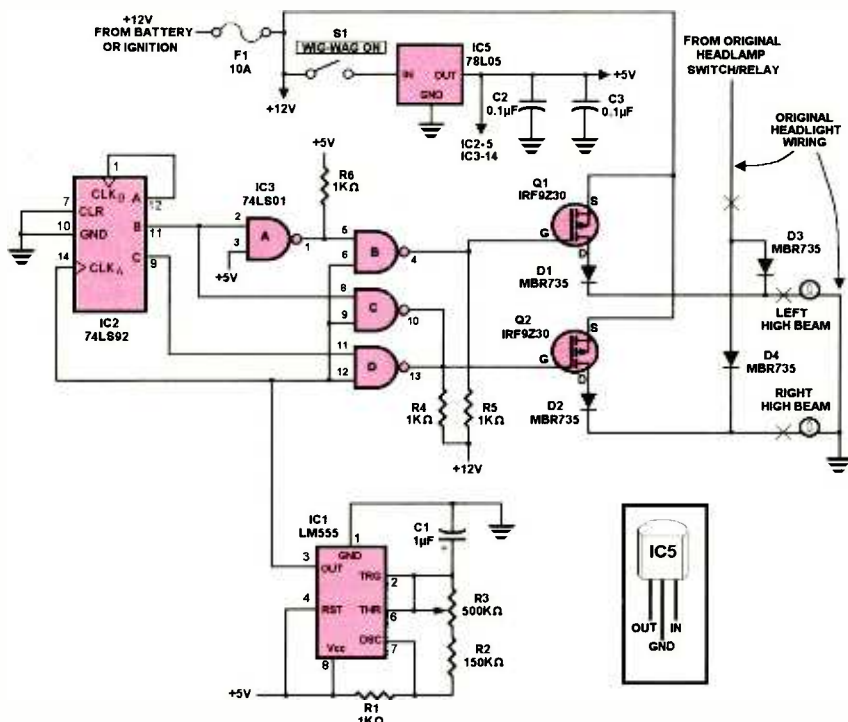


Fig. 1. This modified "Wig-Wag" circuit is an even smaller version than was originally presented and uses the output of a 74LS92 counter to generate the needed timing.

uses a cathode-ray tube. (See previous discussion in June column.)

## Monodigichron Help

In the July 2002 column, a reader asked for help in finding corrections for an "ancient" project. Reader Lynden McIntyre writes to mention an article in the January 1978 issue of **Popular Electronics** (page 70) titled "All Clock Chips Are Not Alike" by Michael S. Robbins. He says that according to the article, "National [Semiconductor Corp.] made a change in chip size in the chips dated 75/76 and the multiplex resistor (100K ohms) needs to be 200K or 300K ohms to work properly. The capacitor should be + or 2/3 [should that have been 1/3, Lynden?] its value to match the resistor change respectively. Pin 23 is the MUX timing and in the Monodigichron circuit, this pin is connected to IC1, Q1, Q2, and A3. The author states that this change should be applied to the clock in the January 1976 issue of **Popular Electronics** and other past circuits."

Unfortunate circumstances have forced me to box up all my old magazines, Lynden, so I won't have easy access to them for a few months. I would normally check the cited article thoroughly to make sure that we've covered all the bases. In the interest of getting that Monodigichron circuit operating, I won't worry about double-checking things this time. Thanks for your input on this one. It would have taken a really thorough and in-depth magazine indexing system to have found that article in any way except for a cover-to-cover read of every issue.

## "Well!" said Mr. Benny.

Last month, I had an analog design for a timer circuit that was used as the annunciator for monitoring the activity of an otherwise silent submersible deep-well pump. I threatened to try a digital version in this month's column. I'm going to have to put that one off until I can get something better than my first run at the digital version. Try as I might, I still end up needing two timers. By the time I'm done, I still end up using 4 or 5 chips compared to 4 chips in the analog version; and the "digital" circuit is still a third analog. I was building the thing around a 4017 Johnson counter, a CMOS chip that I've learned to like quite a bit, running it with a one-second

clock. Even if it does use an extra chip, it will eliminate around 20 passive components and 40 holes in a circuit board, so maybe it's a good trade-off. I still want it to be more digital than I have at the moment, so I'll wait. If I can't improve on it, I'll publish it anyway. I hope none of you were holding your breath for this one. Readers, feel free to submit a digital version of the annunciator portion of the circuit. If it works and has a minimal parts count, I'll run it in the column, give you all kinds of credit and maybe send you a few coupons that I've clipped from the Sunday paper. The input to the annunciator circuit will still be a zero-volt level

when the pump is off and a +12 volt level when the pump is on. See last month's column for the other specifications.

## The Whiners

**Q** *Thanks for another informative issue of Poptronics. I am now retired, but have spent my entire life in electronics, both professionally and as a ham with the same call since 1948. 37 years of that professional life was spent with 2-way radio and microwave, the last 15 as the department director of communications for a state-controlled turnpike.*

*In the July issue you list a number of sources of interference from automobile ignition sys-*

### 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.electronics.repair*, *sci.electronics.components*, *sci.electronics.design*, and *rec.radio.amateur.homebrew*. "For sale" messages are permitted only in *rec.radio.swap* and *misc.industry.electronics.marketplace*.

Many electronic component manufacturers have Web pages; see the directory at [www.hitex.com/chipdir/](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 Claggg, 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.

tems. There is one major one just now becoming more and more prevalent that you missed. I have had trouble with my own mobile installation along with many others who have the newer cars that use a fuel-tank-enclosed fuel pump. These are notorious for excessive ignition-type noises. I know of particular noise problems with both Ford and GM cars and trucks. I was not exposed to Chrysler products or foreign vehicles in the same way, but the nature of a remote fuel pump lends itself well to much ignition noise. Mostly it will sound a lot like spark-plug-type interference, but not as strong. It does go up in pitch with higher engine speeds.—Carl Fisher

**A** Carl, I had forgotten about those little monsters in the tanks. After replacing one on our Cherokee, I never did understand why they don't mount those things externally so that they're easier to replace. It makes no sense to place a motor that runs almost constantly (i.e., prone to a high failure rate) in such a beastly location. At least on older vehicles with steel tanks, the pump being inside that tank means that most of the RFI is sent out along the electrical lines and not radiated through the tank. The new vehicles with plastic tanks don't fare quite as well, and the noise is a little harder to squelch. Thanks for your insight into our noise problem. I believe that I was spending most of 1948 in gestation. Best of fortune in those active "retirement" years you mentioned in your letter.

## Reruns

So far, this column is turning into one dedicated to following up on previously-published topics. I guess that happens sometimes. I wanted to mention that reader Eloy Gonzales and others have reported that they have built the "In-Circuit Capacitor Checker" project using the layouts that I had provided in the February 2002 column and on the "new" Electronic Bench forum ([www.poptronics.com](http://www.poptronics.com)), and that they have worked well. This was good information for me, since I had designed the layout but had never built the project; so it hadn't been verified as a good layout yet. Whew! Now the pressure's off.

## Nuclear Timekeepers

**Q** I have read *Poptronics* and its predecessors for many years. However, I have never seen an article about atomic clocks.

*Mine is wonderful except when it goes crazy. Apparently, since it is inside the house which probably shields it, it does not get a good RF signal. What is the frequency? When is the signal sent? What is the code? I'd love to see something on this.—J.B., Visalia, CA*

**A** Because of my background in metrology, this is a subject near and dear to my heart to which I could easily devote three months of columns. You have to go back 30 years to find any article on that subject. In the 1970s, **Radio-Electronics** featured a construction article for an "atomic clock."

We can measure time more accurately than anything. If we could measure the distance between a stake in the center of Oklahoma City and a stake in the center of Tulsa (about 100 miles) with the same precision, we would be accurate to around 6 micrometers. To really drive the precision home for electronics students here in southeast Missouri, I calculated it once in deer-hunting terms, which may be politically incorrect for some of you. Disregarding all physical properties of and effects on projectiles, if you could aim and a rifle could fire with that same accuracy, you could sit on the moon with your rifle and pick the spot on a deer you wanted to hit.

Normally, the term "atomic clock" is used synonymously with "atomic frequency standard," which is usually a cesium-beam frequency standard or could be the less-accurate rubidium frequency standard. Put simply, cesium-beam standards lock a microwave oscillator onto the very accurate atomic vibrations of the cesium atom as developed in a special cesium beam tube. Agilent (formerly Hewlett-Packard) is undisputedly the world leader in that technology. World time and frequency standards are based upon the cesium standard, which is a primary standard. A primary standard is inherently accurate and cannot be adjusted. They can only be compared against other primary standards and checked for general agreement.

In our hobbies, our best frequency standards were usually a crystal calibrator in a shortwave receiver or the crystal oscillator timebase in a frequency counter. Receiving the standard frequency shortwave broadcasts of WWV, WWVH or CHU (Canada) was our best method of checking these standards for accuracy, and they weren't that great. Because of the effects of the ionosphere on radio signals, good, ovenized crystal oscillators

have better stability than the shortwave broadcasts. Still, for many applications, the shortwave broadcasts are great.

In industry, you could use more expensive VLF receivers to pick up the 60-kHz WWVB broadcast. The accuracy was far better, especially if you compared the signal against your local standard for several days. Ultimately, the best accuracy could be found only if you had access to a rubidium or cesium frequency standard.

There was a refreshing burst of technology in the 1970s when television networks began using rubidium or cesium standards for their broadcasts. This kept the color shifts to nearly zero as the signal changed sources. The National Bureau of Standards, or the NIST (National Institute of Standards and Technology) as we now know it, monitored the network broadcasts and published monthly frequency offsets in arrears. Inexpensive circuits could be made to connect to your television for a near-cesium-quality frequency standard. Unfortunately, frame synchronizers became popular at the network and local levels for their ability to keep a picture on the screen with a signal loss, but these units destroyed the ability to maintain a lock on the originating time standard, so the NIST dropped that service.

GPS (Global Positioning System) satellites have offered a new method of deriving cesium-accurate time signals at an affordable price. For around \$3000, you can buy a GPS receiver that will phase-lock onto the cesium standard used by the satellites and provide nearly the same accuracy and precision as owning a \$40,000 cesium-beam standard.

Depending upon the brand, the clock you have picks up the radio signal from one of the HF (high frequency) WWV/WWVH broadcasts or the LF (low frequency) signal from WWVB. Embedded in any of those signals is a digital time code that the receiver demodulates and translates into the correct time of day. For several years, Heathkit sold the "Most Accurate Clock" kit that scanned the 5-, 10- and 15-MHz WWV/WWVH broadcasts and selected the strongest signal. We kit builders like our finished kits to light up and do something tangible when we first turn them on. Unfortunately, when you first turned "The Most Accurate Clock" on, it sat there with a blank display, dumb as a box of rocks, until it finally

accessed and decoded several consecutive minutes of time signal. For a kit builder, the process was unnerving. In my case, the clock didn't light up until after it had operated overnight, because the internal whip antenna didn't receive the best signal.

If your clock has an external antenna similar to the RadioShack 63-970 Radio-Controlled Clock (the proper name for one of these appliances), try repositioning the antenna 90 degrees from its current location and/or find a spot near a window that faces time mecca: Ft. Collins. If the clock has a built-in antenna, you'll have to move the entire clock to another spot, again a 90-degree shift possibly improving the reception at the internal antenna. You may have to go so far as to buy some strong suction cups so you can mount it in a Colorado-facing window. Of course, if you're living outside of the areas covered by a compatible time-signal transmission, the clock simply will not work.

NIST has a Web page that is a wealth of information about all of its timekeeping services. Nearly everything to know about the time and frequency stations, including the details of the broadcast digital time codes, as well as information on the types of clocks similar to yours are on the site. It's at [www.boulder.nist.gov/timefreq](http://www.boulder.nist.gov/timefreq) and is a fascinating site to explore.

## Prospective Authors

**Q** *I have been trying to ask the editors and producers via e-mail a simple question. I understand how busy all of you may get with mailings, but if there are too many to answer, then their e-mail addresses should not be posted. How do the featured projects get selected for print? Are the projects submitted by enthusiasts or just ideas from the staff? If they are projects submitted by enthusiasts, then how does one go about submitting a project?*

**A** Things do get hectic around the Gernsback office depending upon what time of the month it is and whether there is a lot of work required to straighten out new articles, layouts, authors, columnists, or whatever. Regular magazine staff rarely write for the magazine. Most articles are written by "outside" authors, and even regular columns like this one are generated by "contributing editors." Most of us haven't even seen New York, let alone live there.

Your first mistake may be that you're asking them, "Hey, how would you like me to write an article on atomic-referenced clocks?" If you're kicking tires at the car dealer and some goofy guy comes up to you and says, "Hey, buddy, I'll build you a car better than one of these for only two hundred bucks," you're probably not going to waste any time putting a little distance between you and him. In other words, since the editors don't know you, don't ask about a potential article. Instead, send them the cleanest, nicest-looking article you can conjure up. Slap them in the face with what you can do rather than making them question your abilities. It'll save you a lot of time, too.

How do articles get selected? The selection process depends upon several things. The subject should be one that will interest readers. It should be well-written using good grammar and have that elusive balance between being concise and providing sufficient detail. The article will be an example of the use of traditional high school theme elements. You should have nice drawings, illustrations, and photographs included. It shouldn't be too complex for the scope of the magazine, since the average reader is a hobbyist and not a Ph.D. electronics engineer. Make darned sure that it's your material and not someone else's. Look at the average feature article in the magazine for length. If you run your word processor with the columns set for 2.13 inches, a top and bottom margin of 1 inch and a 12-point font, you'll be close to generating one magazine column with each page, which is the way "Q & A" is set up. But they're experimenting with layout, and you'll notice that many articles are two columns per page, fonts vary, and no longer are all schematics being redrawn in the official **Poptronics** form.

As for submission, I would suggest that you send in your article in "typed," single-sided, full-page, double-spaced format. Illustrations should be separate from the text, included as separate pages in the finest, neatest, clearest form you can produce. Illustration captions should be complete sentences that help to draw the readers' interest to your article. Don't fold anything and send it in a 9- x 11-inch craft envelope. Don't send in anything that you want returned in case something awful happens somewhere along the line.

Your cold article submission is just

like a job application and resume, and you want to put your best foot forward. If the editors see out-of-focus photos and sloppy, pencil-drawn schematics, you'll never get the "interview." Magazine editors salivate over sharp, black-and-white, 8- by 10-inch glossy-finish photos. The less work they have to do increases your chance for selection. Of course, if you've been reading issues from a year ago, you'll note that there are exceptions to the selection process. Some articles selected for publishing have varied a bit from the traditional choices and have generated appropriate reader feedback in the process.

## 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.

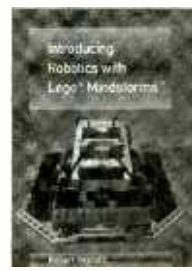
Send questions to Q&A, **Poptronics**, 275-G Marcus Blvd., Hauppauge, NY 11788 or to [q&a@gernsback.com](mailto:q&a@gernsback.com), but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K.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

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## Humidity High Jinks

Everybody talks about the weather, but do you know how the different forces work? This month I talk about humidity and how to measure it.

A recent editorial in *Sensors* magazine really caught my attention. It talked about the migration of smart sensors into everyday appliances—something beyond a simple sun-up/sun-down lamp post fixture. They were alluding to a Web-linked microwave kitchen that starts cooking while you drive home—eh, not my cup of tea. Some things are better left to hands-on.

It got me to thinking about the role that microcontrollers (like the PIC) and sensors play in our everyday lives. Already you'll find a microcontroller monitoring more than one sensor under the hood of your car to meter the fuel mixture for better gas mileage. They can also make sure your air conditioner doesn't turn on until it's time for you to come home, and not while you're at work in an air-conditioned office. I find these trends fascinating.

Another thing that fascinates me is the weather, and what better excuse to segue into this month's column than to pair the two: PICs and sensors. Coincidentally, I recently ran across a cheap humidity sensor that resparked my interest in monitoring atmospheric conditions. This month I put humidity and its sensors into perspective—using a PIC, of course. And so our story begins.

### Give Me Water!

I'm sure most of our readers know about an effect called the wind chill factor, where it really feels colder than the thermometer says. Did you know that an abundance of moisture in the air can cause the opposite—overheating? Of course you do—it's called humidity.

Even though it's commonly referred to as humidity, the correct term for water in the air is *relative humidity*, or RH for short. In this condition it's called water vapor, and the point at which the

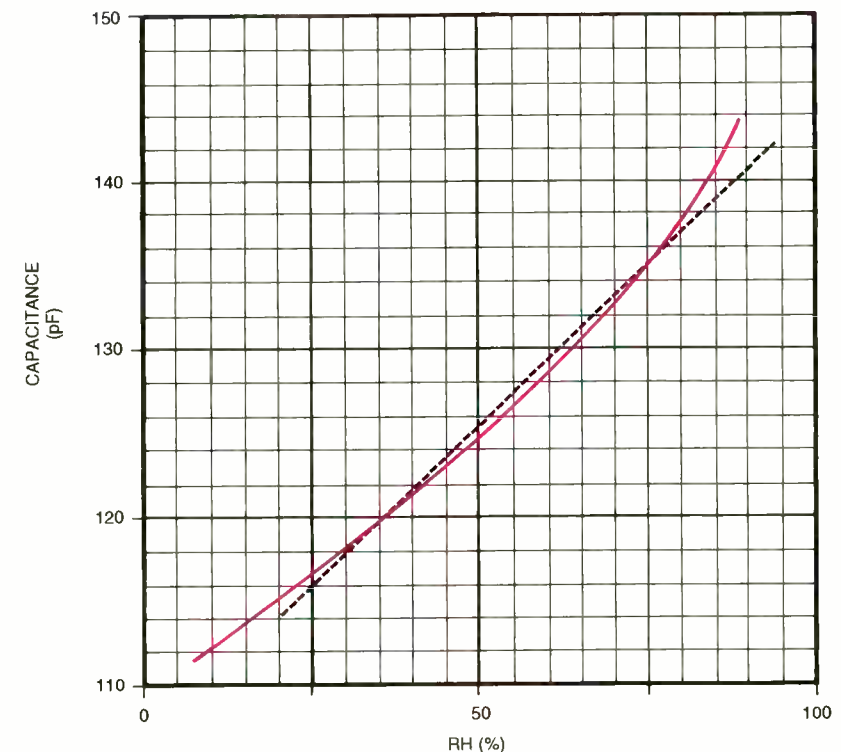


Fig. 1. The RH sensor converts humidity into capacitance.

air reaches water saturation is called the dew point. (Fog is a special case of saturated air that you can actually see.)

Relative humidity is the amount of water in the air relative to the air temperature. The warmer the air is, the more water vapor it can hold. Why is humidity important to us? Our body cools itself through perspiration, which is a venting of body moisture to the outside air—and like the wind chill effect, it cools us. The higher the RH factor, the more water in the air, and the hotter we feel because the skin moisture can't evaporate as quickly.

### About The Sensor

Measuring RH can be tricky. The problem has always been matching the sensor to both temperature and moisture, and a lot of methods have been tried over the years. Most RH sensors

today are capacitance transducers—as the humidity increases, so does the capacitance. This is the type of RH sensor I'll be using for this project (Fig. 1).

If you read last month's column, then you know that I used an *analog-to-digital* (A/D) converter to change a temperature into a voltage and then into a digital value that the PIC processed for display on an LCD. I could have done the same this time by using the capacitance to control the frequency of an oscillator and then using a voltage-to-frequency (F/V) circuit to convert the frequency into a voltage. That takes a lot of external hardware and is a waste of PIC power.

Instead, I used the capacitance to control the pulse width of a monostable multivibrator. As the RH increases, so does the width of the output pulse. Not only does it reduce the external semi-

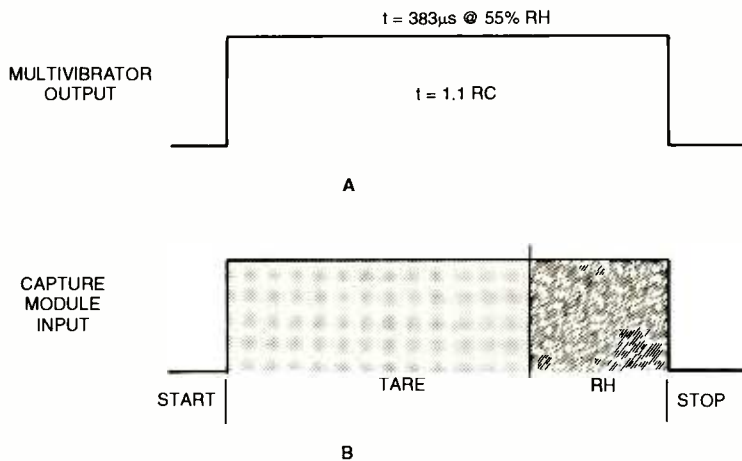


Fig. 2. Scaling the display is achieved by using a "tare" value to offset the latent capacitance of the sensor. This practice also simplifies the program code.

conductor count to a single 555 timer IC—more importantly, it lets me exploit the Capture feature of the 16F628 PIC.

Time is measured in increments, whether those increment be in seconds, hours, or days. This is something a microcontroller like the PIC is good at, because it has a stable clock reference to which an event can be compared. Usually this is done by using the event (in this case, the output pulse from the monostable multivibrator) to begin a counter that counts the number of clock pulses between the beginning and ending of the event. (See Fig. 2a). This is basically what the 16F628 Capture mode does.

### About The Capture Module

Seems simple enough: Start the counter on the rising edge and stop it on the falling edge. However, the number that's returned using this method has to

be scaled using an algorithm (oh, no...not math!) so that the display will read 0% (no moisture) to 100% (fully saturated). This can be tricky: The algorithm has to be fitted for the sensor in hand because no two RH sensors are exactly alike.

Well, I thought and thought, and came up with a simpler way that doesn't involve a conversion algorithm. To understand my ploy, think of a truck going through a weigh station. First the truck is weighed, then the scale master subtracts the weight of the truck from the measured gross weight and comes up with a number that represents the actual weight of the load aboard the truck. The difference between gross and load weight is a "tare."

Guess what? RH sensors have a tare, too, in a latent capacitance value. That is, even at zero humidity the sensor has a capacitance that can be measured. So, it

was a simple task to scale the tare weight so that at 0% the LCD read 00.0, and then measure the time between the tare and the end of the pulse (Fig. 2b). Yes, this took some math to figure out, but you don't have to see it. Suffice it to say that a timing resistor of 2.4 megohms gives exactly 100 clock pulses between a pulse width of 945  $\mu\text{s}$  and 1045  $\mu\text{s}$ —which is the capacitance change of the RH sensor between 0% and 100% for the values above.

Enter the Capture module. The Capture module is a unique PIC feature that acts a lot like a truck scale. On the rising edge of an event, the Capture module starts a counter...well, counting. After a the pulse ends, the tare is subtracted from the time recorded and the difference saved.

### Onto The Capture Code

For this discussion, refer to the code in Listing 1. The Capture module has a 16-bit register (actually it's two 8-bit concatenated registers that are assigned high and low priorities) that can be started on either the rising or falling edge of an input signal. For our application, the rising edge is the trigger. The Capture module is set for rising-edge capture on the first line of the "read-humidity" routine (`movlw b'0000101'`) (see Listing 1).

The Capture flag is cleared and a pulse is output to the monostable oscillator to start the timer. A short routine, "rising\_capture\_loop," ensures the monostable has responded to the trigger pulse by detecting a rising edge on its output and turning the trigger pulse off.

This starts the Capture module (`save_start_time`). It also resets the Capture module to respond to a falling edge—the end of the event. So everything goes, counting the clock pulses, until counting is halted on detection of a falling edge of the monostable multivibrator. Now, the real work begins.

A time stamp was recorded when the trigger was initiated, and another recorded when the counting stopped. The time difference is calculated, and the value passed along to the RESULT register. From this, the fixed value of 945 (the tare value, remember) is subtracted. The result is the actual RH—already scaled—ready for direct output to the LCD display.

Notice that the program only reads the lower section (LSB) of the humidity register and not both the upper and lower for the LCD reading. Why, you

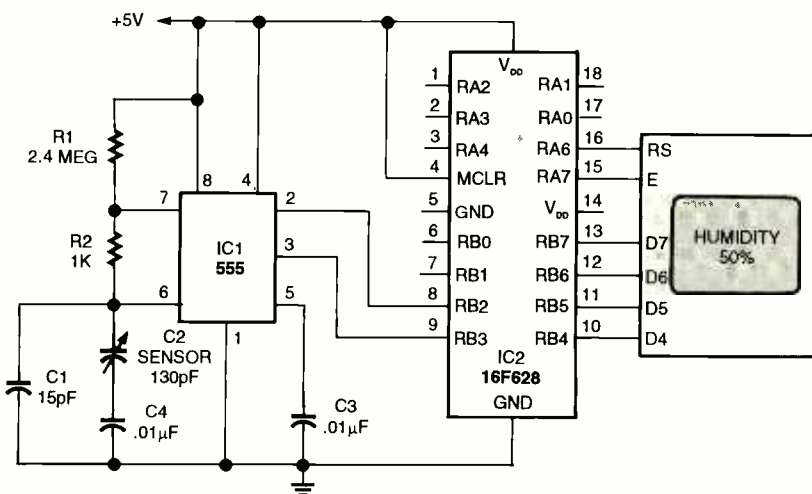


Fig. 3. Above is the schematic of the humidity gauge. The 555 forms a monostable pulse generator; the width of the pulse is controlled by the capacitance of the RH sensor. As the RH capacitance increases, so does the pulse width.



ask? Because the number in that register has a value between 0 and 100. Since both segments of the register can hold 8 bits each, we know that the upper register contains nothing but zeros, so there's no point in looking at it.

### Let's Build It

Enough classroom for today. Let's get our hands dirty and actually make this thing work. Thanks to the Capture module, the external hardware has been reduced to a 555 timer, two resistors, four capacitors, an LCD display, and the PIC itself. The schematic is shown in Fig. 3.

Let's talk about the 555—which must be CMOS type for proper operation—because it is the heart of the circuit. The chip is configured as a monostable multivibrator. Unlike an astable multivibrator, which is free running, the monostable requires an external pulse to start it oscillating. This causes the output (pin 3) to go high. After a time period determined by a resistor-capacitor combination, the output goes low and the circuit resets itself, ready for another trigger pulse to start the timer again.

The RH sensor is part of that timing circuit, and the one I chose has a value of 130 pF at 55% humidity. If you look at Fig. 1 carefully, you'll see that the capacitance curve isn't exactly linear. It deviates by about 1 pF. One way to linearize the curve is to add a small "padder" capacitor across the sensor, like C1 in our circuit. It's not perfect, but it's a lot easier to implement than other methods. I'm sure you'll find more deviation in the RH as you walk past the sensor than you will in the curve itself—I did.

I also noticed that some sensors have a resistance in parallel with the capacitance—a resistance that was affecting the reading. To remove the effect, I placed a .01-μF capacitor in series with the sensor. This capacitance is large enough that it doesn't affect the capacitance value of the sensor ( $C_t = C_{\text{sensor}} + C_4/C_{\text{sensor}} + C_4$ ), but it does isolate the stray resistance to the sensor alone, not the multi-vibrator.

### Calibration

Even though the datasheet specifies 122 pF at 45% humidity (Table 1), it also says that it can vary by as much as ±15%—or 36.6 pF. This variation doesn't affect the linearity, but it will force a change in the value of R1. Using a different type of RH sensor will also

## LISTING 1

```

;*****
**
;*
*
;****          Read Humidity          **
**
;*
*
;*****
**
;Description:   This procedure reads the value of humidity
;               from the attached 555 IC.
;
;Registers Required: Four registers are required in Bank 0, the
;                   y are
;
;                   STARTH ;stores the 16-bit start time
;                   STARTL
;                   FINISHH ;stores the 16-bit finish time
;                   FINISHL
;                   humidity ;stores the result
;
;Pins Required: Two pins are required: on output to trigger the 55
5 input (pin 2)
;
;               and the Capture module 1 input that reads
the 555 output (pin 3).
;
;               #define      trigger      PORTB,2
;               assigned by PIC Capture module 1      EO
RTB,3
;
;               The PORTB,2 pin can be changed to suit any
PIC.
;               The Port direction register (TRIS)also nee
ds to be set.
;
;Procedure Calls:   read_humidity
;
;                   Reads the humidity and places the result i
n the humidity register.
;
;Other Modules Req.: SubInt16.inc
;
;                   The 16-bit integer subtraction routine.
;
;
;*****          Start of Code          *****
***

read_humidity

    movlw    b'00000101'    ;load control register for capture
on rising edge
    movwf   CCP1CON
    bcf     PIR1,CCP1IF    ;clear the capture flag
    movlw   0x00           ;clear timer 1
    movwf   TMR1L
    movwf   TMR1H

    bcf     trigger ;fire negative pulse for 555 trigger

rising_capture_loop

    btfss   PIR1,CCP1IF    ;wait for rising edge on 555 outpu
t
    goto    rising_capture_loop

    bsf     trigger ;rising edge detected, turn off trigger pu
lse

save_start_time

```

(Listing continued on next page) 47

```

    movf    CCP1L,W      ;save start time
    movwf   STARTL
    movf    CCP1H,W
    movwf   STARTH

change_capture_mode
    movlw   b'00000100' ;load control register for capture
    on falling edge
    movwf   CCP1CON
    bcf     PIR1,CCP1IF ;clear capture flag

falling_capture_loop
    btfss  PIR1,CCP1IF ;wait for falling edge on 555 outp
ut
    goto   falling_capture_loop

save_finish_time
    movf    CCP1L,W      ;save finish time
    movwf   FINISHL
    movf    CCP1H,W
    movwf   FINISHH

    movlw   0x00         ;turn off capture mode
    movwf   CCP1CON

subtract_start_finish ;load saved values for subtraction

    movf    FINISHH,W    ;value A is the finish time
    movwf   INTEGER_A_HIGH
    movf    FINISHL,W
    movwf   INTEGER_A_LOW
    movf    STARTH,W    ;value B is the start time
    movwf   INTEGER_B_HIGH
    movf    STARTL,W
    movwf   INTEGER_B_LOW

    call    subtract    ;subtract the start time from the
finish time
                                ;the result is saved in the RESULT
register

subtract_330

    movf    RESULT_HIGH,W ;load result from previous into A
    movwf   INTEGER_A_HIGH
    movf    RESULT_LOW,W
    movwf   INTEGER_A_LOW

    movlw   0x03         ;load 945 into B, fixed va
lue
    movwf   INTEGER_B_HIGH
    movlw   0xb1
    movwf   INTEGER_B_LOW

    call    subtract    ;subtract 945 from the RES
ULT
                                ;place in humidity registe
r

    movf    RESULT_LOW,W ;the humidity value is located in
the
    movwf   humidity    ;lower (LSB) section of th
e register

    return              ;go back to main menu

```

As you know, I program in assembly language using modules. This is the module that converts the 555 output pulse into an RH value.

prompt a change in R1.

Depending on your ambient air conditions, this can be easy or difficult. If you're in an air-conditioned room, it's a

safe bet that the RH is close to 50%. With that in mind, adjust the value of R1 so that the LCD reads 50%. If the original reading is too low, R1 has to be

## PARTS LIST FOR THE HUMIDITY SENSOR

### SEMICONDUCTORS

IC1—555 - CMOS version only  
IC2—16F628 PIC

### RESISTORS

R1—2.4-megohms  
R2—1000-ohm

### CAPACITORS

C1—15-pF  
C2—Philips H1 humidity sensor  
C3—.01-μF  
C4—.01-μF

### ADDITIONAL PARTS AND MATERIALS

LCD display, LM78L05 voltage regulator, 9-volt battery with battery clip, 8-pin IC socket, 18-pin IC socket, prototyping board.

A kit of the above parts is available for \$22 from Futurlec, 1133 Broadway, Suite 706, New York, NY 10010 ([www.futurlec.com](http://www.futurlec.com)), and includes a programmed PIC. A programmed PIC is also available separately for \$12.

increased; too high a reading means you have to decrease R1.

For a more accurate calibration, you'll need to use the Saturated Salt Solution method, which depends on evaporating a salt in a controlled atmosphere. Table 2 is a chart of the saturated salts and their relative humidity value. For best accuracy, the salts should be of lab quality that you can buy from Fisher Scientific ([www.fisherchemicals.co.uk](http://www.fisherchemicals.co.uk)) or The Science Company (800-372-6726; [www.sciencecompany.com/home/prices\\_chems.cfm?site=cosco](http://www.sciencecompany.com/home/prices_chems.cfm?site=cosco)) (see Table 2).

To perform the calibration you need a couple of wide-mouth jars about four inches wide and at least four inches tall. You also need a tight stopper. Dissolve the salt in an amount of distilled water (not tap water) and let it set in a dark place at room temperature so that the air in the bottle saturates with the salt. Insert the RH sensor into the bottle, being very careful not to let it touch the sides or come in contact with the liquid. Replace the stopper, leave everything set for about 15 minutes, and adjust R1 for a proper reading.

If you wish to linearize the scale for better accuracy, take another measure-

**TABLE 1**

PARAMETER	VALUE	UNIT
Humidity range (RH)	10 to 90	%
Capacitance at +25°C; 43% RH; 100kHz	122 ± 15%	pF
Tan δ at +25°C; 100 kHz; 43% RH	≤ 0.035	
Sensitivity between 12 and 75% RH	0.4 ± 0.05	pF/%RH
Frequency range	1 to 1000	KHz
Temperature dependence	0.1	%RH/K
Response time in minutes (to 90% of indicated RH change at +25°C, in circulating air): between 10 and 43% RH between 43 and 90% RH	<3 <5	
Hysteresis (for RH excursion of 10 to 90 to 10%)	=3	%
Maximum AC or DC voltage	15	V
Storage humidity range (RH)	0 to 100	%
Ambient temperature range: operating storage	0 to +85 -25 to +85	°C °C
Mass	=1.3	g

**TABLE 2**

SALT	FORMULA	RH @ 25C
Lithium chloride	LiCl	11.3%
Potassium acetate	KC <sub>2</sub> H <sub>3</sub> O <sub>2</sub>	22.5%
Magnesium chloride	MgCl <sub>2</sub>	32.8%
Potassium carbonate	K <sub>2</sub> CO <sub>3</sub>	43.2%
Magnesium nitrate	Mg(NO <sub>3</sub> ) <sub>2</sub>	52.9%
Sodium chloride	NaCl	75.3%
Potassium chloride	KCl	84.3%
Potassium nitrate	KNO <sub>3</sub>	93.6%
Potassium sulfate	K <sub>2</sub> SO <sub>4</sub>	97.3%

ment using a different salt. It's best to use a low RH salt like magnesium chloride for the first measurement and a higher RH salt like sodium chloride for the next. Compare the two and see if they fall at the right points on the display. If not, adjust the tare value located in the INTEGER\_B register under the "subtract\_330" heading. If the points are too far apart, increase the tare; reduce the number if they are too close together.

When doing this calibration, be aware of the sensor's limitations. It's specified for a range between 10% and 90%, and the closer you get to the end points the more error it will have. Before you go say "oh, great!" keep in mind this isn't supposed to be a laboratory-quality instrument. Instead, it's designed to be a meteorological element for measuring everyday humidity with reasonable accuracy. Other RH sensors, like those from Humirel, have a wider range

and are more linear—and will work fine in this design with the above-mentioned changes. Note that the more accurate the sensor, the more it costs.

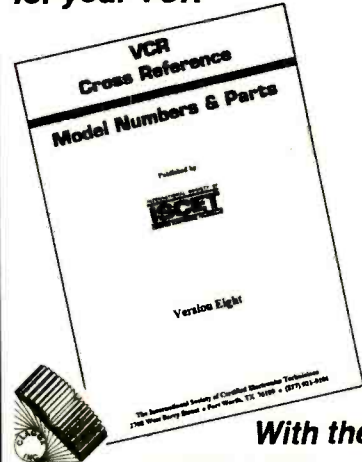
That's it for now. Next month's project is a rotary encoder processor that can be used for absolute shaft position and/or rotational speed. It makes a fine position monitor for a CNC tool—or a nifty wind indicator. 'Til then, have fun. **P**



*"I have one little problem, I don't have any idea what I'm doing."*

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## Bi-Pedal Walker Robot, Part 3

Welcome to Part 3 of our bipedal walker robot. In Part 2 we left off with a single leg on the stand operating from a Windows interface. We continue by building the second leg. The second leg is built the same as the first and is attached to the hip bar.

### Creating A Natural Stance

When the servomotors are attached to the U-brackets, I positioned the servomotor shaft in its center position and placed the servomotor itself in a center position inside the U-bracket. This provided equal servomotor travel in both the clockwise (CW) and counter clock-

wise (CCW) rotation. What I quickly found was that I wanted the bi-pedal robot (legs) to be in a natural stance (balanced and neutral) when standing still. By natural stance I mean that each servomotor should be in (or close to) its center position when in a resting position.

The natural stance position I am trying for this robot is shown in the photo. To accomplish this I needed to offset the servomotors from their original center position. The servomotors are numbered 1 through 4 for the first leg starting at the top with servomotor number one and working down. In the second leg the servomotors are labeled 5

through 8, starting at the top with servomotor number 5.

Examine the photo. Servomotors 1 and 5 are angled at 45 degrees. This means that the U-bracket is at 45 degrees in reference to the servomotor when the servomotor shaft is at its approximate center. Servomotors 2 and 6 are angled at -90 degrees. Servomotors 3 and 7 are angled at -45 degrees. The finished leg is shown to the left.

This is my current starting position and may change as I continue to develop the bi-pedal robot and its walking gait. It's easy to see that other offset angles are possible as shown in Fig. 1. Again let

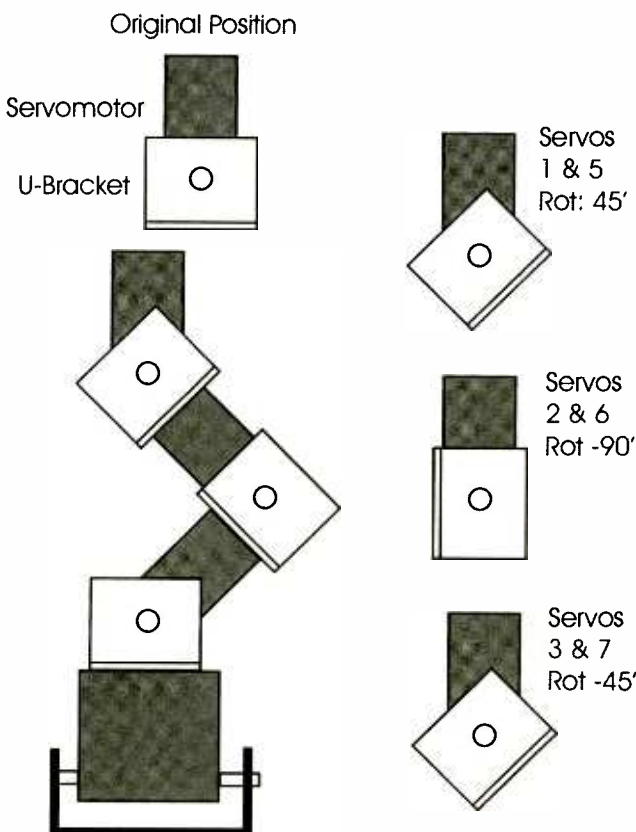


Fig. 1. This is my current starting position and may change as I continue to develop the bi-pedal robot and its walking gait. It's easy to see that other offset angles are possible.

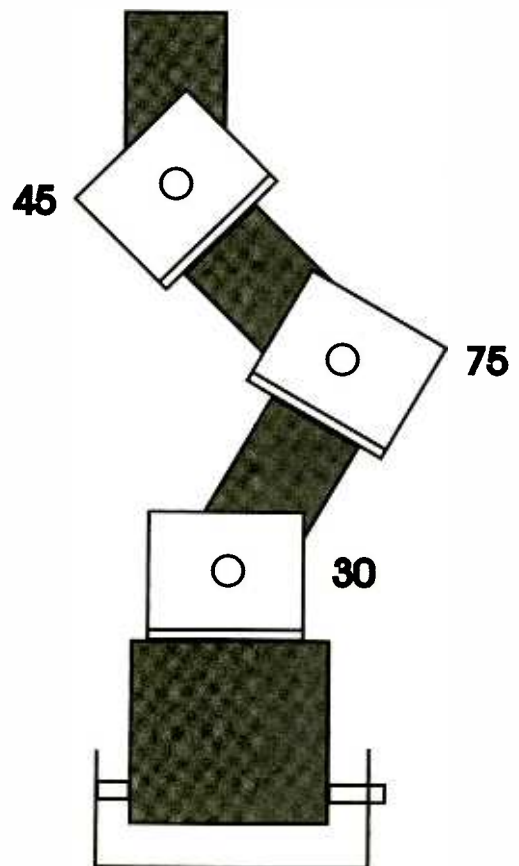


Fig. 2. Using the Windows servomotor program, I am able to position the legs to stand up by themselves without any support from the stand.

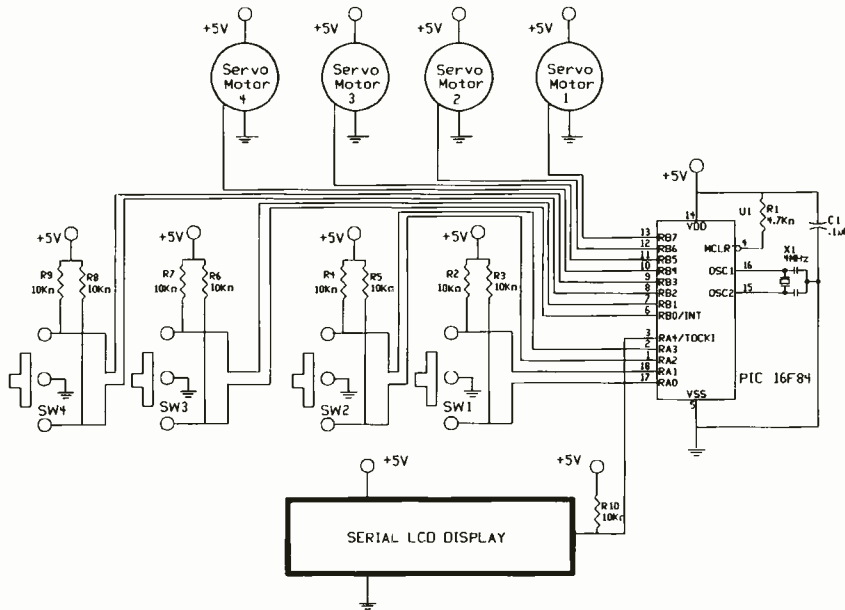
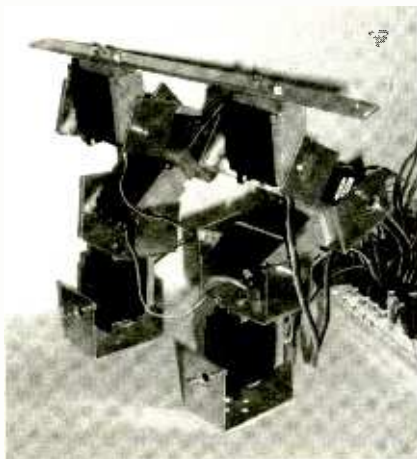


Fig. 3. While the schematic calls for four SPDT switches, I have found it easier just to touch the base of any 10K resistor with a ground wire to activate that function.

me repeat this, I may change the servomotor offset angles in the future.

### Learning To Stand

Using the Windows servomotor program I am able to position the legs to stand up by themselves without any support from the stand, see Fig. 2. However when I tried to move the servos to take a step forward, the bi-pedal falls. What's happening is that the slow update speed (2-3 Hz) of the Windows interface to the PIC servomotor controller makes all the servomotor movements jerky and continually shaking—not what you need when learning how to walk. In addition because of the slow update speed, the servomotors are not producing the torque they are capable of producing. So



The natural stance position I am trying for this robot is shown in the photo above. To accomplish this I needed to offset the servomotors from their original center position.

when attempting to take a step the servomotors are not strong enough to hold their position firmly.

This situation can be corrected by increasing the servomotor update speeds from 3Hz to the proper 50 Hz. My first approach was software. I again tried to increase the baud rate from 2400 to 9600 baud. A 4X increase in update speed just might do the trick; unfortunately, at 9600 baud serial errors crept in again and it failed. Nonetheless, it was an interesting experiment; at 9600 baud the legs were never stable, jerking and dancing about on their own. However, it showed how strongly and quickly the servomotors can respond.

What I need at this point is to achieve a higher servomotor update speed. The weak link is the serial interface between Windows and the PIC Microcontroller. Since the PIC microcontroller by itself

### LISTING 1

PICBasic Pro Program:

'Manual control of four servomotors using 4 SPDT switches

' Use B1 to hold pulsewidth variable for servo 1  
' Use B2 to hold pulsewidth variable for servo 2  
' Use B3 to hold pulsewidth variable for servo 3  
' Use B4 to hold pulsewidth variable for servo 4

'Declare Variables

B1 VAR BYTE  
B2 VAR BYTE  
B3 VAR BYTE  
B4 VAR BYTE

'Initialize Variables

B1 = 150  
B2 = 150  
B3 = 150  
B4 = 150

'start servo 1 at center position  
'start servo 2 at center position  
'start servo 3 at center position  
'start servo 4 at center position

Pause 1000  
tialize

'Wait a second for LCD display to ini-

start:

'Output servomotor position

PulsOut PORTB.7, B1  
PulsOut PORTB.6, B2  
PulsOut PORTB.5, B3  
PulsOut PORTB.4, B4

'send current servo 1 position out  
'send current servo 2 position out  
'send current servo 3 position out  
'send current servo 4 position out

' Check for switch closures

IF PORTA.0 = 0 Then left1  
IF PORTA.1 = 0 Then right1  
IF PORTA.2 = 0 Then left2  
IF PORTA.3 = 0 Then right2  
IF PORTB.0 = 0 Then left3

'is sw1 left active?  
'is sw1 right active?  
'is sw2 left active?  
'is sw2 right active?  
'is sw3 left active?

(Listing continued on next page) 51

```

IF PORTB.1 = 0 Then right3      'is sw3 right active?
IF PORTB.2 = 0 Then left4      'is sw4 left active?
IF PORTB.3 = 0 Then right4     'is sw4 right active?

'Print servomotor data @ 2400 baud Inverted
'Note Serout command will add pause to routine.

SerOut PORTA.4,4,[254,128]      'LCD cursor to line 1 first position
SerOut PORTA.4,4,[#B1," ",#B2," ",#B2," ",#B4," "]

GoTo start

'Routines for Servomotor 1
left1:
B1 = B1 + 1                    'increase the pulse width
IF B1 > 254 Then max1          'maximum 2.54 millisecond
GoTo start
right1:
B1 = B1 - 1                    'decrease the pulse width
IF B1 < 75 Then min1          'minimum .75 millisecond
GoTo start
max1:
B1 = 254                       'cap max B1 at 2.54 milliseconds
GoTo start
min1:
B1 = 75                         'cap min B1 at .75 millisecond
GoTo start

'Routines for Servomotor 2
left2:
B2 = B2 + 1                    'increase the pulse width
IF B2 > 254 Then max2          'maximum 2.54 millisecond
GoTo start
right2:
B2 = B2 - 1                    'decrease the pulse width
IF B2 < 75 Then min2          'minimum .75 millisecond
GoTo start
max2:
B2 = 254                       'cap max B2 at 2.54 milliseconds
GoTo start
min2:
B2 = 75                         'cap min B2 at .75 millisecond
GoTo start

'Routines for Servomotor 3
left3:
B3 = B3 + 1                    'increase the pulse width
IF B3 > 254 Then max3          'maximum 2.54 millisecond
GoTo start
right3:
B3 = B3 - 1                    'decrease the pulse width
IF B3 < 75 Then min3          'minimum .75 millisecond
GoTo start
max3:
B3 = 254                       'cap max B3 at 2.54 milliseconds
GoTo start
min3:
B3 = 75                         'cap min B3 at .75 millisecond
GoTo start

'Routines for Servomotor 4
left4:
B4 = B4 + 1                    'increase the pulse width
IF B4 > 254 Then max4          'maximum 2.54 millisecond
GoTo start
right4:
B4 = B4 - 1                    'decrease the pulse width
IF B4 < 75 Then min4          'minimum .75 millisecond
GoTo start
max4:
B4 = 254                       'cap max B4 at 2.54 milliseconds
GoTo start
min4:
B4 = 75                         'cap min B4 at .75 millisecond
GoTo start

```

is capable of handling multiple servomotors without any problem, I decided to abandon the Windows interface and build a self-sufficient PIC servomotor controller.

### Back To The Hardware

In the past I have learned that to control a servomotor from a PIC chip requires a minimum of three I/O lines. One I/O transmits the pulse width (positioning information) to the servomotor and the other two I/O lines read switch closures for CW or CCW rotation. The 16F84 has 13 I/O lines available. Using this PIC microcontroller allows us to control four servomotors (12 I/O line) plus have one extra I/O line we can use to display the servomotor positions.

Since each circuit can control four servomotors (1 leg) we need two identical circuits to control two legs. The schematic shown in Fig. 3 will control one leg manually. While the schematic calls for four SPDT switches I have found it easier just to touch the base of any 10K resistor with a ground wire to activate that function.

The hex file for the above program (current version and/or improved versions) may be freely downloaded from [www.imagesco.com/catalog/biped/walker.html](http://www.imagesco.com/catalog/biped/walker.html). The weak link in this program is the LCD display routine; it's taking too much time to display the pulse width numbers for each servomotor. With the LCD display routine in the program, the servomotors are still jerky—faster than the Windows interface program, but still a little slow. When I removed the LCD display routine from the program and replaced it with a standard 16-millisecond pause, all servomotor movements become smooth and strong.

I will attempt to tweak the program to improve the LCD display routine; any updates to the program will be on the Web site address above.

### Next Month

Next month we will continue our work with the bi-pedal walker. We will work out a simple walking gait, using the PIC servomotor controller(s). Following this we will begin to design and build small skid-resistant footpads to attach to the bottom servomotors. The footpads may incorporate the pressure sensors we spoke about in Part 1 (if necessary). Finally we will replace the hip bar with a small platform to hold our bi-pedal's power supply and electronics. P

## Repair Brief: RCA EFR485 Color TV Case History

This is the first of an occasional "Service Clinic" dealing with the repair of a specific piece of equipment from my archives. More of these can be found on my Web site, [www.repairfaq.org](http://www.repairfaq.org), under "Sam's Repair Briefs." While it isn't all that likely you will see the identical model with the identical problems, the methodology can hopefully be transferred to other troubleshooting situation.

**Patient**—My color television—the one I actually bought new (what a concept) at a discount store (after the yoke died on my Zenith B/W 21-inch tube set from the 1960s). The RCA was about four years old at the time of this failure.

**Symptoms**—At first, I just thought the camera work on the show I was watching was a little strange, maybe the lighting at dusk or something like that. When the commercials also looked strange, it was obvious that the TV was the problem. There were no yellows or blues! All colors were in shades of red, orange, and cyan. This makes bananas look particularly icky.

**Testing**—I tried different channels, adjusting the user controls, etc. No change. Black-and-white programs were normal, and turning the color control all the way down resulted in a normal B/W picture.

### The Mystery Unfolds

Therefore, the CRT and its drive are fine, no missing colors. This is a case of messed-up colors—and there can be only one small area of the TV's circuitry that can be responsible—the chroma decoder. I suppose, a short between two of the primary color signals—say blue and green—could result in a somewhat similar symptom, but it was clear by rotating the tint control that this simple

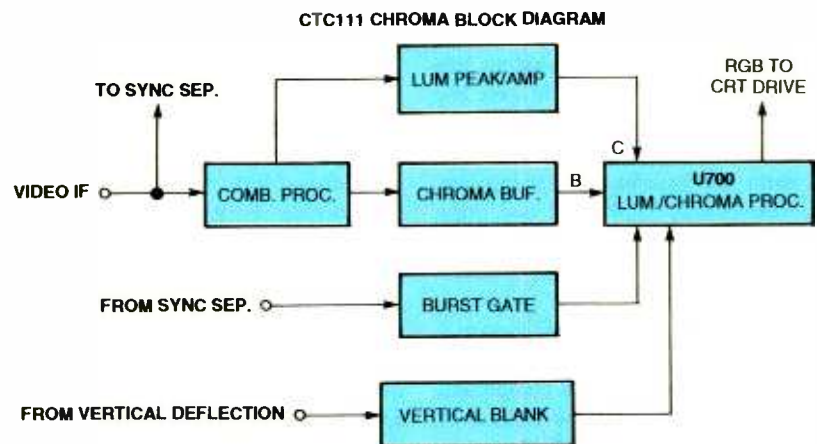


Fig. 1. This CTC111 Chroma Block Diagram was useful when troubleshooting for faults involving the loss of a video signal. Compilations, such as Sam's PhotoFacts contain valuable diagrams and schematics for various equipment.

explanation did not hold up.

For a while, I just watched my weird TV since until I could get the Sams' Photofact for it (Set 2038, folder 1), there would not be much I could do. After a couple of days, it didn't seem as strange; but, nonetheless, I didn't want to have to explain the situation to anyone who visited. So, off to the library I went. This is a good excuse to copy nearly the complete Sams folder for the CTC111 chassis even though a relatively small area is involved (in this problem).

A single IC (U700) performs all the chroma functions including generation of the 3.58-MHz reference; gating of the color burst; I and Q decoding; and generation of the R, G, and B drive to the CRT socket board. A disconcertingly large number of discrete components surround this chip.

### The Investigation

There are basically three signal inputs: luminance (B/W video), chromi-

nance (color information), and a color-burst gating pulse. Since the B/W picture is normal, the luminance input must be fine. There is no likely scenario where a fault in a prior subsystem (i.e., tuner or IF) could mess up the chrominance in any way that would explain the symptoms. The gating pulse matches the Sams' waveform. What about voltage measurements? These seem to be pretty close though at least one appears to be a misprint in the Sams' (I never do quite figure out if it is or not; it did not have anything to do with the problem, but my control settings might not have been the same).

What else is there? The output R, G, and B drives we know are messed up, but do they appear funny in any way? Nope, they are all unique and the amplitudes are similar—thus no apparent shorts between them or to anywhere else.

The chip could be bad. Yes, I should have known better, but this was over ten years ago and ICs in TVs were relative-

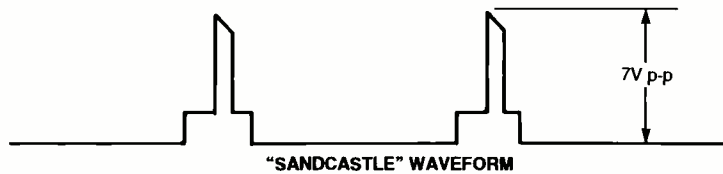


Fig. 2. Here is what the "Sandcastle" waveform should resemble. This signal should look like a 2-volt pedestal during horizontal blanking with a narrow 5-volt pulse riding on top.

ly new. Therefore, I obtain a replacement—\$15, not too bad considering how many legs it has! I carefully unsolder the old one and install a socket (as I always do in these situations as damage to the cheaply made circuit boards is likely if it needs to be changed again or the replacement is bad).

With great expectations, the new chip is plugged in, the TV is turned on and—that looks even worse than before! Not only are the colors more messed up, but the contrast seems to be off as well. So, either the replacement is bad (yeh, right) or the chip is not the problem. While bad parts are possible, the symptoms look suspiciously similar, if not quite identical. Therefore, I conclude that it must be something else. \$15 wasted? No, I learned a lot:

If the chip is good and the signals to it look good, there can only be one set of alternatives—a bad discrete component or solder connection in the vicinity of the chip. Well, they all look like parts. No smoke has leaked out that I can see.

The first step is to determine which parts are likely to affect only the color. Based on the controls (color and tint) and identifying parts that would have an effect on phase or frequency response narrows it down quite a bit. There are some resistors, capacitors, and a couple of small inductors. A methodical test of resistances between pairs of nodes finally turns up something. There is an inductor in what looks like a filter between two pins on the chip, which

measures open! That would do it. It is marked 6 on the schematic, and that is probably the normal resistance—it certainly should not test open. On the parts list, I finally find it—a 39- $\mu$ H inductor. Just as a quick test, I take a 1-megohm resistor and wind a very precise random number of turns of #30 magnet wire around it. The 1-megohm is irrelevant but acts as a convenient form for the coil.

Now, finally, a change in the color. Nowhere near correct, but this is the first time that anything approaching reasonable colors has appeared since the start of this affair. Still not quite right. I get another 1-megohm resistor body and wind a whole bunch more turns onto it. Now, that is a lot better.

Actually, probably good enough, but I have access to an inductance bridge at work. Resistor and #30 wire in hand, I finally manage to come up with a fair approximation to a 39- $\mu$ H inductor. Sure, you are saying, just go buy one. You know that is not my style!

### A Process of Elimination

**Comments**—There is no good excuse for an inductor in a low-power circuit to fail. The only explanation can be that one of the connections to the outside leads was not made properly or the fine wire of the coil had been nicked and finally just broke. I attempted to repair it, but, unfortunately, lost the wire inside the potting compound (it was something like #40 wire—very, very

thin). Just bad quality control, not an induced failure.

Although it cost me \$15 to replace the (good) chip, in the end, this was probably well worth it as it definitively (well, almost) eliminated a large unknown from consideration. The TV worked well for the next 12 years and only recently developed the 'No Picture' problem dealt with below.

**Symptoms**—I turned it on and—sound but no picture. No light visible on the screen. That is kind of strange. Except for the color problem, this has been a reliable set. (No tuner shield solder problems, knock on plastic!)

**Testing**—No user controls have any effect. The screen remains black. There is no flash of light when powering it off either. There is static on the screen however, so I suspect that HV is fine. Nothing is shutting down on its own either.

Since there is sound and HV static, I assume the horizontal deflection is running. As a simple test, I turn up the SCREEN control. This results in a raster. Therefore, the power supplies, horizontal, vertical, high voltage, tuner, and sound are all in fine shape. Just no picture. Well, that narrows the area of search considerably.

This will require the Sams' and a scope to trace—sure, no problem. I still have the photocopied Sams' from dealing with the previous problem, and my scope is just dying to chomp on something interesting. The only difficulty is that the bottom of the main circuit board is not accessible when mounted in the cabinet. However, maybe RCA thought of this—there are two offset screw holes which (whether by design or not, I do not know) permit the circuit board to be moved about 8 inches to the rear—and the cabling is even long enough. Now, with the TV on its side, everything I need to get to is out in the open.

With my isolation transformer—always a prerequisite—I can conveniently examine various points in the video chain. However, some test points are concealed under a shield soldered at multiple points. A slight annoyance—the soldering on this shield is really, really good.

### The Plot Thickens

Just when I have settled in to try to determine where the video signal is getting lost, the picture pops on. Actually,

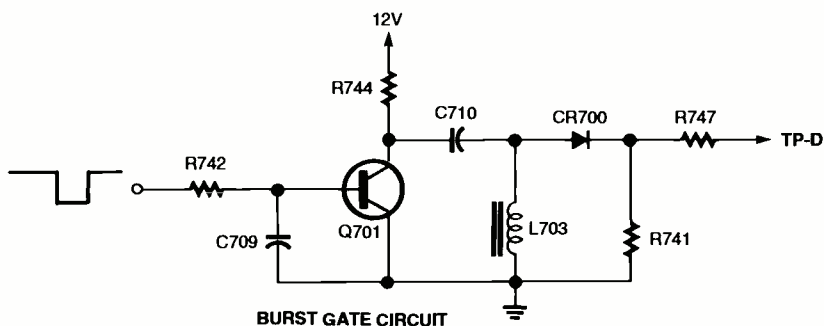


Fig. 3 In this circuit a transistor buffer is driven into saturation by the inverse blanking signal. An RC delays its turnoff at which point the positive-going pulse at the collector is coupled via a C-L-R network via a diode to U700.



it kind of dribbles on—first a weak rainbow pattern and then a second later the good picture. Could this be a bad connection? Perhaps, but no amount of wiggling, jiggling, whacking, or cursing, has the slightest effect. Cycling power also does not induce the problem. It is now as though the TV is not broken.

Hmmm. Sounds like an electrolytic cap or thermal problem. (BTW, Bill—from <A HREF=#rb035">Repair Brief 35: "Panasonic PV1414 Closed Circuit TV Camera with no Video</A> is sure that the problem is a bad electrolytic cap and wants to destroy the ozone layer with a can of CFC based freeze spray to locate it.)

Let it cool for an hour. One hour later—picture comes on instantly! Let it cool for a day. One day later—picture comes on instantly! Leave it alone for a week. Finally, no picture for about a minute, then rainbow, then solid picture.

### Time To Troubleshoot

So, how does one go about troubleshooting a problem of this sort? Give me a problem that takes a minute or hour to show itself any day, but one that is broken for only a minute or two? Not fun.

Well, perhaps even when it is working, there will be some voltage or waveform that isn't quite right. Maybe a visual examination will turn up some potentially bad electrolytic capacitors. Maybe one has lost some of its value and a capacitance check will reveal the culprit. Right, keep dreaming.

First step: Narrow down the search area. At this point, I have no idea exactly where the video signal is getting lost—not even which subsystem! I do know that sync is stable—examining the raster shows that the lines are correctly interlaced when a proper channel is tuned. So, this puts it after the sync separator. Since this is fed from the video at the output of the video IF, I know at least that it is functioning to this point. That leaves the entire luminance channel—joy—as well as the chroma/luminance IC (the one I tried replacing in Part 1 of this story, U700).

I spend some time down one blind alley—the chroma input to U700. Suspecting this signal, I confirm that it is indeed always present even when there is no picture. A simple test of shorting this signal to ground at the chip input would have revealed that the most its absence would do is result in a B/W pic-

ture. This results in one dead end.

Figure 1 shows a rough block diagram of the video chain. I know that the video signal is fine at TP-A at all times. I also know now that TP-B is fine and does not kill the video in any case should it disappear.

Next, I identify the pins on the Lum/Chroma Proc chip (U700) that can possibly kill the picture totally. It appears as though there are only five: four of these are controls or power-supply voltages (constant DC levels); and the other one is the luminance input, TP-C.

### The War Is On

One week later, preparing for battle, I am set to measure the four static voltages as soon as power is applied. The scope is hanging on TP-C as well to determine if that signal is present at all times. A signal here would eliminate all the stuff in the 'Lum Peak/Amp' box from consideration (and there is considerable stuff in this box—I have greatly simplified the block diagram).

Charge!, or, err, power! Voltages: Measure, measure, measure, measure! These all check out within 5 percent or so. TP-C signal: Yep, it comes up immediately and appears to be valid video and of proper amplitude.

There is no detectable change in any of these when the picture appears 30 seconds later. That's just great. All five possibilities seem to be fine. Well, when the plausible is eliminated, check the implausible.

First, however, I break down and decide to swap U700 with my spare in a week when I apply power again. As expected (but hoped against), the screen remains black for the expected minute. When the picture appears, the color balance is somewhat off (recall, that in our last episode, there were more severe problems with this chip but that was when the actual fault had not been located). However, adjustment of the CRT drives fixes this. For all intents and purposes, the replacement U700 performs identically to the original.

So, there must be some other input to U700 that is messed up. Well, there is another possible candidate. I had not paid serious attention to it before, but it is all that is left—the signal derived from 'Burst Gate' and 'Vertical Blank.' I initially discounted this since there was a signal present even when the picture was blank—but was it the correct signal?

Brief checks previously had shown it to healthy—but that was when there was a picture. One way to find out: Short it to ground and see what happens. And, yes, this kills the picture. What is also significant is that when the short is removed, the picture comes back in a very similar way to when the 'problem' goes away—some initial rainbow effects before it stabilizes.

### Catching The Culprit

So, next power cycle (1 week) I am intent on catching this signal in the act! This signal should look like a 2-volt pedestal during horizontal blanking with a narrow 5-volt pulse riding on top. This is called the 'Sandcastle.' I am now thoroughly familiar with what the correct shape should be. Refer to Fig. 2 for a representation of the waveform.

One week passes. Scope, are you ready? "At your service." Look at that! The pedestal is there, but the narrow pulse is missing. Finally, a clue comes to the surface. Some quick voltage measurements of the 'Vertical Blank' circuitry shows that it is impossible for it to be at fault as the pedestal would not appear normal. Therefore, it must be the 'Burst Gate'.

This is a fairly simple circuit—a transistor buffer is driven into saturation by the inverse blanking signal. An RC delays its turnoff at which point the positive-going pulse at the collector is coupled via a C-L-R network via a diode to U700. Figure 3 shows a somewhat simplified Burst Gate circuit.

Next step is to determine if this transistor is working correctly. This time, scope probes on input and output. The verdict: Input and output are both stable instantly at power-on. Having confirmed this, I immediately kill power. Maybe these quick checks will permit whatever is being cured in a minute to remain sick. Now what? What about the other side of C710? Nothing. How can that be? Coupling capacitor? Quickly bridging another one doesn't result in any change. Kill power. I cannot afford the bench space; need to get this wrapped up!

On a hunch, I check the resistance across L703. It reads 20 K ohms. Huh? No way, it is marked 21 ohms on the schematic. Not another dud inductor! (Recall that this was the problem in Part I—messed up colors). I pull L703—it measures open. How could an open inductor result in a flat-line output? One might think this would increase the output.

## A Clue, Mr. Inductor

Well, with the inductor removed or open, the diode charges the capacitor as it would in a power supply and results in the diode output being clamped to zero volts. It actually makes sense. First, I try winding an inductor, but even with as many turns of #32 wire as I can fit on a ½-watt resistor body, the value must be way too low as the output is still dead.

Rummaging around in my inductor drawer, I locate one that looks kind of similar. Unmarked, but of approximately the right size and construction (I really don't have a great stock of inductors). The original is marked 471, which I assume to be 470  $\mu$ H; but I didn't photocopy the page of the *Sams' Photofact* with inductor ratings, unfortunately. The results with my unmarked replacement are mixed—the picture is there (well, that really doesn't prove anything), but it seems a little bright. This signal looks fine; maybe the bright picture is my imagination. OK, try a different larger one. This even measures the same on my ohmmeter as the original should (like that means anything).

However, the picture now appears normal. Since the poor lonely inductor sitting on my bench still measures infinity ohms, I am confident that this is indeed the problem. Exactly what mechanism results in a delayed start inductor is not quite clear. It is not heat, as there is no time for any thermal effects and the power dissipation in the inductor is about as close to zero as one can imagine. Is it simply the voltage pulses appearing across some kind of marginal semiconductor-like junction formed by corrosion between the coil wire and the leads that eventually results in good contact?

Attempting to 'disassemble' the broken inductor simply results in broken inductor pieces everywhere so I will never really know for sure what happened, until another one of the half dozen or so similar inductors in the TV decides to do its open circuit thing.

Maybe some day I will actually order the correct replacements for both of the dud inductors—this new unmarked one and the homemade inductor that fixed the previous messed up color problem. For now, it seems to be fine and the TV shows won't be any better with the proper replacement parts anyhow.

## Reflections


Comments—No doubt next time (sure, if there is a next time), I will test

all the similar inductors first! What could possibly lead to a batch of unreliable inductors is another one of those mysteries of the universe. After all, an inductor is just a coil of wire soldered to a couple of leads. There is no thermal or mechanical shock, and the circuit is very low power in any case. The TV is not in a damp location or subject to any other kind of abuse that I know of, though based on the appearance of the innards of the inductor, some type of deterioration may have taken place.

How should one diagnose a problem of this type? In hindsight, I guess testing components in the vicinity of the Lum/Chroma Proc after waiting a week and with power off would make sense. But, some of the elapsed time was required to localize the problem to that chip. However, once it was clear that one of the signals to U700 was messed up, the ohmmeter checks would have greatly reduced the additional required debug time. Would freeze spray have worked? Perhaps—if anyone had thought to hit the inductor. There were no electrolytic capacitors anywhere in the circuitry around U700.

## Wrapup

Some might consider this set an antique as it was new around 1980. As of 2002, the set continues to function without any more inductors dying. I'm sure many readers would consider a 22-year-old TV something that belongs in a museum. However, while it doesn't have some of the features of a modern TV (heck, it doesn't even have a remote control as I wasn't willing to pay the extra \$50 for that—not being standard in 1980!), the picture and sound quality is still quite good.

I welcome feedback of almost any kind (via e-mail only please to sam@repairfaq.org). And there is much more repair, general electronics, and laser and optics information on my Web site, [www.repairfaq.org](http://www.repairfaq.org). 


## ALL ABOUT

(continued from page 40)

to Rb, the duty cycle can be varied. However, there is a problem. Since the charging path is through Ra + Rb and the discharge path through Rb, they can never be equal. This makes a 50 percent duty cycle unachievable with this circuit, since Ra + 2 Rb always will be > Ra unless Ra is made to be zero. This problem can be corrected by using two diodes (1N914 types, etc.) to steer the charge and discharge paths through only Ra and Rb, respectively. In practice, this allows less than 5% to more than a 95 % duty cycle to be achieved. Note that due to device limitations Rb must be greater than about 3k $\Omega$  for reliable performance. This is shown in Fig. 7. Ra and Rb could be incorporated into a potentiometer to adjust the duty cycle, with C being used to set the frequency.

## Time Delays

Another mode of operation is that of providing a time delay. In monostable operation, a pulse lasting for a predetermined time is generated immediately on triggering. The output goes high immediately and times out after the predetermined time. In time-delay operation, it is desired to have a state change only after a delay. In this mode (see Fig. 8), the internal discharge transistor is not used. The threshold and trigger are tied together. The capacitor C is instead discharged upon the application of a triggering pulse to the transistor. When this transistor is turned on, C is kept discharged. This keeps the trigger and threshold low, and the timer output is forced low. When a negative-going level is placed on the base of the triggering transistor, it is cut off. The capacitor charges toward the supply voltage; and then when the threshold voltage is reached, the output now changes state. The output will then remain unchanged until the triggering transistor is turned on.

Circuits using this device will be discussed in the next part of this article. 

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## Behemoth Readouts

While back I received a call from a friend who runs a high-tech auto service business requesting a larger readout display for some of his electronic equipment. The standard size digital readout on most common digital voltmeters and similar type equipment is one inch or less in height, which is too small for interpretation at a substantial distance. A three- to five-inch high display would be just fine for viewing at a distance of thirty or more feet. With this in mind, stay put 'cause we're going to work on some circuitry to increase the size and readability of the seven-segment LED readout.

The pin arrangement of a typical seven-segment display is shown in Fig. 1, with each segment identified with a letter. Most LED seven-segment displays are between .3 and .8 inches in height. A much larger seven-segment readout can be fabricated by arranging a number of LEDs in a row for each of the seven segments. Interface circuitry connected between the small LED display and the large LED display completes the conversion.

A three-inch high LED readout is shown in Fig. 2, with four LEDs in each segment, for a total of 28 LEDs in all. The LED in each segment is identified

7-SEGMENT DISPLAY

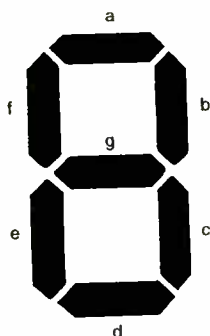


Fig. 1. The pin arrangement of a typical seven-segment display is shown above, with each segment identified with a letter.

as a letter followed by a number, as in *a1*, for the LED located in the top left corner of the display.

### Lighting Up The Segments

A simple seven-segment driver circuit is shown in Fig. 3. Each segment is made up of four LEDs connected in series with a current-limiting resistor. One end of the string connects to the positive supply and the other to the collector of a NPN transistor. A positive input to the transistor turns the LED segment on. The circuit as shown is designed to be driven by circuitry set up for a common anode-type LED seven-segment display. The common anode display has all of the anodes in each segment tied together, requiring each segment's cathode to be pulled to ground or the negative supply to light.

The circuit in Fig. 3 requires a positive input to the transistors to turn on the display segments; however, the circuit may be easily converted to respond to a low input with the addition of a CMOS inverter as shown in Fig. 4. Two 4049 CMOS inverting hex buffers will supply the seven transistor drivers with an inverted output with five buffers unused and available for other applications.

### Picking A Number

Setting up the readout to indicate a number from 0 to 9 without connecting to a display driver can be fun and useful. Each number from 0 to 9 is made up of two or more segments, which must be activated to indicate a selected number. The number 1 is produced when segments *b* and *c* are lit, and the number 8 with all segments lit. One method of selecting a number is shown in the circuit in Fig. 5. A single-pole, ten-position rotary switch selects the desired number from 0 to 9.

Each switch position connects a positive voltage through a number of diodes to the correct segment input transistors

to cause the LEDs to light in the form of the selected number. This method requires 49 1N914 or similar type silicon diodes to isolate the transistor inputs. If the diodes were not used, all segments would be on no matter what position the selector switch was set to.

Let's check it out and make sure that when the switch is in the 5 position the number 5 appears on the readout. In switch position 5, diodes D23, D24, D25, D26, and D27 are connected to inputs *a*, *f*, *g*, *c*, and *d*, respectively. This arrangement will light segments *a*, *f*, *g*, *c*, and *d*. Figure 1 shows that when these five segments are glowing the number 5 is displayed.

Larger displays can be produced by increasing the number of LEDs in series

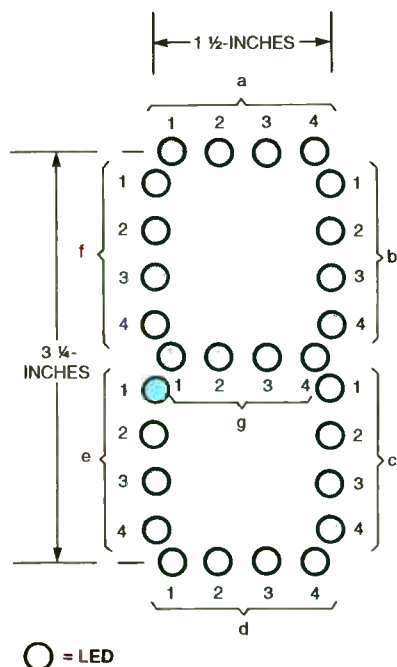


Fig. 2. A three-inch high LED readout is shown here, with four LEDs in each segment, for a total of 28 LEDs in all. The LED in each segment is identified as a letter followed by a number, as in *a1*, for the LED located in the top left corner of the display.

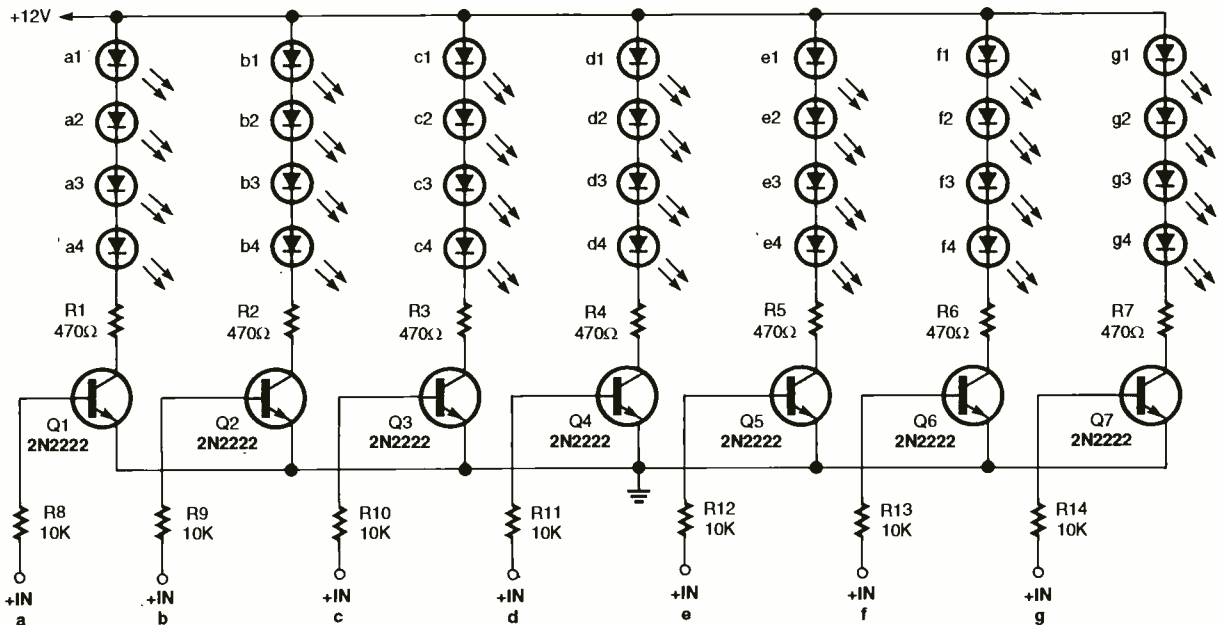


Fig. 3. A simple seven-segment driver circuit is shown in this figure. Each segment is made up of four LEDs connected in series with a current-limiting resistor.

### PARTS LIST FOR THE SEVEN-SEGMENT DRIVER CIRCUIT (FIG. 3)

#### SEMICONDUCTORS

A1–G4—LED, any color, see text.  
Q1–Q7—2N2222 or similar NPN transistor

#### RESISTORS

(All resistors are ¼-watt, 5% units.)  
R1–R7—470-ohm  
R8–R14—10,000-ohm

for each segment; however, either a higher supply voltage or a split driver circuit will be needed.

A string of eight LEDs, see Fig. 6, is powered from a 24-volt power source and is turned on with a single driver transistor. The most common LED color is red, and it normally requires about 2 volts to operate. Most other colors require even a greater voltage. The current-limiting resistor, R1, is selected to limit the maximum LED operating current.

The eight-LEDs-per-segment arrangement may also be operated with a 12-volt power supply by breaking the string into two strings of four LEDs and using two driver transistors, as shown in Fig. 7. The number of LEDs used to make up a segment is by no means limited to eight. The maximum number of LEDs that can be used is limited only by avail-

able power, funds, and housing.

The four-LEDs-per-segment display shown in Fig. 2 can also operate with a 5-volt power supply with the circuit

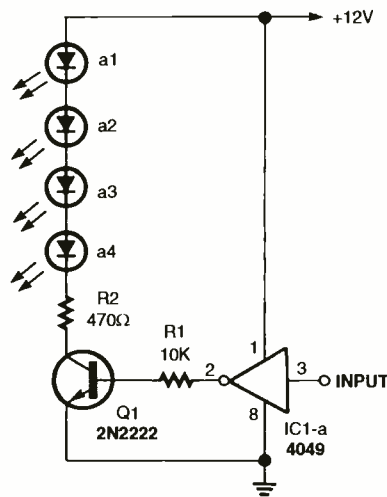


Fig. 4. The circuit shown in Fig. 3 may be easily converted to respond to a low input with the addition of a CMOS inverter as shown here. Two 4049 CMOS inverting hex buffers will supply the seven transistor drivers with an inverted output.

### PARTS LIST FOR THE LOW-INPUT DISPLAY (FIG. 4)

A1–A4—LED, any color, see text  
Q1—2N2222, or similar, NPN transistor  
IC1—½ of 4049 CMOS hex inverter  
R1—10,000-ohm, ¼-watt, 5% resistor  
R2—470-ohm, ¼-watt, 5% resistor

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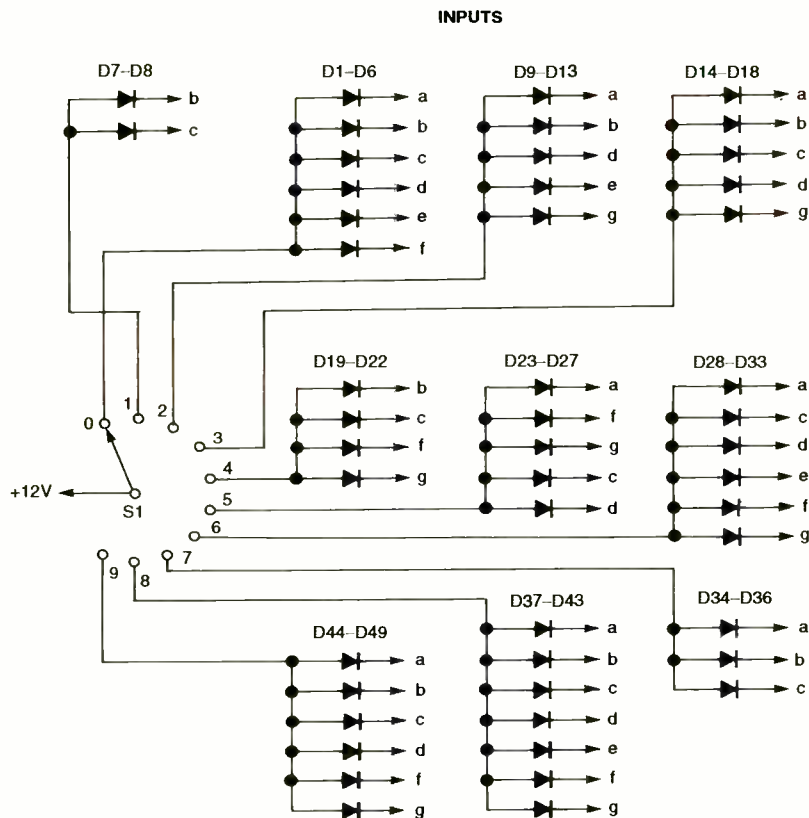


Fig. 5. A single-pole, ten-position rotary switch selects the desired number from 0 to 9. Each switch position connects a positive voltage through a number of diodes to the correct segment input transistors to cause the LEDs to light in the form of the selected number.

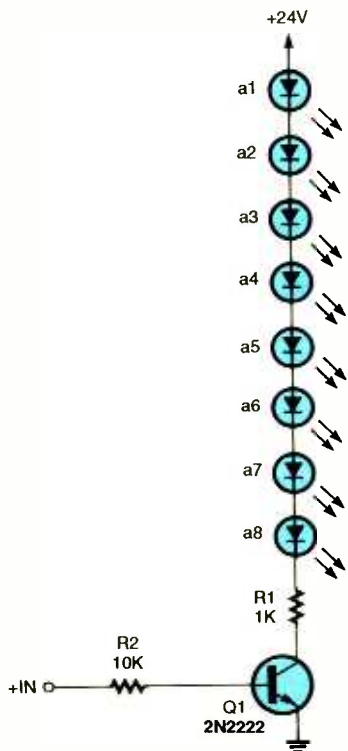


Fig. 6. A string of eight LEDs is powered from a 24-volt power source and is turned on with a single driver transistor. The most common LED color is red, and it normally requires about 2 volts to operate. Most other colors require even a greater voltage.

### PARTS LIST FOR THE HIGH-VOLTAGE DISPLAY (FIG. 6)

- A1-A8—LED, any color, see text
- Q1—2N2222, or similar, NPN transistor
- R1—1000-ohm, ¼-watt, 5% resistor
- R2—10,000-ohm, ¼-watt, 5% resistor

shown in Fig. 8. The LED string is broken in two groups with two LEDs each.

Actually, the eight-string-segment display also could be operated with a 5-volt supply by using four groups of two LEDs in each segment. Of course, operating at a low voltage adds extra components not required with a higher voltage source.

### Picking Up A Light Beam

Going from a standard small LED display to one of our large displays requires drive information from the equipment's circuitry. Getting inside some of the compact equipment that's commonplace today is often a job for a micro-surgeon doing brain surgery. In many cases, the display has all readout segments, in each digit, common to all

### PARTS LIST FOR "PICKING A NUMBER" (FIG. 5)

- D1-D49—1N914, or similar, silicon diode
- S1—10-position, single-pole, rotary switch

digits; and the input drive is a multiplexed signal.

There is a way to pick up information from the face of the LED display with a phototransistor positioned in front of the display's segment. Position seven phototransistors, one in front of each segment, take the output of each phototransistor, and supply a drive signal for the seven transistors in the circuit in Fig. 3.

An opaque holder for the seven phototransistors can be fabricated from a block of wood, plastic, or any similar material in the shape shown in Fig. 10. The seven holes in the block should position each of the transistors directly in front of each segment. The photo-

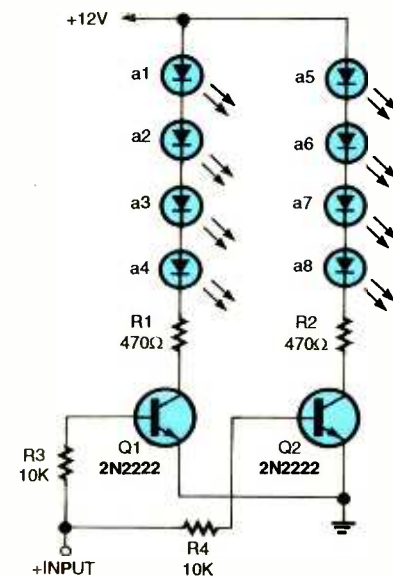


Fig. 7. The eight-LEDs-per-segment arrangement may also be operated with a 12-volt power supply by breaking the string into two strings of four LEDs and using two driver transistors.

### PARTS LIST FOR THE 12-VOLT DISPLAY (FIG. 7)

- A1-A8—LED, any color, see text
- Q1, Q2—2N2222, or similar, NPN transistor
- R1, R2—470-ohm, ¼-watt, 5% resistor
- R3, R4—10,000-ohm, ¼-watt, 5% resistor

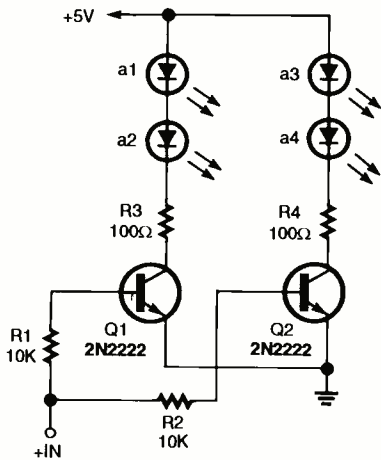


Fig. 8. The four-LEDs-per-segment display shown in Fig. 2 can also operate with a 5-volt power supply with the circuit shown above. The LED string is broken in two groups with two LEDs each.

### PARTS LIST FOR THE LOW-VOLTAGE DISPLAY (FIG. 8)

- A1-A4—LED, any color, see text
- Q1, Q2—2N2222, or similar, NPN transistor
- R1, R2—10,000-ohm, 1/4-watt, 5% resistor
- R3, R4—100-ohm, 1/4-watt, 5% resistor

transistor holder also should set flush against the seven-segment display.

The seven-phototransistor circuitry is shown in Fig. 9. The emitter resistor value for each phototransistor will fall somewhere between 10,000 and 100,000 ohms. The actual value depends on the voltage generated at the phototransistor's emitter when the segment is on. Select a resistor value that produces at least 2 volts at the emitter. If the light output of all of the display segments is the same, the resistors can all be the same value. The actual phototransistor used in this arrangement will depend on the size of the seven-segment display monitored. Very small displays will require locating a sensitive phototransistor that is small enough for seven to fit side-by-side in the holder.

Mouser Electronics (800-346-6873) offers two small phototransistors for less than half-a-buck that are only .116 inches in diameter. The part numbers are 512-QSC112 and 512-QSC113. Several other low-cost phototransistors are available that can be used on larger displays, as well. Also check other suppliers

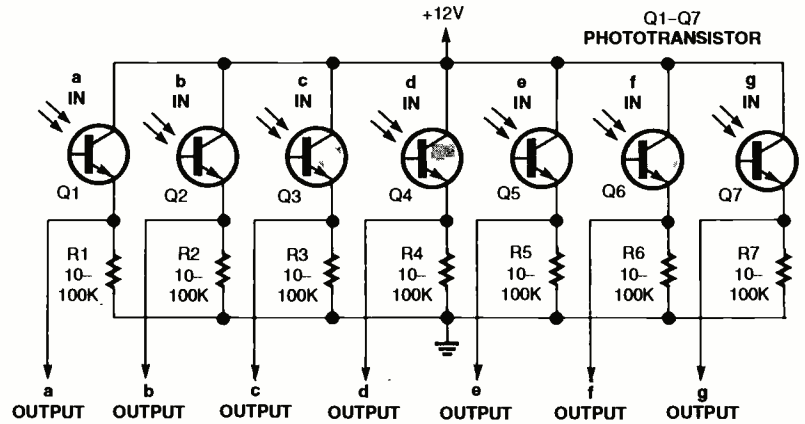


Fig. 9. Here is a seven-phototransistor circuit. The emitter resistor value for each phototransistor will fall somewhere between 10,000 and 100,000 ohms. The actual value depends on the voltage generated at the phototransistor's emitter when the segment is on

### PARTS LIST FOR "PICKING UP A LIGHT BEAM" (FIG. 9)

- Q1-Q7—Phototransistor, see text for types
- R1-R7—See text

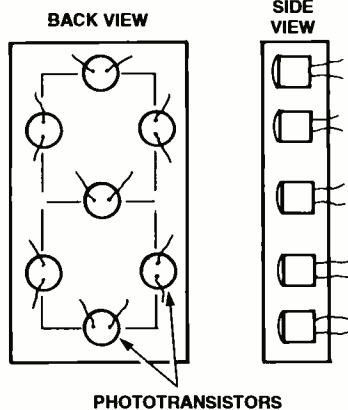


Fig. 10. An opaque holder for the seven phototransistors can be fabricated from a block of wood, plastic, or any similar material in the shape shown in this drawing. The seven holes in the block should position each of the transistors directly in front of each segment.

for similar devices.

That's about it for this go-a-round. Go forth and build a behemoth LED readout and impress your friends, and have fun while doing it. Come back next issue and see what we've got going. **P**

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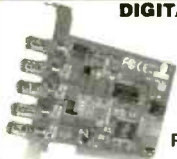
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**PV-140A/B/C/D - \$299.95**

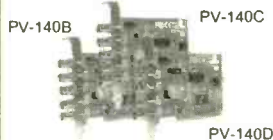
The PV-140 Series turns your PC into a commercial grade digital security system in a few minutes. This incredible series integrates a color quad processor, multi-zone video motion detector, multiplexer, and a real time digital video recorder (DVR). By ordering addition cards, you can increase your surveillance up to 16 different cameras.



### SOFTWARE INCLUDED!!!

#### System Requirements:

- Windows 98/ME/2000/XP
- Pentium III-550Mhz or higher with free PCI slot(s)
- 128 MB+ System Memory
- PCI/AGP bus graphics card (24 bit hi-color or 64 bit)
- Sound Card (optional)
- Hard Disk Space - 1 GB+ per camera; 10GB+ is recommended
- Microsoft DirectX or higher version
- CD-ROM / DVD-ROM device
- Cameras up to 1/24/8/12/16



#### PV140 Card Configuration:

- PV-PACK= 140A+140B+140C+140D (4pcs in 1 pack)(Real time)
- 140A 1st four cameras/windows
- 140B 2nd four cameras/windows (expands to = 8 windows)
- 140C 3rd four cameras/windows (expands to = 12 windows)
- 140D 4th four cameras/windows (expands to = 16 windows)

Cards MUST be utilized in this order.

**SAVE \$100**  
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 4 Pieces/One Pack  
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Now you can enjoy peace of mind with our new wireless observation system. Each comes with a 5" wireless monitor & wireless camera. Just plug & play for perfect wireless video any time!

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This camera merges the gap between bullet (lipstick) camera and full-size housing with camera. Unlike bullet (lipstick) cameras with limited features, this unit has many features only found on larger, "cased" cameras. The AV-48WC8 keeps the best part of the bullet/lipstick line in that they install quickly and come pre-assembled, ready for installation. Auto Iris and vari-focal lens options are available upon request.



**AV-48C8 \$235.95**

We have 6 different configurations to meet your requirements for outdoor or indoor self-contained cameras. Industrial "O" Ring Sealed Aluminum Case

#### 6 Configurations:

- B/W: Regular, Auto Iris, Vari-Focal Lens
- Color: Regular, Auto Iris, Vari-Focal Lens



### 220x ZOOM CAMERA MODULE

AFZ-220X is compact and lightweight. This zoom camera will fit into a variety of applications.



**AFZ-220X \$349.95**

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**USB-01** The USB Video Converter acts as an interface for your analog video sources and converts analog output to digital for your computer. The USB Video Converter accepts high resolution SVHS video and standard composite NTSC video.



**USB-01 \$89.95**

### MICRO BOARD CAMERAS



**MB-780U**  
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### B/W PEN CAMERA WITH AUDIO

Pencam is the newest member to our line of covert cameras. Its small, lightweight design allows it to slip into your shirt or coat pocket. It will video tape with audio capability makes is perfect for a number of applications.



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**PENCAM - \$225.95**

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**26-0300 \$349.95**

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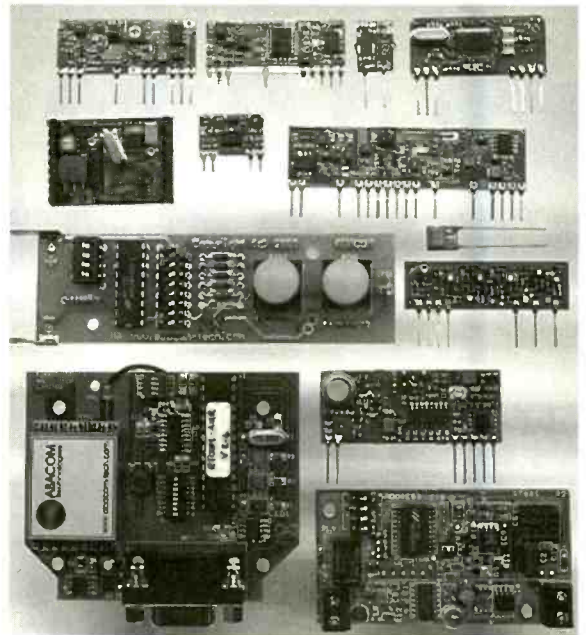
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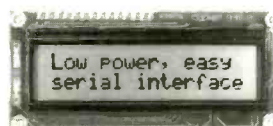
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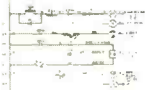
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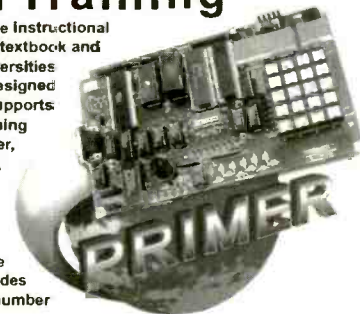
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## Microprocessor Hands-On Training

The PRIMER Trainer is a flexible instructional tool featured in a Prentice Hall textbook and used by colleges and universities around the world. Ruggedly designed to resist wear, the PRIMER supports several different programming Languages including Assembler, Machine Language, C, BASIC, and FORTH. A comprehensive Instruction Manual contains over 25 lessons with several examples of program design and hardware control. The Applications Manual provides theory and sample code for a number of hands-on lab projects.



### Application Projects Include:

- Scan Keypad Input & Write to a Display
- Detect Light Levels with a Photocell
- Control Motor Speed using Back EMF
- Design a Waveform Generator
- Measure Temperature
- Program EPROMs
- Bus Interface an 8255 PPI
- Construct a Capacitance Meter
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The PRIMER can be purchased as an unassembled kit (\$120) or as an assembled/tested kit (\$170). Upgrades provide battery-backed RAM and PC connectivity via an RS232 serial port (shown in picture). Additional options include a heavy-duty keypad (shown in picture) and a 9V power supply - see our website. Quantity discounts are available. Satisfaction guaranteed.

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# Miniature Transmitters and Receivers

## 2 Button / 3 Channel Transmitter



**RF300T**

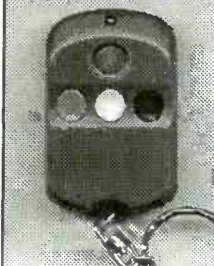
1....\$22.95  
5....\$19.95 ea  
10...\$16.95 ea

**RF300XT**

1....\$25.95  
5....\$22.95 ea  
10...\$19.95 ea

- 300' (XT), 150' (T) Range
- Frequency: 318 MHz
- 59,049 Settable Security Codes
- 12 Volt Battery and Keychain Included
- Current Draw: 4.8 ma
- Fully Assembled in Case
- Dimensions: 1.25" x 2.0" x .5"
- Push both buttons for the 3rd Channel
- Slide Button Cover Included

## 4 Button / 15 Channel Transmitter



**RF304XT**

1....\$27.95  
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- 250' Range
- Frequency: 318 MHz
- 6,561 Settable Security Codes
- 12 Volt Battery and Keychain Included
- Current Draw: 4.6 ma
- Fully Assembled in Case
- Dimensions: 1.35" x 2.25" x .5"
- Push combination of buttons to achieve up to 15 channels

## 2-4 Data / 3-15 Channel Receivers



**RF300RL  
RF300RM**

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**RF304RL  
RF304RM**

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- Compatible with 300/4 Transmitters
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- Binary to Dec / Hex Converter can achieve up to 15 channels

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- Garage / Gate Openers
- Lighting Control

- Magic Props
- Medical Alert
- Monitoring Systems

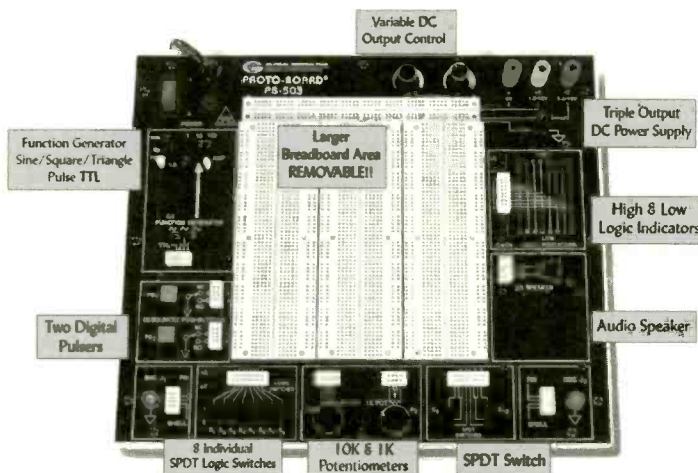
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- Surveillance Control
- Motor Control

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Detailed Specs on the Web

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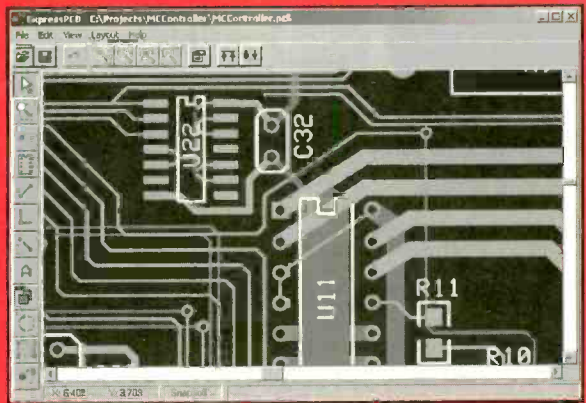
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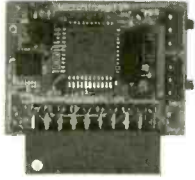
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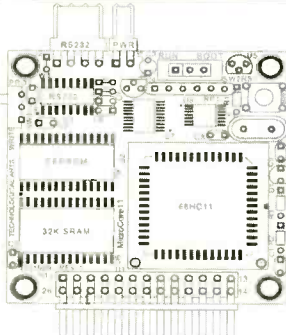
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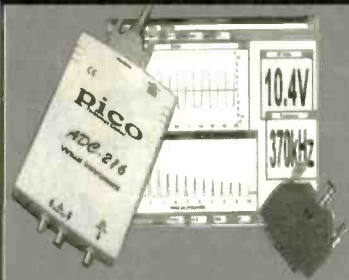
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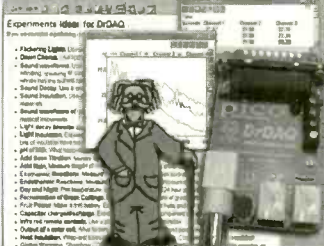
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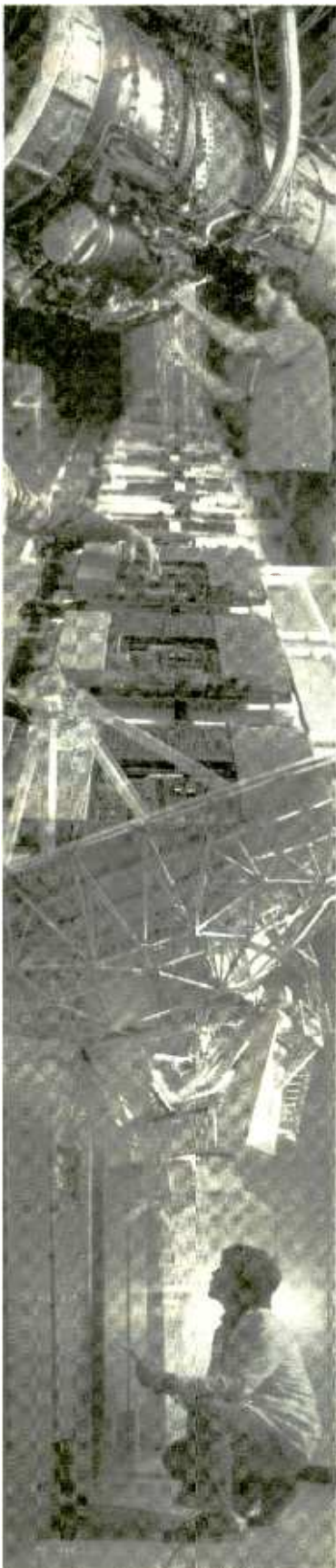
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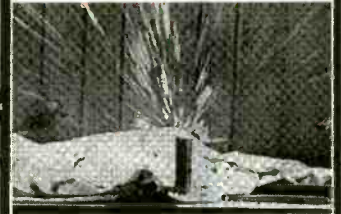
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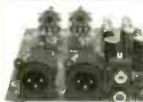


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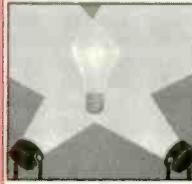


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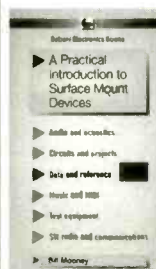
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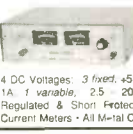
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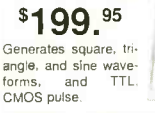
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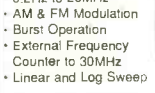


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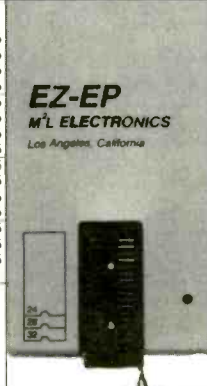
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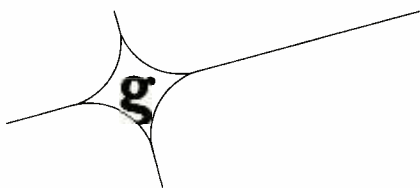
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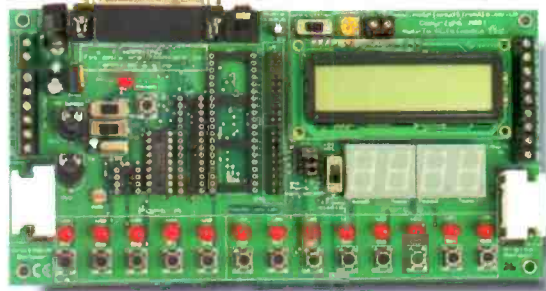
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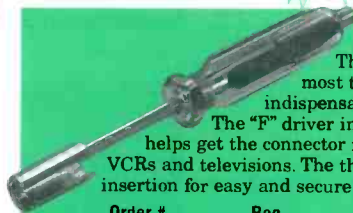
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