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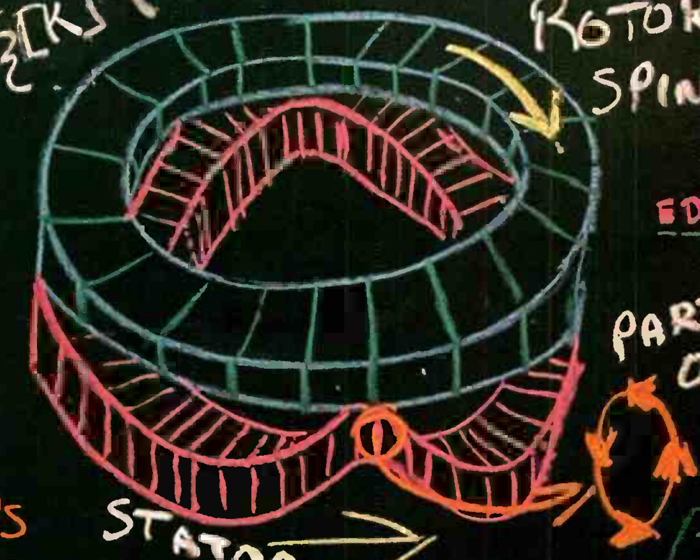

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GERNSBACK PUBLICATION

Electronics Now
January 2001, Vol. 2, No. 1
Popular Electronics®

Poptronics®

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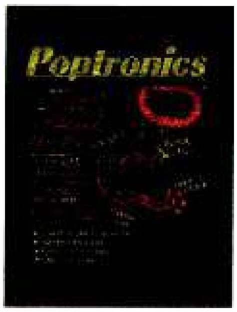
FEATURES



PRODUCT REVIEWS

DEPARTMENTS

AND MORE

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

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

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Ch-Ch-Ch-Ch-Changes

With the simple act of turning the page of the calendar, we change the month, the year, the decade, the century, and the millennium. Not bad for a simple piece of paper.

Change is inevitable, although some see that evolutionary process as bad, even if good comes of it.

Take the magazine you're holding in your hands.

I listen to your wants, needs, and desires. I listen to your kudos and complaints. Sometimes I can't do anything except lend a sympathetic ear.

Sometimes I *can* do something.

Over the next few months, we're going to try some new ideas as we fine-tune **Poptronics** to balance between the three groups of readers we want to reach: former **Electronics Now** readers; former **Popular Electronics** readers; and that elusive group that everyone ignores, those that don't read **Poptronics**...yet.

As a first step in this evolutionary process, we've experimented with some computer-generated schematics in our "RF Field-Strength Meter" feature. Tell us what you think.

I've heard some good ideas from you in terms of new features. Some of the suggestions had been discussed in-house over the years, but the timing wasn't right, for various reasons. There's also at least one idea for a new feature that made me smack my head and exclaim, "Why didn't *I* think of that?"

Some of the new features will appeal to the long-time reader. Some will appeal to the "newbie" picking up an issue for the first time. And, yes, some of the material might not be 100% electronics in nature. The main idea is that it will be *fun*. That's the purpose of a hobby like electronics.

Sitting on my shelf is a small "do-nothing" box that I built years ago. It contains a small circuit and a huge button labeled "THERMONUCLEAR SELF-DESTRUCT. DO NOT PRESS." Whenever I demonstrated it to friends, they invariably ask, "How did you do that?" That's how you interest someone in your hobby: show him or her the fun side.

So look for "something new under the Sun" in **Poptronics** in the new millennium. Keep the suggestions flowing. And have fun in 2001.

Joseph Suda
Managing Editor

LETTERS

mailto: letters@gernsback.com

Metric Temperature Conversions

I enjoy the magazine very much and as a long-time subscriber I must say that I miss my favorite Department "Antique Radio." However, I am writing regarding Mr. John Iovine's metric conversions in the July issue.

As a Canadian who grew up using the imperial scale and now has to deal with this metric system, I have a better way of dealing with the temperature conversions that I can do in my head. It does not use the fraction method that was published and is faster and simpler. Here it is.

F - 32/1.8 = C
C × 1.8 +32 = F
or
212 - 32/1.8 = 0°C
(temperature at which water freezes)
100 × 1.8 + 32 = 212°F
(temperature at which water boils)

This uses standard air pressure. Higher or lower air pressure will change the outcome.

When I was taking a full-time college program in 1990–1991, I wrote this on a test. The teacher was teaching the fraction method. I used my method and got the right answer.

GEORGE T. LOVE
via e-mail

Dialing Again?

I not only have used the Dialpad.com service, but I also have been in contact with the technical staff at *Dialpad.com* about problems. I accordingly regret that your otherwise-interesting column, "Making Free Phone Calls," (Net Watch, July) fails to mention either of two significant limitations inherent in the Dialpad.com service.

1. When used with AOL and similar ISPs, the "click here to listen" hyperlink will NOT function! One has, in cases such as AOL to treat the audio message as an ordinary attachment and go through a downloading-saving-load-an-appropriate-player sequence in order to hear the audio message! In view of the time/effort involved (and the computer skills required of the recipient), it frankly might be better to forget about the audio message altogether and just send the recipient a regular e-mail!

2. One-minute of recording time is allowed per e-mailed audio message. A separate Dialpad audio e-mail will be required for each additional minute of one's audio message. I sincerely hope that the above information/comments will be of help to you.

ERNEST R. BIRNBAUM
via e-mail

Runco Update

I just received the November issue of **Poptronics**. Thanks for including the Runco VX-101 projector. Unfortunately, since issuing that press information in January, Runco has made some changes to this product. While it is still considered an affordable projector—perfect for first-time buyers, the VX-101 is now called the Reflection VX-101c, as the once optional controller now comes standard with the projector.

Therefore the correct price would be $9995. And Runco has just recently introduced a high-definition interface upgrade for the VX-101c—for $1000; this entry-level projector will be able to produce HDTV via outboard decoder.

Thanks again for your support of Runco.

SUE MORGAN
Nicoll Public Relations
via e-mail

KEEP IN TOUCH

We appreciate letters from our readers. Comments, suggestions, questions, bouquets, or brickbats ... we want to hear from you and find out what you like and what you dislike. If there are projects you want to see or articles you want to submit—we want to know about them.

You can write via snail mail to:

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

The End Of TV As We Know It

As we all witness the ushering in of a new era of digital-TV broadcasting (see our September issue), we may also be witnessing the beginning of the end of all free over-the-air broadcasting, an American institution as old as TV itself. You see, the same technology that enables all of these improvements in picture quality and reception formats also makes it extremely easy, and very inviting I might add, for the implementation of a "pay-for-your-reception" type system.

This technology is already in place and proven in the satellite-TV business, and it would be very simple to use that same technology to control your reception on a pay-for-reception basis. The digital scrambling, decoding keys, and other signals used to turn a customers receiver "on" or cut off non-paying customers can be embedded in the digital signal just as easy as the other control signals used to provide this so-called "great" picture quality. Like a Trojan horse, what may be riding in along with this new technology could be very disappointing after we've all been suckered into believing that it's a good thing.

Whether this bad side effect happens quickly or through a relentless, slow process of attrition by network and broadcasting lobbyists, it will surely happen without serious opposition. Write your congressman and senators. Let's make sure that there is legislation put into place to prevent this travesty before it happens.

If they were to make money from pay-for-reception subscribers, they would be getting income from "both ends" of the business; this would of course give them windfall profits and eventually would develop into a price-gouging monopoly controlling everything that we watch and see on TV.

Today, we still have a choice: if we don't want to pay the price demanded for cable or satellite reception, we can still receive free broadcasting. Having this choice keeps a check and balance in place on the prices, quality, and content of the service provided by these companies. Can you imagine what will happen if this check and balance is removed?

"ANONYMOUS TEXAN"
via e-mail

No-Frills "QBASIC"

This no-frills QBASIC program is in answer to Ed Grens' letter in the November issue, concerning the article "LCDs for PCs" found in the March publication. (See sidebar).

SAM BROWNMAN
Montreal, Quebec, Canada

UPDATED "LCDs FOR PCS" PROGRAM

```
5    CLS
8    REM MAGART.BAS using QBASIC
10   REM prog. tested with Sharp LM16X21A and DAEWOO
     16216L-5 LCSs.
30   REM The first nine lines are the initialization process. Line 120
40   REM makes E=H, RS&RW=Low. Line 122 brings E&RS&RW=LOW.
120  OUT &H37A, &H1:   GOSUB700
121  OUT &H378, &H38:  GOSUB700
122  OUT &H37A, &H0:   GOSUB700
125  OUT &H37A, &H1:   GOSUB700
130  OUT &H378, &HE:   GOSUB700
131  OUT &H37A, &H0:   GOSUB700
132  OUT &H37A, &H1:   GOSUB700
140  OUT &H378, &H6:   GOSUB700
141  OUT &H37A, &H0:   GOSUB700
145  REM INITIALIZ. OVER
150  REM for LCD line 1; lines 200-230 place an "S" on screen
200  OUT &H37A,  &H5:  GOSUB700
220  OUT &H378,  &H53: GOSUB700
230  OUT &H37A,  &H4:  GOSUB700
600  GOTO 855
650  END
700  FOR j = 1 TO 2: NEXT
750  RETURN
765  REM line 200 makes RS&E=H, RW=LOW
770  REM line 230 makes RS-H; E&RW=LOW
780  END
855  REM lines 900-920 shift cursor to second line
900  OUT &H37A,  &H1:  GOSUB700
910  OUT &H378,  &HC0: GOSUB700
920  OUT &H37A,  &H0:  GOSUB700
950  STOP
END
```

The Greatest Show Off Earth

While I enjoyed your editorial in the September issue, I wanted to bring an error to your attention. The camera NASA used to televise Neil Armstrong setting foot on the Moon did not use mechanical-scanning with a Nipkow scanning disc. Please recall that in the Baird system, the thing that was scanned was the light source onto the subject. The pickup was non-scanning photo tubes. This had to be done in an otherwise dark room.

What NASA did use was a rotating color wheel, á la the 1949 mechanical color-TV system proposed by CBS, in front of the pickup tube. This was the lowest bandwidth way to transmit color pictures back to the earth. The mechanical color wheel was also used on numerous other NASA missions, both manned and unmanned. With modern electronics, they were able to make the pictures monochrome (B&W) compatible—something that eluded CBS. That's why the FCC rejected the system, and CBS had to buy back all the color sets already sold for their full price of $1000. (In 1949—OUCH!) No wonder CBS was the last network to adopt the NTSC system.

My information about the camera actually came from the television coverage at the time. The color-wheel camera was used on some earlier NASA missions. The most detailed explanation of the technology came out on one of these previous missions. I'm sorry I can't remember the exact one—it's been a long time. I do remember the commentator—I believe it was Jules Bergman on ABC—who did a fairly detailed analysis of this first color-television camera for outer space. I particularly remember his reference to the CBS system, with which I had previously become familiar. What a hoot! ABC talking about CBS technology. Were they secretly gloating? As a teenager very interested in—maybe "obsessed with" is a better description—electronics, I just ate this up. I also remember the reference to this in relation to the Apollo 11 camera.

In retrospect, I find it amazing that the coverage back then had so much scientific depth, particularly Jules Bergman and ABC. The discussion of the reason for this system being a bandwidth issue came from this same coverage. And they made it understandable to more than just a geek kid (I graduated high school in 1967).

My knowledge was supplemented by *Popular Science*, *Scientific American*, and, yes, **Popular Electronics**. (I've been reading Pop 'Tronics since about 1956. When Mr. Gernsback was the editor, I think.) But the majority of this knowledge came from, dare I say it, the "vast wasteland" of television.

As a side note, I do not believe there was ever a mechanically-scanned live-television pickup device that did not swing a spot of light back and forth, up and down, scanning the subject to be televised with the resulting reflection being picked up by photo tubes. This is what was used for the live Baird pickup at the Baird/Marconi shoot at Alexandra Palace (in London) before the start of WW II. The only other source of video Baird had was from film using a flying-spot scanner, again scanning the light, only this time using a CRT as the light source.

As I recall, this was one of the main

(Continued on page 46)

CHRIS LAMORTE

mailto: netwatch@gernsback.com

So You Want to Build A Fighting Robot...

There are numerous video games available that give the player command and control of a giant robot for the express purpose of wreaking havoc. Why settle for a game when you can have the real thing? Robot mania—a mixture of creativity, mayhem, and cutting-edge robot technology—is sweeping America. Crews of technicians and dreamers are creating robot terrors on a small scale. With a new television show illustrating the climax of battles and hundreds of sites pertaining to robot building and competitive fighting emerging each day, now is the time to explore this robotic wave.

The following is only a smattering of information related to competitive robot battles that resides on the Internet:

Biohazard is an example of a prize-winning Battlebot that has its own Web page.

BATTLEBOTS.COM

On the forefront of robotic action lies the domain of *Battlebots*. This is a world where teams develop robots for the sole purpose of destroying other robots. The battlefield is a sadistic arena cordoned off by a chain-link fence. Within are various traps and mechanisms of destruction, often used by the participants in the eradication of opponents. Set upon this stage are the robotic gladiators, each supported and operated by a crew of aspiring champions. You, too, can log on to *www.battlebots.com* and visit the virtual headquarters of this tech-progressive, competitive sport. Any hard-core electronics/robotics enthusiast can appreciate the content of this site.

Let's take a gander inside battlebots.com. "Battlebots" is aired weekly on the Comedy Central cable network. Viewers can go deep behind the scenes via the *www.battlebots.com* Web page. The home page provides links to pages explaining:

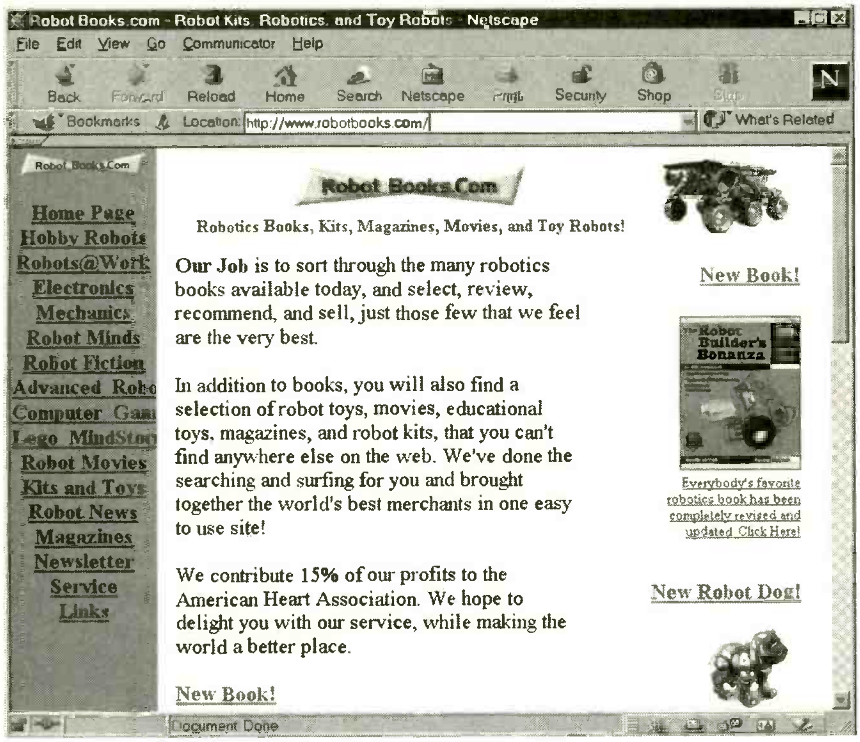
- The concept behind battlebots
- Current competitors, crews, and creators
- Competition rules
- A section dedicated to help people build their very own metal-stomping robot

The competitors seem to range from early adolescents to some seasoned forty-somethings, all with impressive records. By clicking on "Meet the Robots," the viewer can browse through the weight classes and view the stats for each robot. Links are also provided to the page of a robot's crew, a supporting cast of cutting-edge tech heads with names like "Odin," "Das Bot," and "Pressure Drop," who are the true stars of this unique tech environment.

Browsing through Battlebots.com can lead to some interesting sites concerning the building of robots. Two examples are the *Biohazard* homepage and *Robotbooks.com*.

BIOHAZARD

This low-tech site—*www.robotbooks.com/biohazard.htm*—fea-



If you want to learn about robot design and construction, this Web site is "one-stop shopping" for all your information needs.

HOT SITES

BattleBots
www.battlebots.com

Biohazard
www.robotbooks.com/biohazard.htm

RobotBooks
www.Robotbooks.com

tures the robot known as "Biohazard." This winning athlete has made a reputation for itself within the Battlebot circuit. Biohazard's site has a lot to offer, including: action photos of the robot's competitions (complete with text narratives), tips and hints on robot development and construction, and a list of vendors for all your robot-building needs. An example of the myriad of sites created by Battle-bot contestants, this site is just a taste of the numerous references available for neophyte robot builders. The tips offer detailed instructions on tasks such as electronic motor tune-ups, use of capacitors as horsepower boosts, and radio remote-control units

The Biohazard site, like many other novelty sites, is lacking in the pizzazz frequently seen on more expensively produced URLs, but the wealth of information and links is an undeniable asset to avid robot buffs. Biohazard pays homage to a mega-store of robotic resources, Robotbooks.com.

If you find industrial robots dull and boring and NASA-style explorers leave you intellectually exhausted, you can't find more "check-your-brains-at-the-door" fun per kilowatt-hour than with BattleBots!

ROBOTBOOKS.COM

If robotic projects are your bag, you might want to pay a visit to *www.Robotbooks.com.* Reference books and kits are available in abundance within the pages of this virtual robot store. Whether you are looking for the latest video game, a novel, or a pre-built, programmable robot, chances are you can find what you need here. There are hundreds of projects that can be created at home by hobbyists of all ages. A lot of emphasis is placed on technology exploration for kids, but this is balanced out by a selection of advanced kits designed to create some amazing technologies.

This particular site can be likened to the virtual-catalog sites available for book and music purchases. The main difference is that Robot books.com stays true to its exclusive content. An eager hobbyist can certainly find similar sites in practically any form of electronics.

LET YOUR IMAGINATION RUN FREE

The Internet, much like a local library, can be effectively employed as a powerful research tool. Future pioneers of robotics can start their journey with the help of the Internet's seemingly endless source of refer

(Continued on page 66)

CD ROM based resources for learning and designing

matrix multimedia

The internationally renowned series of CD ROMs from Matrix Multimedia has been designed to both improve your circuit design skills and to also provide you with sets of tools to actually help you design the circuits themselves.

Electronic Circuits and Components provides an introduction to the principles and application of the most common types of electronic components and how they are used to form complete circuits. Sections on the disc include: fundamental electronic theory, active components, passive components, analogue circuits and digital circuits.

The Parts Gallery has been designed to overcome the problem of component and symbol recognition. The CD will help students to recognize common electronic components and their corresponding symbols in circuit diagrams. Quizzes are included.

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

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

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

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

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

CADPACK includes software for schematic capture, circuit simulation, and PCB design and is capable of producing industrial quality schematics and circuit board layouts. CADPACK includes unique circuit design and animation/simulation that will help your students understand the basic operation of many circuits.

Analog Filters is a complete course in filter design and synthesis and contains expert systems to assist in designing active and passive filters.

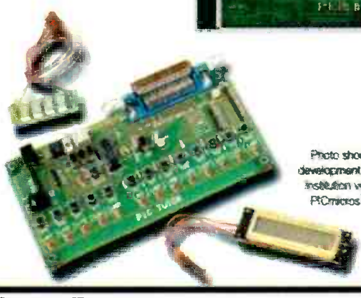


Photo shows PICmicro development kit supplied with institution versions of C for PICmicros and PICtutor

Shareware/demo CD ROM with more than 20 programs $4.99 refundable with any purchase.

Order Form:

Please circle the products you would like to buy on the table below, calculate the total cost, fill in the rest of the order form and send it to us. NY residents add sales tax. Please allow 6 weeks for delivery.

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C for PICmicros	$179	$350
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CADPACK	$75	$159
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Digital Photos Are a Snap

With Nikon's *Coolpix 880* ($700.95), you don't need a background in photography to take great pictures. The digital still camera combines a 3.34 megapixel CCD with a maximum resolution of 2048 × 1536 and a 2.5X Zoom-Nikkor lens. To ensure superior picture quality with every shot, the Scene Mode adjusts the settings for 11 different situations, including sunset, close-up, backlight, fireworks, beach/snow, and landscape. The Quick Review function allows you to see each picture immediately after shooting it or scroll through all previously recorded images, without navigating through complex menus or switching to playback mode. The Best Shot Selector captures consecutive shots and then chooses the best and discards the rest. Operation is streamlined with quick, one-touch startup, mode selection via a pictorial dial, and a USB port for Plug-and-Play connectivity.

Although it offers the simplicity of a point-and-shoot camera, the Coolpix 880 includes a manual mode for more experienced photographers. For added flexibility and expandability, a variety of converters, slide adapters, lenses, and a remote cord are available options. The lenses, which require the use of an optional step-down ring, include telephoto, wide-angle, and fisheye. A Duracell Ultra245 (2CR5) battery and an 8MB CompactFlash card are included.

Nikon Inc., 1300 Walt Whitman Rd., Melville, NY 11747-3064; 800-NIKON-UX; *www.nikonusa.com*.

CIRCLE 50 ON FREE INFORMATION CARD

High-Speed CD Recorder

The dual-tray *XC-RW700* CD recorder ($650) from Aiwa offers 4X dubbing that allows a 60-minute CD to be copied in just 15 minutes. One tray is playback only, and the other can be used for both playback and recording. The unit is compatible with both CD-R and CD-RW discs.

An automatic sampling rate converter that allows you to record from virtually any digital source using sampling rates from 32 kHz to 96 kHz is especially useful when recording from a digital audio tape (DAT) deck. The XC-RW700 also features 96-kHz multi-bit delta sigma digital-to-analog converters and 128X oversampling. For recording and playback flexibility, the CD recorder offers two coaxial and two optical digital inputs, two coaxial and two optical digital outputs, and one set of analog inputs and outputs. One optical input is located on the front panel.

Aiwa America, Inc., 800 Corporate Dr., Mahwah, NJ 07430; 201-512-3600; *www.aiwa.com*.

CIRCLE 51 ON FREE INFORMATION CARD

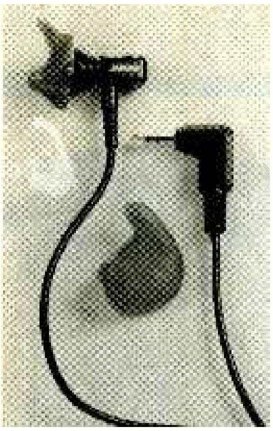
Way to Go

The *V5000 Series Multi-Sensor Vehicle Compass* ($99.95) from California Car Cover Company uses a patented magnetic sensor that is said to electronically compensate for external magnetic fields generated by the vehicle and to eliminate the manual adjustments that are needed with traditional compasses. Besides pointing you in the right direction, the compass provides directional readouts and features an automatic trip timer and trip logs. Equipped with temperature and altitude sensors, the V5000 Series displays the temperature inside and outside the vehicle and offers a digital clock, altimeter readings, and black-ice warnings.

The compass is designed for use in a car, truck, SUV, or RV. It comes with an adjustable mounting bracket that rotates 180 degrees and can be attached to the windshield, dashboard, or headliner with heavy-duty suction cups. It runs on two AAA batteries or can use an optional 12-volt DC power cord.

California Car Cover Company, 9525 DeSoto Ave., Chatsworth, CA 91311; 818-998-2100; *www.calcarcover.com*.

CIRCLE 52 ON FREE INFORMATION CARD



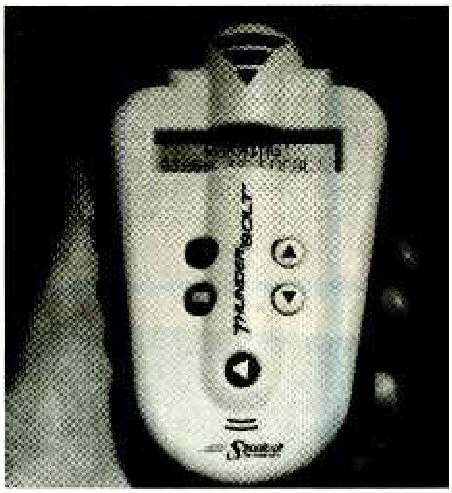
Hands-Free Communications

Holding a cordless phone while trying to work around the house or at the office is inconvenient, and holding a cell phone while driving is downright dangerous. JABRA Corporation offers cellular, PCS, cordless phone, and computer users the freedom of hands-free communications with the *Jabra EarSet* ($39.95). The EarSet combines a speaker and microphone in one tiny earpiece that fits in the outer ear and is nearly impervious to wind and other outside noises. The patented EarGel is a soft, brightly colored, ergonomic ear mold that custom fits the product in the outer ear. Made of easy-to-clean plastic, the lightweight EarGel hugs the ear and can be worn comfortably for hours. Designed to boost sound, it is said to provide better reception than a phone handset.

JABRA Corp., 9171 Towne Center Dr., #500, San Diego, CA 92122; 800-EAR-2230; *www.jabra.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Stormy Weather?



Be forewarned with the *Thunderbolt Storm Detector* from Speedtech Instruments. The palm-sized device is available in purple for personal use ($249) and bright yellow for industrial applications ($399, including utility accessory package). Each model is shock-proof and weatherized for use in extreme conditions. The Thunderbolt has a storm-detection range of 60 miles and is said to be 100% accurate. The easy-to-read LCD automatically displays estimates of storm speed, range, and intensity level. It also lets you know the probability that the storm will strike at your location and the estimated time of arrival, with a message such as: "Storm approaching. ETA 5 minutes."

The Storm Detector provides computer analysis and detection of squall lines and severe storm cells. Besides the text messages, a red LED and an audible tone warn of approaching storms. You can select the warning modes and frequencies, and a connector is provided for an external alarm. The device uses an included 120-volt AC adapter, or can run for about 50 hours on one 9-volt battery. It measures less than 3½ × 6½ inches and weighs 14½ ounces.

Speedtech Instruments, 10413 Deerfoot Dr., Great Falls, VA 22066; 800-760-0004; *www.speedtech.com*.

CIRCLE 54 ON FREE INFORMATION CARD

D-I-Y In-Wall Speakers

The *HomeTech* line of in-wall loudspeakers ($129–$189) from Sonance is designed for easy installation by the average homeowner. The system includes in-wall/in-ceiling speakers and all the mounting accessories needed. The mounting system features dog toggles, making the speakers easier to install. Should problems arise, there's a toll-free installation-help number.

The HomeTech speakers use rubber woofers for durability and enhanced sound quality. The speakers' grilles are pre-painted white and can be painted or wallpapered to match the décor. Round and rectangular models are available. The HT6, sold in pairs, is a rectangular speaker designed for use in home-theater applications. The HT6R, also sold in pairs, is a round, multi-purpose speaker for use with all types of audio equipment.

Optional accessories include speaker selectors that provide safe connection of up to four or six pairs of speakers to a stereo receiver or amplifier and on/off control for each pair; an in-wall speaker volume control; and 50- or 100-foot lengths of stereo speaker cable that is UL- and NEC-rated for Class 2 or 3 low-voltage wiring inside walls.

Sonance, 212 Avenida Fabricante, San Clemente, CA 92672; 949-492-7777; *www.sonance.com*.

CIRCLE 55 ON FREE INFORMATION CARD

42-Inch Flat Plasma Display

With a price tag of $12,995 the *VPW420* plasma display is not for your run-of-the-mill media room, but it is wonderful for its niche market. Only 3.5 inches deep with an 852 × 480 resolution, it delivers a wide 160-degree viewing angle and can be easily mounted on a pedestal, ceiling, or wall.

ViewSonic Corp.; 800-688-6688; *www.viewsonic.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Removable Labels for Rewritable CDs and DVDs

Write-Away Removable Labels, unlike fixed labels already on the market, use a specially designed adhesive placement to minimize contact with the disc's data area. This adhesive allows the user to easily remove the labels, yet holds them securely in place. A kit of 20 labels will sell for $11.95. A pack of 50 will cost $24.95.

Digital Innovations; 888-SMART58; *www.digitalinnovations.com.*

CIRCLE 57 ON FREE INFORMATION CARD

Internet Radio—Computer Not Needed!

Looking like a stylized decorator version of an AM/FM radio, the Kerbango *Internet Radio* (under $300) plays Internet audio of all kinds—without a computer. Plug it into a power source and an Internet connection, and you can tune-in everything: local radio stations, hometown sporting events and programs that are not broadcast locally, Internet-only stations, and your favorite music tracks.

Kerbango; 408-257-4800; *www.kerbango.com.*

CIRCLE 58 ON FREE INFORMATION CARD

Music! In the Palm of Your Hand

What's smaller than a breadbox? The RCA *K@ZOO* ($149 MSRP) is an MP3 music device the size of a matchbox that stores and plays up to one hour of .MP3 files anywhere. Although tiny, the unit has all the features of a full-size device—a built-in preset equalizer, repeat function, and an LCD display.

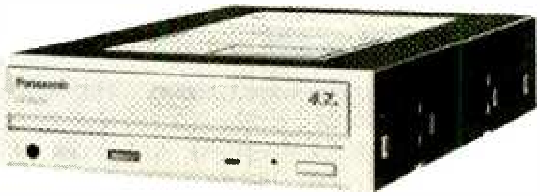
Thomson Consumer Electronics; 317-587-3000; *www.thomson-multimedia.com.*

CIRCLE 59 ON FREE INFORMATION CARD

Super-High-Capacity DVD-RAM Drive

Need a lot of low-cost computer storage? The Panasonic *LF-D201U* will let you store up to 9.4GB—the equivalent of seven CD-ROMs—on a single rewritable double-sided DVD disc. More than 4000 full-color digital images, two hours of MPEG-2 video or over 4000,000 documents can fit on just one single-sided 4.7GB disc.

Panasonic Document Imaging Company; 800-742-8086; *www.panasonic.com/office*.



CIRCLE 60 ON FREE INFORMATION CARD

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

TED NEEDLEMAN

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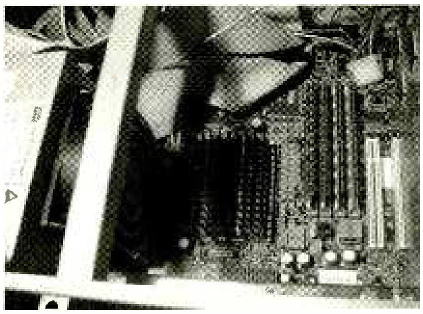
YET ANOTHER UPGRADE?

This has been a pretty good year for upgrading older PCs. Back in the March 2000 issue, we covered replacing an original Pentium processor with an MMX-enabled CPU that was three or four times faster. More recently, we looked at the possibility of replacing a Pentium II or Celeron with a Pentium III.

This time around, we'll look at an alternative for all of those folks who believed Intel when it launched the Pentium Pro as "the next big thing" in November 1995. Actually, Intel was very hopeful about the prospects for this CPU. It contained the core of what would become the Pentium II several years later. The original Pentium, or P5, offered 3.1 million transistors. The Pentium Pro, the first of the P6 series, bumped up the count to 5.1 million transistors. A second data cache, called an *L2* (for Level 2) cache, is integrated into the packaging, though it is located off the CPU die itself. The Pentium Pro really was a much-improved CPU, and initially, PCs incorporating the Pentium Pro sold very well, especially in the corporate market.

Then Intel shot the Pentium Pro in the foot with the release, in January 1997, of the Pentium MMX, or P55C. This Pentium MMX processor was the third generation of the original Pentium, with 4.5 million transistors, a 16K internal data cache, and the addition of 57 new hardware instructions for speeding up multimedia processes. The existing Pentium Pro was faster, had more transistors, and a Level 2 cache that operated at processor speed, rather than the external Level 2 cache that the Pentium MMX required,



The Pentium Pro CPU is hidden under all those heat sink fins.

which operated at the PC's much slower bus speed. In all respects but those MMX instructions, the Pentium Pro was a much better chip.

It didn't much matter. With software vendors quickly incorporating the ability to take advantage of these new MMX instructions to provide increased performance, the Pentium Pro's days were numbered. The end of 1997 quietly retired the chip. A Pentium Pro "Overdrive" processor, which Intel produced to upgrade the Pentium Pro to Pentium II capabilities, also came and went quickly.

A QUICK SHOT IN THE PROCESSOR

While it wasn't available for a long period, Pentium Pro-based systems were popular, as they were the most powerful PCs available at the time. There are still thousands out there, though many are now pretty much at the end of their useful lives. PCs that are much more powerful have been available for quite some time now, and many applications expect—and use—more power than a Pentium Pro is capable of delivering.

That's a shame. Many of these systems have been upgraded over the years, with lots of RAM, larger hard disks, and higher-end video cards. All that's really holding them back is the 180- to 200-MHz Pentium Pro CPUs.

Fortunately, one of the companies most active in processor upgrades has finally addressed this forgotten market. Evergreen Technologies already makes up-grades for the original Pentium-based machines as well as for upgrading Pentium II systems. The newest additions to its lineup are the $179 PerformaPRO 500 and the $249 PerformaPRO 600. These two modules plug into the Socket-8 motherboard socket that the Pentium Pro currently occupies and up-grade the system to an Intel Celeron running at 500 or 600 MHz.

Performing this quick upgrade not only adds a much higher-powered CPU to your old Pentium Pro-based PC, but also gives you the ability to take advantage of the MMX instructions most graphic and multimedia software now incorporate.

We installed the PerformaPRO 600 on a Gateway G6-180 that, except for the CPU, had been upgraded a number of times over the years with a large hard disk, 64MB of RAM, and a Number 9 Revolution128 video card. The PerformaPRO upgrades do not work with every Pentium Pro-based system. The upgrade is only for Pentium Pro CPUs that operate at 180 MHz or faster. In addition, the motherboard and BIOS need to be able to support the new CPU. Before ordering the upgrade, you need to note the vendor and ver-

The completed upgrade adds a fan, but doesn't interfere with any of the other motherboard components.

sion number of your system's BIOS and ask Evergreen if your system is supported. You can usually get this information by watching carefully as the PC boots, or by using a utility, such as the shareware system-information application *SANDRA*, which provides this data.

PLUG AND ALMOST PLAY

Once Evergreen determined that the PerformaPRO600 would work with our intended upgrade platform, performing the actual upgrade was very simple. The Pentium Pro on our Gateway was installed in a ZIF (zero-insertion-force) socket, with a large heatsink clipped to the base. We had to first unclip and remove the heatsink and then move the locking lever on the socket. The Pentium Pro CPU just lifts out, and the PerformaPRO 600 simply plugs into the socket in its place. Because the PerformaPRO 600 has a fan attached to its heat sink, you need to plug the fan into a power connector. A "Y-"type splitter cable is provided for this purpose. You also have to plug in a second power connector that powers the circuitry on the Celeron's adapter card. Once the upgrade is installed, you boot up the system and run a short program on the included floppy disk. This installs a utility that enables the Celeron's on-board 128K Level 2 cache.

Our system booted fine the first time but, after installing the software utility, froze on reboot. We were able to reboot in Windows' Safe Mode, so we removed the line in the AUTOEXEC.BAT file that ran the Level 2 cache enabling utility. With this utility disabled, our upgraded system booted right into Windows.

In testing the upgraded system, we noticed that the CPU was being reported as running at 533-MHz, rather than 600-MHz. A bit of investigation and a call to Evergreen Technologies' tech support uncovered the fact that the front-side bus on our G6-180 was running at 60-MHz. Full performance from the Celeron requires a 66-MHz front-side bus. We tried to reset the bus speed with the motherboard jumpers for this purpose, but the system kept locking up. Finally, we just reset the jumpers to their original location, and resigned ourselves to living with the equivalent of a 533-MHz CPU.

IS IT WORTH THE PRICE?

We measured performance before and after the upgrade using the CPU and CPU Multimedia benchmarks contained in the *SANDRA* utility. Table 1 summarizes those tests. Since the original Pentium Pro did not offer MMX instructions, the column in the table that reports this has "Not Applicable" (N/A) as an entry. A quick look at those particular tests shows between a three- and nine-time improvement, depending on what is being measured.

The real boost shows up when running computing-intensive applications, such as *Photoshop*, *PhotoDeluxe*, or even games; the improvement is immediately noticeable.

Is this particular upgrade worthwhile? The answer is the same as with other upgrades—it depends. With the system we upgraded, we had performed intermediate upgrades of memory, hard disk, and video, along the way over the years. If you haven't maintained your Pentium Pro system and first have to start considering upgrades in these other areas as well, then the PerformaPRO 500 or 600 probably isn't worth doing. By the time you add in more RAM and a new hard disk, you are probably better off just buying a new system.

On the other hand, if your system has been steadily upgraded over the years, the PerformaPRO 500 or 600 is a relatively inexpensive way to both boost performance significantly and get another year or two of use from that Pentium Pro you were probably thinking of dumping.

VENDOR INFORMATION

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Corvallis, OR 97330
541-757-0934
www.evergreennow.com
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TABLE 1

SANDRA CPU BENCHMARK RESULTS

	CPU	FPU	Integer MMX	Floating-Point Multimedia
Pentium Pro	493 MIPS	230 MFLOPS	N/A	257 it/s
Evergreen Upgrade	1496 MIPS	727 MFLOPS	1696	2260 it/s

A Hands-on Electronics® REPORT

Aqcess Qbe Portable Tablet

Here we are at the dawn of a new millennium—again. Every publication is checking out new technology: what's hot and what's not for the 21st century. In the computer realm, the movement is to smaller, flatter, more portable devices—with more and more features. Consumers want sleek, all-in-one devices that recognize their voices, recognize their handwriting, and connect them to the Internet. Something that doesn't need peripherals—no mouse, no keyboard—would be a real hit.

Is the *Qbe Cirrus Personal Computing Tablet* from Aqcess Technologies the answer to that wish? Well, yes and no. First let's look at what this tablet has to offer.

The Qbe is the first Personal Computing Tablet offered by Aqcess with a Pentium II 400-MHz processor. It comes equipped with a 12GB hard drive, 128MB of upgradeable memory, a 56K modem, and a network card. Additional tools include Internet access along with multimedia features.

Most noteworthy is its compact size. The Qbe measures just 14 by 10 by 1.6 inches, slightly larger than a legal pad, and weighs just less than six pounds. Now this is not a palm-size device for jotting notes and reminders, but rather a tablet designed for work.

The included stylus allows users to navigate and write on the eye-catching 13.3-inch, active-matrix, color touch screen. Both handwriting and voice recognition are offered in the Qbe's assortment of tools. (More about these features later.) Other useful extras are a small digital camera and a Smartcard magnetic strip reader.

Panel of Reviewers. We asked a panel of reviewers to put the Qbe through its paces and report their findings. The three reviewers were all excited about working with the feature-rich device. (Speaking of rich, the price for our review unit was listed as $4745, but the price has been reduced to $2999. By the time this was being written, we had received word that a smaller, lighter weight, less expensive version—the Qbe II—was just released.)

Let's look at their reports.

The Network Manager. I was fascinated and intrigued by its design and by the concept of the touch screen. The built-in camera and the credit card swipe were also impressive. The touch screen combined with the Qbe's handwriting recognition ability makes the unit easy to use. I could write with one hand while holding the tablet in my other arm. After a while, the tablet did start to feel somewhat heavy compared to the Palm IV that I've grown quite accustomed to.

I was also impressed when a colleague, who was quite familiar with voice recognition software, showed me the voice recognition on the tablet. However, I did not have the same success and could not get the voice recognition to work.

For the average user, a good laptop and a state-of-the-art Palm Pilot would be a better fit. However, that combination still wouldn't have all the features and benefits that come bundled in the Qbe, which is a lot of fun to play with and a surefire conversation piece.

With all its bells and whistles, I feel the unit will be a must-have for any salesperson out in the field. I suggest that sales reps or warehouse managers should go straight to their IT manager and tell him to get you one immediately!

The Artist. To begin with, I found that the device was fairly simple to set up straight from the box. The unit came with an easy-to-read quickstart instruction sheet. There is no need to be a power user to get the machine running.

The quickstart instructions direct you to hook up the AC adapter, the pen, and the keyboard. As I saw myself slowly become tangled up in a small spider's web of black cables, I was slightly skeptical about how the Qbe was going to be more convenient or fun than my desktop unit.

Once it was fully up and running, I found that I only needed to use the keyboard as a last resort...most of what I needed to do could be done with the pen. The keyboard is a comfy safety net, because no matter how point-and-click oriented you are, you are more keystroke-reliant than you think. I found that out quickly enough.

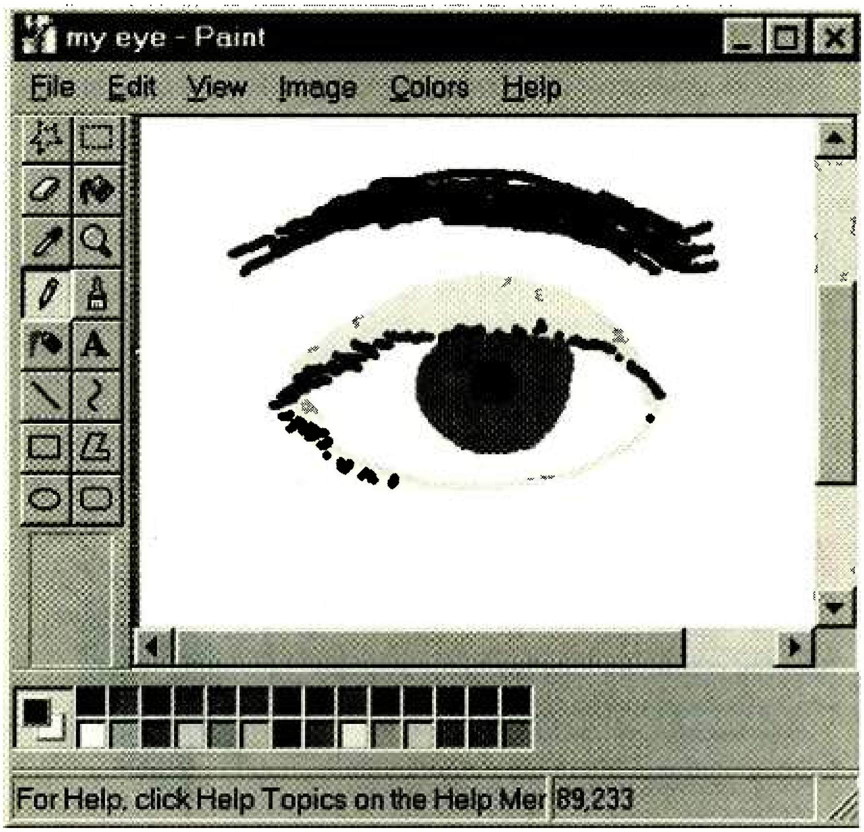
One of the first things I noticed is that the unit is heavy. Quite heavy. Considering all the computing power (CPU, monitor, CD-ROM drive, video capture, hard drive, mouse and pen controllers, touchscreen functions, etc.) that has to be packed into a device about the size of the Sears Christmas Wish Book, this is more than understandable. However, for all the features and weight, there is no removable medium drive (other than the CD-ROM drive). No zip drive. No floppy drive. No ORB drive. No superdisk drive. The only way to get your files out of the Qbe is either to e-mail (or upload) them over the Internet or by connecting it to another computer. For all the convenience of being able to work out in the field and on the fly, there is no easy response to a request for a copy of that file. But I digress.

Let's look at the features. It is exceedingly easy to switch the display from portrait to landscape mode, and back again—just a double-click. Right-clicking is achieved either through clicking on a floating button on the desktop (highly convenient for its proximity and availability and exceedingly annoying because it's obstructing your work area) or by clicking on the button on the frame of the unit itself (not quite as convenient, but much less annoying).

Calibrating the pen is also a simple task, and is highly recommended any time that you switch from portrait to landscape mode (or back).

I work as a freelance artist. True, I do my work on a computer, but my trip to the CRT was a reluctant one. I started out trying a light-pen on my dad's Commodore 64 back in nineteen eighty-something. Given the low resolution of those monitors and the jitter factor of the pen in those days, said pen was useless and was quickly returned to the store for a refund.

Fast-forward about a decade (and a few Intel processor chips) later, I received a tablet as a Christmas gift. I found the pen to be an awkward substitute for my mouse, and an even more cumbersome replacement for my keyboard. When it came to actually using it to draw, that was a different matter. Now if you don't draw, bear with me. If you use paint or pastels or ink or pencils, you apply said tools directly to your paper/ canvas/whatever. What you apply your pigment to and where your eyes are focused are roughly the same point. Now switch to a tablet. When drawing on a slab of plastic (most likely, in your lap), while looking at your



Our artist reviewer created this drawing to test the Qbe's utility as an illustration platform.

monitor, there's a good 90-degree difference in orientation. Granted, I'm not the world's most coordinated soul, but it just felt *wrong*. I'd draw on that tablet, only under duress or when the one who gave it to me was looking, but the moment his back was turned, back to the paper and pencil I'd go.

I thought, If only they could come up with a laptop with a display I could draw on— something where I can look at what I'm drawing on. "Oh, what a happy girl I'd be, my brothers!" When I'd heard about the Qbe, was I ever intrigued.

I calibrated the pen and opened up *Paint*. I found that the level of control was not quite sufficient to the task of creating an illustration. The cursor always seemed just a squeak off—a little too low or a little too much to the side—not a lot, mind you, but more than you would expect from sheer parallax. With practice, I was able to get used to this, after a fashion. It felt unusual, though...a little like tying a string to the butt-end of a paintbrush and trying to paint by holding just the string. I tried drawing using my finger, but precision faltered even more. Included in this review is a quick doodle I created on the Qbe, which I call, "My Eye."

The Qbe is indeed a hot unit. Literally. As in, don't use it on your lap wearing shorts in the summertime hot. Earlier, I had plugged the unit in and placed it on a sofa to charge up (the battery charges up quite quickly—about two hours to a full charge). When I came back, the unit had shut itself down. When I restarted it, I found it hot to the touch, and I powered the unit down to cool.

In general, the heat problem must be addressed. A re-writable removable media drive needs to be added (ORB or Zip).

If the Qbe is being marketed to the artist (which makes exquisite sense), then the precision of the pen interface needs to be tweaked.

If it is being marketed to the guy (or gal) on the go, then the portability has to improve a bit. You need to be able to leave the keyboard and mouse at home.

If asked if I liked the machine, I would have to answer with a qualified "yes." Mind you, a *qualified* yes. It's a nifty little gem and a terrific idea, but the final execution needs a little more time in the laboratory.

The Electronics Enthusiast. The Qbe is a great first step in a new portable device. It is trying to do something never done before—to be a renaissance portable computer that provides all the possible services of a PC, without the need for a keyboard.

When I went through the standard configuration to start it up, I encountered some bugs and "freezes." However, after turning the machine off, pausing for a few seconds, and rebooting, I was pleased to see that it picked up where it left off and I didn't have to start from the beginning. Sadly, such "glitches" are the norm in the computer industry. A small percentage of units shipped from the factory will not start cleanly the first time power is applied. I've seen it happen to machines from Dells and Compaqs down to Packard Bells. The Qbe review unit just happened to be one of those.

Unlike my colleague, I didn't have any problems with the voice-recognition software. I have used voice recognition software in the past—the "one...word...at...a...time" variety—and found the Qbe's natural-speech voice recognition software to work as advertised. After only one training session, I was able to run a test by reciting the Preamble to the Constitution and the opening paragraphs of the Gettysburg Address; the software performed flawlessly. All I can say is that those who have not experienced natural-speech voice recognition are in for a real treat!

On the other hand, I found the handwriting recognition disappointing. It had difficulty recognizing some characters and proofing symbols. Although it did okay one character at a time, it took 5 to 6 seconds to recognize those characters. Perhaps with some judicious tuning and tweaking, I could write more than one word before the recognition routine would kick in, stopping the show, but the time delays were frustrating. As with voice-recognition, I've used handwriting recognition software in the

past on a CalComp tablet, and that software was an absolute dream in terms of speed and accuracy—on a Pentium 90! If I were to keep the Qbe for my own personal use, I would ditch the bundled handwriting software. Unfortunately, CIC (the authors of my old handwriting software) have stopped promoting their *Handwriter* product in the retail market.

As for the built-in camera, it worked well for pictures on the go.

To try out the 13-inch active-matrix screen, I watched a videoCD movie in full-screen mode using Microsoft's *Windows Media Player*. The screen was absolutely gorgeous. Given their diminutive size, the speakers did an adequate job with sound, although like most portables, you shouldn't expect home-theater quality Dolby surround sound. When the movie (Mike Jittlov's *The Wizard Of Speed And Time*) reached the end of the first disk, I popped the disk out of the CD-ROM tray and tapped the screen to return to windowed mode. Instead, I was faced with the dreaded BSoD (Blue Screen of Death). Windows98 had correctly determined that the mounted disk was no longer accessible and was asking me to either clean it or reinsert it in the drive. I was also prompted to either "hit ENTER to continue or ESC to quit this screen."

The Qbe has a couple of buttons along one side that can be used as "emergency 'any' keys," but they only work when the Qbe drivers are running...in Windows98. A BSoD suspends the GUI and drops you into a basic text mode—hence the blue screen with white text à la *WordPerfect 5.1*. I found myself shouting at the Qbe, "How am I supposed to hit the ENTER key when I don't have a @##%&!! keyboard?"

Doing the old "turn-it-off, count-to-ten, turn-it-on" samba brought the Qbe back to life after a fun session of watching *ScanDisk* scold me for not shutting Windows down properly.

This problem is not the fault of the Qbe; I lay it at Microsoft's doorstep. Without access to the Windows source code, it's rather difficult—if not impossible—to teach a "closed-source" operating system something as trivial as "Oh, by the way—you don't have a keyboard to lean on for user input." This is probably part of the same mentality that created the famous error message years ago: "Keyboard Error. Press F3 to continue."

The Qbe's lack of removable media guaranteed alternate methods of communication with other computers. The built-in Ethernet port was simple to use to connect the Qbe to a Novell network. At home, I have an old LapLink parallel-port cable. This type of cable uses the quasi-bidirectional abilities of a standard parallel port for much faster data transfer between computers with the right software. Back in the dark days of DOS, special software such as *LapLink* or *CoSession* were required. Later, Microsoft bundled *Interlink* with MS-DOS 6. Today, Windows comes with *Direct Connect* utilities. I had no problem connecting the Qbe to my home machine through the Qbe's printer port on the bolt-on mini-docking station. After transferring several files back and forth, I shut both machines down for the evening.

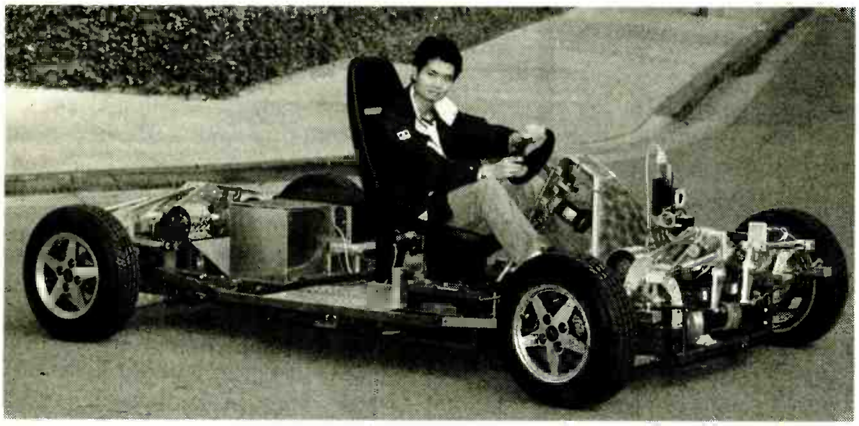
The next day, I hit the Qbe's power button and was greeted with dead silence. Nothing. Not a peep. Had I already broken this wonderful new toy after a couple of evenings? With rising panic, I disconnected the various devices one at a time. When I removed the docking station, the unit came to life. Upon further experimentation, I found that for some strange reason, the LapLink cable prevented the system from starting. Even if it wasn't connected to another machine, the formula *Laplink=no start* held true. Once the system started its BIOS diagnostics, reconnecting the cable had no further detrimental effect. Odd to say the least!

Conclusion. The Qbe packs a lot of punch. It has features galore, not all of which are bug-free, and there are definite design problems. That being said, our panelists agree that the Qbe is an attractive and functional unit for its niche market. However, this model is not all things for all people. We are looking forward to reviewing the next generation Qbe.

For more information on the Qbe, contact Aqcess Technologies, 16800 Aston St., Irvine, CA 92606; 888-818-0055 or 949-567-1000; *www.qbenet.com*; or circle 80 on the Free Information Card. **P**

Prototype

Cars That Drive Themselves



Zilai Zhao, a former UCLA graduate student, shows off the Advanced Vehicle Control Laboratory Vehicle on Wheels, which tests concepts envisioned for vehicles of the future. *(Photo by Todd Cheney, UCLA.)*

A team of UCLA researchers led by Electrical Engineering Professor Ioannis Kanellakopoulos has developed an "Advanced Vehicle Control Laboratory on Wheels." It tests concepts envisioned for vehicles of the future.

Drive-By-Wire

Features currently being tested are Drive-by-Wire, Steer-by-Wire, and distance sensing. Drive-by-Wire allows the speed of a vehicle to be controlled without the need for any mechanical linkage connecting the accelerator and the throttle. Steer-by-Wire alters the vehicle's direction via a computer algorithm, eliminating the need for a steering column. An innovative ranging sensor that calculates the distance between vehicles and acts as a collision-warning device is also being tested.

In addition, the platform is designed to test innovations, which have not yet been developed such as autonomous capabilities that will allow vehicles to drive by themselves.

"We wanted to have the capability to do things that the car companies are not even thinking about so we can do every imaginable experiment," Kanellakopoulos said.

Some of the features—such as Drive-by-Wire—are already available in production versions of higher-end vehicles. Others will be available soon.

Joy-Stick "Shift"

Steer-by-Wire, for example, is still experimental. One of the challenges it poses is providing drivers with appropriate feedback. For assistance in this area, researchers turned to video game designers. The steering wheel on the test vehicle contains an electric motor that provides resistance equal to that experienced when turning the steering wheel of a conventional vehicle. In fact, the effect is so realistic that "if you bump up against the curb, you shouldn't be able to turn the steering wheel and this motor is powerful enough to keep you from doing so," Kanellakopoulos said.

Eliminating the steering column, according to Kanellakopoulos, would increase safety by removing one of the more common objects that cause injury during automobile accidents. It would also increase performance as well as reduce production costs. "You don't even need a steering wheel anymore for that matter. You could have a joystick," he added.

Initial funding for the project came from a grant from the TRW Foundation. Researchers are currently collaborating with Ford and Visteon on a Steer-by-Wire project. (Visteon is a spin-off from Ford, just like Delphi was a spin-off from GM.)

Cars That Help You See More

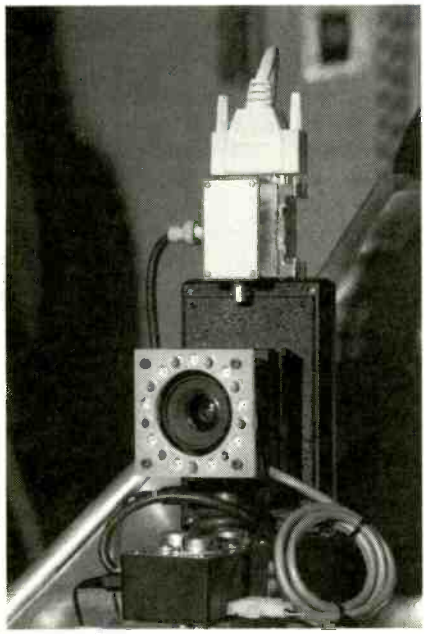
One of the more promising avenues researchers have explored involves the use of an Infrared Ranging via Image Subtraction (IRIS) sensor. IRIS capitalizes on the fact that all vehicles contain retroreflective surfaces. On automobiles, these are found in taillights. Vehicles such as bicycles have similar retroreflectors.

IRIS captures and compares two images: one illuminated with its infrared beam and the other illuminated by ambient light. The difference between the two images is the retroreflective surface, enabling you to see taillights or a reflective bumper sticker.

IRIS could help in the development of "smart cruise control."

"You select not only the speed you want to drive at, but also the distance you want to keep from the car in front of you. If the car in front of you is moving slower than you are, your car slows down to follow it, so you can use just your speed control in city traffic."

But IRIS has its limitations, including penetrating very thick fog or very heavy rain. "It won't see a tree. If there is a child in the street who isn't wearing reflective clothing, you won't see him either. So it's designed for the highway



Infrared Ranging via Image Subtraction (IRIS) sensors can see through fog. IRIS capitalizes on the fact that all vehicles contain retroreflective surfaces. On automobiles, these are found in taillights. IRIS captures and compares two images: one illuminated with its infrared beam and the other illuminated by ambient light. The difference between the two images is the retroreflective surface, enabling you to see taillights or a reflective bumper sticker. *(Photo by Todd Cheney, UCLA.)*

environment where you won't have trees in front of you or pedestrians," Kanellakopoulos said.

Systems on high-end automobiles currently use radar sensors. Radar, however, also has its problems. To remove clutter, most radar sensors separate out and discard signals bouncing back from any objects which are stationary. So even though radar can penetrate fog, it cannot see stopped cars because most radar sensors cannot differentiate between a stopped car and the road. Radar can, however, spot children—which the IRIS system is unable to do.

"But if you've got both of these sensors, you can see the reflection of a stopped car very clearly," Kanellakopoulos said. He envisions such a dual-sensor system for high-end cars, or for trucks "where you want very high reliability, and cost is not the primary issue."

Automated Automobiles

By integrating this technology with GPS, it's possible that the system could turn vehicles automatically.

"It would be great if my car had these fully automated capabilities. So I can get on the freeway and tell it 'I want to get off in 35 miles.' And it gets on a dedicated lane, and this lane goes much faster. I don't have to wait in traffic. I'm polluting less because I'm spending less time sitting idle, and it's safer because if my attention gets distracted I'm not fully responsible for the system at that point."

Anticipating these advances, the test platform is also capable of carrying out experiments in wireless communications. One of the concepts researchers have considered, but not yet pursued, is remote guidance. The car drives itself, but when it comes to an intersection, it stops and waits for directions from the base station.

"You want the car to have autonomous capabilities, but you want to do some guidance remotely," he said. "Imagine now if people really didn't wasn't to drive except on occasion, for leisure, but they don't want to go to the stores." Shopping from home will put increased pressure on the postal service and other package delivery services. "How are they going to deliver millions and millions of millions of packages on time?"

His solution is a fleet of automated vehicles, capable of picking up packages and delivering them to the proper addresses.

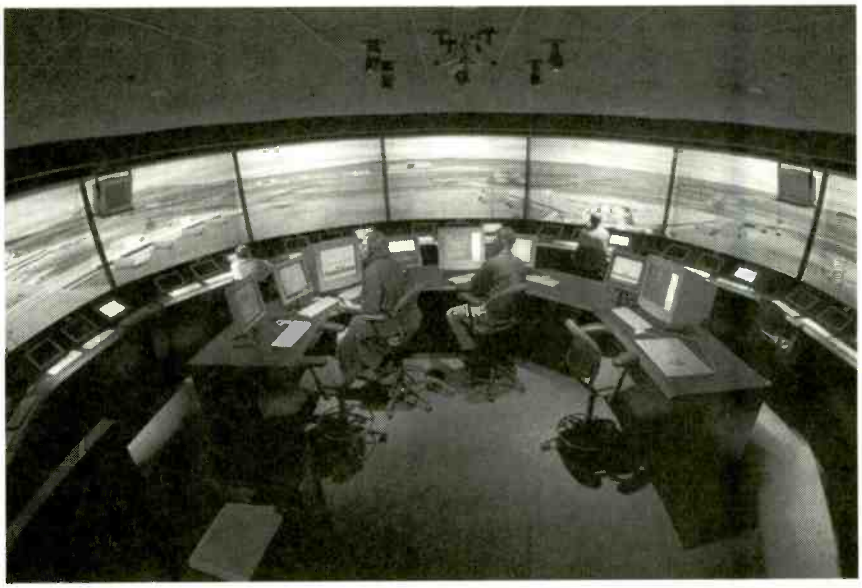
Before any of these innovations show up on the street, there's a good chance they'll be tested on the "Advanced Vehicle Control Laboratory on Wheels." PT

FutureFlight Central

The world's only walk-in, full-scale, 360-degree airport simulator, NASA's FutureFlight Central, permits air traffic controllers and planners to realistically test new airport designs and modifications of future and existing airports. The San Francisco International Airport (SFO) Commission has selected this facility to evaluate new tower positions, and test runways, landings, aircraft movements, ground traffic and many other airport factors in a realistic, computerized world before new construction begins.

"NASA's FutureFlight Central hopes to save airports costly design errors by permitting them to easily experience different, highly realistic versions of their airport design and, most importantly, observe how real people work inside these future environments," said Dr. Paul Kutler, deputy director of the NASA Ames Information Systems Directorate.

The virtual simulator is located at Ames Research Center, Moffett Field, CA, about 25 miles south of San Francisco. The facility can house as many as a



Displayed on the seamless out-the-window field-of-view of FutureFlight Central's tower cab is San Francisco International Airport using combined digitized photo/polygon-textured images. Shown in the photo are research staff Bob McMahon, Jim McClenahen, Boris Rabin, and Cedric Walker.

Pictured here is the fully integrated audio/visual control system for recording/playback, remote viewing, and coordinated communication of a simulation in progress. Equipment includes six RGB monitors, five video monitors (one for quad-split viewing), six VCRs (one Betacam and five VHS), one DVD player, one multi-disc player (laser/CD), timecode units, video text generator, patch bays, microphone, and Crestron touch panel system control.

dozen air traffic controllers, and it can represent the busiest U.S. airport towers in size and capability.

Airport officials say they chose the NASA simulator to help plan airport changes to increase both efficiency and total air traffic capacity. Using the one-of-a-kind airport testing facility, SFO airfield planners, Federal Aviation Administration air traffic controllers, and others will help to select the best location for a new tower.

"Engineers can identify future problems and can try solutions in a safe setting, the computer's virtual world," said Nancy Dorighi, who manages the facility at Ames.

The simulator's artificial world changes in real time. Scenes evolve, in the same manner that real-world changes occur. In the computer world, airplanes not only come and go, but weather changes. Consoles are at each controller's location showing radar, weather maps, runway lights, and touch-screen controls, as well as other readouts.

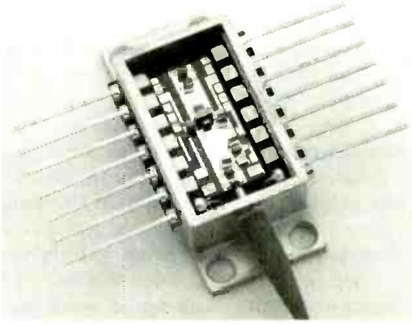
"We are able to represent any airfield in existence or as planned for the future," said Dorighi. "We can measure the impact of a change on the airport's capacity and let the controllers try it first-hand, all before anything is built."

After putting a new airport data set into the computers, FutureFlight researchers can switch to the new artificial airport in moments. Rearranging furniture in the simulator will take longer than activating a new computerized airport, NASA technicians noted.

Other unique features of NASA FutureFlight Central include: capability to move the tower "eye point" to any location, including a "pilot eye view;" precise controls to simulate weather, time-of-day, cloud coverage and lighting; a voice and data communication network, allowing ground-to-tower and air-to-tower human interaction; and video record and playback, allowing analysis of human performance and decisions. PT

Micromachines

At Sandia National Laboratories, researchers are actively pursuing the design and fabrication of LIGA micromachines for defense and other applications. LIGA (an acronym from the German words for lithography, electroplating, and molding) is a micromachining technology originated in the early 1980s at the Karlsruhe Nuclear Research Center. By using the penetrating power of x-rays from a synchrotron, LIGA allows the fabrication of structures, which have vertical dimensions from hundreds of microns to millimeters, and horizontal dimensions, which can be as small as microns.



Alignment structures, less than a 10th of an inch in size in this optical module, use the LIGA microfabrication process. This AXSUN Technologies photonic subsystem sits on an electronic assembly that occupies about 60 percent of the area of a business card (2.5 inches long by 1.7 inches wide).

The height-to-width ratio capability is relevant to the manufacturing of miniature components that can withstand high pressure and temperature and can transfer useful forces or torques. The material flexibility also offers opportunities to fabricate miniature components using LIGA instead of precision machining approaches such as wire EDM.

Sandia is licensing this technology to photonic subsystem provider AXSUN Technologies. Their Agile Photonic Subsytem uses micro-mechanical alignment structures that are fabricated by the LIGA process. These subsytems manipulate light, through tuning or switching signals at the optical layer, allowing existing optical telecommunications networks to increase performance. PT

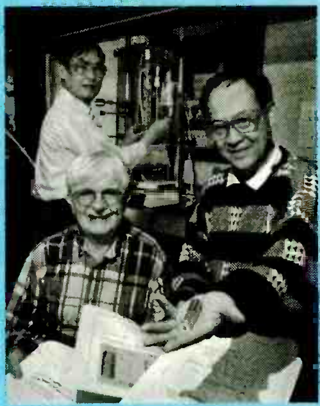
Clouds on Fire

A common pollutant that has been around for thousands of years has been newly identified as a potentially major contributor to global climate change, according to a paper published in the May 12th issue of the journal *Science*.

➤ "Reduced-Salt" Batteries

Researchers at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory have developed a new kind of electrolyte for use in lithium-ion batteries. The new electrolyte is less expensive and more environmentally friendly than those currently used.

Rechargeable lithium-ion batteries now dominate the market for use as a power source in cell phones and many laptop computers. Researchers would like to scale up these batteries for use in electric and hybrid electric vehicles.



Shown here are: Hung Sui Lee (in rear), James McBreen (front, left), and Xiao-Qing Yang (front, right), holding a prototype battery. Photo credit: *Courtesy Brookhaven National Laboratory.*

One problem, however, is that in today's lithium batteries, the salt component of the electrolyte—the fluid that carries the flow of electricity from the positive cathode to the negative anode—is expensive and toxic, explained Xiao-Qing Yang, one of the Brookhaven scientists. With the large quantities required for vehicle batteries, these drawbacks could become prohibitive.

So, with funding from the DOE's Office of Basic Energy Sciences, BNL's team has been looking at ways to improve the electrical conductivity of electrolytes containing less expensive, less-toxic salts. In the technique for which they've been awarded a patent, the researchers have designed and synthesized a series of boron-based compounds that, when added to electrolytes, increase their electrical conductivity to a level comparable with those currently used.

Spectroscopy studies the team is conducting at Brookhaven's National Synchrotron Light Source will help make further improvements. By understanding how these additives work with the salt and the electrolyte at the molecular level, the researchers can modify their molecular structures to improve their performance.

The team, which also included Hung Sui Lee and James McBreen of Brookhaven Lab and Caili Xiang from China, has already gotten inquiries about licensing the invention; but nothing has been agreed to yet. PT

Scientists at NASA and the Scripps Institution of Oceanography report that airborne black soot has the capacity to raise regional temperatures far more than carbon dioxide, a major greenhouse gas that also results from combustion.

According to the research team, the intense sunlight of the tropics heats the soot present in polluted air. This heating burns off the flat tops of shallow cumulus clouds for hundreds of miles downwind of pollution sources. With less cloud cover reflecting sunlight back to space, there is increased solar energy that reaches the Earth's surface and the lower atmosphere. This can significantly heat the atmosphere and oceans, according to the new findings.

"Aerosol pollution can increase or decrease cloudiness, depending on the weather and the particular ingredients of the pollution," said Andy Ackerman, lead author of the paper and scientist at NASA's Ames Research Center in California. "This newly discovered mechanism amounts to a heating effect over the Indian Ocean that is 3 to 5 times as strong as the global effect of increases in carbon dioxide since pre-industrial times."

The research team used measurements of the dark haze covering vast areas of the Indian Ocean (during the dry monsoon in February to March 1998 and 1999) as input to a sophisticated computer model of tropical clouds. Researchers obtained the measurements during the Indian Ocean Experiment (INDOEX).

It is only the soot component of pollution that causes this newly discovered cloud-burning effect. Prior research on aerosol-cloud-climate effects focused largely on other ingredients of aerosol pollution. These components were found to increase cloudiness and oppose greenhouse warming. This occurred because increased amounts of water-soluble aerosols produce more numerous and smaller cloud droplets. Such droplets reflect sunlight more efficiently and are less likely to result in rain.

"While this is an important finding, we should recognize that it is a theoretical-model calculation, which must be tested against actual measurements," said V. Ramanathan, co-author of the paper and director of the Center for Clouds, Chemistry, and Climate at Scripps Institution of Oceanography in La Jolla, California. "Much additional field work remains to be completed."

Solar heating measured during the most recent experiment in the tropics is not considered to be unique or specific to a given time and place, according to researchers. On the contrary, the authors noted that comparable amounts of soot have been measured by previous researchers in other polluted air masses such as those off the mid-Atlantic coast of the US.

The authors of the *Science* paper expect that their recent finding will motivate a new direction of research into aerosol-cloud-climate interactions. It may well lead to further refinements in global climate models and enhance our ability to predict future weather patterns. PT

Ultrasonic Motors

Find out what all the "noise" is about with this unusual method of powering motors.

JIM VAN LAARHOVEN

It is an exciting development when a major change occurs within a seemingly changeless field of technology. Electromagnetism has always been the driving force behind electric-motor technology. The field of *ultrasonics* seems to be changing that driving force and in an amazing way.

With the implementation of piezo-electric-ceramic materials (mainly, PZT—Lead-Zirconium Titanate), electrical motors can now be much lighter in weight and cause little or no electromagnetic interference. In addition, motor-control circuits can be downsized due to the reduced power requirements and the deletion of circuit shielding for electromagnetic waves. Ultrasonic motors (also known as USMs) run quieter than their electromagnetic counterparts because of the drastic differences in their method of operation and the construction materials used.

The reason for this notable change in the field of motors is due mainly to research and development in the area of piezo-ceramics. NASA (along with many corporations and universities) has been developing piezo-ceramic materials for the space, aviation, electronics, and medical industries. For lightweight motor design, active materials are needed that are compact, power efficient, cost effective, and reliable. Piezo-type materials fit the bill to a "T."

One of the chief attributes of the ultrasonic motor design is its ability to be easily miniaturized. The robotics industry benefits from this miniaturization due to the reduced control-circuitry requirements of the USMs. Complex controls can be tightly packed into a smaller area, thereby increasing control and dexterity while decreasing weight and bulk. Robotics applications also benefit from the quiet operation along with inherently reduced production costs. Since these motors have a self-locking mechanism (friction), motor-braking methods can also be eliminated. Gearing mechanisms can be discarded when USMs are implemented. The motor itself has high torque characteristics that virtually do away with the need for added gearing. Another characteristic of ultrasonic motors is their quick start- and stop-response time.

How They Work. It was discovered during the nineteenth century that

This drill, developed at NASA's Jet Propulsion Laboratory, weighs about a pound but can drill with a jackhammer-like motion through rock as hard as granite or basalt. The broken debris is drawn up through the hollow drill shaft. The resulting hole is little bigger than the drill head.

when certain ceramics were squeezed, they would produce a voltage. Current ultrasonic-motor design works from this same principle, only in reverse. When voltage is applied to the piezo-ceramic material, an actual deformation of the ceramic material occurs. This principle allows the development of many different ultrasonic applications.

Ultrasonic motors make use of a ring-shaped piezoelectric crystal with segments having sequentially reversed polarity. This ring is bonded to the surface of an elastic stator (see Fig. 1 for a traveling-wave type motor). The ring is divided into two groups of alternated polarities that are driven simultaneously by cyclic signals that are 90° out of phase. The piezo-ceramic material deforms in response to these electrical signals. The input frequency of these signals needs to be greater than 20,000 Hz, and it is selected to induce a resonance vibration into the stator in the form of a traveling elastic wave. The induced wave involves an orbital motion of the surface particles, which rotates the friction ring and rotor, thereby producing shaft output (Fig. 2). Since the direction of the orbiting particles at the wave peaks is in the opposite direction to the traveling wave, the rotor then turns opposite to the wave. Reversing the polarity of the input power will reverse the direction of the rotation.

Note how the "traveling wave" theory of USMs is similar to the "rotating magnetic field" principle behind AC-induction motors.

Modifications to the basic USM design include adding teeth to the piezo-ceramic stator ring. This addition improves the propelling action and increases the overall speed of the motor. Multiple piezoelectric rings can also be used to enhance performance. Many different rotary designs are currently on the market. Some newer designs use 180° out-of-phase power that uses multiple power inputs. This design seems to work well for stepper-type motor functions.

USMs are well known for their low-speed operation; however, speeds of up to 3000 rpm have been attained. Studies of USM torque characteristics indicate that torque ratings (without gear reduction) average ten times greater than a comparably sized electromagnetic motor.

USM Construction. USM construction tends to be simpler than most electromagnetic (EM)-type motors. Fewer assembly parts mean fewer moving parts. Fewer moving parts mean less wear and therefore less chance of anything going amiss during the life of the motor. Earlier USMs experienced low operational lives (1000 hours or less). This was mainly due to excessive material wear caused by friction and limits to the durability of the bond between the piezo-ring and the stator. Improved materials and fabrication techniques have extended the overall life expectancy of USMs in recent years.

Depending on the manufacturer and the intended application, USMs can appear to be quite different in structure than the model depicted here. However, most of the same principles of operation still apply.

Extensive research has gone into creating durable piezoelectric materials. Early material was extremely hard to work with because of the inherent brittle nature of ceramics. Continuous flexing of the ceramic ring caused the material to stress crack. Later, certain bonding techniques were discovered and implemented, thus reducing the possibility of damage to the PZT ring during operation.

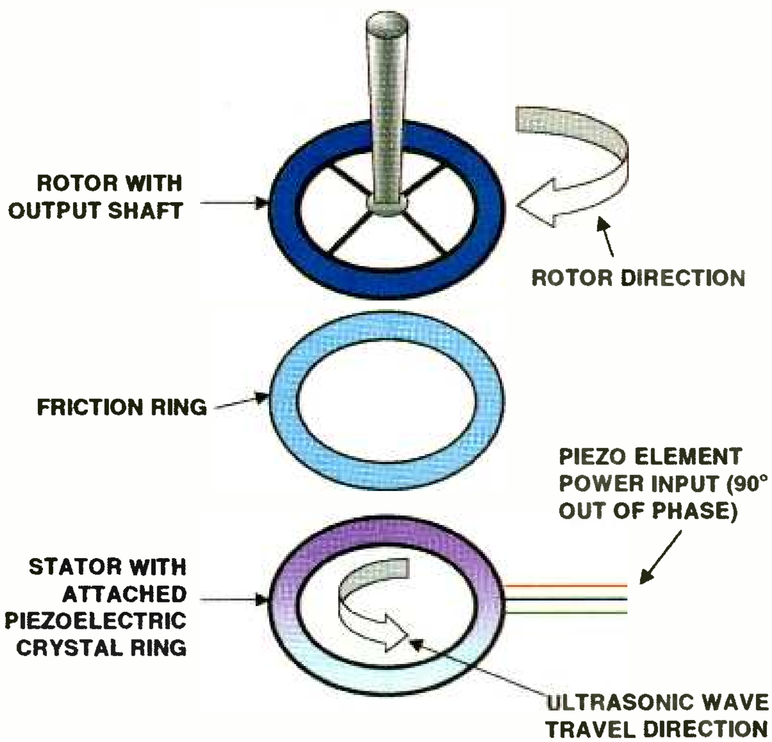


Fig. 1. A basic ultrasonic motor uses a stator covered with piezo-ceramic crystals. When energized in a set pattern, they create a mechanical "wave" that presses against a friction ring. The rippling effect spins a rotor in the opposite direction of the ultrasonic wave.

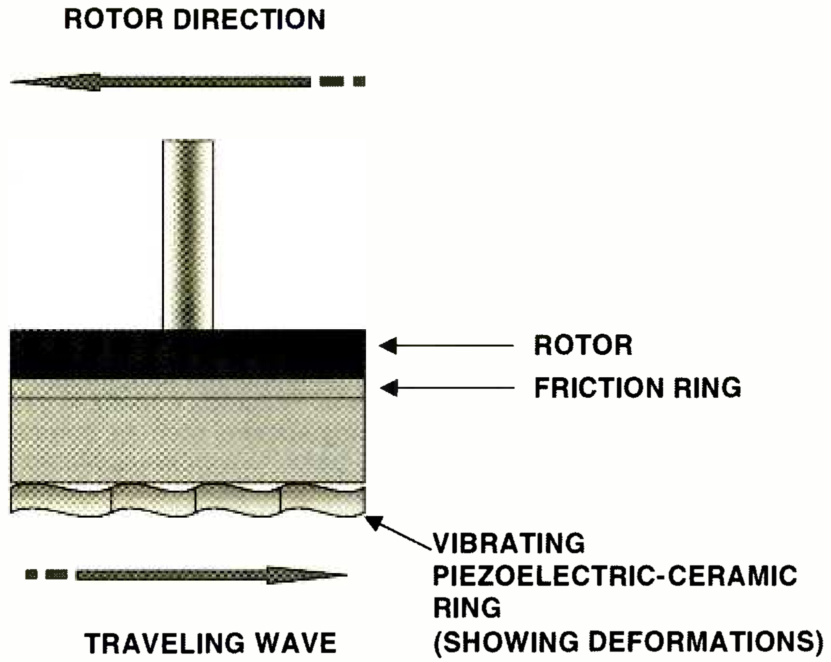


Fig. 2. This side view of a typical ultrasonic motor shows how the ripples in the stator resemble ocean waves. Like water, the piezo-ceramic crystals don't move laterally—only up and down—but the energy moves across the stator face at a high rate of speed.

Discoveries were made that enhance the characteristics of PZT material. One of these enhancements removes resident oxygen from the PZT layers, giving it new and interesting qualities. This process allows the PZT material to exhibit both ceramic and metallic properties. The result is that the enhanced material will become more active with input power applied. Additional PZT activity allows higher displacements within the motor assembly. Higher displacement means that simpler internal designs can be incorporated into the motor along with less complex external electronic drive controls.

Electromagnetic-Motor Principles. Electromagnetic motors rely on the attraction and repulsion of magnetic fields for their operation. Without good noise-suppression circuitry, their "noisy" electrical operation will affect the electronic components inside many pieces of sensitive electronic equipment. Surges and spikes from these EM motors can cause disruption or even damage in non-motor related items such as CRTs (cathode ray tubes) and various types of receiving/transmitting equipment. Anyone who has experienced a computer lock-up the moment the washing machine starts can relate to this problem.

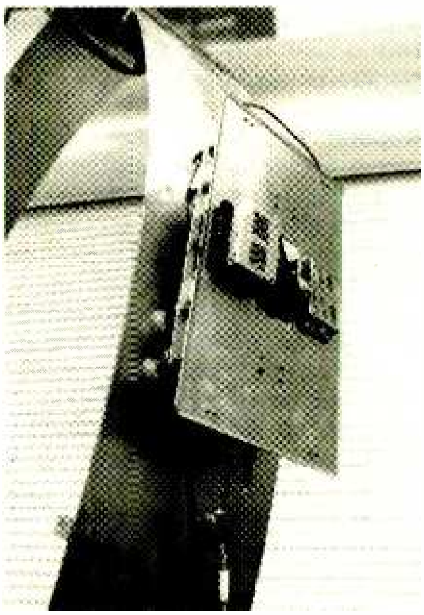
Electromagnetic motors are also notorious for consuming high amounts of power and creating high ambient-motor temperatures. Both of those effects are obviously undesirable from an efficiency point of view. Eddy-current loss and excessive heat mean energy is being wasted. Even the most efficiently rated electromagnetic motors have high input/output energy-loss ratios. Replacing those electromagnetic motors with USMs would virtually eliminate those undesirable effects.

USM Applications. The potential uses for ultrasonic motors are endless. Virtually any electromagnetic motor has the possibility of being replaced by a USM. Currently, USMs have not been designed for large horsepower performance, so this type of replacement may be a distant future possibility. A partial list of commercial applications for ultrasonic motors includes:

- Watch Movements
- Camera Auto-Focus Lenses
- Micro-Positioning Tables
- Inkjet Printers
- Air and Fluid Pumps
- Fiber-Optic Positioning
- Semiconductor Test Equipment
- Sonar
- Robotics and Micro-robotics
- Motor-Stepping Applications
- Computer Disk Drives
- Linear-Scale Encoders
- Micro-Manufacturing Assembly
- Micro-Instrumentation
- Aircraft Inspection Platforms

Ultrasonic Drill. Dr. Yoseph Bar-Cohen, who leads NASA's Jet Propulsion Lab Nondestructive Evaluation and Advanced Actuators (NDEAA) Technologies Unit (*ndeaa.jpl.nasa.gov*), is one of the foremost researchers in the field of ultrasonic motors and actuators. Under a joint program with Cybersonics, Inc., his unit has recently developed an ultrasonic drill for NASA. On this drill, the bit does not turn. The internal mechanism uses a hammering action created by piezoelectric vibration to accomplish its task—much like an ultra-precise jackhammer. A lack of twisting motion prevents the drill head from jamming, a common problem associated with rotary drilling.

One of the drill's practical uses includes the core drilling of hard



The Multifunction Automated Crawling System—MACS for short—can crawl on any flat surface, regardless of orientation. Here, MACS is seen crawling up the side of a simulated C5-A fuselage. If you look carefully, you can see some of the suction-cup feet that hold MACS to the surface. Each leg is powered by an ultrasonic motor. The total size of MACS is about one by two feet.

An unusual application of ultrasonic motors is in pumping fluids. We're not using the motor to drive a conventional pump—we're using the motor as *the pump! This laboratory demonstrator can put out a suprising amount of water given its size and power consumption.*

rock formations such as granite and basalt. This application demonstrates the raw power that some ultrasonic motors can display. Additional uses for the drill include the extraction of pacemaker leads and certain types of human skeletal surgery.

"The drill is an ultrasonic device that offers exciting new capabilities for space exploration in future NASA missions," says Dr. Bar-Cohen. "Besides the immediate benefits of the technology to NASA, it is paving the way for other unique ultrasonic mechanisms that are being developed in our laboratory and elsewhere. Such devices can be made small and lightweight, consuming little power and exhibiting a high degree of reliability."

Robotic Crawler. Dr. Bar-Cohen, along with fellow JPL scientists Dr. Paul Backes and Dr. Benjamin Joffe, has been instrumental in the development of a robotic crawler called *MACS* (Multifunction Automated Crawling System). This robot was created mainly for automated inspection and scanning of hard-to-access areas of aging aircraft. It is specifically designed to turn and move along curved surfaces using a series of suction cups and legs. The legs are controlled by ultrasonic motors and allow mobility, while the suction cups are used for surface adherence.

Piezo Pumps. During normal ultrasonic-motor operation, hills and valleys are produced on the piezo stator. These valleys can act as pump chambers to carry certain liquids. This pumping arrangement eliminates the need for most of the moving parts that a conventional pump requires for operation. Dr. Bar-Cohen and members of his team implemented this principle to produce a novel "piezopump" that has pumped water at a rate of about 5 cc/min.

Planetary USM. Using a segmented piezo-ring, the NDEAA team demonstrated that a USM can be operated for several hundred hours at -150° C and at a pressure of 16 mtorr. A Torr is a unit of pressure equal to about .02 psi—standard air pressure (about 14.7 psi) is equivalent to about 760 Torr or so. Those conditions are significantly more severe than expected on Mars. To that end, a USM is already installed on the prototype robotic arm of a Mars lander.

Other applications for ultrasonic motors on space missions might include release mechanisms, miniature rover wheels, instrument miniaturization, and antenna and instrument deployment. USMs are proving to be an effective motor alternative for NASA in the future.

Ultrasonic Inchworms. The motor depicted in Figs. 1 and 2 is a rotary type. The design depicted in Fig. 3 is a linear style of piezoelectric motor commonly called an "inchworm." A single shaft moves back and forth by means of activated piezoelectric material. The motor consists of three piezoelectric elements: two braking elements and one extender element. Three steps comprise the linear motion:

- Clamp the shaft's back brake
- Stretch the extender
- Clamp the front brake and release the back brake

Those steps are repeated as needed. The resulting incremental movement—measured in nanometers—allows exact positioning. This type of actuator is useful in positioning systems such as scanners and certain tooling-type applications.

Building a USM. By referring to Figs. 1, 2, and 4, a skilled hobbyist can construct a working ultrasonic motor. Access to a few tools, materials, and some electronic equipment will be needed before undertaking this task. The need to reduce and shape the motor components to their proper tolerances may require certain machining tools such as a metal lathe or some type of metal-shaping apparatus. In addition, a signal generator capable of producing two 90° out-of-phase variable signals is required. Frequency output of the generator will need to be around 20,000 Hz depending on how many piezo crystals are used in the piezo-ring assembly.

The next step is to purchase the piezo-ceramic material. Many corporations sell this material to commercial markets and may be willing

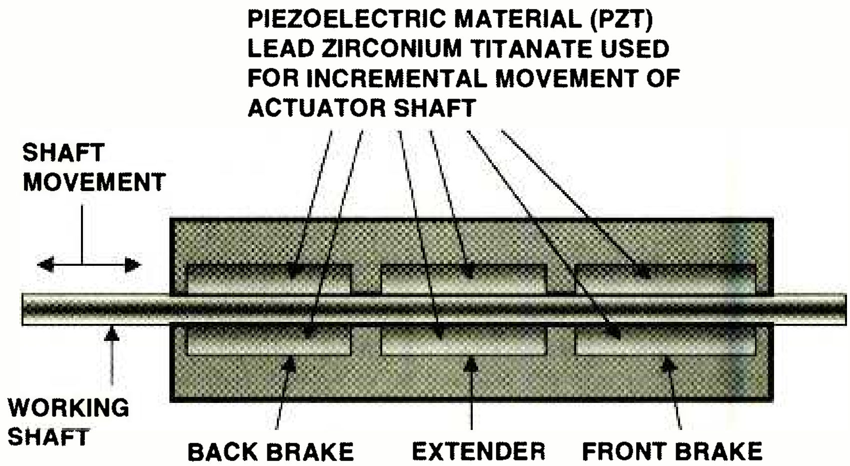


Fig. 3. In the same way that standard electric motors have been "opened out" flat to form linear-induction motors, ultrasonic motors can also work in a linear fashion. This so-called "inchworm" motor uses two "brakes" that surround a central "extender." Ultra-precise movement—in the nanometer range—is possible with this arrangement.

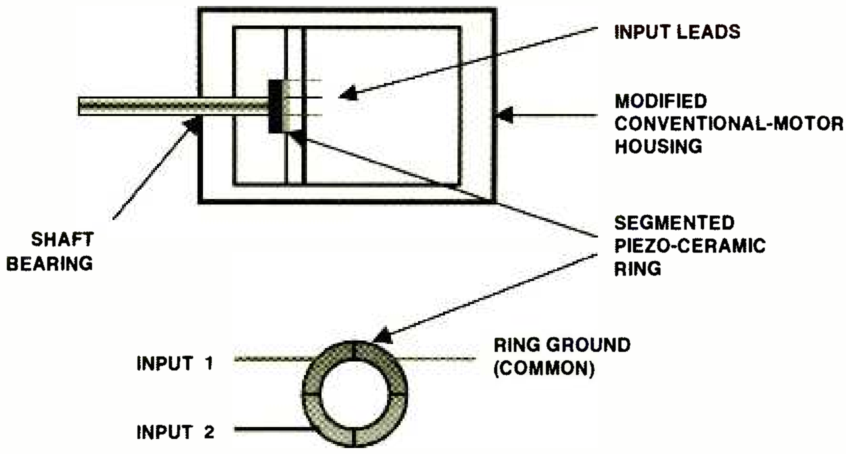


Fig. 4. With skill and patience, it is possible to build an ultrasonic motor in a home workshop. Conventional motors offer many components that can be used as is or modified to suit.

to sell it to the public. The Internet is an excellent source for locating piezo-ceramic manufacturers that may be of help to you during your USM project. When obtaining this material, specify a piezo-ceramic crystal-embedded ring assembly, since this will cut down on the overall assembly time and make the project go a lot smoother. Manufacturers should supply the exact resonant frequency, voltage-input requirements, and any other information that is important when handling the piezo-ceramic material. Premature material deterioration or damage may occur with incorrect power input or mishandling.

In some instances, separate piezo-crystal sets can be purchased and epoxied to a ring. Building such a piezo-ceramic ring is much trickier than buying an already completed assembly. If this type of piezo-ring construction is attempted, it is important to glue the crystal sets in a mosaic pattern around the ring in a "plus-minus, plus-minus" configuration. The two 90° out-of-phase input leads would then attach to the crystals at points coinciding to two separate crystal groupings. The points of attachment will vary with the piezo-crystal arrangement (the manufacturer should supply this information). The third input lead is ground and attaches to the ring itself. It acts as a common return to both out-of-phase input leads (Fig. 4).

Once the rotor/piezo-ring assembly is mated, it needs a motor housing. The motor housing will hold the overall assembly together and maintain the necessary friction between the piezo-ring assembly and the rotor. It will also serve as a bearing guide for the output shaft. Note that the signal leads—like the wiring in a standard electric motor— need to be insulated as they enter the housing and carefully "dressed" so they don't come in contact with any moving parts.

With the USM assembled, connect the leads to the proper phases of the signal generator. The output shaft should start to rotate at the crystal's resonant frequency. That is why a variable signal generator is needed as an input-frequency source. Voltage inputs vary with piezo-crystal assemblies; inputs of around 100-120 volts are not unusual. Generally, if the piezo-ring assembly is of a thinner design, the voltage requirements will be less than that of the thicker-type piezo-ring assemblies. Power requirements for the smaller USM designs usually rate in the 10-watt range.

Inventive hobbyists may find that they can modify certain parts from smaller electromagnetic motors to build many of the components used in an ultrasonic motor. This may substantially reduce the overall project build-time. Electromagnetic motor housings, shafts, and possibly rotors may be reused to assist in the building of a USM. More information about USM construction can be found at the JPL Web site mentioned previously (see page 27).

This project will require some ingenuity to complete. However, it should be satisfying to see it operate when it is finally finished.

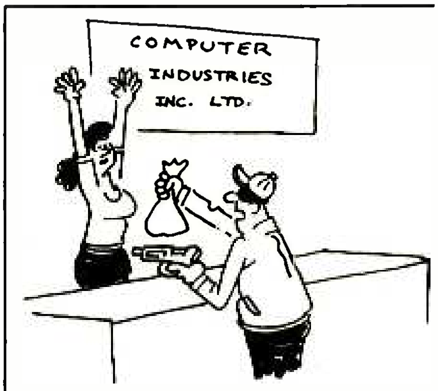
Piezoelectric Possibilities. Research in the field of piezoelectrics is not limited to ultrasonic motors. The prospects for piezoelectric uses extend into fields such as the study of vibration and noise canceling.

Helicopter rotor blades have always had problems with unwanted vibratory loads. This is an issue associated with unsteady aerodynamic loads that are imposed on the helicopters rotor system. Piezoelectric fibers can be embedded into the structure of the rotor blades to induce blade twist. In effect, this will damp the vibratory loads that occur during operation. This project is still being researched and further testing is planned before it becomes fully implemented on helicopter-rotor systems.

Piezoelectric materials are also being tested on military aircraft for vibration and sound damping. Externally embedded PZT material is expected to help reduce vibration and sonic fatigue damage on aircraft that are operating at high angles of attack.

Sound damping is accomplished by using piezoelectric material to cancel unwanted primary sounds by creating a secondary sound-canceling field. This research is currently ongoing.

The advances occurring within the field of ultrasonics permit another glimpse into the technological future. The changes demonstrate the constant forward movement of technology and the improvements these changes eventually make in our lives. P



"Forget about the money! Just fill this bag with RamBUS DIMMs!"

VIRTUAL-RETINAL DISPLAY

The "Ultimate" Head-Mounted Display?

BILL SIURU

The neurosurgeon performs a very complex and delicate procedure on the patient's brain using a technique called "image-guided surgery." Here, the surgeon views complex visual data like X-ray and CAT-scan images during the surgery. Rather than having to take his eyes off the patient to view the information on monitors, the images appear to be superimposed over the target area on the patient's body to help guide his hands through the procedure. The surgeon is using a *Virtual-Retinal Display*, or VRD, being developed by Microvision, Inc., of Seattle, WA.

Virtual-Retinal-Display technology provides high contrast, high resolution, and full-color images in the surgeon's field of view so that he may refer to them at any time without looking away from his work.

Unlike cathode-ray tubes (CRT), liquid-crystal displays (LCD), flat-panel displays, or other conventional display technologies that create images on an intermediary screen before they can be viewed, the VRD projects the electronic image directly on the eye's retina. Using the human visual system, the VRD conveys the image by scanning an electronically encoded beam of light through the pupil to the retina, stimulating the receptors on the back of the eye. The result is that the user has the impression of viewing a high-quality video image an arm's length away.

Drawing On The Retina. As you can see in Fig. 1, the Virtual-Retinal Display consists of four primary components. The drive electronics receive and process signals from an image source such as a computer or a video camera. The processed signals contain information that controls the intensity, color mix, and the coordinates to position the individual picture elements, or *pixels*, comprising the image.

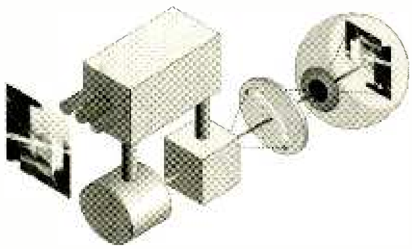


Fig. 1. The Microvision Virtual-Retinal Display consists of four main parts to translate the source image from a computer or camera into an image projected on the eye's retina: drive electronics, a modulated light source, horizontal and vertical scanners, and viewing optics.

The VRD uses a very low-power light source to create and convey a single pixel at a time through the pupil to the retina. With color images, three light sources—red, green, and blue—are modulated and merged to produce a pixel of the appropriate color. Operating at extremely low intensity levels, the VRD poses no danger to the eye. Horizontal and vertical scanners "paint" an image on the eye by rapidly moving the light source across and down the retina, in a raster pattern.

Refractive and reflective optics project the rapidly scanning beam of light into the viewer's eye through

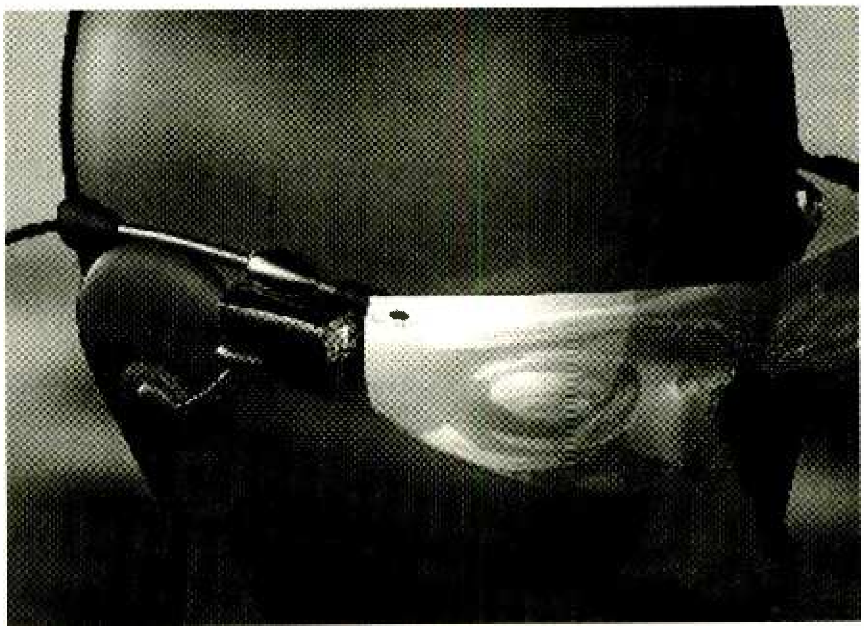


Fig. 2. An artist's interpretation of a "see-through" head-mounted display using VRD technology.

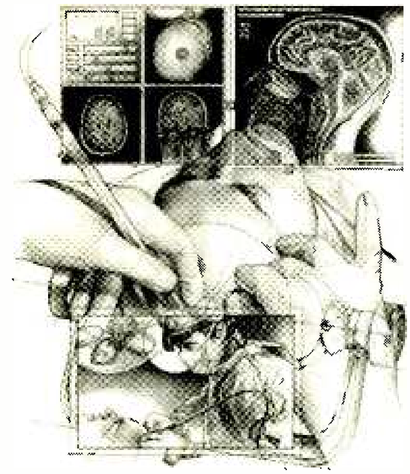


Fig. 3. Application of the VRD technology in neurosurgery.

the viewer's pupil and onto the retina to create a large virtual image.

Building A "Heads-Up" Display. The VRD technology can be used in a variety of head-worn devices. Recently, the Wallace-Kettering Neuroscience Institute of Dayton, OH, chose Microvision to build an Advanced Image-Guided Surgery-Display System for neuronavigation. This system is a head-worn display for neurosurgical visualization that enables surgeons to use images and visual cues to guide navigation.

Microvision's "see-through" head-worn displays, shown in Fig. 2, will provide a major improvement over current surgical-navigation systems that allow surgeons to view anatomical (MRI/CT), biochemical, and physiological (PET/SPECT) images, navigational cues, and other data during surgery.

Projecting a three-dimensional image precisely over the surgeon's view of the real world will enable the surgeon to visualize the least-invasive passage through the complex architecture of the brain and spine. A surgeon performing a delicate procedure, as shown in Fig. 3's inset, would see not only his patient, but related information floating above his patient; his view would probably be similar to Fig. 3. Also, the rate of success for minimally invasive techniques, such as laparoscopy and endoscopy, can be improved significantly by improving the surgeon's hand-eye coordination using VRD-based head-mounted displays.

From Operating Room to Battlefield Ops. The military, already a major user of helmet-mounted displays (HMD) for jet aircraft and helicopter crews, is very interested in the Virtual-Retinal Display because of its ultra-high-resolution capability. This resolution can be equal to that of high-definition TV (HDTV). For example, Microvision is developing a VRD-based HMD for the U.S. Army. The "target" use is in the RAH-66 armed-reconnaissance helicopter. An obvious drawback to traditional "heads-up" displays is that they are statically mounted at the front of the cockpit; not very useful if the pilot's attention is to the side of the aircraft. While HMDs are the first step in solving that problem, early devices were quite heavy. The inertia developed if you have to spin your head quickly can easily snap your neck!

Fig. 4. The military is interested in VRD technology for several applications including improved head-mounted displays for combat pilots.

With a Microvision VRD, the visor on a standard-issue helmet can be substituted; see Fig. 4. The U.S. Air Force and the Swedish aircraft manufacturer, Saab, are working with Microvision on HMDs for use in fighter aircraft as well.

Training And Support Uses. The VRD is not limited to the "blue-sky" environment when it comes to aviation applications. The technology can also be used in aircraft-simulation and training systems. The VRD technology offers significantly better resolution compared to existing HMDs, which are often criticized for their lack of realism and limited

Fig. 5. VRDs could be used to view e-mail, faxes, and other communication media.

range at which detail can be discerned. Microvision has supplied HMDs to Saab for use in fighter simulators and is working on a full-color, high-definition HMD for the U.S. Army's Helicopter-Flight Simulators.

The U.S.A.F. is interested in wide field-of-view, head-worn displays for interactive command- and control-operations-center applications. That would allow Command, Control, Communications, Computer, and Intelligence personnel to view large amounts of mission- and situation-critical data during both wartime conditions and training sessions. The system will offer a 60-degree field-of-view, providing visual capability equivalent to a wide-screen display or a 3-by-3 bank of 17-inch computer monitors. Military commanders currently are limited in their ability to rapidly sort and analyze large amounts of real-time data. Wide field-of-view, VRD-based HMDs offer the potential to reduce this information overload, permitting commanders to instantly scan a huge amount of real-time data to make quick, informed decisions based on a complete and realistic representation of the battlefield situation. Microvision is also building head-worn displays to replace the desktop monitors at workstations within the U.S. Army's tactical-operations center in Leavenworth, KS.

Civilian Uses. Microvision also sees applications in law enforcement, fire fighting, and emergency services, to name a few. There are

(Continued on page 66)

Find RF hotspots and bugs with this SENSITIVE RF FIELD-STRENGTH METER

WILLIAM SHEETS, K2MQJ and RUDOLF F. GRAF, KA2CWL

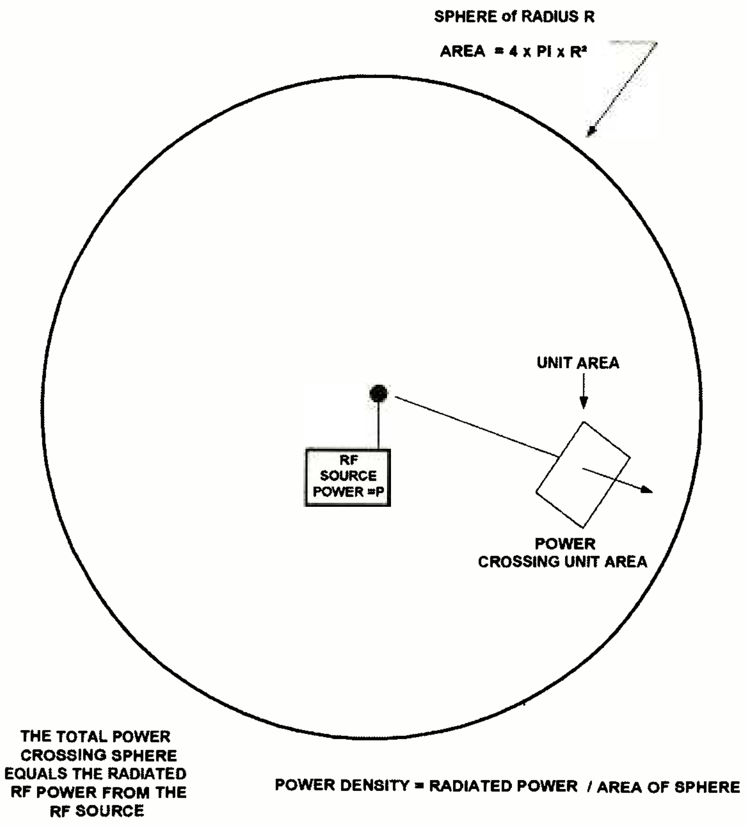
Among the newer RF devices on the consumer market are a wide variety of low-power transmitters. These include cellular telephones, remote-control transmitters for garage-door openers, carrier-current devices, wireless-computer peripherals such as mice and keyboards, and PCS devices.

In addition, many small surveillance devices are out there, including small FM and low-power FM-stereo transmitters, 900-MHz wireless-video cameras, and video transmitters. There is an array of Ham, CB, and family-radio transceivers small enough to fit in a shirt pocket. All of these devices can be used in one form or another as spy devices (bugs).

To locate those bugs and other hidden transmitters, you need the *RF Field-Strength Meter*, presented here. It also sets up and adjusts antennas and tests and detects signals from remote-control transmitters. This device can find small low-power transmitters such as cell phones, amateur radio handy talkies, family radio (UHF handy talkies), and even CB transmitters, as well as antennas for such transmitters.

Another function the RF meter serves is to search for sources of RF and RF interference, in everything from light dimmers, fluorescent lamps, switching-type power supplies, and electronic car "keys." It even checks microwave ovens for excessive leakage and will detect an operating microwave oven 10 to 12 feet away. It can be used to reveal the possible RF hazards from these devices as well. All of these devices produce RF fields.

The Dangers Around You. These days small, relatively high-power (one-watt VHF and UHF) trans-



RF POWER DENSITY

Fig. 1. When measuring the power density of an RF field, the distance from the source must be taken into account. Remember that radio waves travel in three dimensions, so the density in a given area is the surface of a sphere.

ceivers are commonplace. They have small antennas—as short as 5 to 20 cm in length. The result is an intense RF field in close proximity to the antenna. Think about where your cell phone's antenna is when you are using it; often as close as a few centimeters away from the brain or the eyes. The allowable RF-power density is easily exceeded in such cases.

Consider the diagram in Fig. 1 as you read the following example. Your cell phone is located 10 cm (4 inches) from your body, and 0.5 watt is being radiated from the antenna. A 10-cm radius sphere around the antenna has a total area of

$$4 \pi (r^2)$$

or 1256 cubic centimeters. Since 0.5 watt is 500 milliwatts, the average power density crossing the surface of this sphere is

$$500/1256 = 0.398 \text{ milliwatts/cm}^2$$

Although this is less than the 1 mW/cm^2 that is currently thought hazardous, it is an appreciable percentage of that suggested limit. In addition, this assumes an ideal isotropic radiator. (Note: Not all countries use the same level to define the "hazard" limit. In Australia, for example, a power density level of 0.2 mW is considered hazardous.)

In the real world, there are "peaks" and "valleys" in any antenna/ ground system (including the devices themselves, the PC board, and case assembly plus other metal parts). At distances closer than about 0.159 wavelength from the antenna, the near-field components must also be considered. Note that this distance equals ½π wavelengths and is a mathematical approximation; there is no sharp boundary between near- and far-field regions. Nevertheless, the radiated power still has to cross this spherical surface. In addition, note that 5-watt VHF and UHF handy talkies (HTs) are common; antennas are often held closer than 4 inches from the body. You can see that it is quite possible to develop power density levels of over 1 milliwatt per square centimeter with any of these devices. Although the safe exposure limit is not known to any degree of accuracy, erring on the side of safety is always a good policy. The RF field exposure problem is very real and definite. Excessive exposure can lead to health problems and even organ damage.

Realistically, accurate measurement of this radiation requires lab-grade test equipment, with accurate and traceable calibration. The list of needed equipment includes calibrated antennas, an accurate power meter, and a spectrum analyzer or other accurately calibrated receiver, as well as a proper test environment. Furthermore, many of those meters are aimed at one specific frequency range or type of RF emission. This approach limits their usefulness and can lead to a false sense of security. There may be many other frequencies present. Our RF meter can be used to detect and point out the sources and locations of local RF fields. Then, knowing the power, frequency, and other characteristics of these sources, the user can make calculations to determine the strength of the RF fields.

Information on RF fields can be found in the ARRL's *RF Exposure and You* by Ed Hare, W1RFI. This is an excellent work for the average experimenter. This approach would most likely be better than trusting an inexpensive meter of dubious calibration.

Devices other than cell phones—such as those mentioned previously—produce RF fields. With all the RF sources present in our modern environment, it might be wise for a person to have some means of detecting strong RF fields that may pose a health hazard. This article describes such a device, covering 100 kHz to 3 GHz. This would include almost all sources likely to be encountered around the average home. VLF (under 100 kHz) transmitters are uncommon, and their gigantic antenna farms are very obvious. Microwave transmissions are gen-

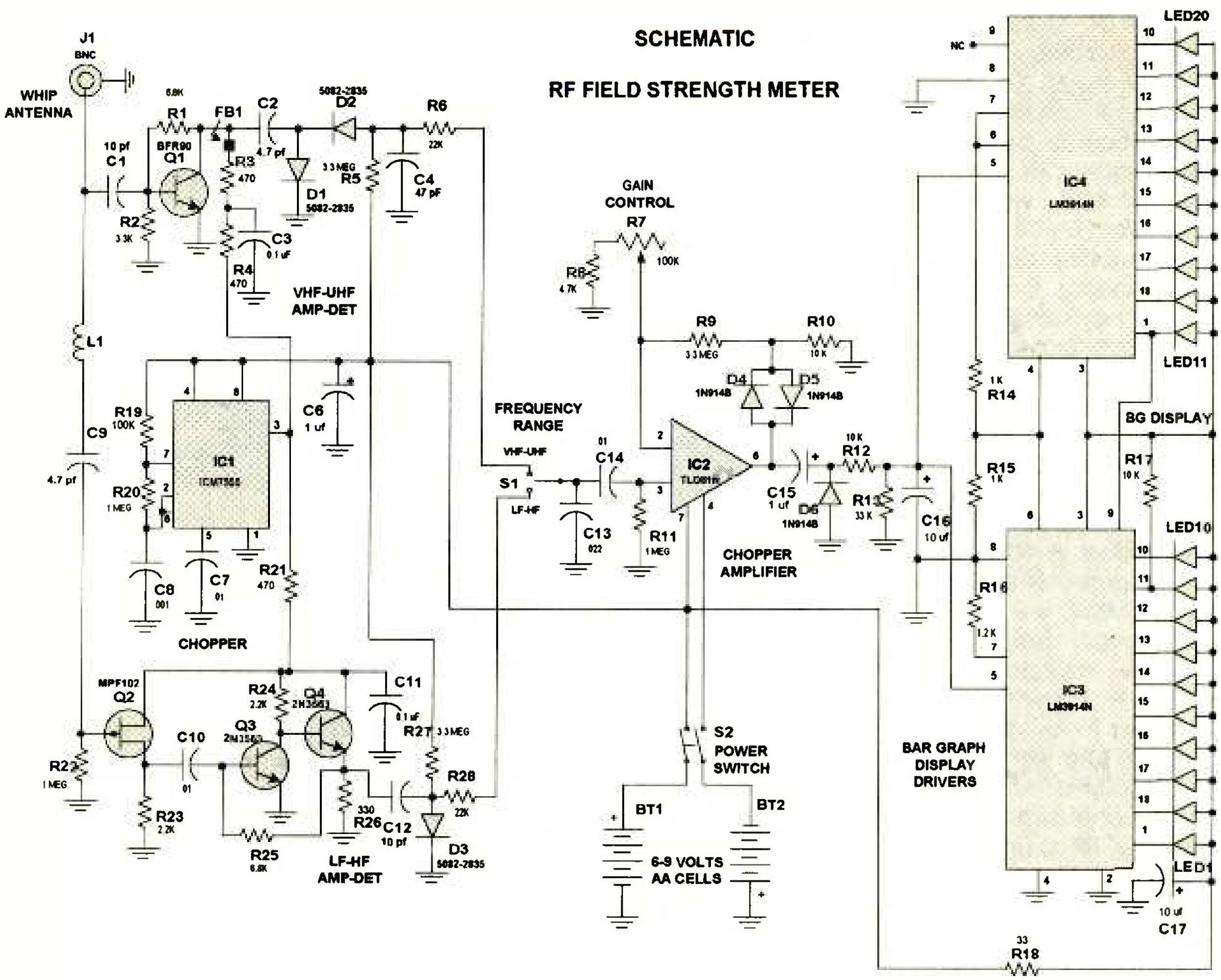


Fig. 2. The RF Field-Strength Meter is a simple detector that is amplified to the required sensitivity without being over-sensitive to the point of being useless.

erally aimed in tight beams away from buildings and are unlikely to be found in locations accessible to unauthorized personnel. (A list of Web sites for further research into this subject is presented in the sidebar.)

Usually all you need to do is to get a relative measurement of RF field strength that is produced by a transmitter or other RF generator. Exact measurement is best done with a spectrum analyzer and a specially calibrated antenna, which in turn is very expensive, and beyond the means of the hobbyist or experimenter. However, the knowledge of the exact field strength is seldom needed unless you're doing measurements such as system performance, certification of equipment to FCC requirements, or detailed RF site surveys for commercial systems. Also, the location of a transmitter or source of RF radiation does not need exact calibration, only relative readings (stronger or weaker, etc).

Generally, a sensitive microammeter (0–50 μA full scale) connected to a diode detector is used for this purpose, and sometimes a DC amplifier is added to improve the sensitivity. However, that approach has its limitations, as the sensitivity is limited by the meter and the forward voltage of the detector diode (about 0.2 to 0.4 volts DC). Forward bias can be used to overcome this, but signal levels of 50 to 100 mV are still needed to show a reading. This limits the sensitivity of this type of meter. A DC amplifier can be used, but is prone to drift; and the meter generally has to be nulled (zeroed) before being used.

The meter described in this project uses an active antenna preamp and Schottky barrier diodes for improved sensitivity. A chopper system converts the detected signal to 700 Hz AC signal. This is amplified with a high gain op-amp AC amplifier (up to 600X), and the AC signal is rectified and used to drive a 20-segment LED bar graph display in the dot mode to minimize battery drain. Diodes in the feedback loop compensate for rectifier nonlinearity. This system lets us detect signals as low as –40 dBm (2.2 millivolts into 50 ohms) over a range of 500 kHz to 500 MHz, with usable sensitivity from 100 kHz to 3 GHz.

Eight AA batteries or two 9-volt transistor radio batteries supply power. Battery drain is around 20 mA, ensuring long battery life. Two ICs (ICM7555 and TL081) and four transistors are used in the meter circuit.

Circuit Operation. In this design, an active antenna circuit is used for the lower frequencies; a broadband preamp improves sensitivity in the VHF/UHF arena. The use of an AC amplifier with a chopper circuit gets rid of DC stability problems. The only adjustable control used in the circuit is a gain (sensitivity) control. The LF/HF amplifier uses a hi-Z input FET stage for better sensitivity at low frequencies with a short pickup antenna, which can be removed via a BNC connector. The VHF/UHF amplifier uses a BFR90 UHF bipolar transistor for wide bandwidth and has about 10 dB gain. This approach proved better than the use of a microwave IC as less current is needed, and higher signal levels can be handled. The BFR90 will output over 1.5 volts to the diode detector, while an MMIC will produce only 300 mV and must be terminated in 50 ohms. Since the diode detector is high impedance, the MMIC will be inefficient as it is generally designed to operate into low-impedance terminations. The RF Field-Strength Meter will respond to a –40 dBm signal level at 100 MHz with usable sensitivity to 3000 MHz.

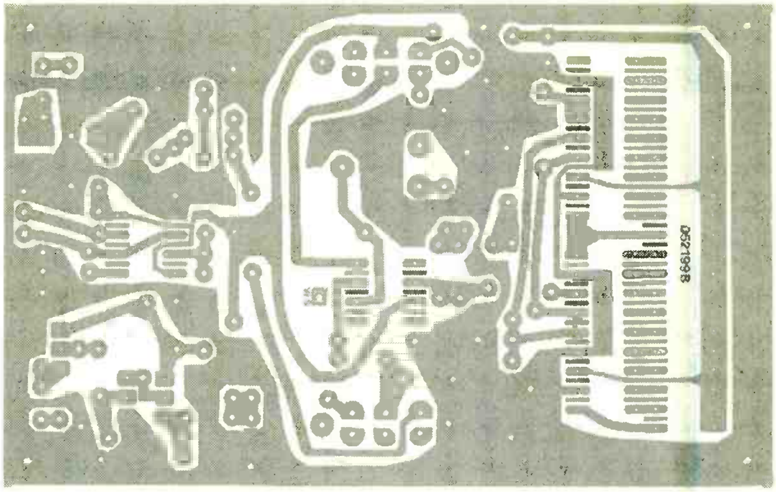


Fig. 3. The RF Field-Strength Meter is built on a single-sided PC board. No ground plane is needed on the opposite side.

A front-panel switch selects the appropriate RF preamp for best sensitivity. There is considerable overlap, and either preamplifier can be used in the 10–100-MHz range. The FET amplifier gives better sensitivity at low frequencies, while the bipolar preamp is best at the higher frequencies. The meter will readily register "static crashes" during an electrical storm (mainly the components below 10 MHz) and is sensitive enough to detect low-power FM "bugs" with a few milliwatts output at distances of several feet. That sensitivity allows the RF Field-Strength Meter to be used as a "bug detector" to check if a person is carrying a hidden transmitter or if a telephone is bugged. However, as with all broadband passive detectors of this type, it will respond to the strongest signal present at its input. Making the detector too sensitive will result in false indications from strong broadcast and commercial signals and possibly from RF noise present in the immediate area. A sensitivity of one to five mil-

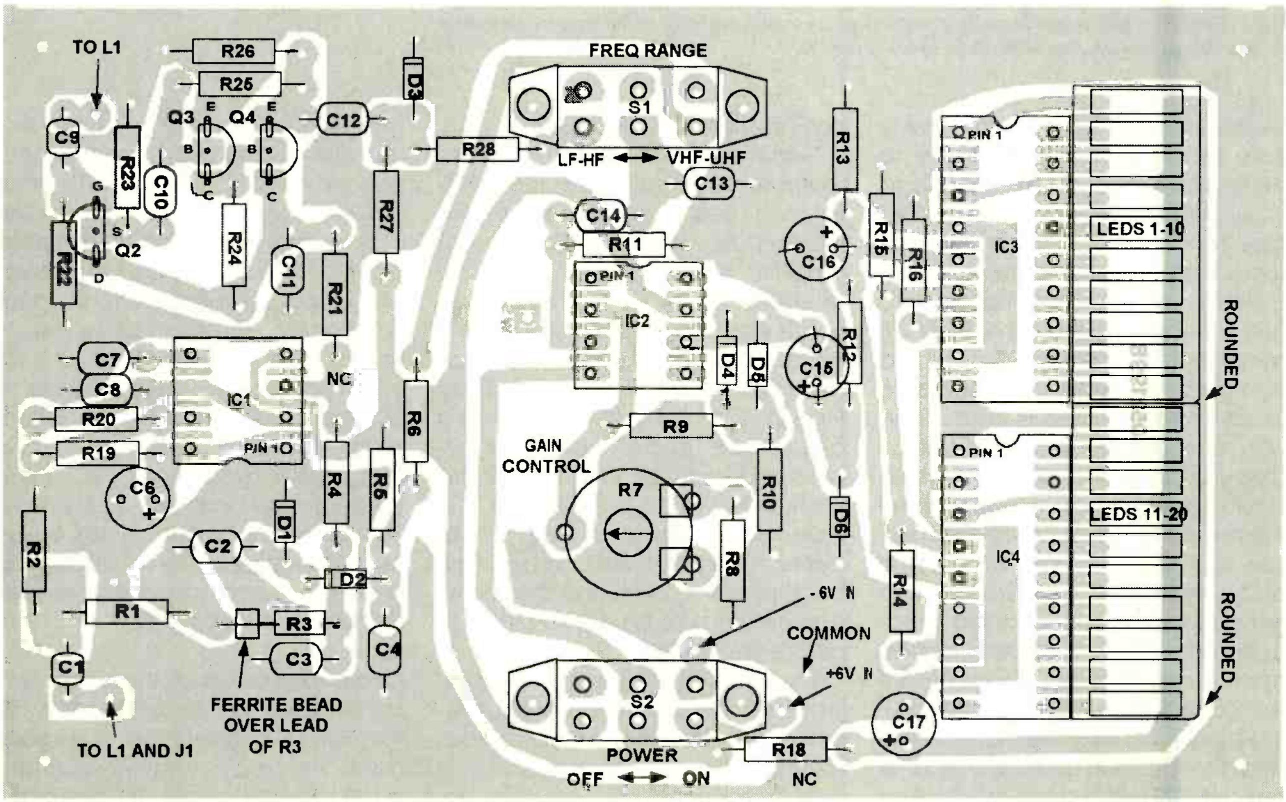


Fig. 4. The majority of the components mount on the PC board in the usual manner.

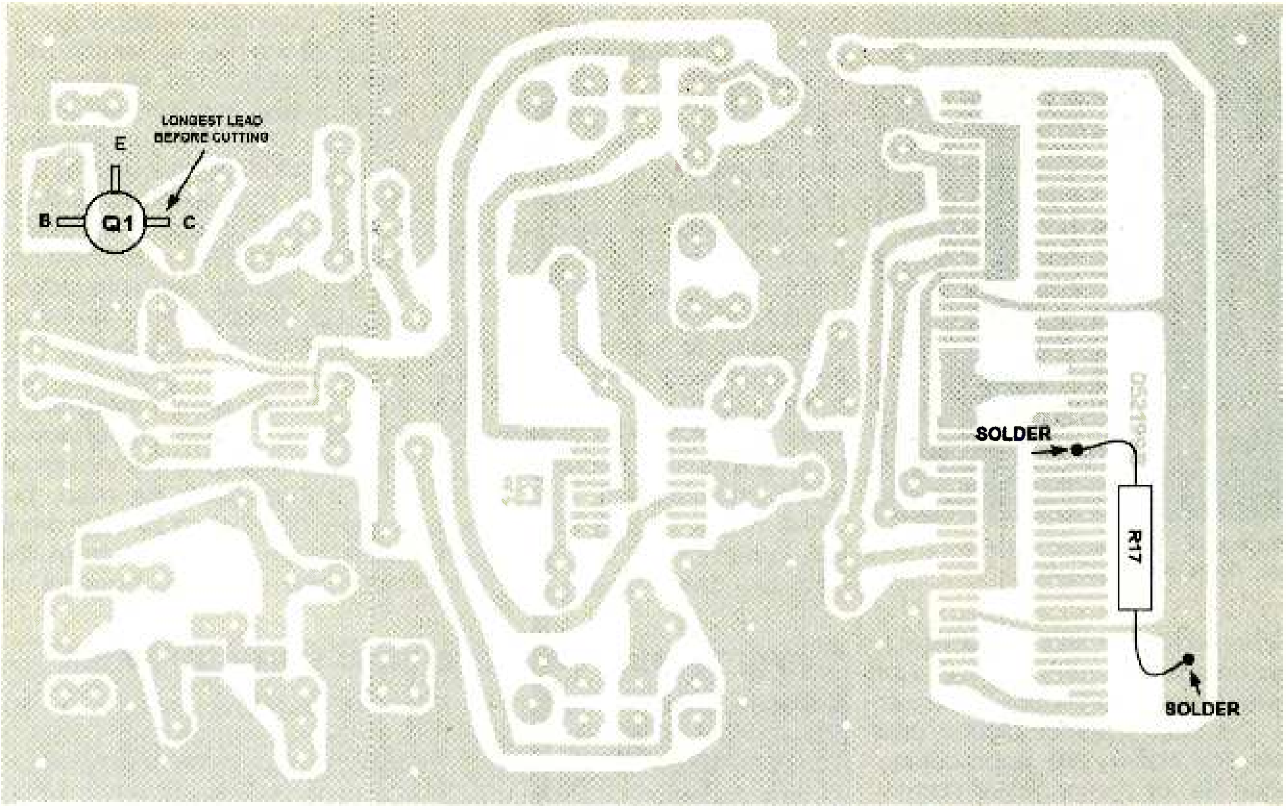


Fig. 5. These two devices mount to the solder side of the board.

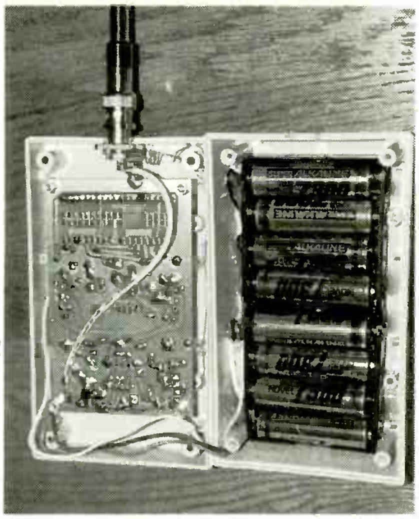
livolts is quite adequate for bug detection, yet not enough to pick up normal-level RF signals from nearby broadcast and commercial stations.

Let's take a closer look at the schematic diagram shown in Fig. 2. A two-foot (60 cm) collapsible whip antenna connected to J1 picks up RF signal. This signal can be anywhere in the 100-kHz to 3-GHz range. Higher frequency signals (over 30 MHz) tend to be opposed by L1 and are coupled to preamp Q1 via C1. Lower frequency signals see C1 as high impedance in series with the low-input impedance of Q1 and L1 as low impedance. The low-frequency signals are coupled to the gate of FET Q2 via C9. The gate of Q2 has a very high input impedance (over 100,000 ohms) to lower-frequency signals; C9, although small, has negligible effect. The VHF/UHF preamp consists of Q1 and a few bias resistors. Resistors R1–R3 bias Q1, the BFR90 UHF bipolar transistor mentioned earlier, to about 3 volts and 5 milliamps of collector current. The gain of the bipolar preamp is approximately two to three times the voltage gain. Using FB1 as an RF choke, the signal is coupled to voltage doubler/detector diodes D1 and D2. These are "hot-carrier" diodes for better sensitivity.

Resistor R5 provides a slight DC bias for improved sensitivity to low-level signals. Capacitor C4 bypasses RF, and the detected signal passes through R6 to amplifier IC2. The low-frequency preamp is fed from source follower Q2. Resistor R22 returns the gate of Q2 to ground while R23 provides a source bias. Capacitor C10 couples the signal into a feedback pair amplifier consisting of Q3 and Q4, bias resistors R24 and R26, and feedback resistor R25. The overall gain of the low-frequency preamp is about 3 to 5 times the voltage gain. That gain value refers to the antenna-to-detector gain. Capacitor C12 couples RF signal to detector diode D3, also a hot-carrier diode. Since the preamp gain is higher than that of the Q1 stage, a voltage-doubler configuration is not needed. Diode D3 is slightly forward biased by R27. The detected signal is taken off through R28.

Both preamps are fed a chopped supply voltage from IC1, a CMOS version of the popular 555 timer. Resistors R19, R20, and C8 form an RC network to produce a nearly symmetrical squarewave. Exact symmetry is unimportant. Capacitors C6 and C7 are bypass capacitors for noise suppression. The supply voltage is fed to pins 4 and 8; the chopped supply appears at pin 3. Capacitor C3 is a "despiking" capacitor to reduce fast transients. Resistor R4 and C3 control waveshaping to preamp Q1; R21 and C11 do the same for the lower-frequency preamp. The effect of using a chopped supply voltage for both preamps is to amplitude modulate their RF outputs. This allows an AC component to appear on the detected signal for later amplification rather than the DC component. The lower limit of detectability is about 5 to 10 millivolts at the detector, which is limited by the presence of chopping-noise spikes and the "square-law" effect of the detector at low levels. With the preamps, this allows two millivolt input-signal levels to be detected.

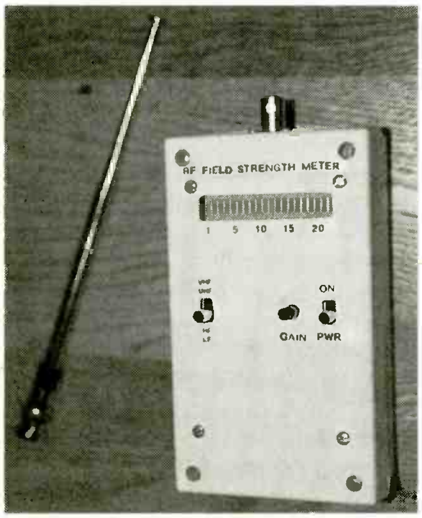
Integrated circuit IC2 is a TL081



The batteries are mounted in the rear of the unit; the PC board sits on top.

FET op-amp that performs all needed amplification functions. Two supplies—positive and negative—power it. This both simplifies biasing and extends battery life approaching shelf life for the negative battery supply, BT2. The positive-battery supply, BT1, must provide 20 to 30 milliamps for the preamps and LED display as well. With intermittent use, BT1's life should also be quite long. Switch S2 is the power switch for the battery supply. Switch S1 is the selector switch, mentioned in the general discussion before, that connects one of the detector outputs to IC2. This op-amp is biased to six to nine volts and is set for a gain of between 30 and 600 via gain control R7 and limiting resistor R8. Diodes D4 and D5, and R10 compensate for the nonlinearity of rectifier diode D6. The amplifier output is coupled to D6 via C15. The DC output is fed to network R12, C16, and R13, which filter the output and remove any AC components, and determines the "ballistic" characteristics of the LED display "meter." The meter acts like an analog mechanical movement. The meter has a full-scale deflection of around three volts. At the full-gain setting, this allows an RF input signal of five to ten millivolts to produce a full-scale indication. This corresponds to a maximum gain setting of R7 (minimum resistance).

The meter consists of IC3 and IC4, a pair of LM3914 LED drivers and two ten-segment LED bar-graph assemblies cascaded to give a 20-segment meter. This is sufficient resolution (5% full scale) for our purposes. Red LEDS were used, but any other color or combinations of colors may be used as long as all LEDS can use the same drive-current level. To meet that requirement with a choice of different colors, you can use separate individual LEDs. Resistors R14–R16 set up the LM3914s for "cascaded" dot-mode operation (only one LED lights at a time like a moving dot on the display). The bar-graph mode (the display forms a line that grows and shrinks) could be used, but battery drain when 20 LEDs are lit would approach 200 milliamps. The dot mode saves the batteries, as



The completed RF Field-Strength Meter is ready to go!

PARTS LIST FOR THE RF FIELD-STRENGTH METER

SEMICONDUCTORS

IC1—TL081N op-amp, integrated circuit
IC2—ICM7555 CMOSA timer, integrated circuit
IC3, IC4—LM3914N bar/graph display controller, integrated circuit
LED1–LED20—Light-emitting diodes or ten-segment bar-graph displays, red
D1–D3—HP 5082-2800 or 5082-2835 hot-carrier diode
D4–D6—1N914B or 1N4148 silicon switching diode

RESISTORS

(All resistors ¼-watt, 5% units unless otherwise noted.)
R1, R25—6800-ohm
R2—3300-ohm
R3, R4, R21—470-ohm
R5, R9, R27—3.3-megohm
R6, R28—22,000-ohm
R7—100,000-ohm potentiometer, PC-mount
R8—4700-ohm
R10, R12, R17—10,000-ohm
R11, R20, R22—1-megohm
R13—33,000-ohm
R14, R15—1000-ohm
R16—1200-ohm
R18—33-ohm
R19—100,000-ohm
R23, R24—2200-ohm
R26—330-ohm

CAPACITORS

C1, C12—10-pF, NPO ceramic
C2, C9—4.7-pF, NPO ceramic
C3, C11—0.1-µF, 50-WVDC, Mylar
C4—47-pF, NPO ceramic
C5—not used
C6, C15—1-µF, 35-WVDC, electrolytic
C7, C10, C14—0.01-µF, 50-WVDC, ceramic
C8—0.001-µF, 50-WVDC, Mylar
C13—0.002-µF, 50-WVDC, Mylar
C16, C17—10-µF, 16-WVDC, electrolytic

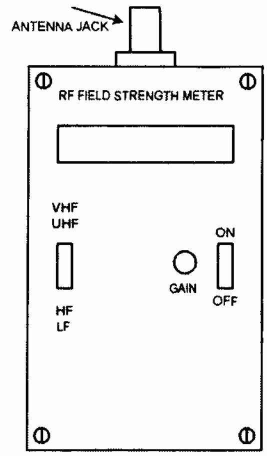
ADDITIONAL PARTS AND MATERIALS

BT1, BT2—6- or 9-volt battery (see text)
FB1—Ferrite bead (Cambion CA515 3225 or similar)
J1—BNC-style jack, panel-mount
L1—coil (see text)
S1—Single-pole, double-throw slide switch
S2—Double-pole, double-throw slide switch
Whip antenna, BNC plug, case, hardware, etc.

Note: The following items are available from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053; *ncradio200@aol.com*; *www.northcountryradio.com*: Kit of all PC-board-mounted parts, BNC connector, drilled and etched PC board, two ten-segment bar-graph displays, case, and complete documentation, $61.60; eight-section antenna with BNC connector, $14. Please add $5 for shipping and handling in the US or $10 for shipping outside the US. NY state residents must add appropriate sales tax.

only one or two LEDs are lit at a time. Resistor R17 cuts off LED10 if any of LEDs 11 through 20 are lit, and C17 with R18 form a filter network to suppress a tendency for the display to be unstable due to possible RF oscillation. In addition, R17 limits the maximum possible LED current in case of a short circuit, avoiding damage to individual segments.

Power is supplied from two six- or nine-volt batteries. A voltage divider or active splitter using an op-amp would permit only one battery to be used, but it was not worth the extra parts as large decoupling capacitors would be needed. Only a few milliamps of negative supply are needed, and the battery life will approach shelf life with such a light drain. The positive supply must handle 20 to 30 milliamps. We used two sets of four AA batteries for a cheap and simple solution, and they fit the case perfectly. Alternatively, two nine-volt batteries could also be used. The circuit will operate down to about 3.5 volts or so.



RF FIELD STRENGTH METER PANEL LAYOUT

ASSEMBLY AND PACKAGING RF FIELD STRENGTH METER

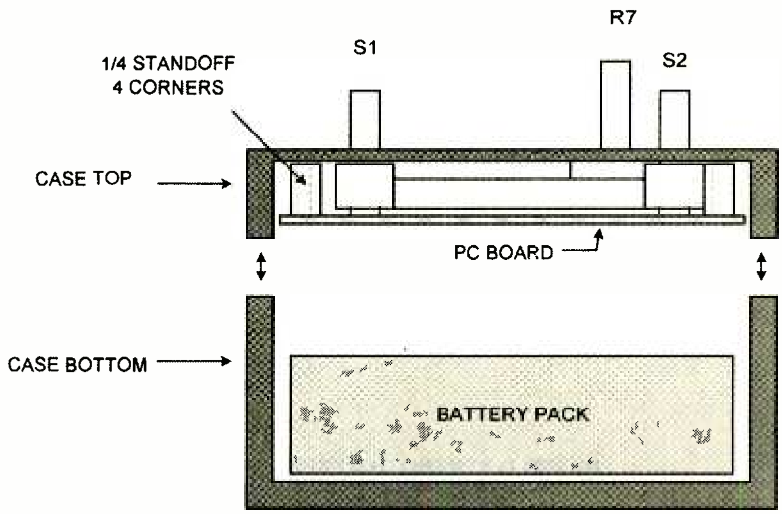


Fig. 6. You can package the RF Field-Strength Meter to suit your needs. Here is one suggested method used by the authors.

Construction. Due to the frequencies involved, the RF Field-Strength Meter should be built on a printed-circuit board. Since board layout is critical to proper circuit operation, it is recommended that you use the foil pattern shown in Fig 3.

Before beginning construction, carefully match all parts against the Parts List. Use good lighting. A magnifier is helpful to see certain color codes and very small part numbers. Check any dubious items with a multimeter to be sure.

Follow the parts-placement diagram shown in Fig. 4. It is helpful to insert larger parts, such as switches and potentiometers, first to serve as landmarks. The larger holes on the board are for the switches and potentiometers. Parts are mounted tight and close to board; short lead lengths are a must for low noise and clean operation. Low-profile DIP sockets can be used to facilitate experimentation and replacement of the ICs and LED displays. Sockets are recommended if you prefer to avoid directly soldering IC chips to the board.

Continue construction by inserting all resistors in the PC board except R17. Make sure that the correct values are inserted. Do not install Q1 or R17 at this time. They will be installed on the bottom side of the board later.

Install D1 through D6 and then all the capacitors. Watch the polarity of the diodes and electrolytic capacitors. Install switches S1 and S2. Potentiometer R7 is installed *without* its shaft. We'll install the shaft later during testing.

Carefully examine the board for any possible shorts between traces and trim any excess solder or material with a sharp knife or razor as needed. Next, install all the ICs. *Watch for correct pin orientation!* Then install the LEDs or the LED bargraph displays.

Install R17 and Q1 on the bottom of the PC board. The locations are shown in the Fig. 5 parts-placement diagram. The long lead on Q1 is the collector. When trimming it to length, you should cut the end diagonally to distinguish it from the other leads. The center lead is the emitter; this lead is soldered directly to the ground plane with the lead as short as possible. Carefully check all work done so far for accuracy and orientation. Now trim all component leads to length, solder all connections, and recheck your work.

You are ready to test the board once everything is satisfactory. If you like, you may mount the board in a case with batteries and jacks before testing. However, if any

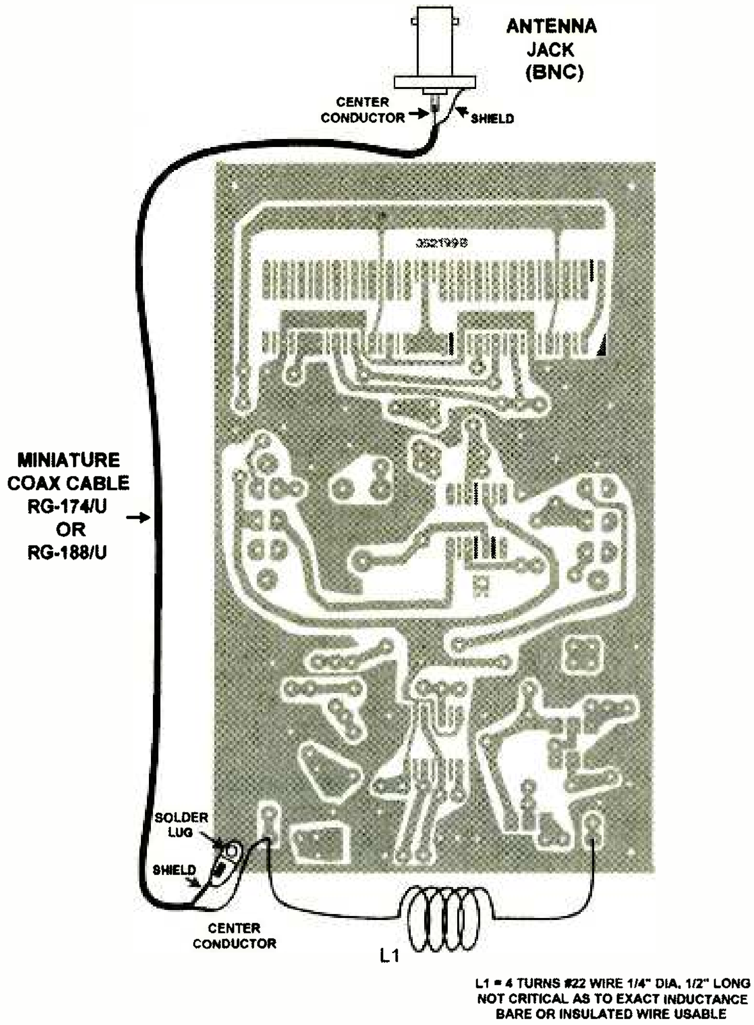


Fig. 7. The antenna is connected through a BNC jack. Wind four turns of 22-gauge wire around a 1/4-inch form for L1.

assembly errors are found, access to the circuit board will be more difficult or require disassembly.

Circuit Test Procedure. To test the circuit board, a +5-volt/ –5-volt power supply should be used. Connect the power supplies to the circuit board at the points shown in Fig. 4. Make sure that S2 is in the "off" position when connecting the power supplies. After checking your wiring, turn on S2. The LED display should flash briefly and return to zero. Rotate R7 fully counterclockwise (minimum gain). Check for the following voltages as listed in Table 1. Some of the readings that are marked with an asterisk might vary from those listed because a square-wave is present at the test point. Depending on the type of meter used, the reading that you get might be somewhat different. The measurements that we took to generate Table 1 were done with an analog FET-based volt-ohmmeter, designed to have similar characteristics to a vacuum-tube voltmeter. Note that digital voltmeters can vary somewhat in their readings.

Note that this test was made with 5 to 6 volts. You may later use a 9-volt battery supply for both batteries if desired, but the meter should work with somewhat less than 5 volts to allow for gradual battery exhaustion.

If your readings are in reasonable agreement with the readings

TABLE 1

TEST POINT	READING
IC2 pin 4	–5 to –6 volts
IC2 pin 6	0 volts ±1 volt
IC2 pin 7	+5 to +6 volts
*IC1 pin 3	+2.2 to +3.0 volts
IC1 pins 4, 8	+5 to +6 volts
IC3 pin 3	+4.5 to +5.7 volts
IC3 pin 6	+0.6 to +0.8 volts
IC3 pin 7	+1.25 volts
IC4 pin 4	+0.6 to +0.8 volts
IC4 pins 6, 7	+1.2 to +1.5 volts
*Q1 Collector	+1.1 to +1.7 volts
*Q1 Base	+0.3 to +0.4 volts
*Q2 Drain	+1.3 to +1.8 volts
*Q2 Source	+0.7 to +1.3 volts
*Q3 Base	+0.3 to +0.4 volts
*Q4 Collector	+1.3 to +1.8 volts
*Q4 Emitter	+0.35 to +0.5 volts

*Reading might vary due to square wave presence (see text).

listed in Table 1, you may assume all is OK. If you have access to a signal generator, apply a 10-millivolt RF signal at 1 MHz to J1. Place preamp-selector switch S1 in the "LF-HF" position. Adjust R7 fully clockwise for maximum gain. The LED meter should indicate at least three-quarters full scale. Place S1 in the "VHF/UHF" position and repeat the test at 100 MHz. You should get similar results.

If you do not have a suitable signal generator, try bringing the meter with a two-foot antenna very close to a fluorescent lamp of at least 40 watts. Some indication should show with S1 in the "LF-HF" position. A computer monitor or TV screen should also show some indication if the antenna is brought close. Be careful not to blow the LF-HF preamp FET from electrostatic discharge; turn on the monitor first and gradually bring the antenna closer. In the VHF/UHF position, a cell phone several feet away should produce an indication. You can use any other VHF or UHF source, such as a two-meter ham rig or a

(Continued on page 66)

Q & A

mailto: *q&a@gernsback.com*

READERS' QUESTIONS, EDITORS' ANSWERS
CONDUCTED BY MICHAEL A. COVINGTON, N4TMI

EDITOR'S NOTE

Altough Michael Covington took his final bows in December, he left us with enough material for one final installment.

So, without furthur ado, **Poptronics** proudly presents Michael's "final curtain call" amidst thunderous applause for a job well done. From everyone on the staff, we'd just like to say (paraphrasing Douglas Adams), "so long and thanks for all the Qs and As!"

Battery Charger

Q *How can I build a 5- to 10-amp, 14-volt charger for car batteries? I have plenty of old VCRs, TVs, and computer power supplies lying around. Also, how do I increase a car's alternator output from 12 or 13 volts to anywhere between 15 and 18 volts?—A. A., Frederick, MD*

A A 5- or 10-amp battery charger requires a big transformer that is otherwise somewhat hard to find; it's cheaper to buy one than to build one. If you want a ½-amp float charger that can be connected to the battery indefinitely, use the circuit in Fig.1, but add a green LED in series with the ground pin of the LM7812 to boost the output to 14.1 volts, and connect it to the battery through a 12-volt, ½-amp light bulb in order to limit current. For more information about charging lead-acid batteries, see *The ARRL Handbook for Radio Amateurs.*

Most car electrical systems already produce more than 14 volts when the engine is running. Modifying a voltage regulator is an automotive engineering question that's outside the scope of this column; therefore, we couldn't tell you what it might do to the rest of the car's electrical system.

Plasma Globe

Q *Have you ever published a circuit for a plasma globe?—J. K., St. Thomas, Ontario, Canada*

A Yes; it was the cover feature of the August 1997 issue of **Electronics Now**. Back issues can be ordered from *bookstore@gernsback.com.*

A plasma globe or "lightning ball" is a glass ball in which you can see electrons flow through ionized gas. The electron flow moves around as you touch different parts of the outside.

Parallel Voltage Regulators?

Q *I need a 12-volt, 4-amp voltage regulator. Can I connect four LM7812 (1-amp) chips in parallel?—P. J., Bellingham, WA*

A No, because the voltage regulators will not produce exactly identical voltages, and the one with the lowest voltage (even if only 0.01 volt lower than the others) will end up trying to carry all the current.

However, you can add an external transistor as in Fig. 2 to increase the current capacity of the LM7812. Note that when you do, overcurrent protection is lost; unlike the LM7812, the transistor will not shut down when you draw excessive current through it. Also, the transistor will need a good heatsink; if the input voltage is 20 volts, it will be dissipating (20–12) × 4 = 32 watts.

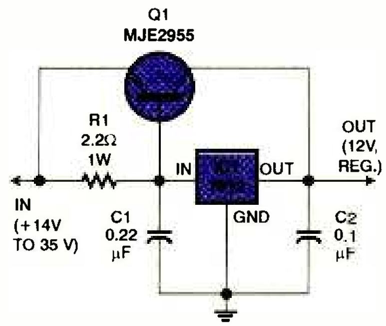


Fig. 2. This circuit lets an LM7812 pass four amps or more. Both the transistor and the voltage regulator will require good heatsinks. The same trick will work with any three-terminal regulator of the 78xx series.

Watchdog Correction

Q *I was excited to see the article "The Watchdog" in the January 2000 issue and was especially interested in the RF modules from Spectrum Microwave Products, but the telephone number listed in the article was wrong. Can you help?—J. G., no address given*

A Oops! Try 888-977-3287 (not 3267) or *www.spectrum-microwave.com.*

Transformer Correction

Q *Your answer to the man in Kambelovac, Croatia, in your September column was correct up to the last two sentences. You said that when using two transformers with their secondaries in series, one should be careful to check phasing so that the voltages add rather than subtract. So far so good.*

You then advise that one should briefly touch the free secondary wires together to check phasing. You state that if a large spark is produced, the windings are out of phase with each other and wires should be swapped. Actually, the opposite is true. If a large spark is produced, the voltages are adding together as intended.

Couldn't the voltages be checked with a voltmeter rather than by looking for sparks?—B. O'B., Gardena, CA

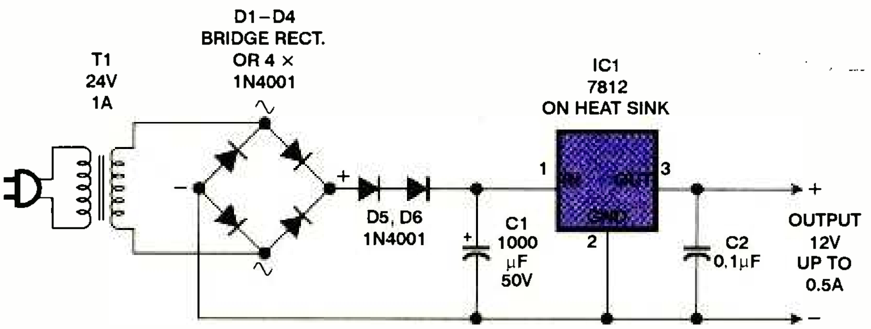


Fig. 1. Here is a complete 12-volt power supply using a 24-volt transformer. See the text for an explanation and suggested improvements.

A You're perfectly right. But this time I get to point the finger—I didn't write those two sentences! They were inserted by one of our technical editors, who apparently was thinking about how to use transformers in parallel (like using two 12-volt, 1-amp transformers to get 12 volts at 2 amps) whereas I was talking about using them in series (to make two 120-to-12-volt transformers into a 240-to-24-volt transformer).

Actually, you can perfectly well put primaries in series and secondaries in parallel. In that case, two 120-to-12-volt transformers make one 240-to-12-volt transformer with double the secondary current capacity.

The phasing should of course be checked with a voltmeter, not by shorting wires and looking for sparks. If you do that, there's too much risk of burning out a winding! Many low-cost transformers, especially the golden-brass-colored ones common in imported audio equipment, are designed to act as fuses and burn out if overloaded.

More About Transformers

Q *Your September column stated that the transformer winding with the highest resistance is the primary. That is not necessarily true for those of us still hanging on to our vacuum-tube gear! Windings that deliver 300 or 400 volts are common, and they have proportionally more resistance than the 120-volt primary.—Greg Cravener, Antique Electronic Supply, Tempe, AZ*

Further to your June column, your reader may be more familiar with the term "megger" (insulation tester) to test the secondary isolation on his transformers. He can visit any electric motor shop to have this test done, maybe even for free.—L. F. Simpson, Aiken, SC

A Both of you are right, of course. Our reader did state that his transformers had low-voltage secondaries. Even if they didn't, no harm will result from using the highest-voltage winding as the primary, even if that wasn't its original function.

As for isolation, we were describing how to check whether the transformer was of an isolating design. Checking how well the isolation actually works does require a "megger" (megohmmeter insulation tester) which applies several hundred volts and checks for leakage. An ordinary ohmmeter, even if it has a high megohm range, can't predict whether the insulation will break down at 500 or 1000 volts.

Of Sounds and Clocks

Q *In the February 2000* ***Poptronics****, you have a circuit for a sound-effects generator. I wanted to use this to surprise or annoy my wife with a sound that changes daily, but all I can get is a constantly changing pitch. Is it possible that the first stage of the diagram is wrong or incomplete?*

Also, I use a Gra-Lab photographic darkroom timer, and I really like its big dial; but because the line power over here is 50 Hz rather than 60 Hz, it runs at only 5/6 the intended speed. Can I build an inverter to power it at the correct frequency?—W. B., Winnert, Germany

A Your sound-effects generator seems to be working correctly; it should sound like a siren, or maybe like a chirping bird if you adjust the first 555 to a very low frequency.

The Gra-Lab timer uses a synchronous motor that requires 120 volts rms, 60 Hz, at just a few milliamps. There is a wide tolerance for the voltage, but the frequency is critical.

What you need is an inverter that produces an accurate 60-Hz signal. Figure 3 shows one circuit that will do the job; it's adapted from the circuits that amateur astronomers use to control telescope drive motors. This circuit requires 12 volts DC at 0.5 amp and produces about 90 volts AC, adequate to run the timer's 4-watt motor. I tried it out with my own Gra-Lab 310 darkroom timer. The built-in buzzer works fine, but don't try to power an enlarger or safelight through the timer, of course.

This RC oscillator should provide stability of 1% or better, good enough for photographic work. If you're interested in quartz-controlled alternatives, see Astrophotography for the Amateur, by Michael Covington (*www.covingtoninnovations.com/astro*) and *www.ai.uga.edu/~mc/alcor.html.*

Ersatz Fox and Hound Revisited

Q *Further to your June column, to trace wires with a radio you don't need a special oscillator. Just make a broadband signal with a battery-powered electric doorbell/buzzer that's coupled to one wire (not both) through a capacitor. An AM radio will easily pick up the noise.—William Folkerts, North Palm Beach, FL*

A Nice idea! Thanks. The circuit should consist of a buzzer powered by a 6-volt battery or four C cells, with one side of the buzzer connected through a 0.01-µF, 600-volt capacitor to the wire you want to trace. If the wire is not "live," you can omit the capacitor and connect to it directly. The wire works as an antenna.

Want to Make .EXE Files

Q *Have you ever had an issue that contained information on making .exe files (executable programs) for Windows?—W. P., address not given*

A We normally leave computer programming to the computer magazines, but you raise an interesting point; the computer magazines don't cover programming the way they did in the 1980s. Almost all of them are about commercial application software or else very advanced programming topics for professionals.

The best way to get started making

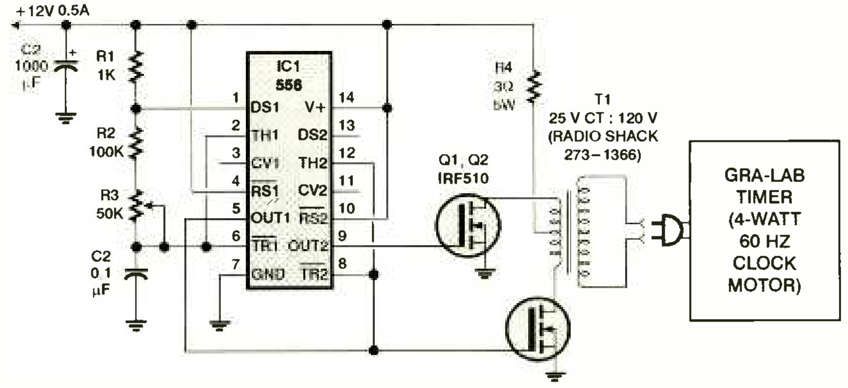


Fig. 3. This inverter circuit will run a 60-Hz electric-clock motor from a 12-volt DC source. Adjust R1 for a 60-Hz frequency.

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

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

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

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

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

Copies of past articles: Copies of past articles in **Electronics Now, Popular Electronics** (post 1996 only) and **Poptronics** are available from our Claggk, Inc., Reprint Department, P.O Box 12162, Hauppauge, NY 11788; Tel: 631-592-6721.

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, PO Box 549, Tooele, UT 84074.

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

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

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

Windows software is to buy *Visual Basic, Borland Delphi*, or *Borland C++ Builder* and one or two good books about whichever one you've chosen.

Should we run an article or two about programming tools for PCs? Readers?

Hot Pentium

Q *Further to your May 2000 column discussing Windows page faults, I had a similar problem after the heatsink broke off my processor chip, causing it to run too hot.*

The new Pentium cards come equipped with "software-controlled" fans. How feasible is it to implement such a fan on an older Pentium, sensing the CPU usage and outputting an appropriate DC voltage into the fan?—M. P., Athens, Greece

A I had a similar problem recently. My video card displayed all the symptoms of defective video memory, but only after running for several hours. When I opened up the case, the problem cleared up. Inspection showed that some cables were blocking the main air-circulation path. I got them out of the way and the problem disappeared.

When an IC gets hot, voltage thresholds shift, leakage increases, and reliability goes down the drain. I think that the correct solution is to install an additional fan that runs all the time. The trouble with software-controlled fans is that they don't work when the software fails! But if you're interested in thermistor-controlled fans, see this column in **Electronics Now**, February 1997; you can order reprints from *bookstore@gernsback.com.*

Strange-Acting PIC

Q *I have an assembly-language program on a PIC16F84 microcontroller that runs correctly after I press the reset switch, but it doesn't always run correctly when the circuit is first powered up. What could be wrong?—N. M., Wolcott, CT*

A Check your configuration settings and make sure the power-up time delay is enabled. This makes the PIC stay reset for a fraction of a second after power-up, giving the supply voltage some time to stabilize.

In MPLAB, you can make this setting with a checkbox. It's better, though, to start your assembly-language program with a configuration directive such as

```
__config _XT_OSC & _WDT_OFF
& _PWRTE_ON
```

This means: Crystal oscillator, watchdog timer off, power-up time delay on. Note that there are two underscore marks in front of config.

If this doesn't do the trick, consider how quickly the power supply reaches normal voltage. If it's slow, you may need to add external circuitry to maintain the reset signal until the power has stabilized.

Writing To Q&A

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

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

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

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

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

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

TED NEEDLEMAN

mailto: computerbits@gernsback.com

STAR LIGHT, STAR BRIGHT—PART 2

In my last column, I started detailing the joys and anguish of my experiences with Celestron's new NexStar5 computerized telescope. To recap, the NexStar5 is a $1200 Schmidt-Cassegrain reflector with folded optics for a short tube. It features a five-inch primary mirror with superb light-gathering capabilities, an interesting Star Pointer finderscope, and a motorized two-axis mount. The attached computerized handset can interface, via an RS-232 port, to a PC or Macintosh. These types of telescopes are called "GOTO" scopes; once they are set up and calibrated, entering an object on the keypad automatically slews the scope to point to the precise position where the object should be visible in the scope.

"Should be" is the operative term. I previously pointed out how my inexperience with astronomy and telescopes in general had initially managed to cancel out of the NexStar5's built-in smarts. The plain fact of the matter is that I assumed that I would actually know if I were looking at the object I wanted to see. But when you look in a telescope with the capability of the NexStar5, you see many objects that just plain aren't visible to the unaided eye.

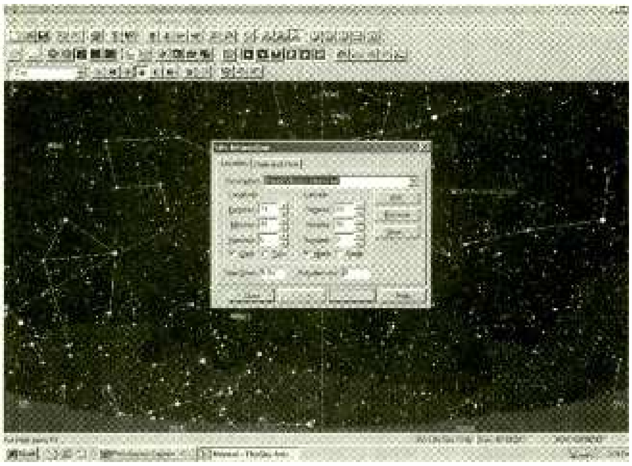
HELP IS ON THE WAY

Fortunately, again computers have come—at least partially—to the rescue. *The Sky* software, from The Software Bisque, which Celestron thoughtfully included along with an RS-232 cable, proved to be a tremendous aid. This particular package costs about $130, but there are many astronomy packages, including shareware and freeware, available. A quick search on the Internet will uncover lots of possibilities, some even with the GOTO capability of controlling a computerized telescope such as the NexStar5.

As a quick aside, while I was fortunate enough to have the folks at Celestron provide me with the superb NexStar5, there are many less expensive telescopes available with both computerized handsets and a GOTO mount. Celestron's parent company, Tasco, now offers both consumer-priced refractor and reflector telescopes with GOTO bases, "Mission Control" computerized handset, the ability to interface with a PC, and *Guide Star* software. The refractor is about $400; the reflector cost a bit more. Meade Instruments also has introduced an under-$400 GOTO telescope, as has Bushnell.

SOFTWARE IS THE KEY

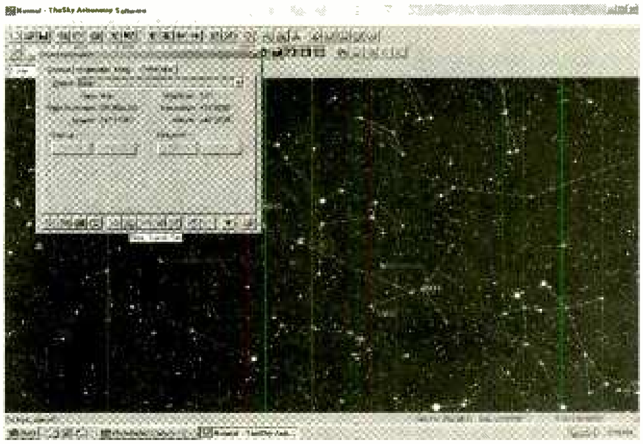
Initially, two factors helped reduce my first experience with the NexStar5 to a guessing game. First, I did not understand what should be visible in the eyepiece. The other was my uncertainty whether the NexStar5 was actually correctly calibrated. The calibration method involves pointing the scope towards the north, entering your site's location, and sighting on two of three bright stars selected by the scope. One



Before you can use The Sky, *the first step is to enter the viewing site information as accurately as possible.*

You need to specify the type of GOTO scope or controller that you are using. Initially, as shown here, The Sky *did not have an entry for the NexStar5. A patch downloaded from The Software Bisque's Web site fixed that.*

Once everything is set up, calibrated, and outside, you can select an object to view.



Click on the "center" icon, and the object will be centered in the PC's display if it is visible in the sky. If it is, click on the "slew" icon, and the telescope will point to the object.

problem was that the list of longitude/latitude figures in the NexStar manual didn't have a city that was closer than 35 miles to where I live. I initially used these figures, but couldn't help wonder if the inaccuracy was causing the scope to point to the wrong object, thus screwing up the calibration.

I went "back to the drawing board" and decided to use *The Sky* software installed on a Compaq Presario 1600 laptop to control the NexStar5 as well as show me what I was actually seeing. I also decided to zoom in more accurately on my viewing site's longitude and latitude.

Another neat gizmo that I have for the laptop, TravRoute Software's *CoPilot 2000* GPS receiver and software, made short work of finding out my exact longitude and latitude. I set up the receiver, went out on my back porch, and let the GPS antenna "find" several satellites. Turning on the "track" function in *CoPilot 2000* provides a real-time read-out of your precise speed, location (both on a map, and if you wish, longitude and latitude), and even elevation. I jotted down the longitude and latitude and was ready to both set up *The Sky* and calibrate the NexStar5. With the exact longitude and latitude, I was a lot more confident that the NexStar5 was correctly set up, solving one problem.

CLOSE ENOUGH FOR GOVERNMENT WORK

In order to use *The Sky* (or most other astronomy software) to both identify objects and control a GOTO telescope, you need to set up the software. The first step is to enter information about the viewing site. As with the NexStar5, the more precise this information is, the more precisely the software will both track the objects you want to view, and be able to point the scope. Again, as with the NexStar5, *The Sky* didn't have a default entry that was anywhere near where I live. After I typed in the longitude/latitude figures obtained from the GPS setup, the display visibly shifted, so 30 or 40 miles did make a difference.

The software also needs to be set up for the type of GOTO scope and mounting that it will interface with. The first time I tried to do this, I discovered that my copy of *The Sky* did not have an entry for the NexStar5. A quick visit to The Software Bisque's Web site provided a patch that added the NexStar to the list.

Next, I made up a list of objects that I wanted to view that evening. *The Sky* offers a "find" function that will highlight the object on the display if it is actually visible in the sky. You can also bring up an information window that provides details about the object, as well as when it will rise and set.

If you perform this function outside with the NexStar calibrated, you can simply click on the "slew" icon and the scope will point to the object that you've selected.

At least I think it does. I'm getting a bit better at identifying objects in the night sky, largely because *The Sky* lets me zoom in on the area around my intended viewing objects. When I actually peer through the NexStar5's eyepiece, it sort of looks like what's on the Presario's screen. The trouble is that until a bit later in the Fall, none of the recognizable planets—like Saturn and Jupiter—are positioned for good viewing. I think I've target

(Continued on page 50)

VENDOR INFORMATION

NexStar5
$1200 (street price)
Celestron International
2835 Columbia St.
Torrance, CA 90503
310-328-9560
www.celestron.com
CIRCLE 100 ON FREE INFORMATION CARD

The Sky Version 5 (Level II) and RS-232 cable
$129 (street price)
The Software Bisque
912 Twelfth St.
Golden, CO 80401-1114
800-843-7599
www.bisque.com
CIRCLE 101 ON FREE INFORMATION CARD

Tasco Sales Inc.
2889 Commerce Parkway
Miramar, FL 33025
954-252-3600
www.tascosales.com
CIRCLE 102 ON FREE INFORMATION CARD

TravRoute
1000 Herrontown Rd.
Princeton, NJ 08540
609-252-8197
www.travroute.com
CIRCLE 103 ON FREE INFORMATION CARD

(continued from page 4)

reasons the Marconi system won, aside from having over twice the resolution. With the Marconi "camera," you could light a group of people on a set with pretty much standard theatrical-lighting techniques, except with a lot more light. The Farnsworth Image-Dissector tubes were very insensitive, but all electronic.

I'm glad to see **Poptronics** survive in the difficult, fragmented electronics-magazine business. It is a publication from which anyone of any education and experience can learn something. I do all the time. Thanks again for helping keep Pop 'Tronics alive and entertaining.
PAUL HAINES
via e-mail

[Thanks for the clarification. My information came from several "space-advocate" friends; I was, apparently, "misinformed." Incidentally, Hugo Gernsback never edited ***Popular Electronics****; it was published by Ziff-Davis through the early 1980s—a good 15 years after Hugo's death.—Editor.]*

A Hobbyist Speaks His Mind

I have been a reader of the Gernsback publications as far back as I can remember, and I am 79! My first electronic project was building a crystal radio (with a true galena) back in the thirties. Being a true long-time "hacker" (in the very old sense of the word), I have truly enjoyed **Popular Electronics, Electronics Now**, and most of their predecessors. I hope the creation of **Poptronics** is not a sign of what I fear—the vanishing of the true electronic and computer hobbyist.

I would like to see some real down-to-earth practical articles on step-by-step making simple digital filters from start to finish. For example, how to make a digital equivalent of a simple low-pass T-filter that one could experiment with. Inasmuch as I can only program in BASIC and PC Machine Language, I hope that a BASIC version would be available for any programming that must be done. Finding versions only in C has been a problem for me.

In the same vein, experimenting with signal processing and with D/A and A/D converters is of interest to me. Lastly, since there is a section on robotics, would articles on the theory, construction, and operation of stepper motors be possible?
ANDRE W. WEITZENHOFFER
Nathrop, CO

Worms in, E-mail Out

I enjoyed Mr. Goldsborough's column ("Surveying the Digital Domain," August) on the myths, mysteries, and moneymaking issues around computer viruses and anti-virus software vendors. Having seen the old (a "Friday-the-13th" infection) and the new attacks (e-mail and attachment sent without the knowledge of the sender), I can relate to your comments.

One issue I must disagree with you on is the impossibility of being infected with e-mail when the attachment is *not* opened/executed.

I recently received a warning from my McAfee program that a virus/worm had infected my system. The worm, something like KAK.WORM, had entered my PC either as an e-mail or while I was reading messages on a newsgroup. According to McAfee, it attacks the Microsoft Outlook Express program specifically (of course). If you have your "preview pane" open or if you have scripting turned on (I don't fully understand all of this), the worm can infect your system when you merely *highlight* the infected e-mail. McAfee recommends turning off the preview pane and disabling the scripting option (I have done both but am still not sure of the worm's origin) and then cleaning or deleting certain files. This particular worm goes out in succeeding e-mails, as a signature, to infect others.

In my mind, this virus/worm is exactly what all those "newbie" PC users worry about. They've been warned, repeatedly, about e-mail viruses, and now one comes along that will prove those warning were "real".

One last thing, for a laugh. Our IT guru at work e-mailed the entire office with a warning about the recent "I Love You" virus. In the body of his message, he instructed users specifically to delete *any* e-mail with the words "I Love You" in the subject line. Guess what words *he* used in *his* subject line...ha, ha!
RANDY JONES
via e-mail

Good point. The virus/worm/trojan world has indeed gotten more complicated lately. Many of the malcontents spreading this evil are targeting Microsoft products such as Outlook Express, for several reasons. They're widespread, they frequently have security vulnerabilities, and a lot of people, whether justified or not, simply hate Microsoft.

One option is to use a third-party e-mail program such as Eudora, which is now free and downloadable at *www.eudora.com*. Another, more extreme, option is to avoid everything Microsoft and use Linux as your operating system, though this isn't practical for many "non-techies."
REID GOLDSBOROUGH

Haves & Needs

I have a special request for **Poptronics** readers. I need someone who can do a computer-aided design (CAD) program of printed circuit boards on a small scale. I will supply a circuit schematic, from which I would like the helpful reader to design a PC board pattern on a computer. The board(s) will each be one of a kind—no larger than 3 by 5 inches in size, and usually smaller. I will be happy to make a reasonable and fair payment for this service. If any reader can help me with this, it would be greatly appreciated.
C. KENDRICK SELLEN
476 Belmont St.
Waymart, PA 18472

I searched the Web for a manual for a General Radio 1633A Incremental Inductance Bridge and had no success. Can any reader help me find the manual or send me a photocopy? I will be glad to pay for the manual or copy.

It would also be helpful if you could publish an up-to-date list of places to find manuals.
JOSE VICENTE
Vicente@asupernet.com.br

[Have you checked the "How To Get Information About Electronics" sidebar that we run monthly in "Q&A?" There is a section on service manuals with some suggestions.—Editor.]

I am looking for a schematic for the Westminster multi-band radio, Model #1428. Any help will be appreciated.
D. GEORGE GOLDBACH
4228 Olney St.
San Diego, CA 92109
858-272-0235

mailto: amazingscience@gernsback.com

JOHN IOVINE

More Fun With Nitinol

Last month, we began exploring shape-memory alloys (SMAs) with a look at two different uses of Nitinol wire: "electric" muscles and the Livewire demonstration product. To recap the properties of Nitinol, the particular alloy used with the muscle has two "memories:" a low-temperature memory of an elongated state and a high-temperature memory of a contracted state. In contrast, the Livewire has a single high-temperature "shape" memory.

We'll continue exploring these "smart" alloys and their unusual properties with experiments and more fun demonstration projects. Before we begin, I'd just like to point out that although we are dealing primarily with Nitinol wire, the alloy is manufactured in other shapes and sizes. Besides various gauges of wire, Nitinol also come in tube (various sizes), strip (various thickness and widths), and cast-component varieties.

Superelasticity

Superelasticity is another unique property of SMAs. If the SMA is deformed at a temperature slightly above its transition temperature, it springs right back into shape. That springy property is the definition of superelasticity. Manufacturers have capitalized on that property, finding useful medical and dental applications.

For instance, low-temperature Nitinol wire is used as orthodontic archwires in braces. The Nitinol wire provides a low constant force at human body temperature used to straighten teeth while reducing the need for wire retightening. The transition temperature of these wires is made so that they generate force at the temperature of the human mouth—about 37° C or 98.6° F.

Superelastic Nitinol tubing is used as surgical catheters. The Nitinol catheters can be bent more often than their steel counterparts allowing surgeons to access difficult-to-reach areas of the human body.

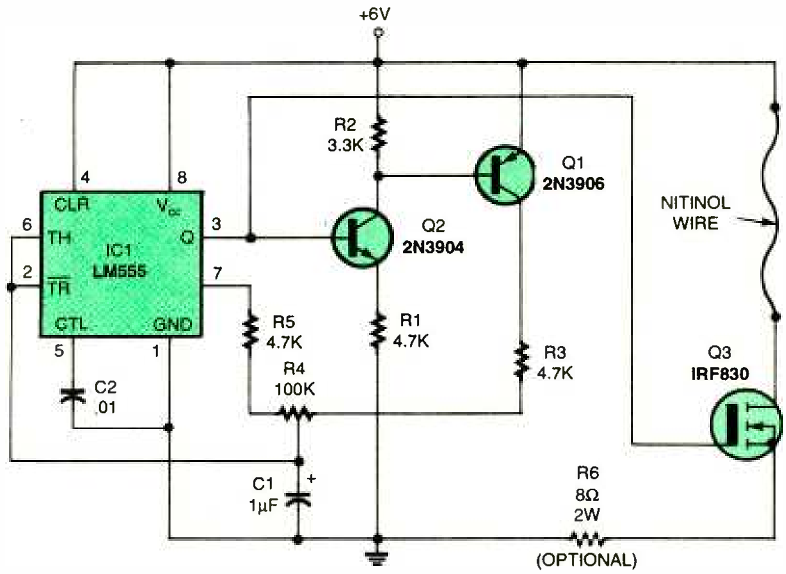


Fig. 1. This pulse-width-modulation circuit offers greater control when heating Nitinol wire. If you still have overheating problems, add an additional resistor in series with the Nitinol wire.

Better Electrical Control

One shaping method we explored in our introduction to Nitinol wire was using a basic DC current to heat the wire. While that works, it is easy to overheat and potentially damage the Nitinol wire. This month, we will construct a pulse-width-modulation (PWM) circuit. Activating Nitinol wire using pulse-width modulation has distinct advantages. The oscillating on/off nature of the power allows for more even heating of the wire by reducing hot spots. The duty cycle of the squarewave can be varied to generate a degree of proportional control over the contraction. These factors allow us to activate the Nitinol wire with better control for longer periods of time without causing heat damage to the crystalline structure of the Nitinol alloy.

The PWM circuit shown in Fig. 1 centers around a 555 timer. By using two transistors (Q1 and Q2) and a potentiometer, we can create an output with a relative constant frequency and a variable duty cycle.

When the output from the timer (pin 3) goes high, both transistors turned on. The current through Q1, R3, and the right-hand portion of R4 charges C1. When the voltage on C1 reaches ⅔ of the supply voltage, pin 3 on the 555 goes low.

At this point, both transistors turn off. Capacitor C1 begins to discharge through the left-hand portion of R4 and R5 to pin 7 (now at ground) of the 555. When C1s voltage drops to ⅓ of the supply voltage, the output switches high and the timing cycle repeats.

Varying R4 can change the duty cycle of the output. The proportions of the left- and right-hand resistances set the ratio of "on" time to "off" time.

Pin 3 of the 555 connects to a MOSFET transistor that switches the current on and off to the Nitinol wire. If the current from the PWM circuit is too powerful to control the Nitinol wire proportionally, place an 8-ohm (two watts or greater) resistor in series with the Nitinol wire to reduce power.

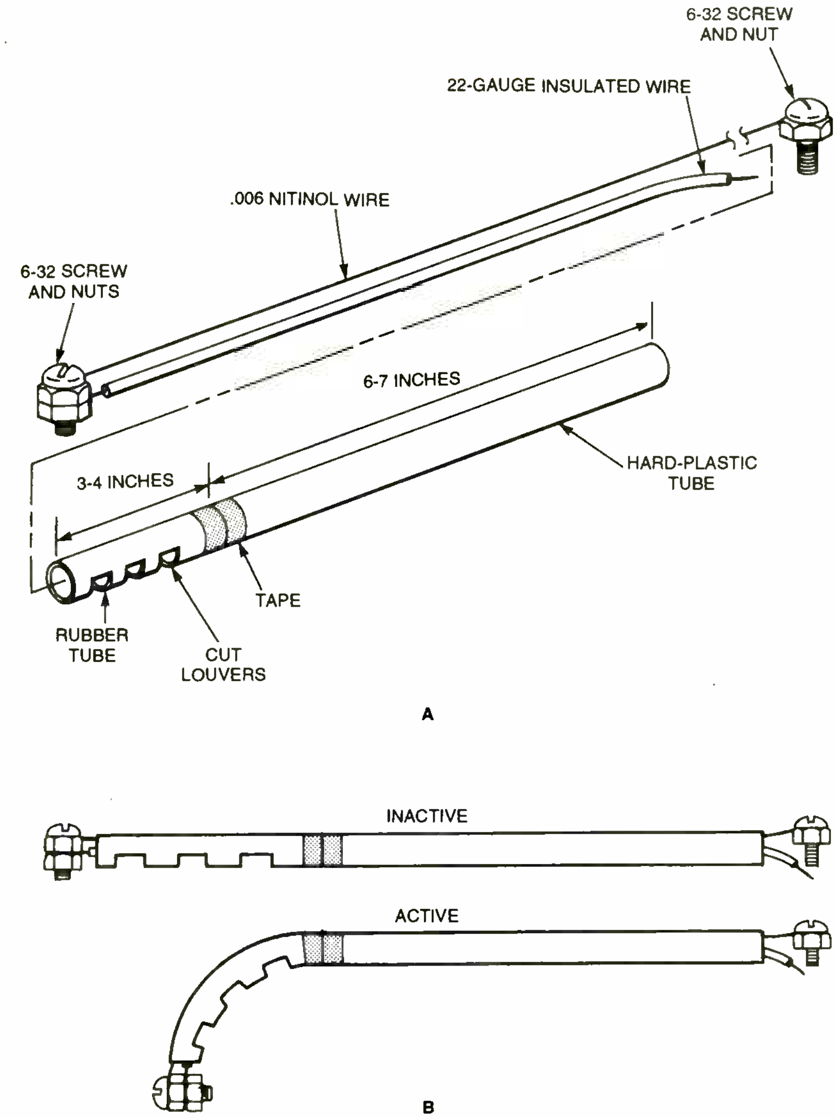


Fig. 2. The "Directional Digit" is a Nitinol-based "finger" that curls and uncurls as the Nitinol flexes. Note the louvers in the rubber tube that control the direction of the bend.

Fig. 3. The Thermobile operates on hot water or solar energy.

Directional Digit

Here's an interesting use of Nitinol wire: a "directional digit." Using three or four directional digits in a circle, one can create a basic robotic arm gripper. The basic digit consists of three or four inches of resilient rubber or silicon tubing, 12 inches of Nitinol wire, 12 inches of 22-gauge insulated stranded wire, a 6-32 machine screw with two nuts, an 8-32 machine screw with two nuts, and about seven inches of hard plastic tubing.

Take the length of rubber tubing and cut four or five louvers on one side. See Fig. 2 for details. You can cut the louvers using scissors or a wire cutter. The louvers force the rubber tubing to collapse to one side when compressed—the "directional" part of "directional digit." Next, wrap one end of the Nitinol wire around the 6-32 machine screw and secure it with a nut. Strip the insulation from one end of the 22-gauge wire and wrap it around the 6-32 screw; use the second nut to hold that wire in place.

Thread the free ends of both wires through the rubber tubing and the hard plastic tubing. The first 6-32 nut should be flush with the top of the rubber tubing. Secure the base of the rubber tubing to the top of hard plastic tubing with tape; masking, cellophane, or electrical varieties will do.

Attach the free end of the Nitinol wire to the 8-32 machine screw and nut as described before. Position the 8-32 machine screw at the base of the hard plastic tubing without any free space in between. You might have to collapse the upper rubber tubing while attaching the 8-32 machine screw to get it to position correctly.

Connect the PWM circuit to the Nitinol wire (via the 8-32 machine screw) and the free end of the 22-gauge wire. By rotating the potentiometer, you will be able to bend the rubber tube like a finger. The digit will bend in the direction of the louvers. Reducing the power allows the digit to straighten out.

After you've played with your Nitinol-powered finger for a while, build two or three additional units. By placing them in a circle with the louvers pointed toward the center, you will have a rudimentary gripper.

Heat Engines

If you thought that Nitinol material would make an excellent material to construct heat engines, you are not alone. Over the years, a number of experimenters and companies have created Nitinol-based heat engines. A patent search on the Internet using the key words "Nitinol" and "engine" turned up several heat-engine designs. Most of the patented designs are mechanically complex and don't lend themselves to quick experimentation. However, there is a simple heat-engine design that found its way into a few toys. Let's take a quick look at this design.

Thermobile

The "Thermobile" (Fig. 3) uses a loop of Nitinol wire to generate power. The Nitinol loop is placed on two free-rotating wheels. These devices use only hot

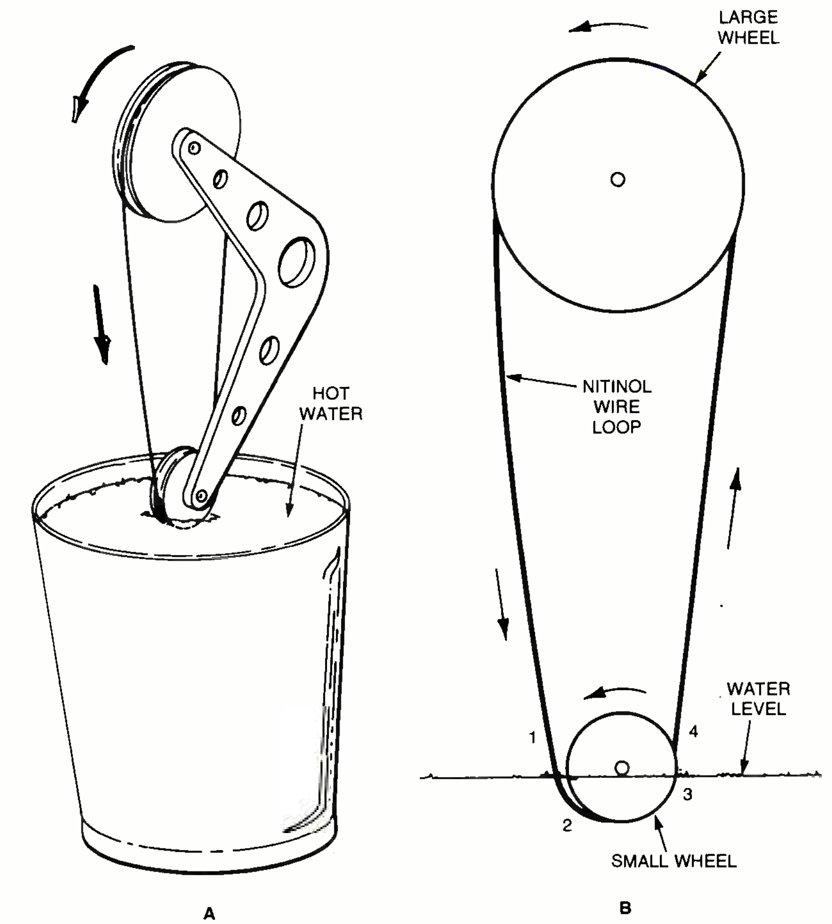


Fig. 4. Detail and function of the Nitinol loop used to power the Thermobile.

water (hot side) and cool ambient air (cool side), with a small brass wheel immersed in the water or other hot liquid.

In the Thermobile, the Nitinol-wire loop has been trained to remember a straight shape. Look at Fig. 4. At position 1, the Nitinol wire is relatively straight and cool. As the wire moves from position 1 to 2, it bends around the brass wheel and enters the hot water. The Nitinol wire rises above its transition temperature and tries to straighten out. When attempting to straighten out, the wire generates a tugging force along the loop. As the wire moves from position 3 to 4, it straightens out. Travelling from position 4 to position 1 through the air and around the large wheel, the wire has sufficient time to cool below its transition temperature and is ready for another cycle.

In short, the temperature differential causes one side of the loop to stiffen (hot-water side); while on the air side of the loop, the Nitinol cools and relaxes. A mechanical force is produced that causes the wheel pulleys to rotate.

In some cases, it is necessary to jump-start the engine by rotating the larger wheel. Interestingly, the Thermobile doesn't have a set rotational direction. Whichever way it is started, it will continue to rotate.

The Thermobile can also be solar powered. A magnifying lens focusing sunlight on the brass wheel also supplies sufficient heat to power the engine.

Larger Thermobile engines have been built and tested. One engine built by Innovative Technologies International (ITI) in 1982 contained 30 Nitinol wire loops. The Nitinol wire used in the loops was 22 mils in diameter. The engine was tested using a hot-water bath set at 55° C and an air temperature of 25° C. The engine reached a speed of 270 RPM and continued to operate for 1½ years without failure. The Nitinol wire had undergone over 200,000,000 cycles without any breakage or observable degradation in performance!

Cool-Craft Boat

The "Cool-Craft" boat of Fig. 5 also uses a loop of Nitinol wire for power. As

Fig. 5. The Cool-Craft uses warm ambient water and ice to create a thermal differential that activates a Nitinol loop to power the boat.

in the Thermobile, a Nitinol loop is placed on two free-rotating wheels as shown in Fig. 6. The smaller bottom wheel has paddles that move the boat when it rotates. The boat has a small ice compartment on top, which chills one side of the Nitinol loop. The other side of the Nitinol loop travels through warm water where the toy boat is placed. The heat differential between the warm water and ice is enough to activate the Nitinol wire loop and power the craft.

Other Heat Engine Designs

This is fertile field for experimentation. I have seen a number of heat-engine designs that use rubber bands. A few of these designs look as though they would lend themselves to incorporate Nitinol wire in place of the rubber. If anyone builds or has built an Nitinol-based heat engine and would like to

PARTS LIST FOR THE PULSE-WIDTH-MODULATION CIRCUIT

SEMICONDUCTORS

IC1—LM555 timer, integrated circuit
Q1—2N3906 PNP silicon transistor
Q2—2N3904 NPN silicon transistor
Q3—IRF830 N-channel MOSFET transistor

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R3, R5—4700-ohm
R2—3300-ohm
R4—100,000-ohm potentiometer, linear-taper
R6—8-ohm, 2-watt (optional, see text)

CAPACITORS

C1—1-µF, 25-WVDC, electrolytic
C2—0.01-µF, ceramic-disc

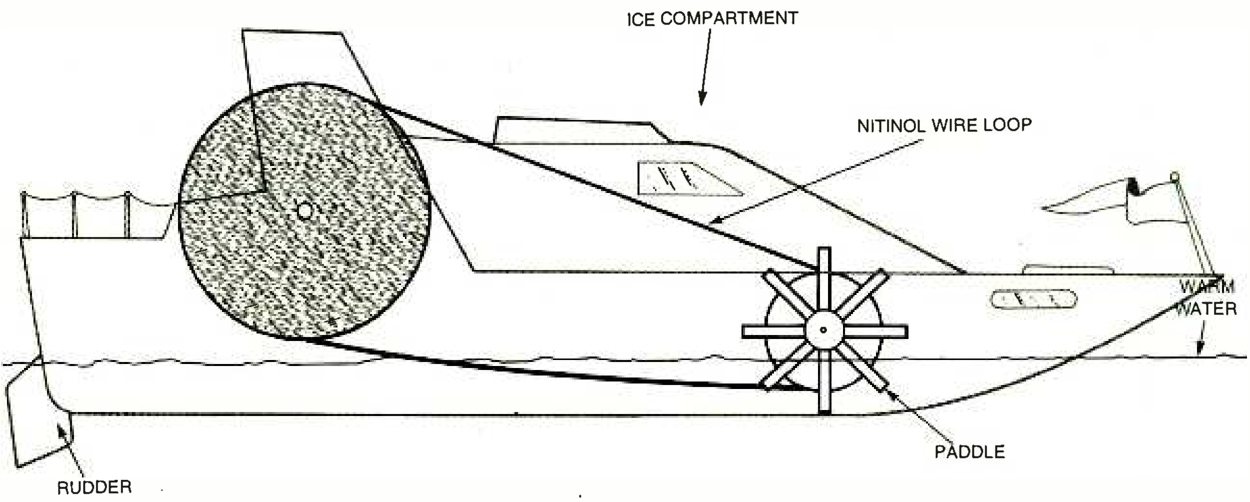


Fig. 6. This cross-section of the Cool-Craft shows the Nitinol loop and the bottom paddle.

share the design—or if you would like to see another column on Nitinol heat engines—write to me in care of **Poptronics** or e-mail; the column address is found at the beginning of the column. **P**

COMPUTER BITS

(continued from page 45)

ed Mars, and of course the Moon is an easy (and breathtaking) object to view. But until I have a lot more hours at the eyepiece, I'm not really ready to make any major pronouncements about what I've seen.

To be truthful, though, I've already started thinking about all of those gorgeous photos of nebulae and galaxies. There's a lot of material on the Web about astrophotography and adapting various CCD video cameras for the task. It doesn't seem like it should be too difficult… **P**

UNITED STATES POSTAL SERVICE™

Statement of Ownership, Management, and Circulation
(Required by 39 U.S.C. 3685)

1. Publication Title	2. Publication No.	3. Filing Date
POPTRONICS	1526-3681	10-1-00
4. Issue Frequency	**5. No. of Issues Published Annually**	**6. Annual Subscription Price**
MONTHLY	12	$24.99

7. Complete Mailing Address of Known Office of Publication *(Street, City, County, State, and ZIP+4) (Not Printer)*

275 G MARCUS BLVD, HAUPPAUGE, NY 11788

8. Complete Mailing Address of Headquarters or General Business Office of Publisher *(Not Printer)*

275 G MARCUS BLVD, HAUPPAUGE, NY 11788

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13. Publication Name	14. Issue Date for Circulation Data Below	
POPTRONICS	JUNE 2000	
15. Extent and Nature of Circulation	**Average No. Copies Each Issue During Preceding 12 Months**	**Actual No. Copies of Single Issue Published Nearest to Filing Date**
a. Total No. Copies *(Net Press Run)*	96,065	89,300
b. Paid and/or Requested Circulation (1) Sales Through Dealers and Carriers, Street Vendors, and Counter Sales *(Not Mailed)*	13,725	14,000
(2) Paid or Requested Mail Subscriptions *(Include Advertisers' Proof Copies/Exchange Copies)*	46,993	47,243
c. Total Paid and/or Requested Circulation *(Sum of 15b(1) and 15b(2))*	60,718	61,243
d. Free Distribution by Mail *(Samples, Complimentary, and Other Free)*	4,470	1,506
e. Free Distribution Outside the Mail *(Carriers or Other Means)*	-------------	-------------
f. Total Free Distribution *(Sum of 15d and 15e)*	4,470	1,506
g. Total Distribution *(Sum of 15c and 15f)*	65,188	62,749
h. Copies Not Distributed (1) Office Use, Leftovers, Spoiled	3,901	1,657
(2) Return from News Agents	26,975	24,894
i. Total *(Sum of 15g, 15h(1), and 15h(2))*	96,065	87,300
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GORDON MCCOMB

Collision Avoidance and Detection: Part 2

Last month, we began our look at near-object collision avoidance and detection. We examined the design criteria for collision avoidance and detection as well as several simple techniques—including infrared light and pyroelectric sensors—for providing near-object sensors in a robot. This time, we'll look at more sophisticated collision avoidance- and detection-systems, including ultrasonic sound-proximity detection, as well as several switch and pressure systems.

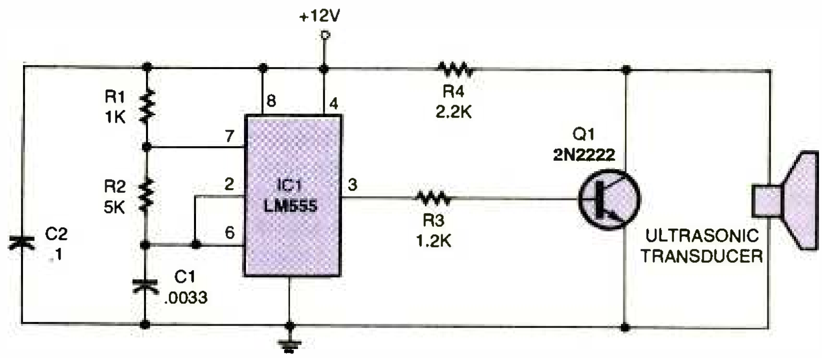


Fig. 1. Schematic diagram for a basic ultrasonic proximity transmitter.

Ultrasonic Sound

Sound, like light, has a tendency to travel in straight lines, bouncing off any object in its path. Sound waves can be used for many of the same things that light can be used for, including detecting objects. High-frequency sound beyond the range of human hearing (*ultrasonic*) can be used to detect object proximity as well as distance.

In operation, ultrasonic sound is transmitted from a transducer, reflected by a nearby object, and then received by another transducer. Sound is not sensitive to color, unlike light. Keep in mind, however, that some materials reflect sound better than others and that some even absorb sound completely. In the long run, proximity detection with sound is a more fool-proof technique.

This system is adaptable for use with single transmitter/receiver pairs or multiple pairs. Ultrasonic transducers are common in the surplus market; new ones cost under $5 each (depending on make and model). Ultrasonic transducers are available from a number of retail and surplus outlets, including DigiKey and Jameco.

Figures 1 and 2 show a basic circuit you can build that provides ultrasonic proximity detection. There are two parts: transmitter and receiver. The receiving transducer is positioned two or more inches away from the transmitter transducer. For best results, you may wish to place a piece of foam between the two transducers to eliminate direct interference. An op-amp, such as an LM741, is sufficient for receiver-signal amplification. The amplified output of the receiver transducer is directly connected to a 339 comparator IC. The ultrasonic receiver is sensitive only to sounds in about the 40-kHz ± 4 kHz range.

The closer the ultrasonic sensor is to an object, the stronger the reflected sound will be. Note that the strength of the reflected signal will also vary depending on the material bouncing the sound. Potentiometer R9 sets the comparator to trigger when the sensor is about 12–18 inches from an object. The output of the comparator will change between low and high as the sensor moves closer or farther from an object.

Once you get the circuit debugged and working, adjust R2 to vary circuit sensitivity. You will find that, depending on the quality of the transducers used, the range of this sensor is quite large. When the op-amp gain is all the way up, the range may be as much as eight to ten feet. The op-amp might "ring," or oscillate, at very high gain levels, so use a logic probe to choose a sensitivity that is just below the ringing threshold.

Contact Detection

A sure way to detect objects is to make physical contact with them. Contact is perhaps the most common form of

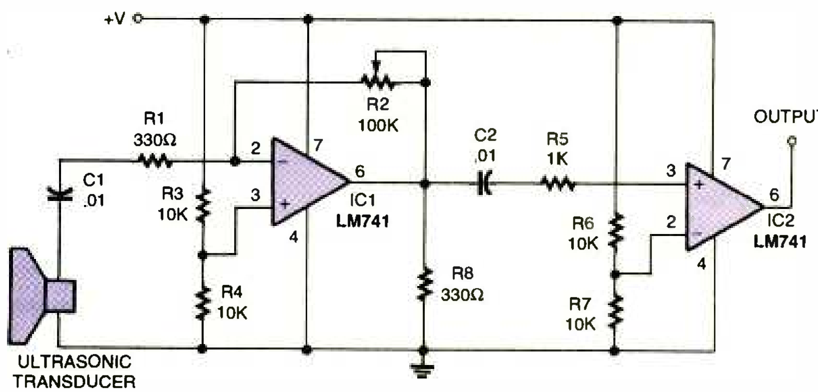


Fig. 2. Schematic diagram for a basic ultrasonic proximity receiver.

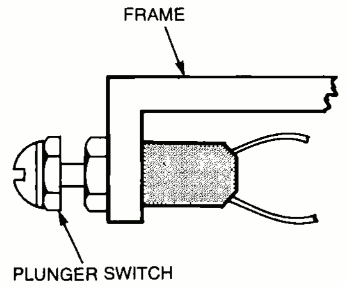


Fig. 3. This single-pole, single-throw, spring-loaded plunger switch mounted in the frame or body of the robot makes a great contact sensor. Experiment with different shapes and sizes for the plunger.

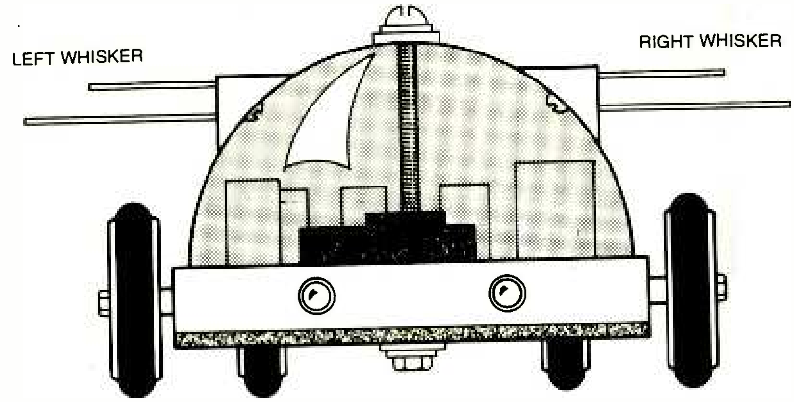


Fig. 4. "Whiskers" added to a robot give it a "cat-like" ability to sense when something is close without having to ram into the object.

object detection and is often accomplished using simple switches. Let's look at several methods, including "soft-contact" techniques where the robot can detect contact with an object using just a slight touch.

An ordinary switch can be used to detect physical contact with an object. So-called "bumper switches" are spring-loaded pushbutton switches mounted on the frame of the robot, as shown in Fig. 3. The plunger of the switch pushes in whenever the robot collides with an object. Obviously, the plunger must extend further than all other parts of the robot. You may need to mount the switch on a bracket to extend its reach.

The surface area of most pushbutton switches tends to be very small. You can enlarge the contact area by attaching a metal or plastic plate, or a length of wire, to the switch plunger. A piece of rigid 1/16-inch-thick plastic or aluminum is a good choice for bumper plates. Glue the plate onto the plunger. Low-cost pushbutton switches are not known for their sensitivity. The robot may have to crash into an object with a fair amount of force before the switch makes positive contact, and for most applications, that's obviously not desirable.

Leaf switches require only a small touch before they trigger. The plunger in a leaf switch (often referred to as a *Micro Switch*, after the manufacturer that made them popular) is extra small and travels only a fraction of an inch before its contacts close. A metal strip, or *leaf*, attached to the strip acts as a lever, further increasing sensitivity. You can increase the contact-surface area with a plastic or metal plate on the end of the leaf. If the leaf is wide enough, you can use miniature 4-40 or 3-48 hardware to mount the plate in place.

Many animal experts believe that a cat's whiskers are used to measure space. If the whiskers touch when a cat is trying to get through a hole, it knows there is not enough space for its body. We can apply a similar technique to our robot designs, without "borrowing" any whiskers from Fluffy. You can use thin 20- to 25-gauge piano or stove wire for the "whiskers" of the robot. Attach the wires to the end of switches or mount them in a receptacle so that a small rubber grommet supports the wire. We'll get to the details in a moment.

By bending the whiskers, you can extend their usefulness and application. You can also use whiskers of different lengths to detect immediate and close objects. For example, Fig. 4 shows two different lengths of whiskers used for the two sides of the robots. The longer length represents a space a few inches wider than the robot. If rubbing against an object actuates these whiskers, but not the short whiskers, then the robot understands that the pathway is clear to travel, but space is tight.

Cut the short whiskers to represent the width of the robot. Triggering the short whiskers on only one side should turn the robot the opposite way to avoid the obstacle. Activating both sides should trigger the "cat" response, "I'm too big for this passageway." Stopping or turning around are two viable responses. Before building bumper switches or whiskers into your robot, be aware that mechanical-switch contacts and most electronic circuits don't mix. The contact has a tendency to "bounce" as it closes and opens, so it needs to be conditioned with "debounce" circuitry or software.

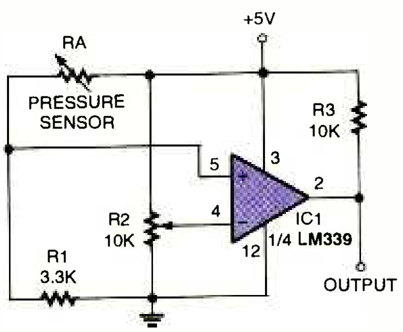


Fig. 5. This circuit converts the output of a conductive foam pressure sensor to an on/off type switch output.

A cheap and easy method of endowing your robot with the sense of touch is conductive foam, packaged with most CMOS and microprocessor ICs. This foam is available in large sheets and is perfect for use as collision-detection pressure pads. RadioShack sells a nice five-inch square pad that's ideal for the job.

Make a "sensor sandwich" by placing the foam between two pieces of copper foil coated with conductive adhesive; this makes it easier to attach connecting wires. Next, glue the pad to the frame or skin of your robot. Unlike fingertip touch, where the amount of pressure is important, the job of a collision detector is reporting contact with something. This makes the interface electronics that much easier to build.

Figure 5 shows a suitable pad interface. Wire the pad in series with a 3.3K resistor between ground and the positive supply voltage to form a voltage divider. Pressing the pad varies the output voltage.

The sensor output—the point between the pad and the resistor—is applied to the inverting pin of an LM339 comparator. There are four separate comparators in the package, so one chip can service four pressure pads. When the voltage from the pad exceeds the reference voltage supplied to the comparator, the comparator changes states, thus indicating a collision. The comparator output can be used to drive a motor direction control relay, or can be tied directly to a microprocessor or computer port. If you aren't using all four comparators, read the LM339's data sheet carefully on the connection of unused inputs and outputs.

What happens when you have many switches or proximity devices scattered around the periphery of your robot? You could connect the output of each switch to the computer, but that's a waste of interface ports. If the computer or microcontroller used in your robot has an analog-to-digital converter (ADC), or you don't mind adding one, you can use another technique to interface multiple switches: the resistor ladder. The concept is simple, as is shown in Fig. 6: each switch is connected to ground on one side and to +V in series with a resistor, on the other side. Multiple switches are connected in parallel to an ADC input. The resistors—each with a different value—form a voltage divider. When a switch closes, the voltage through that switch is uniquely different.

Note that because the resistors are in parallel, more than one switch can be closed at one time. An "in-between" voltage will result. Feel free to experiment with the values of the resistors connected to each switch to obtain maximum flexibility.

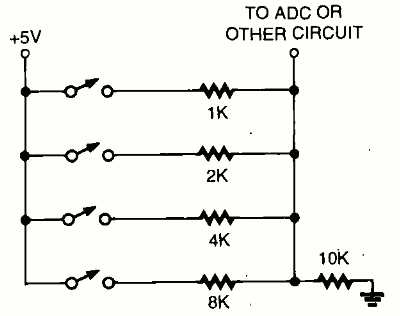


Fig. 6. A resistor ladder provides a way to tap multiple voltage levels. The voltage at the output of the ladder is dependent on the switch(es) that are closed.

Piezo Bar Collision Detector

The last nickname you'd want for your robot is "Bull In a China Closet," a none-too flattering reference to your automaton's habit of crashing into and breaking everything! Unfortunately, even the best-behaved robots occasionally bump into obstacles, including walls, furniture, and the cat (your robot can probably survive a head-on collision with a solid wall, but the family feline...maybe not!).

Since it's impractical—not to mention darn near impossible—to always prevent your robot from colliding with objects, the next best thing is to make those collisions as "soft" as possible. This is done using so-called *soft touch*, or *compliant* collision detection means. We'll look at several approaches. You can try some or all; mixing and matching sensors on one robot is not only encouraged, it's a good idea. As long as the sensor redundancy does not unduly affect the size, weight, or cost of the robot, having "backups" can make your robot a better-behaved houseguest.

The so-called "soft-touch" collision sensor described here, which uses commonly available piezo-ceramic discs, is a good alternative to the laser-optic whisker system for lower-sensitivity applications. A half-round bar increases the contact area.

The main sensing element of a piezo-disc touch bar consists of two one-inch diameter piezo-ceramic discs. These discs are available at RadioShack and many surplus-electronics stores; cost is typically under $1, $2 each, or less for the astute bargain hunter. The discs are attached to a 6½-inch-long support bar, which you can make out of plastic or even a long LEGO "Technic" beam. The discs are glued into place, with ⅛-inch foam (available at most arts and craft stores) stuck to the ceramic surface of the disc to act as a cushion. A length of ⅛-inch diameter aluminum tubing (approximately 8–9 inches) is bent to a half-circle and threaded through two small grommets, as shown in the illustration. The grommets are glued to the support bar.

Flatten the ends of the tubing and bend them at right angles to create a "foot." The foot rests on the foam-padded surface of the discs. For construction, I used hot-melt glue to attach

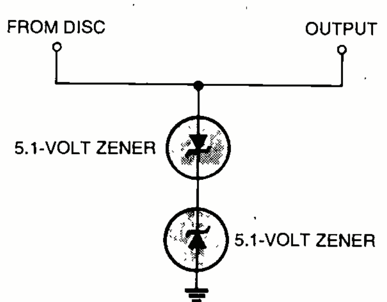


Fig. 7. A suitable interface circuit connects a piezo disc to a TTL-compatible input or op-amp.

the discs and grommets to the support bar. You can use most any other adhesive or glue, but be sure it provides a good, strong hold for the different materials used in this project (metal, plastic, and rubber).

Piezo-ceramic discs are curious creatures: they are both consumers *and* producers of electricity. When a voltage is applied to them, the crystalline ceramic on the surface of the disc vibrates—much like a loudspeaker. When the disc is connected to an input, any physical tap or pressure on the disc will produce a voltage. The exact voltage is somewhat proportional to the amount of force exerted on the disc. Apply a little pressure or tap, and you get a little voltage; a heavier pressure or tap results in a bigger voltage.

The piezoelectric material on the discs is so efficient that even a moderately strong force on the disc will produce in excess of five or ten volts. That's good in that it makes it easy to interface the discs to a circuit, as there's usually no need to amplify the signal. However, it's also bad in that the voltage from the disc can easily exceed the maximum inputs of the interface circuit—computer, microcontroller, or other electronic device. Pound on a piezo disc with a hammer and, though it might be broken when you're done, it will also produce a thousand volts or more!

To prevent overvoltage damage, attach a pair of 5.1-volt Zener diodes, as shown in Fig. 7, to each disc of the touch bar. The Zener limits the output of the disc to 5.1 volts, a safe enough level for most interface circuitry. For an extra measure of safety, use a 4.7-volt Zener.

Note that piezoelectric discs also make great capacitors. This means that over time, the disc will take a charge. That charge will show up as a constantly changing voltage at the output of the disc. To prevent this, a resistor across the disc's output bleeds off any accumulated charge. In my experiments, I found that an 82K resistor eliminated the charge build-up, while not diminishing excessively the sensitivity of the disc. Experiment with the value of the resistor. A higher value will increase sensitivity, but could cause an excessive charge build-up. A lower value will reduce the build-up, but also reduce the sensitivity of the disc. Also helpful is to route the output of the disc to an op-amp, preferably through a 100K or higher resistor.

The piezo-disc touch bar and volt-

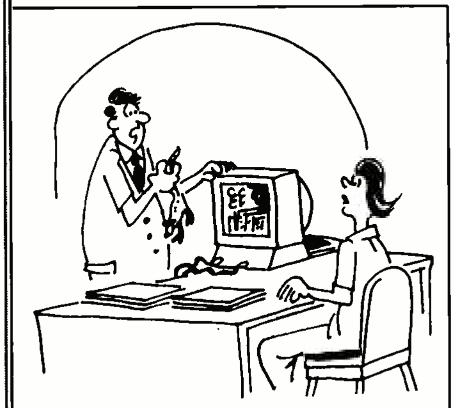
Listing 1

```
' For the Basic Stamp II
' Uses an ADC081 serial ADC
ADres   var   byte   ' A-to-D result: one byte
CS      con   13     ' Chip select is pin 13
AData   con   14     ' ADC data output is pin 14
CLK     con   15     ' Clock is pin 15
Vref    con   0      ' VRef

high Vref

high CS              ' Deselect ADC to start

again:
 low CS                                    ' Activate ADC
 shiftin AData,CLK,msbpost,[ADres\9]       ' Shift in the data
 high CS                                   ' Deactivate ADC
 debug ? ADres                             ' Display result
 pause 100                                 ' Wait 1/10 second
goto again                                 ' Repeat
```

age-limiting circuitry can be attached to the body of the robot. The front of the robot is the likely choice, but you can add additional bars to the sides and rear, in order to obtain a near-360° sensing pattern. The width of the bar makes it ideal for any robot that's between about eight and 14 inches wide.

Since the aluminum-tube-sensing element is a half-round shape, the sensor is also suitable for mounting on a circular robot base. For added compliance, you may wish to mount the bar using a thick foam pad, spring, or shock absorber (shocks made for model racing cars work well). If the bar is mounting directly to the robot, the sensor exhibits relatively little compliance.

Mount the bar at a height consistent with the kinds of objects with which the robot will most likely collide. For a "wall-hugging" robot, for example, you may wish to mount the bar low and ensure that the half-round tube slopes downward. That way, the sensor is more likely to strike the baseboard at the bottom of the wall.



"You've got a bad power supply, but the tread mill looks okay."

Listing 1 shows a short sample program for reading the values provided by the piezo-disc touch bar. The program is written for the BASIC Stamp II microcontroller and requires the addition of one or more serial-output analog-to-digital converter chips (I used an ADC0831 for my prototype). You need only one ADC if it has multiple inputs; you'll need two ADCs if the chips have but a single input. See the comments in the program for hookup information.

There are several other approaches to soft-touch sensors. For example, a resistive-bend sensor changes its resistance when curved or bent—the greater the bend, the greater the change. Positioned at the front of your robot in a loop, the bend sensor could be used as a collision detector. If you like the idea of piezoelectric elements but want a more localized touch sensor than the touch bar described in the previous section, you might try mounting piezoelectric material and discs on rubber or felt pads, or even to the "bubbles" of bubble pack shipping material, to create "fingers" for your 'bot.

Next month, we'll take a hands-on look at the new *Cyber K'Nex Ultra*, a robotics construction set that uses unique building parts, microcontrollers, and downloadable programs. **P**

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES

Proximity Sensors... Or Thereabouts

Download These Circuits From www.electronicsworkbench.com/poptronics

Get ready for an electronic adventure into the world of proximity sensors. Proximity simply means being near in space or time. The types of proximity sensors that we'll be working with detect objects that are close in space, not in time. If you think you've never been exposed to proximity sensors, think again. New-style traffic-light systems use magnetic-field-distortion proximity sensors to detect approaching traffic, letting the system modify the timing sequence for efficient traffic flow. Automatic doors and security lights are often controlled by infrared proximity sensors, where the IR sensor detects the heat from a warm body. Now that we better understand what proximity sensors are used for, we'll take a look at how they work.

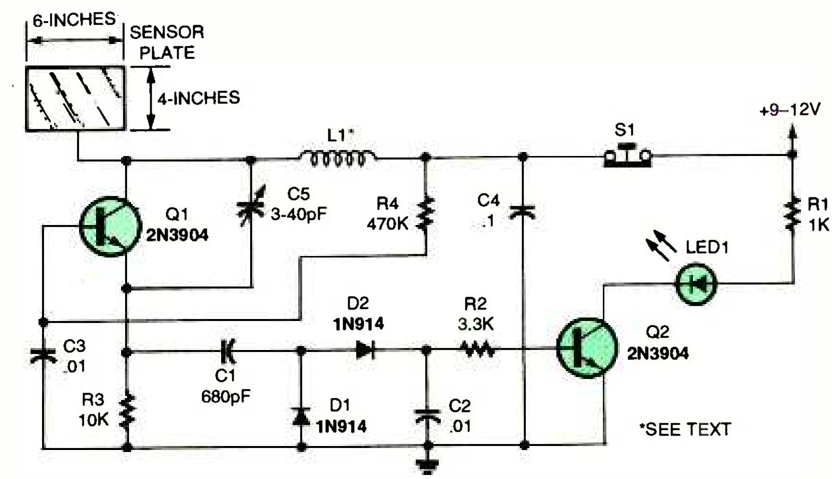


Fig. 2. This simple two-transistor circuit is an embodiment of the Fig. 1 block diagram.

In The Beginning...

Long before the IR detector, the most commonly used proximity sensor was the *capacitance-operated relay*. The capacitance sensor usually consisted of an RF-oscillator circuit that was sensitive to any conductive object near its pick-up sensor plate (Fig. 1). In the days before solid-state devices, vacuum tubes were used in the capacitance circuits; and relays were about the only interfacing components available at that time.

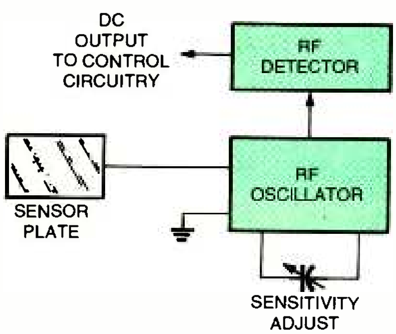


Fig. 1. One simple form of proximity sensor relies on body capacitance. Radio-frequency (RF) oscillators are sensitive to stray capacitance due to the extreme frequencies they generate. A simple detector for the frequency shift can control any electrical device. That sensitivity is why you should use insulated tools when adjusting tuned circuits in radios and TVs.

The block diagram in Fig. 1 shows how the basic capacitance-proximity sensor operates. A metal load plate is connected to the RF oscillator's tuned circuit and serves as the pick-up sensor. The sensor's sensitivity is adjusted with the oscillator's feedback control, which in this case is a small variable capacitor. The capacitor is usually adjusted to a point where the circuit just barely oscillates. The RF detector circuit produces a DC output when oscillating; that output can control other circuitry. Any conductive object positioned near the pick-up plate increases the capacitance between the sensor and ground. That increase in capacitance lowers the oscillator's feedback ratio to a point where oscillation stops; the RF detector no longer produces a DC output.

A solid-state version of a capacitance proximity circuit is shown in Fig. 2. A 2N3904 NPN transistor, Q1, is con-

PARTS LIST FOR THE CAPACITANCE SENSOR (FIG. 2)

SEMICONDUCTORS
Q1, Q2—2N3904 NPN silicon transistor
LED1—Light-emitting diode, any color
D1, D2—1N914 silicon signal diode

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—1000-ohm
R2—3300-ohm
R3—10,000-ohm
R4—470,000-ohm

CAPACITORS
C1—680-pF, ceramic-disc
C2, C3—0.01-µF, ceramic-disc
C4—0.1-µF, ceramic-disc
C5—3-40-pF variable (RadioShack RSU11919081 or similar)

ADDITIONAL PARTS AND MATERIALS
L1—Wire-wound coil (see text)
Sensor plate, wire hardware, etc.

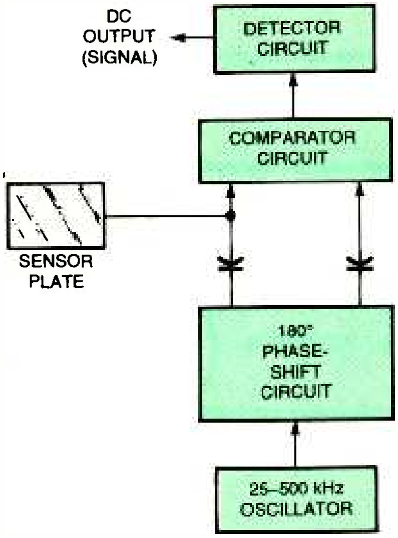


Fig. 3. Another technique is to compare two identical signals that are 180° out of phase. If one signal shifts in phase, the comparator detects the difference and outputs a signal.

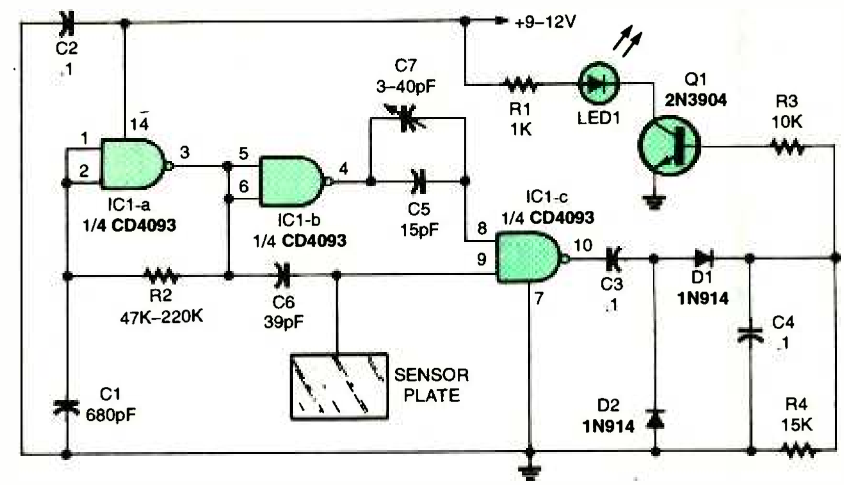


Fig. 4. The simplest way to detect phase changes is with digital-logic gates.

nected in a simple RF-oscillator circuit. The sensitivity control (feedback) is a small 3–40-pF variable capacitor, C5. Two 1N914 silicon diodes detect the oscillator's RF output and feeds the positive DC voltage to the base of Q2, another NPN 2N3904 transistor. As long as the circuit is oscillating, Q2 is turned on and the LED is shining bright.

There are a couple of interesting traits worth noting about this simple proximity-sensor circuit. Inductor L1 can be just about any coil with an inductance of 0.1 to 10 mH. A 100-turn coil wound with 26-gauge wire on a one-inch diameter PVC tube will do nicely. An old AM ferrite-loop coil will do as well. If a large value inductor is used for L1, you might need to increase the value of feedback capacitor C5 to obtain oscillation. A latching function is the other unique feature. After the sensor picks up an object and the oscillator stops operating, Q2 turns off and remains off until S1 is momentarily operated. This interrupts the power and shocks the oscillator back into operation, setting the circuit up for the next detection cycle.

The Old "Yin-Yang"

Our next proximity sensor circuit operates on a balanced—but opposite—signal source, see the block diagram in Fig. 3. The output of a low-frequency RF oscillator is fed into a 180° phase-shift circuit. Both output signals are of the same amplitude but 180° apart in phase. These two opposing signals are fed to a comparator circuit that adds the two signals together. As long as they are equal in strength, the output (sum) is zero. A metal-sensing plate is attached to one comparator input.

Any external capacitance loading on the sensor plate lowers the signal level reaching the comparator input. The comparator outputs a corresponding DC signal.

A working version of the balanced-signal proximity-sensor circuit is shown in Fig. 4. The heart of the circuit is a single CD4093 quad 2-input NAND gate IC. The IC1-a gate forms a super-simple squarewave oscillator. A single capacitor and resistor set the operating frequency, which may be anywhere between 25 and 500 kHz. The oscillator's output splits into two paths. One feeds IC1-c through C6; the other connects to IC1-b. The output of IC1-b is 180° out of phase with its input and is coupled through two parallel capacitors to the other input of IC1-c.

Before going any farther, let's review the function of a NAND gate. An AND gate—stick with me here—goes high when *both* inputs go high. If either input is low, the output is low. A NAND gate simply swaps the high- and low-output levels, high for low and low for high. The output will remain high unless both inputs go high, and then the output goes low.

That is all we need to know about the function of a NAND gate to understand the operation of IC1-c in our circuit. The two signals feeding IC1-c are equal in level but opposite in phase. At any time, at least one of the gate inputs is low, so the output remains high. If either input signal is removed or allowed to drop below the gate's input-threshold level, the gate will produce a squarewave output.

The detector/rectifier circuit of D1 and D2 converts the output to a positive DC voltage, which turns Q1 and the LED on. Capacitor C7 is the sensitivity and balance control. Any conductive object moved in close proximity to the sensor plate shunts some of the RF signal to ground. When the level drops below the gate's input-threshold level, the circuit produces an output and lights the LED. Maximum sensitivity is obtained by adjusting C7 to the point where the LED

PARTS LIST FOR THE BALANCED-SIGNAL SENSOR (FIG. 4)

SEMICONDUCTORS

IC1—CD4093 quad 2-input CMOS NAND gate, integrated circuit
Q1—2N3904 NPN silicon transistor
LED1—Light-emitting diode, any color
D1, D2—1N914 signal silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—1000-ohm
R2—47,000- to 220,000-ohm
R3—10,000-ohm
R4—15,000-ohm

CAPACITORS

C1—680-pF, ceramic-disc
C2–C4—0.1-µF, ceramic-disc
C5—15-pF, ceramic-disc
C6—39-pF, ceramic-disc
C7—3-40-pF, variable (RadioShack RSU11919081 or similar)

ADDITIONAL PARTS AND MATERIALS

Sensor plate, wire, hardware, etc.

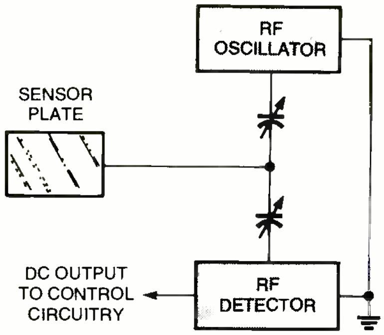


Fig. 5. A subtle yet substantial variation on the Fig. 1 concept is to detect a change in an RF signal after it has left the oscillator; in Fig. 1, the oscillator is directly affected by the sensor plate.

just comes on and then back to a position where the LED just goes out.

Bleeding Excess Signal

Our next proximity sensor, see the block diagram in Fig. 5, uses a simple transmitter/receiver configuration. An RF oscillator is coupled through a variable capacitor to the sensor pick-up and on through another variable capacitor to a RF detector circuit. The detected RF is converted to a DC voltage, which may be used to operate other circuitry. The circuit is adjusted for a minimum receiver-signal level that produces a useable and stable DC output. When a conductive object gets close to the sensor's pick-up plate, some of the RF signal is shunted to ground. If the signal is reduced below the receiver's input-threshold level, the receiver's DC output will disappear, indicating a detected object.

"Hacking" The LM567

An unusual version of the transmitter/receiver proximity-sensor circuit is shown in Fig. 6. The heart of this circuit is an LM567 phase-locked-loop IC that performs double duty: transmitter *and* receiver. The LM567's internal oscillator is set to about 500 kHz with the values shown for C3 and R3. The actual operating frequency is not critical as long as it falls somewhere in the 300- to 600-kHz range. Transistor Q1's only job is to isolate the LM567's internal oscillator from outside loading and to supply a signal to the sensor plate and the receiver input.

Normal operation for a typical LM567, as a receiver or tone-decoder circuit, is to not—under any conditions—receive its own internal-oscillator signal. To do so would make the receiver useless for its intended purpose. In our proximity-sensor circuit, it is necessary to trick the LM567 into detecting it own internally generated signal. We perform a little electronic "magic" by using the LM567's triangle-wave output instead of the more commonly used squarewave output. The triangle wave is taken off at pin 6, isolated with Q1, and fed to both the pick-up plate and the LM567 input at pin 3. Capacitor C5, a 4- to 40-pf variable capacitor, is adjusted to supply just enough signal to the LM567 to light the LED.

Any conductive object large enough to shunt a sufficient amount of the RF signal to ground will cause the LM567 to unlock and turn the LED off. The circuit will detect a human hand at about three inches when a ten-inch aluminum pie pan is used for the pick-up sensor.

It looks like we are just about out of time and space for this visit, and I still have a number of interesting proximity circuits to share. Don't worry...we'll continue next month, so be here! **P**

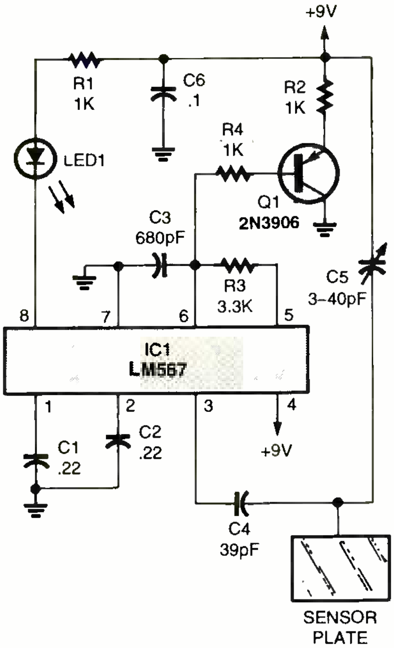


Fig. 6. Although the LM567 is designed to not have interference between its internal oscillator and detector, we've tricked the chip to do just that.

PARTS LIST FOR THE TRANSMIT-RECEIVE SENSOR (FIG. 6)

SEMICONDUCTORS
IC1—LM567 phase-locked-loop tone decoder, integrated circuit
Q1—2N3906 PNP silicon transistor
LED1—Light-emitting diode, any color

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R2, R4—1000-ohm
R3—3300-ohm

CAPACITORS
C1, C2—0.22-µF, ceramic-disc
C3—680-pF, ceramic-disc
C4—39-pF, ceramic-disc
C5—3–40-pF variable (RadioShack RSU 11919081 or similar)
C6—0.1-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS
Sensor plate, wire, hardware, etc.

REID GOLDSBOROUGH

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On-line Shopping: Where Your Money Is Going...Going...Gone!

Even if you haven't experienced it, you've undoubtedly read about it. Shopping on the Internet, whether as a consumer or as a business, is exploding in popularity.

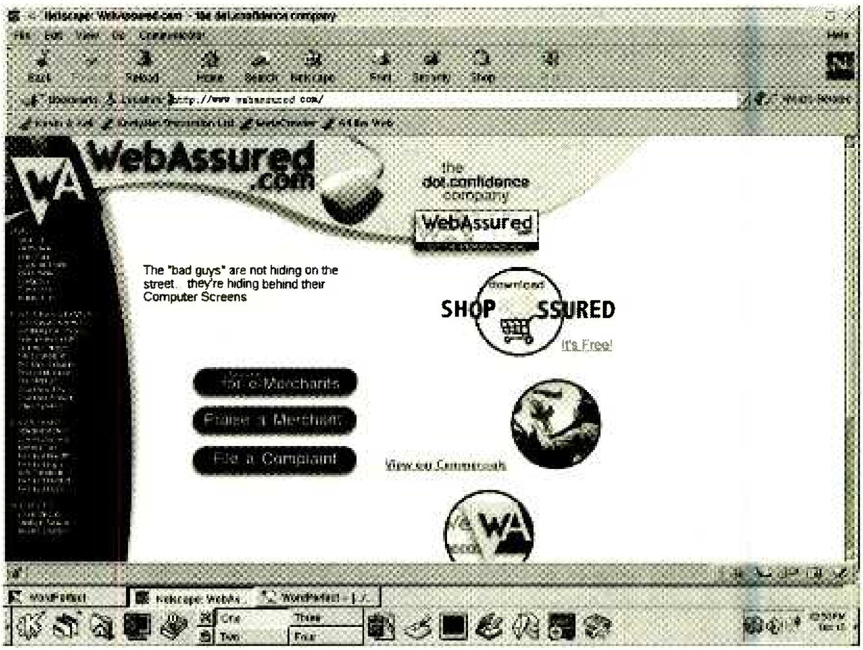
Various studies indicate that from one-quarter to one-half of all Americans have now placed at least one order online. Some analysts believe that eventually e-commerce will account for one-fifth of all retail sales (the figure today is between one and five percent, depending on who's doing the counting). The numbers for business-to-business e-commerce are even higher.

LET YOUR KEYBOARD DO THE WALKING

There's no better way to locate hard-to-find items or comparison-shop for the best deals. I've shopped for cars and plane tickets on the Web. Recently, I bought boogie boards for my kids, videos for my wife, and specialty bath mats and pillow wedges for the house—all items I couldn't find in local stores—at excellent prices.

E-commerce has had a society-wide impact, helping to fuel the economy's decade-long expansion, the longest since records were first kept 150 years ago.

But to almost every upside there's a downside. With e-commerce, you need to beware of scams and foul-ups as businesses and entrepreneurs eager to cash in on the Internet gold rush do so ill-prepared or with venal motives.



Our society has never been able to eradicate fraud; we keep giving them more sophisticated tools to separate you from your money. Web sites like WebAssured *help you fight back by learning to avoid the unscrupulous.*

The incidence of outright fraud appears to be low, with exceptions in the areas of pyramid schemes and, to a lesser extent, online auctions. Common problems are featured products being unavailable, late deliveries, high shipping charges, and orders never arriving.

KEEPING THE FAITH

The key issue is trust. If you're buying, how can you trust Web merchants? If you're selling, how can you engender trust in prospects?

As often happens with Web problems, the Web offers solutions as well.

A number of Web sites track fraudulent Web businesses or otherwise help you avoid becoming a victim. Examples are the National Fraud Information Center at *www.fraud.org*, the Better Business Bureau OnLine at *www.bbbonline.org*, and WebAssured.com at *www.webassured.com*.

Contrary to everyone's perceptions, there are other on-line auction sites than eBay. FairMarket *is one site that doesn't compete with* eBay, *but complements it in other areas such as business-to-business transactions.*

Other sites review shopping sites for qualities such as ease of use, pricing, selection, and service. Some of those include Gomez Advisors (*www.gomez.com*), BizRate.com (*www.bizrate.com*), and Rating Wonders (*www.ratingwonders.com*).

Some sites provide product reviews, such as ConsumerSearch at *www.consumersearch.com* and Productopia at *www.productopia.com*. Then there are shopping-discussion sites such as Deja.com at *www.deja.com* and Epinions.com at *www.epinions.com*, where consumers share their buying experiences.

THE CHECK IS IN THE E-MAIL

Most online shopping at the consumer level is done with credit cards, which is safer than mailing a check because credit-card companies typically limit your liability to $50 in the event of fraud. Almost all Web fraud victims are those who shop without credit cards.

Should you worry that your credit-card information might be heisted as it travels through cyberspace?

No. More and more Web shopping sites use encryption to scramble the credit-card data that you type in, preventing hackers from intercepting it. You'll know encryption is being used if the address of the Web page begins with "https" instead of "http" (the extra "s" stands for "secure").

Should you worry about Web sites selling personal information about your buying habits?

Possibly. Look for a clear privacy statement from a Web site before offering personal information. Organizations such as TrustE (*www.truste.com*) certify the privacy policies of Web sites and provide seals that you can click on to take you directly to a site's privacy statement.

WHO YA GONNA CALL?

Web sites can engender trust by being forthright and by understanding Internet conventions. If you have a storefront (commonly called a "brick and mortar"), post its address along with a telephone number for those who want more than a virtual connection or assurance that you're no fly-by-night operation. Make sure your site loads quickly, is easy to navigate, and has a search feature. Don't send e-mail to Web visitors without asking permission. Respond to all e-mail questions. Let visitors know what information you're collecting and how it will be used. Clearly state your return policy.

LIE DETECTORS

Unfortunately, Web safeguards aren't foolproof. A new, fraudulent Web site may have not yet registered on the radar screens of consumer-watchdog sites. Shopping-review sites seem eager to give sites good marks and reluctant to reveal poorly performing sites. Shopping-discussion sites by definition report anecdotal information that may be useful or misleading. A number of sites have been accused of violating their own privacy policies.

As with nearly everything else about the Internet, online shopping isn't risk-free. But this shouldn't stop you from benefiting from it.

Just remember to keep your eyes open. And sometimes you have to rely on old-fashioned common sense: If a deal seems too good to be true, it probably is.

IT'S GOING, GOING, GONE ... ON THE INTERNET

One of the most curious aspects of e-commerce, and the Internet explosion in general, is online auctions.

Auctions on the Internet may be the purest form of capitalism practiced today, with buyers and sellers coming together in a central worldwide marketplace, unencumbered by intermediaries and, to a large extent, outside regulation. It encompasses individuals selling to individuals, business selling to individuals, and businesses selling to other businesses.

COME ONE, COME ALL

The most popular Internet auction site is eBay, at *www.ebay.com*, the tenth most trafficked of all Internet sites, according to Nielsen/NetRatings. Qualitatively, it's the single best Internet site out there, according to the editors of *PC World* magazine, who recently evaluated factors such as usefulness, content, ease of use, and the "gee-whiz" quotient.

If you've ever bought or sold through eBay or other auction sites, you undoubtedly know what they're talking about. Online auctions are fun. Unlike most in-person auctions, they typically stretch out over days and end at a specific time. The highest bidder, when the clock strikes, wins. There are tricks to placing winning bids, and other tricks in maximizing the bids placed on items you're selling.

The strategizing, ticking clock, and winning and losing impart a game-like quality to online auctions. But they're serious business too. eBay moves $12 million of merchandise per *day*, while its competitors, the auction areas of Yahoo (*auctions.yahoo.com*) and Amazon.com (*auctions.amazon.com*) move $500,000 and $200,000 per day, respectively.

I CAN GET IT FOR YOU WHOLESALE

The business-to-business auction market, exemplified by sites such as FreeMarkets (*www.freemarkets.com*) and FairMarket (*www.fairmarket.com*), is doing even better. Businesses using "dynamic pricing" in selling to other businesses are expected to generate $29 *billion* in sales this year and $60 billion next year, according to the market research group Forrester Research.

Most e-commerce software developers have added auction capabilities to their programs. Some companies have moved their entire sales operation to the online-auction model.

"MOMMY, I WANT...!"

The most popular items for sale at online auctions in the past were collectibles, but lately noncollectible items such as computers, office supplies, and even heavy machinery have become dominant. Of course, you can also bid for the wacky, from taxidermied bats to debris from shipwrecked luxury liners.

PAYING THE PIPER

You can usually pay for auctioned items with a personal check, cashier's check, or money order, though many sellers ship only after a personal check has cleared. Most individuals and many businesses auctioning online don't accept direct credit-card payments because of the transaction fees or the difficulty in obtaining merchant status.

Several online services now let small businesses and even individuals accept credit-card payments. The leader is a darkhorse company called X.com (*www.x.com*) with its *PayPal* service. The company, heavily backed by venture capital, earns revenue through premium services and interest on funds participants elect to keep in their PayPal accounts.

One benefit of paying through PayPal is its fraud protection. As long as the seller is "verified" by providing bank account information to X.com, the company will reimburse buyers for up to $5000 of losses per year due to fraud. eBay provides fraud insurance too, but only up to $200 per item.

YOU MEAN THEY *LIED* TO ME?

Fraud protection is increasingly necessary in the Wild West of online auctions. The Internet Fraud Complaint Center, a new service run by the National White Collar Crime Center and the FBI at *https://www.ifccfbi.gov*, receives more complaints about online auction fraud than anything else.

One common problem is inaccurate product descriptions. When I recently won an auction for a 1799 silver dollar at eBay, I discovered after receiving it that it had a plug in it, a result of someone in the past drilling a hole to make jewelry and someone later filling that hole with a silver plug.

The plug wasn't mentioned in the description of the coin by the seller, a coin dealer who couldn't have missed it. It devalued the coin by two-thirds. The seller agreed to refund my money—only after I spelled out these facts.

Two good Web sites where you can arm yourself against online auction fraud are the FTC's "Internet Auctions: A Guide for Buyers and Sellers," available with other useful tips at *www.ftc.gov/bcp/menuinternet.htm*, and Auction Watch.com, at *www.auctionwatch.com*.

The latter site is a terrific resource about online auctions in general. It provides tips on successful auction strategies, an auction search engine, auction software, news about the online-auction world, and discussion groups.

Among the issues explored by AuctionWatch.com is auction addiction. "Addiction" might seem an improbable word here, but only if you haven't experienced the curious phenomenon of online auctions. **P**

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Deja
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eBay
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FairMarket
www.fairmarket.com

Federal Trade Commission
www.ftc.gov/bcp/menu-internet.htm

FreeMarkets
www.freemarkets.com

Gomez Advisors
www.gomez.com

National Fraud Information Center
www.fraud.org

National White Collar Crime Center
https://www.ifccfbi.gov

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NEW GEAR

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Handheld Oscilloscope/Curve Tracer

CIRCLE 61 ON FREE INFORMATION CARD

THE *HANDHELD DIGITAL STORAGE Oscilloscope/Component Curve Tracer (HH972)* provides two test instruments in one package the size and weight of a digital voltmeter. Its small size (3.6 by 7.1 by 1.4 inches and weighing only 12.7 ounces) and powerful digital storage oscilloscope capabilities make it a natural choice for both bench and field service applications, including digital and analog signals; telecommunications; GPS, TV, and audio signals; line-operated equipment; and sensors. It also performs signal analysis in automobiles (when combined with the optional ST972-EC stand).

In oscilloscope mode, the unit provides full auto-ranging capability; and it automatically measures and displays time, and DC and AC amplitudes. In curve tracer mode, it displays I/V curves for in-circuit component testing—convenient for checking continuity and troubleshooting PCBs, diodes, transistors, and resistors. The HH972 has a wide 5-MHz bandwidth, with digital sampling at 20Ms/sec. Its maximum input voltage is 280-volts true rms AC or 400 volts DC.

Other features of the oscilloscope are automatic capture mode; continuous peak-to-peak measurements; and cursor, scroll, and hold functions. The high-contrast backlit LCD display provides wide-angle visibility, with a resolution of 6 bits for very smooth waveforms and text. The keypad is easy to use, and the Hold key freezes the display.

The Handheld Digital Storage Oscilloscope/Component Curve Tracer (HH972) retails for $259, with test leads and probe included. The optional stand with rechargeable battery is $69.

ALLISON TECHNOLOGY CORP.
2006 Finney Vallet Road
Rosenberg, TX 77471
800-980-9806 or 281-239-8500
www.atcweb.com

Temperature/Humidity Reader

THE *MODEL 725 TEMPERATURE/ Humidity Reader* is compact, lightweight, and battery powered. The handheld unit provides a wide range of temperature and humidity readings with datalogging capabilities that can record up to 16,241 data points. Its adjustable interval setting permits recording from four hours to 11 days worth of data. The RS-232

CIRCLE 62 ON FREE INFORMATION CARD

port and included software allow the user to either download data for analysis or control the meter in real time from a PC.

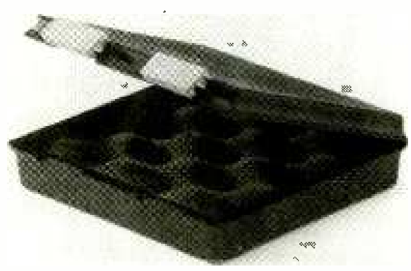
The Model 725 provides state-of-the-art dual function meters with two environmental sensors housed in a remote rod. Both meters feature large, easy-to-read triple LCD displays that show RH and temperature readings simultaneously, and a second K-type thermocouple port. The remote rod permits the user to place the sensors right where they are needed.

The Model 725 Temperature/ Humidity Reader comes complete with instruction manual, battery, carry case, software, calibration screwdriver and windscreen, RS-232 cable, and K-type bead probe and has an MSRP of $369.

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

Protective Case for Computer Modules

AN IDEAL CASE FOR PEOPLE WHO travel with extra modules or external hard drives, the *DoubleCLIC* protective case helps extend the life of valuable computer modules by offering shock absorption and protection from dust and debris. This lightweight, compact case made of impact-resistant plastic accommodates most any module and provides complete protection while traveling.



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The contoured inside foam cushioning forms around different shapes and sizes, keeping the module in place. This cushioning also allows the case to remain slim and compact, easily stored in a briefcase or on a cluttered desktop. Its sleek, extra-wide, recessed, double clasps eliminate the possibility of snagging or accidental opening.

The DoubleCLIC protective case for computer modules sells for under $20.

POINTER PRODUCTS
231 Moorgate St.
Winnipeg, Manitoba
Canada R3J 2L3
866-776-1659
www.pointerproducts.com

Desoldering Handpiece

THE *SX-80 SODR-X-TRACTOR* HANDpiece offers several design features that reduce costs, increase productivity, and help protect the environment. At the heart of the system is a disposable cardboard solder and flux trap that not only reduces handpiece cleaning to a 15-second operation, but provides an environmentally friendly means of reclaiming the solder. Additionally, the SX-80 uses a modular plug-in heater, which decreases maintenance downtime. The handpiece also uses clog-resistant, long-lasting Endura Desoldering Tips.

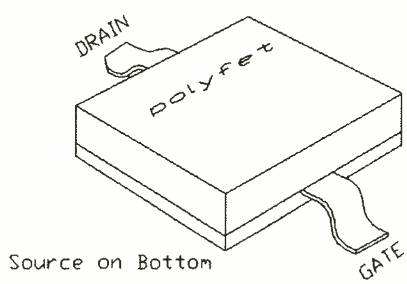
CIRCLE 64 ON FREE INFORMATION CARD

The SX-80 Sodr-X-Tractor lists for $225.

PACE, INC.
9893 Brewers Court
Laurel, MD 20723-1990
888-535-7223 or 301-490-9860
www.paceusa.com

LDMOSFET Transistor

DESIGNED FOR BOTH NARROW- and wide-band data/voice communication, the *RF Power LDMOSFET Transistor* is not internally matched and will perform well down to DC. This 7.5-volt 6-watt surface-mount transistor exhibits 10 dB gain at 500 MHz. Data sheets, Spice models, and S-parameters are available at the Web site below.



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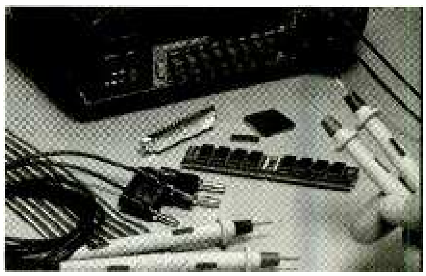
The RF Power LDMOSFET Transistor sells for $23.78.

POLYFET RF DEVICES
1110 Avenida Acaso
Camarillo, CA 93012
805-484-4210
www.polyfet.com

Kelvin Probe Set

OFFERING TECHNICIANS A FAST and accurate means of measuring electrical resistance at levels below 1 ohm, the *Model 6303 Kelvin Probe Set* is meant for applications requiring milliohm accuracy. The probe's single-tip design makes it easier to use in dense circuitry than traditional Kelvin clips, with comparable accuracy. It's ideal for testing intricate surface-mount and small, hard-to-reach components, such as connectors, high-density IC devices, and printed circuit modules. The notched tip design prevents slipping or sliding off the test points.



CIRCLE 66 ON FREE INFORMATION CARD

The set is compatible with most popular four-wire test instruments. The probe uses four-wire measurement to minimize errors due to the resistance of the test leads. Consisting of one red and one black probe, with 48-inch coaxial leads, the 6303 features durable, gold-plated Beryllium copper probe tips, banana plugs, and an overmolding of Santoprene rubber for comfort, insulation protection, and wire-strain relief.

The Model 6303 Kelvin Probe Set sells for $75.

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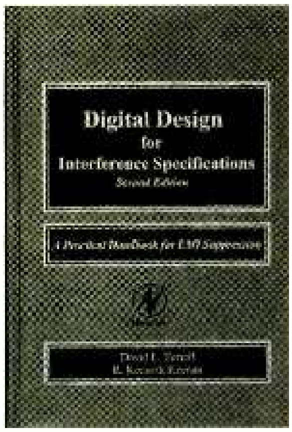
Pomona, CA 91766-3835
909-623-3463
www.pomonaelectronics.com

NEW LITERATURE

Digital Design for Interference Specifications, 2nd Edition

by David L. Terrell and R. Kenneth Keenan
Newnes, Butterworth-Heineman
225 Wildwood Ave.
Woburn, MA 01801
800-366-2665 or 781-904-2500
www.bh.com
$69.95

Targeted toward circuit designers and EMI professionals, this is a practical handbook for EMI suppression and prevention. The material directly applies to circuit designer's projects helping to save time and money on each design and is accompanied by numerous illustrations.

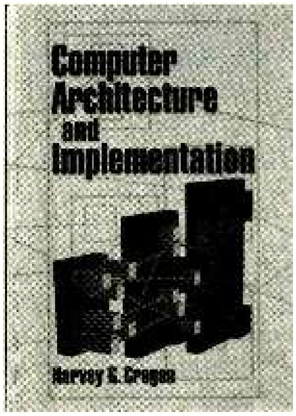


Providing concrete rules that can be applied immediately to the design of new digital products, the authors emphasize techniques of EMI source suppression at the printed circuit board level, and they consider shielding only as a last resort. Written in a how-to format, the book contains brief explanations of why or how design recommendations suppress emissions or reduce susceptibility.

Computer Architecture and Implementation

by Harvey G. Cragon
Cambridge University Press
40 W. 20th St.
New York, NY 10011-4211
800-872-7423
www.cup.org
$44.95

This textbook provides a clear and concise introduction to computer architecture. Two themes are woven throughout the book: an overview of the major concepts and design philosophies of computer architecture and organization and the early introduction and use of analytic modeling of computer performance.



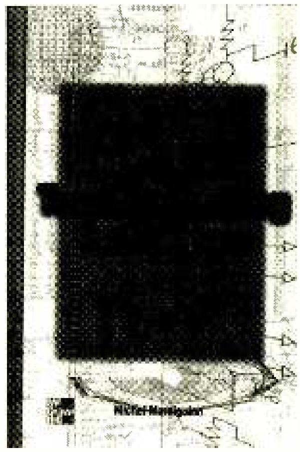
Beginning with the classic von Neumann architecture, the author then presents in detail a number of performance models and evaluation techniques. He goes on to cover user instruction set design, including RISC architecture. A feature of this book is its memory-centric approach—memory systems are discussed before processor implementations.

EMI Troubleshooting Techniques

by Michel Mardiguian
McGraw-Hill
2 Penn Plaza, 12th Floor
New York, NY 10121
800-2MCGRAW
www.books.mcgraw-hill.com
$60

This book is an orderly, methodical approach to locating the cause of and correcting EMI/RFI breakdown. It gives readers hands-on, optimal solutions for designing, lab testing, or on-site troubleshooting for a wide range of electronic equipment.

Included in this reference guide are a solutions matrix that helps pinpoint the right fix quickly and a walk-through chart that simplifies the troubleshooting process. Practical alternatives to lab testing methods and solutions to most electronic envi-



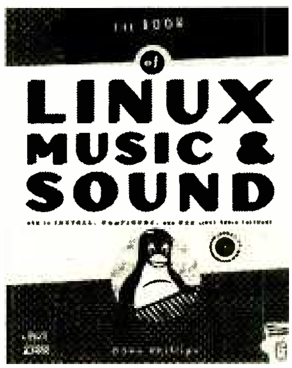
ronments are explored and explained. There is also a discussion of EMI-reduction components categorized by indications, applications, and limitations.

The Book of Linux Music and Sound

by Dave Philips
No Starch Press
555 DeHaro St., Suite 250
San Francisco, CA 94107
800-420-7240 or 415-863-9900
www.nostarch.com
$39.95

As a free operating system with tons of free software, Linux offers electronic musicians an affordable and stable way to manipulate electronic music. This book is an in-depth instruction manual on recording, storing, playing, and editing music and sound under Linux.

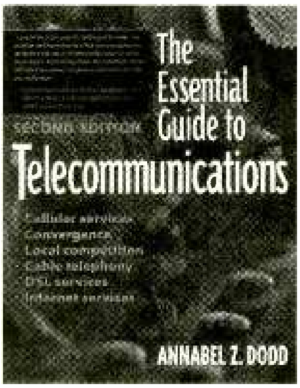
The author explains the basics of digital sound and gives a brief history of sound support under Linux. He describes



the broad range of sound and music applications available for Linux, which includes MIDI, Digital Audio, Music Notation, Games and Notations. A section for developers showcases the various tools available, and the CD-ROM includes over 100 applications, as well as a PD version of the book with live hyperlinks to hundreds of Internet resources.

The Essential Guide to Telecommunications, 2nd Edition

by Annabel Z. Dodd
Prentice Hall
One Lake St.
Upper Saddle River, NJ 07458
800-282-0693
www.prhptr.com
$34.99

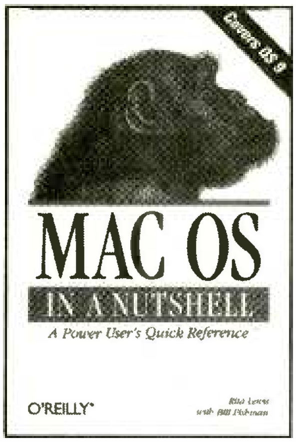


Completely revised, this telecom/Internet guide teaches readers everything they must know to understand the telecommunications industry. There is coverage of today's hottest technologies, including what convergence means and what to expect; revolutionary new IP networking applications; high-speed Internet-access alternatives; frame-relay, ATM, ISDN, wireless, and other business communications alternatives; and Dense Wavelength Division Multiplexing (DWDM).

Mac OS in a Nutshell

by Rita Lewis with Bill Fishman
O'Reilly and Associates, Inc.
101 Morris St.
Sebastopol, CA 95472
800-998-9938 or 707-829-0515
www.oreilly.com
$24.95

This book covers almost every command, Internet configuration/access of the Mac OS. There is information on navigating the basic Mac interface, customizing and tuning your system, and creating themes. Using the Mac as a graphics or desktop publishing tool and connecting the Mac to the Internet or to other Macs is also covered.

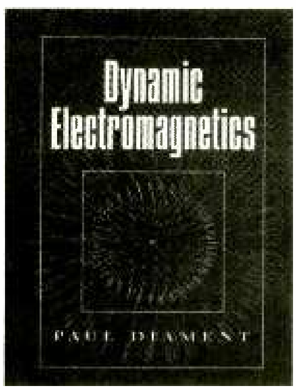


Third-party tools to help manage and maintain the system and the new features of Version 9 of the Mac OS are also discussed. In addition, it also provides clever ways to do familiar and not-so-familiar tasks, giving practical (and sometimes little known) details for everyday use.

Dynamic Electromagnetics

by Paul Diament
Prentice Hall
One Lake St.
Upper Saddle River, NJ 07458
800-282-0693
www.prenhall.com
$100

Designed for an introductory first course in electromagnetics, this textbook stresses time variation, using math at the level of elementary integrated calculus—instead of statics. The focus is on wave propagation, with transmission lines—both transient and steady state—treated in detail.

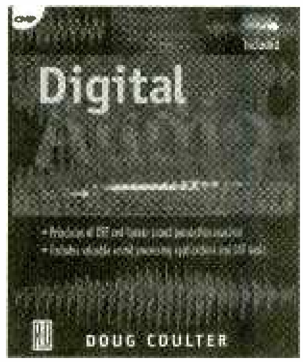


Topics covered include Gauss's Law and Ampere's Law; EMF, field dynamics, and Maxwell's Equation; steady-state wave transmission and plane waves; Poynting theorems and lossy transmission lines; and waveguiding and radiating structures. There are chapter summaries and problem sets and answers.

Digital Audio Processing

by Doug Colter
R&D Books
CMP Media Inc.
6600 Silacci Way
Gilroy, CA 95020
800-500-6875
www.rdbooks.com
$54.95

This book is meant for programmers involved in digital signal processing (DSP) for telephony, audio, video, and user-interface development. It covers techniques for producing normal effects and special effects, noise reduction, and signal generation. Both theory and practice are used to explain the principles of DSP and the basic mechanisms of human sound perception.



Readers are led through the creation of a practical DSP product—a waveform editor for the desktop. Complete source code is provided on the included CD-ROM for many C++ software tools, for the waveform editor, for Windows 32-bit sound programming, for DSP and user-interface advancements for the WinTel platform, and for optimized assembly functions for DSP. P

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Neeham, MA 02494

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Livonia, MI 48150

Purchase Radio Supply
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Ann Arbor, MI 48104

The Elec. Connection
37387 Ford Road
Westland, MI 48185

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Acme Electronics
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Minneapolis, MN 55401

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St. Louis, MO 63130

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Lashen Electronics Inc.
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Supertronix Inc.
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NET WATCH

(continued from page 6)

ence material. Both the veteran technician and the curious novice can benefit from the use of the information superhighway. Forums for discussion and support are available on the aforementioned sites as well as many other locals on the Web. The exchange of ideas via electronic media has led to the creation of a virtual environment where electronic enthusiasts can work together on research and ideas. A person can join in on forum-sponsored chats or post questions for the scrutiny of skilled technicians. Forums are slowly taking the form of guilds in many areas of electronics and other disciplines, providing a nurturing atmosphere for the proliferation of new ideas. The opportunity for learning, sharing, and collaborating is greater than ever before. P

VIRTUAL-RETINAL DISPLAY

(continued from page 32)

also potential uses in manufacturing, maintenance, and construction, as well as for inventory professionals, for such tasks as viewing blueprints, instructions, and diagnostic information. It could also be used with wireless-communication systems such as "personal-data communicators" for viewing e-mail, Web pages, faxes, and other graphical documents. Imagine having a wireless e-mail device, like the one depicted in Fig. 5, that slips in your pocket, but has the viewing capacity of a wall-mounted display. What's more, whatever you're viewing can't be seen by anyone else—especially the person sitting next to you on the airplane casually eyeing your laptop's display. The technology could also be used in video- and PC-based games with incredible virtual reality in three-dimensions.

Perhaps a practical, wearable PC is closer and more affordable than you think.

P

FOR MORE INFORMATION

Microvision Inc.
P.O. Box 3008
19910 N. Creek Pkwy.
Bothell, WA 98011-3008
425-415-MVIS
www.mvis.com

RF FIELD STRENGTH METER

(continued from page 40)

CB radio to check if the meter is operating. A garage-door opener or RF-based remote controller can also be used.

Note that the first segment or two of the LED display may light with no input if R7 is advanced to full gain. This is not significant. Rotate R7 to just barely extinguish the display in that case. In a dimly lit room, a faint glow may be seen from some segments that normally should be "off." This is normal and should be ignored.

Final Assembly. The RF Field-Strength Meter should be housed in a plastic or metal case. Use a full-size layout of the PC board to locate the holes for the display, the switches, and R7. A BNC jack can be mounted on top of the meter to use as an antenna connection. A two-foot collapsible whip antenna is recommended, and this should be fitted with a BNC connector to mate with J1. Packaging is not critical, and you can do this to suit your own preferences. The general arrangement of the author's prototype can be seen in Fig. 6.

A short length of coaxial cable is used to connect the VHF/UHF preamp directly to J1. See Fig. 7. You must fabricate L1. Wrap four turns of 22-gauge bare wire around a suitable form to create a ¼-inch-diameter coil. Leave sufficient wire at each end of the coil for connection to the unit. Again, Fig. 7 shows how to connect L1. If a plastic case is used, this wire will form an adequate 400- to 3000-MHz UHF-pickup antenna. A metal case will shield this, so an external antenna will be needed at J1 for UHF work.

For power, 6- to 9-volt battery supplies are required. You can use AA, AAA, or 9-volt alkaline types with suitable holders. The battery holders can be mounted in the rear half of the case; the circuit board goes in the front half. Connect the batteries to the circuit board using Fig. 4 as a guide.

If you prefer, a plastic filter can be used over the LED display. Use a matching color for whatever LEDs you have used for best visibility. We did not use a filter as we found that none was necessary.

With the case closed, the RF Field-Strength Meter is ready to sniff out all that ails you. P

WEB SITES DEALING WITH RF EXPOSURE HAZARDS

The following list is current as of the date of writing of this article (September 2000). As Web sites are frequently updated and changed, you may have to use your favorite search engine to locate this material if the addresses are no longer current. This is not a complete list of sites, and the listed Web sites often provide links to other related sites.

Electromagnetics Forum
www.tassie.net.au/emfacts/

Institute of Electrical and Electronics Engineers (IEEE)
www.ieee.com

Medical College of Wisconsin
www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html

Microwave News
www.microwavenews.com

National Council on Radiation Protection and Measurements
www.ncrp.com

RF Safety Program, Federal Communications Commission
www.fcc.gov/oet/rfsafety/

Safe Technologies Corporation
www.safelevel.com

University of Michigan
www.sph.umich.edu/group/eih/UMSCHPS/index.html

World Health Organization (WHO)
www.who/ch/programmes/peh/emf_home.htm

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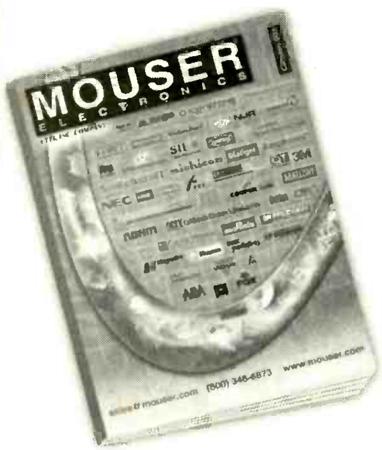

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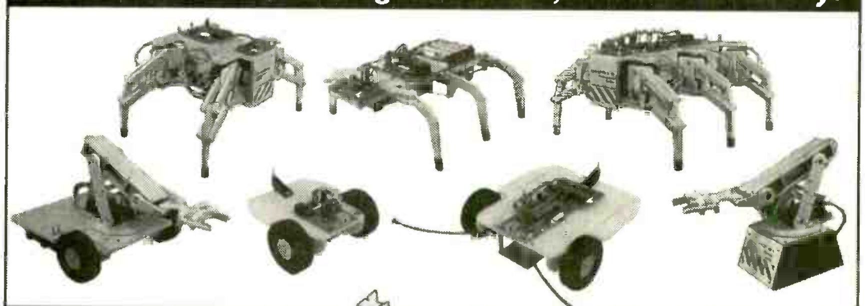

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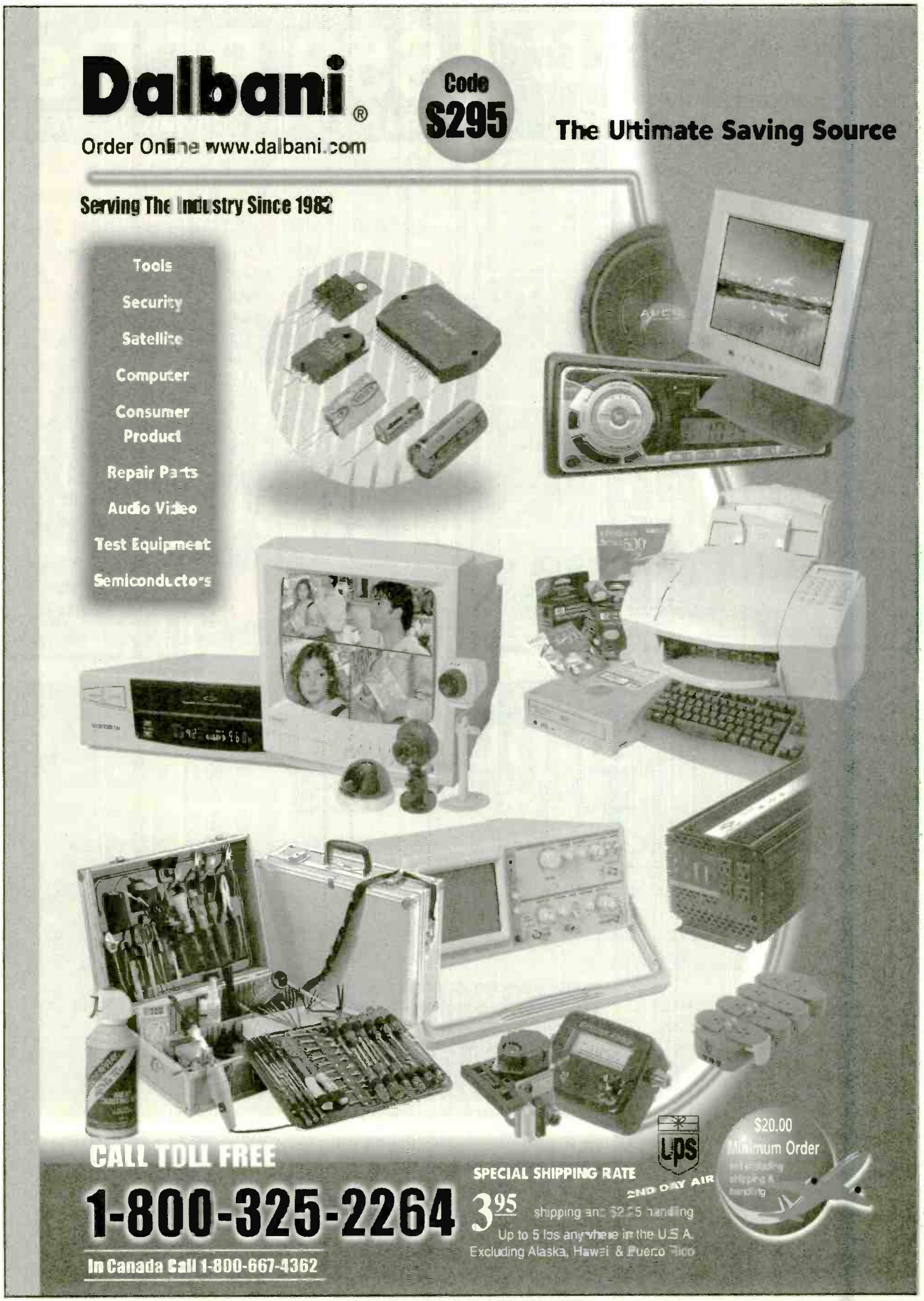

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D/A Trainer

Elenco Model XK-150

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A low cost, full-function digital/analog trainer that meets the needs of electronic training programs. Rugged construction, can be used as fixed lab equipment or be portable. An economical zipper case is available.

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- Variable power control produces 5-40 watts.
- Ideal for hobbyists, DIYers and students.
- Complete with 40W iron.

Weller Soldering Station
Model WES50

50 watts of controlled power - designed for continuous production soldering.

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Deluxe Electronic Soldering Station

Elenco SL-5 Series

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Works w/ any iron! Turn any soldering iron into a variable iron.

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Generators & Counters

B&K 20MHz Sweep/Function Generator with Frequency Counter Model 4040

- 0.2Hz to 20MHz
- AM & FM modulation
- Burst Operation
- External Frequency counter to 30MHz
- Linear and Log sweep

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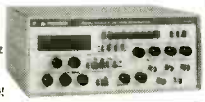
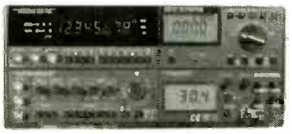


21.5MHz Model 4070	$129!
10MHz Model 4017	$319
5MHz Model 4011	$249

BK PRECISION

Four Functions in One
Elenco Model MX-9300B



$450

Features:
- One instrument with four test and measuring systems:
  - 1.3GHz Frequency Counter
  - 2MHz Sweep Function Generator
  - Digital Multimeter
  - Digital Triple Power Supply - 0-3V @ 2A, 5V @ 2A, 15V @ 1A

Elenco Handheld Universal Counter
1MHz - 2.8GHz
Model F-2800

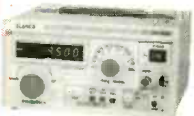
$99

Features 10 digit display, 16 segment and RF signal strength bargraph.

Includes antenna, NiCad battery, and AC adapter.

C-2800 Case with Belt Clip $14.95

Elenco RF Generator with Counter
(100kHz - 150kHz) **Model SG-9500**



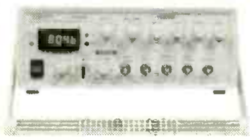
Features internal AM mod. of 1kHz. RF output 100MV - 35MHz. Audio output 1kHz @ 1V RMS.

$225

SG-9000 ....$119.95
(analog, w/o counter)

Elenco Sweep Function Generator
w/ built-in frequency counter Model GF-8046

$195.95



This sweep function generator with counter is an instrument capable of generating square, triangle, and sine waveforms, and TTL, CMOS pulse over a frequency range from 0.2Hz to 2MHz.

GF-8025 - Without Counter **$139.95**

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- For Ages 10 and up.

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Model AM-780K
Two IC Radio Kit

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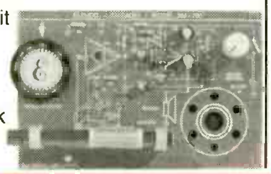

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Doppler Direction Finder

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

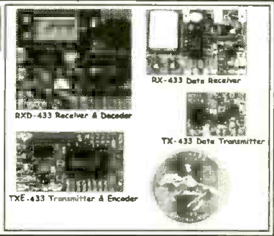
DDF-1, Doppler Direction Finder Kit **$149.95**

1 GHz RF Signal Generator

A super price on a full featured RF signal generator! Covers 100 KHz to 999.99999 MHz in 10 Hz steps. Tons of features; calibrated AM and FM modulation, 90 front panel memories, built-in RS-232 interface, +10 to -130 dBm output and more! Fast and easy to use, its big bright vacuum florescent display can be read from anywhere on the bench and the handy 'smart-knob' has great analog feel and is intelligently enabled when entering or changing parameters in any field – a real time saver! All functions can be continuously varied without the need for a shift or second function key. In short, this is the generator you'll want on your bench, you won't find a harder working RF signal generator - and you'll save almost $3,000 over competitive units!

RSG-1000B RF Signal Generator **$1995.00**

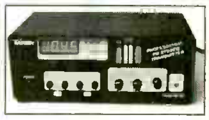
Wireless RF Data Link Modules



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

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

Super Pro FM Stereo Transmitter



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

FM-100, Pro FM Stereo Transmitter Kit **$249.95**
FM-100WT, Fully Wired High Power FM-100.............. **$399.95**

World's Smallest TV Transmitters

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

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

CCD Video Cameras

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

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

AM Radio Transmitter

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

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

FM Stereo Radio Transmitters

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

FM-25, Synthesized Stereo Transmitter Kit **$129.95**

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

FM-10A, Tunable FM Stereo Transmitter Kit................ **$34.95**
CFM, Matching Case and Antenna Set **$14.95**
FMAC, 12 Volt DC Wall Plug Adapter...................... **$9.95**

Mini Radio Receivers

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

AR-1, Airband 108-136 MHz Kit................ **$29.95**
HFRC-1, WWV 10 MHz (crystal controlled) Kit..... **$34.95**
FR-1, FM Broadcast Band 88-108 MHz Kit........ **$24.95**
SR-1, Shortwave 4-11 MHz Band Kit **$29.95**
SCA-1 SCA Subcarrier Adapter kit for FM radio.... **$27.95**
FR-6, 6 Meter FM Ham Band Kit **$34.95**
FR-10, 10 Meter FM Ham Band Kit........... **$34.95**
FR-146, 2 Meter FM Ham Band Kit.......... **$34.95**
FR-220, 220 MHz FM Ham Band Kit......... **$34.95**
Matching Case Set (specify for which kit) **$14.95**

RF Power Booster

Add muscle to your signal, boost power up to 1 watt over a freq range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat finished look, add the nice matching case set. Outdoor unit attaches right at the antenna for best signal - receiving or transmitting, weatherproof, too!

LPA-1, Power Booster Amplifier Kit...................... **$39.95**
CLPA, Matching Case Set for LPA-1 Kit.................. **$14.95**
LPA-1WT, Fully Wired LPA-1 with Case **$99.95**
FMBA-1, Outdoor Mast Mount Version of LPA-1 .... **$59.95**

PIC-Pro Pic Chip Programmer

Easy to use programmer for the PIC16C84, 16F84, 16F83 microcontrollers by Microchip. All software - editor, assembler, run and program - as well as free updates available on Ramsey download site! This is the popular unit designed by Michael Covington and featured in Electronics Now, September 1998. Connects to your parallel port and includes the great looking matching case, knob set and AC power supply. Start programming those really neat microcontrollers now...order your PICPRO today!

PIC-1, PICPRO PIC Chip Programmer Kit **$59.95**

FM Station Antennas

For maximum performance, a good antenna is needed. Choose our very popular dipole kit or the Comet, a factory made 5/8 wave colinear model with 3.4 dB gain. Both work great with any FM receiver or transmitter.

TM-100, FM Antenna Kit **$39.95**
FMA-200, Vertical Antenna **$114.95**

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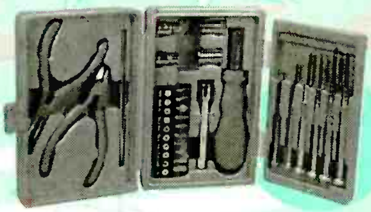
now only! $59.95



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Includes rock steady video test patterns and crystal clear audio test tones to insure your DVD player is performing to an optimal level.

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•Use for repair or modification of equipment, projects or prototype work •4~8ohm impedance •Requires 6~16VDC supply voltage •Dimensions: 50mm x 35mm x 20mm

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handheld 20MS/s Storage Scope

oszifOX is a sophisticated digital storage scope packed into a handy, slim penlike housing. Despite its small size, **oszIFOX** can perform like a service scope with a 20MS/ssampling rate so signals in microprocessor or audio circuits can be measured easily. A built-in backlit LCD shows the waveforms but the recorded signals can also be sent to a PC via a serial interface. Runs from 9V battery or external source. Auto, intemal and external triggers. AC/DC voltameter function too. Only **$129!**

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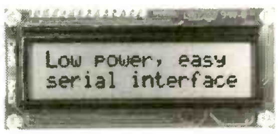
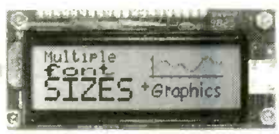


BPI-216N
- 2x16 text LCD
- 2400/9600 bps
- $45 (non-backlit)

SGX-120L
- Mini graphics LCD
- 2400/9600 bps
- just $99



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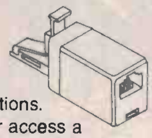


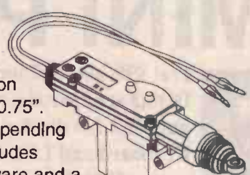
Ora Electronics # MP-700
Protects modem, fax and voice transmissions from interruption. Prevents eavesdropping of phone conversations. The first device to answer or access a line secures the line. All of the others are denied access until the first device hangs-up. Easy to use. Installs in seconds between phone line and wall jack. Note: You need one unit for each instrument sharing a line.

CAT # TLM-20

$1.50 each

10 for $12.50
100 for $90.00

Linear Actuator for Auto Door Lock

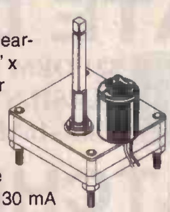


12 Vdc motor-drive actuator for automotive door locks. Nylon plunger moves 0.75". Push or pull, depending on polarity. Includes mounting hardware and a 10" metal extension rod which fits through the hole in the end of the plunger. Overall dimensions of actuator assembly (retracted): 8.42" x 2.35" x 1.15". Rubber boot protects against moisture and dust. Pigtail leads.

CAT # DLA-1

$5.50 each

6 RPM Gear Motor

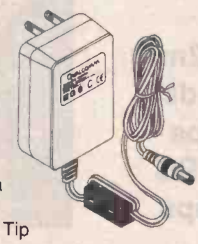


Molon # CHM-1205-5
Powerful 12 Vdc, 6 RPM gear-head motor. Gearbox is 3" x 2.75" x 0.83". Drive motor and shaft are both on the same side of the gearbox. Shaft is 3.3" long, Top of shaft is 0.37" square. Base is 0.5" dia. Motor draws 130 mA at 12 Vdc, no load. Motor protected by removable rubber cover.

CAT # DCM-164

$12.00 each

12 VDC 2.5 Amp Switching Power Supply



Plug-in-wall regulated switching power supply. Ideal for cameras, scanners, cell phones, computers or any devices sensitive to power fluctuations.
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6 foot output cord has a coax DC power plug (2.1mm id, 5.5mm od). Tip positive. Ferrite snap-bead for EMI suppression. Compact, 3.23" x 2.23" x 1.38" UL, CSA, CE.

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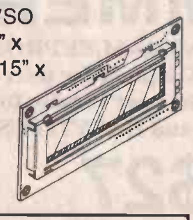

Daewoo # 16216L-5-VSO
5 x 7 dot format. 2.56" x 0.54" viewing area. 3.15" x 1.41" module size. LED backlight. Includes hook-up/spec sheet.

CAT # LCD-53

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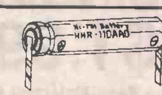

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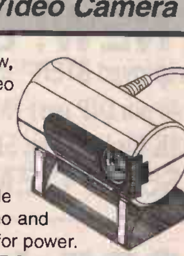

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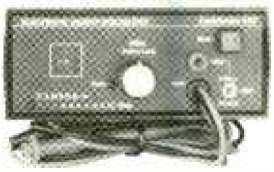

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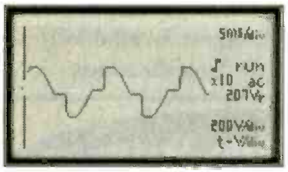
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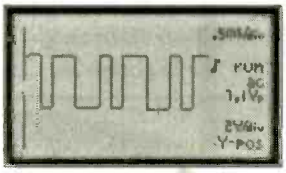
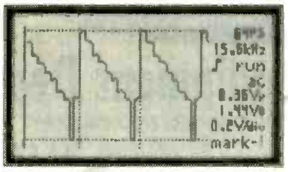
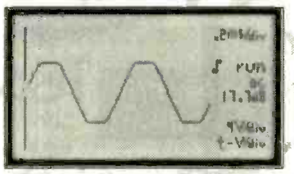

DIGITAL SIGNALS (e.g. pulse train)


TV AND VIDEO (e.g. composite video signal)


AUDIO SIGNALS (e.g. amplifier output clipping level)

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- Maximum sample rate: 5MHz
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- Time base: 20s to 2µs / div in 22 steps
- Input sensitivity range: 5mV to 20V/div in 12 steps (up to 200V/div with X10 probe)
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- Batteries (in option): Alkaline type AA (5 pcs required) NiCd/NiMH rechargeable
- Battery life: Up to 20 hours with Alkaline batteries
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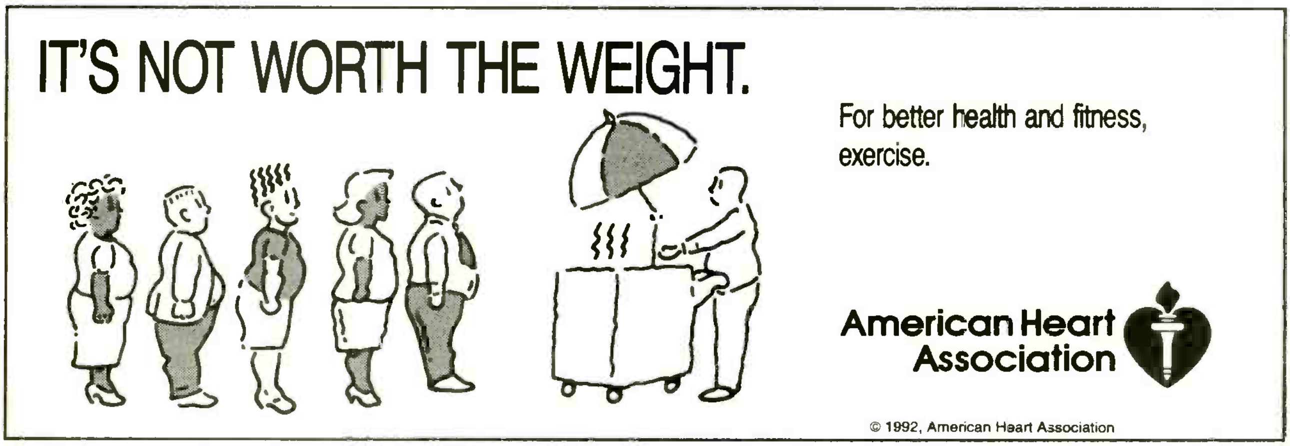

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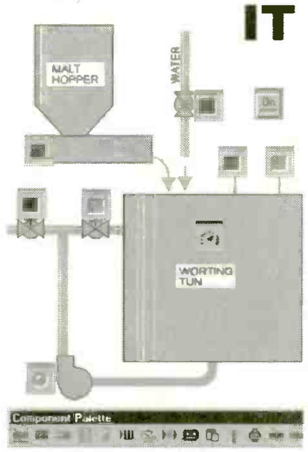

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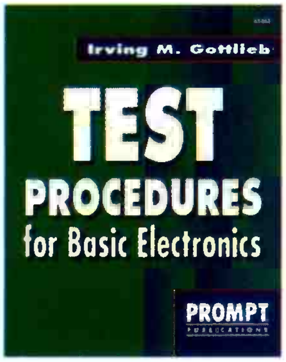

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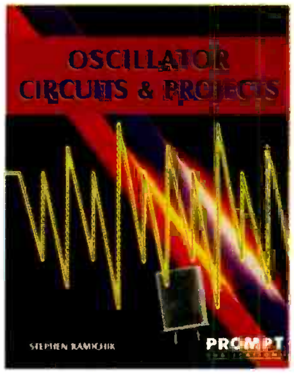

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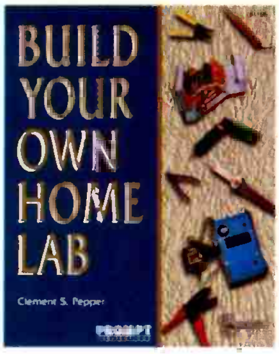

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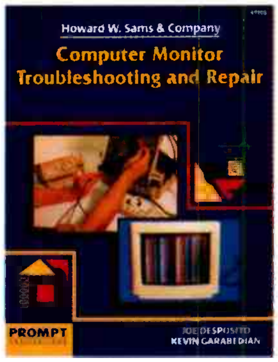

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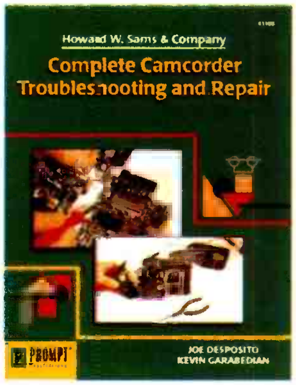

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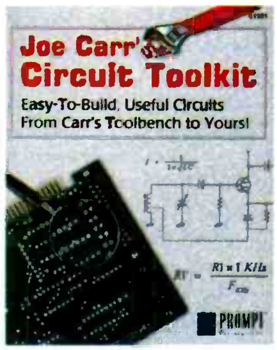

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