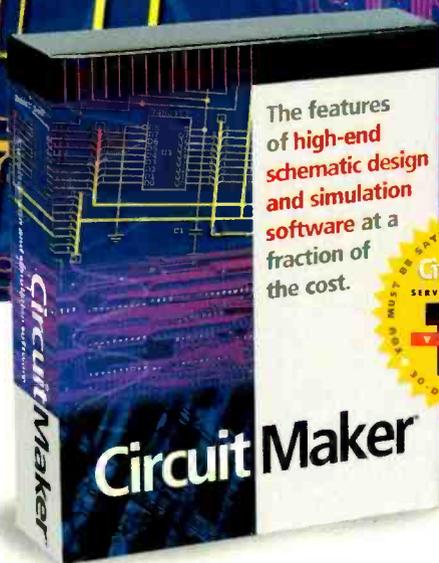




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The millennium is upon us. The year 2000 is right around the corner. What will it bring?  
— **Poptronics** — the magazine for the hands-on electronics activist!

Today's challenging electronics marketplace does not leave room for a variety of competitive publications aimed at the hands-on kind of electronics activist — the professionals who design, build, maintain, and repair all of the electronics gear that fills our lives, the experimenters who build projects, the computer enthusiasts who want to know what's in the latest gear, the activists who want to and are building robots, audiophiles who want to test new circuits and designs, ham-radio operators looking for what's out there to communicate with.

That's why Gernsback Publications is melding our two publications — *Popular Electronics* and *Electronics Now*, into the new, exciting and timely monthly magazine — **Poptronics** — that you will soon be holding in your hands. Coincidentally it will be the January 2000 issue. What a way to enter the new millennium! (Yes I know the millennium actually starts January 1, 2001.)

It's evolution! Starting with the January 2000 issue *Popular Electronics* will become **Poptronics**, the magazine for the hands-on electronics activist! No matter what your specific electronic interest; **Poptronics** will be the magazine for all electronics activists in the 21<sup>st</sup> Century. We've been here since the beginning, when we began in April 1908 with the first issue of *Modern Electrics*. We're still going to be here for the start of the next millennium, the year 3001, with **Poptronics** or its future descendant.

We have brought together all of the very best elements of our existing magazines into **Poptronics**. It is designed to deliver to you, our readers the very best editorial variety we can assemble. We have packaged *Gizmo*, *Prototype*, *Hands-on Reports*, *Service Clinic*, *Peak Computing*, *Robotics Workshop*, *Amazing Science* and other key columns; and wrapped them around a main editorial package of construction projects, product lab reviews, how it works and how to do it articles, to create a wonderful new world of electronics!

Our web site at [www.gernsback.com](http://www.gernsback.com) will still be there too. The forums, searchable index, and links will stay as they are, but you may find a lot of "under construction" signs in other areas. Keep logging in to keep up with what is happening. I believe that you will find it even more useful than before. We will continue the forums that bring thousands of readers to exchange ideas, get questions answered, and find the latest updates on contents in the magazine. It's a great place to search the index for old articles and to download current articles and artwork from the current issue.

If you are a current subscriber to *Popular Electronics*, you will automatically receive upcoming issues of **Poptronics** (starting with January 2000) until your current subscription is fulfilled. If you also subscribe to *Electronics Now* we will combine your subscriptions (if you have 10 more issues of *Popular Electronics* to go, and 5 issues of *Electronics Now* — for example — you will receive the next 15 issues of **Poptronics**).

If we goof and you get two copies of **Poptronics** next month, just cut off or copy the labels on the front cover of both magazines and send them to me. I'll see that your subscription is merged without you losing a single copy.

An exciting new world of electronics publishing begins with the January 2000 issue of **Poptronics**. Be our partner in progress. Stay with us and see just how great our electronics industry can be. We will be bringing you all of the latest electronics news as it happens.

Larry Steckler, EHF,CET  
Publisher



# Popular Electronics®

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

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# EDITORIAL

## The Waves Around Us

You can't feel them. You can't see them. But it doesn't mean that electromagnetic waves aren't permeating the room you're in right now. It's something we have to accept—as technology and electronic devices proliferate, we'll come into contact with more and more EM fields each day.

While the possible harmful effects of EMF can't be proven in a quantified manner, just like no one can tell you exactly how many minutes per day you can safely expose your skin to the sun's rays, there may be cause for worry. People living close to power-line transformers, for instance, seem to develop certain types of cancer in "greater than normal" numbers. And as it turns out, some of the appliances and gadgets we use and take for granted every day are emitting smaller doses of the same invisible EMF.

Fortunately, these smaller doses can be avoided. By measuring the field areas around electronic devices we can take precautions. Moving a microwave perhaps a foot back on the counter, sitting a few inches farther away from a computer monitor ... these and other adjustments could drastically reduce the amount of EMF we come into contact with.

To help you take such precautions and find those older devices that are a bit too radiation-leaky, we're presenting our EMF Meter, a powerful "sniffer" circuit that will find any trouble spots in your home, office, or any other place you frequent. Complicated as field theories may be (for more on these, check out "Electromagnetic Pollution" on page 38), the EMF Meter is only a modestly challenging project to build. Use a PC board and a coil-winding trick we'll show you, and you could be scanning rooms in a couple of nights. Turn to page 29 to get started.

In addition to EMF, something else is "around us" here at Gernsback Publications.

Change.

As mentioned in our publisher's letter on page 1, this is the last issue of **Popular Electronics** in its current form. Starting next month—with the January 2000 issue—we'll have merged with our sister title, *Electronics Now*, to form a new, larger magazine: **Poptronics**.

I'm excited to be taking the helm of this new project, and I know I speak for the entire staff in saying that we're determined to make **Poptronics** the ultimate magazine for hands-on electronics enthusiasts. If it's part of the future of electronics, it will be in this cutting-edge new title.

In about a month, in plenty of time for the 21st century, the first issue will be out. So do find a quiet spot amidst all the millennium madness, and join us for a sane look at the future. We'd love to hear what you think of the expanded coverage and new features of **Poptronics**.



Konstantinos Karagiannis  
Editor

**Popular Electronics**<sup>®</sup>

**Larry Steckler**, EHF, CET,  
editor-in-chief and publisher

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Since some of the equipment and circuitry described in POPULAR ELECTRONICS may relate to or be covered by U.S. patents, POPULAR ELECTRONICS disclaims any liability for the infringement of such patents by the making, using, or selling of such equipment or circuitry, and suggests that anyone interested in such projects consult a patent attorney.

# LETTERS

## GUITAR DISTORTION CORRECTIONS

I noticed that a few errors crept into my article: "Guitar Distortion Pedal" (*Popular Electronics*, September 1999). On page 42, the text states switch S2 is a "double-pole, single-throw switch." It should be stated as a double-pole, double-throw switch, as correctly described in the parts list.

The parts-placement diagram (Fig. 4) and the printed-circuit foil (Fig. 3) do not include the marking of the pads "A," "B," and "S" as stated in the text and shown in Fig. 5. In Fig. 4, potentiometer R4 is shown as connected to three unmarked pads. They should be designated (from left to right) as A, B, and S.

Pad "A" goes to components C2, D1, D2, R4, R8, and pin 1 of IC1. Pad "B" goes to R2, and Pad "S" goes to the common connection of jacks J1 and J2.

Hope this clears up any confusion that may have resulted.

Juan Carlos Morales

## HALLOWEEN CONTEST SAVIOR

My son is a big *Star Wars* fan, and wanted my help in creating a Jedi costume for Halloween this year. He's excited about the costume contest his school will have.

Your October issue came just in time for us to begin our plans. Neither Billy nor I particularly liked the plastic, dim toy "lightsabers" on the market, and decided to equip him with your Plasma Saber instead.

Though Halloween hasn't come at the time of my writing this letter, we're delighted by the way the Saber looks. The kit made it a cinch!

Thanks a million.

K. Cannone  
via e-mail

*We're glad we could help. I realize that we didn't mention any of the Saber's Halloween possibilities in the October issue.*

*Just a bit of advice: Your letter didn't say how old Billy is, but be sure that he doesn't use the Saber for any play*

*sword fighting. Remember, there's a neon tube in there.*

—Editor

## POCKET METRONOME IMPROVEMENTS

I had a great time building "The Pocket Metronome" (*Popular Electronics*, October 1999). After some modifications to the published schematic, I was able to get it to perform flawlessly.

For other readers who may be experiencing problems with this project, these are the changes I suggest:

Remove R7 from IC1 pin 10 (reset) and place it on IC1 pin 9 (output). This attaches the LED to the tone-generat-

ing time output, where it belongs, and frees up the reset pin, which is not used.

Remove R1 and C1 from IC1 pin 4 (reset) and place them on pin 14 (V+). This change supplies power to the pulse-generating timer, and it frees up its reset pin, which isn't used either.

Run a jumper from IC1 pin 5 (pulse-side output) to IC1 pin 10 (tone-side reset). Doing so provides the control link from the pulse generator to the tone generator.

D. V. Raymond  
via e-mail

## HAVES & NEEDS

I have been a subscriber to your magazine from way back in the 1950's. I am seeking a tube tester that will test old tubes, such as the 7c7, etc. I have a Heathkit Digital Meter, Model IM-1202 that I would like to give to anyone who can help me with the tube tester.

I will be happy to pay for the tester and give the meter as a gift.

Thanks in advance for any help.

Tony Gaik  
325 West Highway 89A #13  
Cottonwood, AZ 86326  
e-mail: [vitamins@sedona.net](mailto:vitamins@sedona.net)

I recently saw a miniature wireless video transmitter. It seemed to have no visible parts, except an antenna wire, one positive and negative connection for a 9-volt battery, and a wire connection for video out.

All the components were hidden inside a black box, a bit smaller than a wooden matchbox, with all of the above wires soldered on one side of the box.

I would like to ask your readers if they could tell me what I was looking at and the theory of its operation.

My other question is, I realize, a bit general, but here goes: Does anyone have any tips for making strong FM transmissions or a powerful antenna to pick up weak FM signals?

Rommel Golianeh  
10223-121 Street  
Edmonton, Alberta  
T5N 1K6 Canada

## 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. And now there are more ways than ever to contact us at **Popular Electronics**.

You can write via snail mail to:

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Farmingdale, NY 11735

Please note the above address is the snail-mail way to get the quickest response. Some readers send letters to our subscription address, and although the mail is forwarded to our editorial offices, it does increase the time it takes to answer or publish your letters.

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And don't forget to visit our Web site: [www.gernsback.com](http://www.gernsback.com).

# NET WATCH

## ONE-STOP Holiday Shopping

Longtime readers of this column have probably noticed that around the holidays we tend to cover the best new online shopping sites. This is to spare some of you the agony of going to a mall in December. No one likes to put up with long lines, parking nightmares, and more miles of walking than a typical track athlete does in a season. This year, give up the hassle and shop from your computer desk.

Now, more than a few of you have probably already bought something online. Perhaps a book from Amazon.com? Maybe a CD from CDNow.com? If so, great—these and similar sites can help you out with *some* of your shopping this time of year. However, it's not always easy to shop for a music gift for the teens on your list, for instance, or to know what music they're into now. That's why we're going to look at more diverse shopping sites, catering to all sorts of gift types, as well as budgets. Because there's a lot out there, we'll start with an in-depth look at an innovative site, and then move on to a roundup of spots you won't want to miss.

So whip out the plastic and get ready to finish most of your shopping in (dare we say?) under an hour.

### ELECTRICWISH

Since this is an electronics magazine, we'll begin with a site that provides shoppers with a great choice of items that either have to be plugged in or have batteries added. Designed for easy accessibility to those new to Web shopping or consumer electronics or both, ElectricWish.com is one of the best ways for even Grandma to shop for hip gifts.

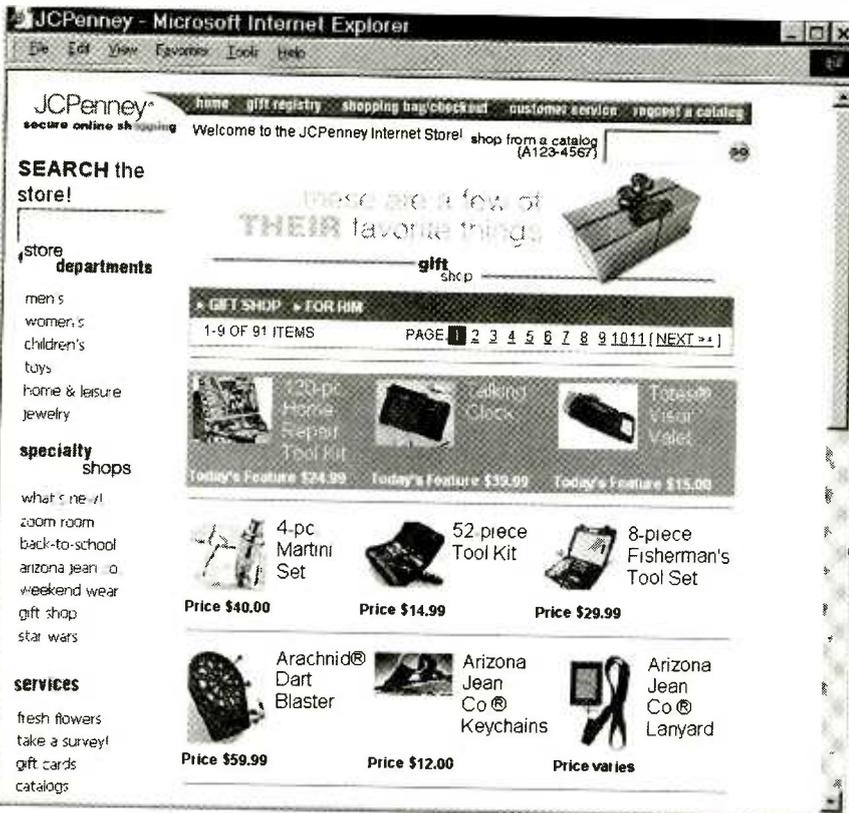
First of all, we should point out that online shops usually lure customers

For a user-friendly experience and terrific deals, consider doing some of your holiday shopping at ElectricWish.com.

with low prices and the fact that there's no sales tax if the buyer's from another state than the store's real-world headquarters (in ElectricWish.com's case, Texas residents add applicable tax). These savings usually make up for the shipping you have to pay. Well, guess what ... ElectricWish.com gives you the money-saving benefits just described plus *free shipping!* All figures totaled, it's clear that you'd have a tough time finding the goodies sold here for less elsewhere.

But you get so much more than just great savings. The designers of this site took a lot of care to create an experience that makes shopping easy and even educational. At the time of this writing, the staff at ElectricWish.com was kind enough to show us a sneak preview of the site's new features, which should be available by the time you read this. They're basically taking a good site and making it great.

For starters, they're expanding the selection. By the holidays, you'll be



The JCPenney Web site has dozens of pages of popular gifts ideas for him, her, and the little ones. You're sure to find something perfect for just about anyone, and in your price range to boot.

able to order cordless phones, TVs (even projection models), VCRs, DVD players, camcorders, portable and deck CD players, stereos, electric knives, breadmakers, blenders, espresso machines, vacuums, and electric shavers, to name a few. As you can see, some of these products will make perfect gifts, depending on whom you're shopping for and how much you want to spend. An electric shaver, for example, is a much more realistic gift for most of us to offer than, say, a 50-inch television!

But a good selection doesn't necessarily make for a good shopping experience. The real strength of the site is that it lets you select just how you want the information on your screen to appear. Techno-savvy individuals will want their product specifications presented as bulleted lists, but those uncomfortable with technical details will want warm, friendly paragraphs describing a unit's pros and cons. A mouse click lets you choose between the two.

There's even a virtual expert in each category (TVs, cooking appliances, etc.) of whom you can ask a question. If the program on the Electric

Wish.com server recognizes the query you type in as being in its database, you'll get an immediate response. Otherwise, a real customer service representative will get in touch with you.

According to the staff at Electric Wish.com, the site was originally launched to be a shopping site friendly to women. However, we think they did one better and made the site "everyone-friendly." One day, we'll all shop this way.

## A SHOPPING HODGEPODGE

As great as ElectricWish.com is, you'll undoubtedly need to hit a few other spots to get your shopping done this year. Let's examine, in rapid-fire fashion, your best bets.

For the kiddies, you'll do well to visit eToys. Right from the opening page, you're offered several browsing options that can speed up your shopping time. Pick an age and get the recommended items of the week, just in case you're not quite sure what little Timmy or Tammy might be interested in. The site's even great for adults (your columnist bought his *Phantom*

*Menace* memorabilia here to avoid the long lines last May). Before you buy, though, you may want to check the prices at ToysRUs.com, too. This Web presence of the famous Toys 'R Us chain may have a better (or worse) deal per item—it always pays to shop around—and is equally pleasing to explore. Just think, no more waiting in a three-hour line only to be told there are no more of this year's hot seller (remember the Tickle Me Elmo craze?).

For that special lady on your list, be she a romantic interest or family member, you'll be delighted to peruse the virtual aisles of the Fragrance Counter. After toy stores, the hardest places to get service around the holidays are definitely department-store beauty counters. At Fragrance Counter, you can pick everyone's favorites and have them gift wrapped and shipped free! Your feet and nerves will thank you.

If you're looking for a really wide variety of options and don't want to spend a lot, consider visiting the online version of a popular American bargain chain: Kmart.com. No, the site doesn't have as many items for sale as a typical Big K, but Kmart.com still has plenty of items for the home and the indi-

## HOT SITES

**Coolsavings.com**  
[www.coolsavings.com](http://www.coolsavings.com)

**ElectricWish.com**  
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**eToys**  
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**JCPenney**  
[www.jcpenney.com](http://www.jcpenney.com)

**Kmart.com**  
[www.kmart.com](http://www.kmart.com)

**ToysRUs.com**  
[www.toysrus.com](http://www.toysrus.com)

vidual that make perfect gifts. The site even has a Gifts Under \$20 section, which links you to products, in the various categories, that fall in this magic price range (magic for the majority of holiday shoppers, that is).

(Continued on page 89)

# MULTIMEDIA WATCH

MARC SPIWAK  
TECHNICAL EDITOR  
COMPUTER RESELLER NEWS

## CD-ROM—Then and Now

About a year before I started writing this column, I bought the fastest computer I could at the time—a 486 DX2/50 that didn't even have a VESA local bus (VLB). It was late '92 or early '93, and my machine didn't come with a CD-ROM drive that was at the time just an expensive 1X unit with little purpose. I paid around \$3000 for that computer, which came with a 15-inch color monitor and a 14.4-Kbps modem.

By '94, multimedia software on CD-ROM started to bloom, with the advent of 2X CD-ROM drives (I guess 1X, 150-KB/sec drives were much too slow to make anything interesting happen from a CD). At some point, I contacted Media Vision and asked for a review unit of the most deluxe 2X multimedia upgrade kit available at the time. I believe it was a \$1200 package, which included a \$600 2X NEC CD-ROM drive, a Pro Audio Spectrum sound card, and speakers. It also included discs such as *Compton's Multimedia Encyclopedia*, *Where in the World is Carmen San Diego?*, and a few others. Soon after, *Multimedia Watch* was born.

A lot has changed since then. But since I started this column because of CD-ROM, it makes sense that I've got a lot of CD-ROM drives covered this month. Today, we can pull data off a CD at 52X, record at 8X on \$1 blank discs, re-record on discs that cost a bit more, and watch full-screen, high-resolution movies on DVD.

### KENWOOD 52X TRUEX

A while back I mentioned how CD-ROM drives never really got much faster after 20X came along. Sure many drives are labeled as being much faster, and they are sometimes



*Kenwood's 52X TrueX CD-ROM drive reads multiple tracks simultaneously, which leads to phenomenal performance gains.*

at the outermost tracks; but for the inner tracks there's really no way to spin the discs much faster than 20X without them wobbling and vibrating too much to be read. This is why so many drives were variable-speed. But now there's a new CD-ROM drive technology that gets around the RPM limit not by spinning faster but by reading more data at once.

Kenwood Technologies' new 52X TrueX CD-ROM drive uses Zen TrueX technology to achieve actual performance levels up to 52X. How Zen's TrueX works is that it lets the Kenwood 52X TrueX read multiple tracks simultaneously, increasing the data transfer rate without increasing rotational speed. A quick and dirty benchmark test I did indicated a speed of 46X, the fastest CD-ROM read I've ever seen. The Kenwood 52X TrueX CD-ROM drive has a transfer rate ranging from 6.75 to 7.8MB per second across the entire disc. Performance generally ranges from 45X to 52X.

The 52X TrueX CD-ROM drive has a suggested retail price of \$129.

### TEAC 8X24 CD-R

CD Recorders are also getting faster, as evidenced by Teac's new 8X24 SCSI drive that can burn CDs at speeds up to 8X and read discs at 24X with a 150-ms average access time. I tested the 8X24, and sure enough it can record at 8X. But I ran into a funny problem where I could copy a disc at 6X but not 8X. My system ran a check on the reader and determined that a limitation in my reader drive kept direct copying to the modest 6X.

Now I'm not even sure what sort of CD-ROM drive is in my test system, but I do know that it's a SCSI unit, probably rated at 24X or 32X. I'll have to redo the test in the same system—a PII 450—but with the Kenwood TrueX 52X CD-ROM drive installed. I'll bet that I can then copy discs with the Teac 8X24 at 8X. This 8X24 CD-R drive comes bundled with Adaptec's *Direct CD*, *Easy CD Creator*, and *CD Copier Deluxe* software.

The Teac 8X24 CD-R drive costs \$449 for the internal version and \$549 for the external model.

### HP 8200i CD-RW

With CD-R blanks costing so little these days, the more expensive re-recordable, CD-RW blanks are best used for more specialized recording needs. CD-R is perfect for copying discs, making music compilations, archiving data, and so on, where you want to keep the data forever. But CD-RW makes more sense for short-term archiving and backups where you don't necessarily want to hang onto the data for very long. And regardless of how long you must save the data, you can still share it with anyone that has a CD-ROM drive (well, almost—some drives can't read CD-RW discs).

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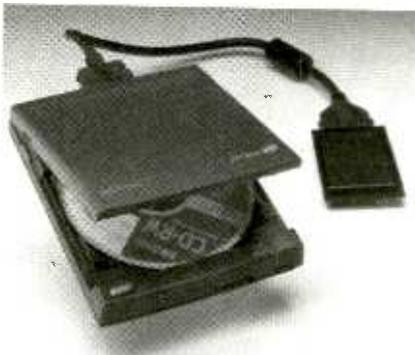
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A new CD-RW drive from Hewlett-Packard offers speed and convenience in an internal form factor. HP's new 8200i CD-RW drive can write or rewrite at 4X and read at speeds up to 24X. This IDE drive lets you back up 100MB of data in about three minutes (like CD-ROM, CD-RW has a maximum capacity of 650MB). Included with the 8200i is all the software you need to get the most from the drive. Adaptec's *DirectCD* and *Easy CD Creator* let you drag-and-drop files for easy storage and access. HP's *Simple Trax* automatically backs up, indexes, and finds files, while HP's *Disaster Recovery* quickly restores hard drives and operating systems from a CD backup that you make.

The drive and impressive software bundle costs \$349.

### HP M820e PORTABLE CD-RW

If you're looking for CD re-recordability in a more portable package, consider Hewlett-Packard's much smaller *M820e Portable CD-RW* drive. This little SCSI drive has a PC Card interface, and it writes and rewrites at 4X and reads at 20X.



*Hewlett-Packard's M820e portable CD-RW drive writes and rewrites at 4X and reads at 20X.*

Measuring 5 by 6.5 inches and less than 1 inch thick, the M820e weighs less than one pound. It's perfect for packing in a briefcase or notebook computer bag. Like HP's internal 8200i CD-RW drive, this portable unit comes with the same great package of CD-R software.

The ultra-portable M820e costs \$599.

### POWERCARD UPS

Everyone knows how important it can be to have a computer protected

by a UPS, or uninterruptible power supply. A UPS is basically a battery backup power supply that sits between your computer and the AC outlet, which is constantly charging the UPS battery array. Under normal power conditions, a UPS will simply monitor the line and pass the AC power through to the connected appliances. But when a power outage is detected, power is switched over to battery and an alarm on the UPS sounds. Depending on how large or powerful a UPS you have, you then have a certain amount of time to save your work and shut down the computer before anything is lost or the computer gets damaged. Servers are set up so that they shut down automatically when the UPS is triggered.

A UPS for a home computer is generally about as large as a shoebox and weighs a surprising amount for its size. It's heavy because of the batteries. After a while this clunky device starts to get in the way—it's amazing how much floor space they really take up. That's all changed now, thanks to a new style of UPS from Guardian On Board.

The *PowerCard UPS* adds protection to your PC without taking up any additional space. The "Card" is available as just that, in either PCI or ISA versions. *PowerCard ISA* is a full-length ISA expansion card with a NiCd battery pack mounted right on the card. *PowerCard PCI* is a half-length PCI card that connects to a separate battery pack, which mounts in the bottom of the computer chassis. Either one outputs 420 volt-amperes (VA) to keep a computer and its monitor running for several minutes before shut down. *PowerCard* not only provides battery backup, it also offers surge suppression and EMI/RFI line noise filtering; and the card includes automatic shutdown software.

Either version of the *PowerCard* is available for \$199.

### COMPAQ AEROS

Windows CE is a powerful operating system for handheld computers, and Compaq has just come out with some interesting handheld units that run the OS. Compaq's *Aero 2100*, similar to a Palm Pilot, lets you access your calendar, contacts, and e-mail, or even browse the Internet offline in full color. The high-resolution color TFT screen, easy PC synchronization, 10-

hour rechargeable battery, touch-sensitive display, and one-handed operation make for a most useful instrument that fits in a shirt pocket. This gadget costs \$449 with 8MB of memory and \$549 for 16MB.

If you want something that's more like a full-sized notebook computer but less like one at the same time, then consider Compaq's new *Aero 8000* handheld PC. Like the Aero 2100, the Aero 8000 runs Windows CE. But unlike the Aero 2100, this model sports a full-size keyboard and can drive a projector or monitor. Unlike a notebook computer, this Windows CE machine offers instant turn-on—meaning that you push a button, the screen lights up, and it's ready to use. The pocket Microsoft *Office* applications are pretty much the equivalent of the bigger cousins, especially if you—like me—don't use 99% of the features they offer. This handheld unit costs \$949.

## TDK CYBEREXPRESS 5614

If you travel a lot, it pays to have a reliable modem so that you get the best possible connection speeds on the

road. TDK Systems' new *CyberExpress 5614* is a full-featured 56-Kbps fax/modem PC Card. The *CyberExpress 5614* supports both K56flex and V.90 standards, and it works with Windows 95/98/NT/2000, Windows CE, and Apple PowerBook notebook computers. The modem auto-senses between K56flex and V.90 standards. The 5614 includes standard 14.4-Kbps send/receive fax, data compression, and error correction features.

The *CyberExpress 5614* has a suggested retail price of \$119.

## CAMERA MEMORY

There is more and more competition in removable media for handheld devices, and New Media Technology Corporation is one player in the market. New Media offers memory in both CompactFlash and SmartMedia formats for use in digital cameras and other equipment.

For those not familiar with the formats, CompactFlash is a matchbox-size module (though only as thick as a matchbook) while SmartMedia cards consist of a flash memory chip embedded in a thin plastic card little larger

than a postage stamp. New Media Technology Corporation offers these memory modules in higher capacities than what normally comes with a digital camera, which means that you can store a lot more images.

Check out New Media's Web site for information on the complete line. The products they sent me were a sample 48MB CompactFlash module that costs \$152 and a 32MB SmartMedia card that costs \$84.

## NEW SOFTWARE

If you collect comic books, you'll want to get your hands on a copy of *ComicBase 4.0* from Human Computing. *ComicBase* is a database of over 100,000 issues and almost 5000 titles, loaded with information in an interactive encyclopedia format. Offerings from over 300 publishers, from humor to super-heroes, are covered—with up-to-date pricing information. Price histories and value graphs for the past four years are included. Of course, *ComicBase* features thousands of full-color illustrations, and even video clips from related movies. The software will even calculate statistics on your col-

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contribute to producing the mysterious cigars. Learn the Cuban cigar's history from the experts, including the owner of one of the most prestigious cigar temples in Europe. This title costs \$24.95.

Like all kids with access to cable television, my kids love *Blues Clues* on Nickelodeon, the animated show featuring a blue spotted dog named Blue and a live actor character named Steve. In the show, Blue and young viewers help Steve find clues to solve basic riddles. Humongous Entertainment's latest title, *Blue's 123 Time Activities*, is now available. This one helps preschoolers practice early math and problem-solving skills with Blue and her friends at the Backyard Fair. Kids strengthen math skills while helping Blue win prizes. This title costs \$19.99.

If you'd like to know more about the Star Wars universe than most people do, then you'll definitely want to check out the *Star Wars Episode I Insider's Guide* from LucasArts. It's loaded with character profiles, cinematic secrets, interviews with George Lucas and the production team, and a lot more. It also features over 2000 images, including concept art, theatrical trailers, film footage, audio clips, and so on. A glossary contains over 500 entries. This neat disc costs about \$30.

I've always been a big fan of Electronic Arts' series of *Need For Speed* driving games. Driving games are my personal favorite, and the latest, *Need For Speed: High Stakes*, is awesome. The graphics are unbelievable and the action first-rate. You choose from 18 of the world's hottest cars and 19 realistic courses. Stakes are high because damage actually slows you down, and you might lose you favorite car if you lose the race. Sound on the game is done quite well. Another game in the series, *Need For Speed III: Hot Pursuit*, lets you play on both sides of the law. You can try to outrun the cops in a number of different super-fast cars or play the good guys in hopped-up cruisers out to nail the speeders. These games have a suggested retail price of \$49.95. ■

## Don't lose sight of Glaucoma.



lection's value and let you print lists and reports. If you sell comic books, *ComicBase* can help with printing price labels. The disc, which is compatible with PCs and Macs, costs \$129.

New on DVD from Manga Entertainment/Palm Pictures comes *Tokyo Fist*, which is one fighting festival of a movie. An insurance salesman runs into his old high-school classmate, now a boxing pro with problems. But the trouble is just beginning. *Tetsuo II: Body Hammer*, is a follow-up movie to the popular *Tetsuo: The Iron Man*. Featuring

a mix of sci-fi nightmares and relentless action, this techno-thriller involves a Tokyo businessman whose son is kidnapped. He then undergoes a transformation into a half-man/half-machine walking arsenal and begins to cause some serious trouble. Both of these titles are intended for mature audiences, and they cost \$29.95 each.

*The Fabulous Story of the Cuban Cigar*, also on DVD from Manga Entertainment/Palm Pictures, covers the rich Cuban soil, special seed, and famous tobacco-growing regions that



## SCANNER SOFTWARE BASICS

Last time, we started talking about scanners, how they operate, and what many of the terms associated with them mean, all in hopes of helping you choose the right machine to start out with. This time around, we'll concentrate on some of the things you'll need to know to actually get some use out of your purchase, and we'll start looking at some basic software applications. Our coverage of the topic will wind up next month with a look at some more advanced stuff you can do with your scanner.

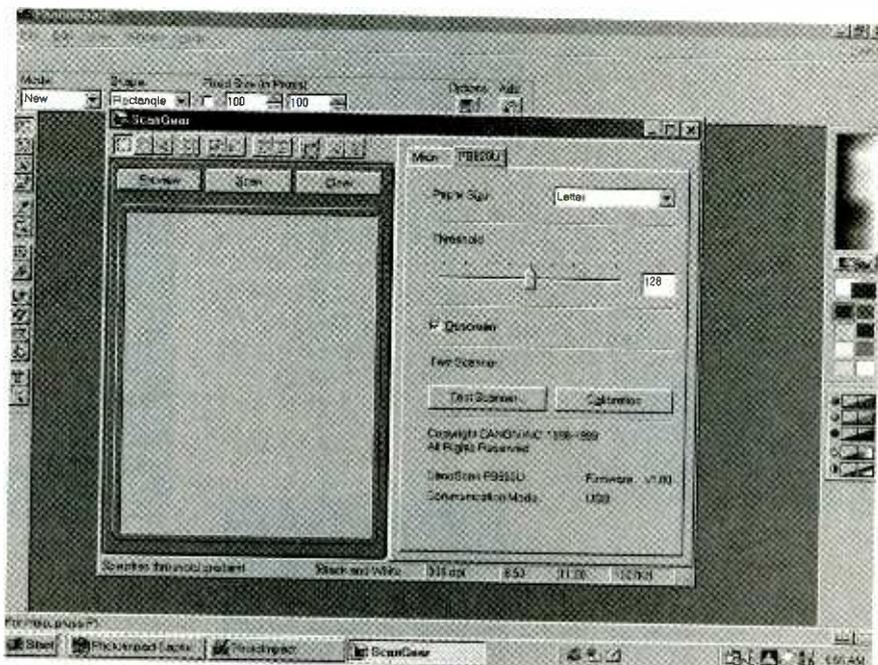
Most scanners come with a bundled collection of software. In truth, many of these bundled applications are so-so, fine for learning with, but often quickly run out of steam when you need to put them to actual use. That's usually not a problem, as there's lots of great scanner-oriented software available, and much of it at very affordable prices. The exception is the TWAIN driver that your scanner vendor provides.

### TWAIN CONTROL

As we mentioned last column, TWAIN is an acronym for Technology Without An Interesting Name. Tongue-in-cheek as this piece of software's name may be, it is far from being unimportant. The scanner's TWAIN driver provides two very significant functions.

The first role TWAIN plays is that of the software interface between the scanner hardware and the Windows (or Mac OS) application that's receiving the scanned image. The TWAIN driver has controls that allow you to pre-scan a document; set the size, resolution, and type of scan to be performed; and then actually perform the scan and send the data to the desired application.

To illustrate how this works, we'll fol-



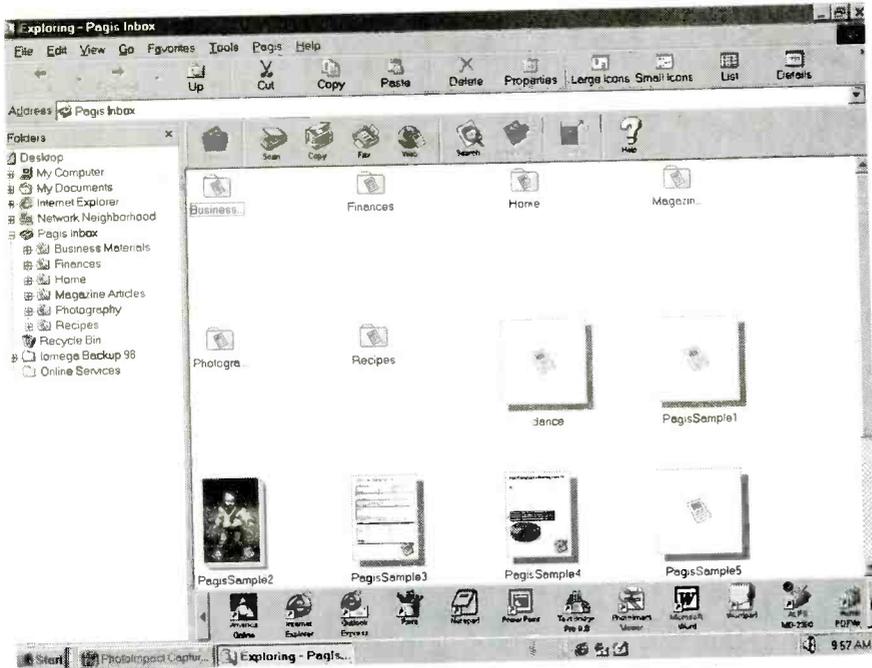
Here's a simple TWAIN-driver control panel that has some advanced controls like the Threshold slider, but lacks some of the others discussed in this column.

low a simple scan of a photograph into an image-editing application. Some of these programs, such as Adobe *PhotoDeluxe*, which is often bundled in with scanners, have a button that you click on to perform a scan. Others, such as *PhotoImpact 4.0*, a package from Ulead Software that I frequently use, have both a scanner icon that can be clicked, and separate commands available from drop-down menus. Windows applications that are TWAIN-compatible have an Acquire command, usually listed under the File heading on the top horizontal menu bar.

Before you can acquire an image from a scanner, you must first select the scanner as the TWAIN source. This is necessary because you may have several TWAIN devices on your computer, and the application needs to know which

device to look at for the image you are trying to acquire. For example, the Compaq Presario 5600s that I frequently use to test hardware and software, currently has a Vision-eer scanner and an Intel PC Camera connected to it. Both are TWAIN devices, so when I go to scan, I need to specify the scanner as the TWAIN source. Fortunately, the application "remembers" the last setting, so I usually don't need to keep setting the source.

With a photo placed on the scanner platen, hitting the scanner icon in the application (or the button on the scanner, if you've programmed it to launch a scan) brings up the TWAIN driver window. When you click on the pre-scan button, the scanner actually performs a quick scan and shows you the image of the



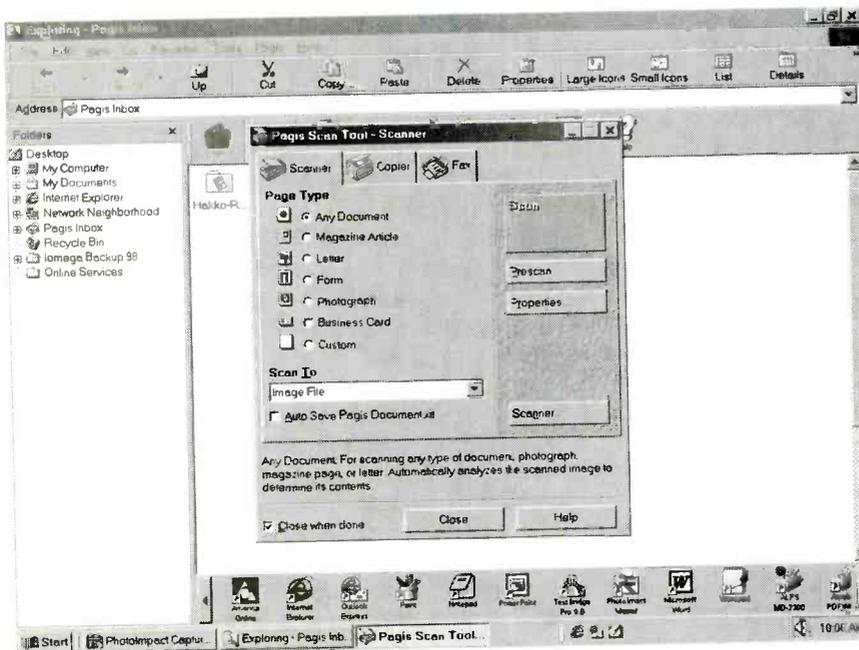
Pagis Pro 3.0 Scanner Suite has a "desktop" onto which thumbnails of scanned documents are placed. You can then just drag then these thumbnails to the appropriate application

document located on the platen. The TWAIN driver allows you to specify the area to be scanned by dragging the edges of the total platen image over to where the edge of the document starts. You can also set the resolution and the type of scan to be performed. Most TWAIN drivers give you the option of scanning line-art (1-bit black and white), grayscale (generally 8 bits for 256 shades), and color in various bit depths.

Which one you choose depends on the original document, and what you will use the scan for. For example, scanning a signature so that it can be included on the bottom of letters you send is usually performed in line-art mode. This mode is also used for scanning a document that will be subject to OCR (optical character recognition). An image for use on an artist's Web site, however, would benefit from 24-bit color (that's more than 16 mil-

lion colors).

We mentioned earlier that the TWAIN driver has two important functions. In addition to providing the basic scanner-control functions we've just discussed, most TWAIN drivers also provide more complex controls. These may not be obvious and are frequently accessed by clicking on a button labeled "Advanced" or something similar. There is no universal or standard set of advanced controls—it really depends both on the particular vendor and at what market the scanner is targeted. Most casual users never see these advanced controls, which can include: the ability to adjust the response histogram to bring out or subdue shadows; individual controls for brightness and contrast; and, often, sliders for red, blue, and green response. These advanced controls let you tweak the image before it ever gets to the application.



Once your scanner is set up in Pagis Pro 3.0, the software lets you "fine-tune" your scans.

## WHERE TO FIND IT

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One advanced control that you will find important, especially if you perform OCR is labeled Threshold. The setting of the Threshold control determines when the TWAIN driver will recognize the existence of a pixel scanned in line-art mode. If you find that you're getting poor accuracy on OCR, and that the original documents you are trying to read don't look noticeably faint, chances are that the Threshold setting needs to be tweaked. Think of it as a kind of sensitivity control.

## GET YOURSELF ORGANIZED

Once you start using a scanner, you  
(Continued on page 89)

## Adding INTERNET FILTERS

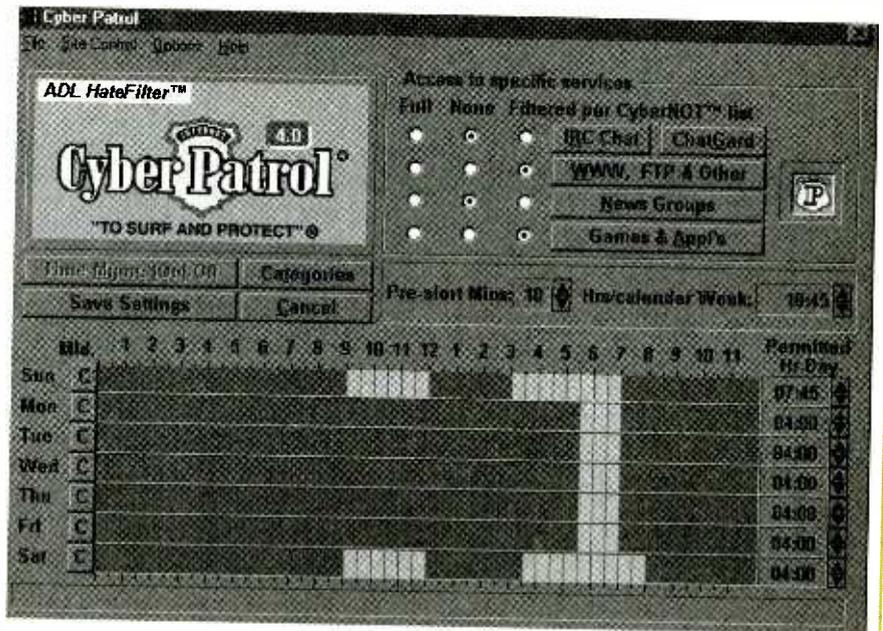
It's doubtful that Gutenberg foresaw the effect his printing press would have on mankind and the changes it would wreak—sometimes softly with a caress and sometimes violently through revolution. Without it, America would never have been born; the Declaration of Independence, the Constitution, and Thomas Paine's *Common Sense* would not have been published or distributed. It wouldn't be an exaggeration to say Gutenberg did as much for us as our ancestors did when switching from four legs to two.

Now, with the dawn of the Internet, and the technologies it has spawned, the reach of the power of publishing has been greatly extended, allowing most anyone to "print" most anything.

And that's the problem. Both technologies have, from their inception, been attacked. Their ability to easily transmit information (for good or evil) has always been somewhat under scrutiny. We have nearly solved the ongoing problem with print, by taking responsibility for the information that we and our children read and controlling the sale of certain books and magazines. However, in order to retain control of what we are allowed to see and what we wish our children to see, we must also take responsibility for the data streams that enter our homes as well.

That's why we're devoting this installment of *Peak Computing* to an upgrade that can make a computer a little safer for the little ones and more immune to data that some grownups find offensive. We're talking about Internet filtering—a technology that's still developing and becoming more and more effective.

After looking at several products, we came across a few that seemed to



With Cyber Patrol installed on your computer, you can vigilantly block inappropriate sites and even control which times and days each user can access the Net.

be the best choices for consumers. While there isn't a single one among them that we can call perfect, they work well enough to satisfy their positions in the market.

Installation of each is accomplished easily. This is truly a light upgrade task and is no more difficult than running a setup program and answering a few questions. As you'll find, a couple offer more individual user "tailoring" and settings that could take up as much time as you're willing to devote to them, but even minimal customization will yield satisfactory results and good degree of parental control.

Incidentally, because kids can be quite clever in getting around things on computers, the programs we look at this month are impossible to uninstall without a password.

Now, on to our roundup. We looked at three programs—*Cyber Patrol*, *Net Nanny*, and *WinGuardian*—and one service, called Dotsafe.

### CYBER PATROL

One of the most robust and customizable filtering products is The Learning Company's *Cyber Patrol*. It lets parents block access to Web pages, newsgroups, Internet Relay Chat (IRC), and file downloads, based on a broad variety of criteria, such as sex, violence, drugs, gambling, and most morally ambiguous behavior.

*Cyber Patrol* works primarily through the use of regularly updated lists maintained by The Learning Company. The "No" list sets up a use paradigm where all sites except the ones in the list can be accessed. The "Yes" list is safer, but

more restrictive, allowing only the use of the sites in the list.

What makes this product so lovely is the amount of control parents have over surfing habits. Parents can modify the lists and add blocked or approved sites of their own. Additionally, they can provide different levels of access to different children.

Another interesting customization available is the ability to set the total number of surfing hours allowed each user each week or each day, as well as *when* they are allowed to surf. You can even set different schedules for each day of the week, if desired.

*Cyber Patrol* has an initial cost of \$29.95 for the program and for the three-month list subscription. List subscriptions are \$19.95 for six months or \$29.95 annually after that.

## NETNANNY

*Net Nanny*, from Net Nanny Software International, is a solid product that blocks the sites that parents want blocked, all with minimal configuration. There are no individual users to configure—the program is either on or off, as determined by password access.

Like *Cyber Patrol*, *Net Nanny* is a list-based program. However, unlike its competitor, *Net Nanny* offers users free updates to lists. Parents can also make additions to the list to block access to specific Web and chat sites that might not be blocked. Another option users have is that they can block all sites, and only allow children to visit parent-designated sites. Again, this is similar to *Cyber Patrol*.

*Net Nanny* also has the interesting ability to block outgoing information. For instance, you can set it up to not allow the little ones to offer an address, telephone, or credit card number over the Net.

Finally, should you want to know just what the PC's users have been up to, the program lets you generate an activity log of visited sites.

The best part of this program is the cost: \$26.95, with the aforementioned free list updates. The one greatest drawback of *Net Nanny*, at press time, was that the program did not support the broadly used AOL 4.0.

## WINGUARDIAN

*WinGuardian* from Webroot Software is possibly the scariest product listed here, and the one most likely

to work with older children. As effective as it is, *WinGuardian* blocks nothing. It works on a different principle.

*WinGuardian* ought to be called WinSpy. It very quietly records keystrokes, program and window openings, and can even take timed screenshots. Webroot calls this a child- and employee-monitoring program. Users have the option of warning those sitting at the PC of the program's existence, or not.

After installing the program we had a hard time finding it. It didn't show up in the Close Program window (invoked by

pressing Ctrl-Alt-Del), create any Desktop or Start menu icons or show up in the Control Panel's Install/Uninstall utility. *WinGuardian* also buries itself quite nicely in the file structure, lest someone be casually searching for it. To access the program's password-protected control console, you need to use a four-key keystroke, which you can set.

Why are we including this program? Consider the effect that you'd achieve if you let your child know that you can see everything that he or she does. It's probably enough to put any kid on his or her best behavior.

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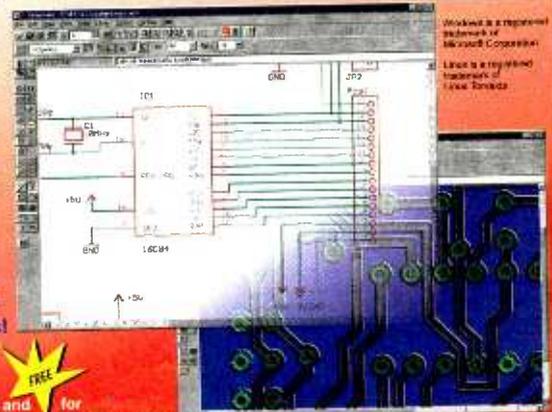


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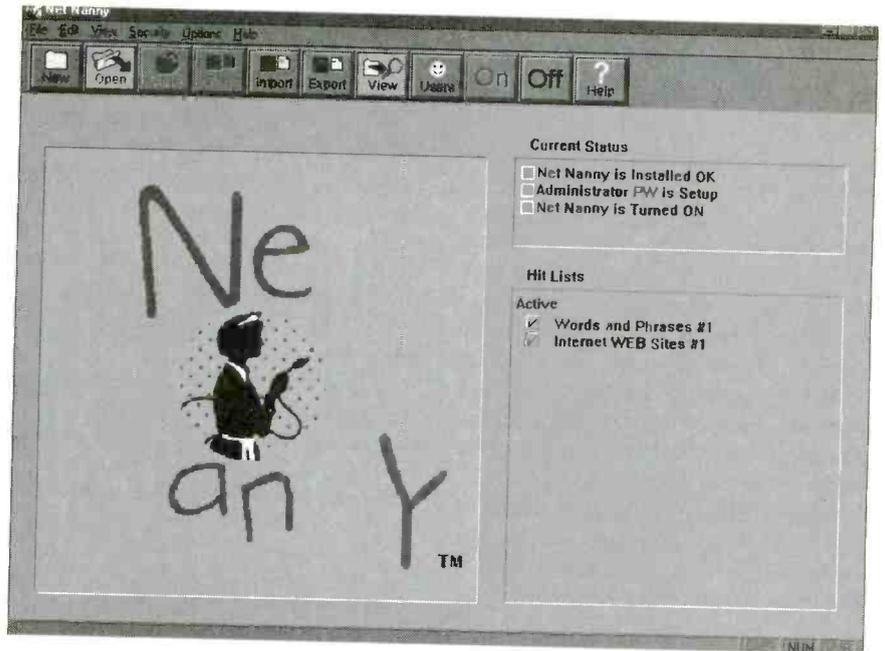
WinGuardian costs just \$39.95.

## DOTSAFE

Now here is an interesting solution to the filtering problem. How would you like to stop offensive content before it even has a chance to get to your computer? There's an Internet service provider (ISP) that makes this possible.

Dotsafe is a full-service ISP dedicated to providing safe content by using server-based filtering. It provides an e-mail box for each member of a household (up to 10 mailboxes total), local access numbers nationwide, and a monthly log of all Internet activity (free for the first two months, then \$5 a month afterwards).

According to Dotsafe, subscribers are protected from most content that would not be found in a "PG movie." Dotsafe's list of banned sites is constantly updated, and parents can also suggest sites to block. When a site does get



Perhaps the simplest filter program to use is Net Nanny, which has easy On/Off functionality, and even offers free monthly updates of its banned-site lists.

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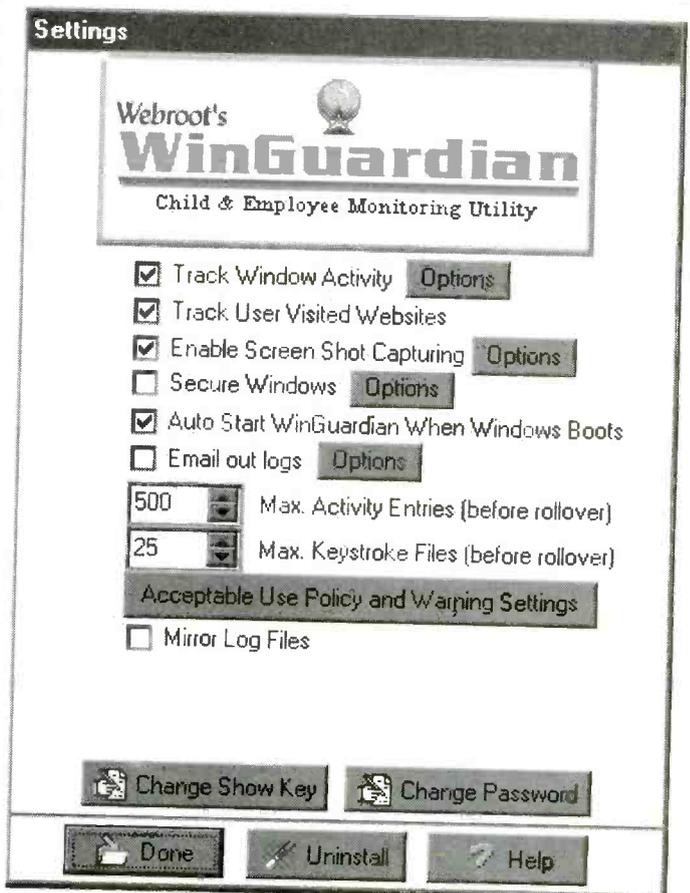
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through its filtering programs, Dotsafe's Internet activity report can alert parents to unsafe surfing and sites that took place, so it won't happen again.

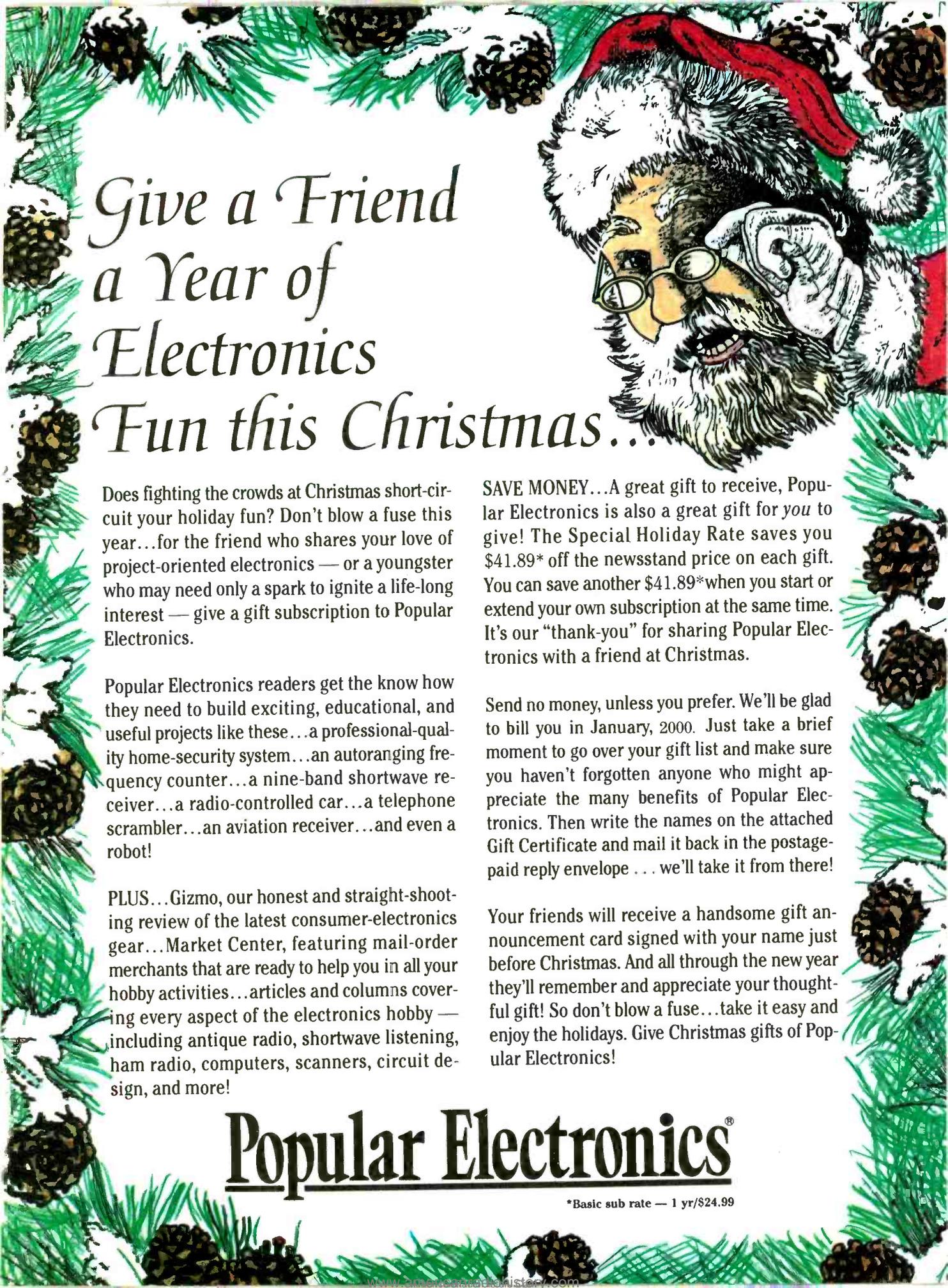
The greatest drawback with Dot-safe is that there are some sites that may not be objectionable to adults in the house, but which will be blocked by the ISP. In this instance, a second ISP would be required for older members of the household (and the password for that account kept secret).

A benefit to the service, though, is that it requires the least effort on the part of parents. Further, if Dotsafe is your only ISP, you won't be spending anything extra (unless if you want the monthly re-

ports). Priced at \$19.95 per month, Dotsafe is competitive with most other providers (note that Dotsafe does have a one-time \$20 setup fee).



Not a filter, WinGuardian lets parents see everything that kids or other users are up to on a machine, no doubt keeping all on their best behavior.



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## HOLIDAY GIFT GUIDE

*As the last holiday season of the 20th century quickly approaches, here are some forward-looking gift suggestions to see you into the new millennium.*

### ON THE HOME-THEATER FRONT

*Prices for entertainment venues are soaring sky-high, and trend forecasters are predicting that Americans will turn more and more to home entertainment in the coming years. Here are some gift ideas to help you get your family happily ensconced around a state-of-the-art home theater.*

### HDTV Projector

For the ultimate in home-theater entertainment, experience the startling clarity of high-definition TV (HDTV) on a large-screen projection system such as Runco's *DTV-863* Super HDTV projector (\$16,995). The detailed image created by three powerfully accurate 7-inch CRT tubes is preserved and projected by a color-corrected, multi-layered-coating, hybrid lens system. An auto-assisted convergence feature saves installation time and makes it easy for the consumer to properly maintain the projector's convergence.

The *DTV-863* uses an outboard digi-

tal video processor that performs "video-scaling" picture enhancement. The high-speed, pixel-based process results in a progressive-scan image that contains 1260 lines per NTSC frame for excellent image detail and accurate color. There are dedicated jacks on the projector and the external processor for connecting the two pieces, and the system provides inputs for composite, S-video, and component video formats.

With eight aspect-ratio options available, the projector is ready to display current and future formats, including NTSC-standard 1.33:1, widescreen 1.85:1, DVD anamorphic, and HDTV 16:9. The system's 32 memory settings can be used for one-touch access to any aspect ratio setting and to store preferences for any combination of inputs, convergence, and processor adjustments.

### Digital With A Difference

The *Lifestyle 30 Series II* digital surround-sound system (\$3000) from Bose combines conventional digital surround-sound decoding with a proprietary technology called Videostage 5. Dolby Digital decoding delivers 5.1 discrete audio channels from any Dolby Digital-encoded source material, whether it's from a DVD player, satellite system, or HDTV. Bose Videostage 5 decoding technology ensures that you will hear five independent channels of audio from five speakers even if the source material is mono or two-channel stereo, giving

VHS tapes, stereo CDs, and mono TV broadcasts the impact of full five-speaker "surround" sound.



Consisting of a silver music center, an RF remote control, five small cube speaker arrays, and an Acoustimass bass module that can be hidden out of sight, the *Lifestyle 30* fits easily into any decor. The tiny Jewel Cube speakers, which measure just 4 × 2 × 3 inches each, unobtrusively deliver mid- and high frequency sound. The patented Acoustimass design, which launches sound into the room on an air mass rather than from a vibrating speaker cone, delivers pure, deep bass without audible distortion.

The music center includes a six-disc magazine-style CD changer, an AM/FM tuner, and inputs for additional sources (of which two are video sources). Multi-source, multi-room capability means that, with the addition of an extra set of powered speakers, two different sources can be played in different rooms at the same time. The radio-frequency remote provides control of the entire system, through walls or floors, without pointing or aiming.



## A/V Receiver

Onkyo's *TX-DS575* A/V receiver (\$529.95) provides built-in Dolby Digital DTS (Digital Theater Sound) and digital-domain Pro Logic surround-sound decoding.

The *TX-DS575* delivers 70 watts to each of its five speaker outputs. All five channels are rated for an honest 70 watts: 20 Hz–20 kHz at <0.08% THD. This full-bandwidth power to all five main channels is particularly important in a digital A/V receiver because discrete 5.1-channel digital surround recordings often make rigorous dynamic demands on all channels simultaneously.



A powerful 24-bit DPS processor implements both Dolby Digital and DTS discrete 5.1-channel surround sound, as well as digital-domain Pro Logic combined with refined music- and video-surround DSP modes. The receiver's 96-kHz/24-bit D/A conversion technology is fully compatible with current and forthcoming "96/24" DVD titles. Three digital inputs accept Dolby Digital, DTS, or PCM bitstreams, while three audio and four A/V input choices include a full input/output tape-loop for a recording component. There's even a phonograph input served by a quality phono-preamp. A discrete 5.1-channel input, offered via a six-RCA-jack grouping, will accept an outboard surround decoder of any current or future format up to six channels, allowing for upgrades down the road.

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## DVD/CD Changer With HDCD Processing

According to Toshiba, its *SD4-109X* six-disc carousel DVD changer (\$699.99) is the world's first to include High-Definition Compatible Digital (HDCD) processing for high-resolution CD audio playback. The HDCD process extends the resolution of HDCD-encoded CDs to a 20-bit level, and it is said to exceed the standard 16-bit CD format and result in a warmer, more natural sounding musical presentation, greater dynamic range, and a wider and deeper soundstage. On-board digital filtering is said to also improve the sound of standard CDs by reducing harmonic distortion and increasing dynamic range.



The changer uses advanced digital technologies—including 10-bit video processing, Dolby Digital and DTS compatibility, ColorStream component-video outputs, and 96-kHz/24-bit audio capability—for improved picture and sound quality. The *SD4109X*'s 10-bit video D/A converter and 27-MHz high-resolution digital filter produce a resolution greater than 500 lines. The built-in Dolby Digital decoder features on-screen control of key surround-sound performance parameters, including speaker management, bass, and system gain. If you don't have surround-sound speakers, Spatializer N-2-2 Virtual Surround Sound creates a multi-channel environment, with well-proportioned stereo, dialog, and sound effects, from just two speakers.

## DTV Now!

Sony's *DTR-HD1* (\$1599) is a set-top digital television (DTV) receiver/decoder that allows today's high-per-

formance analog televisions to display down-converted digital programming, enhancing both video and audio quality. The *DTR-HD1* allows you to take advantage of the increasing amount of free, over-the-air digital programming now available, without buying a digital TV or projector.



When used with an analog television, the *DTR-HD1* will down-convert digital broadcast signals to analog signals and pass them through to the TV's analog tuner. Dolby Digital 5.1 surround sound can also be heard by connecting a Dolby Digital decoder to the unit's optical digital output.

When the decoder is hooked up to a front-projection display that's equipped with the necessary inputs (R/G/B/HV sync) to receive high-definition images, the *DTR-HD1* allows a high-definition signal to be passed through to the display or upgrades a standard definition signal to "virtual HD quality."

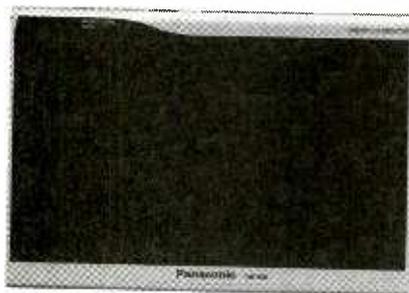
## Color(ful) Television

Of course, not all at-home television viewing is done on large-screen or projection sets integrated into a home-theater system. Sometimes we just want to watch TV, perhaps in a bedroom or the kitchen.

Philips' new "color" televisions look good even when they're not



turned on. The 13-inch **13PT30L** (\$249), shown here, sports an innovative ultra-modern cabinet design in metallic ice blue. The set's glowing translucent feet serve as nightlights in a kitchen or bedroom. On the face of the set is a built-in, round, analog clock display that's backlit to match the set's feet. The set itself can be used as a wake-up alarm, or you can choose to be awakened by the sounds of a harp, a xylophone, or even a crowing rooster. The **13PT30L** provides MTS stereo sound, auto volume leveling, a headphone jack, and A/V input jacks for convenient connection of a video game console, VCR, DVD, or Internet television device.



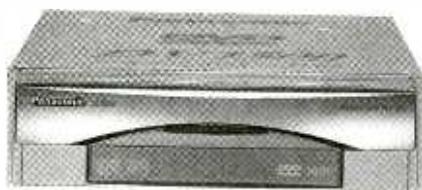
tions of a multi-channel home-theater system, with sound moving from the front to the rear or the left to right with the on-screen action. With a subwoofer output, you'll even feel the bass in explosions and other low-frequency sound effects (which might not be too pleasant for the driver).

## YOU CAN TAKE IT WITH YOU

*No matter how appealing your home—and home theater—might be, you still can't stay there all the time. Whether you're going on vacation, heading for the mall, or just driving to work, here are some electronic gizmos designed for travel.*

### Car Theater

The drive-in theater might be a thing of the past, but the drive-



around theater is just beginning to catch on. The latest car-theater gear is the in-dash DVD player, such as Panasonic's *Model CX-DV1500* (\$1400). Sized at 7 × 2 × 6<sup>5</sup>/<sub>8</sub> inches to fit in any DIN-size car-stereo slot, it delivers the video and audio benefits of the DVD format and does double duty as a CD player.

For the ultimate in "car theater," you might want to add the *CY-VM1500 Car Monitor* (\$1000) and the *CY-AC300 Dolby Digital/DTS Processor* (\$800). The three Panasonic components can emulate the sensa-



The processor can be mounted in the trunk or any hidden spot, along with three amps to drive front- and rear-speaker pairs, a center speaker, and a subwoofer. The flat, 7-inch diagonal LCD monitor can be installed between the front seats, in an overhead panel, or elsewhere for back-seat viewing.

The family will be entertained on long or short trips by DVD movies with nearly 500 lines of horizontal resolution and clean digital audio. A wireless remote control allows viewers to navigate disc menus and make playback choices.

### Portable DVD Storage

So where do you keep your library of on-the-road DVDs? Case Logic



offers portable solutions in the form of three-ring storage albums. The *DVA-10* (\$24.99) has a 10-disc capacity, while the *DVA-20* (\$29.99) holds 20 DVDs. Both albums allow you to insert the DVD title/chapter notes into the front and the DVD disc into the back of each sleeve.

The sleeves are made of patented ProSleeve material, which protects both sides of the DVD surface. Removable sleeves allow you to rearrange the DVDs in the album without removing them from the sleeves.

### Digital AM/FM Car Tuners

The in-dash "digital tuners" that have been sold in recent years merely have digital displays and use ICs to generate analog reference signals. Blaupunkt's *DigiCeiver*, on the other hand, is the first consumer radio to actually digitize incoming AM and FM radio signals so that they can be manipulated by a powerful digital signal processor.



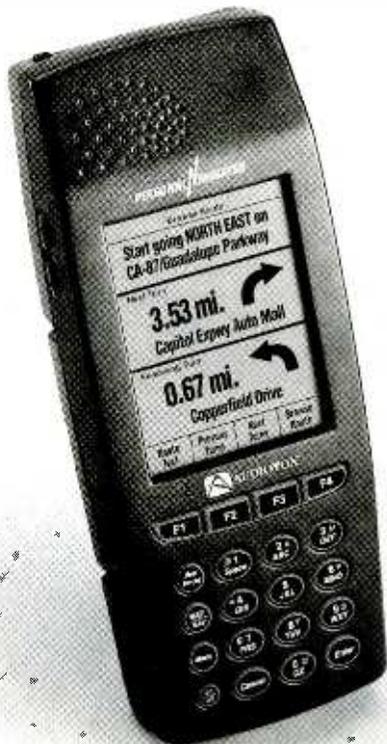
Available in the *Alaska* (\$369.95) model shown here, as well as *Nevada* (\$329.95) and *Florida* (\$289.95) models, the *DigiCeiver* is said to render obsolete most of the circuitry used in a conventional radio. Everything after the antenna and "front end" circuits has been replaced by a very-high-speed A/D converter and a sophisticated DSP. The DSP suppresses radio interference and extracts high-quality audio from the airwaves. It also accommodates a wide array of audio and radio features, including RDS (Radio Data System), reception management, tone controls, volume, and turn-on levels. On the *Alaska*, it also manages the SHARX automatic IF bandwidth switching, which holds weak stations when there is strong interference

from adjacent stations, and a two-band digital equalizer.

All three models debut a CD transport with a "hologram" CD pickup, which, along with proprietary Double V Spring suspension, is said to offer superior disc tracking, better vibration resistance, and greater reliability than conventional pickups. The players can be mounted at almost any angle, including face up in a console. The three units also have 4 × 40-watt power amplifiers, high-voltage (3V) four-channel preamplifier outputs, and RDS. They also have detachable anti-theft faceplates.

## Personal Navigator

For the directionally challenged person on your gift list, the *PN-100 Personal Navigator* (\$1250) from Audiovox can simplify travel. Based on Global Positioning System (GPS) satellites, the PN-100 also features detailed digital maps to generate turn-by-turn directions to any location in its database. The Personal Navigator uses advanced text-to-speech technology to provide voice



directions to the driver at each approaching turn. The instructions also include the distance to and direction of the next turn as well as the name of the street. A backlit 4.1-inch LCD screen offers a choice of moving map, route information, or a graphic display of the next two turns.

The handheld device also includes a points-of-interest database, a personal address book, a calculator, and a calendar. There are more than 30 points-of-interest categories, including restaurants, hotels, gas stations, tourist attractions, banks, and ATMs. The user can find a site by searching either within a five-mile radius of the vehicle's current position or an entire city.

## Talking Radar Detector

Cobra's *ESD-6700* (\$239.95) adds a human touch with its Voice Alert feature, which speaks up to alert drivers of road hazards detected by the unit's built-in Safety Alert Traffic Warning System. The Safety Alert band warns of nearby emergency vehicles, stationary road hazards,



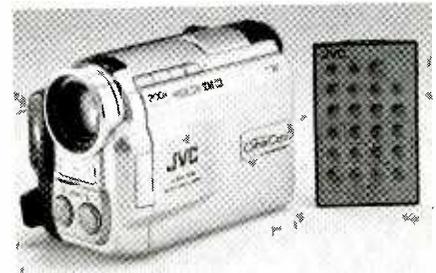
construction sites, and railroad intersections that are equipped with Safety Alert transmitters. If a fire truck is approaching, for instance, the ESD-6700's text display will read "Emergency Vehicle," and its Voice Alert will say "Emergency vehicle approaching."

The six-band detector is designed to pick up all four speed-monitoring systems in use by law enforcement agencies—X, K, Superwide Ka, and laser—as well as Safety Alert signals and VG-2 Alert warnings. The VG-2 band is invisible to other radar-detector detectors. Another feature is LaserEye laser detec-

tion that provides multi-directional protection from laser guns. In addition, the Memo-Set function remembers the settings of dim, muting, and city/highway modes.

## Digital Video Camera

Record your holiday memories and special events the digital way, with JVC's *GR-DVL9500 Mini DV camera* (\$1999), which offers progressive-



scan imaging and high-band processing technologies. A high-performance progressive-scan CCD image sensor creates the equivalent of a 760,000-pixel conventional interlace-scan CCD. Proprietary progressive color filter and high-band processor imaging components help the image sensor deliver a high resolution of 480 lines (vertical) and 500 lines (horizontal).

The progressive mode setting allows the progressive-scan CCD to record an entire frame in one scan at a rate of 30 frames per second, resulting in excellent slow-motion playback and the ability to freeze and grab any frame in a full-motion sequence. Because individual frames freeze sharp and clear, a single Mini DV cassette can yield more than 100,000 high-quality still pictures.

A high-speed recording mode captures action at 120 images per second—twice the speed of traditional camcorders, and twice the number of images on the same amount of tape as traditional recordings. The high recording density allows the use of Pro Slow mode, which provides broadcast-level smoothness during slow-motion (1/10 normal speed) playback.

Pro snapshot mode allows photographers to take full-frame, high-resolution

still shots at the touch of a button. More than 600 stills, with the option of six seconds of audio, can be recorded on a single cassette. A range of photographic effects, including 4- and 9-frame snapshots, frame pin-ups, and color-reversal photos, are available. Auto flash provides four flash modes.

An i.Link in/out (IEEE 1394-based) terminal and direct PC connection via a JLP terminal make it easy to create multimedia video productions. JLP Video Capture uses a single cable connection to grab selected still frames for direct downloading to a PC for conversion to .BMP or JPEG files. Once files have been downloaded, image processing is simplified with the *Presto!* software suite. For professional-quality video editing, the GR-DVL9500's JLP Video Producer links the CyberCam with a PC and VCR to create an advanced editing suite with exact time code settings for linear video-to-video editing.

## Notebook Camera

Sony's *VAIO C1X PictureBook* (\$2299) combines a micro-notebook computer with a digital camera, making it easy to capture, manipulate, and share both still and motion images. About the size of a personal planner and weighing just 2.2 pounds, the *PictureBook* is a full Windows 98, 266-MHz Pentium



MMX system that's designed to meet the demands of traveling executives who need to add images to their electronic communications.

A built-in CCD camera housed in the top bezel of the display swivels to capture a still shot or record up to 60 seconds of video. Click on a button to launch a program that automatically

attaches the image or video to an e-mail. The *PictureBook* eliminates the need for separate devices, cables, or other data-exchange steps for transmitting images.

## THE GIFT OF SOUND

*Today's audio products come in all shapes and sizes, and several different formats. There's sure to be an item below to please the music-lover on your list.*

### CD/MD Car Stereo

According to JVC, its *KD-MX3000* (\$749.95) is the world's first single-DIN receiver capable of playing both CDs and MiniDiscs. The single-pick-

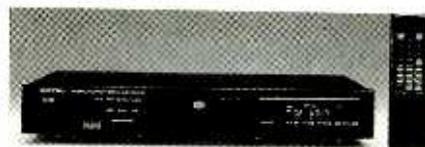


up feature of the receiver is shared by both formats, and a "swing traverse mechanism" with double spindles is said to hold MDs and CDs securely in place. Hybrid elastomer dampers float the entire mechanism whenever a disc is played, protecting them against shocks while in a moving car. When in tuner or changer mode, the mechanism reverts to fixed status for increased stability and safety. A 10-second MD shockproof memory lets the disc keep playing even if the unit is jostled.

The receiver also boasts a CD-changer control with direct disc select, a tuner with 18 FM and 6 AM presets, an amplifier with sound-control memory, and 40 watts × 4 power output terminals (two pair).

### HDCD Player

Rotel's *RCD 971* single-disc CD player (\$699.99) with High-Definition Compatible Digital (HDCD) capability features vibration-resistant transports, sophisticated anti-jitter circuits, 20-bit D/A converters, and carefully crafted analog stages to provide outstanding performance from today's premium CDs.



Pacific Microsystem's PMD-100 HDCD decoder/digital filter not only ensures accurate playback of the many HDCD-encoded discs that are now available, but it also provides advanced digital filtering for conventional discs. HDCD's "double-ended" technique starts by analyzing the psychodynamics of the music, encodes it to preserve all the relevant characteristics, embeds a continuous set of playback instructions, and then plays back the disc through a decoder/filter that dynamically changes operational modes for optimum music reproduction.

The RCD 971's linear motor transport has sufficient overscan capability to retrieve data from any disc, even those discs that exceed the "maximum" 74 minutes of music. The heavily damped, center-mounted disc drawer provides excellent mechanical isolation.

### Colorful Speakers

The B&W *LM 1 Leisure Monitor* (\$350/pair) is an ultra-compact two-way speaker that's available in five high-tech color schemes, including two-tone treatments in black, pearl white, silver, burgundy, and turquoise. Ready to take its place in the multichannel, multimedia era, the LM 1's contemporary, industrial design is highly visible, yet subtle.

Standing less than a foot tall, with a 5.5- × 7.5-inch footprint, the LM 1 can serve as a desktop speaker in



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multimedia computer setups, and is as well-suited for five-channel duty in matched surround-sound systems as in discrete stereo installations. The

LM 1 is fully magnetically shielded. The drivers, enclosure, and electrical components are weather-resistant for use in a bath, pool, or Jacuzzi area. Its

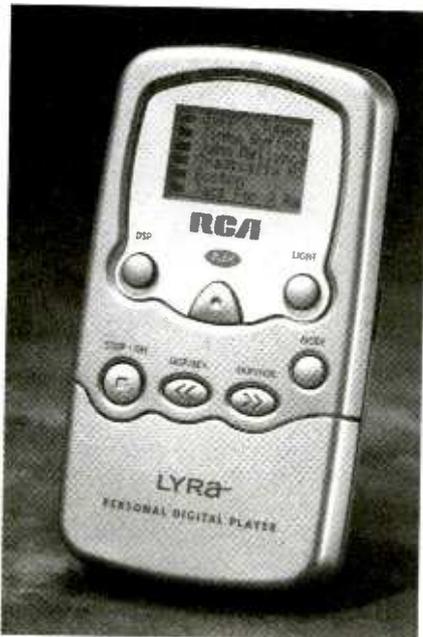
versatile integral mounting system consists of a smoothly contoured floor or tabletop stand that swivels to convert to a wall- or ceiling-mount-

ing bracket.

The two-way LM 1 uses a long-throw, high-output, five-inch bass/midrange driver that exploits its vented enclosure to achieve bass extension to 65 Hz. The driver simultaneously promotes detailed, musical midrange reproduction and a cohesive transition to the LM 1's one-inch dome tweeter, permitting airy, detailed sound to 20 kHz. B&W's signature discrete-mount-tweeter "pod" design is said to promote smooth off-axis treble for more natural and spacious ambiance and to eliminate diffraction effects. Despite its specified sensitivity of 91-dB SPL (measured at 1 meter with 1 watt input), the LM 1 is rated to handle a full 100 watts of power.

## Personal Digital Audio Player

With the ability to decode digital music files in various music-compression formats, the RCA *Lyra* personal digital audio player (\$199) from Thomson offers the best of MP3 Internet audio and the RealNetworks *RealJukebox* music-management system. The *Lyra* delivers digital-quality music from a palm-sized device that reads data from a CompactFlash card and plays compressed music files



organized by a home computer. The player features a digital signal processor that allows upgradable software to support future compression formats.

Out of the box, the device comes with enough memory on a removable card to play about an hour of music. *Lyra* can be upgraded easily with additional plug-in Type I or Type II CompactFlash and microdrive memory, expanding its music playback time to several hours.

*Lyra* will be shipped with RCA *Personal Music Manager* software, which incorporates the *RealJukebox* core from Real Networks. It also comes with all the necessary computer connections to allow you to manage your own music collection.

About the same size as a deck of cards, *Lyra* weighs just 5.2 ounces with two AA batteries installed. Unlike a CD player, the device has no moving parts, which means the music won't skip if users are participating in sports, hiking, or rollerblading. The backlit six-line alphanumeric display includes a table of contents for all of the songs stored on the memory card and also shows song title, artist, and elapsed time when in playback mode. Songs can be organized into root directories and subfolders to easily locate favorite tracks. The basic model comes with headphones, software, a CompactFlash reader/writer attachment for the PC, a 32MB removable memory card, and two batteries.

## In-House Music Festival

Harmon Kardon's *Festival 60* intelligent music system (\$799) is compact and distinctively elegant, provides excellent sound quality, and offers a logical user interface. The system includes a seven-disc CD changer, an AM/FM tuner, a stereo amplifier, and two speakers. With its gracefully curved control console, angular front panels, and contoured speaker grilles, the *Festival 60* is as pleasing to the eye as to the ear.

The unit's intelligent software-



based operating system centralizes all controls in a single window in which information is displayed as needed. "Smart Key" technology automatically reconfigures control keys according to the function or source. The buttons for each source illuminate when that source is selected, and all controls are arranged in a logical fashion.

Setup has also been simplified. The control console, CD changer, and 35 watts-per-channel stereo amplifier link together via a single cable with connectors designed for fool-proof hookup. The speakers connect using the supplied color-coded speaker wire.

The *Festival 60* comes with a pair of two-way loudspeakers featuring an innovative one-inch flared-dome tweeter and a six-inch woofer. The speakers operate in conjunction with an active equalization circuit to provide a frequency response of 50 Hz to 20 kHz.

## THIS 'N' THAT

Got someone on your list who's impossible to please? Here are some unique ideas that just might strike the right note.

## The Sounds Of Silence

Equally pleasing to the budding musician and his parents and neighbors, Yamaha's *Silent Series* of musical instruments will permit completely private practice sessions and performances, using headphones. The series includes the *Silent Electric Cello*, the *Silent Electric Violin*, the *Silent Brass Personal Studio*, and the *DTX Silent*



*Session Drum* (starts at \$1995) shown here.

The DTX electronic percussion system can play articulate buzz rolls, rim shots, double-bass, percussion, and cymbal chokes, all previously possible only on acoustic drums. Percussionists can layer up to five notes on one surface to play stacks of notes or alternating patterns, trigger keyboard sounds from the pads, or practice with the on-board training functions.

The DTX module provides a total of 1056 on-board voices. That total includes 880 drum and percussion voices and effects as well as 48 brass, brass and strings, and mallet voices, and 129 General MIDI-compatible keyboard sounds, all produced using Yamaha's Advanced Wave Memory technology. A built-in five-track sequencer lets MIDI data from the DTX system and from external MIDI keyboards be recorded.

## Harley Phone

Looking for a gift for a biker? Uniden's cordless *Harley Phone* (\$79.95) is modeled after the Harley Davidson "teardrop" gas tank. The base comes with chrome knobs that resemble gas caps, and there's an authentic-looking speedometer on the handset.

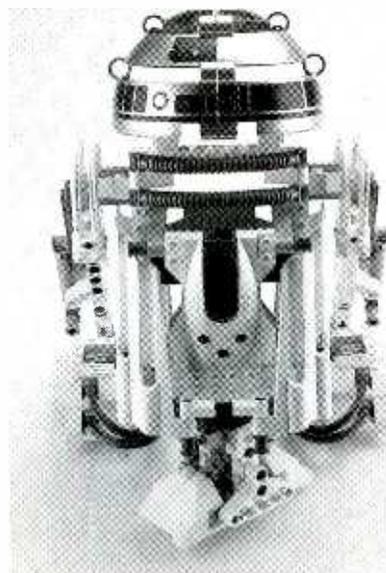
The 900-MHz phone provides extended range and superior voice quality. Its 40-channel autoscan



automatically selects the clearest channel, and noise-reduction technology eliminates background noise. Up to ten phone numbers can be stored in memory for quick dialing, and three one-touch speed-dial keys are provided.

## Droid Maker

Anakin Skywalker built C3-PO out of spare parts, and your young Jedi-wannabe can fashion his own R2-D2 astromech, Battle Droid, or other *Star Wars*-type robot using the LEGO *Mindstorms Droid Developer Kit* (\$99). Aimed at kids nine years and older, the set offers three distinct levels of building difficulty: Apprentice, Jedi Knight, and Jedi Master. The easiest project takes about an hour to complete. The set's



modular building system allows kids to mix and match subassemblies to create dozens of different droids that can move, chirp, and respond to their environment.

The Droid Developer Kit is powered by LEGO's smallest microcomputer. Dubbed the Micro-Scout, it has a built-in light sensor, a built-in motor, and seven behaviors from which to choose. The set contains more than 600 LEGO pieces, including the unique shapes required to create R2-D2's distinctive look. Although the kit does not require the use of a PC, it does come with a CD-ROM that provides additional building tips.

## Podracing Fever

Did you manage to withstand your kids' whining, begging, and pleading



when LucasArts' *Star Wars: Episode I: Racer* for Nintendo 64 (\$69.95) was released around the time of the movie opening? They'll be happy to find it under the tree this Christmas.

Podracer drivers compete by flying across various *Star Wars* landscapes at speeds of up to 600 miles per hour. The vehicles each consist of a small cockpit tethered to dual jet engines held together by a glowing magnetic beam. The competing racers include young Anakin Skywalker and a host of alien creatures from all parts of the galaxy. The reigning champion—the cheating Sebulba—appears along with more than 20 others, some not seen in the *Phantom Menace* film. Each character pilots its own personalized podracer with variable acceleration, technique, and top-speed attributes.

# ELECTRONICS LIBRARY

## '99/2000 CATALOG

from C&S Sales

This full-color 64-page catalog is a one-stop source for electronic products. B&K Precision, Elenco, Fluke, Forefront, Hitachi, OWI Kits, Tekk, Tektronics, Xcelite, and Weller are some of the companies represented. Products covered include meters; function-, audio-, and signal-generators; IC testers; radios; robotic and solar kits; logic probes; trainers; oscilloscopes; books and videos.



Full specs, color photos, and price information accompany each product listing. Among the products featured in the catalog are Tekk family radios and the XK-700 deluxe digital/analog trainer from Elenco. In addition, there are 20 pages of kits, books, and videos.

The '99/2000 Catalog is free upon request from C&S Sales, 150 W. Carpenter Ave., Wheeling, IL 60090; Tel. 800-292-7711; Web: [www.cs-sales.com](http://www.cs-sales.com).

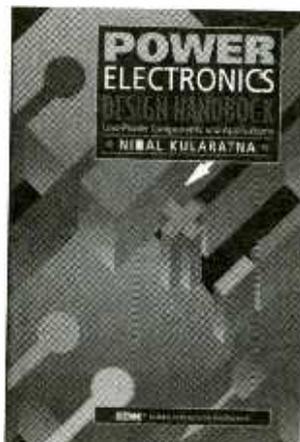
## POWER ELECTRONICS DESIGN HANDBOOK

by Nihal Kularatna

The basics of power electronics theory are covered in this handbook. Modern low-power components and applications are discussed in detail, including power semiconductors, converters, power supplies, batteries, power

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conditioners and ICs, and UPS.

The author, an expert in the field, integrates component and system theory with practical applications, particularly energy-saving low-power applications. Many chapters contain sections on future developments. There are also references for further research and more in-depth technical reading.

*Power Electronics Design Handbook* costs \$59.95 and is published by Newnes, Butterworth Heinemann, 225 Wildwood Avenue, Woburn, MA 01801; Tel. 800-366-2665 or 781-904-2500; Web: [www.bh.com/newnes](http://www.bh.com/newnes).

## RADIO TUBES AND BOXES OF THE 1920's

by George A. Fathauer

On November 2, 1920 radio station KDKA of Pittsburgh began regular broadcasts—a new era of radio had begun. This book illustrates that exciting first decade of home radio. It features over 360 color photos of early vacuum tubes,



as well as 40 magazine ads and examples of company literature.

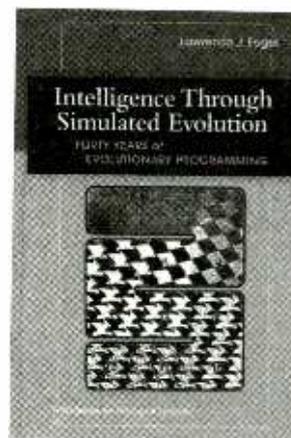
Collectors and historians alike will appreciate this entertaining way of visiting the early days of electronics. A helpful introduction to dating and identifying old tubes is provided.

*Radio Tubes and Boxes of the 1920's* costs \$26.95 and is published by Sonoran Publishing, 116 N. Roosevelt, Suite 121, Chandler, AZ 85226; Tel. 480-961-5176.

## INTELLIGENCE THROUGH SIMULATED EVOLUTION

by Lawrence J. Fogel

This book is a unique, one-stop reference to the history, technology, and methods of machine learning—from 1970 to the present. The author, who is one of the inventors of evolutionary programming, traces all the developments in the field, providing comprehensive coverage of this approach to simulated evolution.



Clear, up-to-date explanations are featured that show how the simulation of evolutionary processes allows machines to learn to solve problems in new ways. The information discussed helps readers understand methods of generating intelligent systems. Engineers and computer scientists in all areas of machine learning will gain insight from this useful resource and learn more about neural networks, fuzzy logic, and genetic algorithm development.

*Intelligence Through Simulated Evolution* costs \$79.95 and is published by Wiley-Interscience, John Wiley & Sons, 605 Third Avenue, New York, NY 10158; Tel. 212-850-6366; Web: [www.wiley.com](http://www.wiley.com).

# THE EMF METER



*If you are concerned about the possible side effects of long-term exposure to electric and/or magnetic field radiation, and you would like to seek out, identify, and perhaps eliminate the sources of that possible health hazard, why not put this "radiated-field bloodhound" to work for you.*

RUDOLF F. GRAF, KA2CWL and WILLIAM SHEETS, K2MQJ

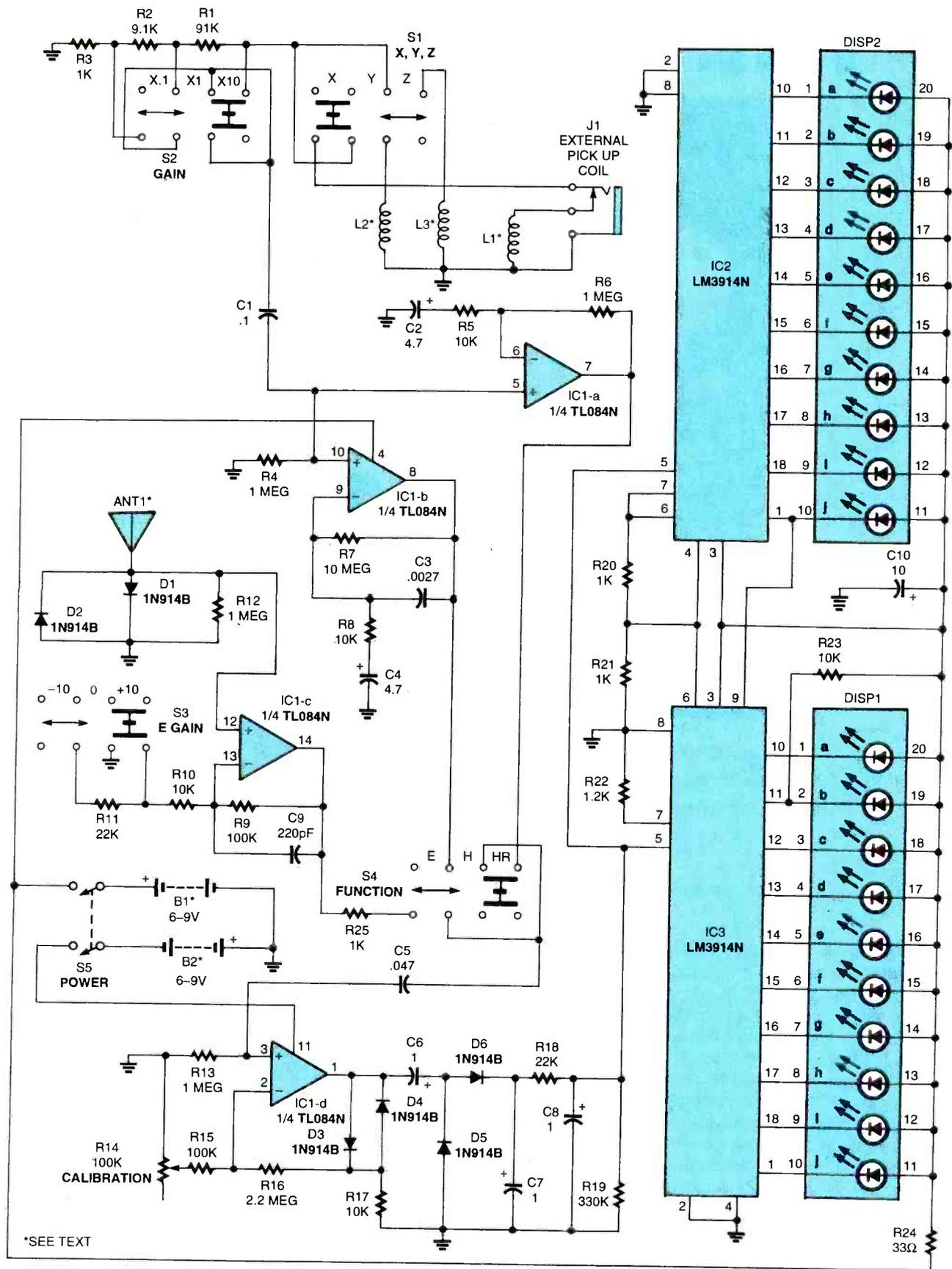
**S**ince the latter half of this century, there have been several published reports concerning the possible health and environmental hazards resulting from long-term exposure to electric and magnetic fields (as discussed in "Electromagnetic Pollution" appearing elsewhere in this issue). Such fields are generated largely by man-made devices, such as power and telephone lines, radio-frequency transmitters, military and commercial aircraft power systems, TV sets, fluorescent lighting, computers, microwave ovens, electric blankets, and many other gadgets that we've come to depend on.

While data supporting the possibility of the negative side effects of electric and magnetic fields is inconclusive, it's always wise to err on the side of caution. Although it is impossible to eliminate all the possible sources of electric- and magnetic-field radiation, there are a number of precautions that can be taken at little or no cost, among them simply shutting down unused equipment or a change in lighting fixtures.

In this article, we'll show you how to build and use a simple electric-(E) and magnetic-field (H) detector—the *EMF Meter*—that allows you to measure the relative field

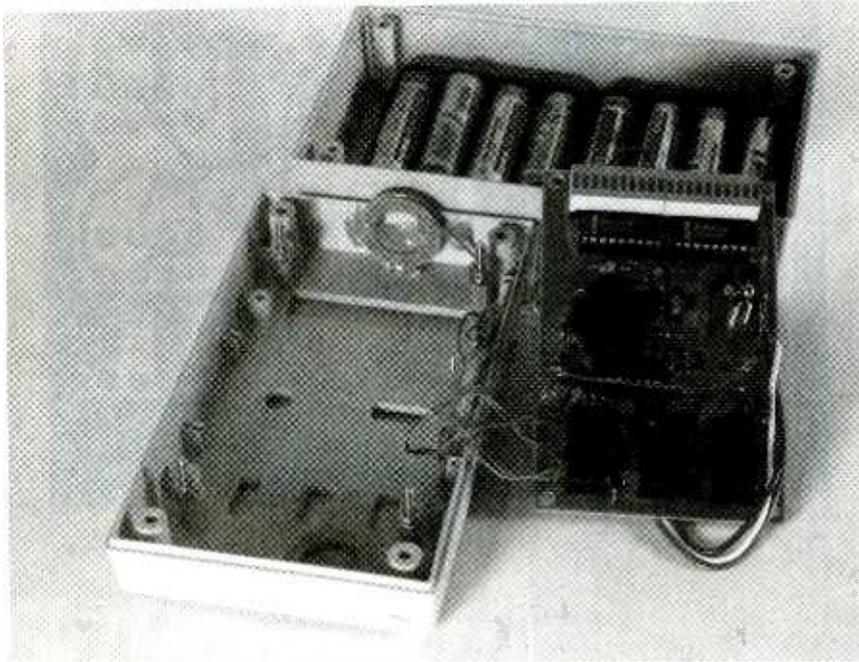
strengths present around all operating electrical devices, and, where practical, reduce or eliminate the possible health risks.

**About the Circuit.** A complete schematic diagram of the EMF Meter is shown in Fig. 1. The circuit—comprised of three integrated circuits, a pair of 10-segment bargraph displays, a few diodes, three hand-wound coils, and a batch of support components—has three functions, "H relative (HR)," "H," and "E," selectable via S4 (a 3-position slide switch). The circuit also allows you to select from three sensitivity (gain) settings:  $\times 10$ ,  $\times 1$ , and  $\times .1$



\*SEE TEXT

Fig. 1. As shown by this schematic diagram, the EMF Meter is comprised of three integrated circuits, a pair of 10-segment bar-graph displays, a few diodes, three hand-wound coils, and a batch of support components.



*In the author's prototype, the three pickup coils were mounted as shown here to the inside of the enclosure so as to provide complete coverage of all three axis—X, Y, and Z—regardless of the meter's orientation. As shown, one coil is affixed flush to the upper portion of the case (up/down axis); another is secured flush to the right side wall of the enclosure (left/right axis); and the final unit is mounted flush to the inside front wall of the housing (forward/backward axis).*

When S4 is placed in the HR position, the meter measures magnetic fields by sensing the voltage induced in one of its pickup coils. The induced voltage in any coil is equal to  $N \phi/dt$ , where  $N$  is the number of turns and  $\phi/dt$  is the rate of change of flux per unit time passing through the coil (axial component). Since flux is equal to  $B \times A$  (magnetic field strength multiplied by the area of the coil), knowing the number of turns in the sensing coil, its area, and the frequency of the magnetic field (60 or 120 Hz), the induced voltage can be measured. That allows you to determine the strength of  $B$  or  $H$ , since  $B = \mu H$ , where  $\mu$  is the permeability of free space ( $4\pi \times 10^{-7}$  henries/meter). The induced voltage is amplified and rectified, and then used to drive a 20-segment LED bar-graph display.

The H position performs the same function, except the amplifier is configured for a  $1/f$  frequency response ( $-6$  dB/octave). The amplifier produces an output voltage that's proportional to flux density and independent of frequency, since doubling the frequency would double the induced volt-

age, but be amplified half as much. That function can be calibrated to give a reading of magnetic field strength. Fields as low as 1 milligauss can be detected using the built-in coils; using an external pickup coil, the meter is able to detect fields as small as 0.01 milligauss.

We are concerned with weak AC magnetic fields around 1 gauss or less. The earth's magnetic field is around 0.5 gauss and is a steady (DC) field. That type of field won't induce any voltage in a coil that is stationary, but can in a coil that is moved so that lines of force (flux) are cut. For that reason, the amplifier used to boost the voltage induced in the pickup coil should not have a response down to DC. It's best to use an amplifier that cuts out at a frequency that is 25-30 % of the lowest frequency to be measured. The lowest power frequency currently in use, as far as the authors know, is  $16\frac{2}{3}$  Hz, which is used by European electric railways for powering traction motors used in locomotives. This would suggest using a low frequency cutoff of around 4-5 Hz. This has proven satisfactory in practice, as moving the meter does not result in a large

"blip" in the reading due to the earth's magnetic field. Reducing the cutoff frequency to 1 Hz definitely causes this effect to be noticeable.

Electric fields are sensed with a short probe connected to a FET op-amp, and the induced pickup is again rectified and displayed on a bar-graph display in the same manner. Calibration could be done but is so subject to error it would be meaningless. The circuit will easily detect the presence of 120 volts AC in a wire (i.e., a lamp cord) several inches away, and it can be used to find "hot" wires without a direct connection. Due to using a short E field probe, sensitivity is proportional to frequency of the field. Frequency response in the HR and E positions is about 5 kHz, with usable sensitivity to well over 50 kHz for use in checking VDTs and TV sets.

The meter uses one quad op-amp (TL084), a display driver (LM3914), and has three pickup coils orthogonally oriented (X, Y, and Z) that have 350 turns of wire each. The coil to be used is selected via a 3-position slide switch. This avoids having to hold the meter at awkward angles. Battery supply can be either  $\pm 6$  or  $\pm 9$  volts supplied by AA cells or two nine volt batteries.

If an external coil mounted on a probe separate from the meter is desired, one of the coils (the X-axis coil) is disconnected from the circuit by a closed circuit jack (J1) when a  $\frac{1}{8}$ -inch plug is inserted. A length of shielded wire is used to connect the coil to the meter. That allows a larger coil with more area and/or turns to be used with a corresponding increase in meter sensitivity. If the number of turns is doubled and the coil area is increased by a factor of five for example, the meter sensitivity will be doubled due to doubling the turns and increased by another five times due to the larger coil area for a total of ten times increase. (In this case we have double the number of turns enclosing five times as much flux, leading to ten times the induced voltage at a given field strength and frequency). The suggested external coil in this article has about one third the number of

turns but 150 times the area of an internal pickup coil, giving up to fifty times the sensitivity. That allows detection of very weak fields, as low as .02 milligauss.

**How It Works.** The TL084 quad FET op-amp performs all the amplification functions needed in this circuit. Switch S1 is used to connect one of three identical 350-turn pickup coils (L1-L3, which correspond to the circuit's X, Y, and Z axis) to the input of the amplifier system corresponding to three axes. The three coils allows the meter to perform without having to reorient it in a possibly awkward position. The three components (HR, H, and E) can be read; the total field vector is the square root of the sum of the squares of the three readings.

Some designs sum the readings arithmetically using diodes, but that does not provide an accurate reading; the results can be misleading. In practice, the strongest reading is used as the significant one for further investigation.

The output of the selected coil is fed to a voltage divider, comprised of R1-R3, which is tapped at the junctions formed by those resistors. Those taps, corresponding to 100%, 10%, or 1% of the pickup coil outputs, are connected to GAIN switch S2. The selected signal is fed to the common inputs of two separate amplifier stages, IC1-a and IC1-b. IC1-a has a gain of 100 (40 dB) and has a 3 dB response of 4 Hz to 20 kHz or better. The output of the IC1-a amplifier is proportional both to flux in the pickup coil and also to the frequency of the magnetic flux in the pickup coil (HR position).

Amplifier IC1-b has a gain starting at 60 dB at around 6 Hz and falling -6 dB per octave (or 20 dB per decade) with a nominal gain at 60 Hz equal to 40 dB, the same as IC1-a. Op-amp IC1-b has a  $1/f$  frequency response that compensates for the fact that the induced voltage in a coil is proportional to frequency. The output of IC1-b is, thus, theoretically proportional to flux in the pickup coil and constant with frequency. For example, a given flux density at 120 Hz will induce twice the voltage in the coil that 60 Hz will. However, it will be

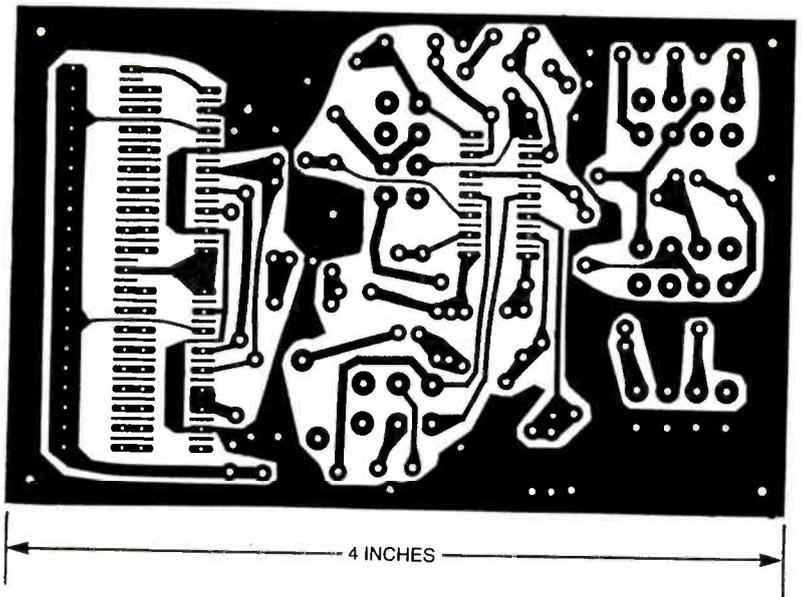


Fig. 2. The EMF Meter was assembled on a printed-circuit board, measuring 4 by 2 1/2 inches. A full-size template of the board's foil pattern is shown here.

amplified only half as much. The output will then ideally be independent of frequency (H position).

Using two separate amplifiers makes it possible to interpret flux readings in two ways. One theory claims that it is the induced voltage in the human body that causes problems. That is proportional to both flux and frequency. Another claims that it is flux alone, independent of frequency up to about 1 kHz, that is harmful. So, we are covered either way by having both measurements available. Both amplifiers have the same gain at 60 Hz, the most common power frequency in the US and Canada. Error at 50 Hz used for power in Europe and Asia is less than 1 dB, and this error can be safely ignored as no exact limits or standards have been found as of yet. C3 can be increased to 0.0033  $\mu$ F to make IC1-a and IC1-b equal in gain at 50Hz rather than 60 Hz if desired.

Components R5 and C2 set the low frequency response of IC1-a, together with C1 and R4, while R8 and C4 set the LF limit of IC1-b. Components R7 and C3 set the gain and frequency response of IC1-b and are chosen for +40 dB at 60 Hz. R6 sets the gain of IC1-a to 40 dB. HF response is limited by the gain bandwidth product of the op amp and this is typically 2 MHz or better, so the closed loop gain of 40

dB (100x) is held out to 20 kHz or better with 40 kHz typical. This is more than adequate for detecting higher frequency fields from VDTs, TV sets, switching regulators, and electronic ballasts used in lighting (compact fluorescent) operating at 10 to 100 kHz. Op-amp IC1-a is typically used for this function (HR position) as IC1-b is operating at less than unity gain above about 6000 Hz.

Op-amp IC1-c is used with an active E-field probe to sense E fields. ANT1 is a short 2-3 inch (or 5-9 cm) pickup wire mounted above the PC board. Strong E fields of 100V/meter or so will induce enough voltage on this wire to produce an indication on the meter. Components R12, D1, and D2 provide bias and input voltage protection for IC1-c. Resistor R9, along with R10 and R11, as selected by GAIN switch S4, set the voltage gain of IC1-c to 0, 10, or 20 dB. Capacitor C9 limits response to 7000 Hz, which is the typical upper limit of the audio range. However, useable response is available to well over 100 kHz, since the E-field pickup probe has a rising response directly proportional to frequency. The E field from a typical TV set can be sensed as far as two feet away from the circuit, and 60 Hz fields from 120V wiring are detected at a distance of six inches from the pickup antenna.

A fluorescent lamp usually gives

an indication at two feet. The meter can also be used to tell if the case of an appliance is grounded or not. A properly grounded appliance will show little E-field indication, while one not grounded will show a strong indication even if turned off. The outputs of IC1-a, IC1-b, and IC1-c are fed to E-GAIN switch S3; Switch S3 is used to select one of the three amplifiers (HR, H, or E) and feeds its output into stage IC1-d, which has a gain of about 34 dB that is adjustable via R14 to calibrate the meter circuit. Components C5 and R13 pass signal to IC1-d whose gain depends on R16, R15, and the setting of R14. The output IC1-d is fed to a voltage doubler/rectifier circuit, comprised of C6, D5, D6, and C7. Components R18, C8, and R19 are used to reduce AC signals on the rectified DC and set the LED meter ballistic characteristics to resemble an analog mechanical meter.

The meter has a full-scale deflection of around 3 volts. Components D3, D4, and R17 are used as a non-linear feedback network so as to

obtain a linear meter indication versus AC input to the input of IC1-d. Overall gain is such that 20 to 40 microvolts of AC input signal from the pickup coils produces a full-scale deflection, which corresponds to a 10- to 20-milligauss full-scale on the highest gain scale. We recommend using a 20-milligauss full-scale calibration.

If greater sensitivity is needed, use a larger pickup coil mounted externally to avoid AC feedback and to allow lower amplifier gain. The total gain can exceed 80 dB, and this is pushing things as far as stability is concerned, due to the use of a single-sided board, an unshielded case, and high-impedance FET circuitry.

The meter consists of IC2 and IC3, a pair of LM3914 LED dot/bar display drivers and two 10-segment LED bar-graph modules, which were cascaded to give a 20-segment meter. That's sufficient resolution (5% full scale) for our purposes. Red LEDs were used, but any other color or combinations of colors could be used as long as it is

remembered that all LEDs are driven with the same DC current levels. Individual LEDs can be substituted for the bar-graph modules.

Resistors R20-R22 set up IC2 and IC3 for cascaded, dot-mode operation. Bar-graph mode operation could be used, but battery drain when 20 LEDs are lit (full scale) would approach 200 milliamps. Dot mode prevents premature battery drain, since only one or two segments are lit at a time. Resistor R23 cuts off a segment of DISP1 when any of the segments of DISP2 are lit. Components C10 and R33 form a filter network that is used to suppress a tendency for the display to be unstable due to possible RF oscillation. In addition, R23 limits maximum possible LED current in case of a short circuit avoiding damage to individual segments. S5 serves as an on-off switch for the circuit. Batteries BT1 and BT2 are six to nine volts each.

Power is supplied for the circuit using two six- or nine-volt batteries. A voltage divider or active splitter using an op-amp could have been used so that there was only one battery, but it was not worth the extra parts as large decoupling capacitors would be needed. Only a few milliamps of negative supply are needed; thus battery life approaches its shelf life. The positive supply must handle 10 to 20 milliamps. We used two sets of four AA batteries, cheap and simple, and they fit our case perfectly. Two nine-volt batteries could also have been used. With a larger pickup coil, fields of less than 1 milligauss can be detected and measured if desired, but the usefulness of doing this is dubious. Magnetic fields of 60 and 120 Hz of this level exist anywhere electrical devices are used. Currently there is no evidence to suggest levels that low are suspect. And there is no real evidence that stronger fields are harmful either, so a level of 3 milligauss is a practical lower limit. This level may be present several feet from an appliance that uses a transformer or coil.

Jack J1 is used to connect an external coil to the meter. The coil is made from # 24 to #30 magnet wire and is six inches square. It is wound on a simple jig made from a scrap

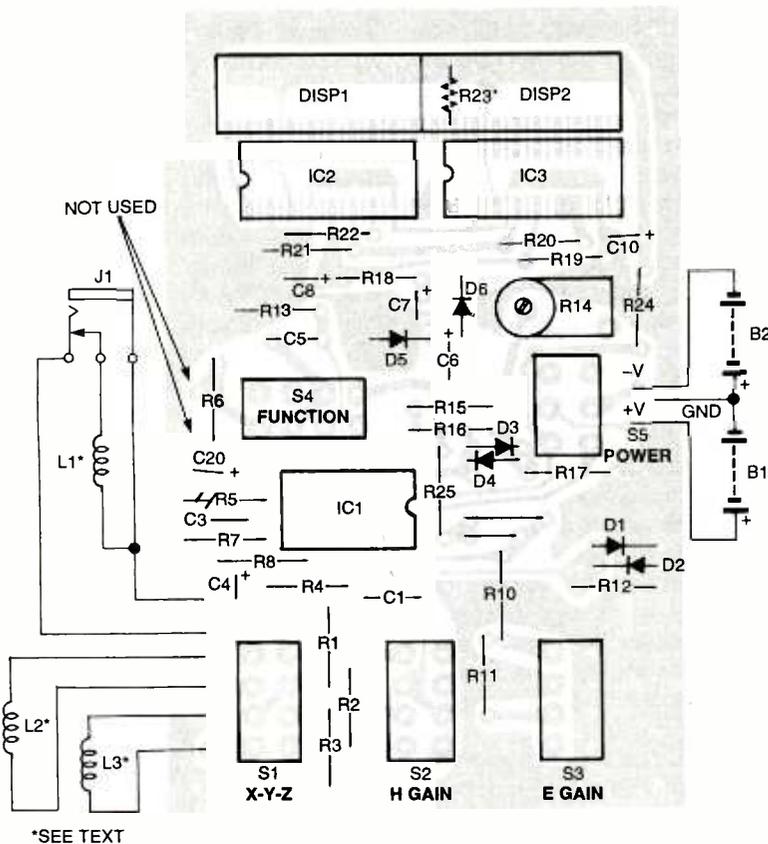


Fig. 3. Once you've etched your board (or purchased one) and obtained all of the components listed in the Parts List, assemble the printed-circuit board guided by this parts-placement diagram.

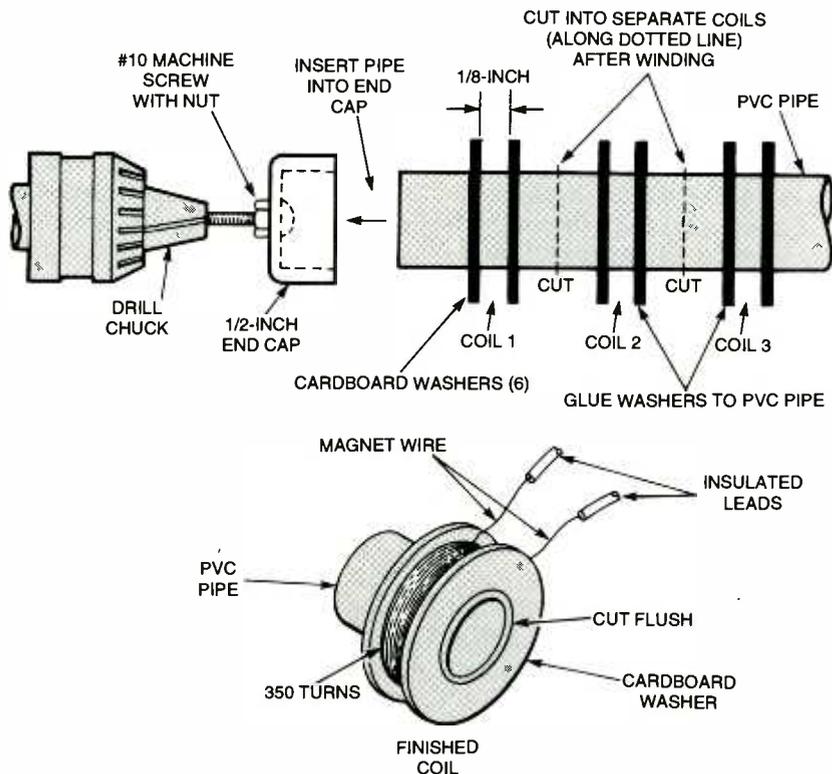


Fig. 4. The three pick-up coils for the EMF Meter were fabricated from a total of about 360 feet (120 feet for each coil) of magnet wire and homemade bobbins (coil forms) manufactured from PVC pipe and cardboard or fiber board. Details of the construction of those components are shown here.

of wood and four nails. A length of audio shielded cable is used to connect this coil to the meter circuitry. The coil can be wrapped with electrical tape and fitted with a wood handle. The meter sensitivity is multiplied 50 times with the external coil, allowing fields of 0.2 milligauss or less to be measured.

**Construction.** The EMF Meter was assembled on a printed circuit board measuring 4 by 2<sup>1</sup>/<sub>2</sub> inches. A full-size template of the printed-circuit board's foil pattern is shown in Fig. 2. That template can be lifted from the page and used to etch you own printed circuit board. The board is supplied with the kit from the supplier given in the Parts List.

Once you've obtained all of the parts listed in the Parts List, construction can begin. Assemble the printed-circuit board guided by the parts-placement diagram shown in Fig. 3. Start by installing DIP sockets for the ICs and bar-graph displays. After that, follow the usual construction sequence, installing all the passive components (resistors, capacitors, switches, etc.) except

R23 and L1-L3, followed by the non-socketed semiconductors (diodes), saving the ICs and bar-graph displays for later. The three coils are hand-wound units that have yet to be fabricated.

After all the passive components have been installed on the top side of the board, mount R23 on the bottom of the board. When installing the polarized components (electrolytic capacitors, diodes, and other semiconductor devices), make absolutely certain they are properly oriented. Installing any polarized component incorrectly can cause the circuit to function erratically, or not at all, and can lead to total component failure.

Before installing S5, solder bare, tinned leads to its lugs and then insert the leads into the board. That's done so that the mechanical mounting height of S5 matches S1 through S4.

In the author's prototype, the three pickup coils (L1-L3; we'll get to their assembly in a moment) were mounted separately to three inner walls of the meter's enclosure so as to provide complete cover-

age of all three axis—X, Y, and Z—regardless of the meter's orientation. One coil is affixed flush to the upper portion of the case (up/down axis); another is secured flush to the right side wall of the enclosure (left/right axis); and the final unit is mounted flush to the inside front wall of the housing (forward/backward axis). A dab of silicon cement (or hot-melt glue) can be used to secure the pickup coils in place. After that, the pickup coils are connected to the printed-circuit board at the points indicated in Fig. 3.

Make sure the coils do not come in contact with the other board-mounted components. When finished, carefully check your work for all of the most common construction errors, which include cold solder joints, shorted components, incorrectly placed or misoriented components, etc. If you spot any construction errors, correct them immediately. Once the accuracy of construction has been verified, it is time to move on to the next phase of construction.

#### Internal Pickup Coil Fabrication.

The internal pickup coils were wound on home-brewed forms that were fabricated from a 3- to 4-inch length of 1/2-inch (ID) diameter plastic pipe; the outside dimension (OD) of the pipe is close to 5/8 inches. Figure 4 outlines the fabrication of the internal pickup coils. Fabricate the three bobbin-like coil forms by placing six cardboard or fiber washers approximately 1-inch in diameter on the 3-inch length of pipe, spacing each pair of washers about 1/8-inch apart, as shown in Fig. 4, and glue them in place. Once the glue has cured, the coil form is ready to accept the coil wire.

The easiest way to wind the coils is to mount the piece of pipe in some type of jig where the pipe can be rotated by crank or motor. The authors used a hand drill to rotate the forms during the coil-winding process. To that end, a hole was drilled into a 1/2-inch end cap, a #10 machine screw threaded through the hole, and the screw secured in place by a nut. The shaft of the machine screw was then

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## PARTS LIST FOR THE E-H FIELD METER

### SEMICONDUCTORS

IC1—TL084N quad op-amp, integrated circuit  
 IC2, IC3—LM3914N dot/bar-graph display driver, integrated circuit  
 D1-D6—1N914B or 1N4148 general-purpose, small-signal, switching diode  
 DISP1, DISP2—10-segment, light-emitting diode, bar-graph display

### RESISTORS

(All fixed resistors are 1/4-watt, 5% units.)

R1—91,000-ohm  
 R2—9100-ohm  
 R3, R20, R21, R25—1000-ohm  
 R4, R6, R12, R13—1-megohm  
 R5, R8, R10, R17, R23—10,000-ohm  
 R7—10-megohm  
 R9, R15—100,000-ohm  
 R14—100,000-ohm potentiometer  
 R11, R18—22,000-ohm  
 R16—2.2-megohm  
 R19—330,000-ohm  
 R22—1200-ohm  
 R24—33-ohm

### CAPACITORS

C1—0.1- $\mu$ F, 50-WVDC, Mylar  
 C2, C4—4.7- $\mu$ F, 35-WVDC, electrolytic  
 C3—0.0027- $\mu$ F, 100-WVDC, Mylar  
 C5—0.047- $\mu$ F, 50-WVDC, Mylar  
 C6-C8—1- $\mu$ F 50-WVDC, electrolytic  
 C9—220-pF NPO, ceramic-disc  
 C10—10- $\mu$ F, 16-WVDC, electrolytic

### ADDITIONAL PARTS AND MATERIALS

S1-S4—2P3T slide switch  
 S5—DPST toggle switch

L1-L3—350-turn pickup coil (see text)

J1—1/8-inch, closed-circuit, phone jack

Printed-circuit materials, IC sockets, wire, solder, hardware, etc

**Note:** A kit of parts—consisting of an etched and drilled printed-circuit board; three pre-wound, 350-turn pickup coils; all board-mounted components; J1; two bar-graph displays; a suitable plastic case; and complete documentation for assembly and test—is available for \$59.95 from North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053; e-mail: [Ncradio200@aol.com](mailto:Ncradio200@aol.com); Web: [www.northcountryradio.com](http://www.northcountryradio.com).

Please include \$4.50 for shipping and handling within the US; \$10 for shipment outside the US. NY State residents, please add \$4.50 sales tax. For a catalog of many other kits, please send \$2 and a stamped (\$0.70) self-addressed envelope to North Country Radio at the address above.

Note the materials for the remote sensing coil are not included and can be purchased locally. Batteries and battery holders are also not included as these are at the discretion of the builder and are also best purchased locally. Try electric motor repair shops as a source of magnet wire.

remove.

Using the nails as a square form, wind 114 turns (approximately 240–250 feet) of 24 to 30 gauge wire, plus or minus 5 percent, onto the form. Make sure to leave a length of wire at each end of the winding for making connections to the cable. Try to leave a little space between the wood and the coil windings so that a piece of tape can be slipped beneath the coil and wrapped around it to keep the windings from unraveling. Carefully remove the finished coil from the form. Removing one of the nails from the wooden coil-form base makes it easier to remove the coil.

Solder the ends of the coil's magnet wire to a 3- to 5-foot piece of good quality RF or audio shielded cable. Use a cable that is flexible enough to bend easily, and still stand up to everyday use without breaking. Connect one lead to the shield, the other to the center conductor. The polarity of the winding does not matter. Solder and tape the connections to prevent shorts. With that done, wrap the whole assembly with several layers of PVC tape to protect it. Bring the cable out at right angles to one side of the coil, making sure it is secured so the connections won't be broken.

Install a 1/8-inch phone plug on the other end of the cable. The plug mates with the 1/8-inch closed circuit jack on the field meter. Test the coil for continuity and to make sure the cable and/or jack is not shorted. Take a resistance reading of the coil: it should read between 4 and 25 ohms depending on the wire size used to wind the coil. The actual DC resistance of the coil is unimportant as long as the coil's impedance is less than 5000 ohms.

An optional handle for the coil can be fashioned from an 18-inch length of 3/4- by 1/2-inch wood or plastic. The coil can then be fastened to the handle using plastic cable clamps or tie wraps. **Do not** use metal for the handle, as it may short the windings or cause problems. When all the coils have been wound and checked, it's time to test the unit.

**Test Procedure.** Connect three wires to the circuit-board power

clamped into the drill chuck. The drill was then activated as 350 turns of #36 AWG enameled magnet wire were fed onto each bobbin. The number of turns can be counted manually. As an alternative, provided that a lathe is accessible, the pipe can be clamped into the lathe's chuck, and the lathe run at low speed as the coil wire is fed onto the forms. If available, a mechanical turns counter can be used to keep track of the windings. Be sure to leave a little extra magnet wire at each end of the coils.

Once all the coils have been wound, 26- or 28-gauge stranded insulated wire should be connected to each coil lead. Each joint should be insulated with a thin layer of Mylar or scotch tape, and then the entire coil wrapped in electrical tape. After winding the coils,

check each unit's DC resistance to make sure the coil is OK. The three coils should each have a resistance of approximately 27 ohms,  $\pm$ 3 ohms; but more important, all readings should closely agree.

### External Sensing Coil Construction.

The external sensing coil is little more than approximately 250 feet of enameled wire formed into a 6-by 6-inch square and then mounted to an 18-inch long piece of 3/4-by 1/2-inch wood. A temporary coil form was fabricated from a 7-inch square, 1/2-inch thick piece of wood by first drawing a 6- x 6-inch square on the surface of the wood and then driving a 6 or 8 penny finishing nail into each corner of the square drawn on the wood. Be sure to drive the nails deep enough so that they are secure, but easy to

supply traces as shown in Fig. 3. It's a good idea to use three different colors (red, black, and white, for instance) to identify the plus, minus, and ground leads. Connect one of the pickup coils to the X input traces (see the parts-placement diagram in Fig. 3). If possible, hold the PC board in a small bench vise or other support to make testing easier. Set S1 to the X position, S2 to the X10 position, S3 to the +10 position, and S4 to the HR position. Set S5 to the off position.

Connect the power source (plus, minus, and ground) to the three power leads. A dual-polarity bench supply or two six- to nine-volt batteries can be used for testing. If a bench supply is used, set it for  $\pm 6$  volts. Flip S5 to the on position; the bar-graph displays should come on and jump briefly to the right, then settle back toward the left—essentially acting like a pointer on a panel meter. It may settle at some mid-point in the display; or if there are no magnetic fields present, it may even go out.

If a fluorescent lamp is near your work area, bring the pick-up coil toward it. Doing so should produce some indication on the display. If that checks out, set S4 to the H position and repeat step 4; you may or may not see a difference in the readout. If the circuit functions as expected, set S4 to the E position, and bring your hand near the pick-up coil; doing so should produce some indication.

If that works out, set potentiometer R14 to its mid-position. If you have some test equipment, you can use R14 to calibrate the meter's sensitivity. If not, leave it at mid-position as no calibration is really necessary—you'll be looking for "hot spots," points where EMFs originate. Those with access to a calibrated audio generator can feed a 20- $\mu$ V, 60-Hz signal to the input of IC1 (S2/C1 junction) with S4 set to the H position and R14 set for a full-scale deflection on the EMF Meter's bar-graph display. As an alternative, a 6- or 12-volt transformer and resistor network (to attenuate a 60-Hz AC line signal) can be used as a signal source. Be aware, however, that the source

(Continued on page 50)

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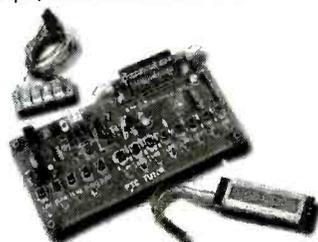
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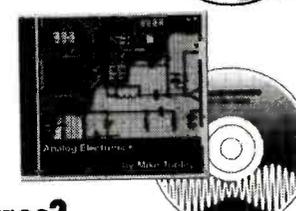
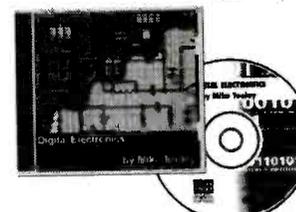
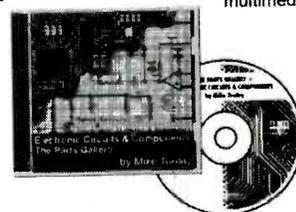
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 John Becker

*Get the facts on electric- and magnetic-field radiation and learn what you can do to combat this possible health hazard.*

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

**S**ince the 1970s, a number of articles have been published concerning the possible health and environmental damage resulting from exposure to electric and magnetic fields. Those fields emanate largely from man-made sources, such as power and telephone lines, and radio-frequency transmitters, or from devices operated by electrical power.

Power frequencies range from a low of 16 $\frac{2}{3}$  Hz used for some railway systems to 400 Hz and higher, used in military and aircraft power systems. Those frequencies are often accompanied by harmonics caused by either waveform distortions in the power as generated or else due to the effects of loads and system unbalances.

However, there is a lot of misunderstanding about EMFs and other fields, which can lead to erroneous assumptions and fallacious ideas, tending towards pseudo science. Because field theory is a very big and complex subject, there will be only a simplified explanation here to facilitate understanding the issues. Purists and perfectionists will have to excuse the simplifications.

**Basic Field Concepts.** There are two types of fields that are of immediate concern. The first is the electric field—a vector quantity (having both magnitude and direction) originating from a definite source and ending at a definite sink. An example would be a charged wire or body above a ground plane. Lines of force (actually a fictitious way of visualizing magnitude and direction) would originate on the charged body and end on the ground plane. The gradient of the field or the change in potential

(volts) along one of those lines for a specific unit of distance (usually meters) is called the field strength—a quantity usually expressed in volts per meter and given by:

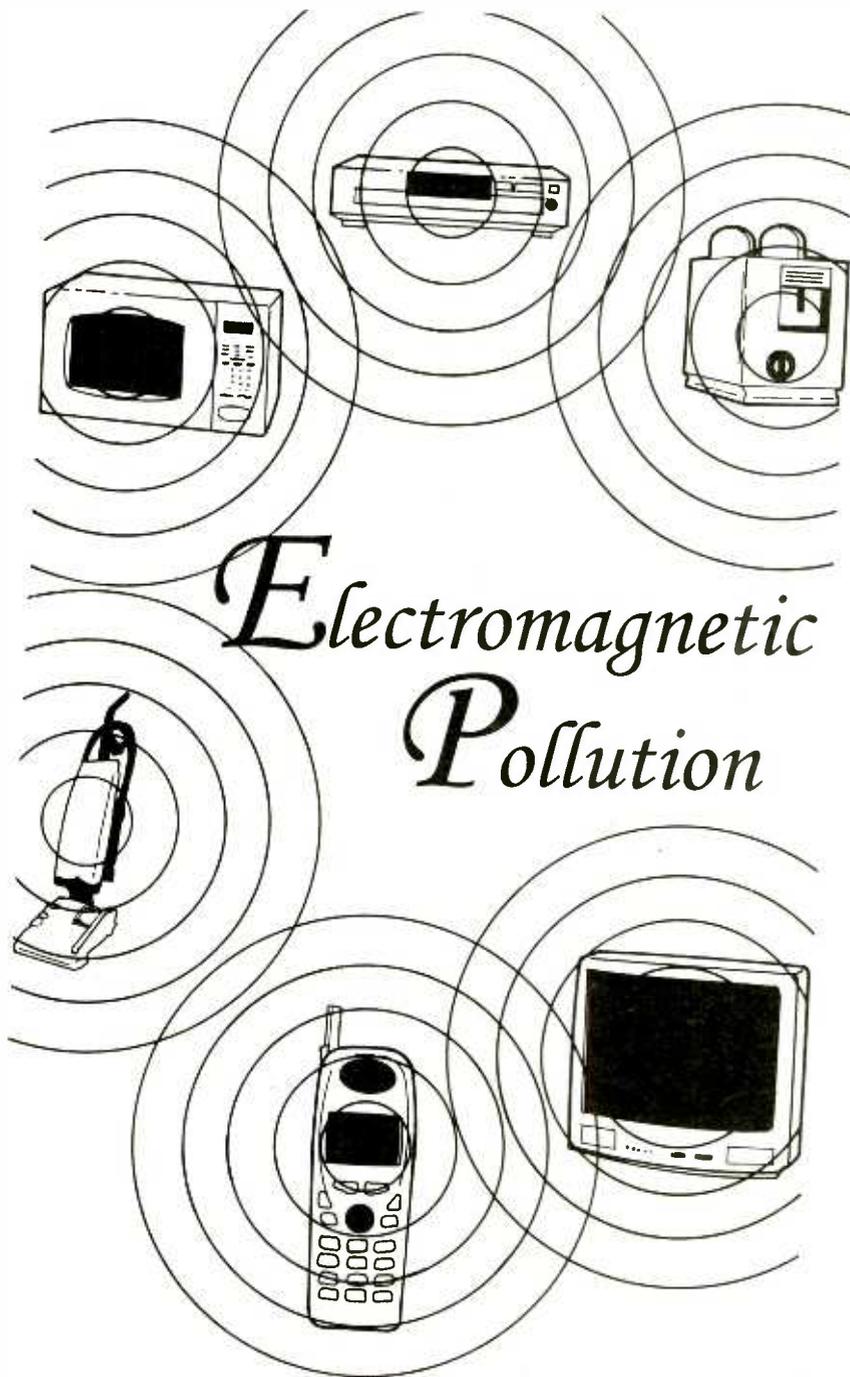
$$E = -\Delta V/\Delta X$$

where E represents the field strength in volts and  $-\Delta V/\Delta X$  symbolizes the derivative or slope of the electric intensity at a point

along X or some other reference axis. The electric intensity is the potential (voltage) with respect to a point at infinity or in practice, a point far enough away so the field is close to zero or ground reference (see Fig. 1).

A charged body having a charge of Q coulombs would produce a field intensity of

$$E = Q/(4\pi\epsilon)r^2$$



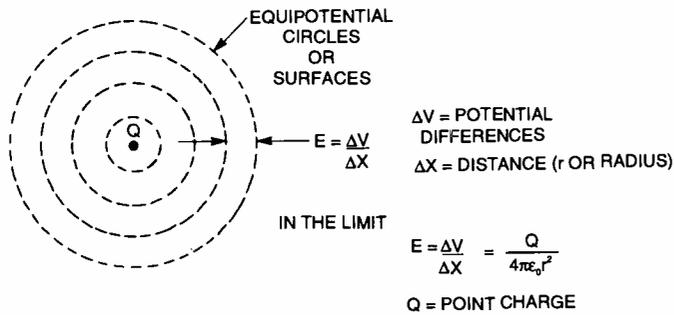


Fig. 1. Electric-field intensity is a measure of the strength of an electric field in volts per meter.

where  $\pi$  (pi) is 3.14159,  $\epsilon$  is  $8.85 \times 10^{-12}$ , and  $r$  represents the radius or distance from center. The charged body is an infinitely small point that can be a sphere or cylinder compared to the distance ( $r$ ) from it. Potential is defined as the amount of work required to bring a charged body in from infinity to a specified distance from another charged body. That energy is referred to as potential energy.

Since two like charges repel each other, the effect can be compared to releasing a compressed spring.

In addition, the electric field is conservative, which means that the work needed to move a charged body is the same regardless of path. If one charged body is released, it tends to fly away from the others with some force. The effects of two charged bodies attracting or repelling each other

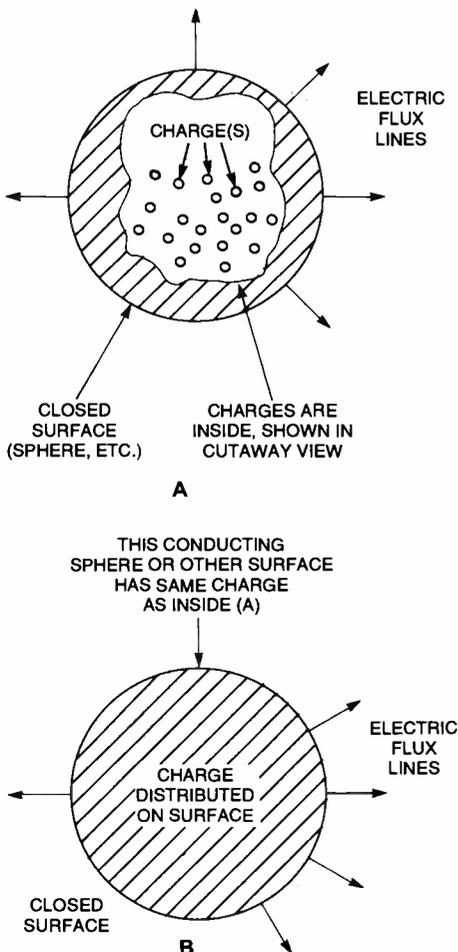
was investigated by Coulomb (for whom the unit of charge is named) in 1785. What he discovered is that force is proportional to the magnitude of the charges and inversely proportional to the distance between them. That effect is also linear—the field from a number of separate charges being the linear sum of the individual fields from each charge.

A coulomb is the amount of charge crossing the surface of an object when one ampere flows for one second across the same surface. Actually, the ampere is defined as one coulomb of charge flowing across a surface for one second, the coulomb being the fundamental unit.

All physical objects have capacitance associated with them. The human body has 50 to 100 pF. A 50-pF capacitor that is charged to one coulomb would have to have a potential of 20 billion volts. That's because the definition of capacitance is the ratio of charge to voltage ( $C = Q/V$ ).

A law known as Gauss's Law states that the total electric flux crossing a closed surface must equal the charge contained within that surface. Therefore, we can replace the point charge with a charged spherical body of arbitrary radius. At all points outside that sphere, the effect of the charged sphere will be the same as an equivalent point charge at the center of the sphere (see Fig. 2).

A sphere 1-meter in diameter charged to one coulomb would produce an electric field intensity of 900,000 volts per meter at 100 meters from the sphere and 9000 volts per meter at 1 km. Two large metal plates 1-meter square that were spaced 10 cm apart would form a parallel-plate capacitor (see Fig. 3A). If 120 volts AC were applied between the plates, an AC field of 1200 volts per meter would exist between the plates. By the same reasoning, the field directly below a 230-kV power line 40-feet high (12.2 meters) would be approximately 18,850 volts/meter (see Fig. 3B). Of course, the actual field intensity would be a function of the surroundings and rather complex geometry, but a "straight-



GAUSS'S LAW

THE TOTAL ELECTRIC FLUX EMANATING FROM A SURFACE EQUALS THE CHARGE WITHIN

$$\int_{\text{AREA}} \mathbf{D} \cdot \mathbf{N} \, ds = \int_{\text{VOLUME}} \rho_v \, dv$$

$\mathbf{D}$  = ELECTRIC FLUX =  $\epsilon_0 \mathbf{E}$  VECTOR

$\epsilon_0$  = PERMITTIVITY

$Q$  = CHARGE

$Q_v$  = CHARGE DISTRIBUTION

AT ANY DISTANCE OUTSIDE THE SURFACE, THEREFORE A & B PRODUCE THE SAME EFFECT

Fig. 2. Gauss's theorem, an expression for determining the intensity of a magnetic field depending on the charge, states that the total electric flux crossing a closed surface must equal the charge contained within in that surface.

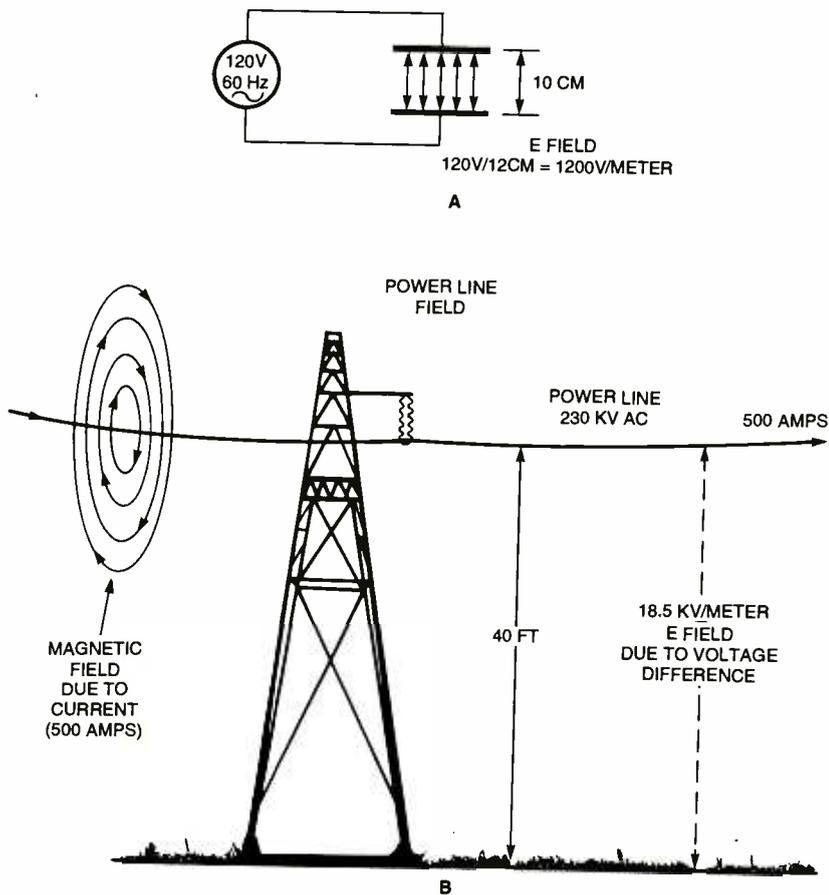


Fig. 3. If 120 volts AC were applied to a capacitor—comprised of two 1-meter square metal plates spaced 10 cm apart (see A)—an AC field of 1200 volts per meter would exist between the plates. By the same reasoning, the field directly below a 230-kV power line 40-feet high (12.2 meters) would be approximately 18,850 volts/meter (see B).

line approximation" would give an idea of the magnitude of the field.

It is also known that a natural electric field—which may be a few hundred volts per meter in fine weather to several thousand volts per meter during electrical storms—exists between the earth and its upper atmosphere. That's because at any given point in time, there are thunderstorms occurring somewhere on earth, and the upper atmosphere and the surface of the earth form a charged capacitor with a large capacitance. The capacitance between two concentric spheres of radius A and B respectively in air or a vacuum is given by:

$$C = \frac{(111.2 \times 10^{-12})(A \times B)}{(B - A)}$$

where A is the radius of the inner sphere in meters, B is the radius of the outer sphere in meters, and C is

capacitance in farads.

For simplicity, assume the earth is one plate of a spherical capacitor and that the other plate is a conducting layer of air located about 10 km above the earth's surface. If that were true, the capacitance between that layer and the earth (radius = 12800 km) would be about 18 farads—imagine the size of such a capacitor (huge to say the least). Of course, that's an idealized case, and the actual capacitance is smaller, but still pretty large.

Note that if B is extremely large compared to A, the  $A \times B / (B - A)$  part of the expression approaches  $AB/B$  and becomes simply A. We mention that fact to show that a spherical capacitor with an infinitely large radius outer conductor (the entire universe; see Fig. 4) becomes:

$$C = (111.2 \times 10^{-12}) (A)$$

That shows that an isolated sphere

or any other shape can act like a capacitor. Anyone who has been shocked by static electricity after walking across a carpet and touching a doorknob has experienced that phenomena. The shock is produced by the charge accumulated and stored on the body and then rapidly discharged onto another body or ground. The body is like a 50 or 100 pF capacitor charged to several kilovolts.

A sphere with a 1-meter radius, in theory, has a capacitance of 111.2 pF. A sphere the size of the earth would have 142 microfarads capacitance with respect to the universe. It is also a fact that there exists a total current flow of about 1500 amperes or more between the plates of the capacitor formed by the earth and the conducting layers of its atmosphere over the entire surface of the earth.

That sounds like a lot of current, but when the area of the earth is calculated (197 million square miles), it's only around 7 microamps per square mile. We mention that to make the reader aware of naturally occurring fields that have been around a lot longer than the human race. If they were harmful, you wouldn't be reading this article. We could not, therefore, escape electric fields even if we returned to the days of antiquity, ages before electricity was known.

However, electric fields terminate at a conducting surface, since for a perfectly conducting surface the magnitude of E tangential to that surface must be zero. In other words, the conductor "shorts out" the field, as zero voltage exists at a short circuit. Therefore, electric fields are easily contained by enclosing the conductors inside a shield or a metal case as most electronic apparatus does. Electric fields also penetrate non-conducting surfaces. Partially conducting surfaces won't provide complete shielding, but can reduce field intensity to some degree. Almost all metals and conductive plastics do a pretty good job, however.

**Magnetic Fields.** Things are somewhat different for a magnetic field. The magnetic field is a solenoidal

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BP290 . . . An Intro to Amateur Communications Satellites . . . . .	\$5.99	PCP114 . . . . . Advanced MIDI Users Guide . . . . .	\$10.99
BP297 . . . Loudspeakers for Musicians . . . . .	\$6.99	ETT1 . . . . . Wireless & Electrical Cyclopedia . . . . .	\$4.99
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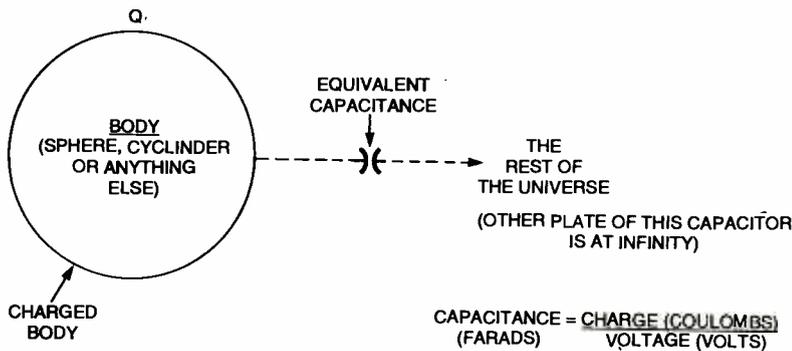


Fig. 4. Almost any isolated object can act like a capacitor, as demonstrated by the shock that occurs after walking across a carpet and touching a doorknob.

field, having no lines that originate or terminate at a source or sink. The magnetic field is inherently present around any current-carrying conductor (see Fig. 5). For a long straight wire, magnetomotive force (MMF), denoted by the symbol  $H$ , is a function of the current in that conductor:

$$H = I/(2\pi A)$$

where  $H$  is magnetomotive force,  $A$  is the distance from wire, and  $I$  is the current in wire

Ampere's Circuital Law states that the magnetomotive force ( $H$ ) around any closed path is equal to the current crossing the surface of which this path is a boundary. The magnetic induction, denoted as  $B$ , is related to  $H$  by the following equation:

$$B = \mu H$$

where  $H$  represents magnetomotive force, and  $\mu$  indicates permeability.

The permeability of a substance or medium is a measure of how easily magnetic lines "flow" through it—in essence, the magnetic analog of conductance in an electrical circuit. Iron, steel, and certain other ferrite materials exhibit high permeability, while air, water, and nonferrous metals have a much lower permeability. The permeability of free space is  $12.56 \times 10^{-7}$  henries per meter and is generally designated as " $\mu_0$ ." The permeability of ferrites and ferrous materials is generally 10 to several thousand times that of free space and is sometimes referred to as  $\mu$ . For this discussion, we're assuming free

space, so the value of  $\mu$  is  $12.56 \times 10^{-7}$ .

The magnetic induction ( $B$ ) is generally given in webers. However that's much too large, so the unit of magnetic induction used is the gauss, which is 1/10,000 of a weber. Therefore 10,000 gauss = 1 weber. In this article, we're concerned with fields of 100 gauss or less. The earth's magnetic field is about 0.5 gauss. As an example, the magnetic field strength around a wire carrying one ampere of current 10 centimeters (about 4 inches) from the wire is:

$$H = I/2\pi A = 1/6.28(0.1) = 1.59 \text{ amps/meter}$$

$$B = \mu H = 12.56 \times 10^{-7} \times 1.59 \text{ amp-henries/m}^2$$

$$B = 19.97 \times 10^{-7} \text{ webers}$$

$$B = 19.97 \times 10^{-3}$$

or about 20 milligauss.

One ampere is a little more cur-

rent than is drawn by a 100-watt, 120-volt light bulb. An AC field of 20 milligauss is present around a wire carrying that current. However, since most AC wiring is of the two-conductor type and the current in each wire flows in opposite directions with respect to each other, the fields nearly cancel each other. The magnetic field surrounding a wire is a set of concentric circles on a plane normal to the axis of the wire (see Fig. 6). The direction of the field is taken as that which a right-hand screw would rotate as the screw is turned, so it advances along the wire in the direction of current flow. That's known as the "right-hand rule." Therefore, two wires in parallel and in close proximity carrying equal currents in opposite directions produce magnetic fields that cancel each other. Wires that carry AC currents are often twisted or bonded together to produce the field-cancellation effect. However, the wires used for overhead AC distribution may be separated by several feet, so complete field cancellation may not occur, as one wire is closer to the ground than the other.

Also, while currents at 60 Hz may be opposite in phase and tend to cancel, their harmonics may not be. A 3-phase AC line consists of three lines with currents and voltages 120 degrees apart. But when two frequencies are multiplied by  $N$ , their phase difference is also multiplied by  $N$ . In that case, ideally the third harmonic currents are 360 degrees apart, which is the same as 0 degrees, and are therefore in

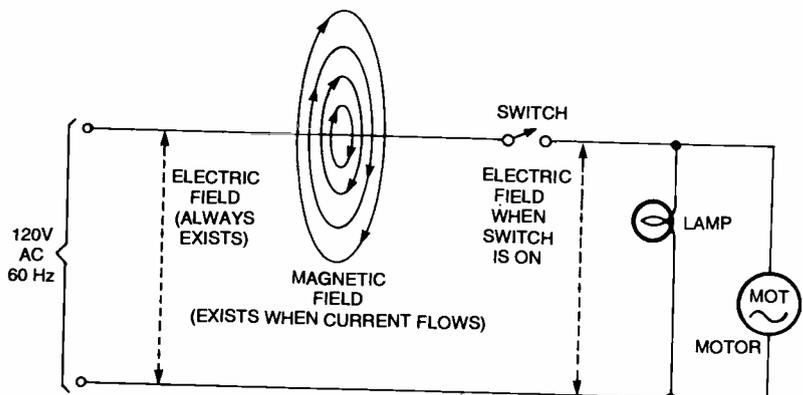


Fig. 5. A magnetic field is inherently present around any current carrying conductor. The magnetomotive force around any closed path is equal to the current crossing the surface of which the path is a boundary.

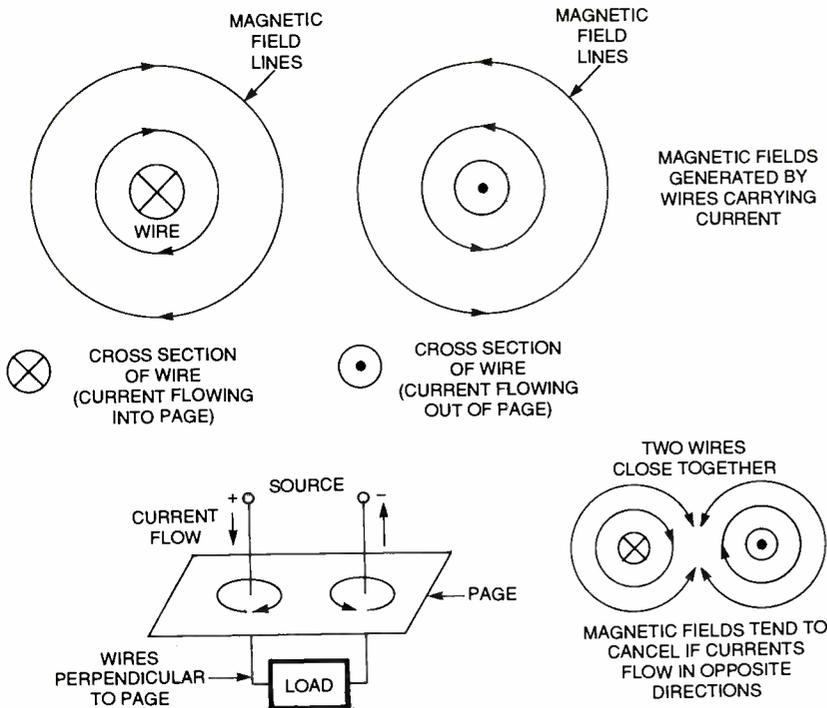


Fig. 6. The magnetic field surrounding a wire is a set of concentric circles on a plane normal to the axis of the wire.

phase. Under those conditions, they can reinforce and produce a strong 180-Hz field.

Harmonics originate from non-linearities in any system, such as core and magnetic saturation in transformers, motors, and rectifiers. AC generators often produce imperfect sinewaves containing harmonics. Non-linear effects and non-linear loads (such as the half-wave rectifiers used in inexpensive radio receivers and TV sets and thyristor devices used in light dimmer switches) are other sources of unwanted harmonics.

The magnitude of  $B$  drops off inversely with distance and is proportional to the current in the wire. (We'll refer to magnetic fields henceforth as  $H$  fields even though the magnetic intensity is given by  $B$ ). In free space,  $B$  and  $H$  are related by a constant. When ferrous materials are in the field, things become more complex, but most non-ferrous materials offer little shielding against  $H$  fields at power-line frequencies. Since AC magnetic fields are produced by AC currents, turning off a circuit reduces the time varying field to zero (unless moving magnets are present). Magnetic-field lines have no

sources or sinks. If a bar magnet with a North and South poles were broken in half, the two new magnets will still have N and S poles. You cannot have two magnets with stand alone North (N) or South (S) poles no matter how many times they are broken in half.

Magnetic lines of force exist only as closed loops. When a wire is coiled on itself, the magnetic intensity ( $H$ ) generated is multiplied by the number of turns in the coil: for example, a 100-turn coil of wire carrying 1 amp is the same as a 1-turn coil carrying 100 amp. The number of "ampere-turns" determines the magnetic intensity. Placing a magnetic material, such as iron or ferrite, inside the coil greatly increases the coil's magnetic induction ( $B$ ), since  $B$  equals  $\mu H$ ; permeability ( $\mu$ ), in this case, may be several hundred times that of air or free space.

Magnetic flux through a coil is the amount of magnetic induction ( $B$ ) passing along the axis of the coil multiplied by the area ( $A$ ) of the coil. Flux is designated by the Greek letter phi ( $\phi$ ). Note that  $\phi = B \times A$ . The voltage induced in a loop of wire is equal to the rate of change of the flux enclosed by that loop per unit time. For a multi-turn coil,

the induced voltage is multiplied by the number of turns. Therefore, if we have a coil of known size (area) and number of turns, measuring the AC voltage induced in the coil allows us to calculate the magnetic induction ( $B$ ) that is present along the axis of the coil.

Field frequency must also be known, since the induced voltage is proportional to frequency. Usually the frequency is taken as 60 Hz, the power-line frequency in the US or Canada. However, bear in mind that other frequencies and harmonics may be present as well. If that's the case, a separate measurement and calculation must be performed for each frequency involved, or else they can be summed and a peak worst-case reading determined. Therefore,  $E$  (electric) fields are generally easily controlled through shielding, but  $H$  (magnetic) fields are more difficult, with iron or other magnetic material needed to do the job.

Components made from ferrous materials are heavier, more expensive, and generally not as "pleasing" to the eye as plastics—which are available in wide range of colors and can be molded into shapes impossible to duplicate in metals at reasonable cost. In addition, plastics reduce or eliminate electrical shock hazards. Unfortunately, such plastics do not shield against magnetic fields and are not usually very effective against electric fields either. Thus, many everyday electrical household appliances can be sources of sometimes strong and possibly harmful magnetic and electric fields. Computer monitors, TVs, radio receivers, hair dryers, coffee makers, shavers, electric blankets, clocks, even the common "wall wart" transformers are strong producers of electromagnetic fields (EMFs).

### The Presumed Dangers of Field Exposure.

Years ago (during the 1970s), concern about the effects of power frequency EMFs arose. For years, it had been observed that electrical workers who were in close proximity to very strong magnetic or electric fields sometimes "saw" flashing lights or patterns believed to be due the effect of those fields on the nervous system.

That was obvious evidence that EMFs affect human beings directly. However, little attention was paid other than curiosity.

A blow on the head, an electric shock, or even a momentarily painful sensation such as stubbing a toe would similarly cause a person to "see stars." So this effect was probably dismissed. After all, the nervous system is known to operate with electrical currents, and it was logical to expect that strong EMFs could induce currents there. In turn, these currents could act as stimuli of some kind, producing such visual effects.

Life evolved in an environment wherein some magnetic and electric fields have always been present. The earth's magnetic field might be used by birds for navigation over oceans, out of sight of land, or during nights when star patterns are not visible. Electric eels use electric fields for sensing their surroundings as well as for self-defense. The point is that some animals may have evolved organs to use naturally occurring EMFs for sensing. No one thought that weak EMFs had any effect on the human body. Then, it was noticed that some electrical workers and other persons exposed to EMFs apparently were experiencing certain of health problems. The problems, whether real or imagined, were occurring at a greater frequency when compared with statistics from the general population. The problems ranged from fatigue and minor headaches to cases of cancer and heart attacks.

However, the correlation was found to be weak or non-existent when studies were made. Some studies claimed a definite link; others revealed none. There were contradictory results, and the studies were largely discredited. However, a nagging doubt remained. In the 1970s, electric power had been used for barely four generations, but in the years before World War II, it was not uncommon to find homes without electricity, especially in rural areas. The postwar years brought explosive use of electrical power with the appearance of new appliances—TV sets, fluorescent lighting, computers, microwave

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*New Yorker*; July 9, 1990

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Paul Brodeur  
*New Yorker*; December 7, 1992

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*Science News*; February 19, 1994, V145, n8, p 127

### **Closing The Book: Are Power Line Fields a Dead Issue?**

Gary Stix  
*Scientific American*; March 1998, p 33

### **Department of Amplification**

Paul Brodeur  
*New Yorker*; November 19, 1990, p 134

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Janet Roloff  
*Science News*; January 30, 1999, V155, p 70

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Robert Pool  
*Science*; September 21, 1990, V249, n4975, p 1378

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Cover story by Dixie Farley  
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Gary Taubes  
*Atlantic Monthly*; November 1994, p 94

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Paul Brodeur  
ISBN # 0-316-10909-6  
Little, Brown & Co., 1993

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David Noland  
*Discover*; December 1989, p 62

### **Rising Tension Over High Tension Lines**

Pam Black  
*Business Week*, October 30, 1989, p 158

### **Study Finds Possible Link Of Cancer And Power Lines**

*New York Times*; November 30, 1989, V139, p B26(L) col 1

### **Utilities agree: The EMF Issue is "very serious"**

*Electrical World*; September 1991, p 14

ovens, electric blankets, etc.—that generated all manner of EMF that had never been encountered before.

Few were aware of or even thought that the 60- and 120-Hz AC fields from electric clocks, hair dryers, and fluorescent lighting ballasts would be a problem. Higher frequency fields of 15–50 kHz generated by video displays, compact fluorescence, or switching supplies were generally not thought about. Today, the average home or office is literally full of field-producing devices. While the jury is still out on the biological effects of these fields, there's still sufficient evidence, both observed and anecdotal, that there may be significant problems. It might be wise to take some precautions to minimize EMFs in new designs, and to check existing equipment for EMFs. However,

one should not become an alarmist or scare-monger.

Actually, many of the EMFs generated by appliances and computers thought to be hazardous are magnetic in nature and disappear when the equipment is switched off. The practice of simply turning off appliances when not in use would be sufficient. For example, do not leave computers turned on when not in use, since there is no evidence turning them off shortens their lives. Yes, the semiconductors have to go through a warm up and cool down cycle, but there is less wear on the fans and drive motors.

Anyway, many computers today have a "green" feature, which removes power from certain components (hard drives, etc.) after so many minutes of keyboard or mouse inactivity. For every reason you should leave the computer on,

## EMF RELATED WEB SITES

**BioElectroMagnetics**  
[www.emfinterface.com](http://www.emfinterface.com)

**Bridlewood Electromagnetic Fields**  
[www.ncf.carleton.ca](http://www.ncf.carleton.ca)

**California EMF Program Home Page**  
[www.dnal.com/-emf/](http://www.dnal.com/-emf/)

**ELECTROMAGNETICS Forum**  
[www.tassie.net.au/emfacts/](http://www.tassie.net.au/emfacts/)

**Electrosensitivity**  
[www.feb.se](http://www.feb.se)

**EMFRAPID Home**  
[www.niehs.nih.gov/emfrapid/](http://www.niehs.nih.gov/emfrapid/)

**EMFs In The Workplace**  
[www.cdc.gov/niosh/](http://www.cdc.gov/niosh/)

**Infoventures**  
[www.infoventures.com](http://www.infoventures.com)

**Note:** These Web sites were accessible as of July 20 1999, but be advised that URLs may change during or after the time of publication.

you can come up with a reason to shut it down. You might as well save electricity, and energy conservation is not a bad idea. Furthermore, you'll be helping to reduce the "electromagnetic smog" that's so prevalent today. Electromagnetic smog will undoubtedly become an environmental problem in the future, and it is already a problem in our cities and crowded suburbs.

The authors are old enough to remember that when AM radios were tuned between stations, you'd hear mainly light background atmospheric noise and distant stations—not a loud, raucous 60-Hz buzzing—and AM reception sounded quite good. Possibly that pervasive racket has contributed to the decline of AM and short-wave radio. In fact, the RF levels of the smog might get bad enough to be hazardous just by themselves.

As a matter of fact, magnetic jewelry and bodywear that emit steady magnetic-field energy are popular today. Such items are sold to cure many ills. The notion that time-varying magnetic fields are

the "bad guys" is currently in vogue. However, if you look at the equations of field theory, time variance of the fields is not the only way currents are induced in objects. If an object is moved in a steady magnetic field, a current will be induced in it. As we move about our planet, we are moving through the earth's magnetic field, which is about 0.5 gauss—100 times stronger than a 5 milligauss time-varying field, a level some would claim is hazardous.

Yet, we do not all move at a steady pace. The instantaneous velocity of various parts of the body when walking, doing tasks, or even from nervous tremors will have some "AC" components. The AC components can be broken down into sinusoidal components, just like an electrical waveform can be broken into a series of sine and cosine waves. A body vibrating at 60 cycles per second (cps or Hz) will have a 60-Hz component induced in it—that applies to any frequency of vibration. That's also the principle behind the operation of a dynamic microphone. So the argument that the earth's steady magnetic field does not cause any harm because it can't induce any current in the body may not be correct. True, the frequencies are lower than power frequencies, but it is not known if the frequency of the induced voltages and currents is a factor. Remember, the motion of any body in a steady magnetic field can have the same effect as a time-varying field on a stationary body. If that were not true, every loudspeaker and dynamic microphone in existence would be in big trouble.

### Possible Hazards and Observations.

The exact mechanism by which EMFs cause damage to the cells of living organisms is not really known, except for the obvious destruction by electrolysis, or heating from resistive losses. The induced currents from weak (<1g) magnetic fields are not sufficient to cause heating. It is possible that the induced currents and voltages may in some way interfere with the transmission of nerve impulses; or in cell division or in ion transport across cell structures during chemical reactions; or could damage DNA; or could

cause other problems not yet determined. So far, the evidence is inconclusive.

In order to reach a credible conclusion, it would be necessary to take a large enough group of people of all ages (preferably a good mix representative of a cross-section of humanity to eliminate any possibility of genetic bias) and split it into two groups. One group would be the control group and have little or no exposure to EMFs. The other (study) group would be exposed to controlled levels for a specified period of time. Medical checkups on all participants would be conducted at intervals and at the end of a period of time the differences in incidence of diseases, etc. between the two groups could be studied.

The experiment could be repeated several times; only then could conclusions be drawn. But, that's obviously inhuman and unethical for any society that considers itself civilized. So we would have to use laboratory animals. Such an experiment would probably take years, and animal results may not apply to humans. So we may have to rely on studies and case histories, and never really get results from which a reliable determination can be made.

**News Flash.** An interesting news item appeared during the writing of this article—in *The New York Times* on July 24, 1999—that had a headline stating "Data tying cancer to electric power found to be false." That broad, sweeping generalization could lead those prone to knee-jerk reactions to conclude that all data found so far is false. They might not even bother to read the rest of the article. What actually happened was that two papers published by one scientist were biased by the elimination of data that did not support his conclusions. It's a pretty safe bet that in the near future another study will refute that finding with data to back up claims that EMFs are in fact hazardous. What is needed is to examine all those things objectively.

First, suppose that EMFs were scientifically proven to cause problems. A lot of big money interests

would get hurt. New restrictive legislation would eventually be passed, requiring shielding, modifications to existing equipment, and placing severe restrictions and code requirements on power line placement, as well as many other bureaucratic nightmares. Just think of what might be: new wiring codes; mandatory relocation of power lines; even condemnation of some buildings, such as factories, schools, offices, malls, and who knows what else.

Naturally, power companies would like the problem (not to mention the critics) to just dry up and blow away. It could be quite expensive to upset the status quo. And don't think it's above big business to cover up and lie about public hazards. It is a sad fact that it is cheaper to let a few people die and simply pay off the victim's families (in or out of court) than to fix the problem—witness the automotive and the tobacco industries. To top it off, governments have lied to the people throughout history as well. So, form your own opinions and **don't** always believe the "hype." Quite a few studies have been done that claim to have definite proof both ways.

**Study This.** The following paragraph mentions some of those studies, observations, and claims. References will be given elsewhere in this article for further reading. It is impossible to go into any details, as space does not permit such an excursion. However, several Web sites will be mentioned where interested readers can go; from those sites, many other links can be found. The amount of information is enormous and often conflicting.

In 1972, some reports from the Soviet Union referred to various health problems noted among those exposed to EMFs. The problems were not generally serious: fatigue, headaches, and general malaise. Then, in 1977, Dr. Robert Becker and biophysicist Andrew Marino testified before the New York State Public Service Commission about some experiments that were made on the effects of low-frequency magnetic fields on health.

Two years later, epidemiologist

Nancy Wertheimer and physicist Ed Leeper published a study that showed a link between some childhood cancers and power-line proximity to homes.

A 1982 study in the state of Washington showed that leukemia rates were elevated in 10 out of 11 occupations studied where workers were exposed to low-frequency EMFs. In 1988, a Maryland Department of Health and Hygiene study noted a higher than normal rate of fatal brain cancers in men employed in electrical occupations. Johns Hopkins University in 1989 found an elevated cancer risk in New York Telephone Company cable splicers. But, the articles in *New Yorker* and books by Paul Brodeur appearing in the early 1990s (see bibliography) probably were the ones that caught the attention of the public.

A study in 1991 in Los Angeles found significant associations between childhood leukemia, which is a form of cancer, and power-line proximity. Studies in Mexico and Sweden between 1992 and 1993 also showed increased incidence of leukemia in children that lived near power lines. Studies made in Denmark in 1993 found a correlation between increased incidences of childhood cancers and proximity to power lines, but not specifically leukemia. A Finnish study found an association with nervous system tumors in boys. There were eight studies made examining cancer risk for adults living near power lines, two of which found significant risk. Facts concerning those studies can be found at the Web site of Information Ventures Inc., as well as the National Institute for Occupational Safety and Health (NIOSH); those sites have links to many other sites.

**Reducing Exposure.** What can be done to reduce exposure? As mentioned before, no exact cause and effect relationship has, as of yet, been shown, nor have any exact levels been established. That's true of a lot of things in every day life, where definite cause and effect answers are not available, only trends and correlations. Answers probably won't be available in our

life times—a long time is needed to compile statistically sufficient amounts of data.

A great many factors are involved that must be considered. In light of those facts, a "play-it-safe" approach may be the best course of action. Take the action that, based on best available knowledge (which may turn out to be incorrect), has the fewest risks and/or greatest rewards. However, remember you could be wrong.

In the case of EMF, there are several approaches, which would reduce exposure yet not impact too severely on your lifestyle. Those approaches may reduce energy consumption; lower your electric bill; reduce electromagnetic smog, noise, and environmental pollution; and even improve radio and TV reception. They won't be harmful or unsafe and can easily be changed, added to, or eliminated, based on future evidence.

There is one test you can make very easily in your own home: Take a small portable AM radio and tune it to a frequency below 550 kHz where no station is received. You should hear just a hiss or light crackling noise due to atmospheric static. If you hear buzzing, a hum, or a loud raspy noise that sounds like bacon in a hot skillet, you've got some work to do. Much equipment that generates possibly hazardous EMFs also generates enough harmonic energy at AM-radio frequencies to be easily detectable on an AM radio as noise. Passing that test is no proof that there are no strong fields present, as it will not detect magnetic fields, but a failure almost guarantees that they are there. Most homes in suburban or city areas fail the test.

Further investigation requires a field meter, such as the test gear described in the "E-H Meter" article found elsewhere in this issue. If you build the project discussed in that article, you'll be able to find many of the sources of these fields in your

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home or office, often in very unexpected places. Unless you own the business, you probably won't be able to do very much about fields around the office. If you live in an apartment, you have little control over what is coming from adjacent apartments. However, you certainly can correct some situations at home. Most of the fields generated by household devices are confined to within a few feet (1 meter) of their sources, dying off at greater distances. Microwave ovens can be an exception, however, and electric ranges may also be exempt, as their coils carry large currents. A list of some offenders found in one of the authors' homes is given in Table 1. That listing is not meant to be complete.

In practice, electric fields are easier to reduce or eliminate. However, they are present around anything connected to a 120- or 240-volt source, even if the device is turned off. That's because the hot lead of the 120-volt line is brought into most items and connected to a switch. There is some capacitive coupling to the device or appliance housing, plus the 6- or 8-foot cord is a good "radiator" if plugged into an outlet. Of course, grounding the device's chassis through a 3-conductor cord reduces the level of the electric field. However, many common small appliances, such as table lamps and clocks, are powered through two-wire cords and contain many metallic parts that are left floating, depending solely on insulation. While that protects from electric shock, it does nothing for E-field reduction.

Many older appliances that have only a 2-wire cord are still in use. In addition, many individuals live in older homes or apartment buildings that still have obsolete 2-prong AC outlets. People living in such residences often cut the grounding pin off 3-prong plugs so they'll fit the old 2-prong sockets. That dangerous practice is quite common, and there's no protection at all against E-fields in such instances. The best way to reduce electric-field exposure is to unplug appliances when not in use.

However, that's not very practical in the case of frequently used

appliances such as table lamps or where furniture must be moved to gain access to a wall outlet. Cords can be kept as short as possible by coiling the excess length. Three-conductor grounding cords can also be installed on appliances with metal parts, in some cases. In addition, cords can be routed away from areas that are occupied for long periods of time, such as beds, desks, and chairs.

Magnetic fields can be reduced or eliminated by turning off power to the offending appliance. Magnetic fields at 60 and 120 Hz arise largely from AC current flow, and if the current is zero, there is, obviously, no magnetic field. However, some of the worst offenders are items that are constantly energized, such as wall transformers and chargers (commonly called "wall warts"), appliance and light timers, bell transformers, and 120-volt clocks.

Another source of magnetic fields are so called "leaky" appliances—those that consume some power even when turned off. Remote-controlled TV sets, stereo receivers, fan and light controls, etc. contain receivers that must be powered at all times in order to process a turn-on command. In fact, attention has been called by some critics to the energy-wasting characteristics of those appliances. It would not be surprising to find in an average home 100 watts of electricity used by appliances that are supposedly turned off. And those appliances have 60-Hz transformers that are constantly energized, constantly generating magnetic fields.

Several things could be done in the average home to help the situation. For example, make sure all appliances are properly grounded. Use power outlet strips with a master switch on all remote-controlled equipment. Of course, doing so means giving up the remote turn-on function (but the exercise might be good for you). It also makes it easy to unplug things during vacations or lightning storms. Besides, the VCR clock can be fairly useless, since power interruptions will likely wipe out the time settings, unless the unit is equipped with a backup-battery feature.

Do not leave "wall warts" plugged in when not in use. They'll last longer and not burn out from power surges or lightning hits. Get rid of light dimmers in your home. The high-peak current spikes can generate more intense magnetic fields since the resistance of a cooler (dim) filament is lower, drawing high instantaneous currents. Yanking the dimmers is sure to improve radio reception, since few dimmers incorporated adequate RFI suppression, with many low-end units containing no RFI suppression at all.

If you have track lighting or low-voltage halogen lamps, be aware that some low-voltage lighting may use high-frequency inverters to reduce weight and cost, powering the lamps with high-frequency AC. Such light fixtures may radiate EMF much like a poorly shielded computer monitor. Use lamps that operate directly from 120 or 240V when possible, so no transformer is required.

Replace fluorescent lighting in living areas and kitchens with old fashioned incandescents. Incandescent lamps are generally easier on the eyes, and generate no RFI and very little EMF. Of course, they're not very energy efficient; but look on the bright side, the heat they generate is not always wasted, particularly during the winter months when the heat from incandescent lamps can actually contribute somewhat to heating the house, thereby, reducing the load on the furnace.

Because of the lower energy consumption of fluorescent lighting, people are encouraged to leave them on, resulting in the constant generation of strong electric and magnetic fields. The magnetic fields from fluorescent ceiling fixtures can easily penetrate the ceiling, producing a strong field near the floor above the ceiling. You should not see much difference in your electric bills after going to incandescents if you acquire the habit of turning off the lights when not in use.

Stay away from compact fluorescents. They, like regular fluorescents, generate strong fields, plus they're expensive, do not work well

(Continued on page 50)

# Product Test Report

## Samsung Widescreen LCD Rear-Projection TV

STEPHEN A. BOOTH

It seems appropriate that for this final lab-test of the current millennium we examine a TV display format for the 21st century. Samsung's PLH403W is novel and unique: It's the first LCD-based rear-projection TV available to consumers.

It's also a coup of sorts for the Korea-based innovator. The smart money would have bet that LCD-pow-erhouse Sharp would be first-to-mar-ket with such a set. Indeed, Sharp has shown LCD rear projectors in proto-type, but to date has "choked" at the plate—in baseball parlance—while sassy Samsung pulled a squeeze-play and got home first.

Not content to be a me-too provider of commodity TVs, Samsung some time ago put the afterburners on R&D programs to develop next-generation audio, video, and PC products—espe-cially LCD. Samsung now is a major producer of those flat-screen displays and is giving the folks in the land-of-the-rising-sun a run for the money.

So, what's the big deal, you say. Bragging rights are swell, but what's in it for consumers?

Here's what—and why Samsung's gambit is right on the money.

The PLH403W is a widescreen (16:9 aspect ratio) TV that's just 14 inches deep with an honest avoirdupois of 65 pounds. That means it takes up no more real estate, moving away from the wall, than a typical 13-inch cathode ray tube (CRT) TV. In other words, for anyone who has ever despaired of having a large-screen display for the Super Bowl or World Series, it's the big-screen set for small rooms. Meanwhile, weight-wise, it probably could be lifted or shifted by the daintiest, 100-pound mortal.

Comparably, a 32-inch direct-view CRT display weighs in at about 180 pounds and has a front-to-back girth around 23 inches. Meanwhile, the tale-of-the-tape-measure reads about the



same for the trimmest of so-called "tabletop" CRT rear-projection sets (41- to 46-inch diagonal). But each of these max-out at 4:3 aspect ratio—which means widescreen programs from DVD or satellite get "letterboxed," thereby robbing the buyer of about 25% of vertical resolution. Comparably, the 16:9 ratio Samsung delivers the whole widescreen movie edge-to-edge, and all of the possible 484 lines of vertical-scan resolution viewable in the 525-line scanning NTSC format (the set has a resolution of 760,000 pixels).

So, you rightly ask, what's the com-

promise?

Here, we refer you to the accompanying charts on performance measurements, provided as always by the Bethel, CT-based Advanced Product Evaluation Laboratory—reputed among manufacturers as the rock-solid reef where badly-launched products go to die.

### EVALUATION

Savvy readers will look at the test data and realize that Samsung's PLH403W concedes nothing to CRT-

## TABLE 1—PERFORMANCE MEASUREMENTS

The following test results were furnished by the Advanced Product Evaluation Laboratory (APEL), an independent testing facility located in Bethel, CT.

**BRAND** Samsung  
**MODEL** Tantus PLH403W Widescreen LCD Rear-Projection TV  
**PRICE** \$2499

### VIDEO SECTION

Maximum Usable Luminance (in ft./lamberts @ 36.5% white window):  
 On Axis (Horizontal/Vertical)  
 55.3 ft./L. (Standard Mode)  
 58.5 ft./L. (Maximum Brightness/Contrast)  
 Off Axis (Horizontal-only, Standard Mode)  
 18.6 ft./L. (45 degrees)  
 05.0 ft./L. (60 degrees)  
 Horizontal Resolution 400 lines  
 Frequency Response 5.0 MHz

### Overscan (by Picture Mode):

	Vertical	Horizontal
Normal	0%	0%
Wide	0%	0%
Panorama	0%	0%
Zoom-1	12%	0%
Zoom-2	24%	0%
Convergence (Center and Corners)	100%	
Geometric Distortion (Pincushion Type)	0.5%	
Transient Response	Excellent	
Black Level Retention (10-step linearity pattern)	100%	
White Uniformity	Excellent	
Color Quality	Soft—good, but not vibrant	

### Color Temperature (degrees Kelvin, by Kelvin Temp. Mode):

Normal	10,150 deg. K
Wide	10,500 deg. K
Others	10,400–10,700 deg. K.
Reception Quality (Antenna Input @ 100 microvolt/Meter)	Fair (snowy, at fringe area 50 mi. from Xmitter)

### AUDIO SECTION

Audio Output:  
 Frequency Response 20 Hz–20 kHz  
 Signal-to-Noise Ratio ("A" weighted) 77.9 dB  
 Total Harmonic Distortion (1 kHz @ –10 dB) 0.38%

### TV Stereo Section:

Frequency Response (–20 dB re 100% channel modulation)	38 Hz–14 kHz
Channel Separation (@ 1 kHz, –20 dB re 100% channel modulation)	26 dB
Signal-to-Noise Ratio (100% modulation @ 1000 mV, "A" weighted)	57.0 dB
Total Harmonic Distortion (1 kHz @ –20 dB)	0.49%

### S.A.P. Mode:

Frequency Response (re 100% channel modulation)	20 Hz–8 kHz
Signal-to-Noise Ratio (100% modulation @ 1000 mV, "A" weighted)	78.1 dB
Total Harmonic Distortion (1 kHz @ –20 dB)	0.50%

### Monaural Mode:

Frequency Response (re 100% channel modulation)	28 Hz–3 kHz
Signal-to-Noise Ratio (100% modulation @ 1000 mV, "A" weighted)	56.2 dB
Total Harmonic Distortion (1 kHz @ –20 dB)	0.52%

### ADDITIONAL DATA

Picture Size (16:9 aspect ratio)	40 in. (diagonal)
Power Requirements	175 watts
Dimensions (HWD, inches)	29 × 39.5 × 13.75
Weight	65 lbs.

based direct view or rear-projection TVs in video performance—except in one key parameter: Maximum Usable Luminance, a.k.a "Brightness." Secondly, horizontal resolution (at 400 lines) isn't up to what you'd expect from many direct-view sets, but the PLH403W's 480-line progressive scanning makes up for this shortcoming by doubling the vertical resolution of interlaced sources such as broadcasts, videocassettes, and even DVD and satellite TV.

The lower brightness is to be expected from an LCD projection unit, given its dependence on an outboard fluorescent or halide-bulb backlight, compared with the light-gun that's integral with CRTs.

For the same reason, Color Quality in the LCD rear projector is softer (not as saturated) as with CRT monitors—and Color Temperature is not user-adjustable. It's 10,150 degrees Kelvin in standard mode, veering toward the "cool" or blue end of the spectrum, not the "warm-looking" NTSC-standard 6500 degrees K that purist videophiles prefer. Even so, the PLH403W is less blue and more "cinematic" than most LCD PC-monitors and some TVs.

Nonetheless, the PLH403W delivers very well-balanced color—an attribute of LCDs.

Bottom line: This is not a TV that you'd want to watch with windows wide open in bright daylight. It's more suited to home-theater conditions, viewed in subdued light.

But increasingly, even for sports fans, "subdued lighting" is how most TV is viewed these days.

The Super Bowl, most post-season baseball games, and all pro- or collegiate basketball matches are broadcast after dark, when you don't have to worry about glare from unshuttered windows (at least in the Eastern time-zone, and it's near-dark on the West Coast). As for the kids viewing TV in daytime hours, most of what they watch is heavily saturated animation and shouldn't suffer from the relatively low luminance of the PLH403W. In any event, most parents probably trim the blinds anyway to avoid washout on any TV.

## WONDERFUL INNOVATION

Absolute positives for Samsung's innovation:

The TV has a 3D digital comb filter and two-tuner PIP (picture in picture).

designed to bring to life, the set can handle four display modes, from standard 4:3 ratio through Cinemascope. The screen's even scratch-resistant to ensure viewers can still enjoy multiple video sources for years to come.

We like the convenient side-and rear-component and S-Video inputs. The latter are the most important connectors, of course, as DVD and other high-quality video sources deliver signals of higher quality than RCA-type composite video.

Keeping up on the audio side, there's a 13-watt-per-channel amplifier. As Table 1 shows, sound quality was better than average. In fact, this TV stands up well to any of the best direct-view types we've tested. For private listening, there's even a headphone output (although it's placed on the rear panel).

If you've longed for a big- and wide-screened display and have the bucks but not the real estate, Samsung's PLH403W could fit your available space and, possibly, your budget.

For more information on the Samsung Tantus PLH403W Wide-screen LCD Rear-Projection TV, contact Samsung Electronics America, 105 Challenger Road, Ridgefield Park, NJ 07660; Tel. 201-229-4000; Web: [www.sosimple.com](http://www.sosimple.com); or circle 50 on the Free Information Card.

## EMF METER

(continued from page 37)

may contain harmonics, so a good audio generator is the best way to go. Make sure that the only signal that reaches the meter comes from your source and not from stray pickup.

If the LED display seems to "stick" to the right, especially when S4 is set to the  $\epsilon$  position, try operating the meter from a battery supply and physically moving it to a location away from noise sources. If that helps, then the meter was simply picking up noise. That effect is most troublesome when S4 is in the  $\epsilon$  field position. On the other hand, if that doesn't help, adjust R14, or move the  $\epsilon$ -field pickup wire closer to S1, S2, and S3 and/or shorten it a little. The amplifiers provide high gain and present a high-input imped-

ance—a combination that has a tendency to produce oscillation due to feedback.

If the amplifiers are not the problem, check the bar-graph display circuitry for wiring or assembly errors. If no indication occurs and the bar graph is known to be working then check IC1 and associated components.

Mount the board in a suitable plastic enclosure and connect the pickup coils and battery pack to the board as illustrated in Fig. 3. Hot glue can be used to be used to hold the pickup coils and wiring in place. If no external coil is to be used, J1 can be eliminated. The meter can also be assembled, if you prefer, with only one pickup coil. But be aware that if the meter is configured in that manner, it must be properly oriented to pick up the field being measured.

Remember that the EMF Meter is essentially a highly sensitive AC voltmeter that only measures the voltage induced in the pickup coil (H Field) or on a voltage probe (E field). You can also assemble custom coils or probes designed to suit your specific needs. In any event, keep in mind that the high gain of the circuit requires that the circuit be properly shielded and grounded.

## EM POLLUTION

(continued from page 47)

at low temperatures ( $<10^{\circ}\text{C}$ ), and are rather inefficient for outdoor applications in colder climates. Incandescent lamps, which can last for 1000 hours and are 20 cents or less (US), can be purchased at bargain prices from many discount stores. That in and of itself diminishes the appeal of a \$15 compact fluorescent that may last 5000 hours at best, especially considering the EMFs and RFI they produce.

Replace electric motor-driven clocks with battery-powered units. They are just as accurate, do not need resetting after a power interruption, and they generate negligible EMF. Place monitors and TV screens at least 2-3 feet from viewing positions. Use a larger monitor if needed. Most of the newer monitors have improved shielding against EMFs. Enable the "green" feature via

the CMOS setup or the operating system.

If you are building a new house, use metal conduit for all wiring if you can. Some codes require it in new construction. Also use metal rather than plastic boxes. Steel affords some magnetic shielding as well as complete E-field protection. Install an underground service entrance. While no protection against magnetic fields, it gets rid of E fields and an unsightly wire. Make sure all wiring carrying heavy currents is kept as far as possible from areas that are occupied for long periods, such as bedrooms. If you are buying a home, avoid properties in close proximity to high-voltage power lines and power substations.

With the exception of the last paragraph, those measures are just prudent energy-saving measures requiring only a little effort. The use of incandescent lighting is admittedly a step backwards in energy conservation, but it eliminates possibly hazardous EMFs from ballasts. Ignoring health hazards to save energy is not a wise move.

In conclusion, it would be wise to minimize exposure to electric and magnetic fields by taking some simple measures to reduce their levels in the home if possible. Unfortunately, it'll probably take some form of legislation to institute controls over the other field sources such as power lines and industrial equipment. And to accomplish that will likely require valid data gleaned from years of scientific research.

A bibliography of articles for further reading is supplied in the boxed copy entitled "Bibliography of EMF Books and Articles," which appears elsewhere in this article. ■

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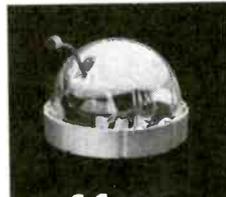
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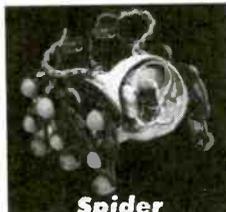
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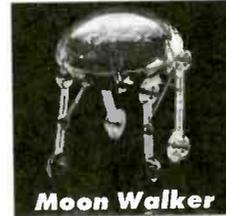
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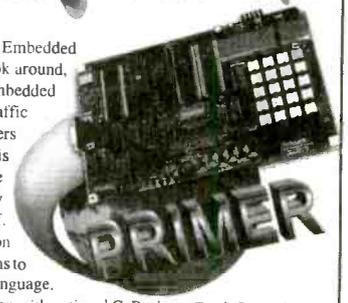
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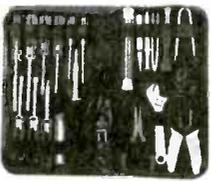
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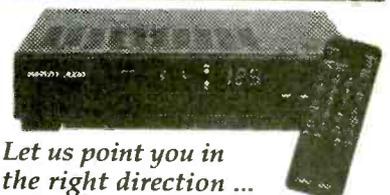
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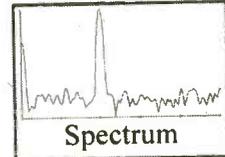
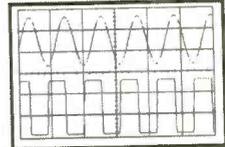
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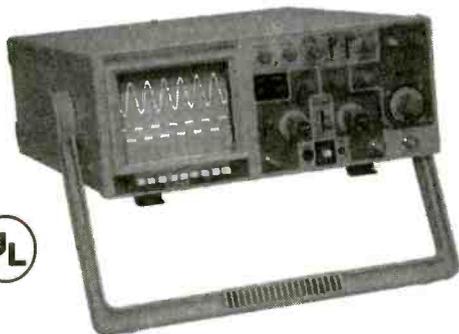
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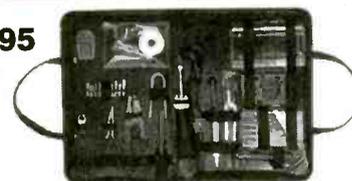
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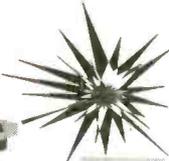
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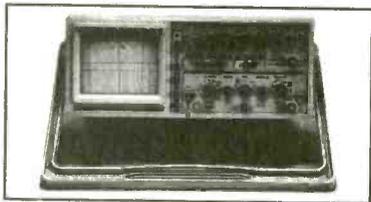
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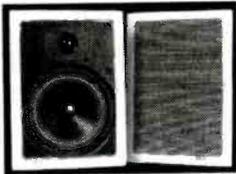
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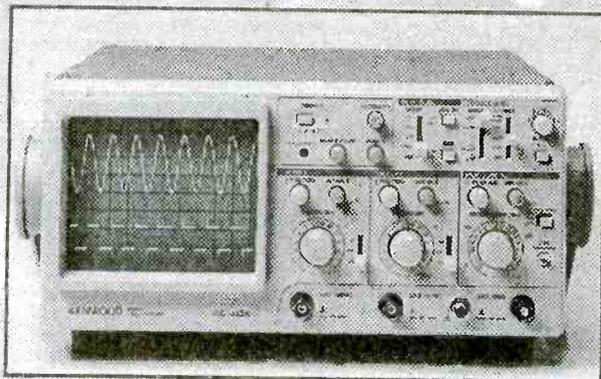
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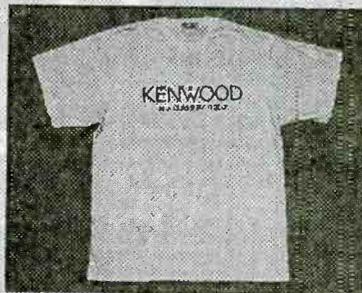
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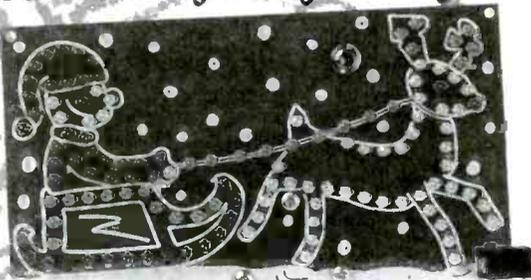
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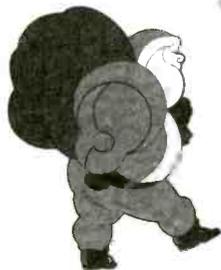
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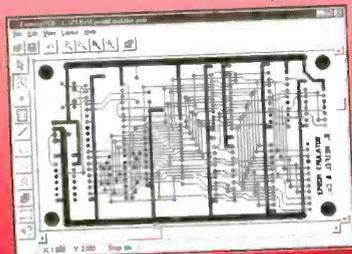
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Max Sweep Rate	to 5V/Div	to 5V/Div	to 5V/Div	to 5V/Div
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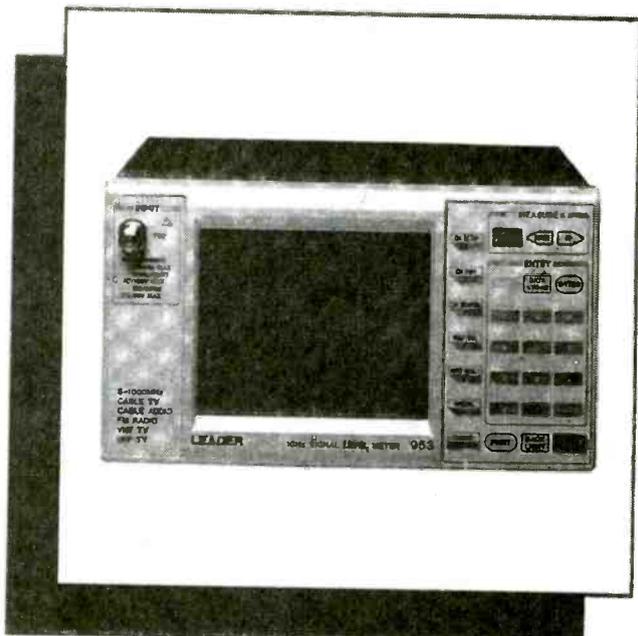
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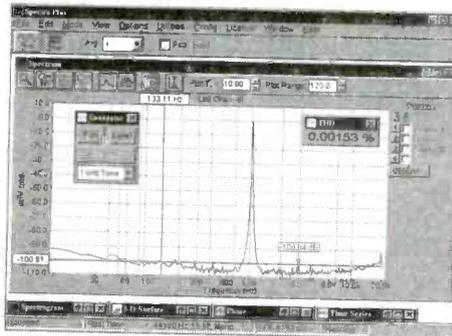
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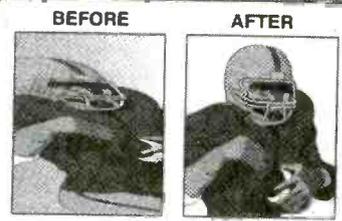
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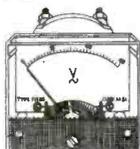
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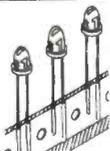


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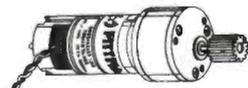


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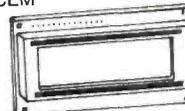
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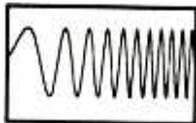
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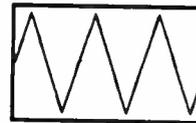
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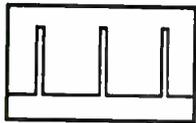
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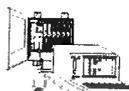
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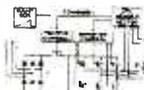
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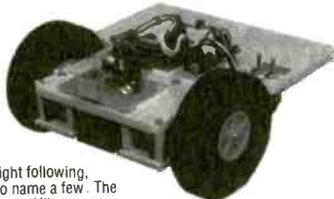
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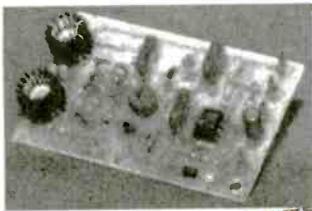
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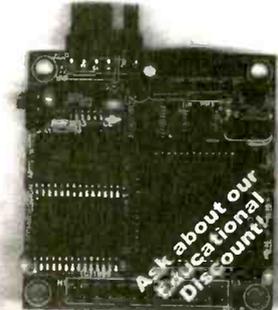
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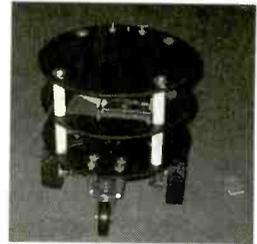
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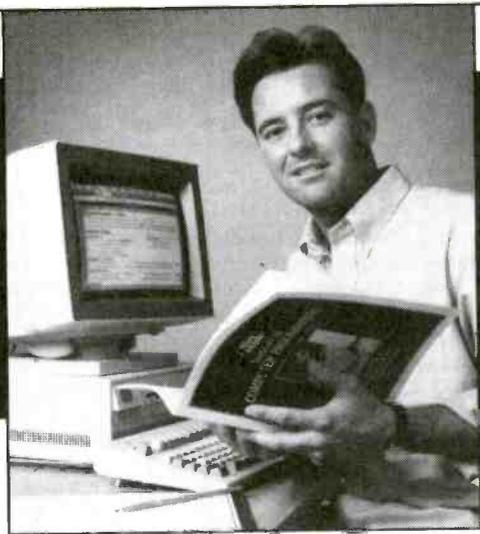
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# AMAZING SCIENCE

## Speech Recognition, Part I

JOHN IOVINE

**T**his column begins a two-part exploration of speech recognition. We'll build a speech-recognition circuit this month. Next month, we will interface the circuit to the outside world to create speech-controlled devices.

The speech-recognition circuit featured is user-programmable, in the sense that you choose and program the words (or vocal utterances) for the circuit to recognize. The circuit allows you to experiment with many facets of speech-recognition technology. In addition, the circuit may be embedded into existing products to create speech-controlled devices.

There are a few key points that separate this speech-recognition circuit from other products on the market that may at first appear similar. Primarily, this circuit is always listening. Whenever it hears a word that it recognizes, it activates the appropriate output code. Many other speech-recognition products require the user to first press a button to have the circuit recognize a word. Pressing a button to activate speech recognition is counter-intuitive to the whole idea of speech recognition.

For instance, suppose you built a voice-activated VCR using that type of speech-recognition circuit. Imagine needing to press a button before issuing each verbal command; why not just press the command button, such as PLAY, STOP, REWIND, etc.—to begin with. That type of "push-the-button-first" speech recognition may be useful for voice security and identification, but not for speech-activated products.

The circuit that we'll build can recognize, in stand-alone mode, up to forty words or phases lasting up to 1 second each. When a word is recognized, the circuit outputs a BCD (binary-coded decimal) number corresponding to the word. The output lines associated with the BCD number are brought high. That signal can be used to con-

trol external devices with a minimum of external hardware.

Before we go further into the features of the speech-recognition circuit, let's take a quick overview of speech-recognition terms that will help in our understanding.

### SPEAKER-DEPENDENT/SPEAKER-INDEPENDENT

Speech recognition is classified into two processing categories—speaker dependent and speaker independent. Speaker-dependent speech-recognition systems are trained by the person who'll be using the system. Such systems achieve a high command count and better than 95% accuracy for word recognition. The drawback to this approach is that the system responds accurately only to its individual trainer. However, the advantage is that the circuit can be trained to recognize any language. In some cases, language itself isn't a necessity—a series of grunts and whistles (as long as they are accurately repeatable) can be used in place of words. That's helpful to people who through accident or illness have lost the ability to speak.

On the other hand, speaker-independent systems attempt to recognize words regardless of the speaker. To do so, the system must respond accurately to a large variety of speech patterns, inflections, and to the enunciation of every command word. Because of the extra processing power and memory requirements, the recognition word count is lower than that available from speaker-dependent systems. Industrial applications more often require speaker-independent voice-recognition systems, such as the systems used by AT&T and other telephone companies.

Our speech-recognition circuit is speaker-dependent. That's the approach used in speech-recognition software for personal computers.

### LEARNING TO LISTEN, THEN TO HEAR

We take our abilities to hear for granted. We realize how much so as soon as we try to implement hearing in artificial systems. For instance, we can listen to one person speaking among several ongoing conversations. We can tune into that one person's speech and tune the others out. Speech-recognition systems, on the other hand, have not evolved to the point where they are capable of separating and filtering out what should be considered extraneous noise.

Speech recognition is not speech understanding. Because a computer can respond to a vocal command does not mean it understands it. Future voice-recognition system may be endowed with the ability to distinguish nuances and meaning of words, to "Do what I mean, not what I say!"

### RECOGNITION STYLE

Speech-recognition systems deal with another factor in the style of speech they can recognize. There are three distinct styles of speech recognition: isolated, connected, and continuous. Isolated speech-recognition schemes can *only* handle words that are spoken separately. That's the most common form of speech recognition available today. In such schemes, the user must pause between each word spoken (much like the vocal computer in the movie "War Games"). Ideally the word will be "isolated" by a moment of silence before and after it is spoken.

Connected-speech recognition is halfway between isolated-word and continuous-speech recognition. Connected-speech allows the user to speak multiple words. The speech-recognition circuit that we'll discuss can be modified to recognize verbalizations of up to 2 seconds long. However, that limits the number of word the circuit can recognize to twenty.

Continuous speech is the natural,

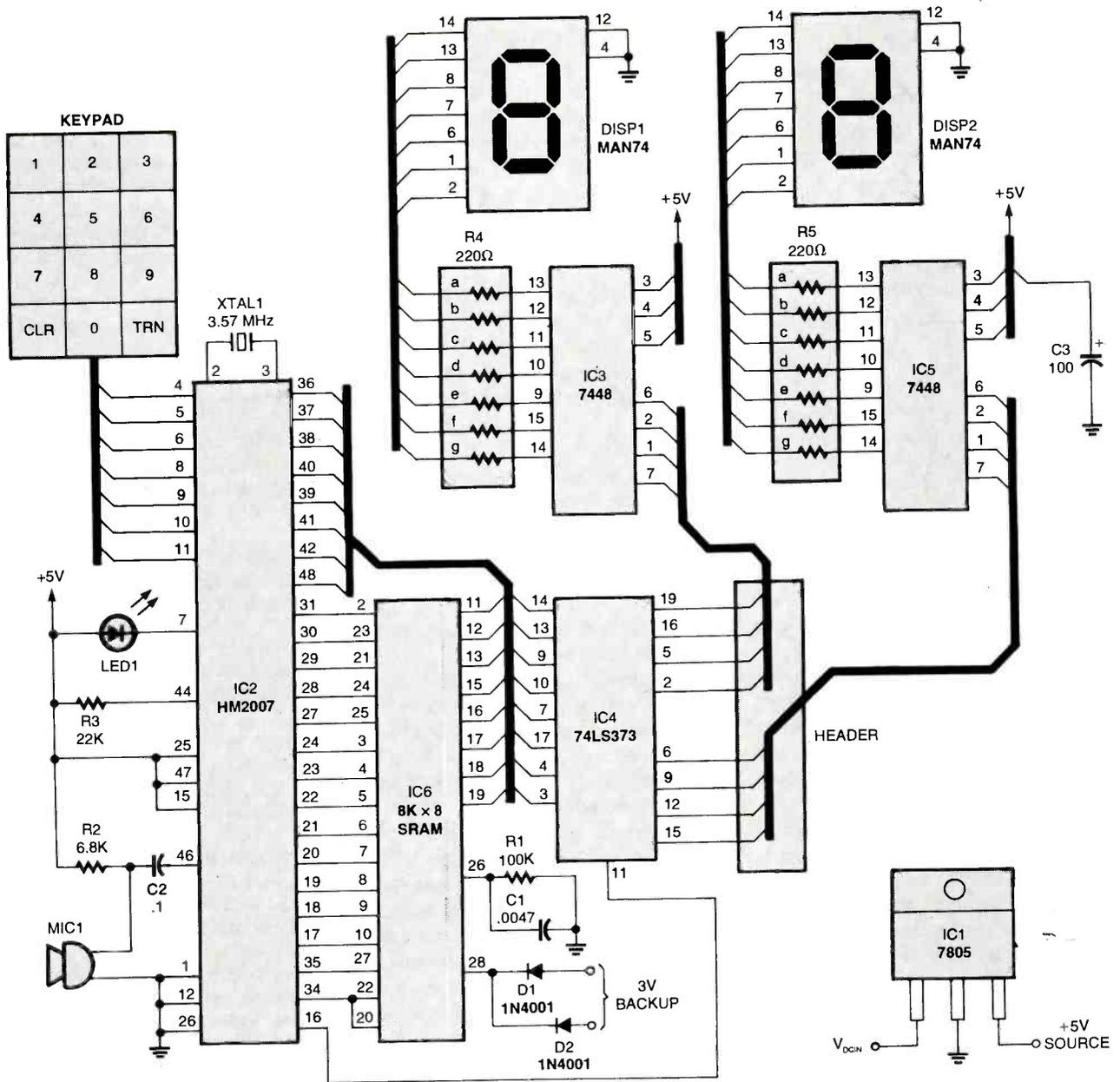


Fig. 1. The speech-recognition circuit is comprised of six integrated circuits, a pair of 7-segment display modules, a homemade 12-key keypad, and several support components.

conversational speech we are used to in everyday life. It is extremely difficult for a recognition system to sift through speech, since the words tend to merge together. For instance, "Hi, how are you doing?" sounds like "Hi,how-r-u-doing?" Continuous-speech-recognition systems are on the market and are under continual development.

Regardless of the recognition style, there are several major areas for application of voice-recognition technology—speech-controlled appliances, games, and toys; speech-assisted computer games; and speech-assist-

ed virtual reality. Speech recognition is gaining popularity as chips and system prices decrease. At its most basic level, speech control allows the user to perform parallel tasks, (*i.e.*, hands and eyes are busy elsewhere) while working with the tool, toy, or appliance.

### CIRCUIT CONSTRUCTION

The heart of our circuit is the HM2007 single-chip speech-recognition system. That IC can recognize 40 words, each word with a maximum length of .96 seconds. An optional feature that allows you to switch to 2-sec-

ond word length with a 20 word vocabulary will be discussed next month.

Some features of our circuit are a self-contained, stand-alone, speech-recognition circuit, user-programmable words, and a 40-word vocabulary (again each 0.96 second in length). It is multi-lingual, has a non-volatile memory backup, and is easy to interface to some device, allowing it to control external circuits and appliances.

A schematic diagram of the speech-recognition circuit is shown in Fig. 1. The components for the system can be purchased separately or in a kit with all

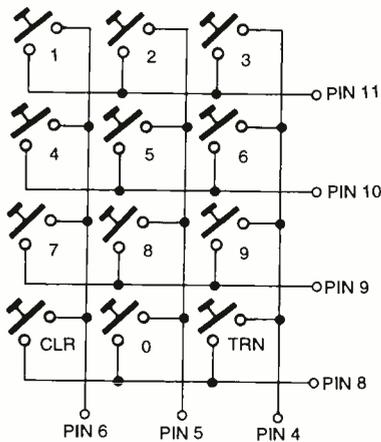


Fig. 2. The keypad for the speech-recognition system was fabricated from 12 individual normally-open, pushbutton switches laid out in a matrix configuration, as shown here, and connected to the speech-recognition circuit through 3- to 4-inch lengths of insulated wire.

the components and a printed-circuit board for \$100 from the supplier listed in the Parts List. If you're not a kit person (preferring to purchase the components separately), there is nothing critical about putting the system together—the circuit can be assembled on a solderless breadboard, perfboard, or on protoboard.

The keypad for the system is comprised of 12 individual momentary-contact pushbutton switches wired in a matrix configuration, as shown in Fig. 2. Once the keypad has been assembled, connect three- to four-inch lengths of wires between the keypad and the main speech-recognition board.

## USING THE SPEECH-RECOGNITION CIRCUIT

The keypad and display are used to program and test the speech-recognition circuit. When power is applied to the circuit, the display comes up showing "00," and LED1 (READY) lights, as the circuit awaits your command. At that point, press button "1" on the keypad. That causes the display to change from "00" to "01" and LED1 to turn off. Next, press the "TRN" button to enter training mode; LED1 turns back on. Speak the target word into the microphone. If the word is accepted by the circuit, LED1 will flash off momentarily. The word you just trained (entered) is now identified as the "01" word. If the LED did not flash, repeat the word louder or start over by press-

ing the "1" key and then the "TRN" key.

You can continue training new words into the circuit in the same manner, incrementing the word number as you continue. Press "2" then "TRN" to train the second word, and so on. The circuit will accept and recognize up to forty words (numbers 1–40).

It is not necessary to use all forty word spaces. If you only require five or ten target words, then that's all the training the circuit needs. It is also not necessary to train words in any sequence. You can train four words with the numbers 7, 2, 13, and 29, for instance, without any problem.

## TESTING

Speak a trained word into the microphone. The corresponding number of the word will be shown on the display. For instance, if the word "directory" was trained as word number 25, saying the word "directory" into the microphone will cause the number 25 to be shown on the display.

The speech-recognition chip also provides the following error codes: If the display shows "55," it means that word is too long; 66 means the word is too short; and 77 means the word has no match stored in memory.

To erase a word, press the word number and then press "CLR". To erase all the words at once, press "99" then "CLR." The numbers will quickly scroll by on the display as the memory is erased. Retraining and changing words is no more difficult than erasing them. The circuit allows you to retrain and change individual words without affecting the status of any other word held in memory. To retrain or change, press the word number, then press "TRN." Say the word into the microphone, and the word is changed (or retrained).

## NON-VOLATILE MEMORY BACK-UP

Whether you build the circuit from scratch or assemble it from the kit offered in the Parts List, provisions have been made in the circuit for a back-up power for the memory. If you are building the circuit from scratch, the memory back-up supply connects to the anodes of D1 and D2. If, on the other hand, you're building it from kit, the board has two solder holes where-by you can add the secondary 3-volt power supply.

## PARTS LIST FOR THE SPEECH-RECOGNITION SYSTEM

### SEMICONDUCTORS

- IC1—7805 5-volt, 1-amp, fixed-voltage regulator, integrated circuit
- IC2—HM2007 speech-recognition system, integrated circuit
- IC3, IC5—7448 BCD-to-seven-segment decoder/driver, integrated circuit
- IC4—74LS373 octal TRI-state transparent D-type latch, integrated circuit
- IC6—8K × 8 (80ns) static RAM, integrated circuit
- D1, D2—1N4001 1-amp, 50-PIV, rectifier diode
- DISP1, DISP2—MAN74 seven-segment LED display
- LED1—Light-emitting diode

### RESISTORS

- (All resistor are 1/4-watt, 5% units, unless otherwise noted.)
- R1—100,000-ohm, 1/8-watt, 5%
  - R2—6800-ohm
  - R3—22,000-ohm
  - R4, R5—220-ohm × 7 DIP resistor

### CAPACITORS

- C1—0.0047-μF, ceramic-disc
- C2—0.1-μF, ceramic-disc
- C3—100-μF, 16-WVDC, electrolytic

### ADDITIONAL PARTS AND MATERIALS

- XTAL1—3.57-MHz crystal
- Keypad—12 PC-mounted momentary contact switches
- MIC1—Microphone
- Printed-circuit or perfboard materials, header, battery and battery clip, wire, solder, hardware, etc.
- Note:** A kit of parts, containing all of the components listed above (except D1 and D2), is available from Images Company (PO Box 140742, Staten Island, NY 10314; Tel. 718-698-8305) for \$100. IC2 (HM2007 speech-recognition system) only is available separately for \$25. The printed-circuit board with keypad is available for \$30.

With the back-up supply in place, the word patterns in IC6 (the static RAM) are retained when the circuit is turned off. That alleviates having to retrain the circuit whenever it is turned off. The 3-volt supply—a pair of "AA" batteries connected in series—makes the static RAM non-volatile. The current drain on the batteries is so low, that the lifetime of the batteries will approach their shelf life.

(Continued on page 79)

# Robotics Workshop

## Building a Line-Tracing Robot

GORDON MCCOMB

It's easy to make your robot navigate through space. No, not the "outer-space" kind of space, but the space between two chairs in your living room or the space between your bedroom, the hall bathroom, and the closet. Or the space outside your yard by the pool.

Robots suddenly become useful once they can master their surroundings, and endowing them with the ability to wend their way through their surroundings is the first step towards that mastery. The techniques used to provide navigational abilities are varied, and covering them all would require several large volumes. So, for this month's column, we'll examine just one fairly low-tech approach that will get you started experimenting with robotic self-navigation systems. Introducing the "Line-Tracing" robot—an automaton that uses IR emitters and detectors to navigate.

### CREATING THE LINE-TRACING ROBOT

In some industries, robots are used as a direct replacement for human workers. Most of those robots are secured to the ground and are able to perform perfect single-function operations, such as spot-welding various points on car doors. The other robots, which aren't secured to the ground, are given "errand" type work, such as delivering mail or sweeping or waxing the floor.

Mobile robots that work in factories or deliver mail in large buildings use tracks to keep them on course. (Think of it as guiding a dog on a leash.) The track can be a groove in the floor, a strip of reflective tape stretched out on the concrete, or a wire buried in the carpet. The reflective tape method is preferred because the track can easily be removed or the path altered without ripping up the floor.

You can easily incorporate a tape-track navigation system in your robot.

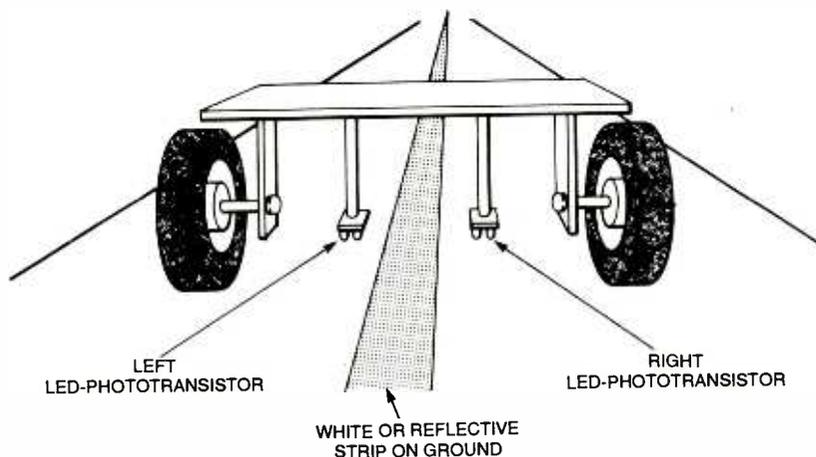


Fig. 1. The line-tracer robot uses two powered wheels for locomotion (two casters or rollers are added to the front of the robot for balance). For line detection, emitter/detector pairs (IR LED and phototransistor) are located on the underside of the robot.

The so-called line-tracing feature can be the robot's only means of semi-intelligent action, or it can be just a part of a more sophisticated machine. You could, for example, use the tape to help guide a robot back to its battery-charger nest. For the purposes of this column, however, we'll look at just the basic line-tracing function and leave the more automated features for another time.

For best results, the floor used with a line-tracing robot should be hard—wood, concrete, or linoleum—not carpeted. One or more emitter/detector pairs—comprised of an IR LED and a phototransistor—are placed on the robot. In operation, the IR LED emits radiation, which is then reflected back to the robot by the tape. When infrared radiation emitted by the IR LED and reflected by the tracking (art) tape is detected by the phototransistor, it turns on. Obviously, the darker the floor the better, because against a dark background the white tape provides a better contrast.

When building the line-tracing robot, the LEDs and phototransistors must be mounted to the bottom of the robot, as shown in Fig. 1, in emitter/

detector pairs. In Fig. 1, the two emitter/detector pairs are placed a little further apart than the width of the tape. I used ¼-inch art tape in the prototype and placed the sensors ½ inch from one another. A cone of black electrical tape can be wrapped around each LED/phototransistor pair to prevent stray light from activating the phototransistor. Be sure that the tape does not fold back over either the LED or the phototransistor, or else the line-tracing function may be impaired.

Figure 2 shows the emitter/detector pair incorporated into a comparator circuit that forms the basis for the line-tracing system. Potentiometer R2 (a 10,000-ohm unit) is used to set sensi-

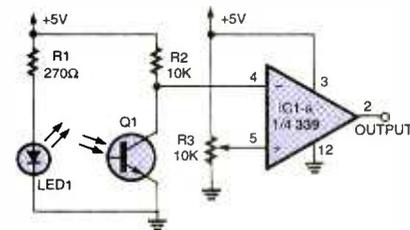


Fig. 2. The line-tracer robot uses an LM339 quad comparator as a form of digital on-off switch, based on the amount of IR radiation from the LED that strikes the photodetector.

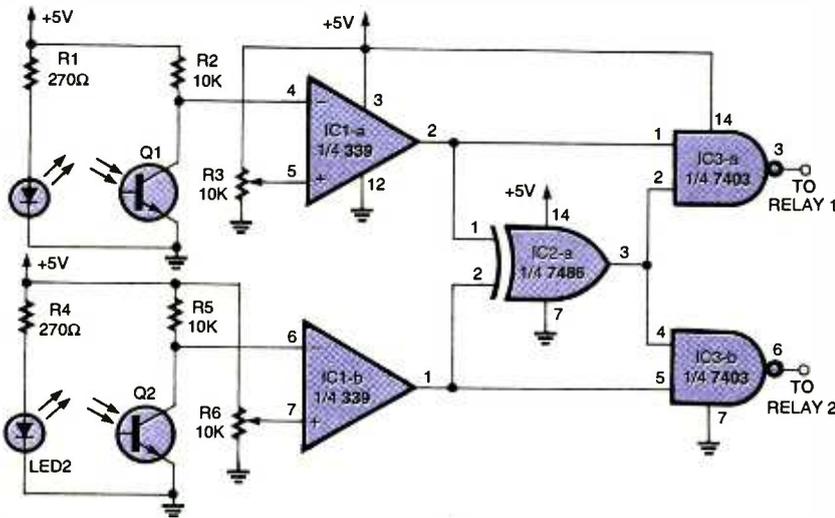


Fig. 3. Shown here is the heart of the robot's tracking-control system. Follow this schematic diagram when assembling the line-tracing robot. The outputs of the 7403 (IC1-a and IC1-b) are routed to the relay configuration shown in Fig. 4.

tivity of the transistor, thus determining the minimum reflected IR intensity to which the robot's navigation system responds.

## HOW IT WORKS

The robot is placed so that the tape track is centered between the robot's two emitter/detector pairs. When the robot is set in motion, as long as no light is reflected off the tape, the transistor remains in the cutoff state. Under that condition, the voltage applied to the inverting input of the

comparator (IC1-a, 1/4 of an LM339) at pin 4 is equal to or greater than the threshold (or set point) voltage (as determined by the setting of R3) applied to pin 5 (the non-inverting input of IC1-a). That causes the output of IC1-a to remain unchanged. And so, the robot continues on its merry way, making no course corrections.

On the other hand, when the robot veers off-course, IR radiation from one or the other IR LED strikes the tape and is reflected back to its companion detector, causing the transistor to go into saturation (switch full on). If R3 (the sensitivity control) has been adjusted properly, the voltage at the pin 4 (inverting) input of IC1-a drops below the threshold (reference) voltage, causing its output to toggle high, triggering the motor relay. A double-pole, double-throw (DPDT) relay is connected so that when actuated, the motor turns in the reverse direction.

The schematic diagrams shown in Figs. 3 and 4 constitute a complete line-tracing system, suitable for use with most any small two-wheeled robot. Figure 3 is an expanded version of the circuit in Fig. 2, in which the previous circuit is duplicated twice. In that configuration, the outputs of the two comparators (IC1-a and IC1-b) are fed to separate NAND gates (IC3-a and IC3-b, respectively). At the same time, taps on the comparator outputs route a portion of the two signals to a single XOR gate (IC2-a). The job of IC2-a is to prevent both motors from reversing at the same time, thereby preventing the

robot from simply backing up when it veers off course.

Let's see how that works. Assume that Q1 has detected no reflected IR radiation, so the output of IC1-a remains low, and that IR radiation detected by Q2 has caused the output of IC1-b to go high. The low output of IC1-a is fed to pin 5 of IC3-a, while the high output of IC1-b is fed to pin 5 of IC3-b. At the same time, a portion of the two comparator output signals is fed to IC2-a at pins 1 and 2. Recall that an XOR gate produces a high output *only* when one input is high and the other is low; *all* other input combinations produce a low output. With pin 2 of IC2-a high and its other input low (no reflected signal detected), the output of IC2-a goes high. That high signal divides along two paths, feeding a high to pins 2 and 4 of IC3-a and IC3-b, respectively. Because the output of IC1-a is low and the output of IC2-a is high, the output of IC3-a remains high (recall that the output of a NAND gate goes low only when both inputs are high). At the same time, because both inputs to IC3-b are high, its output goes low.

The outputs of the two halves of the Fig. 3 circuit are fed to the motor control relays shown in Fig. 4. Because the input to RY1 in Fig. 4 is high, its connected motor (MOT1) continues to rotate in the forward direction. But since the input to RY2 is low, the relay toggles, causing MOT2 to reverse direction and seek a spot where reflected IR radiation is no longer detected. Obviously, the line-tracer robot is designed so that when both phototransistors "see" the background, the wheels roll straight ahead. If the robot strays off to the left, the right sensor sees the tape, so the right motor reverses to place the robot back on course.

Before using the robot, block the phototransistors so that they don't receive any light. Adjust R3 and R6 until their respective relays kick in, then back off again. You may have to experiment with the settings of R3 and R6 as you try out the system. Depending on the motors you use, and the switching speed of the relays, you may find your robot waddling its way down the track, over-correcting for its errors every time. You can help minimize that tendency by using faster acting relays (which usually means

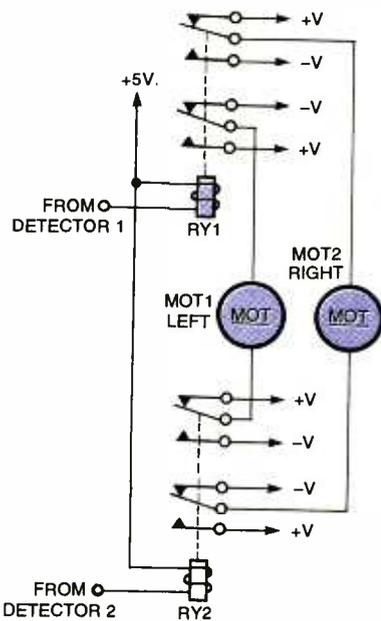


Fig. 4. This simple switching arrangement allows two small relays to be used to control motor direction.

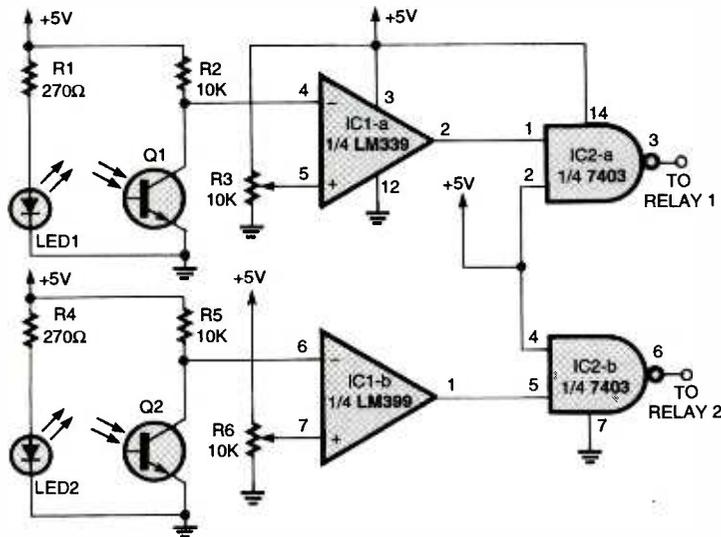


Fig. 5. The electronics circuitry for the guidefence robot shown here differs only slightly from that of the line-tracking unit illustrated in Fig. 3. Use this circuit configuration in conjunction with the motor-control relay arrangement shown in Fig. 4 when assembling the guidefence robot.

smaller units). The so-called "overshoot" effect can be minimized by carefully adjusting potentiometers R3 and R6. Another approach to correcting erratic behavior is to vary the gap between the two sensors. By making the gap wide, the robot won't be turning back and forth as much to correct for small errors.

You can also build a line-tracing robot to detect a black line on a large piece of white paper. Simply switch the two input connections to IC1-a and IC1-b, and the system will work in reverse. You can also cause the same change by reversing the connections on the relays. And, try reversing the connections to just one of the comparators and placing the sensors so that one works normally when it sees the line, and the other works normally when it doesn't see the line. When R3 and R6 have been set up correctly, the robot will turn in a circle when it loses the line, but straighten out when the line is picked up again. That setup has the effect of picking up a lost line after a few spins around the floor. With the previous method, the robot just goes on its way after it loses the guide path.

## STAYING BETWEEN THE LINES

The line-tracing robot is one approach to optical navigation. Another approach is the "guidefence" robot, using the slightly modified comparator circuit shown in Fig. 5. Here, two white

strips are placed any distance apart. You could, for example, construct a six- or seven-inch wide "roadway" for your robot. When one of the lines is struck, the robot counters by moving in the opposite direction. You can also use this system to keep your robot from entering a protected area.

Take note: You'll hardly ever see a railroad track that has a turn tighter than about eight degrees. There is good reason for that. If the turn is made tighter, the train cars can't stay on the track, and the whole thing derails. There is a similar limitation in line-tracing robots. The lines cannot be tighter than about 10 to 15 degrees, depending on the turning radius of the robot, or the thing can't act fast enough when it crosses over the line. The robot will skip the line and go off course.

If your robot has a brain, whether it be a computer or central microprocessor, you can use it instead of the direct connection to the relays for motor control. The output of the comparators, when used with a +5 volt supply, is compatible with computer and microprocessor circuitry. The emitter/detector pairs require only two bits of an eight-bit port.

Sadly, that's about all the time and space allotted to us for this month. Be sure to join us again next time around, when we'll discuss more robotic circuitry and hardware. Until then, try out the circuits that we present so far. In

the meantime, if you have any questions or comments pertaining to the material presented here or the robotic hobby in general, please feel free to send them to *Robotics Workshop Popular Electronics*, 500 Bi-County Blvd., Farmingdale, NY 11735. ■

## AMAZING SCIENCE

(continued from page 76)

## THINKING ABOUT APPLICATIONS?

Next month, we will build an interface to control devices with our speech-recognition circuit. I'm sure many people are already planning their own speech-controlled application. My advice is to consider applications carefully; there have been a few commercial blunders. For instance, one company blundered by requiring a user to visually confirm an oral command. They quickly found, as did the consumer, that mixing oral and visual information did not work—it reduced efficiency. Products that can recognize commands when given in an unstructured format will better survive the market place.

Till next month. ■

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# Circuit Circus

## A Potpourri of Designs

CHARLES D. RAKES

Welcome back, Circuiteers, for another installment of the *Circus*. Get ready for a little circuit diversity this time around, as we stir up the old electro-pot and see what floats to the surface.

So often it seems that when we start to design a circuit to perform a particular function, the end result doesn't always live up to expectations. In some cases, we miss the mark completely and have to start over, while, on rare occasions, we end up producing a circuit that really shines. What I'm trying to say is don't be too quick to abort a good circuit just because it isn't exactly what you originally had in mind. Such circuit designs should be filed away, for that discarded circuit may turn out to be ideally suited to some future project. That's pretty much what this month's column is all about—circuits that on the surface seem to offer little to your present project, but may come in handy in the future.

### ELECTRONIC TOUCH SWITCH

Our first offering this month is an Electronic Touch Switch that came about in response to the request of a friend who needed a simple bridging touch circuit that would produce a positive-going output pulse that could be used to turn on an LED. The outcome of that request—a circuit that performed as required—is shown in Fig. 1.

That simple circuit is built around a pair of transistors: one a high-gain

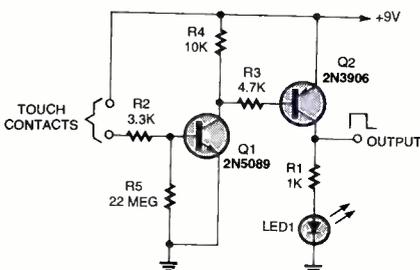


Fig. 1. The Electronic Touch Switch is a simple circuit built around a pair of transistors and a few support components.

### PARTS LIST FOR THE ELECTRONIC TOUCH SWITCH (FIG. 1)

#### SEMICONDUCTORS

- Q1—2N5089 high-gain NPN silicon transistor (Digi-Key)
- Q2—2N3906 general-purpose PNP silicon transistor
- LED1—Light-emitting diode (any color)

#### RESISTORS

(All resistors are 1/4-watt, 5% units.)

- R1—1000-ohm
- R2—3300-ohm
- R3—4700-ohm
- R4—10,000-ohm
- R5—22-megohm

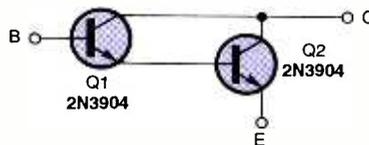


Fig. 2. The input sensitivity of the Fig. 1 circuit can be greatly enhanced by substituting a Darlington pair, comprised of two general-purpose 2N3904 transistors, for Q1.

2N5089 NPN unit, Q1 (which has an hFE gain figure of 450 and is used as the sensing device); and the very popular 2N3906 general-purpose transistor, which has a gain figure of 100. The operation of the touch circuit is very simple. When power is applied to the circuit but the touch contact remains unbridged, no bias current is applied to the base of Q1. That keeps Q1 at cutoff, forcing its collector voltage to rise to near the supply rail (+9 volts). That voltage is applied to the base of Q2, causing it to remain in the cutoff state. With Q2 at cutoff, the output of the circuit (at the collector of Q2) is low (near zero potential).

However, when the touch contacts are bridged, a bias current is fed through R2 to the base of Q1, causing it to turn on. That, in turn, pulls the base terminal of Q2 to ground potential; thereby, forward biasing Q2, caus-

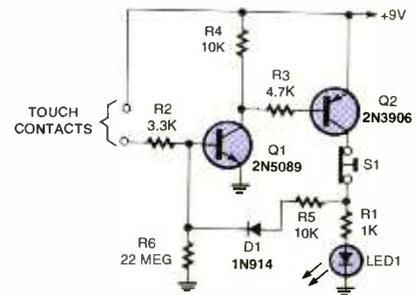


Fig. 3. The basic touch-switch circuit outlined in Fig. 1 can be easily transformed into a latch and hold touch switch with the addition of only three components—D1, R5, and S1.

### PARTS LIST FOR THE LATCHING TOUCH SWITCH (FIG. 3)

#### SEMICONDUCTOR

- Q1—2N5089 high-gain NPN silicon transistor
- Q2—2N3906 general-purpose NPN silicon transistor
- D1—1N914 general-purpose, small-signal, silicon switching diode
- LED1—Light-emitting diode (any color)

#### RESISTORS

(All resistors are 1/4-watt, 5% units.)

- R1—1000-ohm
- R2—3300-ohm
- R3—4700-ohm
- R4, R5—10,000-ohm
- R6—22-megohm

#### ADDITIONAL PARTS AND MATERIALS

- S1—Normally closed switch

ing it to conduct and to produce a positive pulse at its output.

The circuit's input sensitivity can be greatly enhanced by connecting two 2N3904 NPN transistors (see Fig. 2) in a Darlington configuration and substituting them for Q1. The hFE gain for the Darlington pair is near 10,000. That would be a good modification to make to the circuit if the bridging resistance source is extremely high.

The design process of the Electronic Touch Switch also led to a pair of expanded touch circuits that fall into the orphan category.

## LATCHING TOUCH SWITCH

Figure 3 shows the first derivative of the basic touch-switch circuit outlined in Fig. 1. By incorporating only three additional components—D1, R5, and S1—the Fig. 1 circuit becomes a latch-and-hold touch switch. The operation of this circuit is essentially the same as the Fig. 1 circuit, except for the extra function provided by the three additional components. As before, when the touch contacts are bridged, Q1 turns on, pulling the base of Q2 to ground potential. That causes Q2 to turn on, producing a positive output voltage at its collector.

That voltage is fed through S1, R5, and D1 to the base of Q1, latching it in the saturated (fully on) condition. Once the circuit is in the hold or latched condition, the touch input has no effect on the circuit's operation or output condition. The circuit remains latched until S1 is opened or power is completely removed from the circuit.

The latching circuit could be used in a manufacturing process to set a production line in motion and maintain operation until a reset signal is given. There are probably dozens of applications to which such a circuit might be well suited. But, since it is classified as an orphan circuit, I'll let you decide its fate.

## LATCH/UNLATCH TOUCH SWITCH

Incorporating three additional components into the latching touch switch in Fig. 3 transforms that circuit into the Latch/Unlatch Touch Switch illustrated

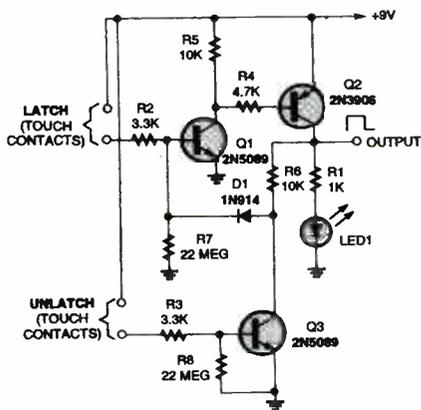


Fig. 4. This latch/unlatch touch switch is another derivative of the Fig. 1 touch switch. In this case, the addition of three additional components—Q3, R3, and R8—gives the circuit unlatching function.

### PARTS LIST FOR THE LATCH/UNLATCH TOUCH SWITCH (FIG. 4)

Q1, Q3—2N5089 NPN high gain transistor  
 Q2—2N3906 general-purpose PNP silicon transistor  
 D1—1N914 general-purpose small-signal silicon switching diode  
 LED1—Light-emitting diode (any color)

#### RESISTORS

(All resistors are 1/4-watt, 5% units.)  
 R1—1000-ohm  
 R2, R3—3300-ohm  
 R4—4700-ohm  
 R5, R6—10,000-ohm  
 R7, R8—22-megohm

in Fig. 4. Components Q3, R3, and R8 make up the unlatching circuitry for the present incarnation of the touch switch.

Once the circuit is latched on, bridging the unlatch contacts turns Q3 on, pulling its collector to ground potential. That removes the bias from Q1's base

terminal, releasing the latch. If both inputs are bridged at the same time, the output function is determined by whichever touch contacts are the last to be released (unbridged). If the latch input is last to be released, the circuit remains latched on; and if the unlatch input is the last to be unbridged, the circuit's output unlatches.

## FULL-WAVE DUAL-POLARITY POWER SUPPLY

Our next candidate, a quick and cheap Dual-Polarity Power Supply, is shown in Fig. 5. That circuit, comprised of a switch, a fuse, a transformer, a couple of capacitors, and four diodes that form a full-wave bridge rectifier, can be built for a few bucks. It does an excellent job of powering most op-amp circuits that do not require a regulated source. Just about any 12-volt transformer with a center tap will work.

To ensure a clean, relatively ripple-free output voltage, the filter capacitors (C1 and C2) should be 5000- $\mu$ F or larger electrolytic units. If you have difficulty finding 5000- $\mu$ F

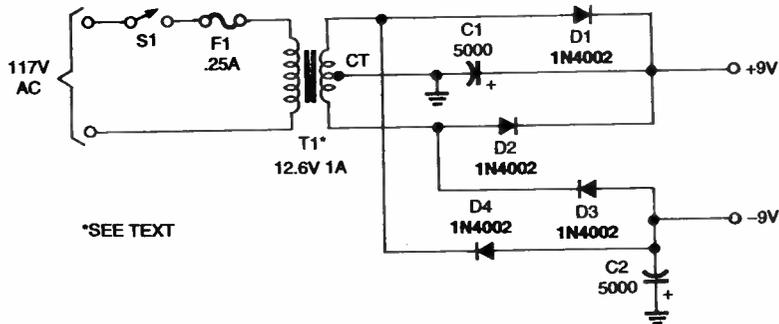


Fig. 5. There is nothing unconventional about this Dual-Polarity Power Supply, which is comprised of a switch, a fuse, a transformer, a couple of capacitors, and four diodes that form a full-wave bridge rectifier.

### PARTS LIST FOR THE FULL-WAVE DUAL-POLARITY POWER SUPPLY (FIG. 5)

D1—D4—1N4002 or similar 1-amp, 100-PIV, silicon rectifier diode  
 C1, C2—5000- $\mu$ F, 15-WVDC electrolytic capacitor  
 T1—12.6-volt CT, 1-amp, step-down, power transformer (see text)  
 S1—Single-pole, single-throw, toggle switch  
 F1—1/4-amp fuse

units, several 1000- $\mu$ F or greater capacitors can be connected in parallel to produce the equivalent capacitance. For example, if three 1500- $\mu$ F and one 500- $\mu$ F capacitors (or any other combination that adds up to 5000  $\mu$ F) are connected in parallel, they form a 5000- $\mu$ F equivalent unit.

Because the current requirement in most op-amp applications is usually very low, just about any 1-amp silicon diode with a peak-inverse (or reverse) voltage (PIV or PRV) rating of 50 volts or more will do.

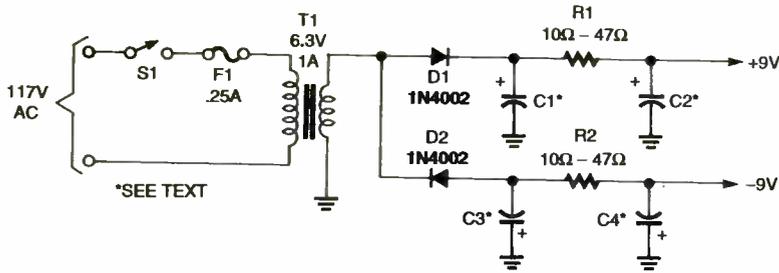


Fig. 6. The Half-Wave Dual-Polarity Power Supply—which is really two half-wave circuits, one negative output and the other positive—has a considerably higher ripple content than the full-wave circuit shown in Fig. 5.

### PARTS LIST FOR THE HALF-WAVE DUAL-POLARITY POWER SUPPLY (FIG. 6)

- D1, D2—1N4002 1-amp, 100-PIV general-purpose silicon rectifier diode
- C1—C4 —1000 to 5000- $\mu$ F, 15-WVDC electrolytic capacitor
- T1—6.3-volt, 1-amp, step-down, power transformer (see text)
- S1—Single-pole, single-throw toggle switch
- F1— $\frac{1}{2}$ -amp fuse

### HALF-WAVE DUAL-POLARITY POWER SUPPLY

If you are building the circuit from junkbox parts and the only thing available is a 6-volt transformer, you might consider building the dual-polarity power supply shown in Fig. 6. This dual-polarity power supply, unlike the

### PARTS LIST FOR THE IR LATCHING CIRCUIT (FIG. 7)

#### SEMICONDUCTORS

- IC1—H21A1QT-ND (Digi-Key) or similar IR interrupter module
- Q1—2N3904 general-purpose NPN silicon transistor
- LED1—Light-emitting diode (any color)

#### ADDITIONAL PARTS AND MATERIALS

- R1—1000-ohm,  $\frac{1}{4}$ -watt, 5% resistor
- R2, R3—10,000-ohm,  $\frac{1}{4}$ -watt, 5% resistor
- S1—Normally open pushbutton switch

previous circuit, is actually comprised of two half-wave circuits; one providing a negative output and the other providing a positive output voltage. Because the output of that type of circuit has a considerably higher ripple content, it requires additional filtering.

The values of R1 and R2 are determined by the power supply's load current. A 47-ohm,  $\frac{1}{4}$ -watt resistor can be used for load currents of 0.025 amps or less; for currents of no greater than 0.1 amp, a 10-ohm,  $\frac{1}{4}$ -watt resistor will do. The circuit is not suited to applications requiring currents much higher than 0.1 amp because the ripple factor increases rapidly as the current demand goes up.

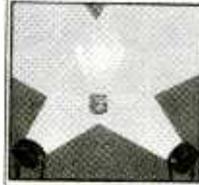
Both circuits can be converted to dual regulated 5-volt supplies by adding a 7805 regulator at the positive output and a 7905 regulator at the negative output. A 0.1- $\mu$ F, 50-WVDC capacitor should be included across the outputs of both the IC regulators.

Our next circuit is an orphan simply because it was assembled just for the fun of it and not to serve in some specific application.

### An Introduction to Light in Electronics

#### An Introduction to Light in Electronics

F. A. WILSON

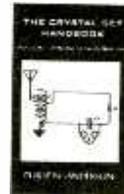


Taken for granted by us all perhaps, yet this book could not be read without it, light plays such an impressive role in daily life that we may be tempted to consider just how much we understand it. This book makes a good start into this fascinating and enlightening subject. It has been written with the general electronics enthusiast in mind.

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Fig. 7. At the heart of this unlatching circuit is an IR interrupter module, a device whose design is similar to that of conventional optoisolator/couplers. The module produces an output when the IR beam linking its two active internal components is interrupted.

# COMM Links

## Some EMI/TVI Fixes

JOSEPH J. CARR

Everywhere you look today, electromagnetic interference (EMI) is proliferating for one simple reason: electromagnetic devices and products sensitive to electromagnetic interference are proliferating. Let's look at some fixes for this problem.

The EMI emissions that play havoc with communications can originate from a variety of sources. There are both natural and man-made sources of noise, so much so that one might wonder how cell phones, two-way radios, broadcast receivers, or ham radios work at all! One clinical engineer in a hospital told me that solving EMI problems is a major portion of his work. The hospital uses a wide range of electronic devices, many of which cause or are susceptible to noise.

If you enter a hospital building, you'll see signs demanding that you not simply refrain from using your analog or PCS cellular telephone, but turn it off completely! The reason is the phone might interfere with radio telemetry (which is used in coronary care units (CCUs)) and wireless local area networks (W-LAN) used all over the hospital. I witnessed a security guard confiscating a cellular telephone from one guy who refused to heed the admonition of an emergency room nurse to turn off his phone.

### HARMONIC ELIMINATION

There is no such thing as a perfectly linear amplifier (although some types work better than others). Nor is there any such thing as a perfectly pure oscillator. In all such circuits, the supposedly pure sine wave actually contains at least some distortion. The result is that harmonics are generated at frequencies that are integer multiples of the fundamental frequency. For example, if  $f$  is the frequency, the harmonics are  $2f$ ,  $3f$ ,  $4f$ ,  $5f$ , and so forth. Of those, the most common offenders are the second and third harmonics because they are the largest.

The Federal Communications Commission in the US (and corre-

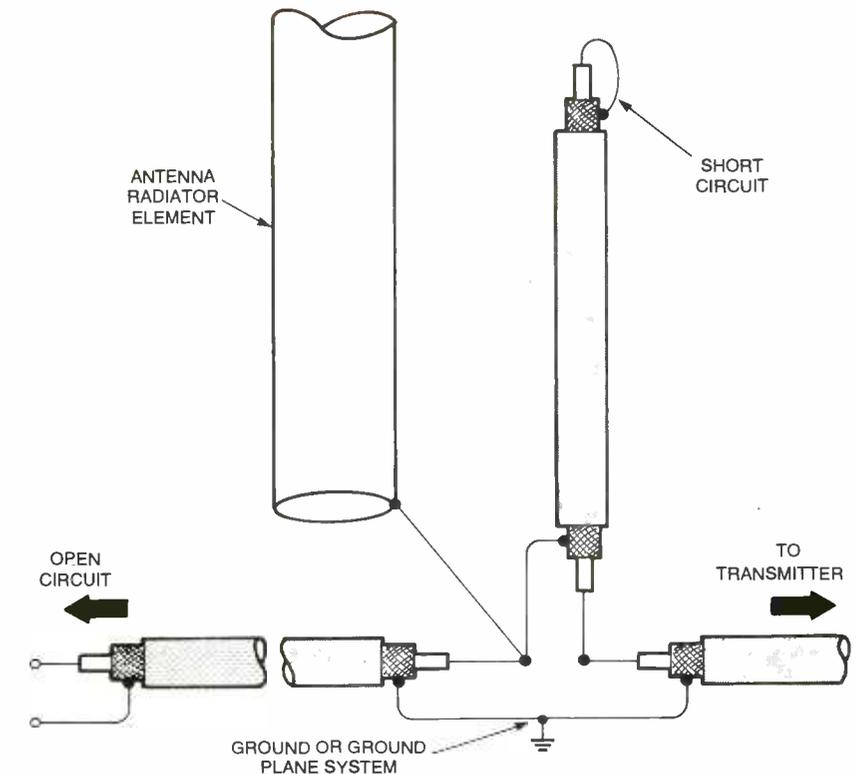


Fig. 1. Here is a method of harmonic suppression that's based on the properties of a quarter-wavelength stub. This method, widely used for VHF/UHF transmitters, is well suited to suppressing third-harmonic radiation and can be implemented with only a little bit of coaxial transmission line.

sponding agencies in other countries) requires that harmonics and other spurious emissions be suppressed by a specified amount. Depending on the service the transmitter is licensed for, the second and higher harmonics must be suppressed  $-40$  dBc (decibels below carrier),  $-50$  dBc, or  $-60$  dBc. In some instances, a higher standard may be required, especially at repeater sites where multiple high-powered transmitters and sensitive receivers share the space. A suppression specification that protects receivers 500 feet away may be totally insufficient when the receiver shares an antenna mast with the transmitter, and the pair are located a few feet apart.

The classic method for eliminating harmonics is to place a filter at the output of the transmitter. Ham-radio operators using the high-frequency (HF)

shortwave bands place a low-pass filter (LPF) between the antenna output of the transmitter and the antenna. Those filters have a  $-3$  dB cut-off frequency between 30 and 40 MHz, and so provide a huge amount of loss at 54–60 MHz (Channel 2) and higher. The idea is to permit operation at frequencies as high as the 10-meter band without putting out too much energy in the lowest VHF television channel.

The problem for other users is a bit different. If the transmitter and receiver operate in the VHF/UHF bands (including both commercial and amateur radio), then the problem is that a simple LPF or high-pass filter (HPF) may not adequately protect the other users. That's because the other systems may be above or below your operating frequency. It would be easy

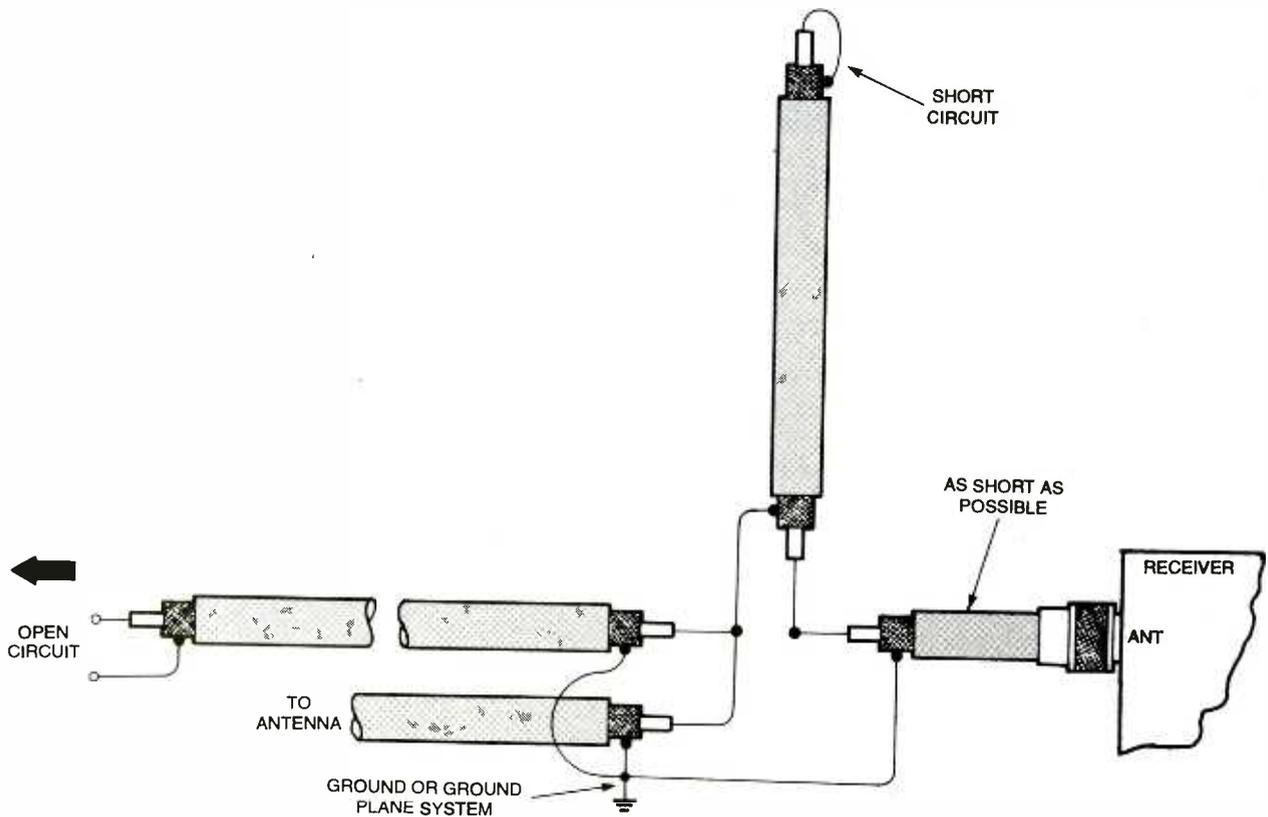


Fig. 2. Suppression methods used to prevent transmitters from spewing interference are also effective in combating its reception. Here is how the stubs are placed for this purpose.

if all other users were either above or below, but that's not usually the case.

One solution is to place a relatively narrow, bandpass filter (BPF) at the output of the transmitter. Such filters severely attenuate frequencies above and below certain cut-off limits, passing only those signal frequencies right around the transmitter's carrier.

### TUNED-STUB SOLUTION

Figure 1 shows a method of harmonic suppression that is widely used for VHF/UHF transmitters that can be implemented with only a little bit of coaxial cable transmission line. That approach, which is based on the properties of a quarter-wavelength stub, is well suited to suppressing third-harmonic radiation, and is used in applications where one particular harmonic is the problem.

In this approach, two quarter-wavelength stubs are connected at the base of the antenna. Both stubs are tuned to the third-harmonic of the transmitter frequency (or whichever harmonic is causing offense). A shorted stub is placed in series with the transmission line going to the transmitter. That shorted line presents a high impedance to the offending

harmonic, and so (because it is in series with the transmission line) suppresses the harmonic.

The second quarter-wavelength stub is the open-circuited stub connected between the antenna feed point and ground (or the ground plane in the case of some antenna designs). Whichever is the case, it is across the feed point of the antenna. The open-circuited stub presents a low impedance to the resonant frequency, so it provides additional suppression of the offending harmonic.

The combined effect of the two harmonic suppression stubs is that they act like a voltage divider with a high/low ratio at the resonant frequency of the stubs, and a low/high ratio at other frequencies. As a result, the third harmonic is seriously suppressed.

### STUB PHYSICAL SIZE

The quarter-wavelength stub is not a physical quarter-wavelength long because of the velocity factor (V) of the transmission line. The velocity factor is the percent (expressed as a decimal) of the speed of light at which the signal propagates in the line. Different types of coaxial cable offer different

velocity factors. For example, transmission lines with polyethylene as the dielectric have a velocity factor of 0.66; polyfoam-dielectric cables have a velocity factor of 0.80, and Teflon dielectrics have a 0.70 velocity factor.

For the physical quarter wavelength, we would find length by:  $L_{\text{INCHES}} = 2952/f_{\text{MHz}}$ . But with the velocity factor considered the proper expression is:

$$L_{\text{INCHES}} = 2952V/f_{\text{MHz}} \quad (1)$$

where  $L_{\text{INCHES}}$  is the length of the stub in inches,  $f_{\text{MHz}}$  is the frequency in megahertz, and V is the velocity factor of the transmission line. For example, suppose a transmitter is operating at 146.91 MHz and must not interfere with a receiver operating near its third harmonic of  $146.91 \text{ MHz} \times 3 = 440.73 \text{ MHz}$ . Find the physical length of a quarter wavelength stub at the third harmonic frequency if polyfoam coaxial cable is used.

$$L_{\text{INCHES}} = 2952V/f_{\text{MHz}}$$

$$L_{\text{INCHES}} = (2952)(0.80)/440.73\text{MHz} = 2361.6/440.73\text{MHz} = 5.36 \text{ inches}$$

(Continued on page 86)

# SCANNER SCENE

## A Miscellany of "Point"ers

MARC SAXON

**U**niden's new BC248CLT desk-top scanner takes a novel approach. This unit combines a 10-band, 50-channel scanner (with the channels arranged in five memory banks) with an alarm clock, emergency weather alert, and an AM/FM radio that allows for 20 presets. Here's a scanner designed for both general household news and entertainment purposes, for staying ahead of weather emergencies, and for scanning a number of area two-way communications.

Among the features are police, fire/EMS, aeronautic, maritime, and weather-service search capabilities. The BC248CLT also has channel lock-outs and delays. It can scan the memory channels in ascending or descending order. Those channels may also be stepped through manually.

At the time this was written, no price information or additional specs were available. You can see the new BC248CLT at any Uniden dealer.

### MAILING LIST UPDATE

A few months ago we mentioned online scanner-related mailing lists, and we have received requests for additional information. These are free services available to all who own computers capable of accessing the Web. Numerous lists currently exist, each dedicated to a specific monitoring interest or geographic area. When you subscribe to a list, you are able to send/receive daily e-mail postings that could include frequencies and other useful information specific to that list's subscribers. Many mailing lists require the list's owner to approve each new applicant seeking a subscription. All these lists will require potential subscribers to provide a little relevant information, such as name, e-mail address, *etc.*; and most of them reserve the right to kick out members who become disruptive.

One of the largest online hosts of all types of mailing lists is Onelist.com. Go to URL: [www.onelist.com](http://www.onelist.com) and search through their scanner-related lists. You'll find more than 50, including



*The Uniden BC248CLT takes a novel approach to scanning, by combining a 50-channel scanner with an alarm clock, an emergency weather alert, and an AM/FM radio.*

those for specific cities, states, and provinces; for trunking buffs; for those seeking technical reviews of equipment; and so on. Another excellent list host can be found at URL: [www.qth.net](http://www.qth.net), which offers scanner lists.

Those interested in a list providing general scanner news will probably like SCAN-L. Request subscription information by e-mailing the person who runs SCAN-L at: [owner-scan-l@uafsysb.uark.edu](mailto:owner-scan-l@uafsysb.uark.edu). Lastly, a service called The Scanner WebRing has direct links to nearly 250 great scanner-related Web sites such as clubs, dealers, etc. It's a wonderful resource. The URL is: [www.webring.org/cgi-bin/webring?ring=radioscanner&list](http://www.webring.org/cgi-bin/webring?ring=radioscanner&list).

However, here are a few cautionary words about online mailing lists. Some of them will provide you with dozens of e-mails daily. Unless you want to spend a lot of time reading the mail, you'll want to restrict your subscriptions to no more than two or three at a time. You can always unsubscribe to a list that turns out to be of no value to you, and add a new one in its place.

### SHIP-TO-SHORE

Cellular phones have become so popular aboard small boats that

they've gone a long way towards virtually replacing the old 160-MHz VHF marine operators. The 160-MHz marine operator service usually offers only one active channel per area, limiting the number of calls that can be handled at a time. Not only that, but waiting for the live operator to get around to responding and processing a call often results in a lot of wasted time. Still, in the pre-cell phone era, boaters relied upon this system. But even convenient cell phones, with no waiting for a clear channel or alert operator, never offered the ability to communicate from as far offshore as the 160-MHz radios.

Looks as though the 160-MHz service is getting a new lease on life. A company called MariTEL has contracted the Harris Corp. to join them in establishing a new \$55-million national maritime communications network known as MariTEL. Offering 100-mile communications range from each of 300 coastal stations, it will process calls to/from the public phone network automatically, and without the need for operators. The service will be available along navigable inland waterways and all coastal areas. MariTEL will handle phone calls, faxes, and e-mails.

At least nine shore/ship channel pairs will be available from each shore station: 161.80/157.20, 161.825/157.225, 161.85/157.25, 161.875/157.275, 161.90/157.30, 161.925/157.325, 161.95/157.35, 161.975/157.375, and 162.00/157.40 MHz.

## POINT OF ORDER

Many times when speaking with scanner enthusiasts, I have noticed the tendency to state frequencies (for example, 154.37 MHz) as one five four DOT three seven. Far be it from me to stifle free expression, but that's incorrect. A dot is something in a computer address or maybe in the design of your Aunt Clara's scarf. The popularity of computers has caused some newer scanner owners to misidentify the symbol used in frequencies. When it comes to frequencies we deal with decimal points, not dots.

A typical scanner frequency, therefore, would properly be said aloud as one five four POINT three seven, or alternately, one five four DECIMAL three seven.

In a related topic, there has always been some user confusion relating to programming a specific type of VHF high-band frequency into the memory of certain scanner models (especially handhelds). No problem if you program frequencies such as 155.67 MHz or even 154.385 MHz. But there might be a problem trying to force feed in something with four digits beyond the decimal point, such as 165.2875 MHz. Even if those digits show up on the LCD as you press the programming keypad, when you hit <ENTER>, you may be dismayed to learn the scanner simply will not accept that exact frequency. You might end up with 165.285 or 165.29 MHz on the scanner display. You didn't want either of those frequencies! Some scanner owners panic because they're afraid they won't be able to monitor certain desired frequencies. No to worry.

Some scanners are simply not designed to accept VHF high band federal (162–174 MHz) frequencies with 12.5-kHz spacing. A frequency such as 165.2875 MHz indicates one of those channels. Your attempt to program in one of these frequencies causes some scanners to automatically round off your choice to the nearest point based upon the regular VHF high band's (152–162 MHz) 15-kHz channel spacing. But that's a mere 2.5 kHz away from the exact frequency you

specified, and nothing to cause you to lose any sleep. Standard NFM transmissions and scanners are broad enough to permit monitoring any transmissions on your desired channel, regardless of it being tuned 2.5 kHz off center. You'll never notice any difference from being tuned in exactly.

Be aware that the new FCC channel setup going into effect on the 152–162 MHz VHF high band has channels spaced at 7.5-kHz intervals. When stations become active on channels that closely spaced, current scanners will not be capable of adequately tuning in the desired frequencies, nor of blocking interference from stations using adjacent frequencies. The same problem will be noted with forthcoming UHF assignments when those stations become spaced at 6.25-kHz intervals instead of the present 12.5 kHz. ■

## COMM LINKS

(continued from page 84)

## RECEIVER APPLICATIONS

Quarter-wavelength stub system can be used to eliminate incoming signals that are causing interference. Figure 2 shows a receiver application based on that premise. The stub system can be placed at the antenna. In Fig. 2, however, it is placed as close as possible to the receiver in order to eliminate any radiated interference that is picked up on the line. The lengths for the stubs in Fig. 2 are calculated to remove the frequency that is causing the interference. It might be the third-harmonic of a nearby transmitter or a completely different frequency.

One of the major problems associated with a multi-system site is intermodulation distortion (IMD) interference. When two or more signals are present at the input of the receiver, there's always a good chance of generating additional frequencies (especially if at least one of them is a strong signal). The frequencies generated are:

$$f_{\text{NEW}} = mf_1 \pm nf_2 \quad (2)$$

where  $f_{\text{NEW}}$  is a new frequency generated by the nonlinear combination of  $f_1$  and  $f_2$ . The order of the product is given by the sum of the integer coefficients to  $f_1$  and  $f_2$  (i.e.,  $m + n$ ). Given input signal frequencies of  $f_1$  and  $f_2$ , the main IPs are:

<b>Second-Order</b>	$f_1 \pm f_2$
	$2f_1$
	$2f_2$
<b>Third-Order</b>	$2f_1 \pm f_2$
	$2f_2 \pm f_1$
	$3f_1$
	$3f_2$
<b>Fifth-Order</b>	$3f_1 \pm 2f_2$
	$3f_2 \pm 2f_1$
	$5f_1$
	$5f_2$

Whenever an amplifier or receiver is overdriven, the second-order content of the output signal increases as the square of the input signal level, while the third order responses increase as the cube of the input signal level . . . which can cause serious problems. As a result, when troubleshooting a problem with interference, you must sometimes look for completely unrelated frequencies that will satisfy equation 2 and, thereby, land on your frequency. When troubleshooting that type of problem, it is necessary to place the notch on the frequency of one of the two offenders, preferably the strongest.

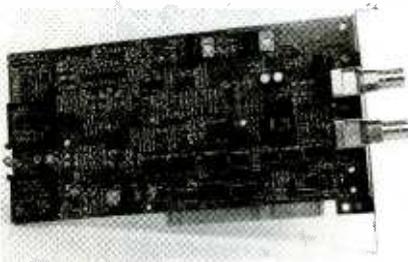
The IMD problem occurs because the combined strength of the two signals drives the receiver's RF amplifier or first mixer into a deeper region of non-linear operation. If the applied RF-signal levels are low enough, then no problems occur. Of course, all mixers operate non-linearly, so we look to the *third-order intercept point* (called either TOIP or IP3). The TOIP is usually specified in terms of dBm (decibels above one milliwatt).

When evaluating receivers, a TOIP of +5 to +20 dBm usually represents excellent performance, while up to +27 dBm is relatively easily achievable, and +35 dBm is been achieved with good design; anything greater than +50 dBm is close to miraculous (but, if manufacturer ads are believed, at least attainable). Receivers are still regarded as good performers in the 0 to +5 dBm range and middling performers in the -10 to 0 dBm range. Anything below -10 dBm is not usually acceptable. ■

# NEW PRODUCTS

## SINE-WAVE AND CLOCK GENERATOR

Combining a direct-digital-synthesis (DDS) circuit with a multi-stage amplifier, the PCI-305 Sinewave and Clock Generator provides a convenient and low-cost method to generate 25-MHz sine waves and 50-MHz TTL clock signals in a PC-based test system. The PCI-305 also performs smooth amplitude, offset, and frequency changes. The sine-wave output supports waveform summing and is protected against reverse-power situations.



It is designed for test engineers to use in ATE systems, impedance analyzers, loop-stability analysis, and in communications systems. Unlike box function generators, the PCI-305 doesn't need an IEEE-488 interface card and interface cable. The half-slot ISA card fits into PCs and comes complete with *BenchCom* and *BenchTop Lite* software packages for Windows NT, 98/95, 3.X, and DOS applications.

The PCI-305 Sinewave and Clock Generator costs \$995. For more information, contact PC Instruments Inc., 526 S. Main Street, Akron, OH 44311; Tel. 330-762-8500; Web: [www.pcinstruments.com](http://www.pcinstruments.com).

**CIRCLE 80 ON FREE INFORMATION CARD**

## MULTIBAND TRANSCEIVER

A small, handheld, four-band radio, the IC-T81A features clear wide-band reception, 124 memory channels, and simplicity of design. Function keys can be confusing, so the IC-T81A doesn't use any. Instead, the radio offers a five-position "joystick" for easy control of operating band, scanning, and more, as well as an alphanumeric display

for memory-channel naming.

This powerful radio covers the six-meter, two-meter, and 440-MHz bands at 5 watts output power and the 1.2-GHz band at 1-watt output. With the IC-T81A, listeners can go beyond the ham bands to monitor wide-band FM/VHF band communications—hear-



ing everything from a ball game on the radio or TV audio broadcast to air traffic control, or even to scan for police activity. Slim, compact, and durable, the transceiver measures 2.3 by 4.2 by 1.1 inches, weighs 9.9 ounces, and boasts water-resistant construction.

The IC-T81A costs \$479. For more information, contact Icom America, Inc., 2380 116<sup>th</sup> Avenue, NE, Bellevue, WA 98004; Tel. 425-454-8155; Web: [www.icomamerica.com](http://www.icomamerica.com).

**CIRCLE 81 ON FREE INFORMATION CARD**

## LINEAR POWER SUPPLY

Designed for use on the lab bench or for a systems application, the *HWD Series of Constant Voltage/Current Linear Power Supplies* are single-output, 200-watt, full-range, adjustable instruments. All the units feature

remote sensing terminals and remote programming. The availability of RS-485 and RS-232 programming options makes them versatile systems-test instruments.



Their digital voltmeters and ammeters provide full-rated, accurate voltage or current readings without the need of external DVMs. Measuring only 4.5 by 8 by 14 inches, the models include maximum voltages of 6-, 10-, 20-, 40-, 60-, 100-, 200-, and 400-volts DC. The voltage and current levels are fully adjustable by means of 10-turn controls.

The HWD Series of Constant Voltage/Current Linear Power Supplies has a range in price from \$950 to \$1200. For more information, contact Mid-Eastern Industries, 100 School St., Bergenfield, NJ 07621; Tel. 201-385-0500; Web: [www.mideastind.com](http://www.mideastind.com).

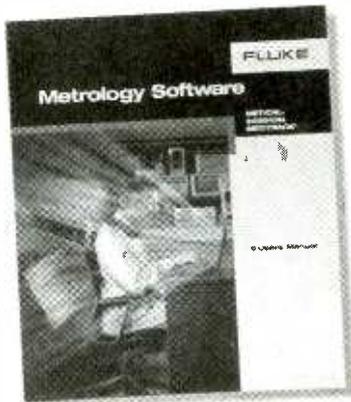
**CIRCLE 82 ON FREE INFORMATION CARD**

## CALIBRATION SOFTWARE

*MET/CAL Plus Calibration Software* extends workload coverage to include RF and microwave instruments like signal generators. This software also meets new international standards for calculating and reporting measurement uncertainties, and it adds synchronization and Web-server options. Version 6 supports RF power meters, counters, signal generators, modulation analyzers, measurement receivers, and distortion and spectrum analyzers from Hewlett-Packard, Marconi, and Rhode & Schwarz—more than 82 instruments are directly supported.

At the heart of the system is MET/BASE, a powerful industry-standard SQL server that provides secure,

dependable storage for calibration information. The system is scaleable and can be installed on anything from a laptop to a multi-mode, multi-site network. More than 2000 procedures for more than 600 makes and models of test and measurement instruments are shipped with the software.

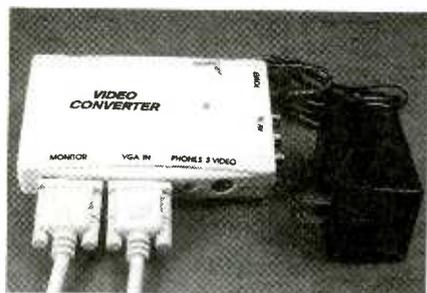


The MET/CAL Plus Calibration Software has a list price of \$3800. For more information, contact Fluke Corp., P.O. Box 9090, Everett, WA 98206; Tel. 888-492-7554; Web: [www.fluke.com](http://www.fluke.com).

**CIRCLE 83 ON FREE INFORMATION CARD**

### PC MONITOR CONVERTER

The *VGA-801 PC Monitor Converter* provides an easy, low-cost way of displaying B/W or standard NTSC/PAL color video directly on any existing VGA/SVGA computer monitor. With 24-bit, 16.7 million true-colors processing, it triples the resolution of a standard TV in B/W and doubles the resolution in color mode. The built-in audio amplifier has a true frequency response from 100 Hz to 31.5 kHz and provides for headphone use.



This standalone device, with overall dimensions of 4½ by 2½ by ¾ inches, 88 plugs directly into any VGA/SVGA

monitor. The VGA-801 uses a three-way switch that allows the monitor to be used with a computer, a standard video source (such as a security camera), or a special Sony S-Video input. A wall-mount regulated power supply is included.

The VGA-801 PC Monitor Converter starts at \$69. For more information, contact MATCO, Inc., 830 East Higgins Road, Suite 111-P, Schaumburg, IL 60173; Tel. 800-719-9605; Web: [www.mat-co.com](http://www.mat-co.com).

**CIRCLE 84 ON FREE INFORMATION CARD**

### WIRELESS WEATHER STATION

The full-featured model *WS2010 Wireless Weather Station* includes readings of wind speed and direction, a rain gauge, and indoor/outdoor temperature and humidity. It provides minimums and maximums of all readings with time and date recorded, a 24-hour pressure history bar graph, weather forecast, and pressure trend indicator with storm alarm.



Outdoor sensors are solar powered with back-up Lithium batteries, and the display unit uses 4 AA batteries. Measuring 8½ by 1½ by 6 inches, the WS2010 comes with mounting brackets for all sensors; and the display can be desk- or wall-mounted.

The WS2010 Wireless Weather Station has a suggested retail price of \$499. For more information, contact Speedtech Instruments, 10413 Deerfoot Drive, Great Falls, VA 22066; Tel. 800-760-0004; Web: [www.speedtech.com](http://www.speedtech.com).

**CIRCLE 85 ON FREE INFORMATION CARD**

### RTD/THERMOCOUPLE THERMOMETER

With this heavy-duty precision *RTD/Thermocouple Thermometer, Model 407917*, users can measure tempera-

ture with the platinum RTD or select from five thermocouple types. Measurements are displayed on a 4½-digit (19999 count) LCD with Data Hold and Max/Min/Relative readings. Basic accuracy is ±0.1% full scale.

A front-panel pushbutton allows the user to select the input sensor type. Other features include selectable °C/°F temperature units, the choice of 1° resolution or 0.1° resolution, and an RS-232 PC interface. The thermometer, which measures 7.1 by 8 by 1.3 inches and weighs only 10 ounces, comes complete with a rubber holster and a 9-volt battery.

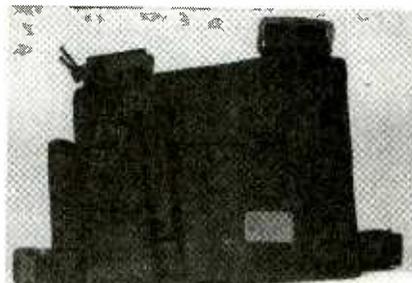


The RTD/Thermocouple Thermometer, Model 407917 costs \$219. For more information, contact Extech Instruments Corp., 335 Bear Hill Road, Waltham, MA 02451; Tel. 781-890-7440; Web: [www.extech.com](http://www.extech.com).

**CIRCLE 86 ON FREE INFORMATION CARD**

### CHEST HARNESS

Ideal for emergency radio operators and hams on the move, the rugged *Ham Gear Tactical Chest Harness* holds a handheld radio or cellular phone snugly to the chest for hands-free and worry-free operation. Made of durable, heavy-duty twill burlap that's water-resistant, the chest harness



cushions the radio from scrapes and blows. It holds the radio vertically to improve reception, and it has twin elastic antenna holders for short and long HT antennas.

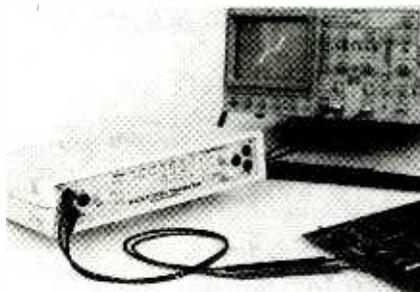
The shoulder straps and elastic belt are fully adjustable to fit any size radio and any size person comfortably. In addition, there's a 5-inch by 7-inch cargo pocket to hold another radio, maps, or tools; as well as a pen pouch.

The Ham Gear Tactical Chest Harness (MFJ-18) costs \$29.95. For more information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762; Tel. 800-647-1800 or 601-323-5869; Web: [www.mfjenterprises.com](http://www.mfjenterprises.com).

**CIRCLE 87 ON FREE INFORMATION CARD**

### TROUBLESHOOTING TOOL

Designed to work with any oscilloscope that can be operated in an X/Y mode, the *Tracker 200* is a quick and effective tool for power-off, component-level troubleshooting of printed circuit boards. The oscilloscope displays the current-voltage "analog signature" generated by the *Tracker 200* of a device under test. With the combined scope/*Tracker* capabilities, engineers and technicians are able to go from basic circuit analysis to comprehensive component-level diagnosis.



This unit features four test ranges, plus an additional low-voltage (3-volt) range for low-power surface-mounted devices. Three of the test frequencies allow for the testing of capacitors and inductors, while a variable DC level tests gate-fired devices. For quick diagnostic troubleshooting, the instrument can be operated in a two-channel comparison mode where it can be switched between a "known-good" signal and the signal being tested.

The *Tracker 200* sells for \$995. For more information, contact Huntron

Instruments, 15720 Mill Creek Blvd., Ste. 100, Mill Creek, WA 98012; Tel. 800-426-9265; Web: [www.huntron.com](http://www.huntron.com).

**CIRCLE 88 ON FREE INFORMATION CARD**

### NET WATCH

*(continued from page 6)*

Now, for those of you looking to hit a more traditional department store, check out JCPenney. Although we don't recommend buying gifts of clothes online (you're almost guaranteed to have to do a few mail returns), some people on your list might have set-in-stone sizes (such as a dress shirt or socks) that you're pretty safe relying on. For these and other purchases such as jewelry or accessories, you'll find JCPenney to be a handy site to visit. In fact, of all the sites so far mentioned, this one probably has the most items available in each category. Don't let the seemingly small menu on the first page fool you. Each of those offerings, such as Men's or Women's, opens up to about a dozen subdivisions with many products in each. There are even a couple of categories of "perfect gift ideas," should you be in a real rush. If you've been to the real-world version of Penney's or have seen its catalog, you know just how much the chain carries. And most of it seems to be online now—nice.

Finally, music to every shopper's ears around this time of year is the concept of saving money. If you'd like to get free online coupons for most of the sites we've looked at, as well as several others, be sure to visit [Coolsavings.com](http://Coolsavings.com). You'll have to fill out some demographic info, but it will be well worth the money you'll save.

Until next time, happy shopping. Here's hoping that you use those hours or days you save to actually enjoy the holidays!

As always, you can contact me via snail-mail at *Net Watch*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735, or e-mail at [netwatch@gernsback.com](mailto:netwatch@gernsback.com).

### COMPUTER BITS

*(continued from page 13)*

quickly come to realize that keeping track of your scanned documents,

photos, and other images can become a full-time job. Many scanners come with software suites or document manager for this purpose. There are also many of these applications on the market, some better known than others. The two that I have the most experience with both come from ScanSoft, a division of Xerox.

*PaperPort*, which was originally produced by scanner vendor Visioneer, was purchased by ScanSoft a bit over a year ago. ScanSoft has its own product, called *Pagis*, and continues to sell both. Different scanner vendors, including Visioneer, Canon, Epson, and others often include versions of *PaperPort* or *Pagis* with their scanners.

*PaperPort* was one of the first scanning utilities to incorporate a desktop metaphor. A thumbnail-sized representation of the document, when scanned, appears on the application's "desktop" panel. From there, you simply drag the thumbnail over to the application in which you want to use it. You can store the document in a folder by dragging it over to an image of a file cabinet, or automatically launch OCR software by dropping the document icon on that of a word processor.

*Pagis Pro 3.0 Scanning Suite* is very similar in appearance and function. There's a quick action toolbar, for when you want to make a color copy (scan a document and send the image to a color printer), or scan and fax. There's also a desktop, where the thumbnail of the scanned document can be maneuvered as discussed above. *Pagis* calls this the *Pagis Inbox*. The latest version of *Pagis Pro* is a terrific utility and can be purchased at most computer stores for about \$120. It incorporates the next-to-the-latest version of ScanSoft's *TextBridge Pro* OCR software and a copy of Adobe's *PhotoDeluxe Business Edition* image-editing and project software. The OCR has a utility that converts scanned documents into forms that can be electronically filled-in, and you can even search your document database of scanned pages for text strings and keywords.

Next time, we'll put *Pagis Pro 3.0* to use on a couple of projects—see you then. In the meantime, as always, I value your comments and input. You can reach me at [tneedleman@aol.com](mailto:tneedleman@aol.com).

And a Happy Holiday season to you and yours.

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**New Models with Newly Added Features!!**

# TOUCH DISPLAY MODULE



**CTD1047** COLOR

10.4-inch color TFT

NEW

**CTD5741** COLOR

5.7-inch color STN

Model in photograph enclosed in case. (CTD5741-11)  
CTD5741 is 100% compatible with  $\mu$ TD4141.

NEW



**$\mu$ TD4141**

5.7-inch monochrome



## Development Support Tool

For Windows 98/95

\$150

NEW



## New Features

### Personalized Color Palettes

You can personalize the tone of the built-in 16-color palette by setting RGB (brightness) level.

### Copying

Areas of the screen can be selected and copied onto other screens.

### Expanded Flash Memory

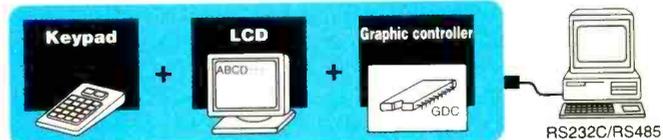
#### Image Manipulation

Images imported from digital cameras or other sources can be easily bitmapped and registered on screens or keycaps. (The demonstration fish was created with the Development Support Tool.)

#### Screen-to-Screen Group Move

Screen data can be selected, grouped and moved to other screens.

### System Setup Example



Specification	Model	$\mu$ TD4141	CTD5741	CTD1047
Display	LCD	5.7-inch, monochrome	5.7-inch, color STN	10.7-inch, color TFT
	Resolution	320 × 240	320 × 240	640 × 480
	Maximum digits	40 columns × 30 lines	40 columns × 30 lines	80 columns × 60 lines
	Effective display area (mm)	116 × 87	116 × 87	211 × 158
Key matrix input		10 × 6	10 × 6	13 × 10 (640 × 480)
Key size (mm)		12 × 14	12 × 14	15 × 15
Power supply		5V DC 0.8A	5V DC 1A	5V DC 1.2A
Dimensions (mm)		W189 × D112 × H32	W189 × D112 × H32	W272 × D205 × H43
<b>Standard price</b>		<b>\$555</b>	<b>\$740</b>	<b>\$1225</b>

\*Escutcheons and cases available for all models.

- Via RS-232C communications, simple commands let you easily display characters, draw graphics or collect key-input information.
- The built-in display memory can hold 4 full screens, making paging and other screen operations more convenient. (Up to 54 screens can be added with the Expanded Flash Memory.)
- Expansion features can be easily used with the Development Support Tool optional software.

- A wide array of characters can be displayed including kanji, kana, alphabet, numerals and special patterns.
- Key-input can be selected between polling and interrupt.
- Equipped with buzzer ON/OFF and backlight ON/OFF commands.
- Characters can be displayed as large as 64 × 64 dot.
- Easy backlight replacement (for color LCD models).
- Portrait monitor and RS485 model are available as special specification.

URL = <http://www2.dango.ne.jp/onomichi/inh/>

E-mail = [inh@orange.ocn.ne.jp](mailto:inh@orange.ocn.ne.jp)

**INH** International Hanbai Co., Ltd  
22-30 Kanda-cho, Onomichi, Hiroshima, 722-0016, Japan

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**Tight Integration with Multisim** Supports forward and back annotation with Multisim, so that the programs share important design information.

**Flexible Editing** Full support of power and ground planes, with or without thermal relief. 'Reroute while move' to move copper without losing connectivity.

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