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MAY 1999

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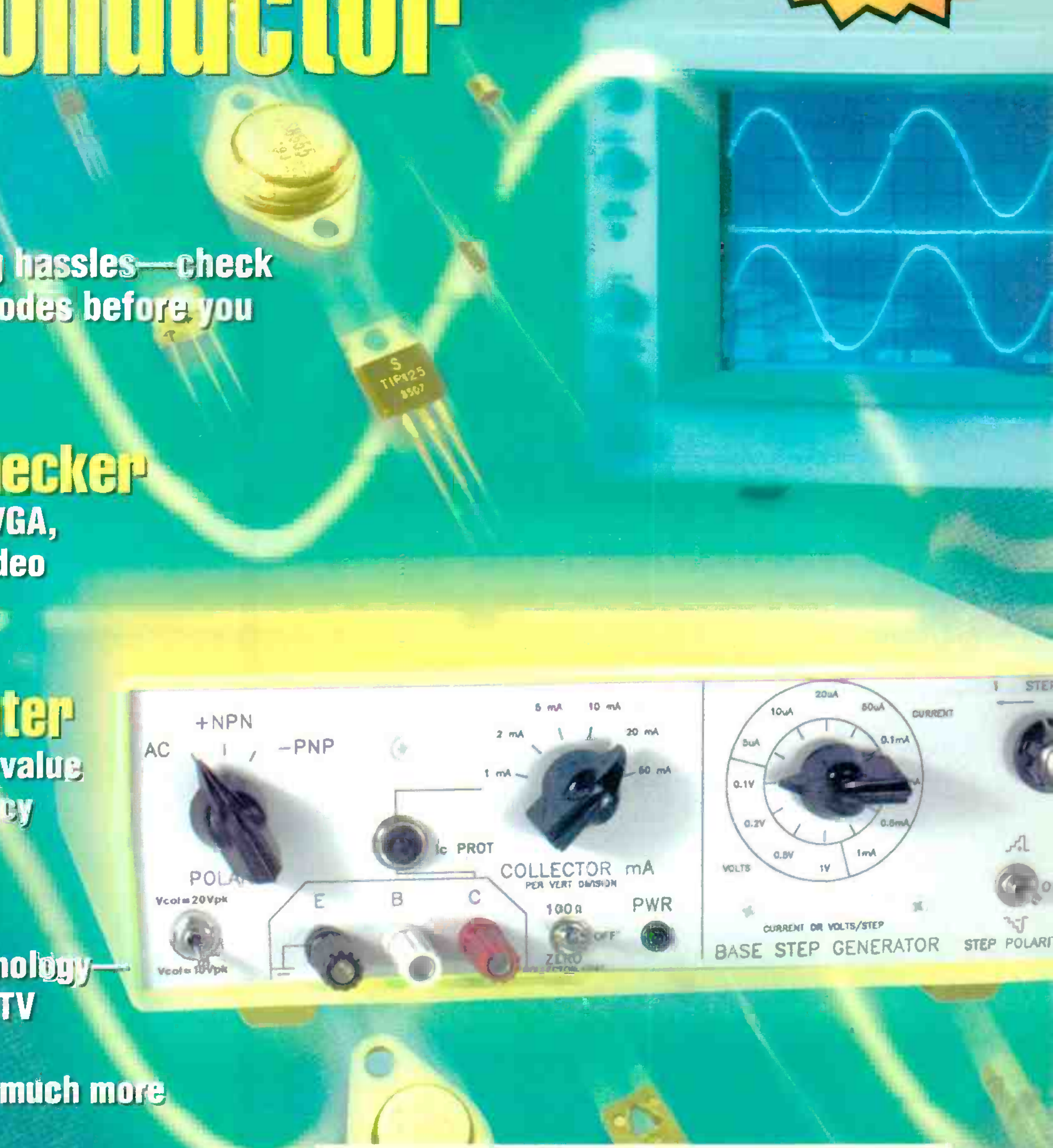

Semiconductor Tester

Avoid troubleshooting hassles—check out transistors and diodes before you use them in circuits

PC Monitor Checker

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Electrolytic Meter

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- Scanning on Airplanes
- Building an HF Receiver

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MAY 1999, Vol. 16, No. 5

Popular Electronics®

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

CONSTRUCTION ARTICLES

SEMICONDUCTOR TESTER .... *Charles Hansen* 31
Use it with an oscilloscope to determine if transistors and diodes are working properly
ELECTROLYTIC METER .... *Eugene Vahle* 42
Identify those large-value capacitors in your junkbox with this accurate device
PC MONITOR CHECKER .... *Chet Roher* 47
This video source can test MGA, EGA, VGA, and composite-video displays

PRODUCT REVIEWS

HANDS-ON REPORT 13
CLAGGK PICtutor CD-ROM/Trainer Board
GIZMO 20
The cutting-edge from CES—interactive and digital TV, better-than-CD audio, home networking, and more

COLUMNS

PEAK COMPUTING .... *Andrew T. Angelopoulos* 3
Time for a New Video Card?
MULTIMEDIA WATCH .... *Marc Spiwak* 5
Portable MP3 Music, Canon Peripherals, and More
NET WATCH .... *Konstantinos Karagiannis* 8
Help for Newbies and the Experienced
SCANNER SCENE .... *Marc Saxon* 15
InFlight Listening
HAM RADIO .... *Joseph J. Carr* 53
Building a Top-Notch HF Receiver
DX LISTENING .... *Don Jensen* 55
X Marks the Spot
CIRCUIT CIRCUS .... *Charles D. Rakes* 57
More Hall-Effect Circuits
THINK TANK .... *Alex Bie* 61
Lights on with Photodiodes
ANTIQUE RADIO .... *Marc Ellis* 65
Those Magnificent Philco Cathedrals

DEPARTMENTS

EDITORIAL 2
LETTERS 10
NEW PRODUCTS 12
ELECTRONICS LIBRARY 28
POPULAR ELECTRONICS MARKET CENTER 71
ADVERTISING INDEX 90
FREE INFORMATION CARD 90A

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Editorial

Really Doing it Yourself

Sweeping changes are happening here at **Popular Electronics**. As part of our new direction—to include more hands-on and cutting-edge material—we are introducing a new column and devoting this month's issue to building test gear.

First, about the new column, *Peak Computing*. While there are plenty of computer magazines out there dealing with what PC to buy and so on, there's very little practical material available on how to keep the computer you have in peak shape. In our new column, you'll learn in clear, step-by-step language how to upgrade, fine-tune, and enhance your system. While computers are undoubtedly a part of electronics, shopping for a new system every month shouldn't be—check out *Peak Computing* on the very next page. It and all computer-oriented columns will now sport a new look.

Our collection of construction features this month focuses on test gear that will help you troubleshoot and identify components, as well as check if a certain important device is working. While these are somewhat advanced projects, and require patience to build, we felt many of our readers could use home-built, yet sophisticated test devices ... hence this special issue.

Our Semiconductor Tester lets you determine if transistors and diodes you're about to use in a project are up to the task. Learn how to build this oscilloscope add-on by turning to page 31.

If you've got a bunch of large-value capacitors sitting around and want to verify if any are just right for your next circuit, use the Electrolytic Meter. Find out how to build the accurate device on page 42.

Is your video monitor acting up? Whether it's an MGA, EGA, VGA, or even composite-video unit, your CRT can be given a great exam with our PC Monitor Checker. The story begins on page 47.

Next month, and in the issues following, we'll be balancing complexity levels by running some simpler gadgets. Coming soon are circuits that let you take control of your home, experiment with high voltage, and even reach out to the stars! Despite the amount of mail we might get on that last statement, you'll just have to wait and see what it means....

Until next time, we hope you enjoy the new direction of our old friend.

Konstantinos Karagiannis
Editor

ANDREW T. ANGELOPOULOS

Time for a New Video Card?

Is your computer system beginning to feel a little sad? Do you find yourself turning off clouds, terrain, textures, and everything else in your favorite game to keep the frame rate up? Even when your system meets or exceeds the minimum and recommended requirements? Are you tired of looking at low-resolution presentations and multimedia effects because it's the only way to get 16-bit color?

All these problems might not be your processor or memory. It might just mean that a new video card could solve your problem.

Whether you have a 90-MHz Pentium with MMX or a 450-MHz Pentium II powerhouse, adding a new video card for optimal system performance is not as hard, or as expensive, as it sounds. It's quite easy—all you need are a small Philips- and a flat-head screwdriver—and cost effective, with new video cards costing $100–$200.

Attention, gamers! Diamond Mulimedia's Monster Fusion card has all the power you need, fueled by 3Dfx's Voodoo Banshee chip. In both PCI and 1X AGP models, the 128-bit card supports Direct3D, Glide, and MiniGL; has 16MB of SDRAM on board; and handles refresh rates as high as 200 Hz.

TYPES OF CARDS

There are two types of video-card interfaces available: the Accelerated Graphics Port (AGP) and Peripheral Component Interface (PCI). Most, but not all, Pentium II and AMD K6-2 systems use AGP, a dedicated video pathway, for their video needs. All other Pentium-class machines get a PCI port.

There are important differences here. AGP and PCI cards are *not* interchangeable. AGP connectors, introduced a little over a year ago, are video dedicated. PCI slots share the PCI infrastructure with modems, sound cards, and almost anything else you have installed, thereby sharing PC resources in a less than desirable fashion. Think of the plumbing in your home; the more faucets turned on in a house the less water each gets.

At their most basic, AGP cards are plenty faster than PCI cards. While PCI limits video to 133 MB/sec of data transfer, AGP 1X doubles that number to 266 MB/sec. Faster versions of AGP are also available, with 2X providing 533 MB/sec speed, and 4X a whopping 1.07 GB/sec! This kind of video data will blow a hole in the bottom of the aforementioned sink.

Of course, you can only take advantage of AGP if your system's motherboard supports the bus. The good news is that either type of system—AGP or PCI—can benefit from an upgrade. Regardless of what the standards imply about computer slots, the cards that go into them are not equal. Compared to the card that came with your system, a new card will certainly handle data more effectively, come with more memory (which is directly related to color depth and resolution—more memory means more of both), and integrate the latest standards (important for gaming, especially).

In deciding on a video card you have to be realistic about your needs and system. A 90-MHz Pentium will not run a game that requires a faster CPU (check a title's box), even with the best video card. However, word-processed documents, browser pages, and multimedia presentations will draw faster and look great with 16- or 24-bit color and the resolution set to a sharp 1024 × 768 or better.

Modern video cards offer combined 2D/3D solutions. Game cards offer superior 3D, running Direct3D, Glide, or MiniGL programming languages (essentially, these make games that support them look sharper and run smoother). Business video cards are strong 2D performers, offer a comfortable amount of memory for high resolutions and color depth, and have decent 3D performance for multimedia needs. Both categories work well for users who use their machines for both work and play.

SOME CARDS TO START WITH

On the gamer's front, Diamond Mulimedia's new *Monster Fusion* card comes in both PCI and 1X AGP models. It is based on 3Dfx's Voodoo Banshee chip and supports Direct3D, Glide, and MiniGL. It offers 128-bit performance, 16MB of SDRAM, and a 250-MHz DAC, and will support monitor refresh rates as high as 200 Hz. The

VIDEO CARD MANUFACTURERS

ATI Technologies Ltd.
33 Commerce Valley Drive East
Thornhill, Ontario
L3T 7N6 Canada
Tel. 905-882-2600
Web: *www.atitech.com*

Diamond Multimedia Systems, Inc.
2880 Junction Avenue
San Jose, CA 95134
Tel. 800-468-5846
Web: *www.diamondmm.com*

Hercules Computer Technology, Inc.
3839 Spinaker Court
Fremont, CA 94538
Tel. 800-532-0600
Web: *www.hercules.com*

Matrox Graphics, Inc.
1055 St. Regis Blvd.
Dorval, Quebec
H9P 2T4 Canada
Tel. 800-361-1408
Web: *www.matrox.com*

Number Nine Visual Technology
Domestic Sales
18 Hartwell Avenue
Lexington, MA 02421
Tel. 800-GET-NINE
Web: *www.nine.com*

Real3D
12506 Lake Underhill Road, MP-811
Orlando, FL 32825
Tel. 800-393-7730
Web: *www.real3d.com*

AGP version comes with DVD MPEG-2 decoding ability. This card runs so fast and hot that it comes with its own cooling fan. It looks like it will be a solid card. The PCI version requires a 90-MHz Pentium. And at $149.95 for each model, not too expensive either.

One of Number Nine Visual Technology's best, the *Revolution IV 2X AGP* card also offers 128-bit performance and comes with either 16MB or 32MB of SDRAM. While this card is good for lunchtime combat, it's geared more towards the serious business user. It supports Direct3D, OpenGL (under Windows NT only), and 3D Studio Max. It has a 250-MHz DAC and will support refresh rates as high as 150 Hz. The 16MB model sells for $169 and the 32MB model for $219.

There is a third option for those who feel that their current system is adequate or could use a low-cost tweak: add-on cards, like Diamond Multimedia's *Monster 3D* and *Monster 3D II*. They work with existing video cards; you connect a cable from your video card to the Monster and from the Monster to your monitor. The cards install just like other video or computer cards.

The Monster 3D is based on 3Dfx's Voodoo chip and supports Direct3D, Glide, and MiniGL. It has 4MB of EDO DRAM—2MB dedicated to a frame buffer and 2MB dedicated textures. It lists for just $99 and will work with any existing 2D (or 2D/3D card) card, adding excellent 3D features.

The Monster 3D II is an improvement on the Monster 3D and is based on 3Dfx's Voodoo2 chip. The 12MB (4MB frame/8MB texture) version goes for $169 and the 8MB (4MB frame/4MB texture) version for $149. The primary card of this add-on must be a 2D/3D video card. The Monster 3D and Monster 3D II both require at least a 90-MHz Pentium with MMX and an open PCI slot.

So far we've been talking about replacing video cards. What if you have a system with integrated PCI or AGP video? You should check to make sure that you can install a new video card. Integrated PCI systems may not have a free PCI slot. Integrated AGP systems may or may not even have an AGP slot for a new card. There are three ways to find out: check your manual, check with your manufacturer (Web or phone), or peek inside. Of course, non-integrated video is not a problem. Pop out the old card and pop the new one in its place.

A LITTLE RECON

Peeking inside your PC is a good idea if you want to check on your computer's video-card status; after all, you'll have to open the case to install your new video card. First, unplug the system from the outlet and any external connections. Then discharge yourself of static by touching something metal and grounded. An accidental discharge inside the system can destroy it.

Remove the chassis cover of your system. If you see a PC card located where you connect your monitor, you've found your video card.

If your video is integrated, then you'll

(continued on page 16)

MARC SPIWAK
TECHNICAL EDITOR
COMPUTER RESELLER NEWS

Portable MP3 Music, Canon Peripherals, and More

Did you know that right now you can download hi-fi digital audio from the Internet? I'm not talking about .WAV files—at CD-quality settings, they're tremendous. No, there's a much more compact file format out there—.MP3—and there are tons of audio files available in this form, which is a standard that took shape on its own, with no help from any standards organizations. MPEG is an industry-standard method for compressing video, and the same technique that compresses the audio that accompanies the video is used on just audio in the case of MP3 or Layer-3 audio.

There are good things about MP3 audio and bad things about it, depending on who you are and how you look at it. A typical CD audio track is generally about 50 megabytes worth of data, where whole albums can consume 650 megabytes or more. Distributing songs and entire albums of this nature over the Internet is impractical to say the least.

MPEG Layer-3 audio compression works by removing signals that are recorded in a track but are canceled out by one another when played so that you don't hear them anyway. Files end up being compressed by about 10:1, so that 50-megabyte song is now only 5 megabytes. Five megabytes, or entire albums totaling 65 megabytes, are easy to download if you have a fast connection—a cable modem or T1 line does nicely.

Now that we have a practical way of distributing audio over the Internet, there is a need for MP3 encoders, players, search engines for media, and so on. And wouldn't you know it? All those needs have been met. Do a search on the web for MP3-related material and you'll turn up a wealth of sites that hand out the stuff for free. *WinAmp* is a shareware player I've used quite a bit (download a copy at *www.winamp.com*).

Download an MP3 file, download a player, and hi-fi audio plays on your computer. Depending on how well the original file was made—who did it, what equipment was used, the compression level applied, *etc.*—and how good your multimedia system is, .MP3 files can sound as good as CD audio. But the files are apparently stuck in your computer—or are they? No, they are not!

Diamond Multimedia's Rio PMP300 is a hand-held music player for compressed MP3 audio files. MP3s can be obtained via the Internet or can be made using software included with Rio.

Other shareware will convert .MP3 files to .WAV files. And then Adaptec's sophisticated *Easy CD Creator* software can convert those .WAV files to CD audio files for burning an audio CD. It's all very automated. I've made a few CDs in this manner, and most of them sound terrific in my car stereo. So audio made its way to the Internet, to my computer, to my CD recorder, to my car. Because it's digital, sound quality does not deteriorate.

WHO WANTS MP3 AND WHO DOESN'T

Lots of individuals are in favor of MP3, aside from the millions of Internet users looking for free audio. There are plenty of music artists that will never be big enough to have their CDs on store shelves. But their work can now be distributed with little overhead over the Internet. Even the major recording labels can distribute samples and entire products via MP3 and the Internet over secured ordering connections. But the record companies also have a lot to lose, because any knucklehead armed with a shareware MP3 encoder and some music CDs can post digital audio illegally.

There are lots of battles going on right now over how MP3 should be used or if it should even be used at all. But I see no way of stopping it, because it started on its own. Everyone, including the industry, will have to learn to live with MP3. But it's actually the Internet that we're all getting used to. It's a new world now, one where I can create my own custom CDs using free material off the web and $1 blank discs, without leaving my comfy chair.

DIAMOND RIO

One company that is at the head of the curve when it comes to MP3 audio is Diamond Multimedia. Diamond's *Rio PMP300* portable MP3 player is an ultra-small, ultra-cool device. It's a hand-held headphone-equipped music player that downloads MP3 files from a PC and lets you play them in any order.

Diamond Multimedia's Rio PMP300 portable music player is indeed the Walkman-like gadget of the 21st century. This unique device plays MPEG Layer-3 audio files from its internal memory through a headphone jack. MP3s can be obtained via the Internet or can be made using MusicMatch's *Jukebox* software, included with Rio.

Rio contains no moving parts, so it's immune to skipping caused by jostling the device. It includes 32 megabytes of internal memory, which is enough to store about a half hour's worth of CD-quality MP3s. Rio also has a slot for accepting a SmartMedia memory card, which can add more storage to the device. You can buy these cards with as much as 64 megabytes of memory.

Rio comes with all the software you need to use it. The included software, which runs on Windows 95/98 only, lets you transfer MP3s from your PC, through a parallel interface, directly into the Rio's memory. The Rio is quite small and fits easily into a shirt pocket. It weighs a mere 2.4 ounces. The device is powered by a single AA battery, which is good for about 12 hours of continuous playback. It retails for $199.

CANON PERIPHERALS FIT SMALL OFFICES

I recently received some really neat peripherals from Canon Computer Systems. One of them is an all-in-one printer/scanner/copier that prints in color. Canon's *MultiPass C5500* is a multifunction unit that's perfect for the small or home office with limited space. Plus you can add color to all of your work. Pop-in cartridges make this device easy to use for anyone, plus it comes with all the software you need. What's best is that it can operate as a color copier without a PC.

Canon's Bubble Jet technology delivers photo-realistic color printing. An optional *Photo Kit*, with special ink, offers true photo-quality printing. The C5500 lets you receive crisp plain-paper faxes and scan everything from photos to text in color or black and white. It even includes Canon's *Desktop Manager 3.0* software, which helps you keep track of all incoming and outgoing documents. *Canon Creative Pro* helps you create and print stationery, brochures, labels, and more.

The MultiPass C5500 does plain paper faxing at up to 6 seconds per page, and it can store up to 42 pages of incoming messages while the machine is printing, copying, or scanning. It prints photo-realistic output at 720 × 360 dots per inch (dpi). Print speed is rated at 6.5 pages per minute in monochrome or 2.5 pages per minute in color. Optional photo inks allow true photo-quality printing.

Canon's PowerShot A5 digital camera fits in a shirt pocket and has a maximum resolution of 1024 × 768. It comes with a rechargeable NiMH battery pack.

General copying in black and white is done at 360 × 360 dpi, and it can scan at 400 dpi when software-enhanced with 256 levels of grayscale. It does color scanning at 600-dpi, software enhanced, in 24-bit color. The TWAIN-compliant scanner measures 15.8 by 14.2 by 7.8 inches (WDH) and weighs 13.2 pounds. It costs $449.

Canon is also manufacturing some of the world's most affordable and compact flatbed scanners. The *Canoscan FB 320P* is easy to use—just plug it into an outlet and your PC's parallel port, and it's ready to scan at 300 dpi in grayscale and color. The output can be interpolated to 1200 × 1200 dpi. The FB 320P comes with all the software you need to scan and enhance images. Adobe *PhotoDeluxe* lets you enhance and manipulate images and *TextBridge Plus* OCR software lets you import scanned text. The FB 320P weighs only 4 pounds and measures 10.1 by 14.7 by 2.5 inches (WDH). It costs only $79.

The *Canoscan FB 620P* has the same small size and weight as the FB 320P and comes with the same software, but it scans at 600 dpi, which can be interpolated to 2400 dpi. It, too, connects to the parallel port. The higher resolution unit costs $99.

I've also been playing with a rather unique kind of photo printer from Canon. It's similar to Olympus' *P-300* photo printer that connects directly to Olympus cameras and prints beautiful color prints without needing a computer. Though I've raved about the Olympus P-300, it can't print from video sources. But Canon's *CD-200* digital printer can.

The CD-200 accepts digital images from a CompactFlash card and makes 4 × 6-inch glossy photo prints with an image area of 3.2 × 4.2 inches, without connecting to a PC. It has a video output to view on a TV images for printing. A CompactFlash card is a memory module commonly used in digital cameras. You can pop a CompactFlash card out of a camera and into the CD-200. Prints are ready in 95 seconds.

Not only does the CD-200 print from CompactFlash cards, it is also Windows and Macintosh compatible with its Centronics and RS-422 connectors. But what's really cool is that the CD-200 also has a video input so you can capture and print still images from TV programs, camcorders, and other video sources. The CD-200 is a dye-sublimation printer with a resolution of up to 288 dots-per-inch. Its image quality can rival that of 35mm prints, depending on the source images. The CD-200 costs $499, and refills containing a print ribbon and 50 sheets of glossy photo paper cost $30.

Canon's *PowerShot A5* is the perfect digital camera to use with the CD-200 printer. Naturally the A5 uses CompactFlash memory cards. The camera has a sleek alloy body and it's small enough to fit in a shirt pocket. It has a maximum resolution of 1024 × 768 in 24-bit color. The camera is 4 by 2.7 by 1.3 inches (WHD) and weighs only 8.1 ounces. An 8MB CompactFlash card comes with the camera. The camera has its own 2-inch color LCD monitor for composing images and reviewing stored images—it also has an optical viewfinder to save battery power. The camera comes with a rechargeable NiMH battery pack and an AC adapter, all for $699.

While on the subject of digital cameras and memory, I might as well mention Lexar Media. Lexar is busy manufacturing CompactFlash cards that fit cameras such as the Canon A5, and SmartMedia cards, which are even more compact cards used in Olympus cameras. The SmartMedia also fits in Diamond's Rio player. CompactFlash and SmartMedia memory comes in various capacities to suit your needs, up to 64MB.

NEW SOFTWARE

New from Psygnosis comes *O.D.T.*, meaning you have to escape ... Or Die Trying. *O.D.T.* takes place in the World of Tonantzin where an epidemic is consuming the city. The only hope is to use the magic powers of the green pearl. Captain Lamat and his crew of four people man the ship, the Nautiflyius, which crashes in the forbidden zone. The group must fend off endless attacks from hideous monster-like enemies in the dark and unfamiliar terrain. *O.D.T.* costs $44.99.

Lucas Arts' *Grim Fandango* drags you into the Land of Dead. Manny Calavera is a travel agent for souls on their journey to eternal rest. But a conspiracy that threatens everything must be solved. This adventure pays homage to Mexican folklore with a dead cast of 55 characters, hundreds of puzzles, 90 exotic locations, and lots of fun. Characters come to life as skeletons depicted in a folk-art style. This title costs about $40.

The 1999 Grolier Multimedia Reference Suite includes four titles on five CDs.

I recently came across an interesting CD-ROM title from Synthonics that's

(continued on page 14)

KONSTANTINOS KARAGIANNIS

Help for Newbies and the Experienced

Whether you're new to the world of the Internet or have been searching its terabytes of data for years, you've probably figured out that you have to learn to make the most of your time online. It really is a "big" place, and it's far too easy to lose track of the hours you spend pointing and clicking your way through it.

While many of the sites we've covered may save some of our readers time (*e.g.* one-stop online shops), this month we're going to shift our focus to address two types of users: beginners who need to learn more about the Net and experienced users who want to get quality information faster.

First we'll deal with three sites that can make the Internet a more user-friendly place. Visiting these spots will help beginners get the most out of the Net in the least amount of time. Our second feature this month is a new type of search site that grants you access to real, human experts instead of just a crawler engine. No more completely irrelevant hits ... finally!

FOR NEWBIES ONLY

New Net users or "newbies" are sometimes intimidated by the scope of what they have to explore online. In addition to feeling as if they click and click and don't get anywhere, many newbies have the extra frustration of encountering enough acronyms to make them think they're reading Top Secret government project files. Getting online isn't enough for most people—sometimes guidance is nice. That's what the following sites provide.

First we checked out NetWelcome, a really simple site with some useful information and plenty of links. Reading the page only takes a minute or two and gets beginners on the right track. What we found most helpful, though, is that each brief section (Netiquette, Browsing the Web, Getting in Touch, and Talk the Talk) either has links to software you can download for tasks such as browsing, e-mail, and newsgroup use or links to more detailed documents describing some of the basics.

NetWelcome was designed to take newbies by the hand and show them the basics of the Internet. The site features links to dozens of useful, free documents.

The next site we accessed also keeps visitors from getting overloaded. Newbie dot Org presents less information on each screen (NetWelcome is one long page), but overall it lets you click from useful fact to fact. Each link contains clear and concise data.

Newbie dot Org contains three main classes: Newbie 101, Newbie 201, and Newbie 301. The first of these deals with basics like settings that you need to know about your account and preparations you need to get your browser ready to surf and print what you find. Newbie 201 explores plugins, newsgroups, e-mail, and searching. The last, Newbie 301, teaches the basics of creating Web pages and writing HTML. You'll also learn how to recover from crashes and shop safely online.

Finally, we visited a site called New Users. It's mainly composed of text like the other sites, but New Users is probably the most complete of all of them (*i.e.* be prepared to spend a little more time reading through the pages here). One of the best features is the Where to Start booklet, which includes dozens of tips and even an Acronym Dictionary. Do you know what *IITYWTMWYBMAD* stands for? Visit the site and find out. Incidentally, it's the longest acronym listed at the site (most have three letters).

Another great feature of New Users is a listing of Internet Service Providers. This list could come in handy if you're browsing for the first time on a friend's machine and want to set up your own account at home.

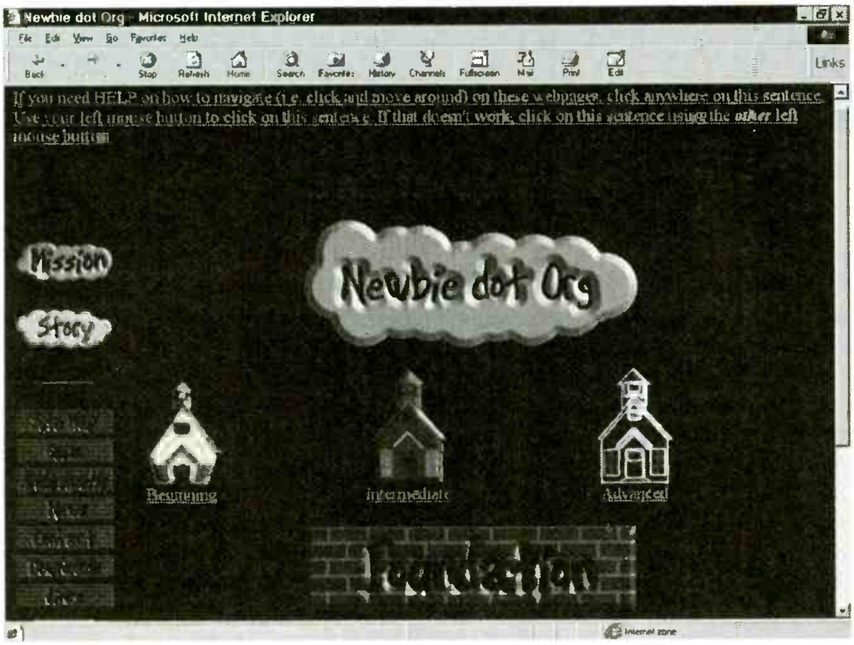
HOT SITES

Mining Company
www.miningco.com

NetWelcome
www.netwelcome.com

Newbie dot Org
www.newbie.org

New Users
www.newusers.com



Visiting Newbie dot Org can expand a beginner's knowledge of the Net in minutes. Concise and accurate, it's a great starting point.

TRUSTING THE EXPERTS

One of the first sites you should point your browser to after you're done reading this magazine is the Mining Company's terrific offering. Whether you've just started using the Net or have been punching in search queries for eons, you'll appreciate the one factor about Mining Co. that separates it from all those other search sites on the Web. Rather than rely on software engines, Mining Co. has 500 expert guides who "mine" the Net to find valuable information about thousands of topics.

Ever use a search engine and get back some results that don't make sense? We typed in a search for a semiconductor once and got back info on a sale for silverware! Or perhaps you've simply gotten back a list of dead links? Say goodbye to all these problems if you use Mining Co.

The site can be used in one of two main ways. First, you can type in a search query and let the system check its database for appropriate subject matches. We typed in "Star Wars" and got a list of great, *still functional*, Web sites, as well as a listing of categories at Mining Co. where more or relevant information about the saga might be lurking (for example, the Games section has info on *SW* titles). Why did we search for *Star Wars*? Come on, with the new *Episode I* movie coming out on May 21, do you really need to ask?

The other way to search, which eventually takes you to the same types of screens, is by clicking on subjects and browsing them. Examples of these include Arts/Entertainment, which has selections on books, music, and humor; and Computing/Science, which helps you with online info, software, physics, and a variety of techie subjects. Each of the main subject groupings has so many subcategories that you'll be hard pressed to find something missing.

Whichever search method you use, you eventually end up at a subcategory of interest. At the top of the screen will be a picture and e-mail address of the Mining Co. guide in charge of gathering site links related to the subject. Above the top of the main window will be a frame bar that shows, from left to right, the hierarchical structure of the subcategory (*e.g.* Computing/Science / Science / Archaeology). If you click on one of the recommended sites on the page, you never really leave Mining Co. The bar will stay at the top, allowing you to go to another part of the hierarchy (*e.g.* you can click "Science" from our last example) even though your screen's main window shows the site to which you "moved."

Newbies who didn't visit one of our earlier mentioned sites might want to check out Mining Co.'s excellent Net Basics link (right on the main page). It's got handy tips on Netiquette, basic HTML and Web publishing, connectivity, computing basics, and more.

As usual, you can send questions or comments via snail-mail to *Net Watch*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735, or e-mail to netwatch@gernsback.com. ■

Rather than using a crawler program to gather data, Mining Co. relies on experts in various fields to set up links to sites that they feel are of interest and that are actually still up and running—no more dead links!

LETTERS

NOT EASILY DISMISSED

Regarding the *Computer Bits* column: "Mass Storage for the Millennium" (**Popular Electronics**, March 1999), I must take issue with Mr. Holtzman's critique of the Imation LS-120 SuperDisk Drive. To wit: Mr. Holtzman didn't do his homework regarding these drives, as he only reviewed the parallel-port version of the LS-120 SuperDisk drive. To be thorough in his research, he needed to work with the internal ATAPI version, which is far superior to the parallel-port version in speed and throughput performance.

I personally have an internal ATAPI LS-120 drive, distributed through Digital Research Technologies (*www.dr-tech.com*). I can say this drive has a raw throughput and access speed comparable to a Maxtor 7120AT hard drive (which I had installed in a 286 machine). True, the LS-120 drive has an initial delay when starting up, but once it's spinning, you'd swear you were dealing with a hard drive, rather than a "SuperFloppy." As for the drive making a racket while operating, the internal ATAPI drive is no more noisy than a regular floppy. In fact, the start-up noise when a disk is inserted tells me that it's properly read the type of disk and is ready to use.

However, in all fairness, I do have three criticisms of the LS-120 drive:

First, it's occasionally finicky, sometimes failing to properly read an inserted disk. However, simply ejecting the disk and reinstalling it usually takes care of that problem. In rare situations, I need to reboot my machine to clear the fault.

Second, the drive can be a pain to install. Which motherboard, chipset, and BIOS vintage you have has a big impact on the ease of installation, as does the version of Windows. Thankfully, Mitsubishi's Web site—*www.mitsubishi.com*—has lots of information on the LS-120 drive, since they manufacture the drive mechanism. Ultimately, a little time and patience result in a fairly dependable drive installation.

Finally, because the LS-120 can also read and write standard 3.5-inch floppies, we're back to the dilemma that occurred with writing/formatting 5.25-inch, 360K floppies in 1.2MB, 5.25-inch drives: potential data-read errors. Thankfully, the LS-120 documentation specifically cautions against formatting 720K or 1.44MB floppies in the LS-120. In fact, the manual strongly advises using pre-formatted disks to ensure readability of LS-120-written standard floppies in standard drives.

I hope this letter clears up any misinformation and misconceptions regarding the LS-120 SuperDisk drive. While it's true the Iomega Zip drive came first and has a larger installed base than the LS-120, the latter is not a drive to be "easily dismissed." Because it has the ability to read/write standard floppies (unlike the Zip drive), it's best suited to be "the only floppy drive needed" in computers today.

K.S.
Auburn, WA

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

You can write via snail mail to:

Letters
Popular Electronics
500 Bi-County Blvd.
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.

Send e-mail to:

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Of course e-mail is *fast*.

Check the end of your favorite columns, too. Many of them list individual e-mail addresses for their respective authors.

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

MASS STORAGE APPROVAL

Thanks for publishing Jeff Holtzman's *Computer Bits* column. His March column on mass storage was especially timely for those of us preparing to buy a CD-RW drive. I'll miss Jeff's columns and hope to see occasional contributions from him in future issues.

Incidentally, in his final column, Jeff observed that HP claims the life of its new CD-RW disks is about 30 years and that of its CD-R disks is about 100 years. While these are impressive numbers for this technology, consider the competition. Read/write manuscripts on acid-free paper and parchment have lasted thousands of years. Read-only manuscripts on clay tablets have lasted much longer. The situation is reminiscent of photography, a field in which 100-year-old black-and-white prints look as good today as when they were printed. But today's color prints can fade after several years. Maybe a **PE** reader will someday invent a form of mass storage that will begin to match the storage life of these much older media.

F.M.M. III
via e-mail

OUT OF BUSINESS

It has come to our attention that Checkpoint Laser Tools, whose Sound Alignment System was covered in *Gizmo* in the March 1999 issue, is no longer in business.

—Editor

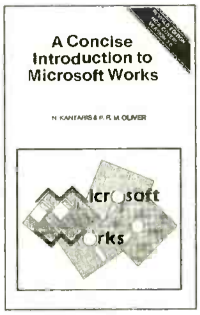
ADVICE WANTED

How come I never see any articles about CD recorders? I'm about to pur-

(continued on page 64)

Buyers' Budget Books Better Buys

☐ **BP294–A Concise Introduction to Microsoft Works $6.99.** In the shortest and most effective way, you can use the word processor to advantage to type, edit, print and save documents. It goes on to explain how Works can be used to build up simple spreadsheet examples, edit them, save them, print them and retrieve them. It informs you how to create simple macros, and enables you to simplify long repetitive tasks and to customize the program to your own needs.



☐ **BP349–Practical Opto-Electronic Projects $6.99.** If you shun opto-electronic projects for lack of knowledge, this is the book for you. A bit of introductory theory comes first and then a number of practical projects which utilize a range of opto devices, from a filament bulb to modern infrared sensors and emitters.

☐ **BP350–Electronic Board Games $6.99.** Twenty novel electronic board games that you can build from the plans in this book. Whether you are interested in motor racing, searching for buried treasure on a barren island or for gold in Fort Knox, spinning the wheel of fortune, or doing a musical quiz—there is something for you to build and enjoy!

☐ **BP378-45–Simple Electronic Terminal Block Projects $6.99.** Contains 45 easy-to-build electronic projects trhat can be built by an absolute beginner. Projects are assembled on terminal blocks using only a screwdriver and other simple hand tools. No soldering is required.

☐ **BP432–Simple Sensor Terminal Block Projects $6.99.** This book is the next logical step from *45 Simple Electronic Terminal Block Projects* (BP378), by the same author. The former describes an easy method of constructing transistor circuits without the need for soldering. It is an *open sesame* to the practical world of electronics for youngsters or beginners.

☐ **BP367–Electronic Projects for the Garden $6.99.** Electronics enters the Garden! New exciting book points out how gardeners can build simple gadgets to promote success where the elements work against you. Some of the projects are: over/under temperature monitoring, dusk/dawn switching, automatic plant watering, warming cables, etc.

☐ **BP368–Practical Electronics Musical Effect Units $6.99.** There is a constant hullabaloo for musical effects projects by the hobbyist community. This book provides practical circuits for several projects that range in complexity and are sure to work. All the circuits are easy to build and use readily-available parts.

☐ **BP385–Easy PC Interfacing $6.99.** The built-in ports in your PC provide an easy and hassle-free way of interfacing your circuits. This book provides useful PC add-on circuits including the following: Digital input/output ports; analog-to-digital and digital-to-analog converters; voltage and current measurement circuits; resistance and capacitance meters, temperature measurement interface, biofeedback monitor, and many other useful interfaces.

☐ **BP396–Electronic Hobbyists Data Book $7.99.** This book provides a wide range of data. If, for example, you require details of a modern five-band resistor code or an old color code for a ceramic capacitor, the formula for parallel resistance, or basic data on an NE5534AN operational amplifier, it is contained within these pages. The subjects covered are numerous and widespread to cover all hobbyist interests.

☐ **BP343–A Concise Introduction to Microsoft Works for Windows $7.99.** The book explains and details: How the Works for Windows package fits into the general Microsoft Windows environment; how to use the word processor to advantage; how to use Microsoft Draw to create and edit graphics and place them in your documents; how to build up simple spreadsheet examples; and how single, and multiple charts, or graphs, of different types can be generated. And there's much more!

☐ **BP282–Understanding PC Specifications $5.99.** This book explains PC specifications in detail, and the subjects covered include the following: Differences between types of PC (XT, AT, 80386, 80486, Pentium etc.); math co-processors; input devices (keyboards, mice, and digitizers); memory, including both expanded (EMS) and extended RAM; RAM disks and disk caches; floppy disk drive formats and compatibility; hard disk drives; and display adapters (CGA, Hercules, super VGA, etc.).

☐ **BP298–Concise Intro to the Macintosh System and Finder $5.99.** Although the Mac's WIMP user interface is designed to be easy to use, much of it only becomes clear when it is explained in simple terms. The book explains: The System and Finder, what they are and what they do; how to use the System and Finder to manipulate disks, files and folders; configuring and printing files from the Finder; getting the most from the system utility programs; and running MultiFinder.

☐ **BP88–How To Use OP Amps $5.99.** The Operational Amplifier is the most adaptable circuit module available to the circuit designer. It is possible to purchase a low-cost integrated circuit with several hundred components, very-high gain and predictable performance. This book has been written as a designer's guide for most Operational Amplifiers, serving both as a source book of circuits and a reference book for design calculations.

☐ **BP316–Practical Electric Design Data $7.99.** A builder's bargain book–a comprehensive ready-reference manual for electronic enthusiasts with over 150 practical circuits. It covers the main kinds of components (from pig-tail leads to surface mount), pinouts, specs and type selection. Basic units are defined and most used formulae explained. Five additional sections are devoted to circuit design, covering analog, digital, display, radio and power supply circuits.

☐ **BP346–Programming in Visual Basic for Windows $7.99.** This book is a guide to programming. The reader is not expected to have any familiarity with the language as both the environment and statements are introduced and explained with the help of simple programs. The user is encouraged to build these, save them, and keep improving them as more complex language statements and commands are encountered.

☐ **BP345–Getting Started In Practical Electronics $6.99.** If you are looking into launching an exciting hobby activity, this text provides basic essentials for the builder and 30 easy-to-build fun projects with which every experimenter should toy. Printed-circuit designs are included to give your project the professional touch.

☐ **BP451–Troubleshooting Your PC Printer $8.99.** Explains the different printer types, their suitability for different tasks, the costs of running them, how to connect them and get the driver software running and, of course, what is most likely to go wrong and what you can do for yourself. Most important of all, it warns you of what you should quite definitely NOT try to do for yourself.

☐ **PCP112–Digital Electronics Projects $10.99.** Contains 12 digital electronics projects suitable for the beginner to build with the minimum of equipment — from instrumentation to home security, and a few "fun" projects too. With one exception, all projects are battery powered, and therefore, are completely safe for the beginner or young constructor.

☐ **PCP107–Digital Logic Gates and Flip-Flops $10.99.** Intended for enthusiasts, students and technicians, this book seeks to establish a firm foundation in digital electronics. It is for the user who wants to design and troubleshoot digital circuitry with full understanding of the principles. No background other than a basic knowledge of electronics is assumed.

☐ **BP76–Power Supply Projects $3.99.** Presents a number of power-supply designs including simpled unbiased types, fixed voltage-regulated types and variable voltage stabilized designs. All are low-voltage types intended for use with semiconductor circuits. Apart from presenting a variety of designs that will satisfy most applications, the data in this book should help the reader to design his own power supplies. An essential addition to the experimenters electronics library.

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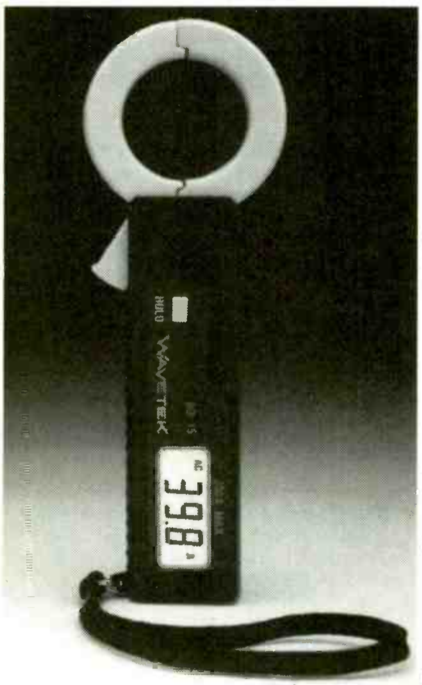
NEW PRODUCTS

AC AMMETER

The miniature *AD15 DMM* can take measurements in even the tightest spaces. Its size (2.1 by 6.1 by 0.8 inches) and its digital display make it ideal for the electrical contractor and the handyman to use anywhere for light commercial and residential applications.



Features of the AD15 include two measuring ranges (20A and 200A), a data hold function for taking measurements in difficult-to-read places, and a slip-proof grip on the side. The ammeter comes with batteries and a wrist strap.

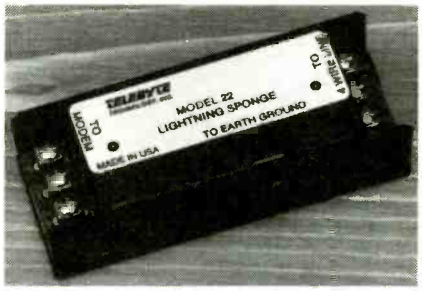
The AD15 DMM has a suggested retail price of $49.95. For more information, contact Wavetek Corp., 9045 Balboa Ave., San Diego, CA 92123; Tel. 619-279-2200; Fax: 619-565-9558; Web: *www.wavetek.com.*

CIRCLE 80 ON FREE INFORMATION CARD

LIGHTNING PROTECTION

The *Model 22-64 Lightning Sponge* is designed for use on 64-Kbps communications circuits. This device accommodates lightning strikes and safely diverts them to a low-impedance path to earth ground before they can damage any network equipment and computers.

It uses three stages to limit high-voltage transients—gas tubes and two stages of semiconductor avalanche diodes. The Model 22-64 includes four circuits whose data rate does not exceed 64 Kbps.



The Model 22-64 sells for $72 in single quantity, and $57.60 each in quantities of 100. For more information, contact Telebyte Technology, Corp., 270 Pulaski Road, Greenlawn, NY 11740; Tel. 800-835-3298; Fax: 516-385-8848; Web: *www.telebyteusa.com.*

CIRCLE 81 ON FREE INFORMATION CARD

GRAPHICAL PROGRAMMING SOFTWARE

Students can use the *LabVIEW Student Edition* to design their own experiments, acquire data, perform analysis, test hypotheses, and perform simulations. Included with the student edition is *Learning with LabVIEW*, written by Dr. Robert Bishop.

The software contains many examples, exercises, and solutions that are presented in the book. There are also tools for displaying data over the Internet and for performing interactive data visualization and numerical analysis.

The LabVIEW Student Edition has a suggested retail price of $60. For more information, contact National Instruments, 11500 N. Mopac Expressway, Austin, TX 78759-3504; Tel. 800-258-7022 or 512-794-0100; Fax: 512-794-8411; Web: *www.natinst.com.*

CIRCLE 82 ON FREE INFORMATION CARD

BENCHTOP SIGNAL GENERATOR

Designed for test, simulation, and characterization of telephony, and for COTS and DT testing, this function and arbitrary waveform generator, the *BNC Model 625A SmartARB* allows users to sweep through ranges without

skipped points. It provides function, arbitrary waveform, and pulse-generation capabilities.

Modes include not only the standard sine, square, ramp, triangle, and random waveform, but also AM, FM, PM, SSB, FSK, BPSK signal modulation, DTMF detect, voltage and power measurement, and data and word generation. All operating parameters are presented on a single display. Values can be entered via the numeric keypad or rapidly changed with a rotary knob. Modes are clearly labeled on and selected by the keypad in a single operation.

(continued on page 68)

A Hands-on Electronics® REPORT

CLAGGK PICtutor CD-ROM/Trainer Board

Learn how to get the most out of Programmable Integrated Circuits with this comprehensive bundle.

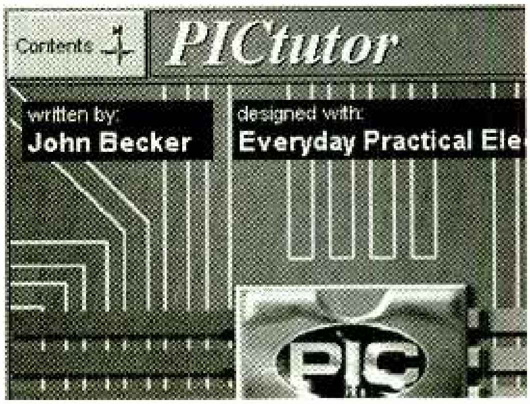
It is without a doubt that many of our readers have computers. True, more people are into computers as a hobby than electronics, but there are lots of computer owners who want to learn more about electronics. A great place to start doing so on a PC is with various CD-ROM titles.

One of the most fascinating, but little-understood components used in electronics today is the PIC, or Programmable Integrated Circuit. PICs are found in all types of circuitry, and understanding how they operate and how they are programmed is an important part of being a good technician or engineer heading into the 21st century.

The *PICtutor* CD-ROM is an interactive computer-based multimedia laboratory/textbook that teaches the basics behind PICs in electronics—the theory, circuits, parts, and so on. The CD-ROM is bundled with a circuit board that contains a working PIC, and the board connects to a PC for programming.

Quite a Bundle. *PICtutor* is useful for students, technicians, engineers, teachers, and so on. Not much of a PC is required, so finding an adequate system on which to run the disc shouldn't be a problem. System requirements include an IBM-compatible 486/25-MHz PC, Windows 3.1 or 95 (or 98), a mouse, CD-ROM drive, VGA graphics with 256 colors, 8MB of RAM, and about 10MB of hard disk space. You do not need a sound card.

The software is easy to install. Menus and sub-menus take the user through different sections of the disc. Each section includes diagrams, text, drawings, and so on. The PIC trainer board works off a DC power supply and connects to the parallel port of a PC. Together, the software and trainer board help the user gain a good understanding of how PICs operate. While playing with a CD-ROM and trainer board is no substitute for a college degree or hands-on experience in the field, the package is a good resource for anyone involved in electronics.



Part of the PICtutor *package is the comprehensive CD-ROM with an easy-to-master interface.*

The *PICtutor* CD-ROM is intended to teach users of all levels how to write machine code programs for PIC microcontrollers. The CD-ROM contains 39 tutorial sections that guide the user through PIC architecture, commands, and programming. Included are advanced programming techniques with discussion, and examples of watchdog timers, interrupts, sleep modes, and more.

The CD-ROM includes over 80 exercises with tests for the user. An onscreen "virtual PIC" lets you write and test programs without ever leaving your PC. Over 30 working example programs are included, along with a shareware assembler.

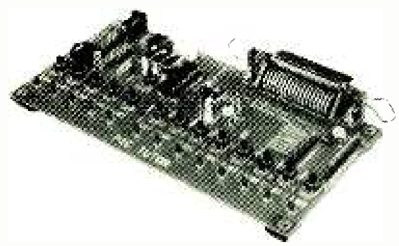
The PIC trainer board is designed for use with or without the CD-ROM. This fully populated board contains a programmable PIC16C84 microcontroller plus associated switches, LEDs, and various support circuitry. The trainer board helps teach users how to program PIC microcontrollers and is also useful in developing one's own PIC projects.

To connect the PIC board to a PC parallel port, you use a standard Centronics printer cable. An assembler and download software are included. The board can be upgraded to drive a quad 7-segment display and intelligent alphanumeric display. The board requires a 12- to 14-volt DC power supply. A battery holder for eight AA cells is provided with the development board.

You use a word processor or text editor when editing or creating .ASM files for assembly through *TASM*, the shareware assembler included with the CD-ROM/trainer board bundle. The *PICtutor* CD-ROM contains the PIC programming software and *TASM* documentation, plus all the demonstration files used in the tutorials. All the demo files are supplied as ASCII text files with a .ASM extension and as assembled object code files with a .OBJ extension—these demos are suitable for direct downloading to the PIC on the trainer board. The demo files were also written using the *TASM* programming software.

During the tutorials you are asked to modify some of the .ASM files and to write your own command sets. If you make an error in your typed command line, a message will appear. Other messages appear depending on the nature of the error.

The CD-ROM/trainer board bundle is a valuable learning aid for PIC theory and use. You should consider investing in this bundle if you have a general interest in learning more about PIC usage, or even if you are already using PICs in your own circuit designs.



Here's the trainer board that lets you actually get some hands-on experience with PICs.

Testing out your own circuit theories on the trainer, before implementing a working circuit, can save you a lot of time at the prototyping bench. Besides, it's just a matter of time before you have to spend some time troubleshooting a PIC-bearing circuit. And the more you understand about PICs now, the better off you'll be with your future PIC encounter.

The *PICtutor* CD-ROM/PIC trainer circuit board bundle is available for $179. Contact CLAGGK, Inc., PO Box 4099, Farmingdale, NY 11735; Tel. 516-293-3751; or circle 50 on the Free Information Card. ■

MULTIMEDIA WATCH

(continued from page 7)

perfect for science and history buffs. The *Smithsonian Museum Collection* is an overview of all 16 Smithsonian museums and the National Zoo. It contains 670 images of historic artifacts featured in Smithsonian museums. The CD-ROM is a virtual museum in itself, containing accurate 3D digital replicas of many artifacts. Artifacts are presented such that you can examine them in ways not possible in museums. This title costs $24.95.

A new book from Jamsa Press is a good reference piece for beginners and novices alike when it comes to using Windows 98. *1001 Windows 98 Tips* by Kris Jamsa is loaded with pointers to help speed up productivity. Learn about the Start menu, Taskbar, the World Wide Web, and more. Discover undocumented features and put them to good use. *1001 Windows 98 Tips* costs $39.95.

Grolier Interactive is always at it, updating its wonderful CD-ROM reference material. The latest product is the *1999 Grolier Multimedia Reference Suite*, a set of discs that puts almost any bit of information in the world at your fingertips. The suite's made up of 1999 Grolier Multimedia Encyclopedia Deluxe Edition, Hammond Atlas of the World, Bartlett's Familiar Quotations Expanded Multimedia Edition Version 2, and the Wall Street Journal Almanac. This valuable set of CD-ROMs costs only $89.99.

Cyber Strike 2 from 989 Studios is a shoot-em-up game loaded with battling robots and spaceships. It takes place in a futuristic world of 3D graphics filled with explosive action. There are 50 single-player missions and network battles with up to 32 players. Check out *Cyber Strike 2* if the mood to strike out at cyborg enemies should strike you. It costs around $20.

MetaCreations' *Dance Studio* makes for good family fun by letting you create your own custom, cartoon-like music videos on a PC. You pick one of several different male or female characters, a dance style, an environment, and a favorite music CD, .WAV file, or MIDI file—*Dance Studio* does the rest. It makes the chosen character dance around to your favorite music. The product is geared more toward kids than adults. It costs $49.95.

Activision's interactive game, *Sin*, lets players explore the chaotic 21st century where crime runs rampant and vices are plentiful. *Sin* is a violent title that is powered by id software's *Quake II* engine, so smooth action is guaranteed. You're searching for the source and distribution channels of a highly addictive drug called U4. But ridding the streets of U4 will be dangerous—that's a sure bet. *Sin* costs $49.95. ■

WHERE TO GET IT

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Web: *www.activision.com*
CIRCLE 60 ON FREE INFORMATION CARD

Canon Computer Systems, Inc.
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Costa Mesa, CA 92626
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InFlight Listening

MARC SAXON

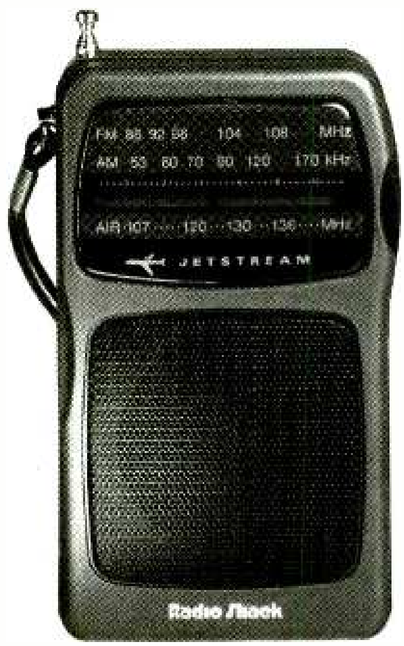
A few months ago I flew on a commercial airliner. But when I took out my scanner and earphone, the flight attendant politely advised me that it was against the airline's regulations for passengers to use scanners. When I asked why, I was given some double talk about how scanners cause interference to the aircraft's so-called delicate navigational instruments. Fact is, I later came to learn from a pilot, that many airlines simply don't want passengers listening to the aircraft's captain (pilot) communicating on their operational frequencies (in the 128.85- to 132.0- and 136.625- to 136.975-MHz bands).

In the past, readers had mentioned problems like this to me, but it's the first time I had ever attempted using my scanner on an airline.

The airline company operational frequencies are where, among other things, captains report writeups, that is, things they've discovered that are wrong with their plane. These include things like flashing warning lights, panel gauges that provide incorrect readings, malfunctioning radars, non-working headphones, cracked windshields, and worse. Or maybe the drinking water tastes bad, the lavatories are long overdue for service, several seats won't recline, there's a strange foul odor in the aircraft, or they need security personnel to show up at the gate in order to deal with a rowdy passenger. Whatever the problems might be, many airlines prefer their passengers don't hear such revelations about the aircraft in which they are flying. Hence, their ban on scanners.

BE HAPPY, GET SNEAKY!

A couple of weeks ago, I flew again, but this time I was smart. I was able to eavesdrop on everything, and with the full blessings of the airline. I had picked up a small, harmless-looking, tunable AM/FM pocket radio that just happened to also include the entire VHF aeronautical band. First, I showed it to the flight attendant and asked if there would be any problem if I listened to FM music through an earphone. No problem at all, she said, happy to accommodate me. I spent the entire trip monitoring the plane's captain yakking on the company frequency. Not that it overjoyed me to learn he was getting an incorrect reading showing the aircraft's flaps were partially down and that he had complained about it previously.



RadioShack's Jetstream is a small, tunable AM/FM pocket radio that just happens to also include the entire VHF aeronautical band.

The little pocket receiver I used was a RadioShack *Jetstream* (catalog # 12-615), which cost less than $25! It did a great job.

However, I find it much more reassuring and enjoyable to monitor these exciting frequencies from my base station. Because of VHF's line-of-sight characteristics, high altitude airliners can be monitored while they're more than several hundred miles distant. At any given moment, numerous airliners are within air/ground monitoring range. After allowing my scanner to search these bands, I was able to compile a listing of the most active frequencies in my area. Then I programmed each into my scanner's memory. Never a dull moment.

SCANNER DX

Most scanner enthusiasts don't think of themselves as DX chasers, but it's rather an exciting aspect of the hobby. When conditions are right, the NOAA's 162-MHz weather channels occasionally provide some unusual ground/ground DX. Rare temperature inversions (when the high altitude air is warmer than the air below) are most often what's responsible for DX in the VHF high-frequency band. You might hear NOAA and other VHF stations from hundreds of miles away.

Ionospheric skip is responsible for DX on HF and the scanner lowband. This type of DX peaks in an 11-year cycle, and we are now emerging from one of the DX valleys and heading towards the next peak. You'll probably find low-band (30–50 MHz) stations from extreme distances can be heard at various times.

One interesting frequency to monitor is 28.20 MHz, between 0000–0300 UTC (2000–2300 EDT). That's where and when specific amateur radio CW beacons from all around the world are coordinated to take 10-minute turns transmitting. During its assigned slot, each station sends its call letters followed by a series of dashes, at the same time reducing its power from 100 watts to less than 1 watt in distinctive steps.

The stations in the order of their 10-minute transmissions: CS3B/Madeira; LU4AA/Argentina; OA4B/Peru; YV5B/Venezuela; 4U1UN/New York; VE8AT/NWT (Northwest Territories, Canada); W6WX/California; KH6WO/Hawaii; ZL6B/New Zealand; VK6RBP/Australia; JA2IGY/Japan; 4S7B/Sri Lanka; 5Z4B/Kenya; 4X6TU/Israel; OH2B/Finland. Note there are no transmissions presently operational between 0150–0210 UTC, which are the two slots reserved for Russia and

China.

Assuming you have a standard scanner, monitor the frequency in AM mode. Of course, if you have a more formidable piece of equipment, then place it in CW mode.

FORBIDDEN FRUIT

Ron C., of Idaho, wonders whether full-coverage 800-MHz scanners are sold in nations beyond the borders of the United States. That is, whether manufacturers block certain 800-MHz frequencies from all of their equipment, worldwide, or only from those sets made for sale in the U.S.

My impression is that our nation is a pioneer in the area of federal restrictions requiring blocked frequencies in its citizens' consumer-grade receivers. Freedom of speech seems somehow diminished without the guarantee of freedom to listen. Other nations still have full-frequency scanners available, however.

While snooping around on the Web, I came across a communications dealer outside of the U.S. who states he ships "around the world." The dealer carried a full line of handheld scanners, all of which have full unblocked coverage of the 800-MHz band. I have no idea what the service or warranty ramifications might be with regard to obtaining equipment from any of the dealers in Europe and Canada selling unblocked scanners. It occurred to me that it would be one way of someone obtaining a full-frequency scanner. But, inasmuch as Americans aren't allowed to import such equipment here, I wonder if any of these companies would ship the stuff. Not that anyone here would order it. Just thinking out loud.

You might want to look over a few Web sites of dealers outside of the U.S. that carry full-frequency scanners, anyway. Check out: *www.interlog.com/~ahr/scan.htm*, *www.durhamradio.com*, and *www.waters-and-stanton.co.uk*. Searching will probably reveal many other similar dealers.

Let us hear from you! Please share with us your thoughts, ideas, frequencies, and column ideas. Our direct e-mail address is Sigintt@aol.com. By snail mail, we can be reached at *Scanner Scene*, **Popular Electronics**, 500 Bi-County Blvd. Farmingdale, NY 11735. ■

PEAK COMPUTING

(continued from page 4)

have to look around a bit inside. You'll notice several slots towards the back of the case, where the serial, video, and input connectors are. There are three possible types of slots: ISA, PCI, and AGP. The ISA slots are distinguished by their length and are the longest slots in your system. PCI slots are about half as long. These two kinds of slots rest side-by-side, evenly spaced in a row, and are on the edge of your motherboard closest to the case's rear panel. An AGP slot, if available, is as short as a PCI slot but is offset from the PCI and ISA slots.

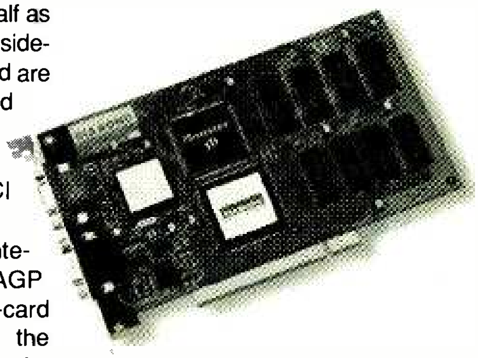
If you *know* that you have integrated graphics and don't see an AGP slot, you can still use the add-on-card option mentioned earlier. Even the best PCI video card is no match for integrated AGP video. Another option is to check with your PC manufacturer to see if it's possible to install additional video memory to boost video performance. Then hop in the car and buy your new video card.

INSTALLING THE CARD

Read the instructions that came with your card before you begin your installation. Certain cards have special considerations (for example, jumpers that need to be set).

Handle your new card by its edges. Don't touch any of the circuits or connectors to keep from accidentally damaging it. If you haven't done so already, remove your PC's case and identify your old card or a free slot (if you had integrated video). In either instance, you'll notice that the card or the case's slot cover is held in place with a small screw. Remove the screw and then firmly, but gingerly, remove the old video card or cover and put it aside. Hold your new card by the edges and line it up with the slot into which you wish to insert it. Slide the end opposite the VGA monitor connector in first, slightly, and work your way towards the other end of the card. Then press down firmly till it softly clicks into place. If the video card shakes or the motherboard bends you are pressing too hard. Pull it out and try again. There is a small tab on the video card's external faceplate that must rest inside a catch on your case. Make sure that it slips in. Once the card's inserted, you can replace the screw, tighten it, and put the whole kit-and-caboodle back together again.

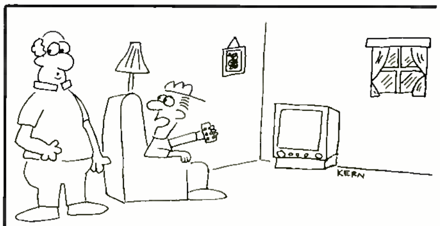
When everything has been reattached, it's time to power up. Turn on your monitor, CPU, and wait. The Plug-and-Play feature of Windows 95 and 98 identifies the card and prompts you for the driver disk or CD-ROM. Follow the prompts and



Is it possible to get a video boost on a budget? Rather than replacing your system's card altogether, consider getting a 3D add-on card that "takes over" whenever your PC needs to process game graphics.

then install any additional software that came with your card. The procedure doesn't change for integrated video. There is nothing to "turn off," as it were.

There are instances where you may have to do more. If your video doesn't work, remove and re-seat the video card. Also, sometimes Windows accepts your card but doesn't ask for the manufacturer's driver disk. Instead, it installs the standard Windows display drivers. Generally, clicking on the Setup icon on the driver CD-ROM or disk will take care of this. If not, go to your Control Panel, click on Display, then Settings, then Advanced Properties. There, under the Adapter tab, click on Change. Insert the manufacturer's disk and then choose the Have Disk option. You're done. Enjoy the new video. ■



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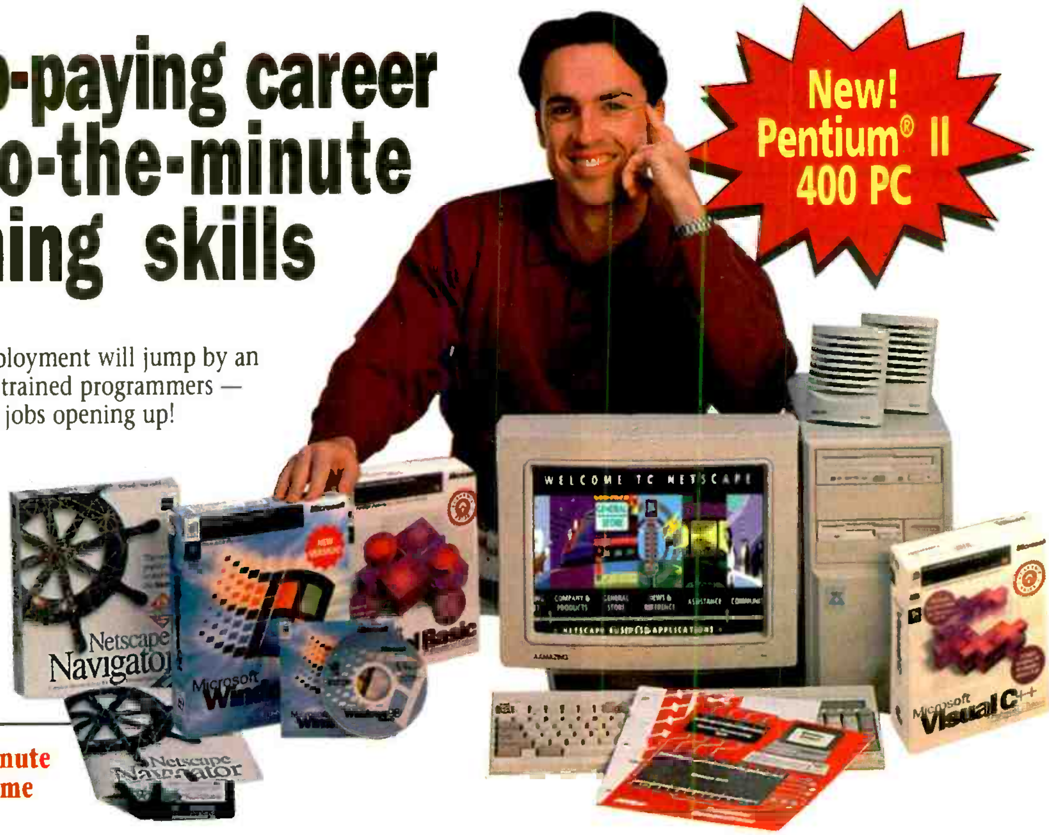

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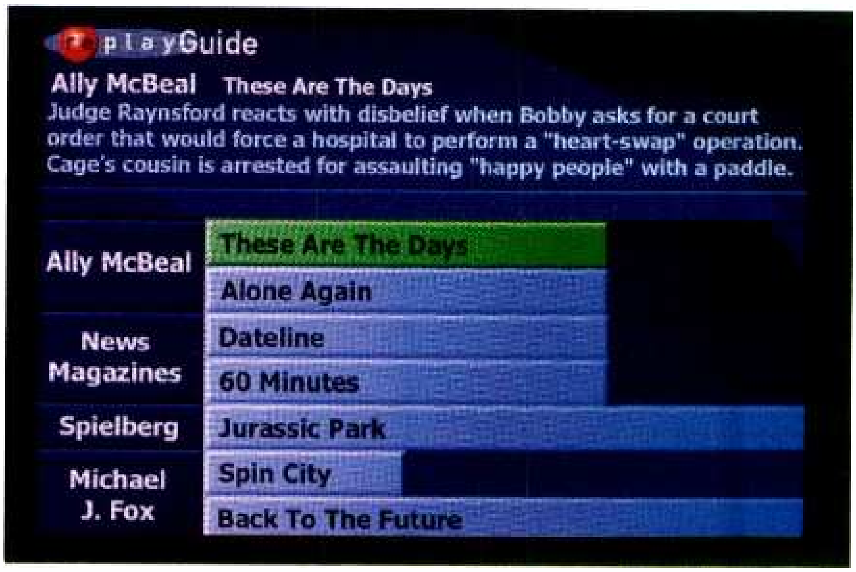
GIZMO®

The View From Vegas

*The 1999 International Consumer Electronics Show, held in January in Las Vegas, has come and gone, leaving in its wake a host of new industry buzzwords, emerging technologies, and some exciting new products (much of it last year's vaporware, finally available to consumers). In this month's **Gizmo**, we'll fill you in on all of that. But first, we'll take a look at some products that took home Innovations awards from the Design & Engineering Honors Program of the Consumer Electronics Manufacturer's Association (CEMA; Web: www.cemacity.org).*



Audio On Demand

The *RCA CA-1000* from Thomson Consumer Electronics will deliver to consumers Command Audio's personalized audio-on-demand service, which lets the user choose his own programming from hundreds of local and national programs that are selected from both print and broadcast media. Along with continuously updated local traffic, weather, news, sports, business, and finance reports, Command Audio will feature programs on topics such as home improvement and investing. Program sources include National Public Radio, ABC news, *Time* magazine, *People* magazine, and *Sports Illustrated*. Well-known radio personalities such as Dr. Laura, Art Bell, Jim Rome, and Bob Edwards, and television's Ted Koppel and Jim Lehrer will be broadcast.

The service is aimed primarily at commuters whose favorite radio programs don't always coincide with their drive times. The Command Audio service lets commuters quickly check the latest traffic and weather updates, and then spend the rest of the trip listening to things that truly interest them.

The pocket-sized CA-1000 receives wireless program transmissions from Command Audio. No computer or Internet connection is required to receive, select, or play back audio. Selections play wirelessly through the car radio; other listening options include headphones or the unit's built-in speaker. The user can skip from program to program, pause, scan by subject, or save shows for later listening. An "eyes free" interface makes it easy to use even when driving.

Available later this year, the CA-1000 will have a suggested retail price of $199. The subscription-based audio-on-demand service will cost $15 a month.

Video On Demand

Replay Networks, Inc. introduces a similar on-demand concept for video, allowing you to arrange TV programming around your schedule, instead of the other way around. With *ReplayTV*, however, you're not limited to someone else's programming choices. The ReplayTV device is a set-top box that finds your favorite programs and stores them digitally for playback when you want it. The onscreen program guide and free Replay Network Service allow you to

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create personalized channels using a remote control. You might want to designate an all-*Jeopardy* channel, for instance, or one that stores every episode of every generation of *Star Trek* that airs.

ReplayTV, which picked up the Best of Show award in the video category, allows one-touch recording, storing shows digitally on a hard drive. That means there are no tapes to rewind, and recorded shows are easy to find and access. Using random-access storage, the device can record and play two different sections of a show simultaneously, allowing you to pause, rewind, and fast-forward live TV shows when your viewing is interrupted by a phone call, for instance. Finally, the ReplayTV is a learning device. Tell it to search for and record shows based on certain criteria—perhaps your favorite actor's name or "home-improvement shows"—and the device will create a Replay Channel in which those shows are stored. Tell it to record *ER* every week, and each episode will go into the ER Replay Channel. The continuously updated program guide, which covers broadcast, cable, and/or satellite stations, is loaded each night via the telephone line. Up to six hours of programming can be stored in the base model. A future expansion module, which will connect to an IEEE-1394 port, will provide yet more storage.

Product roll-out begins in the first quarter of 1999 in selected markets. The base ReplayTV box costs $699; there is no subscription fee.

Parental Guidance Simplified

Providing a less sophisticated method of controlling your family's video viewing, Principle Solutions' *TVGuardian Foul Language Filter* is a set-top box that removes curses and other offensive words and phrases from television shows and videotapes. It works by carefully monitoring the closed captioning, checking each word against an internal dictionary. When it encounters an offensive word, TVGuardian mutes the audio and replaces the closed-caption with a more socially acceptable word. Unlike the V-chip, TVGuardian doesn't block out portions of the film. You and your kids can watch the entire program, without being exposed to any offensive language.

The device offers three modes. In Tolerant Mode, curses and harsh phrases are removed. The Strict mode also eliminates mild expletives and references to God and Jesus Christ (taking the Lord's name in vain). The off mode allows programming to be heard in its original form.

The TV Guardian, a three-award Innovations winner, costs $149.95.

TV/PC Network

Audio-on-demand, video-on-demand, ... do we sense a trend here? Philips Electronics and ShareWave snagged a Best of Show award for yet another in the take-control-of-your-electronics-through-new-electronics category with *Ambi*, a digital wireless PC peripheral that transmits PC functions, from software applications to Internet access, to any television set. By allowing different applications to be run at both locations simultaneously, it effectively doubles the functionality of the PC.

Designed for one-computer/many-user households, Ambi uses "advanced concurrent technology to create multiple desktops." Translation: You can prepare a report or spreadsheet while your kids play their favorite PC games (or vice versa). Both applications reside on a single PC. Ambi also allows multiple users to share printers and scanners and permits double Internet access over one phone line with one ISP account.

Ambi uses a high-speed (4-Mbps) radio combined with wavelet compression technology to transmit multimedia data (text, audio, video, and graphics) at an effective rate of 120 Mbps, delivering full-motion video across the wireless communication channel. Display-enhancers ensure

that images look as good ten feet from a TV screen as they do two feet from a computer monitor.

Ambi will come with PC antenna, TV terminal, PCI card, and infrared keyboard. It should be available by the time you read this in key markets, priced between $500 and $700.

Digital Home-Control Network

Not content to take digital control of just your AVC (audio/video/computer) products? Want to master the rest of your domain?

Axlon Electronics' *PalmPal*—another Best of Show winner—is an integrated home system based on a 900-MHz digital wireless platform. Dubbed DWKTS for Digital Wireless Key Telephone System, the PalmPal system allows three telephone lines to be shared by up to 16 wireless handsets and a wired door phone. Each handset has its own extension and voice mail, and an LCD screen that displays Caller ID, time, speed dial, and message information. Each phone also

has five programmable smart keys that can be used to dim the lights, activate a security system, or mute the stereo.

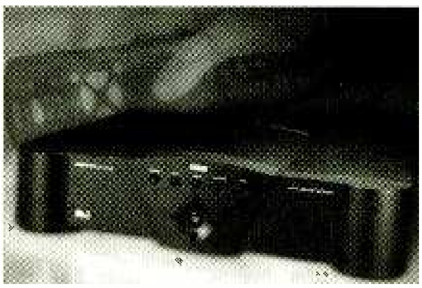
PalmPal can be used within the home or from remote locations. Answer the front door from the backyard. On your way home from work, turn on the air conditioner, lights, and your favorite CD. The system monitors sensor devices and phone-line status, directs messages to appropriate users where and when they need the information, and can react to certain situations—warning of an intruder, for instance.

Pricing depends upon configuration. PalmPal is distributed by Phast Corporation.

DTV Set-Top Converter

Thomson made news at CES—and took home a Best of Show Innovations award—for breaking the DTV price barrier with its $649 *RCA DTC100* digital set-top box. The multi-platform digital receiver/decoder connects to any television to provide enhanced picture performance from analog NTSC broadcasts.

Moreover, it performs double duty by serving as a DirecTV satellite

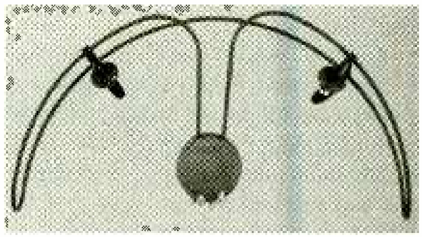


receiver (when used with a three-foot elliptical dish), as well as picking up terrestrial broadcasts (when used with a standard off-air antenna). It also contains a built-in Dolby Digital decoder.

The RCA DTC100 can handle all 18 Advanced Television Systems Committee (ATSC) digital formats, automatically converting the signals into significantly improved analog pictures and sound on today's TV sets. When connected to a high-resolution monitor, it can deliver the increased resolution of HDTV programming. The built-in onscreen programming guide lists available programs, lets you create customized favorite-channel listings, and provides one-touch VCR recording and one-touch tuning.

Rabbit Ears Redux

An offshoot of the DSS explosion is the renewed popularity of outdoor television antennas, needed to pick up the local broadcasts that satellite providers are not allowed to transmit in most areas. Terk Technologies' *TV42* amplified outdoor antenna, winner of the Best of Show award in the accessories category, is designed to clip right on to the DSS dish. It is



quick and easy to install, requires no extra wiring or special tools, and is completely unobtrusive. Patented clips hold the antenna to the back of the dish, neatly out of sight.

The TV42, designed for use with dual-LNB satellite dishes, has a built-in diplexer to combine local-antenna and satellite signals, eliminating the need for extra wiring from the dish to the home. Its highly tuned, efficient receiving element is said to provide superior reception of local programming, and a built-in amplifier ensures against signal loss in the cabling running from the dish mount to the TV, a common problem with long wire runs.

The TV42 will be available early this year at a suggested retail price of $79.95.

Portable Two-Way Voice Mail

The Best of Show award winner in the mobile-office category was Maxon America's *Responder*, which "combines the reply capability of e-mail with the tone and inflection of voice."

Responder is a pager-sized two-way voice mail system that receives and stores voice messages sent over the cellular network. You can play messages at your convenience and reply to a message by pressing a button and speaking into the handset. Responder can be called from any phone and can send a reply to any phone, and users are guaranteed to get every message.

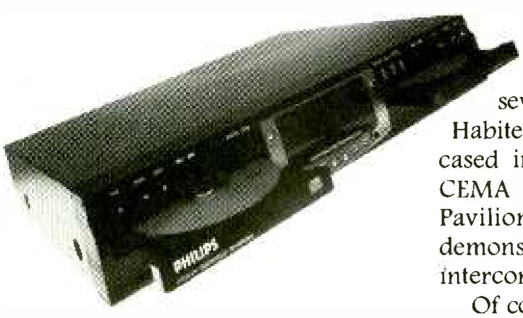
You can create and send voice messages to other Responder users or

groups of users, directly from the handset. As many as 25 voice messages and/or memos can be stored in the Responder. The device is also capable of placing a live telephone call to an emergency service number or to a limited list of key personal numbers.

Responder will be available later this year. Prices not available.

Dual-Deck CD Recorder

CD-recording decks have given consumers the ability to dub their own discs. Philips won a Best of Show



Award for the *CDR765 Audio CD-Recorder*, the first dual-deck CD recorder, which combines the ease of use and versatility of a dual cassette deck with the digital sound and convenience of the CD format.

The CDR765 lets you transfer complete CDs and individual songs from the play deck to the record deck at double the standard playback speed, halving the time needed to create a new CD. With no need to connect a stand-alone CD player to serve as the source, the recording process is streamlined and simplified.

The CDR765 carries a suggested retail price of $649 and is currently available. (By the way, Philips announced at CES that it was significantly dropping its prices on CD-R and CD-RW blank media, reducing 74-minute CD-R discs from $5.99 to $3.99 and halving the industry-average $29.99 price for CD-RW discs.)

CES 1999 Show Roundup

"Consumer electronics" is a broad heading that encompasses dozens of diverse categories, hundreds of established and emerging technologies, and thousands of different products ranging from pocket calculators to HDTV sets. Likewise, the Consumer Electronics Show is actually several shows rolled up into one.

At the Las Vegas Convention Center, and at several off-premise sites, exhibits are generally grouped by product category: Mobile Electronics, Home Office, High-End Audio, Home Theater, Antennas, Telephony, and the like. The main floor of the center is home to the major manufacturers, each displaying its whole line of products. CES also hosted several "Technology Pavilions": Habitech Institute '99, which showcased integrated home systems; the CEMA DTV Center; the Antenna Pavilion; and the 1394 Pavilion, demonstrating IEEE-1394 standard interconnectivity.

Of course, the primary purpose of a trade show such as CES is to sell products to retailers, which means presenting those products in exciting (generally noisy and flashy) ways on the show floor. But for retailers to successfully sell complex pieces of electronic equipment to the public, they first must have an understanding of what that product does, how it works, and what it offers to the consumer. So the secondary goal of CES is to educate retailers (and the press) about new technologies. Complementing the manufacturer exhibits and technology pavilions were a series of educational seminars to help attendees make sense of some of the new products, terminology, and technologies being presented—and that's exactly what we'll try to do here.

Our Digital Destiny

Despite the size and diversity of the show, there was one common thread running throughout: digital technology. In and of itself, that doesn't sound too exciting. After all, most of us use CD players and computers on a daily basis, and millions of us are watching digital video from digital satellite TV systems or on DVD.

But that overwhelming level of acceptance of things digital *is* big news, perhaps not in and of itself, but for what it heralds. Combine it with the arrival of digital television—which we'll all be accepting within the next decade!—and the foundation is laid for the integration of digital technologies within the home. You can call it convergence, or home integration, or interconnectivity, or home networking. The name isn't as important as the concept that, in the not-too-distant future, all of your electronics gear will be able to communicate, coordinate, and cooperate. Imagine, soon one remote control will be able to operate everything from your home theater to your home-security system.

And at the center of that digital conglomerate will be your big, new digital television set. The user-interface—remote control and on-screen menus—is comforting in its familiarity. The peripherals—DVD, DVD-Audio, CD recorders—surely will change and evolve, but all of them will be digital, and capable of being controlled by a single, integrated home network via menus displayed on a DTV.

Here (in excerpts from his opening keynote address) is how Sony Chairman and CEO, Howard Stringer, envisions it: "Your digital television will become the centerpiece, at the nerve center of the home of the future ... a home which will be as connected as any office might be today. Whether wired or wireless, your home network will be the platform for dozens of consumer devices co-existing within the home ... set-top boxes, smart phones, a whole new class of devices designed for what Sony calls the coming era of intimate computing. These devices will have to be simpler to use ... devices intelligent enough to recognize one another, to anticipate user choices, and to perform as expected without cumbersome commands and menus.

Philips displayed at CES its 64-inch, rear-projection HDTV set, currently available in major markets at a suggested retail price of $9990.

"The digital home must offer needed relief to a people weary and oppressed by vexatious VCRs and unruly remote controls. Every product and distribution system should be responsive ... to the most technophobic of customers."

Of course, such grandiose digital dreams are just that, unless the various industry players (manufacturers, broadcasters, content providers, and the FCC, to name a few) can learn to communicate, coordinate, and cooperate as well as they expect their home networks to do! We'd love to report that everyone is in agreement on formats and standards. But, hey! We're talking consumer electronics here. When was the last time you can remember everyone being in complete agreement on anything?

Zenith displayed its Model IQADTV1W Digital HDTV receiver/decoder set-top box.

Let's take a look at some of the emerging technologies, while we try to wade through the morass of conflicting formats and confusing jargon that will be thrown your way in the coming months and years of digital transition.

DTV Debuts

You probably don't have one, you might not even have seen one (we have), but digital televisions are here. We gave you a pretty thorough rundown of the who, what, when, where, and why of DTV in February's *Gizmo News*. Of course, things have changed since that column was penned last fall, particularly in light of announcements and new product introductions at CES.

A quick recap: DTV is a collection of 18 different formats of varying resolutions (all of which offer improved picture quality and sound when compared with NTSC), ranging from Standard Definition TV (SDTV), which delivers DVD-quality 300,000 pixels per frame, to High Definition TV (HDTV), with 2-million pixels per frame. Digital broadcasts began last November on a very limited (in terms of times and markets) basis.

At CES, there were almost two dozen separate exhibits featuring over-the-air HDTV broadcasts. The show came close on the heels of the November 1998 DTV launch, but preliminary sales figures were announced during a DTV "SuperSession" seminar. By early January, the industry had sold more than 13,000 DTV sets to dealers. Are those sets moving out of the showrooms and into some living rooms? Perhaps not as quickly as manufacturers (and retailers) would like to see.

Quipped Sony's Howard Stringer, "With the commencement of digital TV sales in your stores—at least sales in theory if not so much in actual practice—the transition from analog to digital took a significant leap forward. Now that the holiday sales results are in, one might be inclined to view this occasion as one very small step for the consumer electronics business and one giant leap for digital hype."

Thomson's first entry in the direct-view HDTV market is this 38-inch ("the world's largest direct-view HDTV color TV picture tube") ProScan set, expected to be available by year's end.

That's not to say sales are non-existent. In fact, one of the SuperSession panelists, Tom Campbell of Dow Stereo/Video, noted that the chain had already sold 100 DTV sets—and that's

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Web: *www.directv.com*
CIRCLE 104 ON FREE INFORMATION CARD

Echostar Communications Corp.
5701 Santa Fe Drive
Littleton, CO 80120
Tel. 303-723-1000
Web: *www.dishnetwork.com*
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Hitachi Home Electronics (America), Inc.
1855 Dornoch Court
San Diego, CA 92173
Tel. 619-661-0227
Web: *www.hitachi.com*
CIRCLE 106 ON FREE INFORMATION CARD

JVC Company Of America
1700 Valley Road
Wayne, NJ 07470
Tel. 973-315-5000
Web: *www.jvc.com*
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Kenwood U.S.A. Corporation
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Long Beach, CA 90801
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Web: *www.kenwoodusa.com*
CIRCLE 108 ON FREE INFORMATION CARD

Maxon America, Inc.
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Kansas City, MO 64153-1238
Tel. 816-891-6320
Web: *www.maxonusa.com*
CIRCLE 109 ON FREE INFORMATION CARD

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052
Tel. 425-882-8080
Web: *www.microsoft.com*
CIRCLE 110 ON FREE INFORMATION CARD

OpenTV, Inc.
401 E. Middlefield Road
Mountain View, CA 94043
Tel. 650-429-5500
Web: *www.opentv.com*
CIRCLE 111 ON FREE INFORMATION CARD

Phast Corporation
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Salt Lake City, UT 84107
Tel. 800-979-9637
Web: *www.phast.com*
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Philips Consumer Electronics Co.
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Atlanta, GA 30346-6401
Tel. 770-821-2400
Web: *www.philips.com*
CIRCLE 113 ON FREE INFORMATION CARD

Pioneer Electronics
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Tel. 310-952-2218
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Principle Solutions
3708 Lehman Court
Rogers, AR 72758
Tel. 501-936-8443
Web: *www.tvguardian.com*
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Palo Alto, CA 94303
Tel. 650-968-9912
Web: *www.replay.com*
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Web: *www.sharewave.com*
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Tel. 201-930-1000
Web: *www.sony.com*
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63 Mall Drive
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Tel. 516-543-1900
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CIRCLE 120 ON FREE INFORMATION CARD

Thomson Consumer Electronics
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INH-310
Indianapolis, IN 46290
Tel. 317-587-3000
Web: *www.rec-electronics.com*
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TiVo, Inc.
894 Ross Drive
Sunnyvale, CA 94089
Tel. 708-747-5080
Web: *www.tivo.com*
CIRCLE 122 ON FREE INFORMATION CARD

Zenith Electronics Corp.
Commercial Products
1000 Milwaukee Ave.
Glenview, IL 60025
Tel. 847-391-7000
Web: *www.zenith.com*
CIRCLE 123 ON FREE INFORMATION CARD

in an area in which DTV broadcasts have not yet begun. The buyers (including a young Navy couple who took out a second mortgage to cover the cost of a set) are hooked when they see how the sets improve the quality of NTSC reception and want to be prepared for when digital broadcasts commence.

Optimism of manufacturers, broadcasters, and retailers—as well as those early adopters—was bolstered by HBO's announced plans to begin DTV broadcasts this spring. DIRECTV announced that it will join with New Line Cinema to distribute HDTV pay-per-view movies in May. Initial titles include *American History X*, *Living Out Loud*, and *Pleasantville*. EchoStar said it plans to deliver HDTV programming via its Dish Network, but offered no specifics.

The cable industry, on the other hand, is still dragging its collective heels over the switch to DTV. And content providers, concerned about digital piracy, are waiting for a digital copyright protection scheme to be adopted before they are willing to wholeheartedly embrace digital TV.

Copy protection is an area in which battle lines have been drawn between opposing camps. The two major proposals (outlined in last month's *Gizmo News*) are 5C, backed by Sony, Hitachi, Intel, Matsushita, and Toshiba; and Extended Conditional Access (XCA), favored by Thomson and Zenith. At the Consumer Electronics Show, however, Thomson surprised everyone with a demonstration of a Divx-ready HDTV DVD player, in which the Divx encryption system provided copy protection.

So, what if you decide you absolutely must be the first one on your block to own a DTV? The good news is there are plenty of choices out there, and you won't necessarily have to take out a second mortgage. (But you'd better stop throwing out those "You're pre-approved" credit-card offers that come in the mail each day!) By far the cheapest DTV solution is Thomson's $649 set-top converter box. It won't let you see HDTV on your analog set, but DTV should significantly enhance the picture. Nine other manufacturers are offering set-top boxes, in prices ranging from $1500 to $5000.

Add to those an HD-ready television, and you can view anything right up to HDTV. At least a dozen manufacturers are selling such sets, and most offer more than one model. Prices range from $2799 for a 36-inch direct-view set from Hitachi, up to a whopping $69,995 for a front-projection unit from Ampro.

Or you can go for an integrated set. There are less than a dozen models currently available, and almost all are rear-projection units, with prices ranging from $7000 to $10,000. Sony has the only direct-view HDTV set to date, the $8999 34-inch FD Trinitron Wega. Sanyo plans to market a 32-inch direct-view integrated set by the end of this year, and Thomson's 38-inch ProScan direct-view set will arrive in "late 1999." Almost all of the integrated sets offer NTSC line doubling and a built-in Dolby Digital decoder.

DVD Branches Out

DVD had an impressive first year, with over a million units sold, and it's predicted that sales figure will double this year. That's despite the conflict between DVD and Divx; both types of deck are selling well.

Two new DVD technologies are poised for market introduction—once some issues are resolved, that is. First (watch out, VHS!) there's DVD/RW: recordable digital video discs. Then there's DVD-Audio, or DVD-A.

Pioneer demonstrated a prototype DVD/RW unit that it planned to have on the market six months after copy-protection issues are ironed out by the DVD Forum, which the company hopes will be by the end of the year. The working prototype provides up to 1.5 hours of recording on a 4.7GB disc at full DVD resolution. The actual product is expected to have a full two hours recording time. DVD/RW discs won't be playable on today's DVD decks, but future decks should be compatible with DVD-Video, DVD/RW, CD-RW, and DVD-Audio discs.

DVD-A offers artists and producers a variety of linear PCM (pulse code modulation) modes and allows them to select the number of channels, quantizations, and sampling frequencies. Whereas most of the storage space on a DVD-Video disc is used for video, DVD-Audio discs are devoted almost entirely to multi-channel sound. It's expected, however, that many record labels will release high-resolution (96-kHz, 24-bit) two-channel discs for the audiophile market. The discs have enough storage space for liner notes, still images, and even full-motion video.

JVC is showing its XV-D701BK ($599.95)DVD player, complete with Dolby Digital decoder and 5.1-channel analog output, as well as the XV-DX1BK ($699.95), which adds a Divx decoder/modem.

Several companies, including Pioneer, JVC, and Kenwood, showed prototype DVD-A players, some of which also can play DVD-video discs. Meridian demonstrated a DVD-Video player that can be upgraded to include DVD-A.

The DVD Forum's audio group hoped to announce final specifications at the show, but said instead that the final version 1.0 DVD-Audio format is expected to be finished early this spring. Once again, copy-protection issues are holding things back.

Pulling It All Together

DTV, HDTV, SDTV, DVD, Divx, DVD-A, CD, CD-R, DVD/RW—not to mention digital camcorders and still cameras, PCs and handheld "digital assistants," computer peripherals, and whatever other digital devices the future holds in store—will all be interfaced in home networks ... someday. The vision is broad and ambitious. The goal is to simplify and enhance the lives of consumers by providing one standard network that will easily control a plethora of digital devices. Once again, the industry is striving to come up with a universal standard—this time, one that will allow any consumer electronics product, from any manufacturer, to interconnect with those from other manufacturers.

The CES seminar "Home Networks: Ready to Come Home?" made it woefully clear that the answer is "No!" Representatives from Microsoft, Intel, Compaq, Sony, and Pioneer did their best (within the limited time frame of a two-hour seminar) to outline the various options and state their company's positions. Although they did not manage to convey a clear sense of the state of the home network, some trends did emerge.

The computer manufacturers agree that, in the words of Microsoft's public networks product group manager, Joseph Mouhanna, "The Swiss Army knife of networks does not exist." He sees a slow path toward consumer acceptance, the need for compelling applications to be created, and the coexistence of two or more networks within each home.

Sony and Pioneer are both backing the IEEE-1394 interface as the basis for any future home networks. The interface allows products to send and receive streams of digital audio, video, and control data at speeds up to 400 Mbps. Both companies also see Cable Lab's Open Cable digital interface with copy protection as being an integral component. Pioneer New Media Technologies' senior VP of sales and marketing for optical products, Paul Dempsey, envisions a digital media receiver as command central for the home network.

Out on the show floor, virtually every major company was displaying its idea of home networking, with its own catchy moniker. Sony's is the "VAIO World." Philips is touting "Personal TV," Pioneer calls it "Digital Networked Entertainment." You get the picture—but not yet!

Interactive TV

Actually, there are a few current (or soon-to-become-available) products that foreshadow the interconnected future of home entertainment. Their scope is not broad enough to place them in the "networked" category. Instead, we'd have to call them convergence products, even though that concept has met with consumer resistance.

Not surprisingly, the folks who brought you digital satellite TV are now ready to offer other digital services via your TV.

EchoStar's Dish Network is taking two approaches to interactive television. First, the company announced a joint venture with Microsoft's WebTV network in which some Dish Network set-top boxes will house a WebTV-Plus

TiVo is the ingredient that brings Philips' Personal TV to life.

terminal. WebTV-Plus offers an interactive onscreen programming guide (which will replace EchoStar's own guide), giving viewers access to online banking, shopping, game-playing, and e-mail via their television sets. Viewers will be able to surf the web while watching TV in a small window inset. The WebStar set-top box, expected to cost between $300 and $400, will also offer Video Pause, a feature that allows viewers to store live programming to a hard drive (when the phone rings during a favorite show, for instance), and then resume watching at their convenience. (Philips, by the way, is also offering WebTV-Plus, in a set-top box that's currently available for $199.) EchoStar also will offer a Dish Network PCI receiver card that will allow PC users to access Dish TV programming on their computers.

Second, EchoStar is partnering with OpenTV to offer interactive television in its new generation of satellite receivers. The OpenTV platform will provide e-mail, electronic banking, e-commerce, and data-enhanced TV programming. OpenTV will be included as a standard feature on

Wink interactive services, to be available through DirecTv, will offer in-depth additional program information to TV viewers.

basic-level Dish Network units, with WebStar considered the next step up in interactivity.

Meanwhile, DIRECTV plans to offer Wink analog interactive services in its set-top boxes later this year. Wink-enhanced broadcasting will provide DIRECTV subscribers with access to in-depth information on programming (and commercials) and with the ability to participate in polls, conduct e-commerce, and get in on special DIRECTV promotions.

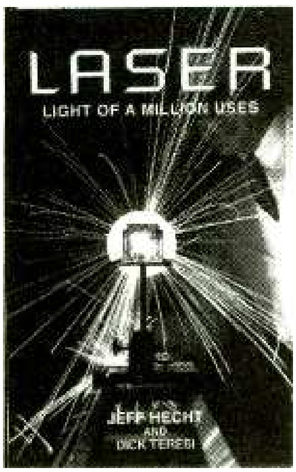
DIRECTV also announced its alliance with Philips, which will offer DirecTv satellite receivers that incorporate TiVo's personalized "push" service. An integral part of Philip's first Personal TV product, TiVo offers an intelligent program guide with the ability to "learn" a viewer's preferences so that it can automatically locate and record to a hard drive those programs it determines the viewer would like.

The first Philips-brand, TiVo-equipped DIRECTV unit should be available later this year. Plans are in the works for a second-generation unit, expected to be available in the first half of next year, which will include an ATSC receiver, "adding the benefits of digital television picture quality and programming." G

Electronics Library

LASER: LIGHT OF A MILLION USES
by Jeff Hecht and Dick Teresi

In clear, jargon-free language, the authors explain what lasers are, how they work, and their rapidly increasing uses—from checkout counter scanners to CDs to fiber-optical systems. In medicine, lasers have revolutionized surgery. The military is using them in the production of sophisticated weapons, while new uses for lasers are being found in many other areas, from holography to manufacturing, entertainment, and more.



This authoritative, user-friendly volume satisfies the curiosity of anyone interested in this field. It includes a new preface on the latest laser technology, a discussion of the future of lasers, and an appendix on laser safety, as well as 44 illustrations.

Laser: Light of A Million Uses costs $8.95 and is published by Dover Publications, Inc., 31 E. 2nd St., Mineola, NY 11501; Tel. 516-294-7000; Fax: 516-742-5049.

CIRCLE 90 ON FREE INFORMATION CARD

FUN PROJECTS FOR THE EXPERIMENTER
by Newton C. Braga

As electronics continues to become more involved in chemistry, biology, and physics, the need to understand its basic principles grows. Aimed at students, hobbyists, and experimenters, this collection contains fifty fun and easy-to-build projects that give the electronics enthusiast practical experience in the application of electronics theory.

With this book, hobbyists can learn to build everything from LED flashers and electronic fishing lures to wireless beepers and signal tracers. These are primarily stand-alone, low-cost projects, with few components, intended for one night of work. The components for each project are listed, and schematics are provided. Hints and questions about the circuits are included to stimulate ideas about possible modifications and alternative uses.

Fun Projects for the Experimenter costs $24.95 and is published by Prompt Publications, Howard W. Sams & Company, 2647 Waterfront Parkway, East Drive, Suite 300, Indianapolis, IN 46314-2041; Tel. 800-428-7267; Web: www.hwsams.com.

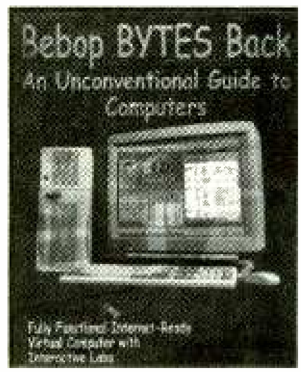
CIRCLE 91 ON FREE INFORMATION CARD

BEBOP BYTES BACK: AN UNCONVENTIONAL GUIDE TO COMPUTERS
by Clive "Max" Maxfield and Alvin Brown

Providing an in-depth introduction to the way computers work, the book describes the design of a simple microcomputer, starting with the AND gate; continues through the design of the arithmetic/logic unit (ALU); adds the CPU; and discusses the external components required for a complete system.

Accompanying the book is a CD-ROM containing the fully functional, Internet-ready Beboputer Virtual Computer. It is a simple microprocessor-based computer with an easily understood instruction set, but implemented as a virtual machine in software.

The book also documents a series of step-by-step interactive labs to be performed on the Beboputer, from running a simple 9-byte program to designing an assembly language.

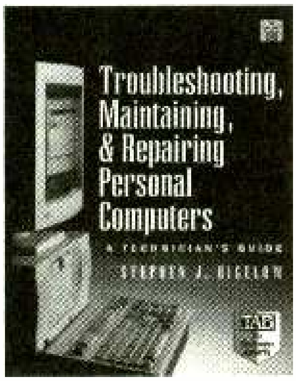


Bebop Bytes Back costs $49.95 and is published by Doone Publications, 7950 Hwy. 72W, #G106, Madison, AL 35758; Tel. 800-311-3753 or 205-837-0580; Fax: 205-837-0580; Web: www.doone.com.

CIRCLE 92 ON FREE INFORMATION CARD

TROUBLESHOOTING, MAINTAINING & REPAIRING PERSONAL COMPUTERS
by Stephen Bigelow

This hands-on reference for technicians provides efficient, cost-effective troubleshooting and repair techniques. There are nearly 400 problems completely explained, as well as hundreds of POST and diagnostic codes to help identify and cure even the most difficult problems. Supplementing the written material is one of the largest available collections of ready-to-use diagnostic freeware, shareware, and utilities on the included disc.



Three handy sections help readers get fast answers. Section I is a technician's primer; Section II discusses system data and troubleshooting, offering an extensive array of documented service procedures; and Section III is filled with real-world advice and procedures for maintenance and support. The nine appendices offer resource and reference information, useful forms, a sample certification test, and more.

Troubleshooting, Maintaining, & Repairing Personal Computers costs $44.95 and is published by McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020; Tel. 800-2MCGRAW; Web: www.ee.mcgraw-hill.com.

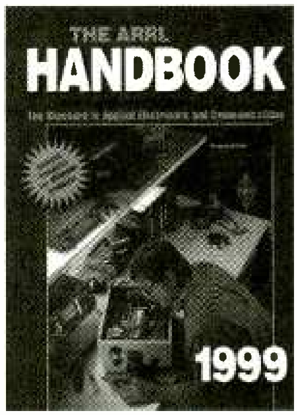
CIRCLE 93 ON FREE INFORMATION CARD

THE ARRL HANDBOOK FOR RADIO AMATEURS: 1999 EDITION

edited by R. Dean Straw, N6BV

Over the past 75 years, this handbook has been an essential resource for projects for all levels of building experience and an invaluable source of reference material. The 76th edition of the handbook continues this tradition, providing a thorough foundation of electronics and communications theory for hams, students, engineers, and technicians.

The new projects in this edition include a 13.8 V/40 A switching power supply, a legal limit Svetlana 4CX1600B amplifier, and a voice keyer, as well as an enhancement to the high-power antenna tuner introduced last time. In response to reader's comments, this volume includes PC templates for the weekend projects. The larger more complex templates are on the ARRL Web site. In addition, the software for the book can be downloaded from the Web site or from its *Hiram* BBS, or it can be ordered for a nominal cost.



The ARRL Handbook for Radio Amateurs: 1999 Edition costs $32 and is published by American Radio Relay League, 225 Main Street, Newington, CT 06111-1494; Tel. 800-243-7767; Fax: 860-594-0303; Web, www.arrl.org.

CIRCLE 94 ON FREE INFORMATION CARD

1999 CATALOG

from Antique Electronic Supply

Offering all types of tube gear, including vacuum tubes, transformers, capacitors, parts, supplies, and literature, this 72-page catalog contains

many new products. Among them are ferrite rods, inductor coils, gift items, a line of Hammond classic 300 series power transformers, and many other products.

Another new product line is high quality, beautifully made, and reasonably priced telegraph keys. Imported from Spain, they have gold-plated brass keys on an olive wood base, and teakwood handles and knobs. Three types of keys are available: straight key, iambic paddle, and a dual straight key and iambic paddle.

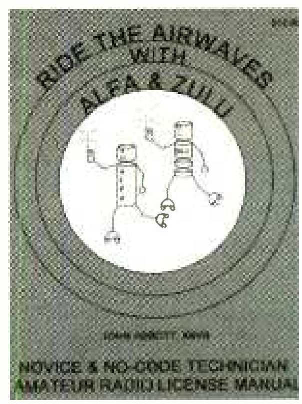
The 1999 Catalog is free upon request from Antique Electronic Supply, 6221 South Maple Avenue, Tempe, AZ 85283; Tel. 602-820-5411; Fax: 800-706-6789 or 602-820-4643; Web: www.tubesandmore.com.

CIRCLE 95 ON FREE INFORMATION CARD

RIDE THE AIRWAVES WITH ALPHA AND ZULU

by John Abbott, K6YB

In cartoon format, this manual leads the novice step-by-step through the basics required to pass the novice and no-code technician amateur-radio license exams. Each lesson is accompanied with a short quiz on the material covered.



From getting on the air to everything a beginner needs to know about antennas to an introduction to Morse Code—all are covered in a clear and easy style. The second section continues in the same manner for the material students need to know for the more advanced technician exam.

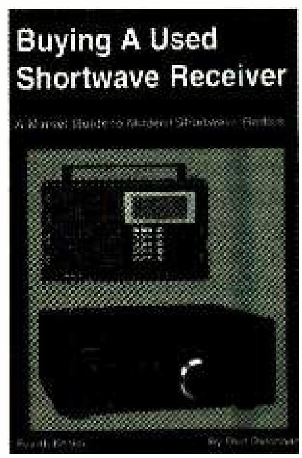
Ride the Airwaves with Alpha and Zulu costs $14.95 and is published by Abtronix, P.O. Box 220066, Newhall, CA 91322-0066; Tel. 805-222-7384; Fax: 805-222-7384; Web: http://home.earthlink.net/~abtronix.

CIRCLE 96 ON FREE INFORMATION CARD

BUYING A USED SHORTWAVE RECEIVER: FOURTH EDITION

by Fred Ostermann

This book provides all the information you need to intelligently select the right used SW receiver at the right price. Features to consider are coverage, specifications, ratings, price when new, size, and weight.



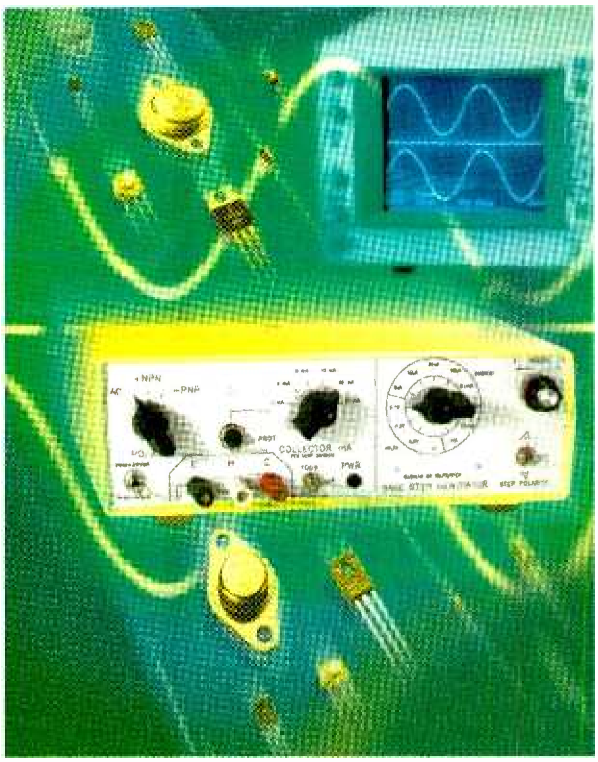
The 100 most sought-after receivers, portable and tabletop models from the last twenty years, are discussed. Among the selected models covered in the book are Allied, AOR, Drake, Grundig, Icom, Kenwood, Panasonic, Sony, and Ten-Tec units.

Buying A Used Shortwave Receiver costs $5.95 and is published by Universal Radio Research, 6830 Americana Parkway, Reynoldsburg, OH 43068-4113; Tel. 800-431-3939 or 614-866-4627; Fax: 624-866-2339; Web: www.universal-radio.com. ■

CIRCLE 97 ON FREE INFORMATION CARD

SEMICONDUTOR TESTER

CHARLES HANSEN



Build this curve-tracer adapter and eliminate one of the most frustrating dilemmas that electronics hobbyists face in assembling homebrew and published electronics circuits.

No one will dispute that the development of semiconductor components has simplified the manufacture of electronic equipment. But in spite of all the good the "new breed" of components has wrought, it has also spawned a new set of problems. Chief among the difficulties associated with semiconductors is testing them for adherence to manufacturer's specs.

On the manufacturing level, testing is accomplished through specialized equipment. But, what's a hobbyist to do when confronted with a possible semiconductor malfunction? In many cases, the hobbyist is left to devise unconventional testing schemes that may or may not reveal pertinent information about the operability of the component.

In this article, we'll show you how to build the *Semiconductor Tester*—an instrument that allows you to measure both the static and dynamic characteristics of semiconductor transistors under simulated operating conditions. The tester is a curve tracer adapter that incorporates a collector supply and base-step generator, which together produce voltage and current signals that are applied to the device-under-test (DUT). The effects of the signals on the DUT produces a family of characteristic responses (curves) that can then be displayed on an oscilloscope and compared to manufacturer's specifications.

The tester can be used to measure and display a number of bipolar-transistor parameters simultaneously—for example, it can be used to plot the I_C vs. V_{CE} characteristics of a transistor, determine saturation voltage, calculate gain (h_{FE}), and look at the spacing and slope of h_{FE} curves. The Semiconductor Tester is not limited to bipolar transistors—it can also be used to test JFETs, MOSFETs, SDs, rectifiers, and Zener diodes.

The Big Picture. Figure 1 is a functional block diagram of the tester, with a bipolar NPN transistor connected as the DUT. In this curve tracer adapter, collector-supply and step-generator circuits produce signals that are applied to the oscilloscope through J1 and J2. The collector-supply output is also applied to the collector of the DUT via J3, while the step generator feeds current to the DUT's base through J4. Base current is stepped up in equal increments, starting from zero and increasing to its maximum, then returning to zero once the selected number of steps is completed. Step increments are controlled via S2.

Collector current flows through an emitter resistor, producing a voltage drop that serves as the vertical (Y-axis) signal (J1). The range of collector current is controlled by S7.

Circuit Description. A complete schematic diagram of the Semiconductor Tester is shown in Fig. 2. The circuit is comprised of six integrated circuits, four transistors, 17 diodes, a fullwave bridge rectifier, an LED, two transformers, and a goodly amount of support components.

The Semiconductor Tester contains two supply circuits: one supplying operational power to the adapter and the other (the collect supply circuit) providing the required collector and emitter signals. The collector-supply circuit is comprised of T2 (a 12.6-volt, 1.2-amp step-down transformer), BR1 (an 8-amp, 250-volt, fullwave bridge rectifier), and S4 (a single-pole double-throw switch), which allows the user to determine the voltage (6.3 or 12.6 volts) applied to BR1 for rectification. The resulting DC output of BR1 is applied to S6-b and S6-c. Those

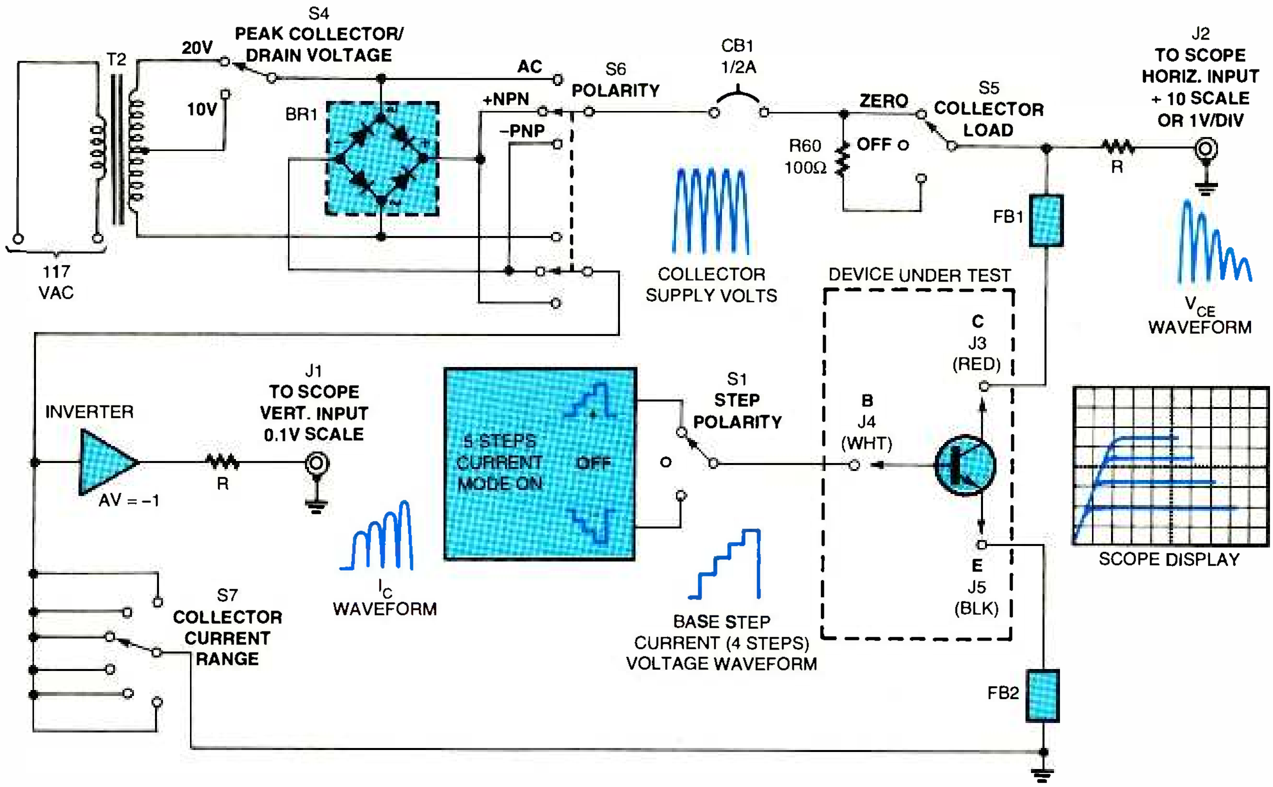


Fig. 1. As illustrated by this functional block diagram, the Semiconductor Tester is comprised of several sub-assemblies that coalesce to produce scope displays that reveal the "health status" of several two- or three-terminal semiconductor devices.

two sections of S6 (a 4P3T switch) permit the user to select any one of three sweep outputs (+NPN, −PNP, or AC), while a third section of S6 (S6-a) is used to ground J4 when the circuit is set for the AC mode.

The maximum amount of collector current applied to the DUT is controlled through S7, which places one of six resistors (R41–R46) in series with the emitter of the DUT. Placing S7 in the 50-mA position produces a maximum collector current of 0.63 amps, which should be adequate for testing most small-signal and medium-power bipolar transistors (up to TO-220 or TO-66 packages).

Note that a circuit breaker (CB1) is connected in series with the output of the collector-supply circuit in order to protect it from overload conditions.

The signal delivered to the DUT through J3 is also applied to J2 through R47, whose presence in the signal line sets the output impedance to approximately 600 ohms. A ferrite bead, FB1, connected in the lead to J3, prevents the DUT from breaking into oscillation.

Switch S5 lets the user reduce the peak collector/emitter voltage applied to the DUT to less than that selected via S4 by placing R60 (a 100-ohm resistor) in series with the collector sweep signal. Placing S5 in the off position disrupts collector-signal flow to the DUT (via J3) when inserting or removing a transistor.

Both the collector and base currents are returned to a common ground at J5. A ferrite bead, FB2, connected in the lead to J5 helps prevent DUT oscillation.

Since the polarity of the voltage across R41–R46 is negative with respect to ground, IC4-b inverts the signal that's applied to J1, producing a family of correctly oriented curves when viewed on an oscilloscope. Resistors R37 and R38 set the gain of IC4-b, while R39 ensures that the input bias current at pins 5 and 6 are equal for best accuracy. Resistor R40 sets the output impedance at J1 to approximately 600 ohms.

Voltage Step Generator. The step generator portion of the circuit is comprised of four major sub-assemblies: a clock, a counter, a step-level converter, and a step amplifier. The step generator is designed to supply discrete current (or voltage) levels to the base (or equivalent terminal) of the DUT for each cycle of the collector-supply sweep. The discrete levels are generated in ascending steps with a fixed, 1-volt separation.

A signal plucked from the secondary winding of T1 and fed to a clock circuit comprised of D1/D2 and Q1/Q2 determines the rate of change in the step-generator's output. The AC voltage diverted from the secondary of T1 is fullwave rectified by D1 and D2 and applied to the base of Q1 via R1. That causes Q1 to saturate (turn full on) during each AC half-cycle, producing a 120-Hz clock frequency. The output of Q1 is applied across R2 (which supplies a negative bias voltage that ensures that Q1 turns off at zero crossing) to the base of Q2. Transistor Q2 inverts the Q1 output, producing a clock signal that is applied to IC1—a 4017 decade counter/divider that is used as a step-level converter—causing its ten decoded outputs (Q0–Q9) to sequentially go high. (Note: The Q0 output of IC1 is not used and represents the zero-level base step.)

The outputs (Q1–Q9) of IC1 are fed through individual resistor/diode pairs (comprised of R5–R13 and D3–D11) and S8, producing a voltage across R14 that increases in 1-volt steps.

Potentiometer R14 is used to calibrate the step voltage, while diodes D3–D11 block reverse-current flow to the outputs of IC1 when they are low. When set to the HOLD 1V position, S8 provides a fixed 1-volt reference to aid in checking the base-step generator's output stage during initial tests.

The summed output-voltage steps of IC1 are buffered by IC2-a (half of an LF412 dual op-amp), which is configured as a unity-gain voltage follower. The output of IC2-a is monitored by IC4-a (which is configured as a comparator). When the output of IC4-a at pin 3 reaches the level set by R18, IC4-a pin 1 goes high, resetting IC1 to zero, and the step count begins over again. Diode D18 prevents the −12-volt DC output of IC4-a from damaging IC1. Resistors R16 and R17 provide offsets so a single step is produced at the minimum setting of R18 and nine steps are produced at maximum rotation.

The negative-going voltage steps are generated by inverting op-amp IC2-b. Base-step polarity is determined through S1, which lets the user select between the output of IC2-a and the output of IC2-b. Switch S1 can also be used to remove the step signal from J4 when inserting or removing a transistor. Resistors R23 and R24 set the gain of IC2-b, while R22 ensures that the input bias current at pins 5 and 6 are equal for best accuracy.

The step signal from S1 drives two circuits. The first is a voltage divider, which provides the gate voltage steps necessary to test FETs. Resistors R32–R35 form a resistive divider network, which provides 0.1-, 0.2-, 0.5-, and 1-volt stepped outputs that can be selected through the first four positions of S2. The larger steps are required for power MOSFETs.

The counter can be reset after 1 to 9 steps have been produced, with the number of steps determined by the setting of R18.

Voltage-To-Current Converter. In order to generate the base-current steps required to test bipolar transistors, a voltage-to-current converter is required. One way of accomplishing that is by placing a series resistor at the output of the voltage-step generator in order to produce current steps. The down side to that approach is that an offset voltage is required for the first step because it takes from 0.5 to 1.0 volts to forward-bias the base-emitter junction. The base-emitter voltage increases exponentially and is not the same at all collector currents. The base-emitter voltage increases even more in the saturation region, while also varying with temperature, so the series resistor method is not a good solution for accurate measurements.

Fortunately, there is an alternative—a bilateral current source built around an op-amp-based, voltage-to-current converter. The op-

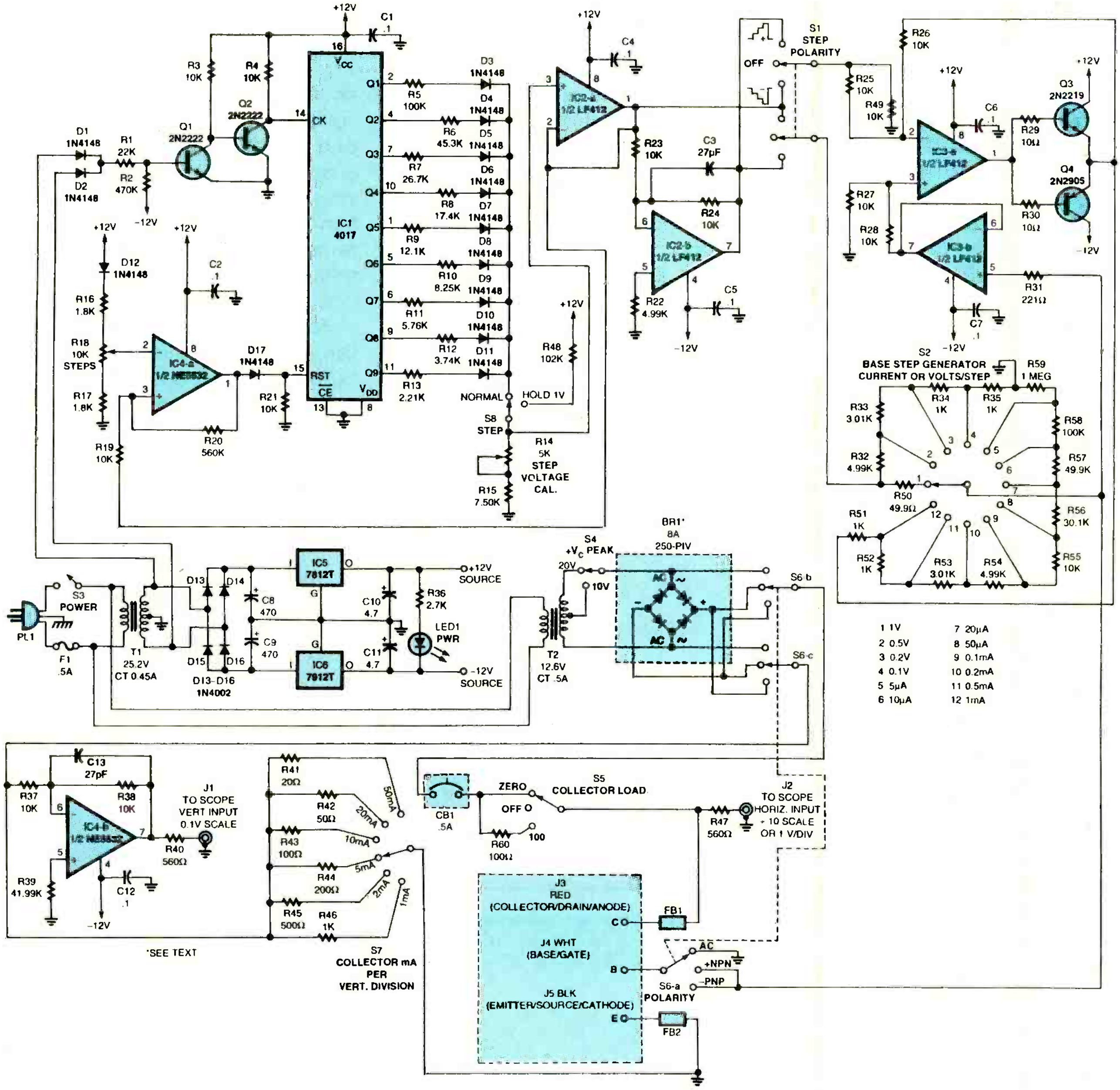


Fig. 2. The Semiconductor Tester is comprised of six integrated circuits, four transistors, 17 diodes, a fullwave bridge rectifier, an LED, two transformers, and a goodly amount of support components.

amp-based converter supplies a current that is proportional to the input voltage and, more importantly, drives a load referenced to any voltage within the output-swing capability of the op-amp. The voltage-to-current converter consists of dual low-offset, low-drift JFET op-amp IC3 along with a current amplifier that is composed of Q3 and Q4.

The base voltage steps are applied to IC3-a pin 2 via R25. Resistor R49 provides a ground reference when S1 is in the OFF position to park the current output at zero. Negative feedback is taken from the emitters of Q3 and Q4 through R26.

Positive feedback is provided through R27 and R28 via IC3-b. The positive feedback increases the output impedance to a very high value, which is the characteristic of a true constant-current source. The input signal is amplified by IC3-a, which, if you make all of the feedback resistors *exactly* equal (R25 = R26 = R27 = R28), produces an output current of:

$$I_{OUT} = -V_{IN}/R_{SELECTED}$$

Note that the voltage-to-current converter produces an inverted output. Thus, S1 selects negative voltage steps to produce positive current steps and vice-versa. Since the voltage-step generator produces one volt steps, the current steps can easily be selected by changing a single resistor, $R_{SELECTED}$. Thus, the output current is determined by the value of the resistor (R51–R58) selected via S2. The current can be varied from 5 μA/step

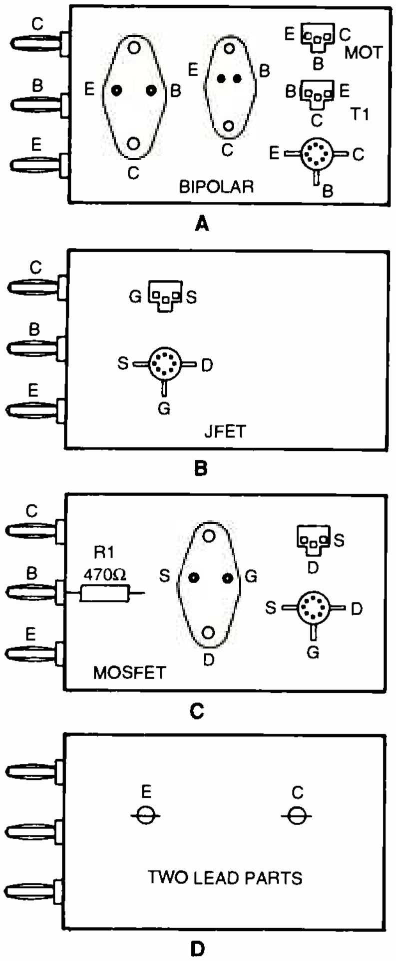


Fig. 3. The author's unit includes several test fixtures that are designed to plug directly into J3–J5 of the Semiconductor Tester—each containing several three-terminal sockets to accommodate various standard transistor-pin arrangements. The one in A is intended for testing bipolar transistors; the one in B is for JFETs; a fixture for testing MOSFETs is shown in C; and the final one shown in D is designed for two-terminal devices, such as rectifier and Zener diodes.

to 1 mA/step. Resistor R59 provides a ground return for the voltage-to-current converter when S2 is in one of the voltage-step modes.

The voltage-to-current converter delivers the current set by the selected resistance, independent of any load resistance at J4, even if the other side of the load is not sitting at ground potential, such as when a base-emitter junction is interposed between J4 and J5. Under that condition, positive feedback through R27 and R28 tends to reduce accuracy. To prevent that occurrence, IC3-b is configured as a unity-gain buffer with an extremely high input resistance to drive positive feedback network R27 and R28. Since R25 = R26 = R27 = R28, the output current is independent of the feedback voltage. The output resistance of the circuit is given by:

$$R_{SELECTED} \times (R/\Delta R)$$

where R is any one of the feedback resistors (R25, R26, R27, or R28) and ΔR is the change in the resistor value due to component tolerances. Because of that, the feedback resistors should be selected to be equal in value. In order to facilitate matching, 10k 1% metal film resistors are used, even where less precision is required. That allows a larger selection of resistors (14) from which to match R25 through R28.

The circuit must be driven from a source resistance that is low by comparison to R25, since that resistance also unbalances the circuit, while affecting gain and output current. The low output resistance of IC2-a and IC2-b meets that requirement.

The output of IC3-a is applied to the base of Q3 and Q4 through R29 and R30, increasing the output drive current to the level required for the higher base-step current levels.

Once the collector supply and the step generator outputs have been applied to the DUT, measurements of the voltages and currents seen at the collector (or equivalent) terminal of the device must be displayed on the vertical and horizontal axes of an externally connected oscilloscope.

Collector current is measured on the vertical X-axis of the oscilloscope. It is measured across one of the resistors (R41–R46) between ground and the current return to the collector supply by measuring the voltage developed across this resistor. Switch S7 selects the current sensing resistor, which varies the deflection factor of the scope display between 1 mA/DIV and 50 mA/DIV. The resulting voltage is inverted by IC4-b and applied to J1 through R40.

Collector-emitter voltage is sensed at J3 and sent via J2 to the horizontal Y-axis of the scope. Resistor R47 provides an output impedance of about 600 ohms.

Power for the Semiconductor Tester is provided by a conventional dual-voltage (±) supply circuit, comprised of T1 (a 25.2-volt center tapped transformer), and D13–D16 (four 1N4002 1-amp, 100-PIV diodes that form a fullwave bridge rectifier). The resulting DC voltages are applied to IC5 and IC6 to produce positive and negative DC voltages, respectively. The outputs of the regulators are filtered by C8 through C11. An LED (LED1) connected across the power supply output serves as a power-on indicator.

Components IC2 and IC3 were selected for precision and low input offset voltage in order to ensure the accuracy of the base-step voltage and current; and they should not

TABLE 1—TEST CONNECTIONS

	DEVICE	COLLECTOR POLARITY	STEP POLARITY
BIPOLAR	NPN	+NPN	+
	PNP	−PNP	−
JFET	N-Channel	+NPN	+
	P-Channel	−PNP	−
MOSFET	N-Channel	+NPN	+
	P-Channel	−PNP	−

Scope Connections:

1. Horizontal input to main trigger or amp in
2. Time/division to amplifier (was 10 ms)
3. Main trigger source to ext. ÷10 (was int.)
   Deflection Factors:
   - Ext. × 1 = 0.1V/Div
   - Ext. × 10 = 10 mV/Div
   - Ext. ÷ 10 = 1V/Div
4. Vertical = 1V/Div
5. NPN = dot lower left, PNP = dot upper right

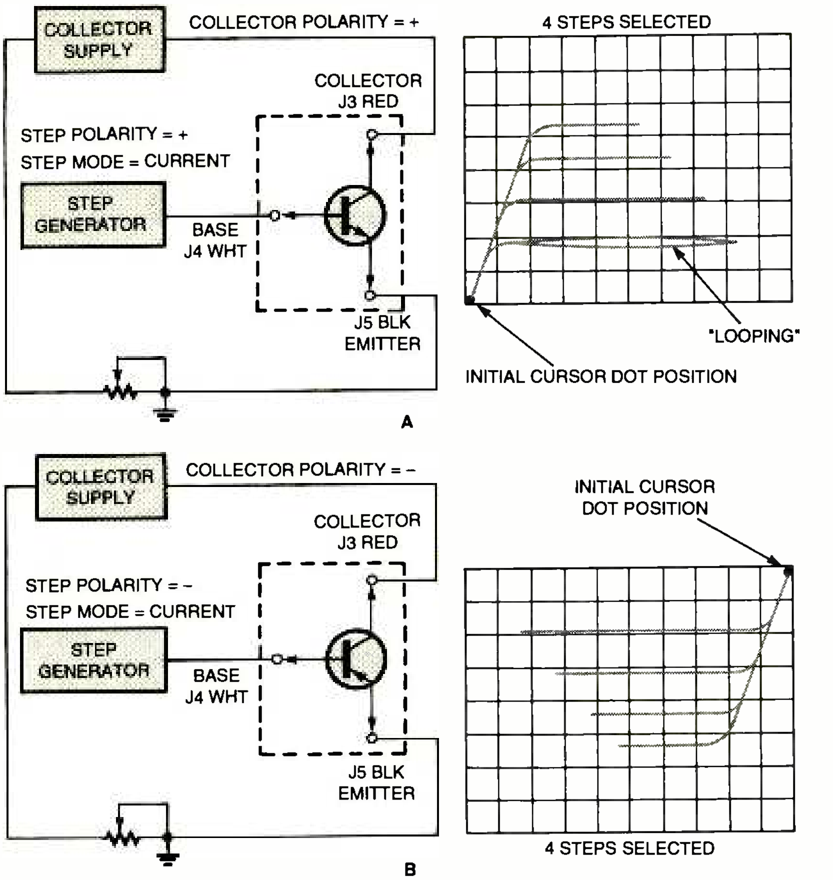


Fig. 4. Shown here is the correct way to connect bipolar transistors to the test fixture. The illustration in A shows how a bipolar NPN transistor is connected to the fixture; the DUT's characteristic curves are also shown. The illustration in B shows the PNP terminal connections and characteristic curves.

be replaced with less accurate FET op-amps, such as the TL072 or LF353. Precision op-amps such as the AD712JN or LT1057CN8 are acceptable substitutes. The NE5532 op-amp (IC4) was selected for its ability to drive the standard test equipment 600-ohm output impedance. Most other op-amps are only rated for 1k or higher loads.

Construction. The Semiconductor Tester was assembled on a fairly large section of Vector board, with point-to-point wiring techniques then brought into play to complete inter-component connections. Because no printed-circuit pattern is provided for this project, the circuit must be assembled according to the Fig. 2 schematic diagram. Be careful when assembling the circuit—this type of construction is more prone to errors than the printed-circuit method.

In keeping with good circuit-board assembly practice, install the least sensitive passive components (resistors, capacitors, inductive devices, *etc.*) first, followed by the semiconductors.

Sockets should be provided for all DIP components. Install all of the semiconductors except IC1–IC4. When that's complete, double check the orientation of all polarized components—that includes all electrolytic capacitors and semiconductors (diodes, transistors, IC, *etc.*).

Note: Many of the resistors associated with switches are not mounted to the board, but are instead mounted directly to the switch terminals. For example, R32–R35 and R50–R59 are mounted to S2; R60 is mounted to S5; R43–R46 are mounted to S7. All the components associated with the collector supply are mounted on the front panel. Resistors R41 and R42 are mounted to 5-lug terminal strips that were cut down to 3 lugs. Flat-head screws were used to mount the 3-lug strips and BR1 to the front panel.

A tapped turret-terminal caps the mounting screw for BR1 and serves as a grounding point for the collector supply circuitry, power supply, and base-step generator. That ground point is then wired directly to emitter jack J5. Another turret terminal is used for R47 near J2 on the rear panel. LED1 has its own integral lens holder.

Since the base-step generator processes very low voltages and currents that are sensitive to noise, the wiring associated with S2, S6, and J4 is twisted (2–3 turns per inch) with another wire, forming a pseudo shield. The pseudo shield should then be grounded at one end only. Other than that, the circuit and wiring layout is not critical.

The outputs of power transformers can be connected to the circuit board through 0.062-inch Molex crimp-terminal plugs and receptacles. That allows easy removal of the board for servicing should the unit require it somewhere down the road.

Once the board (minus the off-board components) has been assembled, put the board to the side for a moment and prepare the enclosure that will house the unit. Make sure when selecting an enclosure that it has sufficient room inside for the board and all of the off-board-mounted components (including the panel-mounted parts).

Drill holes in the front panel of the enclosure for the switches (S1, S2, and S4–S8), jacks (J3–J5), LED1 (the power "on" indicator), and potentiometer (R18). Follow that by drilling holes in the rear panel for the fuse holder, S3, J1, J2, and a hole through which to feed the unit's line-cord to the transformers. Next drill mounting holes in the bottom of the enclosure for the transformers.

Once the holes have all been drilled in the front and rear panels of the enclosure, dry-transfer lettering can be used to label the unit's panel-mounted control and jack positions as to their functions. The method used by the author for labeling the unit involved making a full-size copy of the front panel layout on transparent, adhesive-backed plastic appliqué film

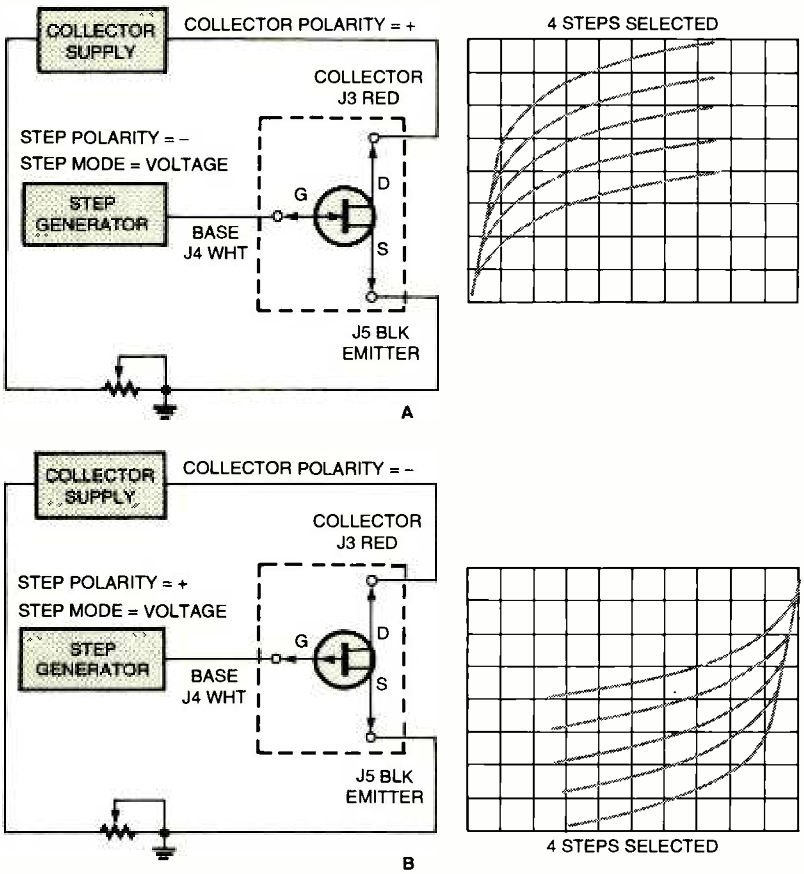


Fig. 5. The test setup and characteristic curves for an N-channel JFET is shown in A, while the test setup and characteristic curves for P-channel JFETs is shown in B.

(which is available from drafting and art supply houses).

Initial Checkout. At this point, attach the Molex connector to T1, plug in the unit, and check for the presence of +12 and −12 volts at the supply terminals of the sockets for the four ICs not yet installed. If all is well, power down the unit—allowing sufficient time for the power-supply capacitors to discharge—and install the four ICs. Again apply power to the circuit and check that the clock and counter (IC1) are working properly. Place S2 in the 1-volt position and, with a scope connected to J4 and J5, view the voltage step pattern. You should be able to vary the number of steps in 1-volt increments from 1 to 9 by adjusting R18.

Next, connect a 1000-ohm, 1% metal-film resistor from J4 to J5. This time set S2 to the 1-mA position and again observe the scope display; you should be able to vary the number of steps in 1-volt increments from 1 to 9. If the step generator is not working properly, you can use S8 to hold a single 1-volt step for troubleshooting.

Next, plug in the Molex connector for collector-supply transformer T2. View the waveform of the collector supply from J3 to J5. Select each polarity and verify that the 10- and 20-volt peak taps of T2 work properly.

Test Fixtures. The author's unit includes a test fixture that's designed to plug directly into J3–J5 of the tester. The test fixture—which contains three-terminal sockets to accommodate various standard pin arrangements (TO-3, TO-66, TO-220, TO-5, *etc.*)—provides a simple method of connecting the device under test to the Semiconductor Tester.

Figure 3A shows a fixture designed to facilitate the testing of bipolar transistors. Note that the fixture includes sockets to accommodate TO-3 and TO-66 transistor packages, as well as a pair of TO-220 sockets, which are configured to accommodate both "E-B-C" and "B-C-E" pin arrangements. The fixture in Fig. 3B is designed for the testing of JFETs. Note that the drain of a JFET corresponds to the collector terminal, the gate corresponds to the base, and the source corresponds to the emitter of a bipolar transistor. A MOSFET test fixture is shown in Fig. 3C. Note that the correlation between the terminals of bipolar transistors and JFETs is identical to that between bipolar and MOSFETs. Notice that the MOSFET fixture contains a 470-ohm gate resistor, which is required to prevent DUT oscillation during tests. A two-pin fixture like the one shown in Fig. 3D (which includes alligator clip leads) can be added to your collection of fixtures and used to test signal and Zener diodes. In that case, the anode and cathode of the DUT correspond to the collector and emitter, respectively, of the bipolar transistor. When assembling any of the fixtures, be sure that the banana plugs are situated so that the fixture does not interfere with any of the front panel controls.

For comparison testing, you can develop a dual-socket test fixture with a DPDT center-off switch to alternately test two like devices. In such an arrangement, the unswitched emitter terminals can be connected together.

PARTS LIST FOR TEST FIXTURES

TO-3 socket (Mouser 534-4601)
TO-66 socket (Mouser 534-4611)
TO-220 socket (Digi-Key WM2550-ND)
TO-5 socket (Mouser 151-TO-5320G)
R1—470-ohm ¼-watt, 5% carbon film resistor (MOSFET fixture *only*)
Panel-mount banana plugs (Digi-Key J148-ND), 4.375 × 2.437 × 1.25 inch enclosure (Radio Shack 270-221), wire solder, hardware, *etc.*

Jacks J3–J5 also accept lead wires, spade lugs or banana plugs (spaced at a standard ¾-inch) so that almost any device can be connected to the Semiconductor Tester without requiring a specific test fixture.

Operation. The BNC connectors, J1 and J2, (which are mounted to the

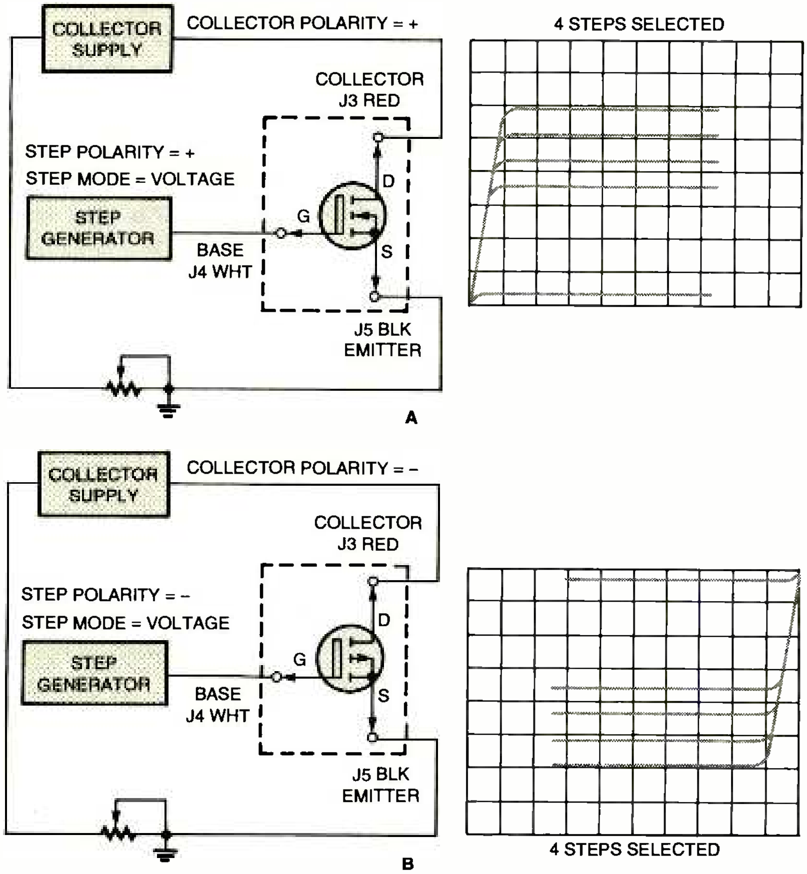


Fig. 6. Here we have the test setup and characteristic curves for MOSFETs: The drawing in A is for N-channel MOSFETs, while the one in B is for P-channel units.

rear panel of the unit) are used to connect the tester to your oscilloscope. Both the X and Y channels must be DC-coupled, but don't need a wide bandwidth on any of the channels. The scope's vertical input should be set to the 0.1 volt/DIV scale to provide proper collector current readings as indicated by the scale of S7. The scope's horizontal input should be set to the 1 volt/DIV scale to provide proper collector-emitter voltage readings.

If using a single channel scope, turn the time-base switch to the X or external position. A two-channel scope with an XY time-base switch position can use one channel as the X channel and the other channel as the Y channel.

Table 1 gives the scope connections and polarities for bipolar and field-effect devices; that table can be modified as required (to match your scope) and attached to the top of the tester as a reference, as was done in the prototype.

The step polarity and the collector voltage polarity switches should be set for the DUT. **CAUTION:** A number of the Semiconductor Tester's controls, if set too high, could cause damage to the DUT. The adapter's base-current capability is high enough to drive most power transistors to maximum collector current. When the tester is set to the high collector-supply-voltage range and the 50-mA/DIV range at the same time, the connected transistor can heat up rapidly. If you accidentally reverse-bias the base-emitter junction of a transistor, it may permanently increase the device's noise figure. Therefore, be sure to always double-check the pinout of all devices and make sure that the correct collector-voltage polarity and base-step polarity is applied to the DUT.

Let's make the first test with a small signal NPN transistor (2N2222, 2N3904, *etc.*). Set the front panel controls as follows: S6 to the +NPN mode, S4 to 10 volts peak, S7 to 1 mA/DIV, S5 to off, S2 to 5 μA, R18 for 2 or 3 steps, S1 to off, move the cursor dot to the bottom left-hand corner of the display grid, connect the NPN transistor to the E-B-C terminals using the correct device pinout, set S5 to zero, and set S1 to + steps.

Connect a bipolar transistor to the test fixture as shown in Fig. 4. Figure 4A shows how an NPN transistor is connected to the fixture along with the DUT's characteristic curves, while Fig. 4B illustrates PNP terminal connections and characteristic curves. The scope display should show two or three curves similar to those shown in Fig. 4. Note that the curves in Fig. 4A are the exact opposite of those in Fig. 4B.

Move the bottom curve to the bottom left-hand corner of the display grid. That establishes the zero reference from which all the other voltage and current measurements are taken. The vertical-collector-current deflection depends on the transistor gain. It may be necessary to increase the base current (via S2) to get the traces shown in Fig. 4. You can also vary sensitivity via S7 for tests at collector currents other than 10 mA/div.

To calculate gain, select one of the horizontal curves, let's say from the third base current step. In Fig. 4A, that lies on vertical grid 3.1, which represents 3.1 mA (1 mA/vertical division). We know the third base step is 10 μA (5 μA/step, with the first step equal to zero). Therefore the gain is:

$$h_{FE} = I_C/I_b, \text{ or } 3.1\text{ mA}/10\text{ }\mu\text{A} = 310$$

You can also find saturation voltage, the vertical region of each characteristic curve.

Device Test Setups. When testing a device with unknown characteristics, set S2 to 5 μA/step for bipolar transistors or 0.1 V/step for FETs. Set S4 to 10 V and S7 to 10 mA/div. Set R18 for 2 or 3 steps. That limits the dissipation to a safe level for any device.

Some of the characteristic curves displayed may consist of loops (as shown on the second step in Fig. 4A) rather than well-defined lines. That effect is known as looping and is noticeable at very low or very high current levels. Looping is a phase shift caused by device capacitance and stray capacitance within the adapter, which allow collector current to bypass the DUT itself. It may also be caused by heating of the DUT. While lab-grade curve tracers use elaborate capacitance-cancellation circuitry, that is beyond the scope of this article. The best approximation of the actual characteristics curve when looping is present is an imaginary straight line drawn down the middle of the loop.

Refer to the test setup and characteristic curves for a PNP transistor shown in Fig. 4B. Note that for P polarity devices, the initial cursor dot position is in the upper right corner of the scope grid, and the collector voltage and the step polarity are reversed. The deflection now will run from right to left, and from top to bottom, with the curves displayed "upside down."

Similarly, Fig. 5 shows JFET drain current vs. drain-to-source voltage for various steps of gate voltage. To calculate transconductance (gm), select one of the horizontal curves. Since gm = I_D/V_{GS}, that parameter can be found for any step of gate voltage.

Figure 5A shows test setup and characteristic curves for an N-channel JFET. For JFETs, the drain is connected to J3 and the source is connected to J5. The JFET gate (connected to J4) is driven from the volts/step portion of S2. JFETs are different from bipolar transistors in that they conduct maximum current with zero gate voltage, so the step polarity must be opposite that of the collector supply polarity. The

PARTS LIST FOR THE SEMICONDUCTOR TESTER

SEMICONDUCTORS

IC1—CD4017 decade counter/divider, integrated circuit (Jameco 12749)
IC2, IC3—LF412CN dual, low-offset, FET-input, op-amp integrated circuit (Newark LF412CN)
IC4—NE5532 dual, low-noise, op-amp, integrated circuit (Jameco 27385)
IC5—7812T fixed, positive 12-volt regulator integrated circuit (Jameco 51334)
IC6—7912T fixed, negative 12-volt regulator, integrated circuit (Jameco 51481)
Q1, Q2—2N2222A general-purpose NPN silicon transistor (Jameco 38236)
Q3—2N2219A general-purpose PNP silicon transistor (Jameco 38228)
Q4—2N2905A general-purpose NPN silicon transistor (Jameco 38279)
BR1—8A, 250-PIV fullwave bridge rectifier (RadioShack 276-1181)
D1–D12, D17—1N4148 general-purpose, small-signal, silicon diode (Jameco 36038)
D13–D16—1N4002 1-amp, 100-PIV, silicon rectifier diode (Jameco 76961)
LED1—Red light-emitting diode with holder (RadioShack 276-011)

RESISTORS

(All fixed resistors are ¼ watt, 1% metal-film, units, unless otherwise noted.)
R1—22,000-ohm, ¼-watt, 5%, carbon-film
R2—470,000-ohm, ¼-watt, 5%, carbon-film
R3, R4, R19, R21, R23, R24, R37, R38, R49, R55—10,000-ohm
R5, R58—100,000-ohm
R6—45,300-ohm
R7—26,700-ohm
R8—17,400-ohm
R9—12,100-ohm
R10—8250-ohm
R11—5760-ohm
R12—3740-ohm
R13—2210-ohm
R14—5000-ohm 15-turn, cermet, trimmer potentiometer, (Mouser 323-4290W-5K)
R15—7500-ohm
R16, R17—1800-ohm, ¼-watt, 5%, carbon-film
R18—10,000-ohm linear, conductive-plastic, potentiometer (Digi-Key RV4N103-ND)
R20—560,000-ohm, ¼-watt, 5%, carbon-film
R22, R32, R54—4990-ohm
R25–R28—10,000-ohm (see text)
R29, R30—10-ohm, ¼-watt, 5%, carbon-film
R31—221-ohm
R33, R53—3010-ohm
R34, R35, R52—1000-ohm
R36—2700-ohm, ½-watt, 5%, carbon-film
R39—4199-ohm
R40, R47—560-ohm, ¼-watt, 5%, carbon-film
R41—20-ohm, 10-watt, 1%, wire-wound (RS-10, Newark 13F136-20)
R42—50-ohm, 5-watt, 1%, wire-wound (RS-5, Newark 13F143-50)
R43, R60—100-ohm, 5-watt, 1%, wire-wound (RS-5, Newark 13F143-100)
R44—200-ohm, 3-watt, 1%, wire-wound (RS-2B, Newark 13F142-200)
R45—500-ohm, 3-watt, 1%, wire-wound (RS-2B, Newark 13F142-500)
R46, R51—1000-ohm, ½-watt, 1%, metal-film (Mouser 29MF500-1K)
R48—102,000-ohm
R50—49.9-ohm
R56—30,100-ohm
R57—49,900-ohm
R59—1-megohm

CAPACITORS

C1, C2, C4-C7, C12—0.1-µF, ceramic-disc (Mouser 140-CD50Q9-104Z)
C3, C13—27-pF, NPO, ceramic-disc (Mouser 141-100N5-027J)
C8, C9—470-µF, 50-WVDC, aluminum electrolytic (Mouser 140-XAL50V470)
C10, C11—4.7-µF, 35-WVDC, aluminum electrolytic (Mouser 140-XRL35V4.7)

ADDITIONAL PARTS AND MATERIALS

T1—25.2-volt, center-tapped 0.45-amp transformer (RadioShack 273-1366)
T2—12.6-volt, 1.2-amp, center-tapped transformer (RadioShack 273-1505)
CB1—½-amp circuit breaker (All Electronics CB-05)
F1—½-amp fuse
FB1, FB2—Ferrite bead (All Electronics TOR-3)
S1, S5—DPDT center-off mini toggle switch (Jameco 21952)
S2—SP12T shorting-type, rotary switch (Mouser 10WW112)
S3—DPST, 3-amp, 250-volt AC slide switch (Digi-Key CKC5105-ND)
S4—DPDT miniature toggle switch (Jameco 21979)
S6—4P3T non-shorting, rotary switch (Mouser 10YX043)
S7—2P6T non-shorting, rotary switch (Mouser 10YX026)
S8—SPDT miniature PCB slide switch (Jameco 109170)
J1, J2—BNC receptacle UG-1094A (Mouser 532-31-221-RFX1)
J3—Red banana jack (Newark 39F1546)
J4—White banana jack (Newark 39F1545)
J5—Black banana jack (Newark 39F1547)
P1, P2—Molex connectors, optional, see text
Experimenter's circuit board, enclosure, T-49 wire-wrap pins, wire-wrap IC sockets, 5-lug terminal strips, fuse holder, hardware, spacers, solder, hookup wire, rubber feet, power cord, grommet, *etc.*

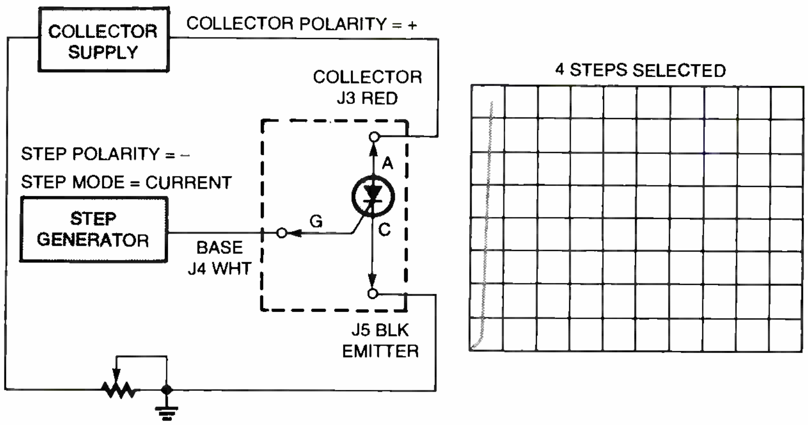


Fig. 7. The test setup and characteristic curves for an SCR are shown here.

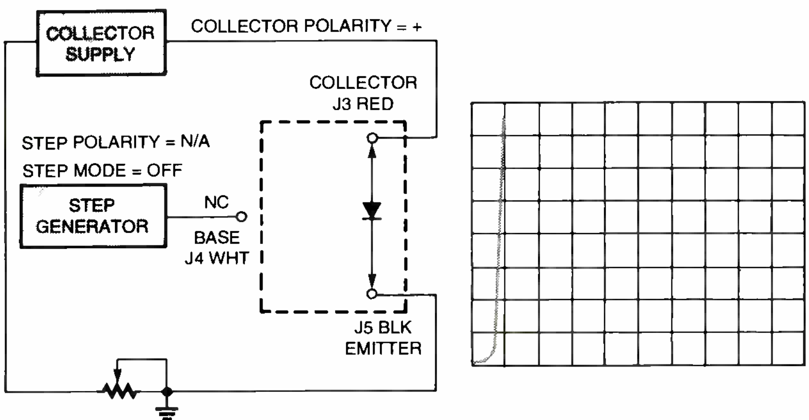


Fig. 8. The test setup and curve for a diode is shown here.

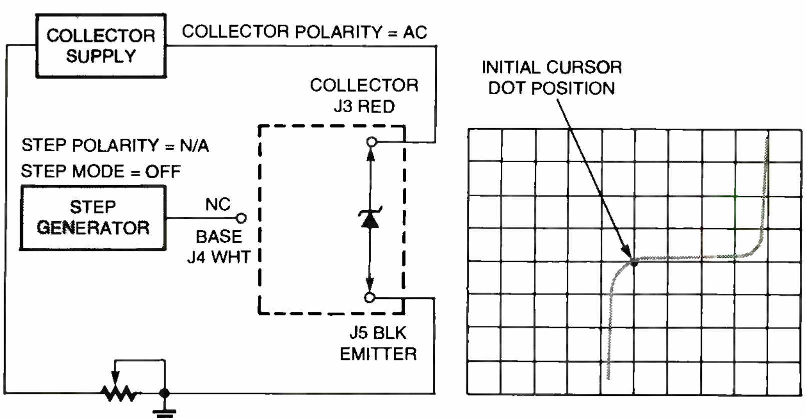


Fig. 9. Shown here is the test setup and curve for a Zener diode.

first step curve is on top; additional steps reduce drain-to-source current, producing additional curves *below* the first one. Figure 5B shows a test setup and characteristic curves for a P-channel JFET.

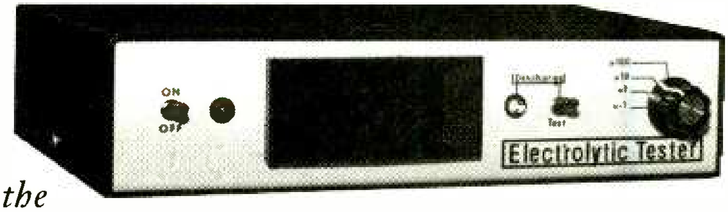
Figure 6A shows test setup and characteristic curves of an N-channel MOSFET. JFETs and MOSFETs have a tendency to oscillate on any curve tracer, producing "fuzz" in the scope display. To guard against oscillation, the tester and MOSFET test fixture have built-in resistors in series with the gate, and the tester has ferrite beads at the collector and emitter jacks. Figure 6B shows a test setup and characteristic curves of a P-channel MOSFET.

Figure 7 shows the test setup and characteristic curves for an SCR. Note the similarity to the diode curve (Fig. 8) once forward conduction is achieved.

Figure 9 shows the test setup and curve for a Zener diode. Note that the initial position of the cursor dot is in the center of the scope grid. If more vertical resolution is required, the cursor dot can be positioned in the lower left corner and positive collector polarity can be used to view only the reverse breakdown voltage portion of the curve. ■

ELECTROLYTIC METER

EUGENE W. VAHLE JR.



Build a troubleshooting aid that can go a long way to determining the condition of the electrolytic capacitors commonly found in the power-supply circuits of computers, TVs, and other electronics equipment.

If you do any type of electronics testing, troubleshooting, or repair, you're probably well aware of how useful a decent capacitance meter can be. In most cases, the capacitance function of your DVM—which can normally handle capacitances of up to about 470 µF—will do. But what do you do when you need to check out the large capacitors that are found in TVs, VCRs, and computers?

Needing to measure capacitances of up to about 300,000 µF at voltages as low as 5.5 volts, the author developed the *Electrolytic Meter.*

Features. Many capacitor testers rely on frequency to measure capacitance, but the Electrolytic Meter is based on the RC time-constant method. That allows the unknown capacitor to be linearly charged from 0–4.4 volts. The graph in Fig. 1 illustrates the difference between series-resistor charging and the constant-current charging ($t = R \times C$, where R is the value of the selected range resistor, and C is the value of the unknown capacitor).

An important feature of the Electrolytic Meter—which has an accuracy of better than 5% (±1 of the least significant digit)—is its ability to discharge capacitors before and after the testing with the flip of a switch to prevent the destruction of the meter. Most electrolytic capacitors have large tolerances, ranging from −20% to +80%, meaning that a capacitor specified at 1000 µF might have an actual capacitance of as little as 800 µF (−20%) to as much as 1800 µF (+80%). Other capacitors have a lower tolerance (±10%). For capacitors with series resistance (such as those used in memory backups), the formulas provided can be used to find the actual capacitance and series resistance.

The display portion of the circuit is comprised of four 7-segment common-cathode display modules (of your choice), allowing the Electrolytic Meter to count and display any value up to 9999. That allows large capacitors to be tested on lower ranges.

About The Circuit. A schematic diagram of the Electrolytic Meter is shown in Fig. 2. The circuit is comprised of four integrated circuits—IC1, a 7805 positive 5-volt, 1-amp, fixed, voltage regulator; IC2, a 74C925 4-digit counter/multiplexed 7-segment display driver; IC3, a 7555 CMOC oscillator/timer; and IC4, a 79L05 negative 5-volt, 100-mA, fixed-voltage, low-power regulator—ten transistors (Q1–Q10), a fullwave-bridge rectifier (BR1), two light-emitting diodes (LED1 and LED2), four common-cathode seven-segment LED displays (DISP1–DISP4), and several support components.

The Power Supply. The Electrolytic Meter is powered from the 117-volt AC line. The AC voltage is applied to T1, a 12.6-volt, 1.2-amp step-down transformer, whose output is rectified by BR1 (a 1-amp, 50-PIV fullwave bridge rectifier) and filtered by C1 (a 470-µF capacitor), producing a voltage of between 16 and 19 volts DC. That voltage is applied along two circuit paths.

In one path, the output of BR1 is applied to IC1 (a 7805 positive 5-volt regulator), which produces a relatively ripple-free 5-volt output. In the other path, the output of BR1 is fed to a second regulator (that's set up, as explained later, in an unconventional configuration), a range-select network, and transistor Q10, which together form a constant-current source circuit.

Reference Voltage. The reference voltage (+4.5 volts) is provided by a voltage-divider network that's comprised of R16 and R17. The reference voltage is used to clamp the voltage across the test capacitor at 5 volts through Q10. The reference voltage—in conjunction with a two-transistor comparator comprised of Q5 and Q6—is also used to halt the count when the voltage across the test capacitor reaches 4 volts.

Two-Transistor Comparator. When S2 is in the discharge position, +5 volts is fed through R15 to the base of Q6, turning it off, which, in turn, sends Q5 into cutoff. With Q6 turned off, pin 5 of IC2 is pulled low through R14, latching the count into IC2 and transmitting the latched data to the display. At the same time, with Q5 cutoff, pin 12 of IC2 goes high, resetting IC2's internal counter to 0000 (resetting the counter has no effect on the latched data).

When S2 is set to the TEST position, the base of Q6 is pulled low (through the unknown capacitor, which initially acts as a short), turning it on. That forces pin 5 of IC2 high, turning the latch off. At the same time, a low is applied to pin12 of IC2, resetting the counter.

At that point, the charge on the unknown capacitor begins to rise. When the charge reaches about 4 volts, Q6 turns off again, latching the final count to the display and resetting the counter again. In the meantime, the charge on the unknown capacitor continues to increase until it reaches a level that's sufficient to forward-bias Q10, clamping the voltage to about 5 volts. Note: Capacitor C9 is included in the circuit to keep the two-transistor comparator (Q5/Q6) from false triggering, while C5 injects a delay between latching and resetting operations. When S2 is returned to the DISCHARGE position, the unknown capacitor discharges through R18.

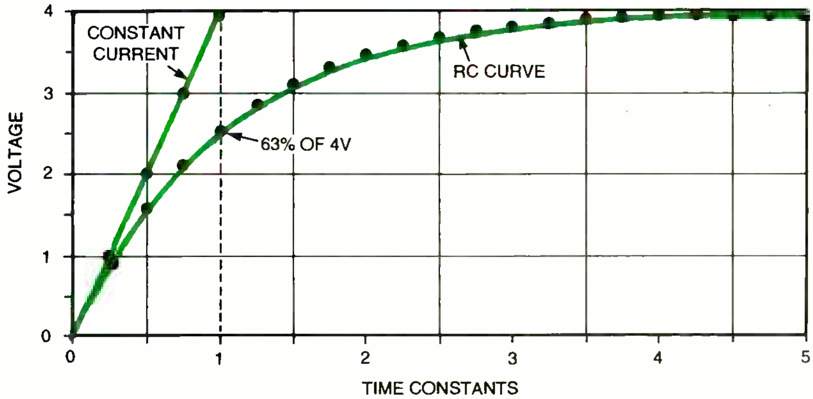


Fig. 1. This graph illustrates the difference between series-resistor charging and constant-current charging.

DC Amp. As the unknown capacitor discharges, the voltage developed across R18 is amplified by Q7 and Q8. While that's happening, LED2 (DISCHARGE) lights to indicate the condition of the circuit. When the voltage across R18 drops to 0.4 volt, LED2 extinguishes, indicating that the unknown capacitor has been safely discharged. Note: If you plan to test a capacitor more than once, be sure to allow enough time between doing so for it to completely discharge.

Clock/Display-Driver. The counter/display driver (IC2) requires a clocking signal, which is generated by a 7555 CMOS oscillator/timer (IC3). The reason that the CMOS version of the 555 was chosen was because it has a cleaner output than the standard 555. The clock is configured to produce an output frequency of 105 Hz. A 10k potentiometer, R11 (FREQ. ADJUST) is included in the clock circuit, allowing the output of IC3 to be fine tuned.

The 105-Hz clock output of IC3 is fed to pin 11 of IC2. When IC2's reset terminal is pulled low, the value latched into the counter is output to DISP1–DISP4 (four common-cathode 7-segment LED display modules with right-hand decimal points). The decimal points are controlled through a section of S3 (the RANGE switch). When S3 is in the ×1 position, DISP4's decimal point turns on. When S3 is in the ×.1 position, DISP3's decimal point lights. The other two positions of S3 do not need a decimal point.

The digit drivers of IC2 (pins 6, 7, 9, and 10) scan the display modules, sequentially activating them through driver transistors (Q1–Q4) at a rate determined by IC2's internal clock. While that's going on, IC2's segment-driver outputs (pins 1–4 and 13–15) activate the appropriate segments of DISP1–DISP4.

Resistors R2–R8 (43-ohm units), which are connected in series with IC2's segment-driver outputs, serve as current-limiting resistors.

Constant-Current Source. You've no doubt noticed the unusual configuration of IC4 (a 79L05 negative 5-volt regulator). In that configuration, the IC4's input is grounded, while the common (ground) terminal is tied to the positive supply rail. Because under that condition, ground is negative with respect to the positive supply rail, IC4 outputs a regulated −5 volt signal. That voltage is dropped across the base-emitter junction of Q9 and the range resistor selected by S3. Subtracting the average 0.6 volt dropped across the base-emitter junction of Q9, the voltage drop across the selected range resistor is approximately 4.4 volts.

Current through the selected range resistor equals 4.4 volts divided by the range resistor value—44 μA for the ×0.1 range, 440 μA for the ×1 range, 4.4 mA for the ×10 range, and 44 mA for the ×100 range. **Note:** When the Electrolytic Meter is operated on the 44-mA range, Q9 starts to warm up, slowly increasing the voltage across the range resistor until it stabilizes. Therefore, you have to wait a couple of minutes before testing an unknown capacitor on that range.

Capacitor C10 is included in the circuit to filter the output of IC4, while R22 places a slight load on IC4's output. That's done because on the 44-μA range, the current needed for Q9 is very small (in the order of 0.4 μA). Capacitor C11 is included in the circuit to help prevent false triggering of the comparator. Resistor R27 controls the current to the decimal point selected through S3.

Construction. There is nothing very critical about the assembly of the Electrolytic Meter circuit, which was assembled in four sections—the display board, the power supply, the main board (which contains the comparator, the DC amp, the voltage reference, and the constant-current-source), and the counter/display driver board (which includes the clock circuitry)—on individual perfboards with inter-component and inter- board connections accomplished through 30-gauge (awg.30) wire-wrap wire (for the most part) and point-to-point wiring techniques. A heavier gauge wire (awg. 22) was used for the power-supply connections. Since the readout is the least complicated of all of the subassemblies, let's begin construction of the meter by starting with the display board.

The Display Board. The size of the board depends on which displays

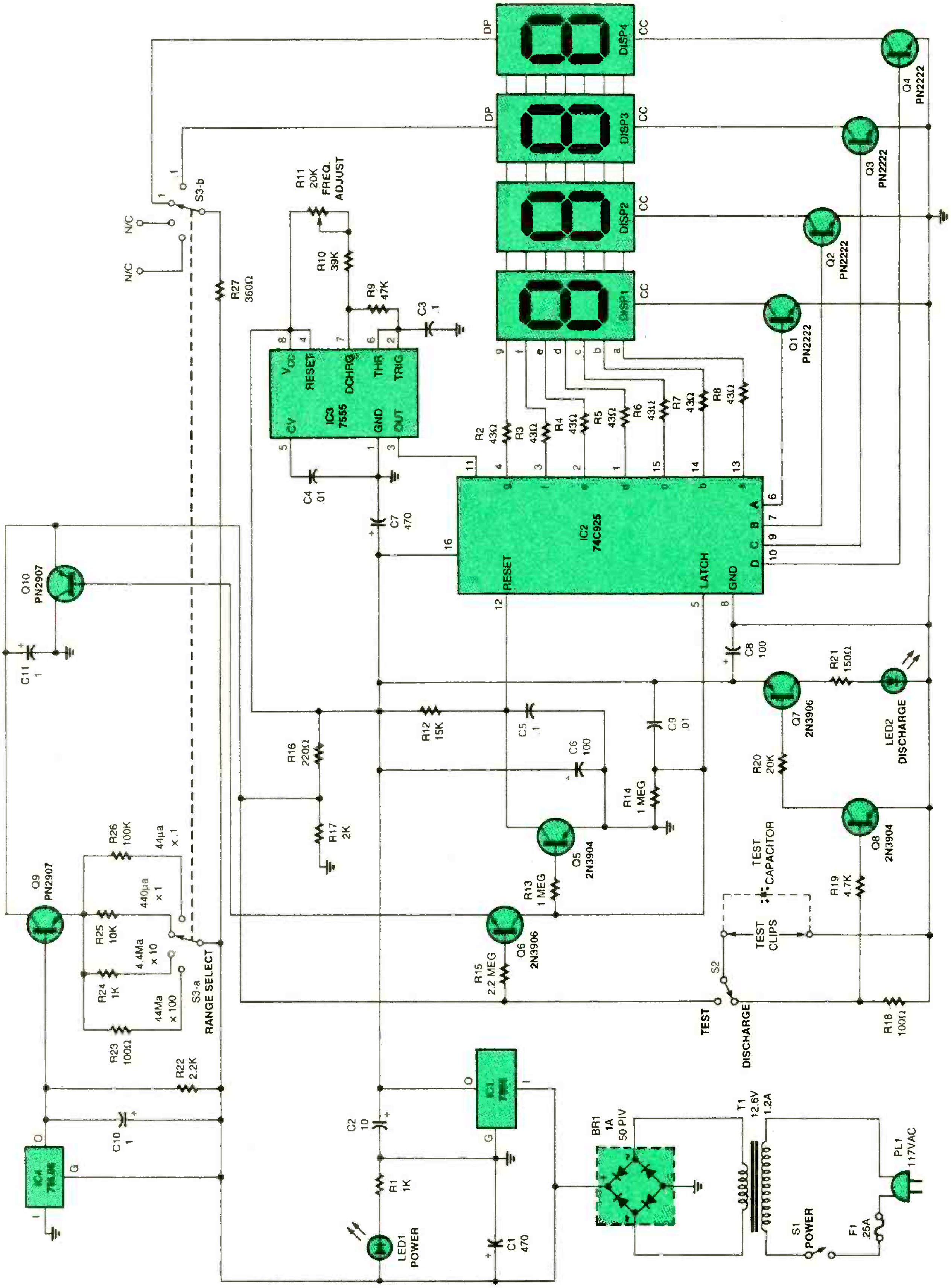


Fig. 2. The Electrolytic Meter is comprised of four integrated circuits (IC1–IC4), ten transistors (Q1–Q10), a fullwave-bridge rectifier (BR1), two light-emitting diodes (LED1 and LED2), four common-cathode seven-segment LED displays (DISP1–DISP4), and several support components.

are used. That's because no particular display modules are specified. Any common-cathode 7-segment modules with right-hand decimal points will do. The perfboard selected for the display should be large enough so that mounting holes can be drilled in the corners of the board without interfering with the display modules. Irregardless of the display modules selected, you'll need a pinout diagram of the modules for this operation.

Place and solder the four 7-segment display modules to the board (horizontally), and then wire like-segment (all "a" segments, all "b" segments, *etc.*) terminals together in a bus configuration. Upon completion of that task, attach lengths of hook-up wire to each of the seven strings of segment terminals and label them "a," "b," "c," *etc.* Next connect four lengths of hook-up wire to the common-cathode (CC) terminals, and label them 1-4. The leftmost module (DISP1) connects to the "A" driver output of IC2; DISP2 connects to "B," and so on. Attach lengths of hook-up wire to the decimal-point terminals of DISP3 and DISP4. When done, you should have seven wires for the seven segments, four common wires (one for each display), and two wires for the two decimal points (total of thirteen wires). Once that's done, check your work for the usual construction errors.

If all is well, place the board to the side for the time being, and move on to the next phase of construction—the power-supply board.

Power Supply. All of the components for the power supply (except T1 and IC4) were mounted to a small section of perfboard. The transformer was mounted to the inside-left rear corner of the enclosure with the power-supply board mounted to the right of the transformer.

Place and solder BR1, C1, R1, and C2 to the component side of the board. Mount IC1 to the bottom of the enclosure using appropriate non-conductive spacers and heatsink compound. Mount the power LED1 and S1 to the front panel of the enclosure. Solder everything together using the schematic as a guide. Since this is the power supply, it's is wise to use heavier gauge wire (awg. 22) in this section of the circuit. The fuse will be added later.

TABLE 1—USING THE ELECTROLYTIC METER

ACTUAL READINGS			
HIGH RANGE	**LOW RANGE**	**WITHIN 10% OF EACH OTHER?**	**CAPACITOR CONDITION**
Low	Low	Yes	Has low capacitance; use high-range reading for correct capacitance.
Low	High	Yes	Slightly low capacitance; use high range reading for correct capacitance.
High	Low	Yes	Not possible unless the checker is not functioning properly.
High	High	Yes	Has some leakage but capacitor is usually OK. Use high-range reading.
Low	Low	No	Has some series resistance. Use low range reading for correct capacitance.
Low	High	No	May have both leakage and series resistance. Measure leakage with ohmmeter. If OK, use lower range reading.
High	High	No	Has some leakage; use ohmmeter to test. Use high-range reading for capacitance
If tester continues counting non-stop on either range.			Capacitor has serious leakage or internal short.

APPROXIMATION FORMULAS

ESR = Equivalent series resistance HR = Capacitance measured on x10 range LR = Capacitance measured on x100 range ESR = HR − LR/0.011 × HR	EPR = Equivalent parallel resistance HR = Capacitance measured on x1 range LR = Capacitance measured on x10 range EPR = 6321.2 × HR/(HR − LR)
Actual capacitance if series resistance is present (e.g., memory backup capacitors	HR = capacitance measured on × 10 range LR = capacitance measured on × 100 range

$$C = (11 \times HR) - LR/10$$

Main Board. Mount all the parts for the comparator, DC amp, +4.5-volt reference, and the constant-current source to the perfboard. The main board was mounted to the right side of the enclosure. Mount S3, S2, and LED2 to the front panel of the enclosure, and then solder the range resistors (R23-R26) and R27 directly to S3. Solder everything together according to the schematic. Next, connect lengths of wire to the B+, regulated +5-volt, and ground points on the power supply board. In addition, connect two wires to S3 (B+ and center tap of range resistors). Three wires must go to the clock/display driver board (latch, reset and ground.). Two wires go to LED2. Three wires go to S2 and two wires go to the test clips outside the enclosure for testing capacitors (total of fifteen wires). Attach B+ (on S3) to the range resistors and R27.

Clock/ Display Driver. The other PC board in the Parts List is for the CMOS clock and display driver (IC2 and IC3). This board should be mounted in front by the display. You should now mount the display board to the front of the enclosure (I cut the rectangular hole with a Dremel drill and cutoff wheel). The black display cover was an old cover I found in the junkbox. It made the project a little more professional, but isn't needed if you don't have one. Solder the parts of the clock and display driver to the board. Be sure C7 (470 µF) is close to IC2. Solder a couple of fuse clips to the left of the board for F1. One fuse clip is connected to S1 and the other to 117 volts AC. Keep the fuse and its solder joints well away from the other parts and connections on the board! You can use a panel-mount fuse holder instead, if you wish.

Solder everything together according to the schematic diagram. You'll need +5 volts and

PARTS LIST FOR THE ELECTROLYTIC METER

SEMICONDUCTORS

IC1—7805 positive 5-volt, 1-amp, fixed, voltage regulator, integrated circuit
IC2—74C925 4-digit counter/multiplexed 7-segment display driver, integrated circuit
IC3—7555 CMOC oscillator/timer, integrated circuit
IC4—79L05 negative 5-volt, 100-mA, low-power, fixed, voltage, regulator, integrated circuit
Q1–Q4—PN2222 general-purpose NPN transistor
Q5, Q8—2N3904 general-purpose NPN transistor
Q6, Q7—2N3906 general-purpose PNP transistor
Q9, Q10—PN2907 general-purpose PNP transistor
BR1—1-amp, 50-PIV, fullwave bridge rectifier
DISP1–DISP4—Common-cathode, seven-segment LED display with right-hand decimal point (RHDP)
LED1—Green light-emitting diode T1-3/4
LED2—Red light-emitting diode T1-3/4

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—1000-ohm
R2–R8—43-ohm
R9—47,000-ohm
R10—39,000-ohm
R11—20,000-ohm, PC-mount potentiometer
R12—15,000-ohm
R13, R14—1-megohm
R15—2.2-megohm
R16—220-ohm
R17—2000-ohm
R18—100-ohm, ½-watt, 5%
R19—4700-ohm
R20—20,000-ohm
R21—150-ohm
R22—2200-ohm
R23—100-ohm, ½-watt, 1%
R24—1000-ohm, ¼-watt, 1%
R25—10,000-ohm, ¼-watt, 1%
R26—100,000-ohm, ¼-watt, 1%
R27—360-ohm, ½-watt, 5%

CAPACITORS

C1—470-µF, 35-WVDC, electrolytic
C2—10-µF, 10-WVDC, electrolytic
C3—0.1-µF, metal-film
C4, C9—0.01-µF, ceramic-disc
C5—0.1-µF, ceramic-disc
C6, C8—100-µF, 10-WVDC, electrolytic
C7—470-µF, 10-WVDC, electrolytic
C10, C11—1-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—12.6-volt, 1.2-amp transformer
PL1—117-volt AC line cord with molded plug
F1—0.25-amp slow-blow fuse
S1—SPST toggle switch
S2—SPDT momentary switch
S3—3P4T rotary switch
Perfboard materials, 8- (W) × 6- (D) × 2- (H) inch metal enclosure, heatsink and heatsink insulators, heatsink compound, test clips, LED holders, power cord, fuse-holder, knob, IC sockets, strain relief, wire, solder, hardware, *etc.*

ground from the power supply. Connect the three wires from the comparator board. Attach the thirteen wires from the display (four go to Q1–Q4, and seven go to R2–R8). Connect the other two wires from the display decimal points to their appropriate places on S3. Note: S3 is a 3P4T switch. You only need two of the three poles. (It's hard to find 2P4T switches.) The extra pole was used to tie the range resistors together.

Calibration. First, test the B+ and +5-volt supplies for the correct voltages. Check ripple, if you can, on the B+ line. It should be *no* greater than 5 volts peak-peak (= 1.78 volts rms). If the ripple voltage exceeds 5 volts peak-peak, replace C1 with 1000-µF capacitor. Next, check the current of each range by connecting a DMM (set as an ammeter) across the two test clips. Don't worry, doing so won't hurt anything. The approximate currents should be: ×.1 range = 44 µA, ×1 range = 440 µA, ×10 range = 4.4 mA, ×100 range = 44 mA. Note: The current will rise on the ×100 range from about 43 mA to 44 mA until it stabilizes. To improve accuracy, each of the range resistors can be replaced by parallel combinations of resistors in order to generate more precise test currents.

If you have a known good electrolytic (say, 10,000 µF or more), connect it across the test clips. Test the capacitor (on the ×10 range). Adjust R11 as required until the display shows the correct capacitance. Keep testing and adjusting until the display matches the value of the known capacitor. If you don't have a known capacitor, then get several capacitors of the same value (say 10,000 µF or more). Test each one to find the one that you think is the correct value. Set R11 as described for the known capacitor, using the value of the one you chose. Note: Overall accuracy is better on the ×10 range.

Using the Meter. When testing unknown capacitors, it is not unusual to get readings that differ from the unit's specified value. When that happens, Table 1 can help you to figure out the reason for various readings. Normally, a quick check is all that is needed to find a bad capacitor. There will be times when the meter won't stop counting. As illustrated by Table 1, that may be an indication that the capacitor has excessive leakage or an internal short.

When using the ×100 range (44 mA), you should let the meter warm up for a couple of minutes to allow the circuit to stabilize. That's because Q9's base-emitter junction voltage tends to vary as Q9 warms up. Although that does not pose a major problem, it can decrease accuracy until the circuit stabilizes. Also, remember the last digit may be off by ±1.

Computer-grade capacitors are designed to have a low equivalent series resistance (ESR) while memory backup capacitors have a fairly high ESR. When testing a capacitor that has a high ESR, use the formulas in Table 1 to find the correct capacitance and ESR. The formulas are not perfect, but they'll get you close enough. Power supplies hate capacitors with high ESR! When making a power supply, it's better to use a couple of capacitors in parallel than to have a single capacitor with too much ESR. The voltage drop across the unit's internal series resistance develops as current—not a good condition for capacitors used in power-supply applications.

The meter can be allowed to roll over (count to 9999 and continue)

(continued on page 52)

PC MONITOR CHECKER

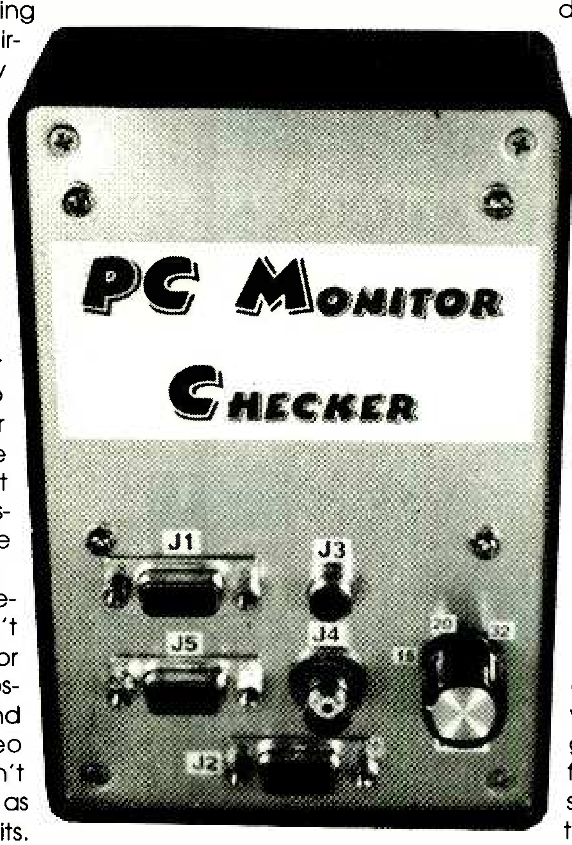
You stare at the blank display and it stares right back, as you wonder: "Is the display broken or is it the video card?" If it's simply the video card, there might be a couple of hours of work involved in getting the system up and running again. Simply buy another circuit card, install it, and away you go. On the other hand, if the monitor is sick, you might be looking at a lot more than just a few hours of down time—not to mention, lightening your wallet by at least a couple hundred dollars.

If you are like me, then you do your own repairs regardless of how much hair pulling it might entail. In order to keep your sanity (and reduce your hair loss), you need effective diagnostic tools. A decent video source for testing the display is a good first step in the right direction.

The *PC Monitor Checker* presented in this article doesn't generate numerous NTSC color signal patterns, nor does it possess the special functions found on commercial-grade video testers; however, it also doesn't cost upwards of $300 dollars as do most of the off-the-shelf units. The PC Monitor Checker is designed to test EGA, VGA, and Hercules MGA (monochrome) displays, as well as composite-video monitors. With the addition of an RF modulator, it can also be used to test the video portions of a television set—ranging from the tuner through the deflection circuit. On top of that, the PC Monitor Checker is inexpensive to build (between $25 and $35); it's battery operated, and can be assembled in about ten hours.

Circuit Description. A complete schematic diagram of the PC Monitor Checker is shown in Fig. 1.

C.C. ROHER



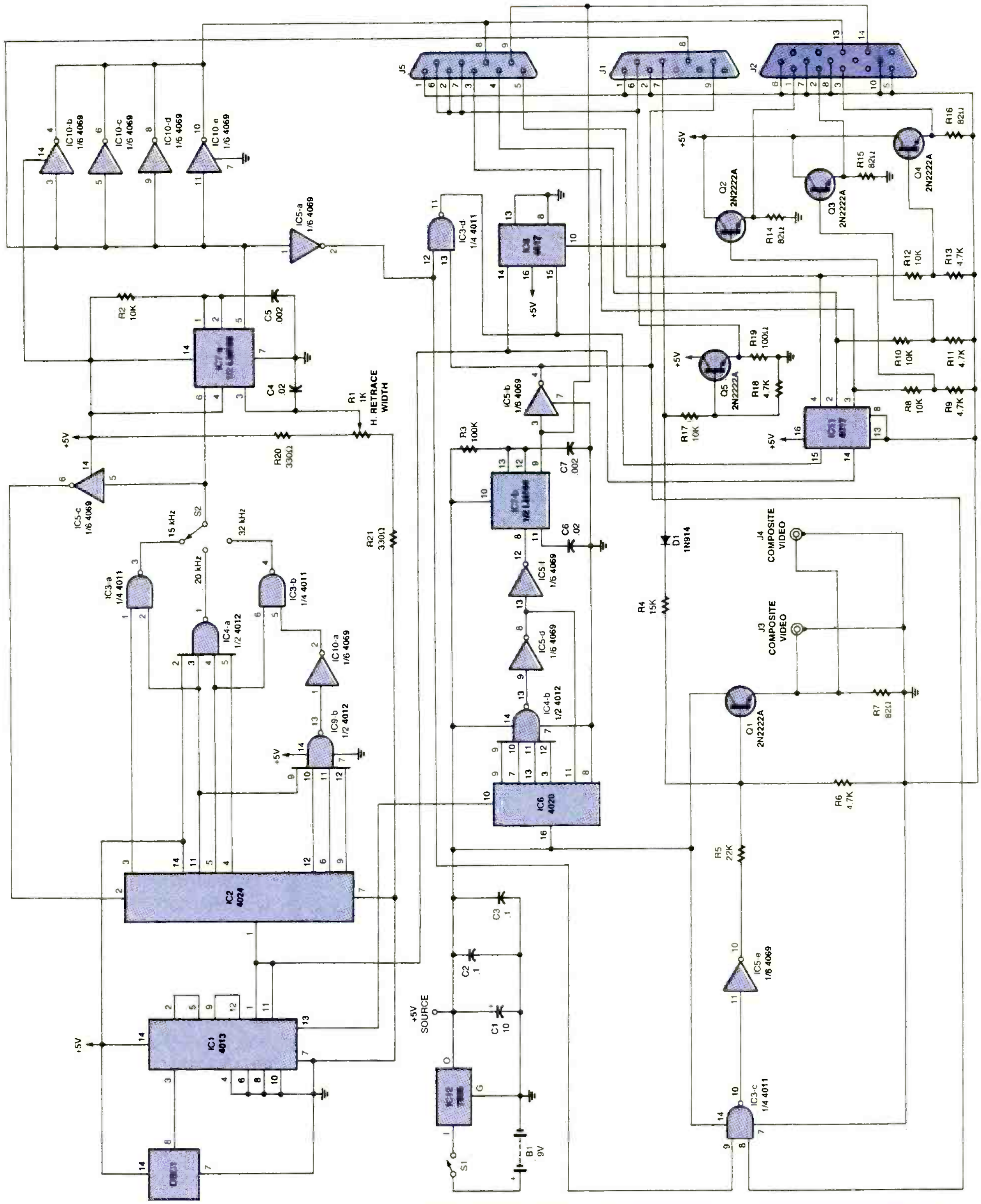
Whether you're an avid do-it-yourselfer or a professional computer repair technician, this evaluation circuit is sure to come in handy when trying to ascertain why your PC monitor—be it EGA, VGA, composite video, or Hercules MGA video displays—has suddenly gone dark.

The Checker is comprised of three primary sections: an oscillator (OSC1) with decoders for horizontal- and vertical-sync frequency generation, a sync-retrace section, and an output section. Power is derived from a 9-volt battery (B1), which is connected to a 5-volt regulator (IC12) through power switch S1. The maximum current drain from the fully loaded unit is between 30 and 40 mA, so the battery should last 2 to 3 hours. Most of the current drawn is used by IC7, an LM556 dual oscillator/timer. The dual oscillator/timer can be replaced by a CMOS unit, such as the 75561PD, thereby significantly reducing current consumption.

Oscillator/Sync Frequencies. The circuit uses a crystal oscillator (OSC1) to generate a 2-MHz squarewave signal. The output of OSC1 is fed to IC1 (a 4013 dual D-type flip-flop). The 4013 divides the oscillator frequency to produce 1-MHz and 500-kHz squarewave signals, which are used to generate three horizontal-sync frequencies and a 60-Hz, vertical-sync pulse. The 1-MHz signal is further divided and decoded by IC8 and IC11, and used to develop the various video pulses.

Horizontal and Vertical Sync. The sync section is divided into two sub-assemblies: one of which develops the horizontal-sweep frequencies, while the other produces the vertical sync. Most common monitors use horizontal sweep frequencies in the 15-kHz to 32-kHz range. The 60-Hz AC line frequency is most often used for the vertical sync.

The 1-MHz squarewave output



J5	
1	GROUND
2	R. INTENSITY
3	PRI. RED
4	PRI. GREEN
5	PRI. BLUE
6	G. INTENSITY
7	B. INTENSITY
8	H. SYNC
9	V. SYNC

J1	
1	GROUND
2	GROUND
6	+INTENSITY
7	+VIDEO
8	+H. SYNC
9	-V. SYNC

J2	
1	RED VIDEO
2	GREEN VIDEO
3	BLUE VIDEO
5	GROUND
6	GROUND
7	GROUND
8	GROUND
10	GROUND
13	HORIZONTAL SYNC
14	VERTICAL SYNC

Fig. 1. The PC Monitor Checker—which is designed to test EGA, VGA, and Hercules MGA monitors, as well as composite-video displays—is comprised of three primary sections: an oscillator (OSC1) with decoders for horizontal- and vertical-sync frequency generation, a sync-retrace section, and an output section.

PARTS LIST FOR THE PC MONITOR CHECKER

SEMICONDUCTORS

IC1—CD4013 CMOS dual D-type flip-flop, integrated circuit
IC2—CD4024 CMOS 7-stage ripple-carry binary counter/divider, integrated circuit
IC3—CD4011 CMOS quad 2-input NAND gate, integrated circuit
IC4, IC9—CD4012 CMOS dual 4-input NAND gate, integrated circuit
IC5, IC10—CD4069 CMOS hex inverter, integrated circuit
IC6—CD4020 CMOS 14-stage ripple-carry binary counter/divider, integrated circuit
IC7—LM556 dual oscillator/timer, integrated circuit
IC8, IC11—CD4017 CMOS decade counter/divider, integrated circuit
IC12—LM7805 5-volt, 1-amp, fixed voltage regulator, integrated circuit
Q1–Q5—2N2222A, 2N3904, or similar general-purpose NPN silicon transistor
D1—1N914, 1N4148, or similar general-purpose, small-signal, switching diode

RESISTORS

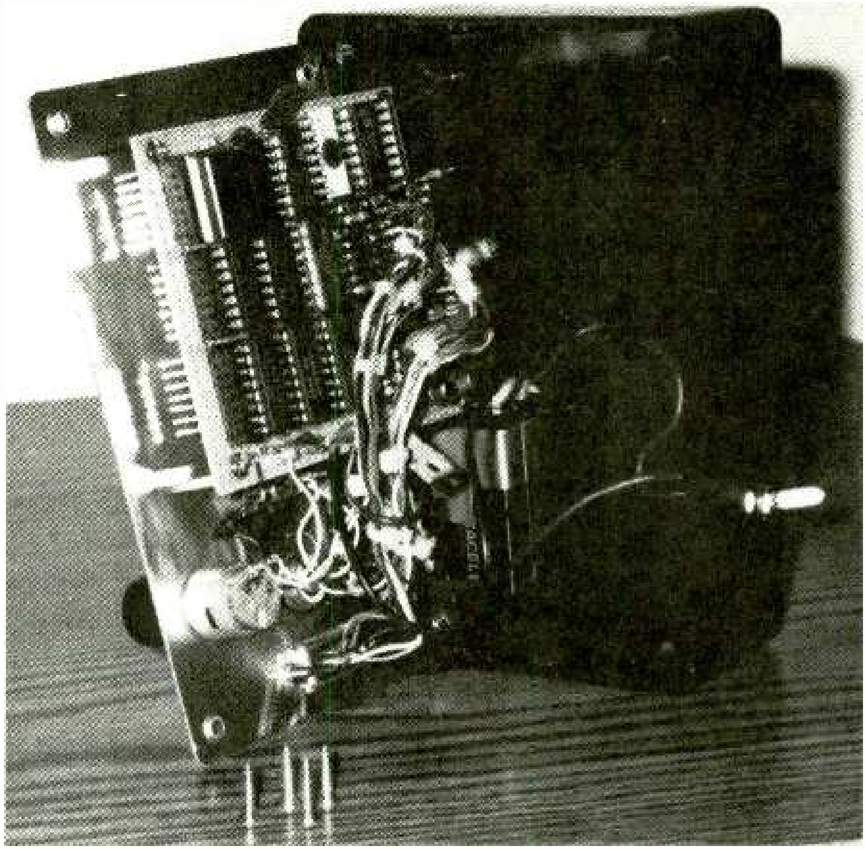
(All fixed resistors are 1/4 watt, 5% units.)
R1—1000-ohm, 10–15-turn potentiometer
R2, R8, R10, R12, R17—10,000-ohm
R3—100,000-ohm
R4—15,000-ohm
R5—22,000-ohm
R6, R9, R11, R13, R18—4700-ohm
R7, R14, R15, R16—82-ohm
R19—100-ohm
R20, R21—330-ohm

CAPACITORS

C1—10-µF, 16-WVDC, tantalum
C2, C3—0.1-µF, ceramic-disc
C4, C6—0.02-µF, ceramic-disc
C5, C7—0.002-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

OSC1—2.000-MHz crystal oscillator
S1—SPST miniature toggle
S2—SP3T non-shorting, miniature rotary switch,
J1, J5—9-pin, D-type connector
J2—15-pin, D-type connector
J3—RCA phone jack
J4—BNC jack
B1—9-volt transistor-radio battery
Perfboard materials, 6 1/4- (L) × 3 3/4 (W) × 1 5/16 (D) inch enclosure (RadioShack 270-627), wire-wrap IC sockets, 0.8-inch threaded spacers, push-in flea terminals, headers, 9-volt battery holder and connector, wire, solder, hardware, *etc*.



As shown in this internal shot, the author used perforated construction board and point-to-point and wire-wrapping assembly techniques in the PC Monitor Checker.

of IC1 is fed to IC2 (a 4024 CMOS 7-stage ripple-carry binary counter). The output of IC2 is applied to IC3-a, IC4-a, and IC9-b, where the signal is decoded to provide three selectable (via S2) signals: 15 kHz, 20 kHz, and 32 kHz. The selected output is fed back through IC5-c (1/6 of a 4069 hex inverter) to the reset input of IC2 at pin 2, causing it to generate a fast negative-going pulse that is applied to IC7-a (1/2 of the LM556 oscillator/timer) and used to generate the horizontal retrace signals. Given OSC1's frequency and the fact that the counter and decoders do integer division only, it should be obvious that precise frequencies are generated by the circuit. For example, the 15-kHz sweep frequency is really 15,150 Hz. That's not a problem. Adjusting the horizontal sweep on older monitors produces a good lock. In VGA monitors, the sweep is automatically/internally adjusted, within certain limits.

The horizontal retrace signal is another story: Every monitor that was tested or researched appeared to have different retrace time periods that range from 5 to 20 microseconds, with most hovering at the greater time period. The retrace time determines how much picture is displayed horizontally. Potentiometer R1 can be adjusted to produce retrace widths of about 10 to 25 microseconds.

The 500-kHz output of IC1 at pin 13 is fed to IC6 (a 4020 14-stage ripple-carry binary counter) at pin 10. The binary counter then produces several output signals that are applied to IC4-b (half of a 4012 dual four-input NAND gate). That NAND gate decodes the signals, producing a positive pulse through IC5-d that is fed back to the reset input of IC6 at pin 11. At the same time, a fast negative-going pulse output by IC5-f is fed to pin 8 of IC7-b, causing it to generate a 220-µs wide, fixed vertical-retrace pulse. Like the horizontal-retrace pulse, the vertical-retrace pulse widths seem to be unique for every monitor researched or tested and ranged from 75 µs to 1 ms. In some of the monitors tested (MGA and composite types), a dark horizontal space appeared at the top and bottom portions of the screen. With the newer VGA types, however, the vertical size of the picture is adjustable and the spaces could be eliminated.

Monitor Outputs. The checker produces several different "species" of monitor video: MGA, EGA, VGA, and composite. Many of the older model monitors and a very, very few of the newer models use the composite format. The composite format consists of a serial signal composed of video, vertical sync, and horizontal sync. The video signal "rides" on top of the peak sync-signal level in between the retrace pulses. The entire signal is approximately 1-volt peak-to-peak with the sync level being about 0.2 volts and the video ranging between 0.5 and 1 volt. The video amplitude determines the intensity of the displayed picture.

In the checker, composite video/sync is generated by ANDing the video signal from IC8, the horizontal-retrace signal from IC5-a, and the vertical retrace signal from IC5-b at the base of Q1 through a voltage-divider network comprised of R4–R6. Transistor Q1, which is configured as an emitter follower, provides composite video/sync to both J3 (an RCA jack) and J4 (a BNC jack).

Although there aren't many monitors out there that use this format, the checker provides a monochrome graphics adapter (MGA) output at J1. All of the MGA-format outputs are TTL compatible except intensity. The intensity output mimics the video output, but at a maximum level of 0.7 volts. As with the composite video level, the greater the amplitude of the intensity signal, the brighter the picture.

Currently, the VGA video format is the one of choice for monitor manufacturers and buyers. The VGA signal is made available through J2 (a 15-pin D-type connector). A 4017 decade counter/divider (IC11) divides the 1-MHz squarewave into three separate video signals: PRI. RED, PRI. GREEN, and PRI. BLUE. In the VGA format, video-color intensity is determined by an analog representation of the signal level, with 0.7-volt representing the brightest illumination.

The outputs of IC11 are fed to a series of resistive voltage dividers—R8/R9, R10/R11, and R12/R13—to produce red, green, and blue drive signals, which are buffered by Q2, Q3, and Q4, respectively. Buffering is required because the mandated VGA video source impedance should be approximately 75 ohms. The sync signals are TTL/CMOS logic levels and are as-marked on the schematic.

The EGA output at J5 was the only one that we were unable to validate with an operational monitor. Apparently, EGA monitors are fairly rare "animals" and difficult to get a hold of. However, through research, it was discovered that EGA signals and format conform to a hybridization of the MGA and VGA outputs.

The primary EGA color outputs—PRI. RED, PRI. GREEN and PRI. BLUE—which are TTL/CMOS compatible, are provided by IC11. Color intensity is controlled by the output of Q5 at its emitter. The output of Q5 is split among the three intensity outputs available at J5. The voltage level at those outputs, approximately 0.7 volt, gives maximum intensity.

Construction. The PC Monitor Checker was assembled using wire-wrap techniques and some point-to-point soldering. For those of you who crave printed-circuit boards for your projects, you're welcome to design one for the checker if you have the means to do so.

In order to minimize the amount of perfboard "real estate," headers were used for all but two of the resistors. A twenty-four pin header and socket were used for making connections between the board, S2, and the various jacks. When making the connections, use small-gauge stranded wire. Twenty-four to twenty-eight gauge stranded wire serves nicely.

Mount R1 so that the alignment screw head faces out from the circuit board. Take note of the orientation of R1 when installing the circuit board into the enclosure and drill a small "tweaking" hole in the side of the enclosure for alignment purposes. Component R1 should be a multi-turn potentiometer rather than a less-expensive single-turn unit.

Operation. There are no special requirements for using the checker. However, some precautions are in order. Chief among them is knowing what kind of monitor you're testing. Use the appropriate cable type with the required plugs for a particular monitor. Plug the monitor connector into the appropriate checker jack.

As mentioned, the checker does not produce elaborate test patterns. When it's connected to an operational composite-video monitor operating with a 15-kHz horizontal-sweep frequency, six vertical, evenly-spaced bars of video should be seen. When testing MGA monitors, which have horizontal-sweep frequencies of about 18 kHz, set S2 to the 20-kHz position, and the monitor should display four to five vertical bars.

Finally, EGA and VGA monitors have sweep frequencies (automatically adjustable from 31kHz to 37 kHz) that are internally set. Choose the 32-kHz position for S2 for these monitors. Two to three groups of

TABLE 1—OUTPUT SELECTOR GUIDE

JACK	OUTPUT	CONNECTOR
J1	MPG	9-Pin D-Type
J2	VGA	15-Pin D-Type
J3	Composite Video	RCA Jack
J4	Composite Video	BNC Jack
J5	EGA	9-Pin D-Type

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red, green, and blue vertical bars should be seen on the display. There should be evenly spaced dark regions between these groups. Additionally, the red bar in the first group may be slightly narrower than those in the remaining groups. This is not a problem and simply reflects the influence of the horizontal retrace width.

In Conclusion. Computer monitors that use a cathode ray tube for the display have been around for a long time and judging by their continued proliferation will continue to be a big-ticket item when new computer systems are purchased. As complex as they may seem, however, they are nothing more than glorified television sets; minus the sound, of course. In fact, if some of you can remember back that far, many of the first personal computer systems offered the option of using the home television set as the monitor (remember the TRS-80 and the Sinclair ZX-80?).

Taken into perspective, troubleshooting a computer monitor should be no different than testing a television. One key ingredient is the availability of a good signal source. The PC Monitor Checker fits the bill in this regard. ■

ELECTROLYTIC METER

(continued from page 46)

if desired. That comes in handy when it's necessary to test a larger capacitor on a lower range. If you suspect, for instance, that the capacitor being tested has high ESR, testing it on a lower range gives better accuracy because of the lower test current. It is also possible to test a capacitor larger than 1 F on the ×100 range using that method. Let's look at a couple of examples.

Example 1: While testing a 300,000-µF computer-grade capacitor on the ×100 range, the meter's readout displayed 3855. In that case, the actual measured capacitance is 3855 × 100 = 385,500 µF. On the ×10 range, the meter was allowed to roll over 3 times, producing a finished count of 9556. The ×10-range capacitance would then be 39556 × 10 = 395,560 µF. Both readings are high compared with the capacitor's specified value, and both readings are within 10% of each other. Referring to Table 1, note that some leakage is indicated, but the capacitor is otherwise OK, and that the high-range reading is correct (the higher range reading is *not* the same as the high reading!). That means this capacitor is actually about 385,500 µF, and that its capacitance is about 29% higher than manufacturer's specifications—well within tolerance.

Example 2: While testing a memory backup capacitor (specified as 0.047 F) on the ×100 range, the meter produced a readout of 30,100 µF. On the ×10 range, the meter displayed 47,020 µF. The two readings, of course, are *not* within 10% of each other. It is not difficult to recognize that the reading on the ×10 range is closer to the correct value because the series resistance of memory backup capacitors can cause erroneous readings on the ×100 range. In such cases, you could just accept the reading obtained on the ×10 range or use the formula in Table 1 to find the correct capacitance and ESR. Anyway, the high-range reading is too low and the low-range reading is too high. Table 1 indicates that the capacitor has either leakage or series resistance and should be tested with an ohmmeter. Since we're checking a memory-backup capacitor, it becomes obvious that the erroneous reading is probably due to series resistance. In such cases, we'd use the low-range reading of 47,020 µF. Using the formulas for ESR and capacitance:

$$\text{ESR} = (47020 - 30100)/(.011 \times 47020) = 32.7\text{ohms}$$

$$C = ((11 \times 47020) - 30100)/10 = 48{,}712\ \mu\text{F}$$

Example 3: While testing a 2200-µF capacitor on the ×10 range, the display produced a readout of 1610 µF. On the ×1 range, the reading was 1636 µF. Both readings are low and within 10% of each other. Table 1 says the capacitor has low capacitance and to use the high-range reading (1610 µF) as the correct capacitance. As it turned out, the capacitor was low by 27% and unusable!

Conclusion. I hope that you've gained some insight from this article on how to correctly test capacitors; and how to use the Electrolytic Meter to find ESR and leakage. That should enable you to put together a power supply or repair electronic equipment with confidence.

The accuracy of the meter can be increased in many ways. For example, the counter/display driver (IC2) can be replaced by a 74C926 and using its carry-out line to feed another counter, thereby adding another 7-segment display. That would allow you to see the rollover, instead of counting the number of rollovers. Or you could divide the 105 Hz by 10 (when you know you'll roll over), producing an additional range—×1000. Another improvement would be to design a more accurate constant-current source. You may even come up with other improvements to the circuit.

I hope you enjoy testing those capacitors on your shelf as much as I did. Have fun! ■

Building a Top-Notch HF Receiver

JOSEPH J. CARR, K4IPV

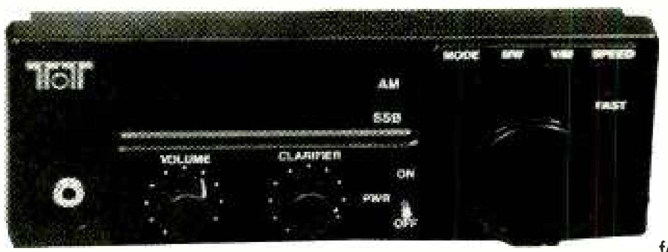
Like many hams my age, I cut my electronic teeth building kits. At one time, kit manufacturers abounded. Allied Radio's Knightkits, Eico, and the venerable Heath Company's Heathkits all had significant offerings for the radio enthusiast (both ham and SWL). For many of us, the first really serious excursion into electronics was building a receiver or transmitter from a kit. The kit approach has a distinct advantage for the newcomer because it offers a guided pathway over territory that might not be familiar. Heathkits in particular had an extremely well done assembly manual to provide that guidance.

My fondness for well-done kits was aroused anew when I saw the advertisements for the Ten-Tec Corporation (1185 Dolly Parton Parkway, Sevierville, TN, 37862; Tel. 423-453-7172 or 800-833-7373; Web: *www.tentec. com*). Ten-Tec has been a ham-gear manufacturer for many years. If you own a top-end, American-made HF transceiver, then chances are pretty good that it's a Ten-Tec. I've always found their HF rigs to be well engineered and well built, so I figured their kits were equally well done—I was right.

TEN-TEC MODEL 1254

The Ten-Tec Model 1254 is a first-class, general-coverage shortwave receiver that handles bands from 100 kHz to 30 MHz and costs only $195. To put the price into some sort of perspective, let me point out that I once paid $249 for a Heathkit receiver of considerably less performance in a time when those dollars were a lot bigger and took a lot more working time to earn. Also by way of contrast, today ready-built shortwave receivers with the specifications of this model cost $700 to $1000. So, by building the Ten-Tec Model 1254 you not only get a first-class SW receiver for a super budget price, but also a lot of experience building a high-tech product.

The Model 1254 has CW, AM, and both SSB modes. The local oscillator (LO) for the receiver is a frequency synthesizer locked to a crystal frequency, so it has a great deal of stability. The synthesizer allows both "fast" and "slow" tuning modes of 2.5 kHz (SSB mode), 5 kHz (AM mode), or 100 kHz. Because the LO is a digital frequency synthesizer, the Model 1254 can offer fifteen programmable memories for favorite or frequently used frequencies.



Here's the front panel of the Model 1254 receiver. When assembled, the kit looks like (and performs like) a receiver worth hundreds more than its reasonable price.

The architecture of the Model 1254 follows modern principles. It is a double-conversion superheterodyne in which the 0.1- to 30-MHz bands are up-converted to a 45-MHz first-IF, where preliminary selectivity is provided by a 45-MHz crystal filter. This architecture is better than those used in the past because of its superior image response.

For example, suppose your older receiver has a 455-kHz IF and is tuned to the 10,000-kHz (*i.e.* 10 MHz) WWV frequency. The LO frequency may be on either the high or low side, so let's assume that it's on the low side. The LO frequency will be 10,000 kHz − 455 kHz, or 9545 kHz. The difference between the LO of 9545 kHz and 10,000 kHz is the IF, or 455 KHz. But there is another frequency that also produces a 455 KHz difference frequency: 10,000 kHz + 455 kHz = 10,455 kHz! As the frequency gets higher, the image more easily passes through the front-end tuning. But if the first IF is 45 MHz, then the image is so far away that it cannot harm reception.

The Model 1254 down-converts the 45-MHz first-IF to 455 kHz. The majority of the gain and selectivity of the Model 1254 are provided in the latter band. This is the classic trade-off of well-engineered double-conversion HF SW receivers. The gain and selectivity are easier and cheaper to provide at a low frequency, so by using 45 MHz for the first-IF and 455 kHz for the second-IF, the best of both selections are obtained.

The Model 1254 offers 2.5 μV for 10-dB signal-to-noise ratio (SNR) sensitivity in the AM mode, and 0.5 μV for 10-dB SNR in SSB mode. The −6-dB selectivity is 4 kHz. Frequency readout is via a six-digit LED numerical display.

The receiver operates from a 12- to 15-volt DC power supply and requires 250 mA of current. A transformer is included with the kit, although you can also operate it from any DC power source. One application, for example, is to use this receiver as part of a battery-operated QRP or "mountain topping" station. In that case, a 12-volt battery would be used for power.

The antenna connector on the rear panel of the Model 1254 is an RCA-style phono jack; the antenna input impedance is 50 ohms. The loudspeaker is internal, but an external speaker or earphones can be operated through a standard ⅛-inch phone jack. Output from the Model 1254 IC audio amplifier is 1.5 watts. The receiver contains ten ICs, 26 transistors, and 16 diodes. The physical dimensions are 2.25 × 6.5 × 6.5 inches (HWD).

The Ten-Tec advertisement claims 25 hours to build this kit. I beat that time, but only by a few hours. Plan to spend at least that much time on this project. If you have never built anything electronic, then I recommend that you first attempt a less complex kit.

One of the really brilliant things about the way Ten-Tec designed the assembly instructions for this receiver is what I call their "build-a-little-test-a-little" philosophy. The printed-circuit board is divided into zones. You will be instructed to build in a particular zone first, and as you finish each zone certain tests will be performed before you go forward. As a result, you are reasonably certain that the receiver will work when you finally finish it.

When you build this kit, be sure to use the right tools. The solder should be 50/50 or 60/40 lead/tin resin-core solder intended for radio and electronic applications. In case this is your first circuit: **do not use acid-core solder**. That form of solder is used in plumbing applications and will make a real mess of an electronic circuit (in the process of destroying it). So buy your solder in a radio store, not a hardware store.

The tools that I used include a 25-watt pencil type soldering iron, small-size needlenose pliers, small diagonal side cutters, a ⅛-inch blade screwdriver (*e.g.* Xcelite red), and a small-size Phillips screwdriver (*e.g.* Xcelite blue). You will also need a multimeter, preferably a digital one. The latter are relatively low cost these days, so I recommend that hams have one in any event, regardless of whether or not you are building a kit.

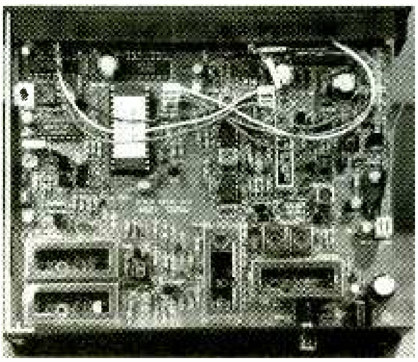
Alignment tools will also be needed. And this is where you might be tempted to use what's on hand. Look at the coils and IF transformers, and buy a small collection of alignment tools to fit them exactly (and use no others).

Use of the wrong alignment tools is one of the principal mistakes made by inexperienced builders. Can you guess what is the most common kit builder's mistake? It's really quite simple. Indeed, it's predictable. The A-number one error made by kit builders is *not following instructions*. The instructions for the Model 1254 are uncommonly detailed and clearly written. Follow them with great specificity and you will be ahead of the game.

The finished receiver performed exactly as advertised and proved to be sensitive. The only thing I would add to the receiver is an external audio filter to provide better selectivity on SSB and CW modes. The 4-kHz selectivity is a reasonable compromise and works well (especially on the shortwave broadcast bands), but for really crowded ham bands an external active filter is recommended. Such audio filters are made by a number of companies (indeed, check the Ten-Tec Web site).

SUMMER'S COMING

One of the interesting aspects of the summer season is the odd VHF Sporadic-E propagation that takes place, resulting in distant VHF signals becoming audible or peaking up to higher values. On the FM broadcast band, for example, one can often hear signals during the summer that are inaudible other times of the year. For a while I was making a 72-mile, one-way commute to my job and would listen to a country-music station on 100.1 MHz that would only barely stick above the noise under most conditions, but when Sporadic-E popped up it was >S9 strength!



While you might not be able to tell from this shot of the Model 1254's internal circuitry, the parts are top notch, including a ceramic filter for the IF selectivity. Sensitive front-end circuitry is enclosed in several different shielded compartments.

During the Sporadic-E event you will be able to pick up signals that are not normally audible and work states and Canadian provinces that are normally beyond your range. So if you do 2-meters, or other VHF bands, then make sure the ol' beam is working right, and wait for the right opportunity.

Summer also affects other bands as well. In the 10-meter band, for example, you will see frequent examples of short-skip. From my home in northern Virginia I normally cannot work North Carolina stations on 10-meters (Florida is easy, but not North Carolina). But during short-skip North Carolina is easily available to me.

Many of these summer propagation changes occur because the Sun is able to ionize the atmosphere to a lower level than before. That's why short-skip works. But summer also brings a higher noise level on the low bands, so there is a kind of seasonal trade-off involved.

Another summer phenomenon is lightning. Although the bolts can occur any time of year, they are more common during summer and spring over most of the country. Now is a good time for you to review your lightning protection. A good ground rod is necessary. It should be at least eight feet long. I use the copper-clad steel type that you get at electrical supply stores, rather than the puny little four-footers (or less!) found in some radio stores. Also, a heavy grade of approved ground wire is needed.

A lightning arrester is absolutely essential to protecting your rig. Will it protect against a direct hit? No, but direct hits are not the only thing that can cause problems. Any lightning in the area, whether an air-to-air or air-to-ground burst, represents an electrical current in motion ... and that means it can induce a high-voltage transient into your antenna. That transient can burn out circuitry in the front-end of a receiver or even a transmitter, even though it won't exactly melt the parts like a direct hit would.

Here is a bit of wisdom: *read your homeowners' insurance policy.* Some policies discriminate against radio antennas unless they are correctly installed according to local electrical codes. Your opinion as to the fitness of the installation is essentially irrelevant if it differs from the electrical code. So make sure that your installation complies with the law. And if inspections are required, be sure that you obtain the signed certificate from the inspector and keep it in a safe place. A guy I once knew had a problem collecting because he could not produce either mechanical or electrical inspection certificates when his 50-foot tower fell over and damaged his house. He prevailed, but it took a lot more effort than if he had complied with his policy's guidance in the first place.

IMPORTANCE OF LOGS

Hams don't keep radio-contact logs like we used to (I still do). Unless you

(continued on page 60)

DX LISTENING

X Marks The Spot

DON JENSEN

Almost shortwave: That's what I considered the frequencies just above 1600 kHz back when I was just getting started in the listening hobby. Back in the ancient 1940s, when this inquisitive kid first tuned the family console and Heterodyne-osaurs still roamed the Earth, you could listen to police calls up here, just beyond the last broadcasting station on the AM dial. That was pretty exciting stuff for an 11-year-old.

When public safety agencies moved up to VHF and UHF, the old police band became a radio ghost town, abandoned and vacant. Now, though, that's all changed, and listener hobbyists again are venturing back to the frequencies between 1610 and 1700 kHz to what now is called the Extended or X-Band.

New occupants of the nearly shortwave frequencies began moving back in the late 1970s and 80s, the Travelers' Information Stations. Today you can find these very low-powered 10-watt stations near airports, parks, and sports stadiums, airing repeated tape-loop messages to motorists. Although several-hundred-mile reception of TIS signals is not unheard of, these stations are intended for local coverage, and a range more like 10 to 20 miles is normal.

But the real change came in the 1990s, when the Federal Communications Commission, faced with a jam-packed AM broadcasting band (540 to 1600 kHz), decided to open up the next one thousand kilohertz of spectrum to new station applicants and to existing AM stations looking for better, less crowded channels.

In 1991, the FCC first invited broadcasters to consider migrating to a new X-Band. After two false starts, the agency in March 1997 issued a band allotment that allows 88 AM stations on 10 new frequencies between 1610 and 1700 kHz. Here they can broadcast 24 hours a day, with 10,000 watts daytime and 1000 watts of power at night.

For those already on the air with limited power on a crowded channel within the 540-1600 kHz AM band, there is the option of using both new and old frequencies simultaneously. After five years, though, they must choose one or the other.

Here's a verification card from Rikisutvarpid, the shortwave Voice of Iceland, currently transmitting on 13,860 kHz.

Slowly stations have come on the air in the X-Band. The first was WJDM (now WBAH), Elizabeth, NJ on 1660 kHz. As this is written, more than 50 stations have been authorized to begin broadcasting, and 17 actually are on the air.

Veteran DXer Jerry Berg observes that the current X-Band situation must be akin to the pioneering 1920s, when AM stations began popping up, one by one, in a previously vacant radio spectrum. "This is a rare opportunity to DX the way it was in the early days," says Berg.

While in some urban areas there may be competition on one or two of the X-Band channels from local TIS stations, mostly the frequencies between 1610 and 1700 kHz have little or no interference.

"And," Berg notes, "the new X-Band broadcast stations use only a thousand watts of power at night. From Massachusetts, I have heard two California X-Banders at 1 kilowatt. That's pretty good DX in my book ... a real kick!"

Because there's still a newness to it all, Berg and other X-Band DXers say the stations seem to be good verifiers, readily replying to listeners' reception reports.

"Now is the time to start monitoring the X-Band," says well-known DXing writer Harry Helms. "This is a once-in-a-lifetime opportunity to hear a new broadcasting segment come to life!"

THE X-FILES

The Federal Communications Commission currently envisions nearly 90 American AM broadcasting stations in 36 states, Puerto Rico, and the Virgin Islands eventually operating on the X-Band's ten frequencies.

At this writing, 17 stations reportedly are on the air (see Table 1).

Mexico has announced allocations for 20 X-Band stations, all within about 100 miles of the U.S. border, according

TABLE—1

1620 kHz	WPHG, Atmore, AL
	KRIZ, Renton, WA
1640 kHz	KDIA, Vallejo, CA
	KKJY, Lake Oswego, OR
	WKSH, Sussex, WI
1650 kHz	KGXL, Costa Mesa, CA
	KCZN, Cedar Rapids, IA
1660 kHz	KXOL, Brigham City, UT
	WBAH, Elizabeth, NJ
	WQSN, Kalamazoo, MI
1670 kHz	WTDY, Madison, WI
	WNML, Warner Robins, GA
1690 kHz	KQXI, Arvada, CO
	WMDM, Lexington Park, MD
1700 kHz	WCMQ, Miami Springs, FL
	KBGG, Des Moines, IA
	KSDX, Sherman-Denison, TX

to Helms. None have been reported on the air at this time. Australia and several other countries also have or soon will have X-Band broadcasting stations.

BITS AND PIECES

The World DX Club's bulletin, *Contact* reports that currently there are no shortwave broadcasts actually transmitted from the mid-Mediterranean island nation of Malta. The Maltese broadcast, *Voice of the Mediterranean* formerly was aired from the so-called Cyclops SW transmitter of Germany's Deutsche Welle, located on the island. But Cyclops closed down for good several years ago.

Today, the *Voice of the Mediterranean* uses Italian and Russian shortwave facilities to broadcast its shortwave programming. *VoM*'s 9,600 kHz transmissions are via a RAI transmitter at Prato Smeraldo, Italy. The 12,060 kHz service comes from a transmitter near Moscow, and the 17,570 kHz transmission is via a station at Khabarovsk, in the Russian Far East.

Australian Defenses Forces Radio airs SW programming for troops training at home and serving aboard, and for navy forces on the high seas, from 10-kilowatt upper sideband (USB) transmitters located at Belconnen, Australia.

The station on 14,790 kHz is for forces performing exercises in Australia or ships at sea, while 15,635 kHz is beamed to New Guinea, where Australian troops are on disaster relief missions, and to Bougainville, where they serve as peace monitors following lengthy civil strife. ADFR broadcasts from 0300 to 0500 UTC.

Two separate Colombian clandestine stations have been operating for years from somewhere in this South American country. The Voz de la Resistencia announced its schedule as 2000 to 2200 UTC daily on 6,226 kHz, although Henrik Klemetz in the Colombian capital of Bogota noted the station near 6,239 kHz.

Klemetz also noted Radio Patria Libre on 6,250 kHz, also in Spanish, announcing its daily schedule as 1800 to 1830 UTV and 2200 to 2230 UTC. If you hear this station, you can send your reception report to Colombia Popular, c/o Tommy Weisbeckerhaus, Wilhelmstrasse 9, 10963 Berlin, Germany.

DOWN THE DIAL

Looking for some shortwave stations to tune? Try these.

ASCENSION ISLAND—17,830 kHz, British Broadcasting Corp. program *Focus Tonight* was noted at 1745 UTC. This signal is relayed by a transmitter on this remote South Atlantic island.

BELARUS—11,960 kHz, Radio Minsk can be found here in English at 2040 UTC with a discussion program and music, followed by ID and frequency announcements. Low modulation of the signal can be a problem.

CZECH REPUBLIC—21,745 kHz, Radio Prague's English transmission is noted at 1320 UTC with identification, interval signal and music. This also broadcasts on 13,580 kHz at the same time.

ECUADOR—4,920 kHz, Radio Quito was logged here about 0650 UTC with kick-by-kick coverage — probably recorded at that hour—of a soccer match. "Gooooooooal!"

HUNGARY—11,685 kHz, Radio Budapest's English news program, *Hungary Today* is heard at 0100 UTC.

ICELAND—13,860 kHz, Rikisutvarpid is the Icelandic name for the national SW outlet at the capital of Reykjavik. Look for this one around 1950 UTC with programming in Icelandic.

IRAQ—11,785 kHz, Radio Iraq International has English at 0300 UTC, with schedule information, news, and a musical segment. Signal is often plagued by muffled audio quality and a hum.

MEXICO—6,105 kHz, XEQM in Merida is a rarely heard low powered domestic SW broadcaster. It has been noted here around 1100 UTC with up tempo Latin songs, Spanish language identifications, and commercials.

NAMIBIA—3,230 kHz, Namibia Broadcasting Corp. in southern Africa operates here at 0500 UTC, when it airs a news program, *The World At 6*.

ABBREVIATIONS

AM = Amplitude Modulation, the transmission mode used by broadcasting stations in the medium wave frequencies, 540–1600 kHz, and the 1610–1700 kHz extended band.
DX, DXing, DXer = Distant broadcasting stations; the hobby of listening to such stations; one who listens to DX.
FCC = Federal Communications Commission, government agency that regulates U.S. broadcasting.
ID = Station identification.
kHz = kilohertz, unit of frequency measurement.
SW, SWLing = Shortwave.
SWL, SWLing = Shortwave Listener, Shortwave Listening.
UHF/VHF = Ultra/Very High Frequency bands.
UTC = Universal Coordinated Time, time standard used by most international SW broadcasters and SWLs; equivalent to Eastern Daylight Time plus 4 hours; CDT plus 5 hours; MDT plus 6 hours or PDT plus 7 hours.

NIGERIA —7,255 kHz, Voice of Nigeria in Lagos signs on at 0500 UTC in English, with African songs, pop music, and a commentary.

PAPUA NEW GUINEA—3,220 kHz, Radio Morobe is one of the domestic service shortwavers in remote Papua New Guinea. It has been reported around 0925 UTC with a rather exotic sound, the blowing of a conch shell horn and the cry of seagulls.

SLOVAKIA—5,930 kHz, Radio Slovakia has English around 0120 UTC and has been noted with identification and Slovakian music.

SOLOMON ISLANDS—5,020 kHz, Solomon Islands Broadcasting Service has Pacific islands type music around 1055 UTC. It was noted signing off at 1200 UTC.

SRI LANKA—15,425 kHz, Sri Lanka Broadcasting Corp. was heard in English from 0100 UTC with a DJ morning program of mixed music, from Hawaiian melodies to country and western. It announced parallel frequencies of 6,075 and 9,730 kHz also in use.

SURINAM—4,991 kHz, Radio Apintie occasionally can be heard here with popular music about 0315 UTC

(continued on page 60)

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More Hall-Effect Circuits

CHARLES D. RAKES

Last month we were deep into magnetic experiments using ITT's CMOS Hall-effect sensors, and time ran out before we could finish. So this column we're going to continue with more circuits and experiments using these fascinating miniature IC sensors (all available from Digi-Key—Tel. 800-344-4539—as well as other sources).

All of the sensors we'll be working with come in the same package and have the same pin configuration (see last month). They all operate with a supply of 4.5 to 24 volts and will supply 10 mA to an external load. I'll repeat the following warning: These are very small devices, measuring only 4 × 3 × 1.5 mm, and will quickly disappear if dropped on a busy workbench.

SIMPLE DETECTOR

Our circuits last month used the HAL115UA-C sensor, which outputs a low when there is no magnetic field present. This month, our first circuit (Fig. 1) uses the HAL214UA-E sensor (Digi-Key part number HAL214UA-E-ND), which outputs a low when a magnetic field *is* present. The "E" extension of the part number designates the IC's operating temperature range, which is −40° to 100° C (compare to the HAL115UA-C's range of 0° to 100° C). Like the other ITT sensors, the HAL214UA-E has a branded side, or side where the part number is printed. The branded side of the HAL214UA-E responds to the south pole of a magnet, and the unbranded side responds to the north pole of a magnet.

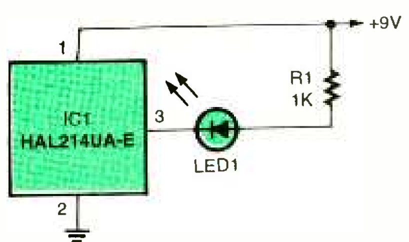


Fig. 1. The LED in this simple detector will light when the south pole of a magnet is brought near the branded side of IC1.

PARTS LIST FOR THE SIMPLE DETECTOR (FIG. 1)

IC1—HAL214UA-E Hall-effect sensor, integrated circuit
LED1—Light-emitting diode, any color
R1—1000-ohm, ¼-watt, 5% resistor

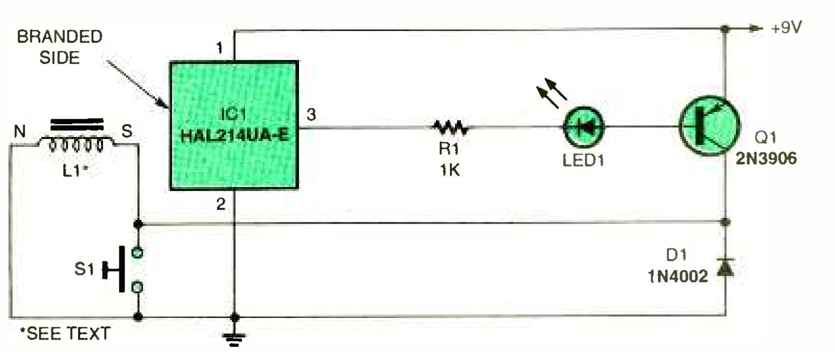


Fig. 2. When building this latching detector, be certain to position the south pole of electromagnet L1 next to the branded side of IC1.

The detector circuit in Fig. 1 shows the sensor operating in its simplest form. Sensor IC1's output is high until a magnet is positioned in the proper polarity to either side of the chip. This sensor is not as sensitive as the HAL115UA-C and will only respond to a small donut magnet at a distance of no greater than half an inch or so. When a magnet is brought close, LED1 will light.

A simple way to check the hysteresis sensitivity range of the chip is to slowly move a magnet with the correct polarity toward the sensor and note the distance at which the magnet turns on LED1. Then slowly back the magnet away from the sensor and note the distance where LED1 turns off. The difference in the turn-on and turn-off points indicates the sensor's hysteresis range. This feature keeps the sensor's output stable during the on/off transition.

LATCHING DETECTOR

Our next circuit (see Fig. 2) contains a bias coil, L1, positioned next to the sensor. With the south pole of the electromagnet coil (L1) facing the branded side of sensor IC1, the circuit is a latching detector. When power is first applied to the circuit and no magnets are near the sensor, the output is high and Q1 is turned off. Pressing S1 sends current through the bias coil, which produces a south-pole field at the branded side of the sensor. This magnetic field turns the sensor on, producing a low output at pin 3 of IC1. Next the base of Q1 goes to ground through R1, turning on LED1 and supplying constant current to L1, the bias coil.

The circuit can be unlatched by positioning the south pole of a magnet near the unbranded side of the sensor, or by interrupting the power source. This latching circuit can be used in alarm

PARTS LIST FOR THE LATCHING DETECTOR (FIG. 2)

SEMICONDUCTORS
IC1—HAL214UA-E Hall-effect sensor, integrated circuit
Q1—2N3906 general-purpose PNP silicon transistor
D1—1N4002 1-amp, 100-PIV silicon rectifier diode
LED1—Light-emitting diode, any color

ADDITIONAL PARTS
R1—1000-ohm, ¼-watt, 5% resistor
L1—See text
S1—Normally open pushbutton switch

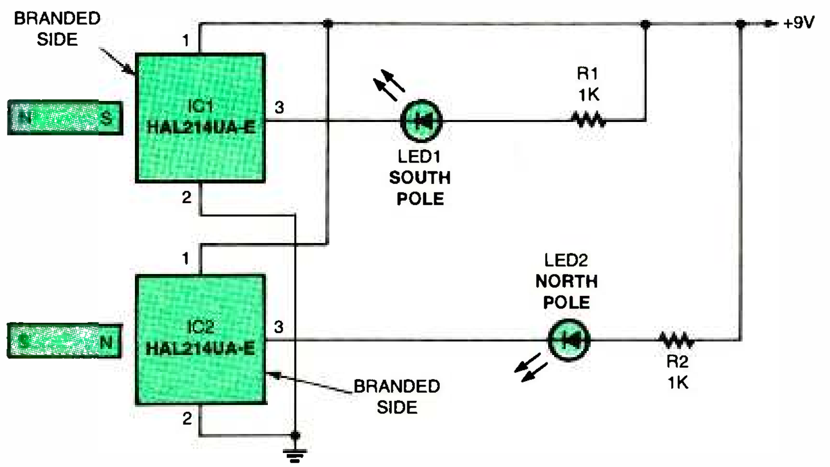


Fig. 3. Wave a magnet over each of the Hall-effect sensors in this circuit and let LED1 and LED2 identify the magnet's polarity.

systems or any similar application where it's desirable to have an external magnetic field be the catalyst that deactivates a circuit.

Bias-coil L1 can be an old relay coil with a DC resistance of 100 to 200 ohms. You can also make your own by winding about 1000 feet of 30-gauge, enamel-covered copper wire on a soft iron core. A soft iron bolt with a diameter of ¼ to ½ inches and a length of about 2 inches will do for the coil's core. Just jumble-wind the copper wire in a solenoid fashion along the length of the bolt.

To determine which side of the coil is the south pole, use a magnet with known poles to determine attraction/repulsion (opposites attract, and like poles repel). Again, position the south pole against the branded side of sensor IC1.

If the circuit doesn't latch when S1 is pressed, the problem could be that the bias coil is either positioned incorrectly or the field developed by the bias coil is too weak. Here you will need to experiment with either a different bias coil or try operating the bias coil at a slightly higher voltage.

POLE IDENTIFIER

A pair of the HAL214UA-E sensors, connected as shown in Fig. 3, can be used as a simple magnet-pole identification circuit. Readers may recognize this design as being similar to one that was discussed last month. Of course, this month's offering doesn't use the HAL115-UA-C sensors.

The HAL214UA-E sensors may be mounted side by side, with the branded side of IC1 facing out and the unbranded side of IC2 facing in. This allows the poles of a magnet to be easily identified by sweeping the magnet over the ICs. You can also mount the two sensors with their unbranded sides positioned face-to-face. The latter will provide a very small footprint, but you'll obviously have to move the pole of the magnet being tested in a different manner. In either case, the function will be the same. A magnet with its south pole placed near the branded side of sensor IC1 will light LED1, and a north pole positioned at the unbranded side of IC2 will light LED2.

PARTS LIST FOR THE POLE IDENTIFIER (FIG. 3)

IC1, IC2—HAL214UA-E Hall-effect sensor, integrated circuit
LED1, LED2—Light-emitting diode, any color
R1, R2—1000-ohm, ¼-watt, 5% resistor

MODERN REED SWITCH

A common item used in most burglar-alarm systems is the magnet-operated reed switch. However, since reed switches are mechanical they can fail in several ways: They are fragile and easily broken, their contacts

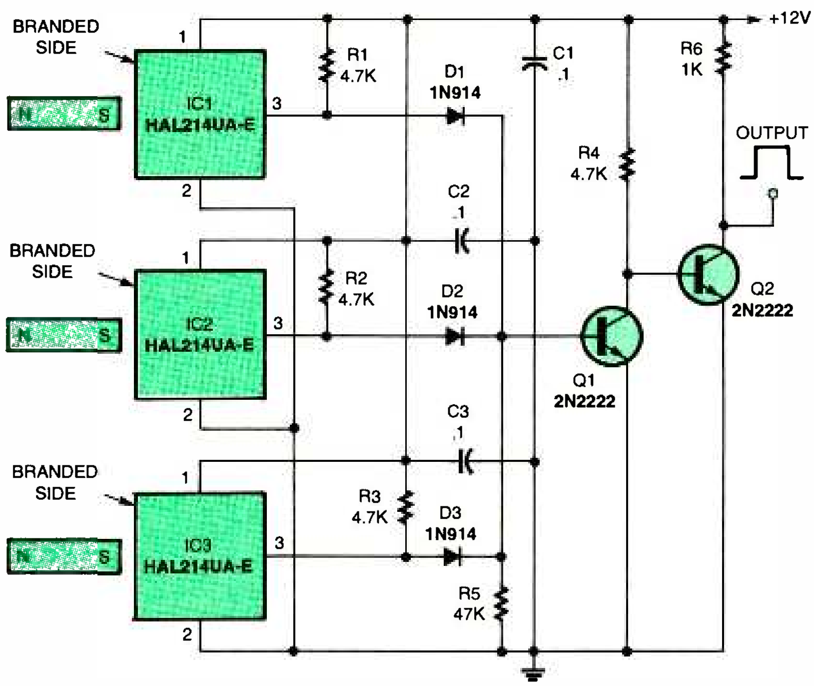


Fig. 4. Replace fragile reed switches with this solid-state version, which is sure to be more reliable.

PARTS LIST FOR THE MODERN REED SWITCH (FIG. 4)

SEMICONDUCTORS
IC1–IC3—HAL214UA-E Hall-effect sensor, integrated circuit
Q1, Q2—2N2222 general-purpose NPN silicon transistor
D1–D3—1N914 silicon signal diode

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1–R4—4700-ohm
R5—47,000-ohm
R6—1000-ohm

ADDITIONAL PARTS
C1–C3—0.1-µF, ceramic-disc capacitor

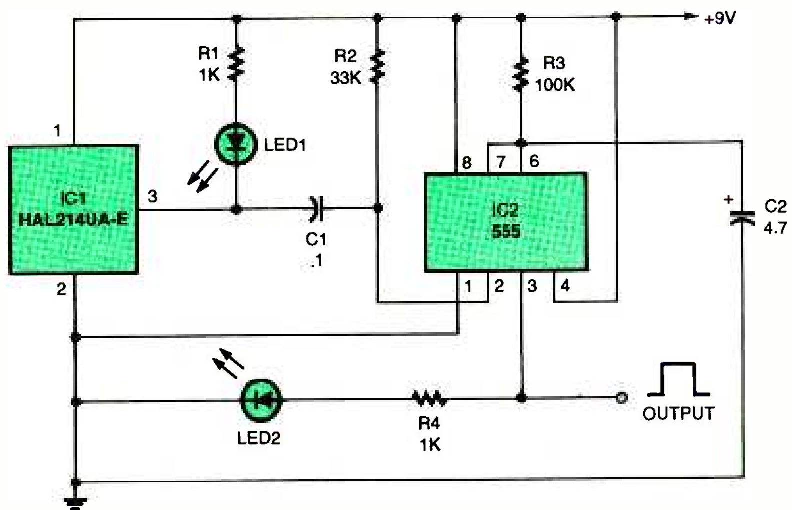


Fig. 5. This magnetic pulser (the duty cycle is set by R3 and C2) can interface with a counter or other digital circuitry.

PARTS LIST FOR THE MAGNETIC PULSER (FIG. 5)

SEMICONDUCTORS
IC1—HAL214UA-E Hall-effect sensor, integrated circuit
IC2—555 oscillator/timer, integrated circuit
LED1, LED2—Light-emitting diode, any color

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R4—1000-ohm
R2—33,000-ohm
R3—100,000-ohm

ADDITIONAL PARTS
C1—0.1-µF, ceramic-disc capacitor
C2—4.7-µF, 25-WVDC, electrolytic capacitor

sometimes stick in the closed position, and in rarer cases their contacts fail to make a good connection.

One solution to these problems is to replace a reed switch with a Hall-effect sensor—exactly what we've done with the circuit in Fig. 4. Here we have a three-sensor input circuit with a common alarm output. In the "set" condition all of the magnets are in place next to the Hall sensors (south pole to branded side) and all outputs are low. The voltage at the base of Q1 is low and the alarm output at Q2's collector is low. If one of the magnets is removed from one of the sensors, the latter's output will go high. A positive voltage is then supplied through the diode to the base of Q1 turning it on and Q2 off, thereby producing a high output. Any number of sensors can easily be added to the circuit by duplicating one of the sensor circuits and feeding its output to the base of Q1 through a 1N914 diode.

MAGNETIC PULSER

Our next circuit, shown in Fig. 5, adds a timed, pulsed output to the basic Hall-effect sensor. The output of the circuit can be used to interface with a counter or some other type of digital circuitry.

If no magnetic field is present, sensor IC1's output at pin 3 is high and the output of 555 timer IC2 at pin 3 is low. Placing a magnet's south pole near the branded side of IC1 produces a low at the chip's output that lights LED1 and sends a negative pulse through C1 to pin 2 of IC2. The timer then produces a one-second positive output pulse at pin 3.

The duty cycle of the 555's output pulse is determined by the values of R3 and C2. You'll have to experiment with the values of these components to find the right time for your particular application (hint: make either or both greater in value for a longer time period, or less for a shorter time period).

SIMPLE LATCHING DETECTOR

The circuit in Fig. 6 uses a HAL502UA-E (Digi-Key part number HAL502UA-E-ND) latching Hall-effect

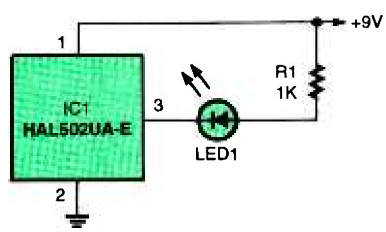


Fig. 6. This Hall-effect sensor will remain latched after detecting a magnetic field. See text to learn how to deactivate it.

PARTS LIST FOR THE SIMPLE LATCHING DETECTOR (FIG. 6)

IC1—HAL502UA-E Hall-effect sensor, integrated circuit
LED—Light-emitting diode, any color
R1—1000-ohm, ¼-watt, 5% resistor

sensor. This sensor has the same operating temperature range and voltage requirements as the HAL214UA-E. Also, the sensor's output is normally high and goes low when the south pole of a magnet is brought close to the branded side of the sensor. However, the HAL502UA-E's output *latches* low, remaining in that state even after the magnet has been removed.

The LED in the circuit lets you know that a magnet has been detected. To reset the circuit, you can either interrupt the power source or bring the north pole of a magnet to the branded side of the sensor.

MAGNETIC LOCK AND KEY

The magnetic locking/unlocking circuit shown in Fig. 7 will be our last entry this time around. This circuit may also be used as a magnetic puzzler for fun and frustration. The "key" for the circuit is made of three small rod magnets. Mount each of the Hall sensors in a hole in a block of wood so that magnets can slide into and make contact with the sensors. You'll have to determine whether the branded or unbranded side of each sensor faces out—in this way you'll set the correct "combination" of magnet polarities that opens the lock.

Why three magnets? They coincide with IC1–IC3, which are HAL214UA-Es. The fourth sensor, IC4, is the normally high HAL502UA-C latching sensor, and acts as a lock primer. Before you can unlock the circuit with the right combination of magnets, you need to first latch IC4 by placing a single magnet over it in the correct polarity (you determine which side of the IC faces out—as with all the sensors, branded sides require a south pole to activate).

After you latch IC4, you have to

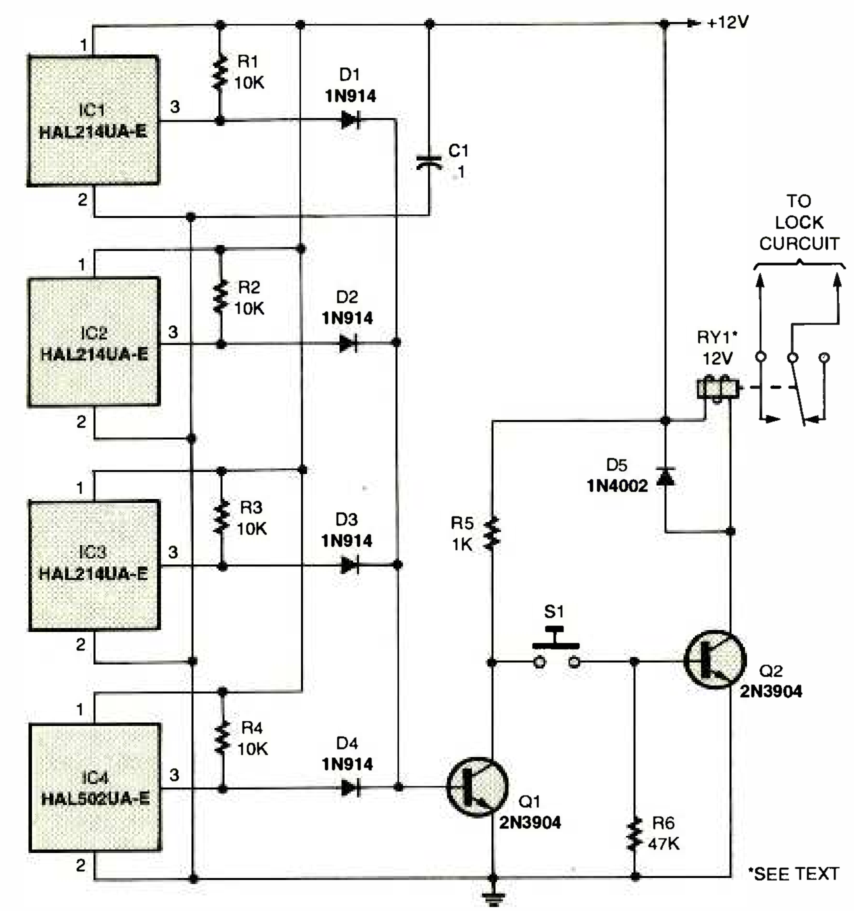


Fig. 7. As explained in text, this magnetic lock-and-key circuit can make it quite difficult for someone to open a circuit, unless they know the secret combination of magnet poles required to activate relay RY1.

PARTS LIST FOR THE MAGNETIC LOCK AND KEY (FIG. 7)

SEMICONDUCTORS
IC1–IC3—HAL214UA-E Hall-effect sensor, integrated circuit
IC4—HAL502UA-E Hall-effect sensor, integrated circuit
Q1, Q2—2N3904 general-purpose NPN transistor
D1–D4—1N914 silicon signal diode
D5—1N4002 1-amp, 100-PIV silicon rectifier diode

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1–R4—10,000-ohm
R5—1000-ohm
R6—47,000-ohm

ADDITIONAL PARTS
C1—0.1-µF, ceramic-disc capacitor
RY1—12-volt DC relay (coil resistance of 100 ohms or greater)

insert the proper combination of three magnets to activate IC1–IC3. When all magnets are in place correctly, the sensor outputs will all go low and Q1 will be turned off (with its collector high at 12 volts). Pressing S1 will turn Q2 on, pulling in relay RY1 and activating any external circuitry connected to the lock. If any of the magnets are incorrectly installed, consequently causing one or more of the sensors' outputs to be high, the circuit will not allow the lock to be activated.

If unlocking the puzzle becomes too easy, try using unmarked magnets and don't allow a compass to be used. Any number of additional stages of sensors may be added to increase the difficulty in opening the magnetic lock.

I hope you have as much fun working and playing with these unique magnetic sensors as I've had. If you are a true experimenter these devices are made for you. So melt some solder and build something, then meet me back here next month at the same time and place.

Until then, may all of your circuits operate as you planned them to the first time around. ■

HAM RADIO

(continued from page 54)

are seeking an award such as DXCC, WAS, or WAC, then you might be less interested than when it was the law. But there is one good reason to do so: science. Every now and then some propagation event occurs that baffles scientists. Last summer, for example, a massive gamma source appeared for a short time, and then died out. It affected HF communications all over the world, especially on the dark side of Earth. Scientists at the National Radio Astronomy Observatory (NRAO) asked hams and SWLs for log details of their reception on that day. Your ham log could have been useful to them ... if you'd had one. The ARRL still sells logbooks, so I recently went out and bought one.

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA, 22041, or by e-mail at carrjj@aol.com. ■

DX LISTENING

(continued from page 56)

despite interference from Peruvian Radio Ancash.

TURKEY—6,900 kHz, Turkish Meteorological station is a seldom-logged SW outlet. While weather news seems to be its reason to exist, it has been heard on the East Coast of the U.S. signing on at 0412 UTC with Turkish music and no announcements.

UGANDA—4,976 kHz, Radio Uganda is heard with English news, advertisements, and public service announcements from 0400 UTC.

UNITED ARAB EMIRATES—15,395 and 21,605 kHz, UAE Radio at Dubai airs its English segment from 1600 to 1640 UTC.

URUGUAY—6,140 kHz, Radio Monte Carlo in the capital of Montevideo has a Spanish news broadcast, *Diario Oral Matutino* after 1000 UTC, followed by ID.

VENEZUELA—4,830 kHz, Radio Tachira begins its programming day around 1016 UTC, with the Venezuelan national anthem, Spanish identification, and some tropical music. This is followed by a religious program at 1030 UTC. ■

Lights on with Photodiodes

ALEX BIE

The photodiode semiconductor is used within the electronics industry in a variety of areas, from detectors in CD players to wide-bandwidth optical telecommunications systems. This device regulates electric current in response to the variation in intensity of light on its surface and owes much of its success to its simple and low-cost (yet rugged) structure.

Structure

Although an ordinary PN junction can be used as the basis of a photodiode, the PIN junction is far more satisfactory and the most widely used type. This structure was developed in the late 1950s from the more conventional PN diode, over which it has many advantages.

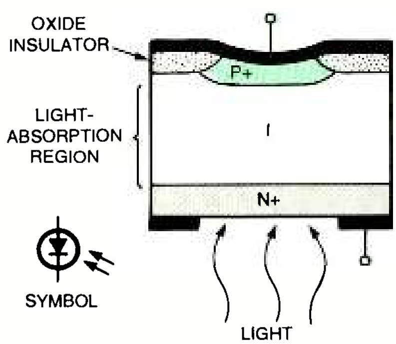


Fig. 1. Here is the buildup of a PIN photodiode.

In the fabrication process, a thick intrinsic layer (I) is inserted between the P- and N-type layers, as shown in Fig. 1. The middle layer may be either completely intrinsic, or very lightly doped to make it an N-layer. In some instances it may be grown as an epitaxial layer onto the substrate, or alternatively it may be contained within the substrate itself.

One of the main requirements of the diode is to ensure that the maximum amount of light reaches the intrinsic layer. One of the most efficient ways of achieving this is to place the electrical contacts at the bottom of the structure as shown. This enables the maximum amount of light to reach the active area. It is found that when the substrate is heavily doped, there is very little loss of light due to the fact that this is not the active area.

As light is mostly absorbed within a certain distance, the thickness of the intrinsic layer is normally made to match this distance. Any increase in thickness over this absorption distance will tend to reduce the speed of operation—a vital factor in many applications. Increasing the thickness of the intrinsic layer any further will not improve the efficiency greatly.

It is also possible to have the light enter the diode from the side of the junction. By operating the diode in this fashion, the intrinsic layer can be made much thinner to increase the speed of operation, although the efficiency is reduced.

Operation

The diode is operated under a moderate reverse bias. This keeps the depletion layer free of any carriers, and normally no current will flow. However when a light photon enters the intrinsic region it can strike an atom in the crystal lattice and dislodge an electron. In this way a hole-electron pair is generated. The hole and electron will then migrate in opposite directions under the action of the electric field across the intrinsic region, and a small current can be seen to flow. It is found that the size of the current is proportional to the amount of light entering the intrinsic region. The more light, the greater the numbers of hole-electron pairs that are generated, and the greater the current flow.

When not exposed to light, the diode follows the normal voltage-current (VI) characteristics expected of a diode. In the reverse direction, virtually no current flows, but in the forward direction it steadily increases, especially after the knee or turn-on voltage is reached. This characteristic is modified in the presence of light as shown in Fig. 2. When used as a photodiode, the greatest effect is seen in the reverse direction. Here the largest changes are noticed, and the normal forward current does not mask the effects due to the light.

Standard hobbyist photodiodes can be found in numerous catalogs. For example, Digi-Key (Tel. 800-344-4539) can supply photo sensors and detectors in a number of configurations, wavelength sensitivities, VI parameters, and size of the active area.

Applications

The PIN photodiode does not have any gain, and for some applications this may be a disadvantage. Despite this, it is still one of the most widely used forms of a diode, finding applications in audio CDs as well as computer CD drives. In addition photodiodes are used in optical-communication systems.

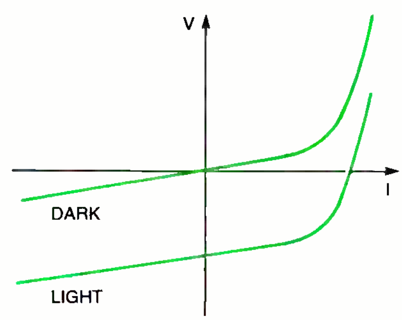


Fig. 2. These curves illustrate the VI characteristic of a PIN photodiode.

These diodes are also used in nuclear-radiation detectors. Nuclear radiation may be in the form of high-energy charged or uncharged particles, or it may also be electromagnetic radiation—the diode can detect all these forms of radiation. Electromagnetic radiation, of which light is a form, generates the hole-electron pairs as already mentioned. The particles have exactly the same effect. However, because only a small amount of energy is required to generate a hole-electron pair, a single high-energy particle may generate several hole-electron pairs.

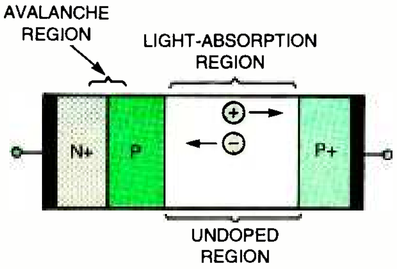


Fig. 3. Here's the structure of an avalanche photodiode.

Avalanche Detector

In addition to the PIN photodiode, avalanche photodiodes or detectors are used in some applications. This device is a modified photodiode, biased just below the avalanche breakdown region. These have the advantage that they use the avalanche process to give high levels of gain. The structure is somewhat more complicated than that of the ordinary PIN device (see Figs. 3 and 4). It can be seen that this structure consists of four layers. There are N+, P, undoped, and P+ regions. Light absorption takes place in the undoped region, which may be relatively thick. The avalanche region

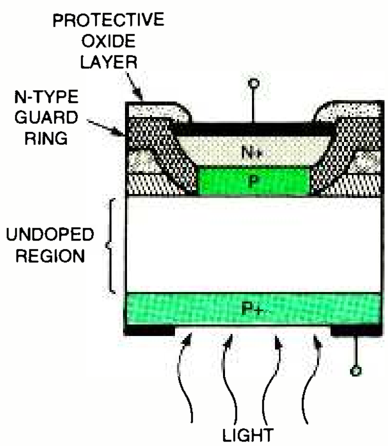


Fig. 4. This is a cross-section of a typical avalanche photodiode.

occurs between the N+ and P regions.

Light enters the undoped region and causes the generation of hole-electron pairs. Under the action of the electric field, the electrons migrate towards the avalanche region. Here the electric field causes their velocity to increase, to the extent that collisions with the crystal lattice create further hole-electron pairs. In turn, these electrons may collide with the crystal lattice to create even more hole electron pairs. In this way, a single electron created by light in the undoped region may result in many more electrons being created.

The avalanche diode has a number of differences when compared to the ordinary PIN diode. The avalanche process means that a single electron produced by light in the undoped region is multiplied several times. As a result, the avalanche detector is far more sensitive. However it is found that its operation is not nearly as linear, and additionally the avalanche process means that the resultant signal is far noisier than one from a PIN diode. The structure of the avalanche diode is also more complicated. An N-type guard ring is required around the PN junction to minimize the electric field around the edge of the junction. It is also found that the current gain is dependent not only on the bias applied, but also thermal fluctuations. As a result, it is necessary to ensure the devices are placed on an adequate heat sink.

The avalanche diodes are not as widely used as their PIN counterparts. They are used primarily where optical gain is of paramount importance and wide bandwidths are necessary. Due to the high voltages required, combined with a lower reliability, this type of photodiode is less convenient to use.

The definitions of many semiconductor terms can be found in Ian Poole's *Radio and Electronics* Web site: *http://website.lineone.net/~ian_poole.*

In next month's column, we will look at the thyristor. Well, enough theory for now—now let's get to our readers' circuits!

BRIGHTER BICYCLE BULBS

My name is Paul, and I live in Bellingham, WA. I am a home-schooled eighth grader. I enjoy your column and have built many of the published circuits. I like programming on our computers in BASIC, and I am working on learning assembly language. I recently finished an interface that allows me to control three motors from a computer, and now am working on making a computer-controlled robot arm.

Here is a tip on how to make bike lights—which are powered by a standard dynamo—many times brighter. The idea requires that the headlight and taillight bulbs be exactly the same type. In the simple circuits shown in Fig. 5, I recommend using two krypton bulbs for I1 and I2, but normal lights will work also. Try riding—the light bulbs, when connected as shown in Fig. 5A, should both glow, but may be dimmer than you'd expect.

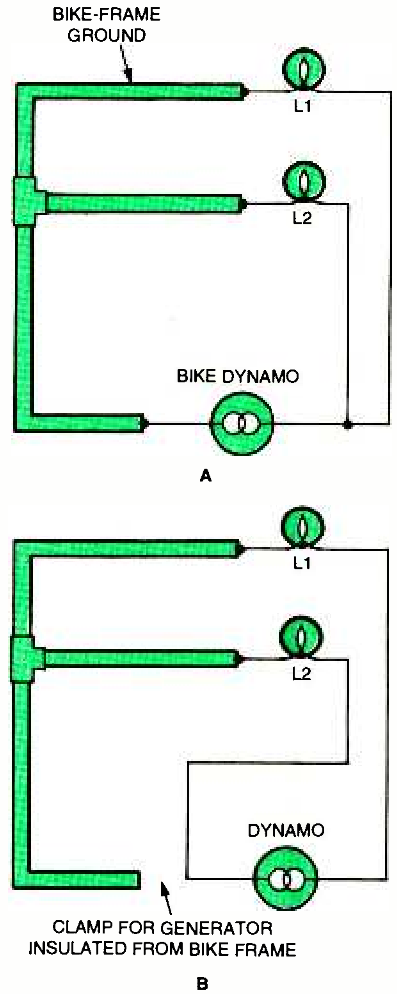


Fig. 5. Change the configuration of your bicycle lamps from A to B to get them to light up brighter.

The reason for the dimness is that bike dynamos are constant-current generators. After reaching a certain speed, pedaling faster will not make the light bulbs any brighter. When pedaled fast enough, the voltage applied to the bulbs will rise until the bulbs consume a factory-set amount of current. Installed according to the manufacturer's directions, the two light bulbs are wired in parallel (again, see Fig. 5A). This means that the light

"Photodiode" introduction by Ian Poole, 5 Meadway, Staines, TW18 2PW, England; reprinted with permission.

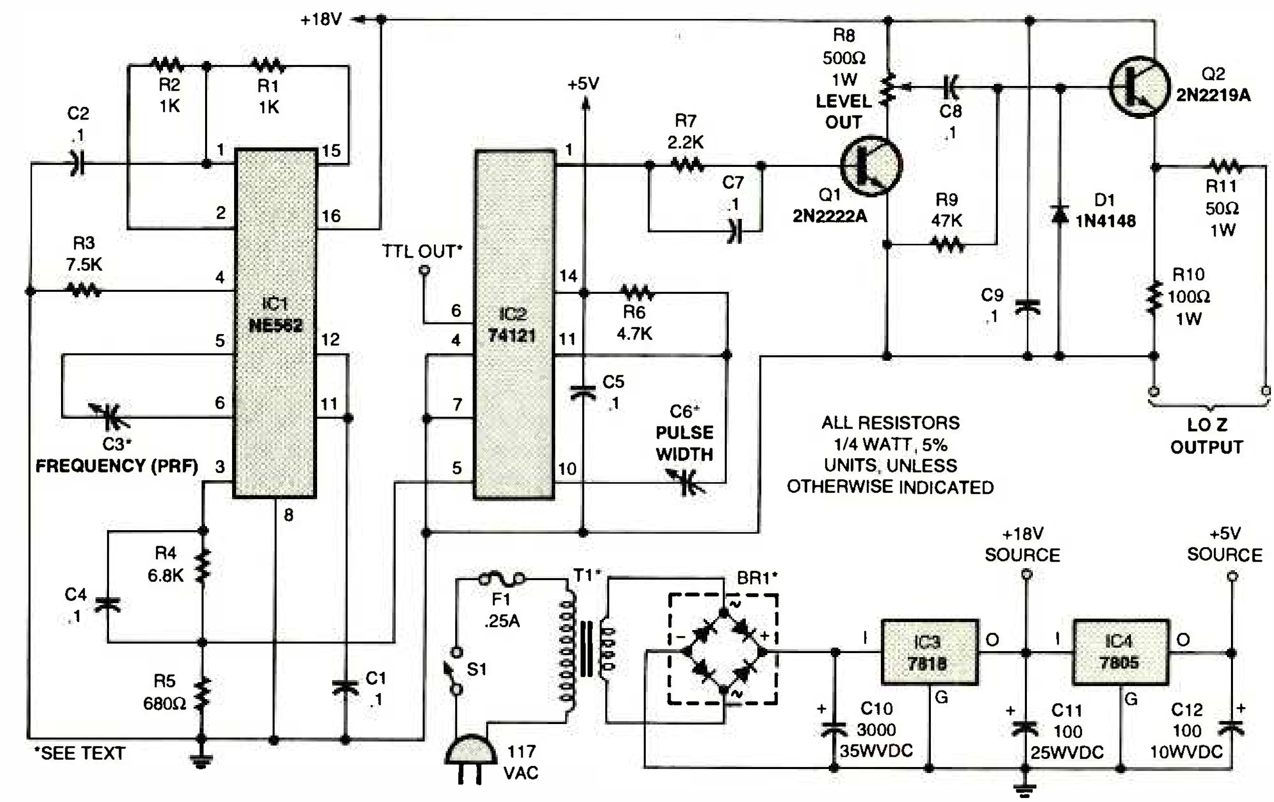


Fig. 6. This low-cost pulse generator features a PRF from 1 Hz to 10 MHz, with pulse width variable from 50 ns to greater than 500 ms. Output amplitude is 14-volts peak unloaded and about 7 volts into a 50-ohm load.

bulbs are only running at half capacity. Setting the light bulbs up in series (Fig. 5B) will make them run at full capacity.

To place the light bulbs in series, it is required to insulate the dynamo from the frame. This can be done by putting about ten layers of paper under the clamp that holds the dynamo to the frame. Leave the head and taillights alone, but disconnect one of their wires from the dynamo and reconnect this wire to the metal clamp of the dynamo. The new series circuit is complete! The electricity comes from the dynamo, lights one bulb, goes through the frame, lights the other bulb, and goes back to the dynamo. If it all works out, the output should be much brighter than it was originally.

—Paul R. Jordan, Bellingham, WA

Great introduction, Paul—it is good to see that eighth graders are so electronically involved. We hope to be seeing more of your circuits. Perhaps you will send us your computer-controlled robot arm project in the future. In this circuit, builders should take care that the return path of the bulbs is insulated from one side of the dynamo, otherwise I2 will be shorted out and the dynamo's full output will appear across I1. Happy cycling!

LOW-COST PULSE GENERATOR

The circuit shown in Fig. 6 is a versatile low-cost pulse generator that can be made with just two integrated circuits, a power supply, and some junkbox parts. The generator's pulse-repetition frequency (PRF) can be selected to operate from less than 1 Hz to over 10 MHz, with pulse width variable from 50 nanoseconds to more than 500 milliseconds.

The generator is designed around IC1, a Signetics NE562 integrated circuit. This IC was originally intended for use in phase-locked loop synthesizers or FM detectors. In this application, only the voltage-controlled oscillator (VCO) portion of the IC is used for the pulse generator, along with IC2, a 74121 monostable multivibrator integrated circuit, which is used to adjust the pulse width. The stability of the free-running frequency of the NE562 is comparable to more costly pulse generators.

The two variable capacitors, C3 and C6, can be any surplus broadcast radio-band types. You can parallel the local-oscillator portion of this type of variable capacitor with the station-tuning sections or switch them to provide a two-range unit. The VCO operates typically to 30 MHz, the limiting factor being the stray capacity and the minimum capacitance of your tuning capacitor. The low end of the VCO is 1 Hz (when C3 is set to 300 F). The 74121 one-shot multivibrator circuit also produces a large pulse width—from 40 nanoseconds to 40 seconds (when C6 is set to 1000 F and R6 is 40 kilohms).

One note of design information: In order to preserve the pulse wave shape, the values of the coupling capacitors will have to be increased as the frequency is lowered. The frequency range of the unit shown in Fig. 6 is from 900 kHz to 10 MHz, and the output pulse width is adjustable from 50 to 800 nanoseconds. You can select your frequency range of interest and change the variable capacitors accordingly. The VCO output of IC1 at pin 3 is coupled to IC2 through components C4, R4, and R5. The inverted output of IC2 at pin 1 is applied to the base of Q1, a 2N2222A transistor amplifier, whose output is variable (through potentiometer R8). The signal is then applied to the base of Q2, a 2N2219A transistor set up in a low-impedance, emitter-follower configuration. One watt of peak power is available from this output into a 50-ohm load (14-volt peak, unloaded). The current sinking capability is limited; however, the generator can be used to trigger SCRs, *etc.*

A simple AC power supply has been included that develops the required 18- and 5-volt DC supplies for the generator. The transformer used is rated at 18-VAC, 0.5A, while BR1 is a standard full-wave bridge, such as the RadioShack 276-1146. To use the generator, turn the power on, turn the pulse width to minimum, set the PRF, and then adjust the pulse width and output level as required.

Those who wish to obtain a foil pattern of the circuit can do so by sending

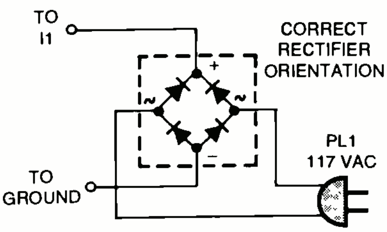


Fig. 7. Here's the correct way to orient the bridge rectifier in Fig. 6 of our February 1999 column.

me a self-addressed stamped envelope.
—Craig Kendrick Sellen, Mallard Meadows RHC, 476 Belmont St., Waymart, PA 18472.

Fine job, Craig. This circuit has many uses on the workbench. However, as Craig pointed out and we confirmed, the NE562 PLL chip might be discontinued and hard to locate. A source which still has stock is Alltronics, 2300 Zanker Road, San Jose, CA 95131; Tel. 408-943-9773; Web: www.alltronics.com. *They also stock the other parts, though you can use substitutions for several.*

A CORRECTION

As a reader pointed out, I made an error in the February 1999 issue. In Fig. 6 from that issue, the bridge rectifier composed of diodes D1–D4 was improperly oriented. To correct it, rotate the entire rectifier diamond shape 90 degrees to the left, as shown in Fig. 7 of this month's column.

That's about it for this month's column. Remember this is *your* column. Keep those circuits, solutions, and ideas coming in for your special gift. Write me at *Think Tank*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735. ■

LETTERS

(continued from page 10)

chase one, and I need to know which are the best for recording; is the sound muffled, is there any hiss, and can I record from cassettes, records, or even the radio? I would appreciate any information.
W.K.
Chicago, IL

Besides the recorder review in this month's Gizmo, *here's a piece of advice about CD recorders: While the sound quality of most, if not all, of these devices is superior to older media, you have to have a good quality source to record from. To record from the radio or other less-than-CD-quality media, you'll need to invest in noise-cancellation hardware or software that can prepare or clean up the audio before you record it digitally.*
—Editor

A READER RESPONDS

Your March issue got right to me, especially your fine editorial. I was even more intrigued with the *Letters* column. I have to agree with the general feelings of D.V. from Los Angeles. Many of your readers want the heavy-duty projects, but don't always have the resources, time, and money for the bigger more complex projects. There are many who also like a smattering of small, simple circuits. They are usually easy to build and enjoy, and they come with easy-to-obtain spare parts or RadioShack parts.

Regarding the letter from John Agugliaro, I also got sick of using those new-fangled volt ohmmeters and got out my old trusty Simpson 260, circa 1965. I too would love to have its schematic.

In response to Leon Howe's request, I don't have what he wanted but I do have a box full of 8-inch reel-to-reel blank tapes, new condition, never opened. If anyone is interested, I would be happy to pass them along. I also have a set of 78-rpm records: a course in phonetics.

Lastly, If given enough time, I think I can dig up an old article on the project that Bill Englander wants, or I may be able to design such an indicator.

I've been a reader of **Popular Electronics** for 36 years or so. It's still the best out there in this competitive field. Keep this fine magazine going.
David Larkin
225 Broad Street, Apt. 1
New London, CT 06320

HAVES & NEEDS

I have a problem trying to find a schematic for a Rosac amp. The power transistors blew, and it's hard to find a match. SEN t73 is on the power transistor. Are there any old books for a reference for a crossover?

Are there any kits to build a preamp for a piezo musical pickup?
Michael Elias
P.O. Box 390494
Anza, CA 92539 ■

Those Magnificent Philco Cathedrals

MARC ELLIS

Last month, we discussed the downsizing techniques that made it possible for radio manufacturers to produce modestly priced receivers for cash-starved, but entertainment-hungry, folks during the 1930s depression years. The new "midgets"—many brands of which were produced by small, unknown manufacturers—were enormously popular. Their sales figures caused more than a few raised eyebrows in the executive offices of the major radio firms. However, most of these firms chose to ignore this trend and stick with their prestige images, continuing to push inlaid wood cabinets and battleship construction. One company did see things a little differently.

Philco took a look at the new downsized radios and identified many marketing points. The portability of the small table models made them more useful and versatile. The family receiver no longer had to remain anchored in the living room, trapped in its magnificent cabinetry; it could follow the family to wherever the action was. Furthermore, the new techniques of integrated construction discussed last month—particularly the downsizing of components, the integration of the power supply into the radio chassis, and the inclusion of the speaker within the cabinet—offered economies that would permit sets to be sold at attractively low prices while maintaining decent profit margins.

But Philco decided to put its own spin on this trend. Rather than churning out minimal midget sets, the canny firm took a compromise approach. They adapted the downsizing methods to produce a line of lower-cost models that still retained some quality features. The result was the famous "Philco Cathedral" that found a very profitable marketing niche at the time and has captured the interest of so many collectors today.

Here's one of the ads that introduced the Model 20 Baby Grand to entertainment-starved Americans during the depths of The Great Depression.

THE ORIGINAL PHILCO CATHEDRAL

Philco's first entry into the so-called "midget" market was the Model 20 Baby Grand, introduced in 1930. The original display ads pictured it next to a bookend, as if it might neatly slide into place on a bookshelf. However, this set was really a serious console radio in a table model cabinet.

It sported a TRF circuit with three type-24 screen-grid tubes as RF amplifiers, a type-27 detector, and a pair of push-pull 71As as audio amplifiers. The speaker was an eight-inch electrodynamic. The heavy-duty transformer-type power supply employed the usual type-80. All this was crammed into a 16 × 17.5-inch case with a nice walnut-finish veneer. The price: $49.50—quite a bit more than the minimal midgets, yet a serious saving over competitive sets having comparable performance.

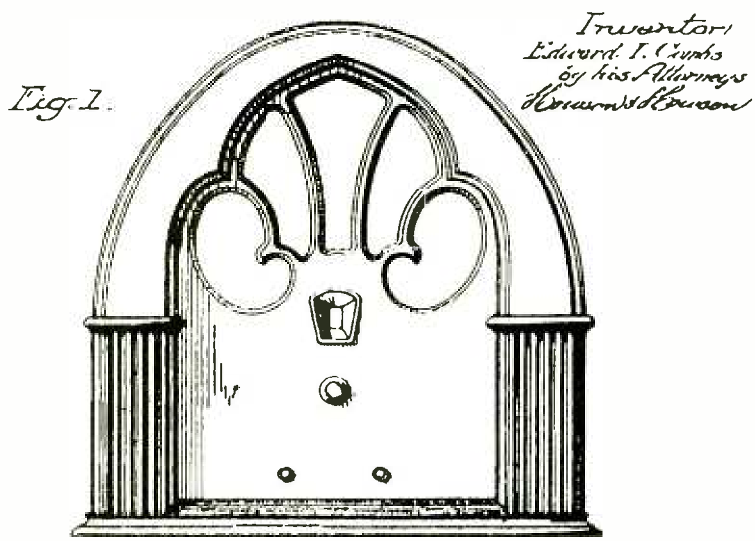
Eventually over 300,000 Model 20 Baby Grands were cranked out, making Philco the foremost radio manufacturer of the era. The Model 20 was a rather plain-looking set, and Philco later dressed it up to some degree by changing the veneer surrounding the top arch to a light-colored curly maple. The company also added a pair of appliqued grooved columns "supporting" the arch on both sides of the cabinet front.

THE IMMORTAL COMBS DESIGN

The year 1931 saw the introduction of the Model 21, which employed the same chassis as the Model 20, but sported a beautiful new cabinet by crack industrial designer Edward L. Combs. Combs retained the columns that had appeared in the later Model 20, simplified the speaker grille treatment, and added a few other deft touches. The result of these changes was a classic cabinet that is arguably the most beloved by today's antique-radio hobbyists.

As proof of this, next time you see an illustration of a cathedral radio in an advertisement or publication of some kind, compare it with the Combs Model 21 patent drawing shown with this article. More often than not you'll find a rather close resemblance!

Philco certainly understood the



UNITED STATES PATENT OFFICE

EDWARD L. COMBS, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO PHILADELPHIA STORAGE BATTERY COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA

DESIGN FOR A RADIOCABINET

This illustration is taken from the design patent for Edward L. Combs' immortal cathedral design.

drawing power of this cabinet, because it was used in four more sets after the Model 21 was discontinued. These were the famous Model 70 and Model 90 superheterodynes, the Model 35 (a battery-operated Model 70), and the Model 46 (a 110-volt DC TRF similar to the Model 21). Though the firm made many cathedral models after this period, the Models 21, 70, and 90 are certainly among those best known to collectors.

MODEL 90 VARIATIONS

Introduced in June 1931, along with the smaller Model 70, the Model 90 was priced at $69.95. It is now probably the most sought-after of the Philco cathedrals. Calling this behemoth superheterodyne a "midget" radio (though it technically might be considered to be one) is a bit of a laugh. Collectors will find three major variations of this interesting set, all with nine tubes.

What appears to be the earliest variation uses four type 24s (as RF amplifier, mixer, IF amplifier, and detector), two type 27s (local oscillator and first audio), a pair of 45s (push-pull audio output), and a type-80 rectifier. Volume control was accomplished by the rather archaic technique of varying cathode bias on the RF and IF amplifiers. And puzzling over the schematic of this version of the Model 90, I was not able to find an automatic volume control (AVC) circuit. There is a 3-position tone control, which is a refinement not found on the predecessor Models 20 and 21.

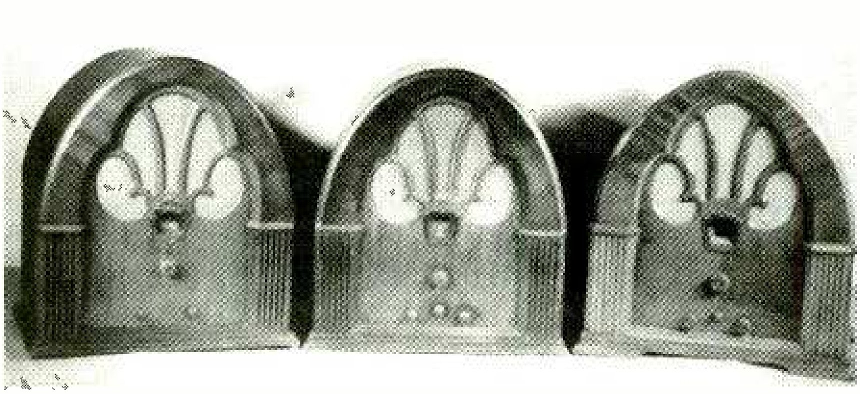
A second variation is rather similar electronically, but uses a single-ended (type-47) audio output stage. Type 24s are used as the RF amplifier, mixer, and IF amplifier; 27s as the local oscillator, detector and first and second audio stages; and an 80 for the rectifier. The volume control is a conventional potentiometer circuit at the first audio grid; there is a 3-position tone control.

The most sophisticated variation of the Model 90 is immediately distinguishable by its use of a pair of push-pull type 47s as the audio-output stage. The newly introduced type-35, remote cut-off or "supercontrol" tube is substituted for the 24s previously used as RF and IF amplifiers. The new type offered smoother, more gradual, control of stage gain by the AVC circuit. The local oscillator tube has disappeared in this model, replaced by a single 24 used as an oscillator-mixer. As in the previous variation, type 27s are used as the detector and in the first and second audio stages, and there is also an 80 rectifier. Volume control is conventional, and the 3-position tone control is retained.

MODEL 70 VARIATIONS

Collectors may find that the popular "baby 90" set is a little easier to locate than its big brother. Over 288,000 of them were made, compared to about 106,000 Model 90s. The difference in volume is accounted for by the fact that the Model 70 sold for twenty dollars less. Two variations are out there to be found: one with automatic volume control and one without it; both use seven tubes.

The front end of the Model 70 *without* AVC is quite similar to that of the first variation of the Model 90. Type 24s are used as RF amplifier, local oscillator, mixer, and IF amplifier. Volume control is by the same cathode-bias method. The major difference is in the audio section, which lacks the "punch" of the 90 variation mentioned—having only a single detector-amplifier (type 24) in place of the 90's separate detector and first audio amplifier, and having a single-ended output stage (type 47) in place of the push-pull 45s. There's the



Here's a group picture of the classic Combs sets. From left, Philco Models 21, 70, and 90.

Budget Project and Computer Books

☐ **BP317–Practical Electronic Timing $6.99.** Time measurement projects are among the most constructed gadgets by hobbyists. This book provides the theory and backs it with a wide range of practical construction projects. Each project has how-it-works theory and how to check it for correct operation.

☐ **BP415–Using Netscape on the Internet $8.99.** Get with the Internet and with surfing, or browsing, the World Wide Web, and with the Netscape Navigator in particular. The book explains: The Internet and how the World Wide Web fits into the general scenario; how do you go about getting an Internet connection of your own; how to download and install the various versions of Netscape browsing software that are available; and how to use Netscape Navigator to surf the Web, and to find and maintain lists of usful sites. There's a heck of a lot more, too!

☐ **BP325–A Concise User's Guide to Windows 3.1 $6.99.** Now you can manage Microsoft's Windows with confidence. Understand what hardware specification you need to run Windows 3.1 successfully, and how to install, customize, fine-tune and optimize your system. Then you'll get into understanding the Program Manager, File Manager and Print Manager. Next follows tips on the word processor, plus how to use Paintbrush. There's more on the Cardfile database with its auto-dial feature, Windows Calendar, Terminal, Notepad, etc.

☐ **BP327–DOS: One Step at a Time $5.99.** Although you spend most of your time working with a word processor, spreadsheet or database, and are probably quite happy using its file management facilities, there will be times when you absolutely need to use DOS to carry out 'housekeeping' functions. The book starts with an overview of DOS, and later chapters cover the commands for handling disks, directories and files.

☐ **PCP119–Electronic Music and Midi Projects $12.95.** Save cash by building the MIDI gadgets you need. Want a MIDI THRU box, program change pedal, Metronome, analog echo unit, MIDI patchbay or switcher? Over 16 practical and very useful music and MIDI projects—all in this book! The projects are explained in detail with full instructions on assembly.

☐ **PCP120—Multimedia on the PC! $14.95.** What is Multimedia? What can it do for you? It can do lots of nice things! This 184-page book helps you create your own multimedia presentation. Multimedia applications by people like you can revolutionize educational and business applications as well bring more fun, fun, fun into your leisure computer activities.

☐ **BP404–How To Create Pages for the Web Using HTML $7.99.** Companies around the world, as well as PC users, are fast becoming aware of the World Wide Web as a means of publishing information over the Internet. HTML is the language used to create documents for Web browsers such as Mosaic, Net-scape and the Internet Explorer. These programs recognize this language as the method used to format the text, insert images, create hypertext and fill-in forms. HTML is easy to learn and use. This book explains the main features of the language and suggests some principles of style and design. Within a few hours, you can create a personal Home Page, research paper, company profile, questionnaire, etc., for world-wide publication on the Web.

☐ **BP377—Practical Electronic Control Projects $7.99.** Electronic control theory is presented in simple, non-mathematical terms and is illustrated by many practical projects suitable for the student or hobbyist to build. Discover how to use sensors as an input to the control system, and how to provide output to lamps, heaters, solenoids, relays and motors. Also the text reveals how to use control circuits to link input to output including signal processing, control loops, and feedback. Computer-based control is explained by practical examples.

☐ **BP411—A Practical Introduction to Surface Mount Devices $6.99.** This book takes you from the simplest possible starting point to a high level of competence in working with Surface Mount Devices (SMD's). Surface mount hobby-type construction is ideal for constructing small projects. Subjects such as PCB design, chip control, soldering techniques and specialist tools for SMD are fully explained. Some useful constructional projects are included.

☐ **BP136—25 Simple Indoor and Window Aerials $2.99.** Many people live in flats and apartments where outdoor antennas are prohibited. This does not mean you have to forgo shortwave listening, for even a 20-foot length of wire stretched out under a rug in a room can produce acceptable results. However, with experimentation and some tips, you may well be able to improve further your radio's reception. Included are 25 indoor and window antennas that are proven performers. Much information is also given on shortwave bands, antenna directivity, time zones, dimensions, etc. A must book for all amateur radio enthusiasts.

☐ **BP379—30 Simple IC Terminal Block Projects $6.99.** Here are 30 easy-to-build IC projects almost anyone can build. Requiring an IC and a few additional components, the book's 'black-box' building technique enables and encourages the constructor to progress to more advanced projects. Some of which are: timer projects, op-amp projects, counter projects, NAND-gate projects, and more.

☐ **BP401—Transistor Data Tables $7.99.** The tables in this book contain information about the package shape, pin connections and basic electrical data for each of the many thousands of transistors listed. The data includes maximum reverse voltage, forward current and power dissipation, current gain and forward transadmittance and resistance, cut-off frequency and details of applications.

☐ **ETT1—Wireless & Electrical Cyclopedia $4.99.** Step back to the 1920's with this reprinted catalog from the Electro Importing Company. Antiquity displayed on every page with items priced as low as 3 cents. Product descriptions include: Radio components, kits, motors and dynamos, Leyden jars, hot-wire meters, carbon mikes and more. The perfect gift for a radio antique collector.

☐ **BP93–Electronic Timer Projects $2.99.** This book covers many of the possible applications of timer circuits. These circuits may turn on or off at either some preset time or after an elapsed time. Some of the more complicated timer and clock circuits are made up from a number of simpler circuits that the author deals with individually. Also included are several special interest circuits such as cars windshield wiper delay unit, a darkroom timer, metronome, etc.

☐ **BP88–How To Use Op-Amps $5.99.** Written as a designer's guide covering many operational amplifiers, serving both as a source book of circuits and a reference book for design calculations. There are chapters on Meet the Operational Amplifier, Basic Circuits, Oscillators, Audio Circuits, Filters, Miscellaneous Circuits, Common Op Amps, Power Supplies and Construction Notes and Fault Finding.

☐ **BP76–Power Supply Projects $3.99.** Presents a number of power-supply designs including simpled unbiased types, fixed voltage-regulated types and variable voltage stabilized designs. All are low-voltage types intended for use with semiconductor circuits. Apart from presenting a variety of designs that will satisfy most applications, the data in this book should help the reader to design his own power supplies. An essential addition to the experimenters electronics library.

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usual 80 rectifier and a two-position tone control.

The Model 70 *with* AVC is quite similar to the third variation of the Model 90 and, like it, uses the Type 35 remote-cutoff amplifier in the RF and IF stages, as well as a type-24 oscillator/mixer. This newer Model 70 variation still has seven tubes because a separate first audio stage has been added (another type 35), following the type-27 detector. Again, there is a single-ended audio output using a type 47.

SOME ACKNOWLEDGEMENTS

Some of the information for this article comes from Ron Ramirez's excellent reference: *Philco Radio 1928-1942*. I'm also indebted to Ron for permission to reproduce illustrations from the book here this month. Other sources are two of Ron's articles on Philco in *Antique Radio Classified Magazine* (February 1991 and June 1993) and the Philco schematics published by John Rider. Those interested in purchasing the Ramirez book (8 ½ × 11, softcover; 160 pages; slick paper; over 800 illustrations; $29.95) will find it on sale at *Antique Radio Classified* (*ARC*; PO Box 2-V127, Carlisle, MA 01741) or Antique Electronics Supply (AES; 6221 South Maple Ave., Tempe, AZ 85283). You may write *ARC* for a free sample copy of their magazine and/or AES for a free catalogue—both of which include a complete booklist.

AN IMPORTANT NOTE—MOVING TIME

Readers, it's time to bid you a sad goodbye! With this column, *Antique Radio* leaves the pages of **Popular Electronics**. But the good news is that we won't be going very far; in fact, we're moving just across the aisle to our sister magazine *Electronics Now*. The move is part of an ongoing reorientation of the editorial balance of both **PE** and *EN*.

I have to be a bit wistful about the change, because I cut my teeth in radio writing as an Associate Editor on the staff of the original **PE**, back when it was a Ziff-Davis publication with offices in midtown Manhattan. When Gernsback Publications purchased and revived the title several years ago, I was pleased to be working for the magazine again. (I had already put in a two-year stint as Antique Radio columnist for Gernsback's *Hands-On Electronics*, which became **Popular Electronics**.)

That was in November 1988 and I've been doing a column a month for **PE** ever since. However, I'm looking forward to putting in *at least* another ten years at *EN*. Look for the next "Antique Radio" in the May issue of *EN*, where we'll continue talking about depression radios. ■

NEW PRODUCTS

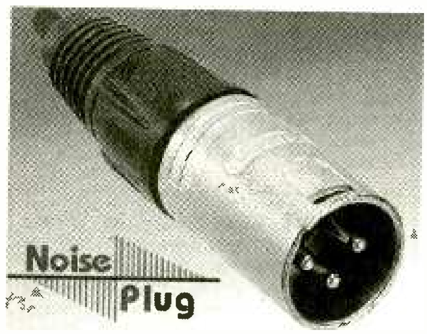
(continued from page 12)

The BNC Model 625A costs $995. For more information, contact Berkeley Nucleonics, 3060 Kerner Blvd. #2, San Rafael, CA 94901; Tel. 800-234-7858 or 415-453-9955; Fax: 415-453-9956; Web: *berkeleynucleonics.com/smartarb/smartarb.htm.*

CIRCLE 83 ON FREE INFORMATION CARD

NOISE GENERATOR

The *Noise Plug* is a complete precision pink-noise generator built in an XLR microphone connector. Simply plug it into a phantom-powered microphone input on your mixer and turn up the volume.



Inside is an ultra wideband, avalanche-junction white-noise source. The output of the source is frequency limited, amplified, and passed through a precision −3dB per-octave low-pass filter. The result is a full audio spectrum noise source with equal energy distribution in all octaves.

The Noise Plug can be used to check over-all audio-system operation; adjust speaker crossover points and balance; check frequency response of amplifiers, tape decks, and other audio components; and adjust system equalization.

Pink noise is also often used in noise-masking systems for the purpose of reducing annoyance from other noise sources.

The Noise Plug costs $49.95. For more information, contact GTC Industries, Inc., P.O. Box 2493, Napierville, IL 60567; Tel. 630-369-9815; Fax: 630-369-9198.

CIRCLE 84 ON FREE INFORMATION CARD

HANDHELD GPS RECEIVER

Combining a world-wide background map with detailed inland cartography and a database of marine navigational aids, the *Map 410* handheld GPS receiver is versatile enough to meet the needs of motorists, mariners, and campers.

The built-in basemap includes coastlines, cities, lakes, rivers, railroads, and highways. Also included is a database of marine navigation aids, such as floating and fixed buoys, lighthouses, and radio beacons. All the data is presented on an ultra-sharp display (240 by 120 pixels).

Because the Map 410 is PC-compatible, users can also download saved locations and routes into their PCs for editing and storage. The easy-to-learn menu interface uses an intuitive operating system and on-screen instructions. Nine graphical-navigation screens, including a real-time multiple-track plotter with adjustable scale show the user where he's going, the path traveled, and the distance to the destination.

The Map 410 has an expected street price of $349.99. For more information, contact Magellan Corp., 960 Overland Court, San Dimas, CA 91773; Tel. 800-611-7955 or 909-394-5000; Fax: 909-394-7050; Web: *www.magellan.com.*

CIRCLE 85 ON FREE INFORMATION CARD

DIGITAL ANEMOMETER

Ideal for field service, engineers, and repair technicians, the *Digital Mini Anemometer* measures air velocity in four different units with 3% basic accuracy. Measurements are displayed on a bright 3-½ digit LCD (1999 count) with low-battery indication. Its battery power and plastic housing, along with its fast sampling rate (0.4 secs.) make the pocket-size vane anemometer and its remote probe very useful for field work.

Measurements range from 160 to 5900 ft./min, 1.6 to 58 knots, 0.8 to 30 m/sec, and 2.8 to 108 km/hr. The low-friction, ball-bearing, twisted-arm vane structure ensures precise low and high readings.

Applications for the anemometer include installation, service, and testing of airways, air-ducts, and ventilation systems; environmental, wind, temperature, and humidity testing; and air-conditioning and heating-system checks, repairs, and optimization.

The Digital Mini Anemometer costs $149. For more information, contact Extech Instruments, 335 Bear Hill Road, Waltham, MA 02451; Tel. 781-890-7440; Fax: 781-890-7864; Web: *www.extech.com.*

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One of the world's smallest Family Radio Service Two-Way UHF radios, the *ENC 5040* measures only 4 ⅜ by 2 ⅛ by 1 inches and weighs only a little over 5 ounces. It is a great way for families, sportsmen, or campers to keep in touch just about anywhere indoors or outdoors—at work, at home, at a campsite, out shopping, or at an amusement park. No licenses are required, and there are no monthly fees.

It is a full-featured model with 14 UHF Family Radio Service Channels, a 9-digit backlit LCD display, and with up to a two-mile transmission range. Other features include low-battery warning indicator, power-save mode, volume control, scan, total time select, busy lock, and a rugged, impact-resistant case.

The ENC 5040 has a suggested retail price of $139.95. For more information, contact ENC Electronics, Inc., 13620 Cimarron Avenue, Gardena, CA 90249; Tel. 800-530-9386 or 310-366-1314; Fax: 310-366-1314; Web: *www.etri.com.*

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METAL DETECTOR

The *CZ-7a Quicksilver Metal Detector* is a microprocessor-controlled, target-I.D. unit. It includes a built-in, sealed weatherproof speaker and a round

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Features of this detector are 7-category visual target I.D., 3-tone audio target I.D., a bell tone for unidentifiable targets, programmable notch discrimination, a wide-scan all-metal auto-tune mode, a wet-sand mode, touchpad VCO pointing, and an LCD display.

The CZ-7a Quicksilver Metal Detector has a suggested retail price of $1050. For more information, contact Fisher Research Laboratory, Dept. PE, 200 W. Wilmott Road, Los Banos, CA 93635; Tel. 800-M-SCOPE or 209-826-3292; Fax: 209-826-0416; Web: *www.fisherlab.com.*

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Meant for use in electronic and electrical field service, plant maintenance, and engineering/R&D applications, the *Models 2880A* and *2890* high-performance, dual-display DMMs are hand-held devices (37 × 90 × 192 mm) offering true RMS measurements. Both models offer RS-232 computer interface and in-depth, long-term signal analysis using the dual display.

The meters provide two user-selectable operating resolutions (4000/40,000 counts), voltage to 1000 VDC/750 VAC, current to 10A, a dual-display offering frequency to 200 kHz with AC signal measurement, resistance to 40 megohms, capacitance to 9999 µF, and diode check and continuity. These instruments feature data hold, relative mode, and MAX/MIN/AVG of inputs with an elapsed timer counting the time to the event.

Single quantity pricing for the Model 2880A is $199 and for the 2890 is $299. For more information, contact B&K Precision Corp., 1031 Segovia Circle, Placentia, CA 92870-7137; Tel. 714-237-9220; Web: *www.bkprecision.com.*

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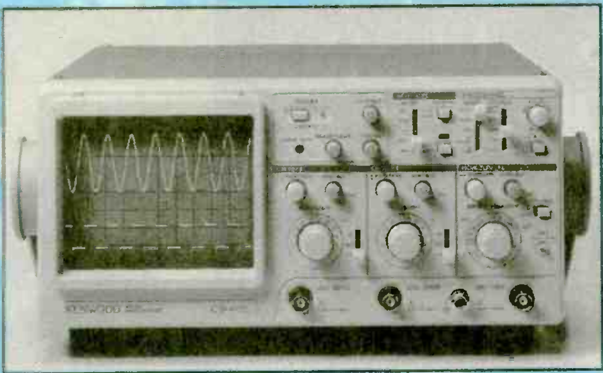

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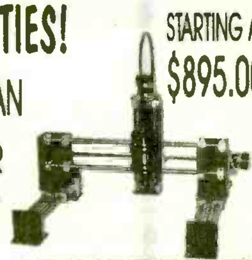

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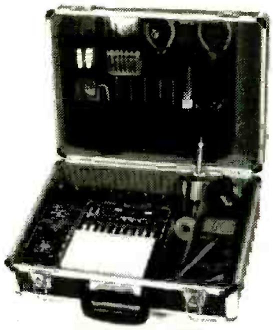

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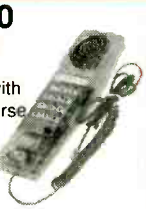

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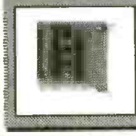

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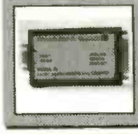

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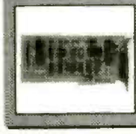

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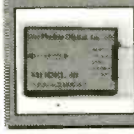

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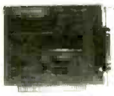

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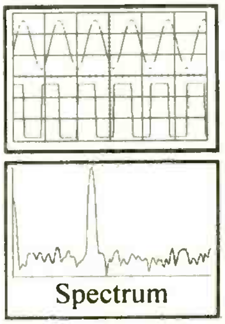

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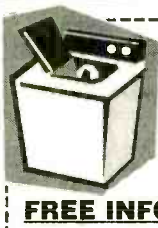

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We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but, in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $1.75 per word. Minimum charge is $26.25 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a Box number you must include your permanent address and phone number for our files. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues. **Sorry, no discounts on credit-card orders. Boldface (not available as all caps)**, add .40 per word additional. **Entire ad in boldface**, add 20%. **Tint screen behind entire ad**, add 25%. **Tint screen plus all boldface ad**, add 45%. **Expanded type ad**, add $2.25 per word.

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. POPULAR ELECTRONICS is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. NO REFUNDS, advertising credit only. No phone orders.

CONTENT

All classified advertising in POPULAR ELECTRONICS is limited to electronics items only. All ads are subject to the publishers approval. WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.

AD RATES: $1.75 per word, Minimum $26.25

Send you ad payments to:
POPULAR ELECTRONICS 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 – Antique Electronics	270 – Computer Equipment Wanted	450 – Ham Gear Wanted	630 – Repairs-Services
130 – Audio-Video Lasers	300 – Computer Hardware	480 – Miscellaneous Electronics For Sale	660 – Satellite Equipment
160 – Business Opportunities	330 – Computer Software	510 – Miscellaneous Electronics Wanted	690 – Security
190 – Cable TV	360 – Education	540 – Music & Accessories	710 – Telephone
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ADVERTISING INDEX

Popular Electronics does not assume any responsibility for errors that may appear in the index below.

Free Information Number	Advertiser	Page
—	AES	79
—	Alfa Electronics	79
—	All Electronics	89
—	Allison Technology	85
—	Amazon Electronics	88
—	Andromeda Research	71
—	Arrow Electronics	84
—	Basic Electrical Supply	82
—	Bsoft	78
32	C&S Sales, Inc.	76
—	Cable USA	80
173	Cadsoft	33
—	Circuit Specialists	79
—	CLAGGK, Inc.	7, 70
—	Cleveland Inst. of Electronics	35
—	Command Productions	78
—	Consumertronics	72
164	Dalbani	83
—	EDE Spy Outlet	87
—	Electronic Tech. Today	11, 67, 88
—	Foley-Belsaw	73
—	General Device Instruments	87
—	Global Electronics	85
—	Grantham College of Eng.	4
—	Grich RC Inc.	85
—	Home Automation Systems	87
—	ICS	80
—	Information Unlimited	84
26	Interactive Image Technologies	CV4
—	Intronics, Inc.	87
—	James Electronic Services	80
—	KDE Electronics	81
—	KNS Instruments	84
—	Lynxmotion	71
161	MCM Electronics	CV3
139	Mendelson's	84
174	MicroCode Engineering	CV2
—	Modern Electronics	85
165	Mouser	81
—	NRI Schools	19
—	PHDI	85
—	Pioneer Hill Software	80
150	Prairie Digital Inc.	78
142	Print	74
143	Print	82
—	ProPlanet	87
—	Securetek	88
—	Silicon Valley Surplus	87
—	Technological Arts	88
137	Telulex	72
—	Test Equipment Depot	81
147	UCANDO Videos	74
—	US Cyberlab	74
163	Velleman Inc.	75
—	Vision Electronics	82
—	Weeder Technologies	71
—	Zagros Robotics	85

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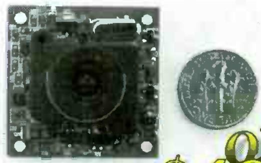

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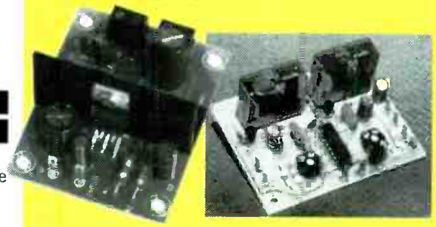

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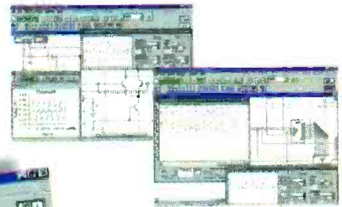

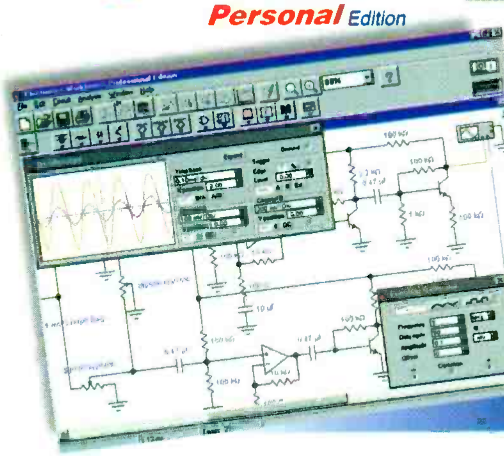

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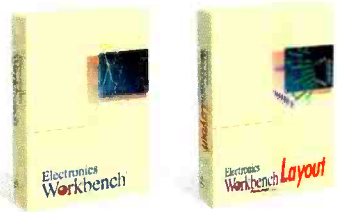

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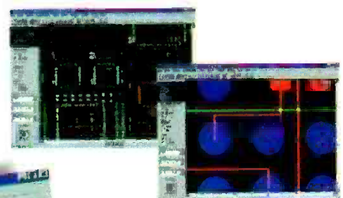

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