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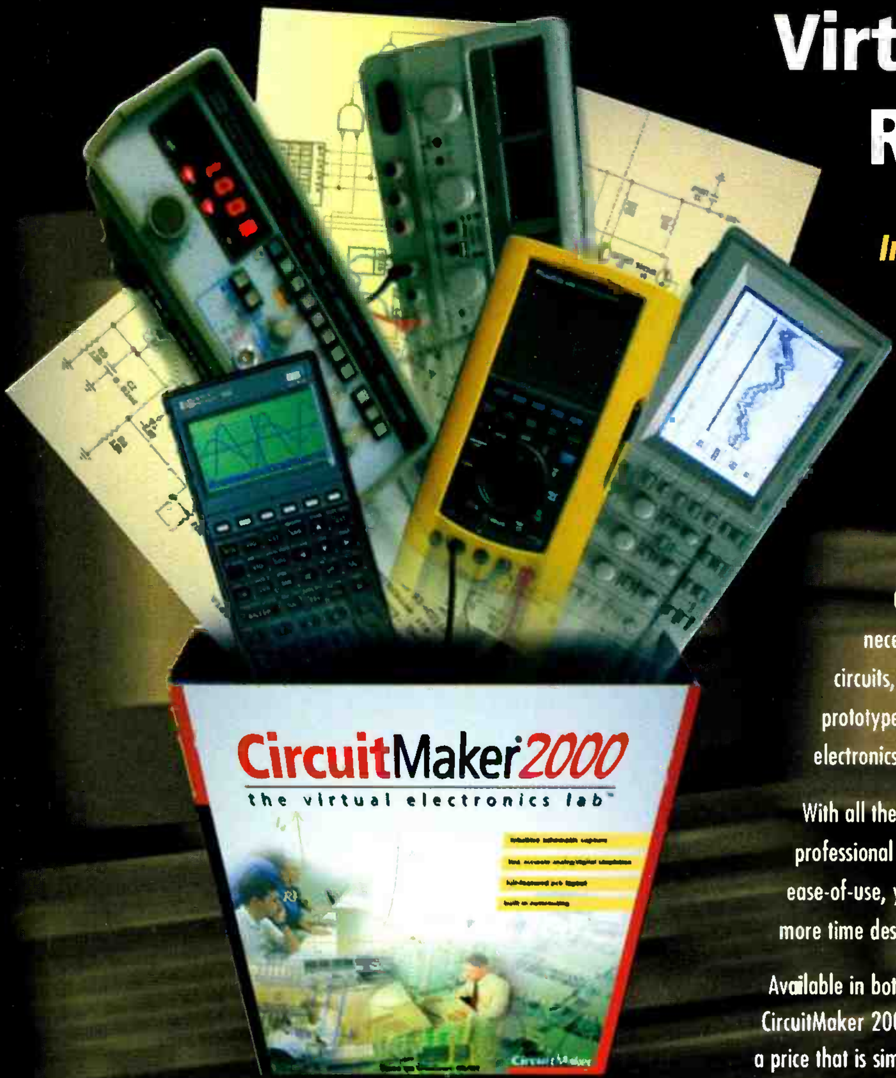

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Electronics Now

August 2000, Vol. 1, No. 8

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Copyright Tyranny

This month, I'm going to step aside and turn the podium over to Gary Shapiro, the president of the Consumer Electronics Manufacturers Association. While I only gave one small example of this escalating problem back in June, Gary takes a look at some of the underlying issues and the somewhat chilling direction that we might be heading.

So without further ado, I'll turn things over to Gary.

Joseph Suda
Managing Editor

Content (or copyright) owners and the consumer-electronics (CE) industry need each other. Hardware needs good content to sell new products. Copyright owners need consumer electronics so consumers can buy and enjoy their content.

But the two industries often have had a strained relationship. The greatest tension occurs because each new technology has been feared by content providers—yet each technology has created vast new revenue opportunities to the content community!

Think back. Movie studios argued that the TV and VCR would reduce their revenues. They fought video rentals and tried to make the VCR illegal. The music industry opposed the analog cassette, the CD, and every other new digital-audio format.

Limiting Consumer Choices
Today, Hollywood and the recording industry are fighting digital delivery of content. They are using lawsuits, licensing, and withholding of programming to pressure everyone from Website owners to hardware makers to restrict the customer's ability to receive, enjoy, or even modify programs. Thus, consumers are blocked from getting digital-TV programming and are in litigation over access to MP3.

The copyright community envisions a world where consumers pay for every use of a copyrighted work or, as we said in recent Congressional testimony, "the 'play' button will become the 'pay' button."

The threat to consumer rights and technology growth is real. The copyright lobby gives millions of dollars to politicians—much more than other groups. Twice they have successfully persuaded Congress to extend the "limited" constitutional term of a copyright. Before 1978, copyright lasted for 28 years and was renewable (after registration) for another 28 years. In 1978, the term was increased to the life of the author plus 50 years. Today a copyright lasts the life of the author plus 70 years and corporate works, or "works for hire," are protected for 95 years.

In 1995, Congress gave the recording industry the right to control performances of their records. In 1998, Congress passed sweeping legislation that allows copyright owners to lock works in technological protection measures and criminalizes the circumvention of those measures. This continued expansion of the monopoly breadth of copyright owners has not only created complex new regulatory schemes, it has increased the cost of technology, slowed the development of digital television, and kept older works out of the public domain.

Speak Out
Only rarely will a politician stand up to these copyright tyrants. Recently, Telecommunications Committee Chair Billy Tauzin (R-LA) momentarily stopped the copyright lobbying juggernaut. He said he grew up by learning from Bookmobiles, a possibility that may not exist in a future pay-per-use society. Chairman Tauzin recognized that Congress creates and expands the copyright monopoly, and as copyright owners' rights increase, the "digital divide" widens.

If politicians yield to copyright tyranny, consumers will lose their ability to gain access to information, education, and entertainment. Restrictions on technology (which can even limit fair-use rights or access to non-copyrighted works) also restrict the growth of new technologies and limit the value of broad public access.

We must be aggressive on this issue. Future generations of technology, and ultimately consumers, depend on our action.

GIZMO®

Network Walkman

The Walkman for the 21st century is Sony's *NW-E3 Network Walkman* digital music player ($330). Music files are stored on 64MB of embedded flash memory. Measuring just $3\frac{1}{8} \times 1\frac{1}{4} \times \frac{1}{2}$ inches and weighing in at 1.6 ounces (including a single AAA battery, said to provide up to five hours of continuous playback), the Network Walkman is tiny enough to fit into the change pocket of a pair of jeans. A shuttle switch lets you navigate through audio track information, with details such as title and length displayed on the backlit LCD.

The digital music player allows you to capture and collect your favorite music from the Internet or download CD tracks to your hard drive to create your own digital music collections. An hour of music can be transferred to the NW-E3 in about 90 seconds. The player comes bundled with Sony's PC-based *OpenMG Jukebox* music-management software to organize music and play lists. The player is compliant with the SDMI (Secure Digital Music Initiative) framework for secure digital music downloads.

Sony Electronics Inc., 1 Sony Drive, Park Ridge, NJ 07656-8002; 800-222-SONY; *www.sony.com*.

CIRCLE 50 ON FREE INFORMATION CARD

Pocketful of E-Mail

Receive instant messages and e-mail wirelessly with the VTech *IMprompt2* (less than $200), a handheld device that's small enough to fit in a pocket. The portable design provides easy-to-use, one-touch access to e-mail from any standard RJ-11 phone jack through *vtechworld.com*, VTech's service provider. You can opt to receive wireless notification of waiting e-mail or choose from one of several "enhanced" wireless service plans that allow you to instantly receive actual short e-mail messages (limited to 300 characters). SkyTel will provide both wireless messaging and information services for the IMprompt2. Flexible rate plans for both wireless and wire-line services will start at less than $10 a month.

The IMprompt2 features a filter to keep out unwanted e-mail and a Sender Buddy List that lets you know when you have a message from a specific sender. More than 500 e-mail messages can be stored. Other features include an address book, e-cards, a calculator, and built-in golf and arcade classic games.

VTech Industries, LLC, 101 East Palatine Road, Wheeling, IL 60090-6500; 847-215-9700; *www.vtechworld.com*.

CIRCLE 51 ON FREE INFORMATION CARD

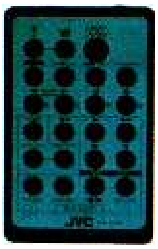
Direct-View HDTV

According to Thomson, its *F38310 HDTV* set, which measures 38 inches diagonally across its widescreen tube, is the world's largest direct-view high-definition television—and its $3999 suggested retail price makes it one of the most affordable HDTV sets yet. Available in "Venetian Suede" as *RCA F38310* and as the *Proscan PS38000*, the set is capable of displaying more than one million pixels of picture information with a 1080i scanning format. The fully integrated set allows reception of over-the-air analog and digital signals as well as built-in standard DirecTV service and high-def programming from the DirecTV satellite network. The 38-inch Performax picture tube uses a precision-focus HD resolution electron gun and .78mm-pitch Invar shadow mask to support the resolution requirements of HDTV. The set also features up to 20 watts of audio power and the Syncroscan HD component input for easy compatibility with digital cable TV boxes that use YprPb component video connections.

Thomson Consumer Electronics, 10330 North Meridian St., Indianapolis, IN 46290; *www.thomson-multimedia.com*.

CIRCLE 52 ON FREE INFORMATION CARD

Digital DualCam



JVC's *GR-DVL9800 Digital DualCam* ($1999.95) combines a 680,000-pixel progressive-scan CCD and high-band processing technologies to deliver digital images with 520 lines of horizontal resolution and 480 lines of vertical resolution. The MiniDV camcorder's progressive mode setting allows the progressive-scan CCD to capture all lines in one scan, making it possible to freeze and grab clear, sharp, full-frame still shots for transfer to a PC. A removable card stores still images.

Besides the ability to capture freeze frames, the camera's dual shooting capability provides, in effect, a separate still camera within the camcorder. It allows you to snap still pictures while recording moving images. In digital still camera mode, images can be recorded in resolutions up to 1024 × 768 pixels (XGA).

An i.LINK (IEEE 1394) in/out terminal makes it simple to download still and video images to a similarly equipped computer. Still shots can also be downloaded via a serial connection. The included image-editing and -processing software—JVC's *PictureNavigator, Presto! PhotoAlbum, Presto! Mr.Photo, Presto! ImageFolio*, and *JLIP Video Producer*—lets you transform your videos into impressive multimedia productions. A full set of analog inputs and outputs lets you re-record VHS or S-VHS tapes in DV format, and a printer port allows direct connection to JVC's GV-SP2 Digital System Printer.

The DualCam offers 2X/4X high-speed recording at speeds of up to 240 images a second, and "Pro Slow" playback at 1/8 the speed of normal playback. It's equipped with a 3.5-inch LCD monitor as well as a 180,000-pixel color TFT viewfinder. It has a 10X optical zoom for close-in shots and a 200X digital zoom for shooting from a great distance. The progressive super-wide mode is ideal for shooting a panoramic vista.

JVC Americas Corp., 1700 Valley Road, Wayne, NJ 07470; 973-315-5000; *www.jvc.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Wake-Up Call

Start your day off on the right foot with Philip's *AJ3965* CD clock radio ($89.95). Its "gentle wake" setting gradually increases the volume of the wake-up buzzer or radio station. It starts out barely audible and increases to a volume loud enough to rouse the soundest sleeper. You can select minimum or maximum volume levels, depending on how much of a jumpstart you need each morning. At bedtime, the gentle wake feature works in reverse. It acts as a sleep timer that gradually decreases the volume. The clock radio is equipped with a digital AM/FM tuner. Two separate and independent alarm settings each offer the option of waking to a CD, radio station, or the buzzer. The "weekend sleeper" function instructs the clock's alarm to sound only on weekdays.

Philips Consumer Electronics, 64 Perimeter Center East, Atlanta, GA 30346-6401; 770-821-2400; *www.philips.com*.

CIRCLE 54 ON FREE INFORMATION CARD

Music Management System for PCs

Threefifteen is an extremely powerful yet easy-to-use, desktop PC music-management system developed by Open G, L.L.C. It is an audio-file player, encoder, and digital audio-file manager that offers a total solution for managing, storing, finding, and playing digital music on a personal computer.

The history log shows all songs that have been played all the way through. Using the log, you can choose some or all music played on a single date, and add them to a queue for instant playback or to a mix for future playback.

One unique feature of the software is its search capability that makes it easy to find and queue up music by using keyword search criteria on any combination of song title, album title, genre, and song comments. Available for free download from the Web site for a 30-day free trial, the threefifteen music system sells for $19.95.

Open G, L.L.C, 1075 Broad Ripple Ave., PMB 315, Indianapolis IN 46220-2034; 317-931-1763; *www.threefifteen.net*.

CIRCLE 55 ON FREE INFORMATION CARD

Personal Computing Tablet

Lightweight and compact, the *Qbe Cirrus Personal Computing Tablet* ($4745) is a truly mobile computer. (It is an updated and expanded version of the unit we reviewed in "PC Gizmo," January 2000.) The Qbe Cirrus is barely larger than a pad of composition paper and just about as easy to carry around, weighing approximately six pounds and measuring just 14 by 10 by 1.6 inches. The first Aqcess Personal Computing Tablet with a Pentium II 400 MHz processor, it comes equipped with a 12GB hard drive, 128MB of upgradeable memory, 56K modem, and a network card. Additional tools include Internet access along with multimedia features.

TouchPen technology provides handwriting recognition, and the included software provides voice recognition. The voice command will navigate the system, create documents, and send e-mail. At 140 words per minute, the voice function is considerably faster than the most efficient typist. In addition, the digital camera allows users to take photos, shoot a video, and even videoconference. Screen images are provided on the 13.3-inch active matrix color display with resolutions up to 768 by 1024. There's also a Smartcard magnetic strip reader for identification or e-commerce purposes.

Housed in a sturdy case of magnesium, ABS plastic, and rubber, the Qbe Cirrus allows users to perform most tasks while in the field, directing the cursor with a touch of a finger. If preferred, they can plug a mouse into the PS/2 port, open the on-screen keyboard, or even plug in a conventional keyboard. A lithium ion battery allows the user to work up to two hours before plugging the unit into a wall socket or recharging the battery.

Aqcess Technologies Inc., 16800 Aston, Irvine, CA 92606; 888-818-0055 or 949-567-1000; *www.qbenet.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Invisible THX

You can enjoy THX-certified sound from speakers hidden within your walls with Atlantic Technology's *THX Ultra-certified System 20*, which includes the *System 20 LCR* front-channel satellite ($799 each) and the *System 20 SR* switchable Dipole/Bipole surround speaker ($1199/pair).

The 20 SR can be flush-mounted in a standard two-by-four studded wall with 16-inch centers. Thanks to a clever rotating and tilting midrange/tweeter baffle, the front satellites are certified for both vertical and horizontal installation. The System 20 LCR is a three-way design with a "D'Appolito" (midrange/tweeter/midrange) module that can be rotated 90 degrees. The mid-high baffle can also be tilted 5 degrees up or down to compensate for less-than-ideal placement. Front-mounted high- and mid-frequency level controls allow further tweaking of the sonic balance.

The System 20 SR THX Ultra surround speaker will normally be used as a frequency-enhanced dipole, creating a diffuse, non-directional sound field. Yet it maintains full-range output, as only one woofer operates below 200 Hz. A front-mounted switch changes the System 20 SR to bipole operation (all drivers in-phase) for those few installations where speaker placement issues defeat the benefits of dipole surrounds.

Atlantic Technology advises using its 372 PBM THX Ultra-certified subwoofer to complete a fully THX-certified System 20 installation.

Atlantic Technology, 343 Vanderbilt Ave., Northwood, MA 02062; 781-762-6300; *www.atlantictechnology.com.* G

CIRCLE 57 ON FREE INFORMATION CARD

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

JOE BLACK

mailto: netwatch@gernsback.com

Buying Cell Phone Services

If you are now sitting at the six-month point in a 12-month cell-phone service contract, you are likely to be one unhappy camper. Cellular-telephone costs have been dropping—rapidly. Probably under the terms of your existing contract, you are paying more—possibly much more—than the current-rate service would cost.

While I cannot help you get out of your current agreement, I can tell you where you can find help when it's time to find a new cell-phone service supplier. The secret is right there on the Internet. You can check out several places. I have a couple of favorites, and those are the ones we will cover here.

Before we do, I have a couple of personal suggestions. Look for a plan that does not require a contract. This way, if a lower rate comes along that suits your usage, you can switch at the end of the current month. Remember when selecting the number of minutes to check your current usage. A plan that provides 500 minutes for $50 is great—*if* you use almost all of the minutes. When you use those 500 minutes, your cost is ten cents a minute. However, if you use only 250 minutes, your cost doubles to twenty cents a minute. You don't want to cut too close to actual usage unless you first check the cost of additional minutes. You have to weigh that cost against the higher price of a plan that includes more minutes.

If you do a lot of long-distance telephoning, you need to consider those plans that include long distance at no extra charge. If you do a lot of traveling, you need to look for plans that do not have roaming charges. A slightly higher per-minute charge is worth it if you can save several dollars a day in roaming charges.

Now on to the Web!

point.com

You'll find this site at *www.point.com;* Fig. 1 shows the opening screen. As you click on through, you will find three major areas to help you. The first and what I consider the most important is the "PLAN" section. Go here, fill in your zip code or city and state, and you can look at all of the cell-phone plans that are available in your area. Then you can select the features that are important to you—no contract, number of minutes, etc. The site will help search out the plans that fit your parameters. Next, you can select a number of plans you would like to compare. That will give you a side-by-side comparison of the selected plans. I selected four plans to compare. The plan comparison I found is shown in Fig. 2. Note that only three comparisons are visible; to get to the fourth one, you need to click on the "Next 1>" button at the top right.

For an even more complete comparison, one more click is needed—"Expand to see Features" at the lower right. Once you have studied all of the

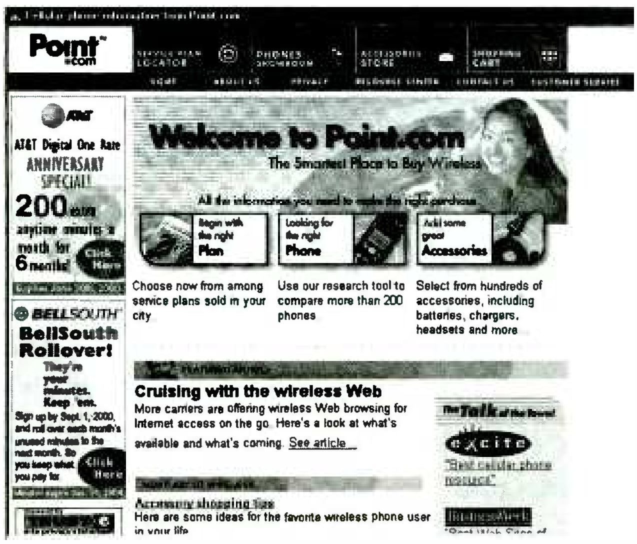


Fig. 1. Welcome screen at point.com. You'll find lots of help and many choices here.

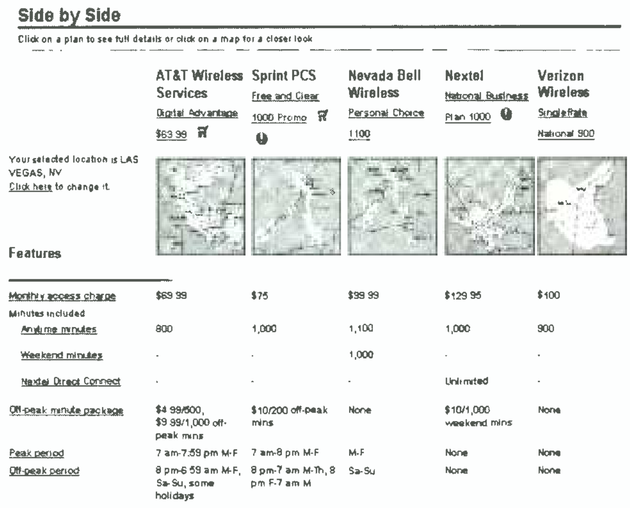
Plan Comparison

Total Plans: 4 — Next 1>

plan	AT&T Wireless	Alltel	Nevada Bell
Plan Details	Wireless $19.99 Digital	Simply Free 125 Digital Toll-Free Plan	PCS Value 650
Monthly Fee	$19.99	$29.95	$29.95
Minutes Included	60	125	150
Peak Airtime Rate	$0.40	$0.33	$0.28
Off-Peak Airtime Rate	$0.40	$0.33	$0.28
Activation Fee	$25.00	$30.00	$25.00
Contract Period	1Yr(s)	1Yr(s)	1Yr(s)
Technology	Digital Cellular (TDMA/800 MHz)	Digital Cellular (CDMA/800 MHz)	Digital PCS (GSM/1900 MHz)
Call Quality	See Map	See Map	See Map
Coverage Maps	See Map	See Map	See Map
Provider Specials	See Details	None	None
features			(Expand to see Features)

Fig. 2. Typical Plan Comparison chart created by the point.com search engine.

Fig. 3. Welcome to decide.com. Just a few more clicks and you're on your way.



Side by Side

Click on a plan to see full details or click on a map for a closer look

Your selected location is LAS VEGAS, NV
Click here to change it.

Features	AT&T Wireless Services Digital Advantage $63 99	Sprint PCS Free and Clear 1000 Promo	Nevada Bell Wireless Personal Choice 1100	Nextel National Business Plan 1000	Verizon Wireless SingleRate National 900
Monthly access charge	$69 99	$75	$99 99	$129 95	$100
Minutes included					
Anytime minutes	800	1,000	1,100	1,000	900
Weekend minutes	-	-	1,000	-	-
Nextel Direct Connect	-	-	-	Unlimited	-
Off-peak minute package	$4 99/500, $9 99/1,000 off-peak mins	$10/200 off-peak mins	None	$10/1,000 weekend mins	None
Peak period	7 am-7:59 pm M-F	7 am-8 pm M-F	M-F	None	None
Off-peak period	8 pm-6 59 am M-F, Sa-Su, some holidays	8 pm-7 am M-Th, 8 pm F-7 am M	Sa-Su	None	None

Fig. 4. Using the decide.com comparison engine, I got this screen of my five plan choices.

options, you can move on and sign up. If you need a new telephone, continue on to the "PHONE" section and then on to "ACCESSORIES." In just a half-hour or so, you will have gone through all of the possible options, phones, and accessories without having to contact or visit each cellular provider separately.

Elsewhere in this site, you will find promotional offers and some advertising. Don't let that distract you from doing the comparisons you need and selecting the service that does the best possible job for you. You never want to lose sight of the fact that the dollars you are spending are your dollars.

decide.com

When you click on through to *www.decide.com*, you see the screen in Fig. 3. Again, a variety of options and tools are available to help you find a cell-phone provider. In addition to service plans, telephones, and accessories, it is possible to select and purchase prepaid long-distance calling cards here.

In a slightly different format, you can again punch in your zip code or city/state information. Then you can examine a variety of available plans including current promotions. If you select and then compare, you'll get a screen like the one in Fig. 4. After selecting the plan, you can move on to a choice of telephones and accessories. Here, I have a suggestion. If you are going to need a new telephone, select one that has an earpiece and microphone attachment, if available. In Las Vegas, where I live, Sprint is offering their customers a free earpiece and mike add-on at no charge. It's a safety feature that provides handy hands-off usage. However, if you are not careful, people around you may think that you are talking to yourself. On the other hand, perhaps that's not so noticeable in this day and age…

HOT SITES

Point.com
www.point.com

Decide.com
www.decide.com

WINDING DOWN

Knowing the Internet the way I do, I realize that there are likely to be many other sites of use to those looking into new cell-phone providers. If you have any suggestions, pass them on to me and I'll look them over. I can add them into a future column to help other readers. Just e-mail me at the address at the top of the column.

Now back to the net; I've got three weeks to come up with another column!

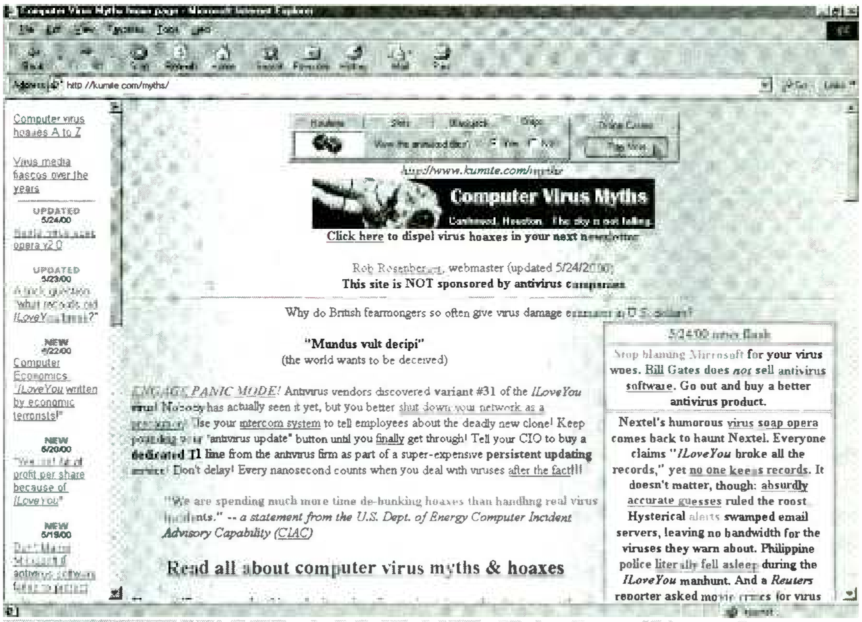
REID GOLDSBOROUGH

mailto: digitaldomain@gernsback.com

Computer Viruses and Operating Systems: Choosing Your Poison

How many times have you heard a comment like this: "My computer is acting up. It must be a virus." The truth is, most computer glitches are caused by software conflicts or "user error." Viruses do get a lot of publicity, and it's easy to see why. They have an ominous and mysterious aura. How can a machine catch a virus? Can computer viruses, like such human viruses as HIV, be deadly?

Computer viruses are simply small computer programs whose sole aim is to do harm. They're written by disturbed individuals, the kind of sociopaths who indiscriminately slash tires or poison bottles of Tylenol. Like human viruses, computer viruses can replicate, spreading like a disease from one computer to another through shared floppy disks, infected CD-ROM discs, or over the Internet.



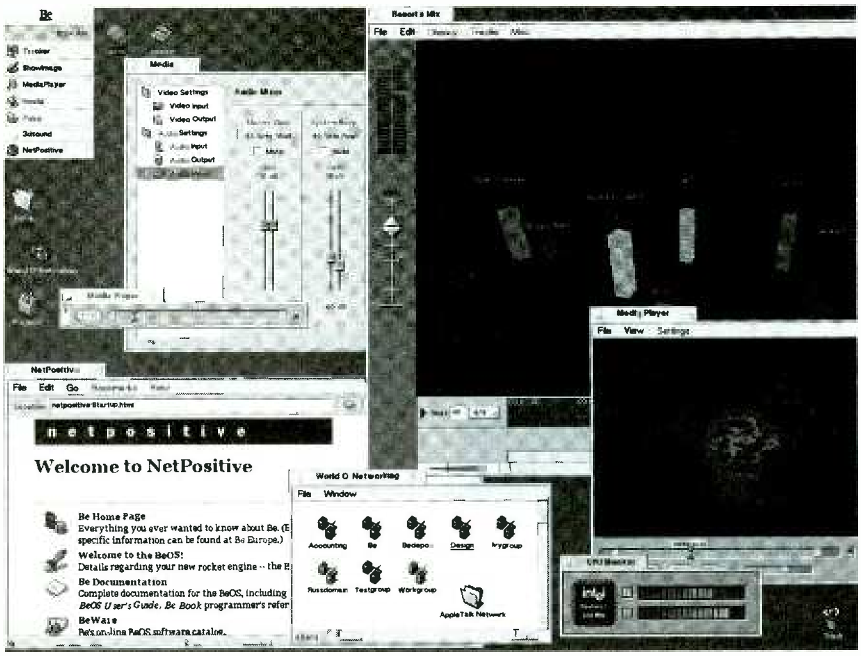
Several Web sites, such as this one, tell the tales behind some of the more well-known virus hoaxes.

Some viruses—more hoaxes than true viruses—are innocuous, doing no more harm than scaring people with a message flashing on their screen that reads "Gotcha!" Other viruses can destroy all the data on your hard drive. Computer viruses can't harm your hardware. The first line of defense, as with every potential computer disaster, is to make regular backups of the vital data stored on your hard drive and to ensure that the backups themselves are reliable.

The next safety step is to consider using antivirus software. Some people suspect that new viruses are created and spread by the very companies who develop antivirus programs. After all, there's a lot of money to be made here. Sales of antivirus software are over $100 million a year, according to market research firm PC Data. According to Ziff-Davis' *Market Intelligence*, five of the ten top-selling utility programs are antivirus packages.

Virus-protection developers do what they can to keep viruses in the mind of the public. A survey by the National Computer Security Association indicated that 99.33% of medium and large organizations in North America have experienced at least one virus infection, and that every year on average four out of every ten computers in these organizations become infected. That sounds dire indeed. But who paid for the survey? Virus-protection companies.

It should be pointed out that the National Computer Security Association includes as one of its aims the promotion of ethical practices among



BeOS, from Be, Inc., is an alternative operating system to the one that came bundled on your machine.

virus-protection companies. There's no evidence that a virus-protection company has ever let loose a virus it was studying in its labs. What's more, despite the sensationalism, investing in an antivirus program is still a prudent course of action if you do a lot of program downloading or otherwise try out lots of new software—especially if several people have access to your PC, or if your PC is part of a local-area network. Whether you buy an antivirus program or not, don't become paralyzed by fear of viruses.

Some people avoid the Internet entirely for fear of catching a virus. A few words of reassurance: There's virtually no chance that your computer can become infected by reading e-mail messages. Viruses, as programs, must be run, or "executed," to do their damage and simply reading an e-mail message doesn't run anything except the programs you already have on your system. The situation becomes more complicated with e-mail attachments. These appendages to e-mail messages can potentially include "macro" viruses, which can infect your system and are the fastest growing type of virus. However, you have to initiate action beyond just reading the e-mail message, such as clicking on the attachment with your mouse, for these mini-programs to do their dirty work.

WHAT CAN YOU DO?

Fortunately, you have protection here as well. The latest versions of antivirus programs include protection against macro viruses. To be on the safe side, many people simply delete e-mail attachments, particularly if they come from someone they don't know. Even if they seem to come from someone you do know, it can be a good idea to phone the sender to verify this, since some viruses can play tricks here. You might have been sent an infected attachment without the sender even knowing it.

It's theoretically possible for your system to become infected with a virus by visiting a Web site whose creator coded in land mines in the form of malicious Java applets or ActiveX controls, but there have been no reports of such sites. If one did appear, it would be shut down quickly.

Along with curtailing your activities, the threat of viruses can also make you scramble needlessly. If you receive an e-mail message warning about a hideous-sounding virus, it might be a hoax. The U.S. Department of Energy has created a Web page at *ciac.llnl.gov/ciac/CIACHoaxes.html* that describes virus and other Internet hoaxes. Another good virus hoax site is Computer Virus Myths at *kumite.com/myths*. Still, virus infections do occur, and they can cause considerable damage. *Norton AntiVirus* is the best all-around antivirus program, though *McAfee VirusScan* has many loyal supporters as well. Both cost less than $50 for the single-user versions.

Finally, be careful out there. Download files only from reputable Web sites or FTP file repositories. Avoid "pirate" sites and the "Warez" newsgroups where people illegally trade commercial programs. These files are more likely than others to be infected with viruses.

POINT AND CLICK

BeOS
www.be.com

Computer Virus Myths
kumite.com/myths

Corel Linux
linux.corel.com

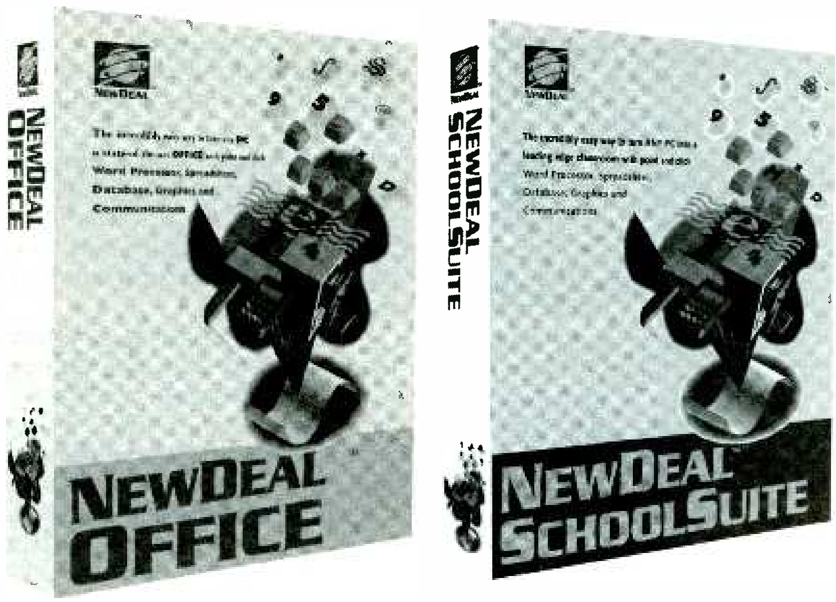
Department of Energy Virus Hoaxes
ciac.llnl.gov/ciac/CIACHoaxes.html

Microsoft Windows 2000
www.microsoft.com/windows2000

NewDeal
www.newdealinc.com

OPERATING SYSTEMS UPDATE

The recent release of Windows 2000, the successor to Microsoft's business-oriented Windows NT, is forcing many people to look again at their operating-system strategy. Whether you use a personal computer at work or home, its operating system affects your choice of software and hardware peripherals, your ease in loading programs and managing files, and your computer's resistance to crashes and security breaches. If the central processing unit, or CPU, is the heart of your machine pumping out data, the operating system, or *OS*, is the brain determining where data should go. Here's a run-down on the state of



NewDeal is a combination suite of applications and operating system that can run on a 10 MHz '286 with only 640K of memory. The SchoolSuite has the ability to network together—perfect for that mountain of ancient systems collecting dust in the closet.

today's operating systems.

Windows 2000—This is Microsoft's best attempt yet to bring the enhanced stability and security of Windows NT to the masses. Windows 2000 (*www. microsoft.com/ windows2000*) still doesn't match the stability and scalability of many Unix-based systems, but it's a good upgrade for most users of Windows NT 4.0, with an easier-to-use interface and support for USB peripherals, DVD drives, and Plug-and-Play upgrading. It's not a good choice for most Windows 98 or 95 users. Despite compatibility improvements, Windows 2000 may not support all of your programs or peripherals. You need a relatively recent computer and at least 64 megabytes of memory to run it effectively. It's also expensive, as are all Microsoft OSs—one of the few software categories that hasn't dropped in price over time.

Windows Millennium—For most people, the successor to Windows 98 will be a better upgrade. Windows Millennium, abbreviated as Windows ME, is scheduled for release later this year and will improve support for the hottest new technologies, such as the Internet audio format MP3, digital video editing, and home networking. Reports from beta testers, however, indicate that Microsoft may remove some business networking features from Windows ME that exist in Windows 98 and 95; they allege that it's an attempt to force business users to upgrade to the more expensive Windows 2000. When it comes to Microsoft operating-system upgrades, the best decision can sometimes be to wait to upgrade until you buy a new computer that comes preinstalled with the new OS. This saves time and money and avoids potential upgrading glitches.

Linux—Microsoft may be the OS Goliath, but there are a few Davids out there, slingshots in hand, with the U.S. Justice Department keeping a benevolent watch on them. The most promising is Linux, the Unix-like OS once strictly for geeks but now moving slowly toward the mainstream. Corel, the Canadian company behind *CorelDraw* and *WordPerfect*, is now distributing Corel Linux (*linux.corel.com*), an easier-to-use version that looks like Windows 98. More Linux software is available, including Corel's own *WordPerfect for Linux*, though the selection is still dwarfed by the available Windows titles. You also may have problems getting all of your peripherals to work with Linux systems. Linux is commonly used as a midrange server OS for delivering data and programs over networks. Never-theless, it will likely show up in the future in more budget-priced computers as well as Internet appliances—inexpensive computer-like devices specifically for connecting to the Net.

Low-Cost Darkhorse—Two other inexpensive, upstart OSs, less widely known than Linux, are BeOS and NewDeal. BeOS (*www.be.com*) is available as a free download for individuals and, like Linux, will be bundled with some Internet appliances. BeOS was originally the OS for a custom-designed PC (*not* an IBM clone that we usually associate with the term). When Be found that selling hardware was a money-losing proposition, they targeted their OS to Apple Macintosh users. When Apple backed out of negotiations to buy it, Be shifted focus. Be customized the latest version of BeOS for Windows 98 and 95 users. Unlike Linux, you can use BeOS without having to create a separate partition on your hard disk. Still, unless you use it with an Internet appliance, it's a tool mainly for multimedia experimenters.

NewDeal (*www.newdealinc.com*) can be a good choice if you have a '286 clunker that's headed for a landfill. The product, created by the people behind GeoWorks, a former Windows competitor now used primarily in wireless devices, is a new graphical OS designed for old PCs. Its minimum requirements are just 640 kilobytes of memory, a 10-megabyte hard drive, CGA graphics, and DOS 3.0.

Old Soldiers—Once heralded as the successor to DOS, IBM's OS/2 is still around, but it's not being actively marketed or upgraded anymore and is used mainly by IBM's corporate customers. Finally, with its legion of loyal followers, the eminently usable Mac OS continues to improve. Mac OS 9, though still available only for Macs, makes it easier to conduct an Internet search and helps different people using the same Mac keep their desktop and Internet settings separate. **P**

LETTERS

mailto: letters@gernsback.com

Socket To Me

I noticed an error in the article "The PIC Replicator" (**Poptronics**, May 2000) on page 37 regarding information on the PIC Replicator's "Socket Farm."

The error begins in the second sentence of the third paragraph. The text indicates that socket SO1 serves the 18-pin and 28-pin devices and that socket SO2 serves the 40-pin and 8-pin devices. An examination of the PC board and the schematic (which agree) would suggest that the reverse is true. Socket SO1 serves the 40-pin and 8-pin devices, while socket SO2 serves the 18-pin and 28-pin devices. I don't believe that construction and use of the PIC Replicator would be adversely effected, but readers could be confused just the same.

Also, unless I just missed it, the article didn't indicate how to position pin 1 of each device to be programmed in the respective 48-pin socket (SO1 or SO2). That too might be helpful to some readers. As always, this project is great, and I will be building and using it soon.

THOMAS SADDLER
via e-mail

[You are, of course, correct in that the designation in the text for the PIC Replicator got SO1 and SO2 backwards. Thanks for pointing that out.

While we didn't specifically say where to put the target chips when programming them, the schematic diagram on page 30 shows the relationship between the pins of the chip being programmed and the socket's pins. For example, if you were to program an 8-pin PIC, the schematic shows that you would use SO1; pin 1 of the PIC would be inserted into pin 21 of the socket.

If you buy an etched PC board from the source given in the Parts List, it comes with a silk screen that indicates where the target PICs should be inserted. You can see that somewhat in the photograph on page 39.—Editor]

PIC Replicator Update

An updated version of the PIC Replicator software (**Poptronics**, May 2000) is up on the *www.edtp.com* site.

PETER BEST
via e-mail

Errors Detected

Joseph Carr's article "Non-Linear Configurations For Linear ICs" (**Poptronics**, June 2000) on "op-amp rectifiers" was interesting, but a few items seemed incorrect. I know that Mr. Carr has written many books and articles, so I expect that some of these things occur when an article is prepared for publication.

- On Fig. 3, the current flow convention for I4 (in D4) was opposite to all others.
- On p. 47, the inverting amp gain formula mysteriously changed to 2Rf/Rin (from the correct version: Rf/Rin).
- Same area: D2's voltage drop "is about 10.6 to 10.7 volts" should, I believe, read "about .6 to .7 volts."
- Below Fig. 7, the filter description should read "—that has a LONG enough time constant —"
- Dead-band circuits: The author did not show any; I was looking forward to a short piece on Schmitt triggers here.

One small point: the term "voltage follower" is usually reserved for UNITY GAIN, NON-INVERTING amps, typically used as buffers to drive filter sections, or to provide a high input impedance to avoid loading previous stages, or a circuit under test.

Notwithstanding these points, I enjoyed the article. I greatly enjoy **Poptronics**, and was a **Popular Electronics** subscriber as early as the 70s. Keep up the great work.

BRIAN KELLY
North Bay, ON, Canada

KEEP IN TOUCH

We appreciate letters from our readers. Comments, suggestions, questions, bouquets, or brickbats ... we want to hear from you and find out what you like and what you dislike. If there are projects you want to see or articles you want to submit—we want to know about them. And now there are more ways than ever to contact us at **Poptronics**.

You can write via snail mail to:

Letters
Poptronics
275-G Marcus Blvd.
Hauppauge, NY 11788

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.

The e-mail address can be found at the top of the column.

Of course, e-mail is *fast*.

Check your favorite columns, too. All of our columnists can be reached through the e-mail addresses at the head of each column.

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

Sorry Wrong Number

There was a typographical error in the telephone number for Sensory, Inc. in the "New Gear" column in the June issue. The correct number should be 408-744-9000. All the rest of the company information is correct. Our apology for any inconvenience this error may have caused our readers, Sensory Inc., and the neighboring bakery that is getting inquiries for a speech recognition kit.—Editor

Out of Business

We have been advised that Allegro Electronic Systems that was mentioned as the source for the ferrite core step-up transformer in the article "High-Voltage Generation" in our June issue is no longer in business.

We always validate our parts sources at the time the article is edited, but unfortunately we cannot guarantee its availability when the magazine gets to the readers.—Editor

Information Please

I can find nothing on the step-up transformer (T1) in the "Amazing

Science" column on the Geiger Counter (**Poptronics**, March 2000). Please provide more information.
RICHARD NELSON
Phoenix, AZ

[We asked John Iovine that question when preparing the column for publication. He did respond before our deadline, but his e-mail got stuck in the gernsback.com mail server's "bit bucket" and was never forwarded to the editorial office network. The information follows: part number–TR-02, turns ratio–57:1, DC resistance, primary–3.3 ohms, and secondary–117 ohms.—Editor]

Robots Rule

No question about it. **Poptronics** definitely has something for everyone who is into electronics! I have subscribed to **Radio Electronics**, **Electronics Now**, and now **Poptronics** since I was 13 years old. Even though I am now 26, it is still exciting when the magazine comes in the mail.

I am especially excited about the new addition "Robotics Workshop." With the ever-growing craze over robotics (myself included), this column will definitely be of great interest. I am looking forward to many more great robotic tips and ideas.

Keep up the great work!
BOBBY JACKSON
Roebuck, SC

What is a Synchro?

The "Tech Musings" column on synchros, selsyns and accelerometers (**Poptronics**, May 2000) calls the synchro a three-phase system. It is not. A three-phase system has at any instant three identical voltage amplitudes differing in phase by 120 degrees. The voltages in the synchro system are never equal and at any instant add to zero. They are in fact three single phase voltages, which are either in phase or 180 degrees out of phase with each other.

The term Selsyn is a Sperry trade name, as are Autosyn for Bendix, Telesyn for Ford Instrument Co., and many others. The British call them Magslips.

I enjoy your magazine very much and look forward to many other thought-provoking articles.
DON BURNS
Comox, British Columbia, Canada

More on Midi Materials

Michael Covington in his "Q&A" column (**Poptronics**, May 2000) in the item on Midi Materials seems to have overlooked the ad on page 66 of the same issue: *Advanced MIDI Users Guide* (Catalog # PCP114) from Electronic Technology Today, Inc.

Also, *The Midi Manual* is an excellent source, although there is a typo on page-21, figure-2.13, where the code for "Note-Off" is incorrect. Aside from that it's an excellent book. It is available in most book stores, music stores, and some electronic stores.

There's also a group of MIDI-based equipment manufacturers, a kind of consortium. They would be the best source of MIDI info. After all, it's their standard.

Happy hunting.
PARTEV SARKISSAN
via e-mail

[The moral of the story is check our advertisers first.—Editor]

Kirlian Comment

I have an interesting note in relation to the Kirlian photography effect, the subject matter of two columns of "Amazing Science" (**Poptronics**, May and June 2000). The spring issue of *21st Century Science & Technology* (*http://www.21stcenturysciencetech.com/*) has an interview with a Russian biologist, Vladimir Voeikov, who said that Konstantin Korotkov reported to the Gurwitsch Conference the use of the Kirlian effect in Tbilisi, Georgia to diagnose cancer with a 95% accuracy.
WES GORDON
via e-mail

A Job Well Done

My compliments on the fine editing of my manuscript, "Two Simple Zener-Diode Testers" (**Poptronics**, May 2000).

However, I did notice some items that might cause a reader some confusion. On page 43 and page 44, "microammeter" should be "milliammeter" since, although it is technically measuring microamps, the current level is beyond most standard microammeters; a milliammeter is a safer bet. This is, of course, a minor terminology correction.

However, the reference to a dual-trace oscilloscope might keep many readers from building these testers. Actually, a regular single-trace scope that has a horizontal input can be used in the same manner. I've used two old single-trace scopes this way; and most old scopes have an "H" input, which can be selected by the sweep control.

It is a pleasure to see my work in your magazine.
FRED BLECHMAN

[In spite *of the misteaks, we hope...oops...—Editor]*

Car Talk

I strongly agree with Tony Neiburg's letter (**Poptronics**, April 2000). We would profit greatly by automobile electric/electrical articles. We need information such as how sensors work and can be tested, what function(s) they perform, and what results when they don't work properly.

Even if today's cars are so complicated that some faults require computer analysis, this is worthless in the hands of someone without the basic knowledge of the automobile system's operation. Also, many troubleshooting procedures don't require any more than a DMM.
FRANKLIN SWAN
Paw Paw, IL

Haves & Needs

I have a 1920 Crosley 1-tube regenerative receiver that uses the type 0/A tube. The volume control rheostat does not have the resistance wire wound on it. I intend to rewire this resistance, but I don't know the wire diameter nor what the total resistance of the rheostat was before the wire was removed. (I bought this set at a yard sale.)

I would sure appreciate this information.
LESTER S. HAUGSDAL
105 2nd Avenue SW
Choteau, MT 59422

TED NEEDLEMAN

PEAK COMPUTING

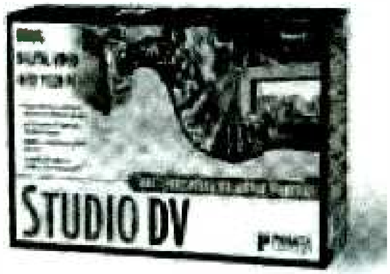
mailto: peakcomputing@gernsback.com

SETTING YOUR PC ON FIREWIRE

Long before there were even PCs, computer scientists were well aware that one of the greatest limitations to computer system performance wasn't processor speed, but input/output (I/O) and internal bus speed. Moore's Law, postulated by Intel founder Gordon Moore, predicted that component microprocessor density would double every 18 months. That's proven fairly accurate, but there's no equivalent prediction, or improvement, in the way data moves in and out of the system.

The real problem in this area isn't technology—we can make much faster interfaces than we can currently employ, and vendors often do construct these for special purposes. What slows down interface speeds are cost and standards. PC vendors have to have a compelling reason to add more components to their motherboards, while peripheral vendors need assurances that enough PCs will have a new interface to make it worthwhile to incorporate into their products as well.

The last interface to face this test was USB, or the Universal Serial Bus. It started off slow and has taken a few years, but USB is fast becoming truly universal. The original versions of Windows 95 didn't support USB at all, though the service releases of this operating system added supplemental support for the interface. With the release of Windows 98, however, USB support was completely integrated into the operating system. Plug a USB peripheral into a USB port, and Windows 98 usually finds it and looks for a device driver.



Studio DV *from Pinnacle transfers full-screen full-video from your digital camcorder to your PC. This high-speed interface is a generation above the USB.*

That's worked out well, and you'll now find at least one USB port on most desktops, laptops, and even Apple's Macintosh computers. On the other side of the usage equation, peripheral vendors are incorporating USB interfaces into printers, scanners, and even digital still cameras. For the most part, everyone is very happy with the way USB has turned out.

NEED MORE SPEED

That "for the most part" is the real kicker. While USB is easy to use and can support up to 127 USB devices on a single PC, it has one limitation that's becoming more evident and annoying the more popular the interface becomes—speed. USB was originally developed to provide a higher-speed interface than those currently in use. Although it's done just that, the data transfer speed hasn't kept up with the growth in data-transfer requirements. Consider the output to an inkjet printer. Several years ago, printer resolution was in the neighborhood of 300 dpi. Today, average print density has jumped to 1200 dpi or higher, and new inkjets from HP and Lexmark boast 2400 by 1200 dpi. Printing at that high a resolution takes a lot of data, and the interface speed really does begin to put a crimp in system throughput. Similar situations exist when you're scanning at high resolution or downloading image or video files.

Current USB interfaces top out at about 1.5 MB/sec. That's really fast compared to the parallel port's speed of 0.115MB/sec. USB version 2 ports are expected to start showing up in equipment this year, and they double the USB transfer rate to 3 MB/sec. Unfortunately, that just doesn't cut it when you're trying to use one of the new consumer camcorders that record the image digitally, rather than in analog format.

FIREWIRE INTERFACE

Apple Computer came up with the answer several years ago—a very fast serial type of interface that it called *FireWire*. Apple often doesn't get much of the credit it deserves for the technical innovations it's introduced over the years. From the first Macintosh, Apple standardized on the SCSI interface for its hard disk drives. This interface not only set a level of high performance on disk operations, but enabled the easy connection of image scanners, which were SCSI-only devices when they were first introduced to the consumer market.

After Apple developed and introduced its FireWire interface in the Mac, it submitted the specifications to the IEEE. The specifications were published to the industry, and after the politicking and other special interest infighting that usually happens when trying to get a standard established, the Institute finally issued the IEEE-1394 interface standard. Apple's current FireWire interface meets this standard, and the industry as a whole frequently uses Apple's FireWire term to refer to the IEEE-1394 interface.

The IEEE-1394 is a serial interface, in that data is sent over the bus in sequential bits. It even looks a bit like a USB port; while the connector is almost the same size, it is shaped slightly different and polarized so that the cable can only be inserted correctly.

Where FireWire/IEEE-1394 really shines is speed. The absolute transfer speed depends upon the precise implementation of the port, but the maximum speed (which is what vendors usually talk about) is up to 50MB/sec. That's not just a bit faster than even the new USB2 standard, but a *lot* faster.

With this type of data throughput, it's likely that many of the vendors that now support USB on their peripherals will also start to bring out versions with an IEEE-1394 interface. The biggest problem is the same one that slowed down the adoption of USB—not many PCs sport IEEE-1394 ports.

That's changed a bit recently. Many large-screen laptops, those with 14 or 15-inch displays, have added an IEEE-1394 port. And most of Compaq's Presario line now sport two IEEE-1394 ports—one on the front panel of the PC and the other on the rear panel. Sony has also adopted the IEEE-1394, calling theirs an *iLink* port and adding it to almost all of its VAIO models.

The largest incentive to add an IEEE-1394 port to your PC is that it's almost a "must-have" if you've purchased, or intend to purchase, a digital camcorder. Many of the consumer-grade digital camcorders, like the Canon Optura, also will output video in S-Video analog format. If, however, you plug the camcorder into an IEEE-1394 port, not only is the video downloaded much more rapidly, but you can use software on the PC to edit video in the camera, as well as control the camcorder from your PC.

Evergreen Technologies produces this fire*Line PCI card that provides high-speed data communications between your computer and up to 63 peripherals.*

BUYING THE BUNDLE

Adding IEEE-1394 FireWire capability to your PC is one of the easier upgrade projects you can undertake. You will, however, need at least a Pentium CPU in your system because both an open PCI expansion slot and overall system performance are needed to support the level of performance that a FireWire peripheral provides.

It's also a good idea to be running Windows 98. Windows 95 wasn't really designed with IEEE-1394 support in mind. Like USB support, if you can get a FireWire port running under Windows 95, it won't be nearly as stable as it will be under Windows 98. In fact, some vendors state Windows 98, Windows NT, or Windows 2000 as a requirement. If your PC meets these requirements, adding IEEE-1394 is as easy as opening up the case, plugging in a PCI card, and installing the requisite drivers when Windows 98 finds the new hardware.

VENDOR INFORMATION

Adaptec, Inc.
691 South Milpitas Blvd.
Milpitas, CA 95035
408-945-8600
www.adaptec.com/products

Evergreen Technologies, Inc.
808 NW Buchanan Ave.
Corvallis, OR 97330
541-757-0934
www.evertech.com

Pinnacle Systems, Inc.
280 N. Bernardo Ave.
Mountain View, CA 94043
800-474-6622 (800-4PINNACLE)
www.pinnaclesys.com

IEEE-1394 interface cards are available from a growing number of sources. Adaptec offers a *HotConnect 8920* card with three IEEE-1394 ports on it. The HotConnect operates at 25 MB/sec. As with all IEEE-1394 interfaces, the card can support up to 62 devices by daisy chaining them together (plugging one IEEE-1394 device into another, with at least one of the devices plugged into the interface card).

Evergreen Technologies, best known for its line of CPU upgrades, also now offers an interface card it calls *fire*LINE. The *fire*LINE card also provides a trio of IEEE-1394 connectors and for under a hundred bucks even includes an IEEE-1394 cable. Evergreen Technologies will also be offering a PCMCIA card version of the interface for laptop owners who want to add this capability. Evergreen has a vested interest in promoting IEEE-1394; it already is shipping an external FireWire hard disk drive and has a FireWire CD-RW drive in the works.

Depending on the applications that you intend to run, you may want to purchase just the interface card, as above, or a bundle containing a card and software. Since the most common application requiring IEEE-1394 capability is video editing from a digital video source, a number of popular software applications already contain FireWire support. These include the latest version of Adobe's upscale *Premiere*, as well as the more affordable MGI *VideoWave III* and Ulead's *Video-Studio 4.0*. Add one of the cards and a digital-video source, and you're ready to go.

For this month's upgrade, however, we selected a complete bundle from Pinnacle Systems. The vendor's *Studio DV* is a complete digital-video-editing solution, priced at an affordable $199. The interface card installs easily—it just plugs in—and an automated installation process on the CD-ROM installs the required drivers and *Studio DV* software. Unlike the two IEEE-1394 cards detailed above, the interface card in the *Studio DV* package has only

(Continued on page 63)

A Hands-on Electronics® REPORT

Keyspan 4-Port USB Hub

It's easy to add USB ports to any computer with this inexpensive little device.

If you are using a new PC or Mac, it's more than likely that there is a USB (Universal Serial Bus) jack on its rear panel. This port is a boon. To it, you can connect a variety of new peripherals. I have an HP scanner, an HP color-inkjet printer, and an Iomega Zip drive connected there. However, to do that, I needed to expand the single port. My solution was to obtain a Keyspan *4-port USB Hub*.

Before going further into the hub itself, let me tell you about one little trick it has made possible. Before I got the color inkjet printer, I was—and still am—using a Panasonic laser printer. I still have that printer connected to the regular printer port. Now it's a cinch to select the desired printer right from the Windows Print menu, with no switch box to deal with.

Piled Higher and Deeper. If four USB ports are not enough, you can add more hubs. You can add as many as four 4-port hubs in succession. Therefore, you can end up with 3+3+3+4 or 13 USB ports. If you cascade hubs, any hub that is downstream from a bus-powered hub must be used in its self-powered mode (more details about that later). However, the more devices that you attempt to use at the same time, the slower the connection. In my case, I never use any of the three devices that I have connected at the same time, so it makes no difference at all to me. If I were to print a long document while using my scanner, it would work; both the printer and scanner speeds would be somewhat reduced. How much depends on the specific actions being performed.

My Keyspan hub is housed in a small, somewhat transparent tangerine-colored box that measures a mere $4^1/4 \times 3^1/2 \times 1$ inches that

you can tuck in just about any little corner. They do come in a wide spectrum of seven different colors; you're bound to find one that suits your tastes.

Installing it was a cinch. After taking it out of the box, I plugged the cable that comes with it between the computer and the hub, connected the power supply, and my computer running Windows 98 told me "new hardware detected." A few moments later, it found and installed the software. With the three peripherals plugged in, it was up and running.

Supplying Power. An important point here is that the Keyspan hub offers you two different power modes. You can run it as a powered hub (with a power supply plugged into the wall) or you can run it unplugged and let the hub draw its power from the USB port. Of course, you will have to find a place to plug in the little power supply if you want to use it. As a self-powered hub, each downstream port gets 5 volts DC at 500 mA. If it is not plugged in, only 100 mA is available to the peripherals. As I mentioned earlier, if you cascade hubs, any hub that is downstream from a bus-powered hub must be used in its self-powered mode.

All devices connected to the hub are connected via a USB device cable. Full-speed devices (printers and scanners fall into this category) are restricted to a maximum cable length of about 16 feet (5 meters). Low-speed devices (mice, keyboards, joysticks, and most adapters—USB-to-serial, USB-to-parallel, and USB-to-Ethernet) restrict cable length to about 10 feet (three meters).

There are six LEDs on the top of the hub. Two of them are red. One lights when the hub is operated in its self-powered mode. Both stay dark if the hub operates in the bus-powered mode. The four port LEDs turn green as soon as the hub has registered on the USB.

Problems, Problems. I haven't had any problems with the hub, but problems do come up from time to time. Most of them can be cured by disconnecting the hub from its power source for a moment—just unplug and replug the power supply. If one of the devices that you have connected to the hub does not operate as it should, here are some things that you can try: Check to see that the cables are securely connected—you'd be surprised how often a cable manages to work itself loose; also, the hub or the device may have created a power over-limit condition. Usually your computer will alert you to this kind of problem.

Keyspan maintains support for its products. You can go to *www.keyspan.com* on the Internet, or during normal business hours, Pacific Time, call 510-222-8802 and ask for technical support. By the way, this $39 device comes with a five-year warranty.

The Keyspan device works for me. If you need a USB port, take a look at it. For more information, contact Keyspan at either *www.keyspan.com* or write to Keyspan, a division of InnoSys, Inc., 3095 Richmond Parkway, Suite 207, Richmond, CA 94806 or circle 80 on the Free Information Card.

Prototype

"Faster Than a Speeding Bullet"

New polymers developed by chemists and engineers at the University of Washington (UW) and the University of Southern California (USC) appear to achieve speed and capacity increases so great that they will revolutionize telecommunications, data processing, and sensing and display technologies.

The materials are used to create polymeric electro-optic modulators, or "opto-chips." These microscopic devices perform functions such as translating electrical signals—television, computer, telephone, and radar—into optical signals at rates up to 100 gigabytes per second (a gigabyte is 1 billion bytes). Polymeric electro-optic materials can achieve information-processing speeds as great as ten times those of current electronic devices and have significantly greater bandwidths than electro-optic crystals currently in use. In addition, the new materials require a fraction of a volt of electricity to operate, less than one-sixth of what crystals require.

New polymers that are being developed appear to achieve great speed and capacity increases. Larry Dalton, a chemistry professor at both the University of Washington and the University of Southern California, is the overall research leader in this area at both universities.

Real-Time Communications

"These electro-optic modulators will permit real-time communication. You won't have to wait for your computer to download even the largest files," said Larry Dalton, a chemistry professor at both UW and USC, who is the overall leader of the research and has full research teams at both universities.

The breakthrough resulted from research by Dalton; William Steier, a USC electrical engineering professor; Bruce Robinson, a UW chemistry professor; and USC graduate students Cheng Zhang and Hua Zhang. (Their work is described in the April 7 edition of *Science*.)

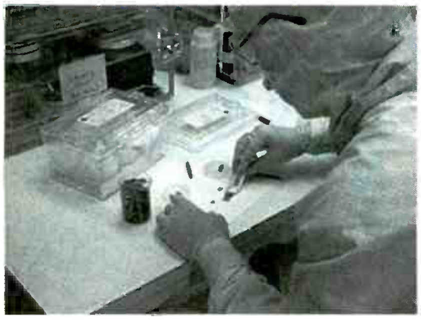
Technology With Bandwidth to Burn

Polymeric electro-optic modulators can be used for information processing, to steer radio waves and microwaves to and from telecommunications satellites, to detect radar signals, to switch signals in optical networks, and as optical gyroscopes to guide planes and missiles.

They serve as a bridge between electronics and fiber optic, providing huge capacity with very low noise disturbance and very low power requirements. They are being tested for ultra-fast analog-to-digital conversion, optical switching elements in flat-panel displays, and voltage sensing for the electric utility industry, Dalton said. Currently, the most commonly pursued applications include signal transducers for cable television, directional couplers or routing switches in optical communications networks, and modulators in phased-array radar systems.

"It's a critical decision-determining technology because bandwidth, bandwidth, bandwidth—like location, location, location in real estate—is critical in making decisions in communications technology," Dalton said.

"This technology has bandwidth to burn."



A researcher works with the polymeric electro-optic modulators or "opto-chips" in a clean room.

Testing and Applications

During testing at Tacan Corp. in Carlsbad, CA, two other co-authors of the *Science* article—lead author Yongqiang Shi (now of Lucent Technologies) and James Bechtel—used the devices to translate electronic cable television signals into optical signals using less than one volt of electricity. Researchers at Lockheed Martin Corp.'s research laboratory in Palo Alto, CA have since replicated those results in tests involving other applications.

Tests indicate that a single modulator measuring one micron (about .000039 inch) can provide more than 300 GHz of bandwidth—enough to handle all of a major corporation's telephone, computer, television, and satellite traffic.

Other applications are so far ranging, Dalton said, that they even create the capability of full three-dimensional holographic projection with little or no image flicker. That makes possible a device such as the science-fictional holodeck, where characters in the "Star Trek: The Next Generation" television series and movies create elaborate holographic worlds in which they live their fantasies.

The research, funded by the National Science Foundation, the U.S. Air Force Office of Scientific Research, and the Office of Naval Research, is aimed at developing new materials based on the principles of condensed-matter theory. Design and molecular synthesis are done at UW; and materials are then sent to state-of-the-art production facilities at USC, where the modulators are fabricated and integrated with both silica fibers and VLSI silicon chips.

The electro-optic modulators in use today are grown as lithium niobate crystals and, rather than being integrated into silicon chips, must be hard wired. Besides having far less capacity and requiring substantially more electrical power than the new materials, they also have greater signal loss because of electronic interference and generate substantially more heat. The special properties of the new polymers, including low heat generation, are particularly important for futuristic device applications, Dalton said. PT

More Power to You

Designer and engineer Bill Dube (left) and another team member assemble a new pack of Bolder TMF cells into the KillaCycle.

The "KillaCycle" set the current record as the world's quickest electric motorcycle. It was set by 23-year-old Kerry Hogan the first day she drove the bike on a dragstrip on March 18, 2000—10.539 seconds @116.565 mph. Designed, built, and until recently driven by engineer Bill Dube, the KillaCycle does 0 to 60 mph in 2.9 seconds. That's a lot like being shot out of a cannon, according to Dube.

Record-breaking driver Kerry Hogan on the KillaCycle.

The bike is a product of the marriage between state-of-the-art battery technology and old-fashioned "do-it-in-the-garage" workmanship, using a converted '77 Kawasaki KZ100 frame. The batteries are thin-metal-film lead-acid cells, each about the size of a roll of Lifesavers, developed and manufactured by Bolder Technologies, Inc. in Golden, CO, for their new SecureStart automobile jump-starter. Six of these powerful little cells are enough to start a car. The cycle uses 456 of them, interconnected in such a way as to produce a nominal open-circuit voltage of 304 volts and up to 3000 amps (at about 150 volts). The 92-pound battery pack supplies a peak power of about a third of a million watts during a run down the dragstrip, enabling the two 7-inch-diameter traction motors to churn out well over 300 horsepower.

"Based on the performance I have seen to date, I believe that when the full power potential of TMF cells is exploited, electric vehicles can have a power-to-weight ratio greater than that found in high-performance engines," Dube said. "The TMF cells have the greatest power-to-weight ratio of any battery currently in production. This makes TMF cells ideal for applications requiring high amperage for short periods or the ability to recharge very quickly."

Constructed with an extremely thin lead foil, TMF batteries are wound tightly to achieve the maximum amount of surface area in the smallest volume. More surface area equates to more power. Unique cast-on end connectors transfer the energy efficiently in and out of the battery cell, eliminating the "power bottleneck" common with ordinary batteries. Think of it as a battery built like a capacitor.

Manufactured using inexpensive, readily available raw materials, the batteries have numerous advantages. This technology does not suffer from the memory effect that reduces the capacity of nickel-cadmium batteries when they are discharged and recharged repeatedly. In high-power applications, such as engine starting and standby-power systems, TMF batteries can do the same amount of work as much larger, commercially available rechargeable batteries. They can be recharged rapidly; have very stable voltage, even during high rate discharge; and their low impedance greatly reduces the amount of heat generated by the battery, simplifying product design.

All batteries lose capacity as the temperature drops. TMF batteries lose significantly less of their room temperature capacity at lower temperatures than other commercially available batteries.

TMF technology is a breakthrough technology enabling new applications that were previously impossible. Designed to quickly and efficiently deliver high bursts of power, TMF cells may enable new applications such as high-power-performance hybrid electric vehicles. The KillaCycle is one example of such an application, and Dube hopes to continue breaking new records with it.

High School Robot Competition

Teams consisting of two robots each competed with similar robot buddy pairs during a high school "botball" tournament at NASA Ames Research Center on March 18th. There were 26 teams from 19 California high schools participating in the tournament, in which approximately 50 student-made robots attempted to put the most Ping-Pong balls into a moveable target within a set time limit. Each team had two small robots that cooperatively worked together to accomplish the goal, one of which had a bigger computer processor than the other. The machines operated on a smooth, 4- by 8-foot surface.

Organizers designed the event to excite high school students about engineering, science, and mathematics. Teaming up with engineers from businesses and universities, students get a hands-on, inside look at the engineering profession. In six intense weeks, students and engineers work together to brainstorm, design, construct and test their "champion robot."

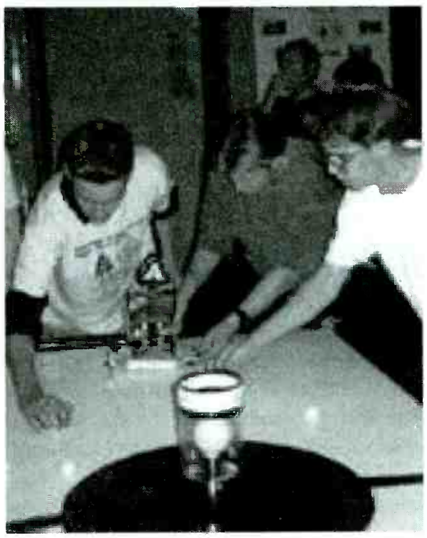
"If you talk to the kids, you'll find that they've seen robot wars on TV during which machines try to destroy one another; we don't do that in the botball tournament," said NASA Ames engineer Terry Grant, who volunteered to help students and teachers. He added that the robots are allowed to block each other.

"The challenge is for the team to design their buddy robots to work together," Grant said.

This year's tournament had about 50 percent more participants than a similar contest last year. Schools receive robot kits, each with hundreds of parts as well as sensors, motors, two battery-powered microcomputer/controllers, and programming software.

The botball program teaches students C computer programming, as well as increases their skills and interests in physics and design. Teachers attend a three-day hands-on tutorial to learn how to use the robotics kits.

Students assemble the mini-robots with help from teachers and representatives of the sponsoring organization, but the students themselves program the robots. The robots must operate on their own; no remote control is permitted during the contest. The schools provide desktop computers and workspace. Assembly of the robots requires no machine tools or electronics laboratories. The schools retain the robotic equipment for educational use.



One of the California high school teams participating in the tournament at NASA Ames, in which the student-made robots attempt to put the most Ping-Pong balls into a moveable target within a set time limit.

The program provides hands-on education by connecting students with companies, government agencies, and colleges. The project is co-sponsored by NASA Ames and the non-profit KISS Institute for Practical Robotics, University of Oklahoma, Norman, OK, and numerous other organizations.

Looking Forward

In the 21st century, particle-atom trapping experiments will provide scientists with more accurate measurements of particle lifetimes and with improved understanding of the weak force, which controls radioactive decay. Weak force is one of the four forces that order the universe. The others are gravity, electromagnetism, and the strong force. Cosmologists eventually will use the data from trapping experiments to refine models of the early formation of the universe.

Atoms and the fundamental units they are made of—electrons, neutrons, and protons—typically zip around the universe at speeds that make them extremely difficult to study. In recent years, however, researchers have slowed atoms to a relative crawl by capturing them in optical and magnetic traps. This ability to trap large numbers of atoms allows researchers to conduct fundamental physics experiments with greater precision than previously possible.

Researchers at Los Alamos National Laboratory developed an atom trap in 1997 that held up to six million radioactive atoms, 100 times as many as any previous effort. The magneto-optical trapping technology uses lasers to trap and cool radioactive rubidium-82 atoms from room temperature down to less that one-millionth of a degree above absolute zero. The process uses six laser beams to trap the atoms as a glowing, millimeter-sized cloud in the center of a chamber. Researchers count the number of atoms in the trap by measuring the amount of fluorescent light emitted by the cloud.

Antiproton trapping research at the Laboratory involves long-standing collaborations with scientists around the world. Los Alamos scientists are partici-

➤ Medical Image Developments

Shown here is an experimental prototype simulator for liver surgery, designed by the Epidaure project for the training of manual dexterity in laparoscopic surgery.

Using medical robotics and imaging combined to improve surgical procedures and success rate is the goal of the Epidaure project. Based in southern France in the Sophia Antipolis INRIA Unit (France's National Institute For Research in Information Technology And Automation), Epidaure is directed by Nicholas Ayache, who leads a team of twenty researchers. Its objective is the design and development of new tools for the analysis of medical images, including tomography, magnetic resonance imaging, ultrasound, and nuclear medicine.

The combination of these tools and images makes it possible to construct virtual models of patients' organs. Surgeons are then able to interact with these models and perform surgical simulations. Using the simulator, the surgeon can manipulate the organ model interactively and virtually repeat the precise surgical movement before intervention without risk to the patient. This tool is particularly suitable for laparoscopic surgery.

Recently, the Epidaure team, in collaboration with outside partners and teams from INRIA, successfully detected and measured changes in multiple sclerosis lesions from cerebral brain images that were acquired at regular intervals. These researchers are on the verge of extracting movement parameters from cardiac images that can be used for the early diagnosis of cardiovascular disease. In collaboration with Ircad, Ayache and his team designed an experimental prototype simulator for liver surgery, pictured above, for the training of manual dexterity in laparoscopic surgery.

In forthcoming work, Epidaure is hoping to develop the modeling of physiological phenomena, such as blood pressure and flow rate, and the use of heads-up display devices for other applications. PT

pating in the ATHENA (AnTiHydrogENApparatus) Experiment now under way at CERN, which hopes to produce anti-hydrogen atoms at low energies, capture the atoms in a magnetic trap, and compare the energy levels of antihydrogen to those of hydrogen.

In 1999, Los Alamos researchers were part of a collaboration that successfully confined neutrons in a three-dimensional magnetic trap to determine how long it takes them to decay. Using the reactor at the Center for Neutron Research in Gaithersberg, MD (part of the National Institute of Standards and Technology), neutrons were directed down the beamline into a neutron trap filled with helium chilled to minus 460°F. A fraction of the billions of neutrons created by the reactor beam were confined in the long, narrow trap, which held the neutrons in the supercold liquid helium until they decayed approximately 12 minutes later.

Atom trapping holds the promise for developing sophisticated tools for use in basic nuclear physics research, cold atomic physics, and ultrasensitive detection for nonproliferation applications. Because the atomic trapping process is extremely selective and sensitive, it can make isotopic ratio measurements in samples as small as 10,000 atoms. This makes it an important tool for nuclear treaty verification and nonproliferation. PT

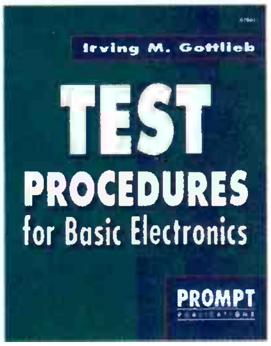
Reducing Medical Errors

At a time when President Clinton has announced that he will order all hospitals in the United States to take steps to reduce medical errors, Motorola's Healthcare Communications Solutions group has developed a message-alert system that is designed to facilitate the communication needs of physicians. DocLink, in its final stage of development, could significantly increase the timeliness of delivering critical patient information to physicians.

The DocLink system is a hardware, software, and communications services solution that improves the time-consuming, manual notification process now in place at most health systems and large hospitals. DocLink's clinical information routing system is designed to send clinical information systems' message alerts to clinician's current communications devices, including pagers, cellular telephones, fax machines, office telephones, and personal computers. The system routes each message alert based on the clinician's pre-determined schedule and the alert's priority. Core features include escalation capabilities that route message alerts to another designated clinician if the primary alert recipient doesn't respond to the message; forwarding capabilities to ensure that the message alerts get delivered to the right clinician; and password-protected access to the system. All these features enhance timely delivery of message alerts to clinicians when, where, and how they specify.

The DocLink system has completed its "alpha" test at Washington University School of Medicine and its teaching institution, Barnes-Jewish Hospital. The results of the DocLink system alpha test showed a reduction in cycle time (measured from "drug order start to drug order stop."). The cycle time improved from 27 hours in daily batch processing mode to four hours in real-time, a 33 percent improvement in the pharmacists' response time when he or she concurred with the system-generated message alert. In addition, pharmacist response times were also reduced when the pharmacist did not concur with the alerts because the dose had already been changed, drug discontinued, patient discharged, or the lab result changed.

"Inadequate communication technology is considered one of the factors contributing to the medical errors problem," said Jim Hubbard, business director of Motorola's Healthcare Communications Solutions group. "More effective and timely communication between physicians, labs and pharmacies creates the need for a better system that can assist physicians and hospitals in obtaining critical information on an immediate basis." PT



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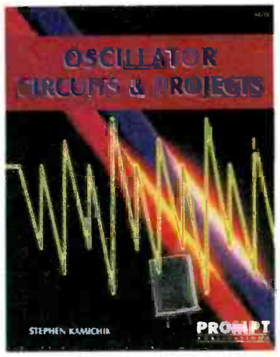

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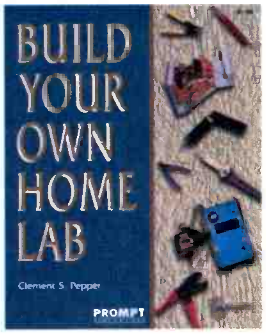

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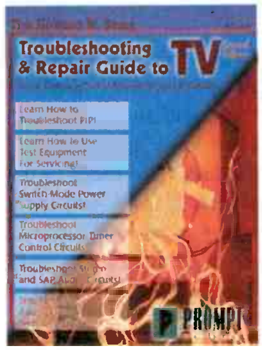

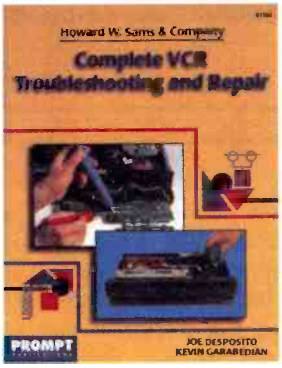

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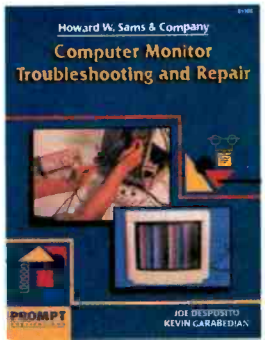

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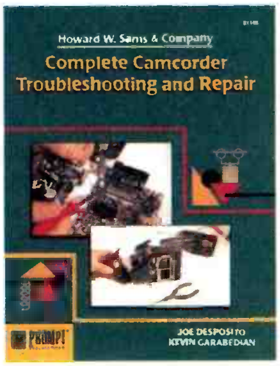

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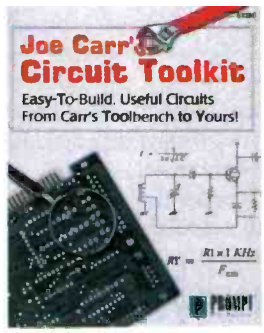

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Sound Spectrography

Q *In the February 2000 issue, you answered a question about measuring voice frequency by recommending an oscilloscope or frequency counter. How about a sound spectrograph, such as* Spectrogram, *available free at* http://www.monumental.com/rshorne/gram.html? *This software works with your sound card to analyze any sound into its component frequencies and will even display the pitch of the dominant tone in standard musical notation.*
—Peter Schneider, Worcester, MA

A D'oh! I'm especially embarrassed because, for my day job, I'm a computational linguist, and I use such things in the classroom. Usually I use a different piece of software, *SpeechView*, available free from *http://cslu.cse.ogi.edu/toolkit/* (the Oregon Graduate Institute); it's depicted in Fig. 1. Although it doesn't do musical notation, it has more features for analyzing speech and has a cursor that you can place anywhere to read out the pitch of the voice.

Both of these programs are good. *Spectrogram* is smaller and downloads more quickly. *SpeechView* is part of a much larger download (a total of about 28 megabytes) that includes many other software tools.

Thanks also to Joe Heck, who wrote with a similar suggestion.

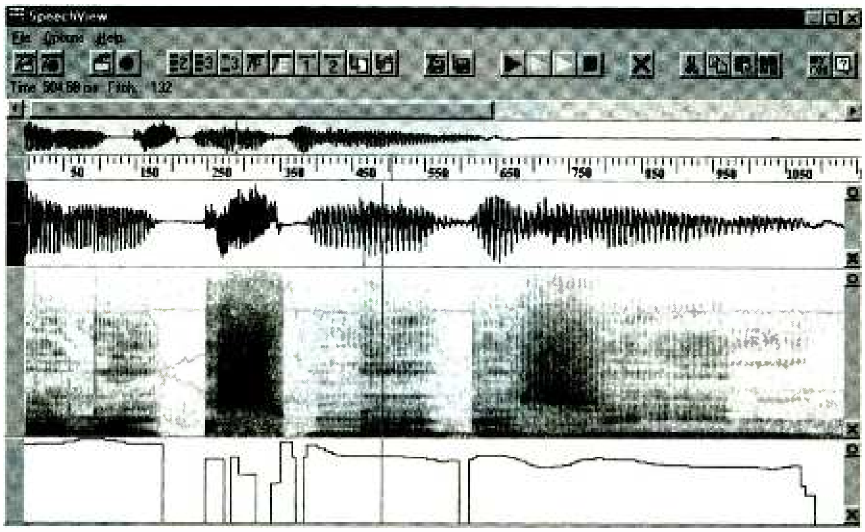

Fig. 1. SpeechView, *from the Oregon Graduate Institute, has many different features and tools for analyzing speech and the human voice.*

Laser Pointer as Remote Control

Q *I need a circuit to control super-bright LEDs that are used to substitute for candles on a wreath high above the altar of a church. Running wires to it is not feasible, but I need a way to turn it on and off, as well as very long battery life. Also, could I use a pulse circuit to keep the lights from steadily draining the battery?—F. A., West Hartford, CT*

A Try the circuit shown in Fig. 2, powered by a 6-volt lantern battery. The load can consist of LEDs with resistors or incandescent lamps; you might get a very nice candle effect by running 12-volt lamps on 6 volts.

Turn the lights on and off by hitting one or the other CdS photocell with a laser pointer. In the "off" state, less than one mA is drawn from the battery.

The circuit uses the hysteresis (latching) property of the LM555 IC, but you should actually use a CMOS version of the chip (LMC555, TLC555, or 7555) to save power. When the input is below $^1/_3$ of the supply voltage, the output turns on. When the input is above $^2/_3$ of the supply voltage, the output turns off. When the input is in between, the output stays in whatever state it was already in.

Thus, when the two photocells are receiving the same amount of light—whatever that might be—the load stays on or off. When you hit one photocell with the laser pointer, you lower its resistance dramatically and the input voltage swings to +V or ground as the case may be; then, the 555 switches state.

You'll need two photocells that are reasonably well matched. One way to get them is to buy an assortment (such as RadioShack 276-1657) and use an ohmmeter to find two that are alike. At very low light levels, they are unlikely to be well matched no matter how carefully you pick them; resistors R1 and R2 swamp out the unpredictable, high resistance of the photocells in the dark. You may be able to further save battery power by using higher values for R1 and R2, such as 47k or even 220k.

Unfortunately, there's no way to avoid having a steady drain on the battery

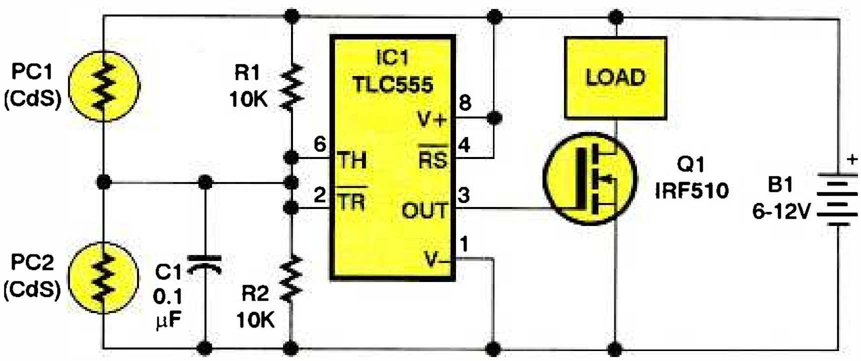

Fig. 2. This simple circuit will let you turn a load on or off depending on which photocell is lit.

when your artificial candles are on. The battery has to supply the energy that comes out of the LEDs in the form of light. Pulse circuits save power by flashing the LED (see this column, last month). If you try to smooth out the pulses with a capacitor, you'll find the voltage is too low—you can't get more energy out than you put in.

TV Becomes Video Projector?

Q *How can I make a video projector by adding a lens to a TV set? I know the picture needs to be upside down and the brightness needs to be increased.—M. K., Plainview, NY*

A The short answer is you can't. The brightness of a TV can't be increased very much without burning up the phosphor on the screen. A video projector requires a lot more brightness and hence a special CRT.

To see why, suppose you're projecting onto a screen 5 times the width of the CRT. This is 25 times the original area, so you'll need 25 times as much light—and that's assuming that your lens picks up all of the light emitted by the screen. In real life, the lens picks up only a small fraction, so you need far more brightness than a conventional CRT can deliver.

Stuck VCR Problem Solved

Q *In your February issue, F. A. asked about a Magnavox VCR that seemed to be stuck in play mode. The problem has to do with how the VCR distinguishes ordinary tapes from prerecorded tapes. When an ordinary tape is inserted, the VCR closes the write-protect tab switch to pull a logic line low for normal operation. The switch is located in the lower left-hand area of the chassis under the cassette basket.*

However, the contacts occasionally oxidize, which means that the switch is never closed. That activates a "feature" of the VCR called AutoPlay. The VCR believes the tape is pre-recorded, automatically playing it as soon as it is inserted. With this feature activated, the tape will automatically rewind at the end, eject, and the VCR will shut down.

To solve the problem, the switch can be replaced or its contacts cleaned.
—Roy L. Huether, Glendive, MT

A Thanks! We also thank Richard Reed, who wrote in with the same information and points out that sometimes the problem is in the tape cartridge rather than the VCR.

Another Ham Theory

Q *Regarding your January column, I think the term "ham" radio came from Hammarlund Manufacturing Company, which made equipment used by early hams.—L. J. H., Portland, OR*

A Nice theory, but Hammarlund started business in 1910 and amateur telegraph experimenters were called "hams" before that, in fact before radio was even invented. See *http://www.arrl.org/whyham.html.*

I stand by my opinion that "ham radio" is related to "ham actor," which dates from 1882 (if not earlier), or maybe from "ham-handed" or "ham-fisted" (describing an inept telegrapher). There may be historical evidence somewhere that will tell us which is correct. Anyone can guess the origin of a word, but proving that a guess is right is not always easy.

Zenith Mystery Solved?

Q *I'll bet that the late-1980s Zenith TV with the intermittent failure described in your April column is a 25-inch color console. Unplug your television, discharge the picture tube, and pull the main circuit board—the wires are numbered to make it easy to put them back. Look for a shiny tin cover next to the flyback transformer. Unsolder it. Inside it is a 100-µF, 25-WVDC capacitor that controls the brightness/contrast voltage to the picture tube. This capacitor has shifted in value, making the high-voltage system shut down. Replace it.*
—Matthew Martin, Alliance, NE

Have your reader check the main circuit board for a burned open (intermittent) solder connection on one lead of a large power diode in the low-voltage power supply.
—Larry Jacob, Goodyear, AZ

Look for a defective capacitor in the power-supply circuit, probably near the VR chip. An ESR meter is the best troubleshooting tool. Capacitor failures are often temperature-related.—Stan Bogovich, Daytona Beach, FL

A There you have it, folks—three possibilities, two of which involve capacitors. Electrolytic capacitors are the second most failure-prone parts in modern equipment. Connectors and solder joints are the first.

Repairman's Blues

Q *I have owned and operated a consumer-electronic repair shop for over 12 years. Lately more than ever, I have been frustrated trying to tackle intermittent problems. Some of these complaints simply would not reveal themselves while the equipment is on the test bench.*

The real problem in some cases is trying to explain to the customer that there is nothing that I can do to pinpoint the problem because as long as the circuit operates properly, everything tests OK. Sometimes a customer says, "With all that fancy equipment, you should be able to tell what the problem is," or "Maybe you just don't know what you're doing," and "I'll tell all my friends not to come here!"

Is there anything that can be said to even the most simple-minded customers to make them understand the situation? If not, can you at least confirm what I've said so I can at least show the customer your magazine?—S. B., Daytona Beach, FL

A You're right—intermittents are very frustrating (try fixing computers, which is what I do a good bit of the time!) I assume that you've tried all the usual things, such as warming the equipment up, raising or lowering the line voltage, and using hair dryers and cooling spray to induce temperature shifts.

Sometimes, simply transporting the equipment will shake up a loose connection and cure the problem, temporarily or permanently. Sometimes the intermittent problem is actually at the customer's site, in a wall outlet or an RF-interference source.

Often, though, intermittents are impossible to track down. There is a solution—simply replace the whole circuit board. It's expensive, but it's how intermittents are handled in industrial electronics. It's also how auto repair is often done. How many cars have had their whole microcontroller system replaced because of one loose connection? The customer doesn't want it diagnosed; he wants it fixed and will pay a high price for it.

Tell the customer that the equipment can be repaired, but it's not cheap. Explain it this way: "One of the parts is just starting to wear out, but because it's not worn out yet, I can't tell which one. The best thing to do is to keep using it until the defective part wears completely out. Then it will be cheap and easy to find and fix. If you want it fixed now, it will cost more because the problem is not yet identifiable, so I have to replace all the parts that might be at fault. If I test everything, I'll find that lots of parts are showing their age, but I still won't know which one is causing this particular problem."

Writing To Q&A

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

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

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

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

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

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

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

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

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

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

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

Copies of past articles: Copies of past articles in **Electronics Now, Popular Electronics** (post 1995 only) and **Poptronics** are available from our Claggk, Inc., Reprint Department, P.O Box 12162, Hauppauge, NY 11788; Tel: 631-592-6721.

Poptronics and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214; (800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, PO Box 549, Tooele, UT 84074.

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

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

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

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SAM GOLDWASSER

VCR Control-System Problems

OK, now we are ready to look at control-system problems that occur in VCRs. One of the most common problems is when the VCR is alive but will not do anything. Typical symptoms are that the front-panel display is active; the clock, timer, or channels can possibly be set; but all transport-related buttons are totally inert. Perhaps there is no response to any button. The VCR may or may not refuse to accept or eject a cassette.

This could indicate a variety of problems, including motor problems as well as a general power-supply or control-system failure. However, you should first try these possible solutions:

- Check for cockpit errors. Someone may have accidentally set the VCR for timer record or turned on the parental-lock mode. See if you can spot a little clock or key symbol on the display. Is there an "L" (or something else you don't understand) displayed? Inspect the position of all slide or push-push switches. Timer mode may be set by a pushbutton, push-on/push-off, or slide switch, or from the remote control. Parental lock is usually accessible only from the remote control. Consult the user manual if in doubt about how the thing is supposed to work!
- Cycle the power by unplugging the VCR from the wall (don't just use its power switch) for a minute or two to see if the microcontroller simply got into a confused state. This is more common than you would think. A random power surge can do it. The VCR may have gotten into a bad (mechanical or electrical) state.
- Unplug the VCR and remove the covers. Rotate the shafts of each of the motors (cassette-loading and tape-loading or main motors depending on your VCR) clockwise a couple of turns (assuming there is no resistance to turning). Now plug it back in and listen for initialization sounds; it should detect that the mechanism has been moved and then reset to a safe position. See if it is now behaving. If it still doesn't do anything, try several turns counterclockwise instead. If there is still no improvement, there may be a more serious power-supply, motor, or control-system problems.

If any of the previous steps appear to solve the problem, it is quite possible that you will never experience it again. However, a dirty mode switch may have resulted in an overshoot to a bad mechanical state and without cleaning or replacement, the same thing may happen again.

VCR Clock Does Not Run

The clock runs either off the power line (zero crossings of the 50- or 60-Hz waveform) or from a crystal (possibly a reference derived from one of the other frequencies used elsewhere in the VCR). Conceivably, a bad backup battery or "supercap" might result in the clock remaining in setup or power-fail mode. Unfortunately, this probably isn't much help since identifying and locating the relevant components will be next to impossible without a schematic.

VCR Attempts to Play Non-existent Cassette

You turn power on or just plug in the VCR to the AC outlet, and it goes through the whirring sounds of playing a cassette, but there is no cassette present. Try unplugging it for 30 seconds or so and plugging it in again. The microcontroller may just have had a bad day and gotten confused—either a bad reset or a power glitch. If that doesn't help, there could be a faulty end sensor or a bad LED or light bulb that provides illumination for the end sensors.

If either sensor's output is the same as when a cassette is present (blocked), it is likely that the microcontroller will be confused. In some designs, this is indistinguishable from a cassette actually being loaded. If the "cassette-in" indicator is on, then this is likely. If a VCR uses an actual light bulb for that central light source and it is not lit when you attempt to load a cassette, then it is burnt out and obviously needs to be replaced. However, the LEDs used in most modern VCRs are of the infrared variety and therefore invisible to the human eye.

With somewhat similar symptoms, it is also possible that the VCR is not able to complete the startup initialization due to a slipping belt, gummed-up lubrication, or other mechanical or motor problem. The clincher would be if you manually load a cassette (by turning the appropriate pulleys, etc. with it unplugged) and then the cassette plays properly and acts normally until you try to eject it. However, don't try this unless you are sure of how the mechanism works, as it is easy to cause damage.

Erratic Behavior in Various Modes

You press PLAY; the VCR gets halfway through loading the tape, suddenly aborts, and shuts down. Another scenario is that you put a cassette in, and it is immediately spit out as though it tasted bad to the VCR. Better still is pressing PLAY and the VCR goes into *rewind* mode. Perhaps you pressed REVIEW, and it ejected or attempted to eject the cassette. Before you break out the screwdriver or shotgun, cover up the IR remote sensor and cassette slot. Some types of electronically ballasted fluorescent lights may confuse the remote-control receiver. On the other hand, someone or something may be sitting on the remote hand unit, or it may be defective and continuously issuing a rewind command! Excessive general illumination may even make its way into the tape start and/or end sensors and trick the VCR into thinking that the tape is at one end. If you are working on the VCR with its cover removed, block any stray light from hitting the area of the tape transport to see if behavior returns to normal. If you have determined that none of the above is the source of the problem, let's see what can be done:

- Eliminate the possible mechanical causes such as slipping belts or a bad idler tire that could prevent the VCR from completing your requested action; it instead shuts down or attempts to return to a safe position.
- Bad connections are a possibility, but not as likely as in a TV or monitor, for example. However, some VCRs (including certain JVC units and clones) ground parts of the circuitry via the circuit board mounting screws; simply tightening these is all that is needed to effect a cure.
- The microcomputer or its associated circuitry could be defective as well, but this is not as common as most people fear.
- A faulty power supply may occasionally result in similar behavior. Its output voltages may be marginal, drop under load, or have excessive ripple due to dried-up filter capacitors.
- A sensor assembly present on most VCRs called the *Mode Switch* or *Mode Sensor* is dirty or bad.

VCR Mode (Sensor) Switches

For the microcontroller in a VCR to confirm correct functioning and completion of operations like cassette and tape loading and roller-guide position, some mechanical sensor feedback is normally used. The most important sensor assembly in most VCRs is called the "Mode Switch" or "Mode Sensor." The purpose of the Mode Switch is to inform the microcontroller of the gross position of the mechanism at all times. For example, the Mode Switch may have five positions:

- Tape unloaded and cassette out
- Tape unloaded and cassette in
- Tape half-loaded against A/C head but not around drum
- Tape fully loaded around drum and roller guides at V-Stoppers
- Pinch roller pressed against capstan—play/record position

The microcomputer monitors the outputs of the Mode Switch continuously when it is executing a mechanical operation (some monitor it at all times—even with the power off). If an operation takes too long to move from state to state or an incorrect state transition occurs, the operation will be aborted and an attempt—possibly several—will be made to return the transport to a safe position, unloading the tape and possibly ejecting the cassette.

Most Mode Switches are actually mechanical rotary or linear switches with sliding contacts. However, some VCRs use optical Mode Switches such as IR LEDs, a slotted wheel or sliding mask, and photosensors. These are much less common, and failures are even less likely. Most of the comments that follow apply only to mechanical devices.

If the Mode Switch contacts are dirty or worn, or if it has somehow loosened on its mountings and shifted slightly, one or more of these positions will report back incorrectly or erratically signaling an error condition. For example, a transition from state 1 to state 4 directly would totally confuse the poor controller. A Mode Switch that shifted out of place (or where other timing relationships in the VCR are messed up) might result in certain operations stopping at the wrong position as well. For example, if the Mode Switch shifts one way, the pinch roller may never quite press against the capstan or the roller guides may not snuggle up to the V-Stoppers as they should in play mode. If it shifts the other way, operations may fail to complete and run against the mechanical stops. Stripped or broken gears may even result.

A dirty or worn Mode Switch can result in cassette- or tape-loading, unloading, or eject operations aborting and resetting or the VCR shutting down. For example, some Emerson VCRs will move part-way when loading and then shut down. Repeated attempts may get them to fully load and play the tape, with other tape-movement operations working properly. However, unloading will result in similar cranky behavior.

Mode Switches are usually linear or rotary slide switches with four or more output terminals. They may or may not be easily accessible. Some are visible once the bottom cover is removed. Others are buried beneath a bunch of mechanical "doohickies" (a sophisticated technical term). Some are held in place by a screw or two and a connector. Others require desoldering and the removal of a whole lot of stuff—all of which must be carefully replaced with exactly the same timing relationships—just to gain access.

Once, you get at them, you can often snap the housing apart and use contact cleaner on the sliding contacts and surfaces. I usually do not use any kind of lubricant as it can gum up on the contact surfaces resulting in erratic outputs; possibly the cause of the original problems in the first place. Some may not come apart, and replacement is the only option if squirting contact cleaner through any visible openings does not help. Note that without disassembly, there is no way of knowing if there is still dirt or gummed-up grease inside or if the contacts are actually pitted. Conversely, if squirting in some contact cleaner does not help, the Mode Switch may still be the problem since you have no way of knowing how far the contact cleaner penetrated or whether it had any effect. Sometimes, bad solder connections to the Mode Switch are the only problem.

In any event, be very careful about not moving anything and take careful notes on the position of any parts that you disconnect as critical timing relationships are controlled by the gear positions. Stripped gears or other broken parts may result when the mechanism cycles. Also, in certain positions, levers or sliders operated by the mechanism that you remove may spring out of position. You will need to make sure that they get put back into the correct slots in any cams when you are done. Mark all gear positions even if they do not seem to be critical.

There are even some poorly designed VCRs where extraneous light through the vent holes or tape door affect sensors and causes erratic operation. If a bright light is shining on the VCR, block it and see if anything changes!

Mechanical Relationships in VCRs

The complexity of the mechanism in a VCR can be quite intimidating. To avoid total frustration and really messing up your day, take careful notes—before you remove anything mechanical—of the precise relationships of any gear, lever, switch, or anything that might possibly get put back together in a different way. Often there are "timing" marks on the gears just as you would find in a lawnmower or automobile engine. These would be little arrows or holes that will line up with stationary marks or with each other on adjacent gears when the mechanism is in a particular position. Often, it is best to put the mechanism in the position where the timing marks line up because there may be fewer levers, cams, etc. that might be under pressure or tension in this position. Not only will it be easier to take apart, but also fewer things will pop out at you. If there are no apparent timing marks, make your own with a scribe or pen. Sometimes mechanisms that at first appear not to be critical really do control critical timing. When in doubt, make more notes than necessary and include a sketch.

Intermittent Behavior

This may mean that pressing on a circuit board, flexing a cable, or operating the VCR in different orientation affects behavior. Sometimes temperature plays a role as well. If this only happens while servicing, confirm that excessive light is not affecting the start/end sensors. Do not confuse these sorts of symptoms with those indicating a faulty or dirty mode (sensor) switch.

Unlike TVs and monitors that have high-power circuitry and are prone to cold-solder joints from poor manufacturing or thermal cycling, most of the circuitry in a VCR is low voltage and low power. Although problems with bad connections to these components are relatively rare, visual inspection should still be performed where erratic behavior is noted. Exceptions include:

- Power-supply regulator or switch-mode power transistor (depending on type).
- Motor-driver (power) transistors or ICs—particularly those for the main (capstan/reel) drive and video-head drum.
- RF, video, and audio jacks since they may be stressed mechanically.
- Internal multiconductor (crimp-terminated) cable connectors. These may just deteriorate with age and use. Clean and reseat the connector(s).
- Circuit board ground screws. One or more of the screws holding a circuit board may also be providing a ground connection. These can work loose or corrode. Remove screw, scrape corrosion, and/or tighten.
- Hairline cracks in circuit boards. If the VCR has been dropped, this is very common. Sometimes, these are very difficult to locate visually but locate them you must!
- Broken or shorted wires. Some of the individual wires that are in various signal cables are quite thin and fragile. Overzealous movement of circuit boards while replacing belts or other maintenance operations can easily pinch these resulting in immediate or delayed failure. This may also take place when replacing boards. It seems that the manufacturers seem to make it impossible to squeeze all the wires back in where they came from!

That last point brings up an important caution when working inside any type of equipment: Always try to avoid pulling on the wires when removing a connector. This will minimize a stress that could result in the wire conductor breaking off inside the insulation—

something that's very difficult to locate.

VCR Does Not Work After Cassette was Forcibly Removed

You were watching your favorite tape when suddenly the VCR emitted a mechanical "eek" and is now dead—or you press EJECT and the VCR shuts down without regurgitating your tape. Worse yet, someone (we will not point fingers) forcibly removed the tape to return it to the video store. Assuming that "forcibly" does not mean that permanent damage was done, then the first place to check, as always, is the idler tire and then all other rubber belts. At this point, it is hard to say whether your problem was compounded by the removal of the tape. If any gears were shifted with respect to one another, parts bent, or springs sprung, then it would be difficult for a technician (let alone someone not familiar with your VCR) to repair it without a service manual.

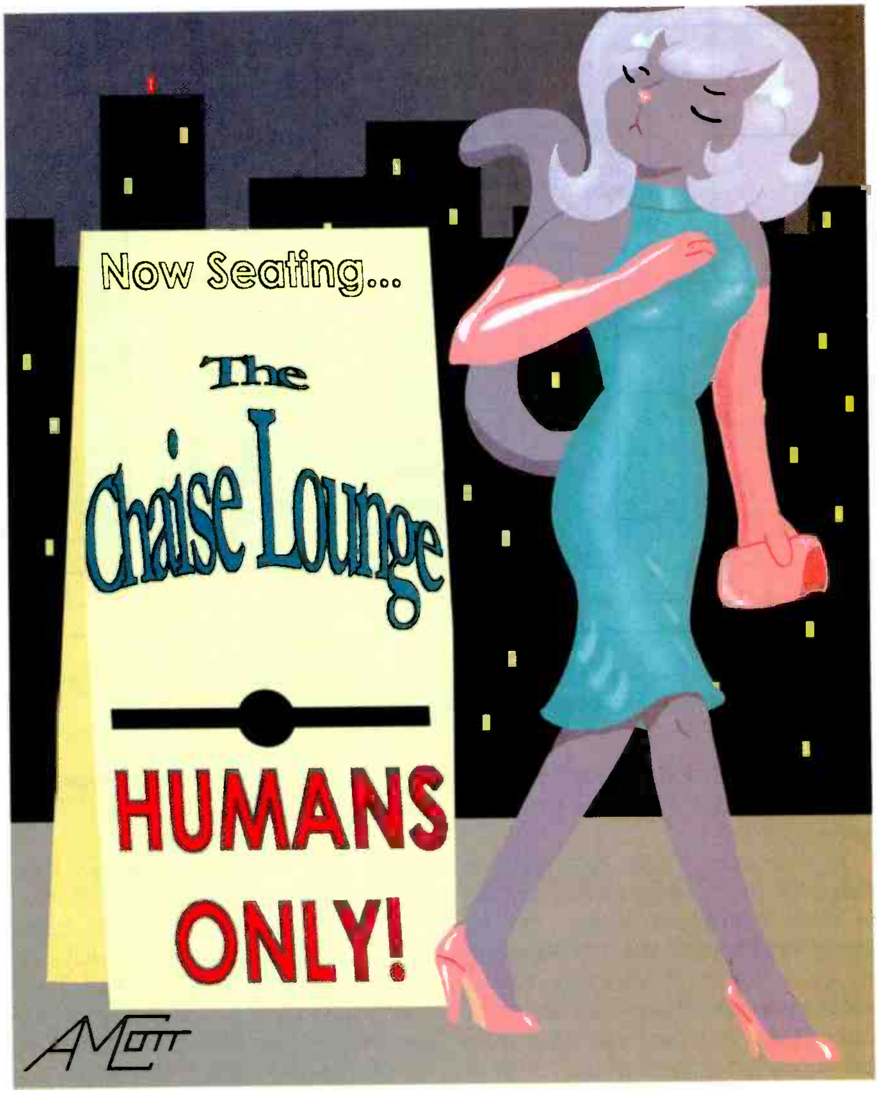
An error at power on usually means that the microcomputer thinks that it is unable to put the mechanism into a "safe" position. This could be due to slipping belts, broken gears, a bad motor, shifted sensors, or faulty electronics. The original symptoms may have been a slipping idler preventing the takeup reel from rotating allowing tape to spill into the machine.

Hope you enjoyed the visit. Next time, we will continue with what the VCR expects to happen when you apply power. Until then, check out my Web site: *www.repairfaq.org*. I welcome comments (via e-mail only, please) of all types and will reply promptly to requests for information. See you next time! **P**

TEACH YOUR PET WHO'S BOSS WITH THE SCATCAT!

RUSS SHUMAKER

If the family pet ventures into or onto forbidden areas of the house when you're not around, like beds, furniture, or kitchen countertops, this device could help.



The family feline, an indoor cat named Fred, had taken to exploring the tops of the kitchen counters during his nocturnal sojourns. He usually got into something he shouldn't, as well as making the kitchen's sanitary condition questionable. Since this is the work area where the resident techie builds his braunschweiger sandwiches, immediate action had to be taken! At a family meeting called to discuss the problem, solutions included:

- High-voltage electric shock (vetoed!)
- Donating the cat to a tennis-racket factory (vetoed!)
- Falling anvil (vetoed!)
- Scaring the bejeebers out of him. (A contender, but one with severe limitations)

Rather than traumatize him, the majority voted to just startle him a bit. This pretty much ruled out the solutions above or a cranked-up version of the finale to the *1812 Overture*.

Since no one volunteered to stay up and lie in wait for Fred with the primary cat-training device (a Big-Blaster squirt gun), the resident techie rubbed his hands together gleefully, cackled, and took up the challenge. The solution would be electronic, of course. That device, presented here, is appropriately called the *ScatCat*.

How It Works. The ScatCat is relatively simple, efficient, and...humane. The pet's presence is detected by a passive-infrared (PIR) motion detector. The detector sends a signal to the main control unit, activating it. The control unit then emits four one-second bursts of high-frequency, low-power sound, accompanied by four one-second flashes of bright light. That combination is quite startling to cats as well as dogs...especially when they think they're putting one over on you!

The sound bursts are approximately 18 kHz. Since higher-frequency sound is directional and the ScatCat's output is low power, it has not yet awakened any of the family. The light source is a com-

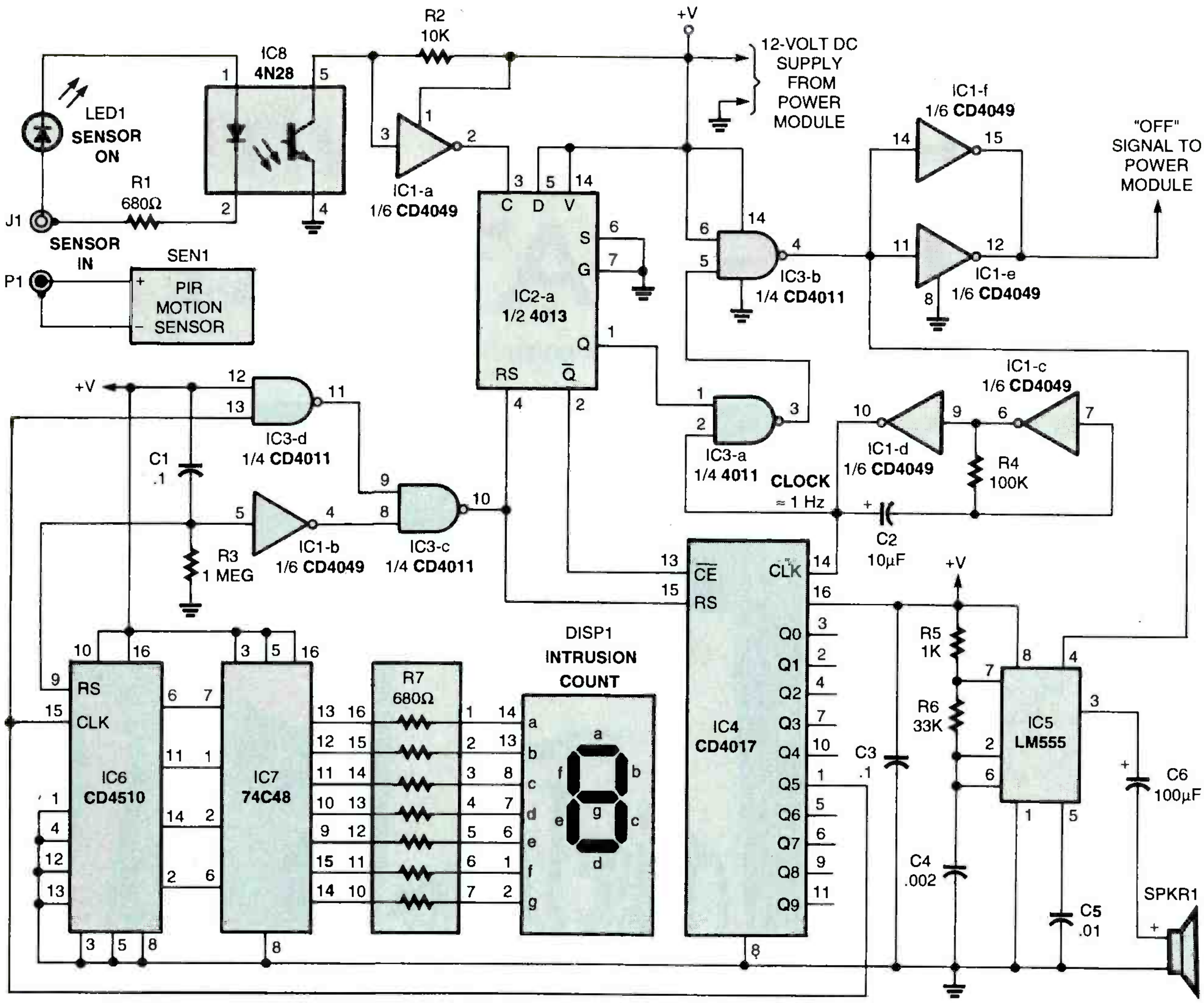


Fig. 1. The ScatCat's control module consists of six simpler sections: On-off control, clock, power-up reset, cycle counter, intrusion counter, and audio-output circuit.

mon 100-watt bulb in a light fixture that plugs into the main control unit.

A clamp-on utility light with a reflector (quite reasonably priced in most hardware stores, and a good addition to the home workshop) is the most versatile, but a table lamp with the shade removed also works. A bare bulb seems to be more effective; more so in a darkened room.

Each time there is an intrusion that activates the unit, a digital-counter readout increments to let you know if your pet is indeed trespassing, and how often. This is the only way to know if the device has been activated and is effective.

The unit also has an internal power-up reset feature to switch off the sound and light outputs and insure that the counter is reset to zero.

About the Motion Sensor. The motion sensor selected for the ScatCat is a self-contained, battery-operated unit that sounds an audible tone when activated. Two reasons made it an ideal choice: Its sensitivity and detection pattern is ideal, and it goes on sale at RadioShack quite regularly. A two-conductor cable replaces its internal speaker. That cable connects the speaker output to the ScatCat's main control. The modification is simple to do, as you'll see later in the construction section.

The sensing medium is dual pyroelectric, which means that it senses body heat as well as motion. Reliable detection occurs when the subject walks across the beam, rather than towards it; something to keep in mind when setting it up.

The motion detector's detection pattern is a two-dimensional fan-like shape that spreads at a 60-degree angle and is sensitive to a range of about 30 feet. A Fresnel lens sets the pattern. With the detector raised above the floor and the fanout horizontal, a pet can walk on the floor below the sensing area without setting it off. Sensors sold for use in home-security systems call that a "pet" pattern. Positioning the fanout vertically results in a vertical detection-area curtain, which could monitor a doorway.

Outdoor security sensors have a three-dimensional sensitivity pattern. They can be used for this

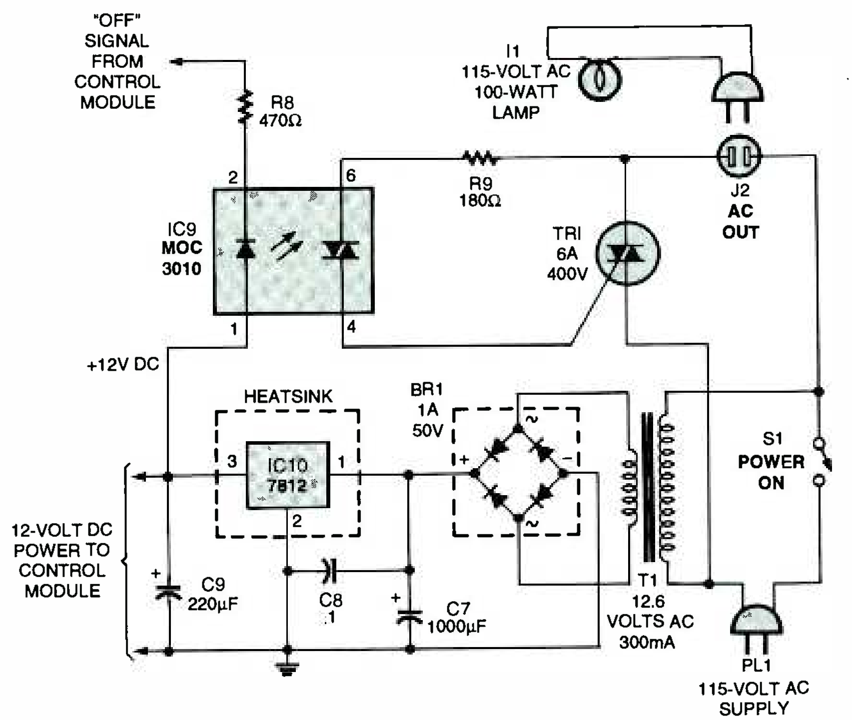


Fig. 2. The power module contains the circuits that deal with AC power: A 12-volt DC supply, which powers the control circuitry; and a solid-state relay circuit, which controls the AC-lamp output.

application if the pattern is taken into account when setting up and aiming the sensor.

There are many motion detectors available at reasonable costs from electronics-surplus vendors. Most can be used with this system. Many have relay-contact outputs. The hookup for a motion sensor with a relay contact output will be discussed later. While we're talking about different types of motion sensors, a break-the-beam "electric-eye" type can also be used with the ScatCat.

The novelty market is awash with big green plastic frogs that "ribbit" when someone passes by. Some are as low as six dollars. Although they don't have a Fresnel lens and the range is somewhat shorter, they most likely have a conical detection pattern, and would probably work. It might be fun to recall high-school Biology 101 (frog dissection), and examine one's "innards." The frog alone might be enough to spook your pets, unless of course you have a Rottweiler, who will probably eat it!

Circuit Description. The circuit for the ScatCat's Control Module is shown in Fig. 1. It seems complex at first glance, but you'll see that it is made from six simpler circuits. Each section will be explained and tied together.

The first section handles on-off control. When SEN1, the PIR motion sensor, is activated, it generates a 6-volt squarewave at about 900 Hz, followed by a 700-Hz squarewave. Originally fed to a speaker, which generated a "bing-bong" tone, that signal is instead sent to the control module through connectors P1 and J1. It then turns on LED1 as a "sensor on" indicator located on the front panel and activates the LED input of optoisolator IC8. A feature of the placement of LED1 in the circuit is that it is powered solely by SEN1, so that the motion detector may be set up and aimed without having to turn on the main unit. That will prevent the sound and light outputs from being activated during the set up.

Optoisolators are current-activated devices and can be used with most sensor inputs with little

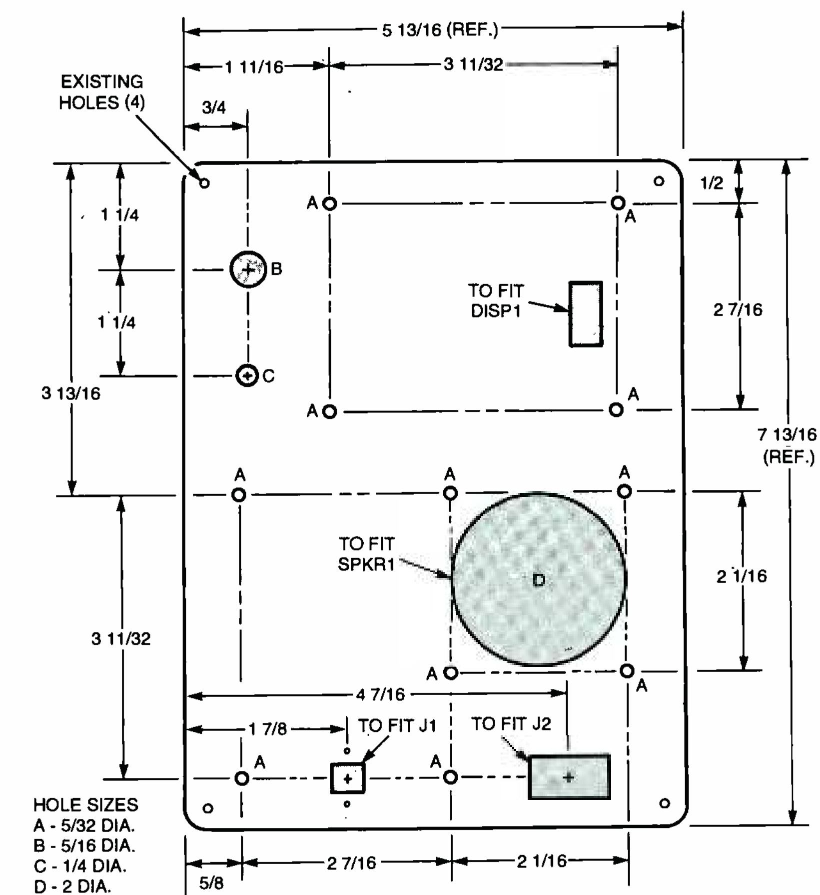


Fig. 3. The ScatCat's front panel needs several holes and cutouts. This arrangement was used in the author's prototype. Some of the cutouts depend on the items that will be mounted in them.

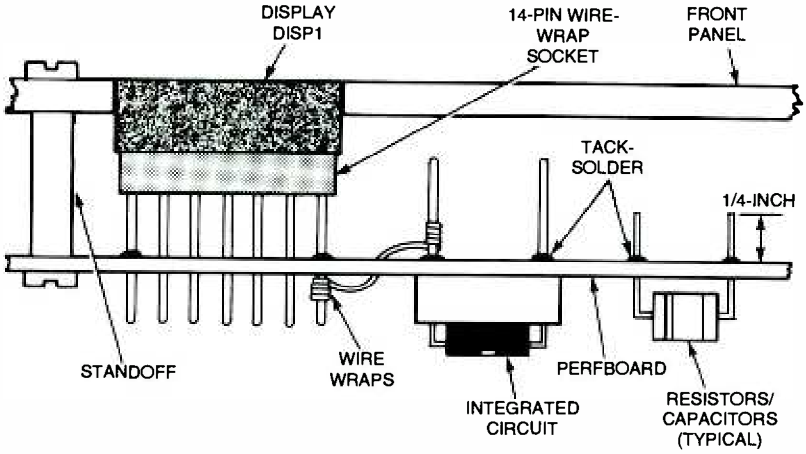


Fig. 4. The circuit boards are mounted to the rear of the front panel as shown here.

regard for voltage levels or common grounding. When using a sensor other than the RadioShack unit specified, select R1 so that IC8's input current is between 10 and 60 milliamps.

The input to IC1-a is held high through R2. When the output transistor of IC8 is turned on, IC1-a's input is pulled to ground, sending a high pulse to clock IC2-a. The beauty of the flip-flop is that any positive-going signal can set it, be it a squarewave, as it is here, or switched DC—another example of the ScatCat's versatility; any type of motion-sensor input can be used.

The next circuit section is the clock. It is an astable multivibrator consisting of inverters IC1-c and IC1-d, R4, and C2. The 1-Hz squarewave sets the on-off times of the sound and light outputs, and increments the four-cycle on-off count.

The third section is the power-up-reset circuit. Its function is to generate a momentary pulse when power is first turned on, which assures that the light and sound outputs are switched off, and that the counter is reset to zero. The momentary pulse is generated by C1 and R1. When the power is first turned on, the input to IC1-b and the reset input to IC6 are momentarily held high until C1 charges; the pulse is then pulled low by R3.

The momentarily low output of IC1-b connects to one of the inputs of IC3-c. Although that gate is technically a NAND gate (the output goes low when both inputs are high), it can also be thought of as a negative-input OR gate (the output goes high if either input goes low). This isn't tricky quibbling over semantics. Note that we're talking about an active-low pulse from IC1-b.

In any case, the output of IC3-c goes momentarily high, resetting flip-flop IC2-a; its output then goes low. The same reset pulse from IC3-c initializes IC4, setting its active output to pin 3 (designated "Q0").

The fourth circuit, the Cycle Counter, is built around decade counter IC4. Its operation is simple: When the reset input (pin 15) and clock-enable input (pin 13) are both low, the IC will switch its outputs high one at a time with each clock pulse. Normally, the chip will count ten separate outputs before recycling, but we're using output Q5 to send a pulse to IC3-d, which sends another "power-up" pulse through IC3-c and back to the reset input of IC4. That gives the four-count timing for the four output bursts of sound and light.

When flip-flop IC2-a is reset along with IC4, its output at pin 2 is high, disabling IC4. Although IC4 always sees a clock pulse, this keeps it from incrementing. Each time there is motion-sensor input, IC2-a "sets," enabling IC4 to count the four increments before resetting the circuit with the "fifth" count.

When IC2-a is "on," its other output goes to IC3-a. That gate allows the clock pulses from IC1-c and IC1-d to pass through to IC3-b during an "intrusion." That second NAND gate inverts the clock signal, with IC1-e and IC1-f re-inverting the signal to normal as well as buffering IC3-b's output for greater output current; we'll discuss where that high-powered signal gets used later.

The fifth section is the Intrusion Counter. This consists of a BCD (binary-coded decimal) counter (IC6), a BCD-to-7-segment decoder (IC7), current-limiting resistor network R7, and a common-cathode 7-segment LED display (DISP1).

With each system activation, IC4 counts to four, resetting on the fifth count. That reset pulse also clocks

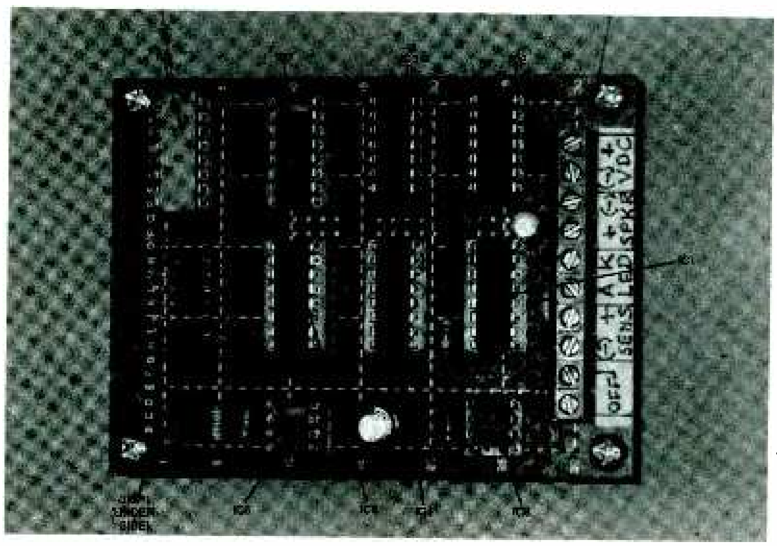


Fig. 5. Here is the control module. Note that DISP 1 is mounted on the other side of the board. Using wire-wrap techniques, the locations need not be exact; this photo can be used as a guide in building your own board.

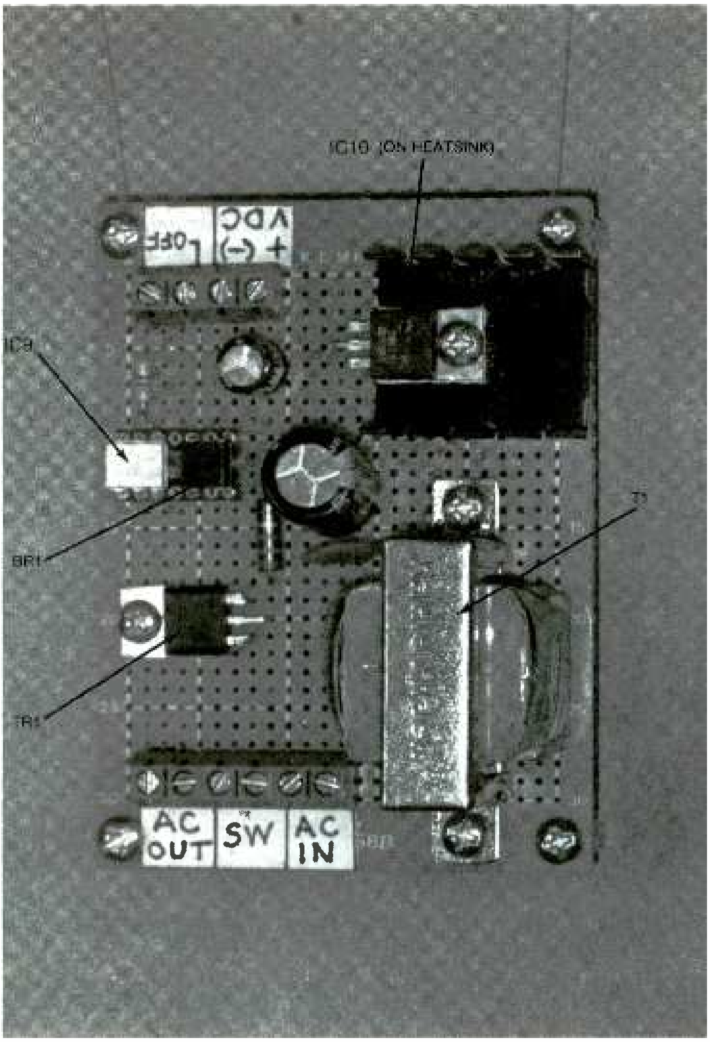


Fig. 6. The power module is built using similar techniques to the control module. Note that you'll have to drill several holes for screw-mounted items, such as T1 and IC10.

IC6, incrementing it each time. The value stored in IC6, therefore, is the number of times that the ScatCat has been set off. The magic of the binary-coded decimal format is that you can't count above nine, making it easy to display the value in a human-readable fashion. The BCD value of IC6 is decoded by IC7 and displayed on DISP1 with R7 limiting the amount of current available to each LED in the display. Without R7, the display (and possibly IC7) would burn out in short order. The reason that we use a resistor network instead of individual 680-ohm resistors is mere convenience; you could substitute standard resistors if you have enough of the right value in your "junkbox."

The last section of the ScatCat's control module, finally, is the Audio-Output Circuit. It is a standard astable-oscillator circuit built around IC5 and its timing components, and SPKR1, a high-frequency piezo "tweeter" normally used in home-audio speaker systems.

The LM555 operates as a free-running multivibrator; it is activated by IC3-b's "on" signal being applied to pin 4 (enable) of IC5. Each pulse from IC3-b results in an 18-kHz burst from IC5. That signal is coupled through C6 to SPKR1.

Power Module. The circuit for the power module portion of the ScatCat is shown in Fig. 2. Optoisolator IC9, together with R1 and R2, form a solid-state relay. The isolated control signal is boosted by TR1 to handle the load connected to J2. The load, in our case, is I1, a 100-watt light bulb. Note that the ScatCat, through S1, must be turned on for any power to reach I1. The signal to control the solid-state relay comes from IC1-e and IC1-f on the ScatCat's main board (see Fig. 1) that we discussed earlier. The current needed to drive this relay is why we used two gates as a current-boosting circuit. The logic is arranged so that when the "OFF" signal is high, I1 is off.

The rest of the power module circuit concerns, surprisingly, the ScatCat's power supply. Wall current is reduced to 12.6 volts by T1, rectified to DC by BR1, and smoothed by C7. This raw DC voltage is regulated by IC10. Capacitors C8 and C9 help stabilize IC1's operation.

The solid-state relay portion of the circuit could be replaced by a single-piece solid-state relay, such as a RadioShack 275-310.

While IC10 is a precision regulator, there are possible situations where the DC voltage could occasionally exceed the 15-volt maximum limit of the CMOS ICs used in the ScatCat. This could be prevented by using Motorola CMOS chips—which have an 18-volt maximum rating—or by changing Transformer T1 to a unit with a 10-volt output. Those changes would allow IC10, C8, and C9 to be eliminated. The entire DC supply could be removed by using a 9-volt DC wall transformer, such as RadioShack 273-1455. This would, however, provide an additional external plug to contend with.

Construction. The ScatCat is simple enough to be built on perfboard using standard construction techniques. Because of that, no PC-board patterns are available. Should you want to use printed-circuit techniques in building the unit, you'll have to design your own patterns.

We'll start actual construction by modifying the motion detector. While these instruction are specific to the unit mentioned in the Parts List, they can be applied to other devices in a general manner; it is up to you as to how to go about modifying any detector that you want to use.

Remove the mounting bracket,

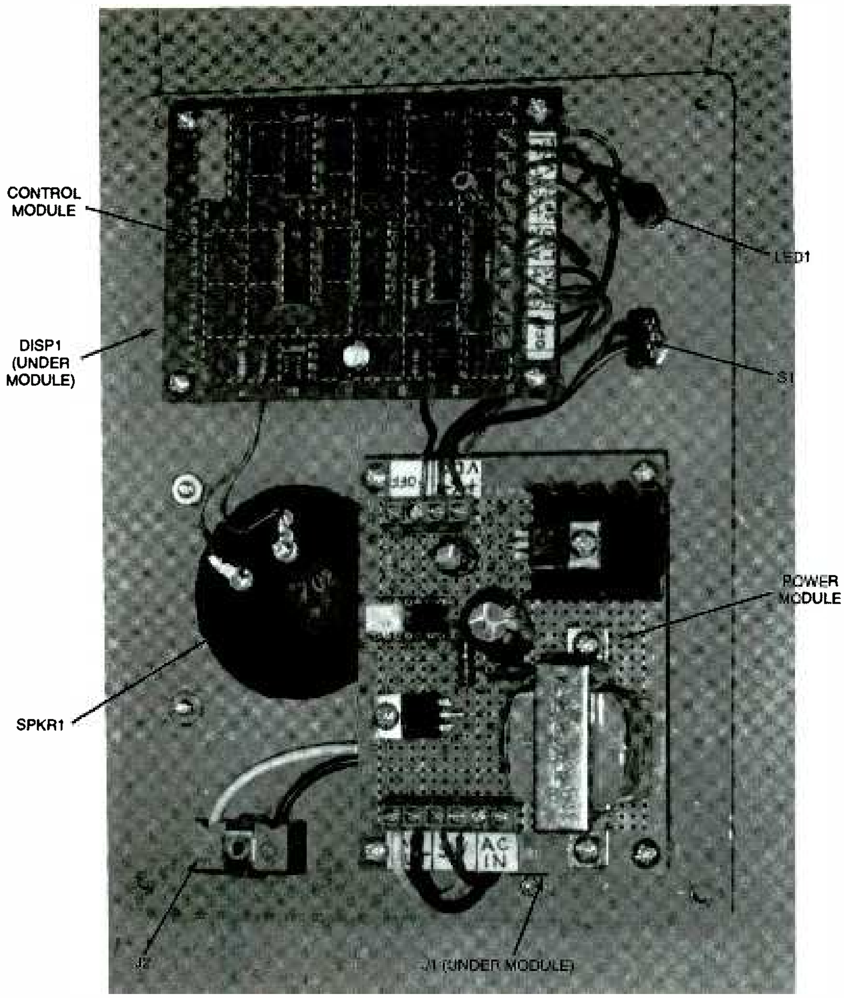


Fig. 7. The completed ScatCat front panel carries all of the various components. Note how they form a neat and handy unit.

open the battery compartment, and remove any battery that might be inside. Open the case by removing the single screw inside the battery compartment. Unsolder the speaker wires from the PC board. In their place, solder a two-foot (minimum) length of small-gauge paired wire, such as intercom twin-pair wire. Two conductors peeled from the edge of a scrap of ribbon cable will work as well. Note the polarity of the connections as marked on the PC board; maintain it through the connectors to the ScatCat's control board. Reassemble the sensor, bringing the new wire pair out through the battery compartment. File a small notch in the edge of the battery cover to allow an exit for the new wire. Reinstall the battery and cover. Insure that the sensor switch is turned off. Add connector P1 to the free end of the wire, observing the correct polarity.

The enclosure used for the ScatCat prototype is a simple 6- × 8-inch project box. Approximate locations of the various holes needed in the front panel are shown in Fig. 3. Keep in mind that there is nothing sacred here about the size or shape of the enclosure or the component locations. You should hold off cutting the holes for the jacks and DISP1 until you have an actual board to measure from. When you have those measurements, you can cut the rectangular holes by first drilling an appropriately-sized hole and using a nibbling tool (such as RadioShack 64-823) to make the final cuts.

The exact location of the mounting holes for the boards should be measured from the actual board being used; the dimensions shown should be close enough to get you started. Install DISP1 into a 16-pin wire-wrap socket and insert the socket into a blank board's solder-ring side at the approximate position indicated in Fig. 3. Mount the board onto the rear of the front panel with standoffs; see Fig. 4. Temporarily place the face of DISP1 against the rear of the front panel. Mark the outline of DISP1 on the back of the front panel, remove the board, and cut out the hole. After cutting, remount the board on the standoffs, set DISP1 so that it is flush with the topside of the front panel, and tack-solder the socket in place.

The control-module board contains all of the circuitry shown in Fig. 1 with the exception of J1, LED1, and SPKR1; we've already taken care of SEN1 and P1. While you can use any layout that you wish, the author's prototype is shown in Fig. 5, with labels showing the locations of some of the major components.

As you did with the socket for DISP1, tack-solder the IC sockets in place. When installing the discrete components (resistors, capacitors, etc.), leave about 1/4-inch of lead protruding when you trim them after soldering. That "pin" will be used to make circuit connections. Details are shown in Fig. 4.

Note that a bank of screw-type terminals are located on the side opposite DISP1; wire connections to the rest of the circuit will be made from there. While using such a terminal is not mandatory, it does make building the project easier when it comes time to do the final wiring.

When all of the components are mounted on the board, make the circuit connections using wire-wrap techniques. Follow the Fig. 1 schematic diagram as you wire the circuit. Work slowly and carefully, double-checking each connection as you go. Care at this point will prevent many frustrating hours of troubleshooting a wiring error later.

Wire wrap was designed with square posts in mind. The wire-wrap style IC sockets have such posts. Note that when you wrap wire around them the corners of the posts "bite" into the wire. The result is a mechanically- and electrically-

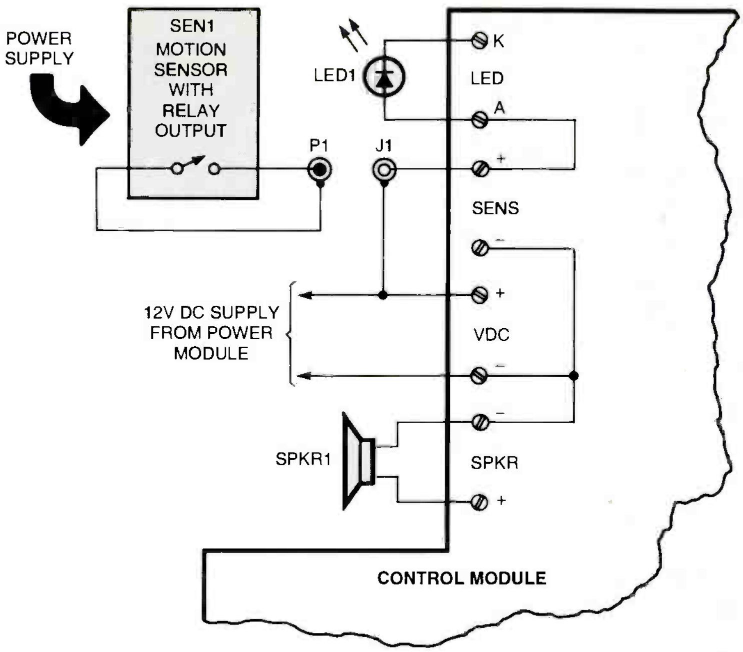


Fig. 8. This alternative wiring arrangement lets you use a motion sensor with a relay output.

solid connection that needs no soldering and can be easily removed for troubleshooting or modification. The only down side to modifying wire-wrap connections is that the wrapped portion of the wire must be cut off and re-stripped; the biting action weakens the wire so that it can only be wrapped once. When you make wire-wrap connections to the round component leads, you must solder those connections so that they will not degrade over time due to corrosion.

The power-module circuit is built on a second board as shown in Fig. 6. The same comments and suggestions made for the control-module board applies to this board as well. Note that IC9 and BR1, a 6-pin and 8-pin DIP component respectively, are placed in a single 14-pin socket. You'll have to drill some holes for screws and nuts to hold T1, IC10, and TR1 in place. Don't forget to use a heatsink on IC1.

Because of the higher currents involved—especially in the power-supply section—use 24- or 26-gauge insulated wire with point-to-point soldered techniques; wire-wrap is not really suitable for these components.

The circuitry for the two modules certainly could have been combined onto a single larger circuit board, but placing AC-power circuitry and DC-control circuitry in close proximity is not a good design practice. In some circuits, AC-to-DC coupling interference can cause circuit malfunction. If there is a miswiring or a short circuit, a catastrophic failure could occur. All of the AC is therefore confined to its own board and opto-isolated from the DC circuitry.

All of the ScatCat components are mounted onto the backside of the front panel. See Fig. 7 for the rear view of the author's prototype.

(Continued on page 58)

PARTS LIST FOR THE SCATCAT

SEMICONDUCTORS

IC1—CD4049 CMOS inverting hex buffer, integrated circuit
IC2—CD4013 CMOS dual D-type flip-flop, integrated circuit
IC3—CD4011 CMOS quad 2-input NAND gate, integrated circuit
IC4—CD4017 CMOS decade counter, integrated circuit
IC5—LM555 timer, integrated circuit
IC6—CD4510 CMOS BCD up/down counter, integrated circuit
IC7—74C48 CMOS BCD-to-7-segment decoder/driver, integrated circuit
IC8—4N28 optoisolator with transistor output
IC9—MOC3010 optoisolator with Triac output, integrated circuit
IC10—LM7812 12-volt, 1-amp positive fixed voltage regulator, integrated circuit
BR1—Full-wave bridge rectifier, 50-volt, 1-amp, DIP package
DISP1—Light-emitting diode 7-segment display, common cathode (RadioShack 276-075 or similar)
LED1—Light-emitting diode, red
TR1—Triac, 400-volt, 6-amp

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—680-ohm
R2—10,000-ohm
R3—1-megohm
R4—100,000-ohm
R5—1000-ohm
R6—33,000-ohm
R7—680-ohm, 8-resistor network, isolated units (Bourns 4116R-001-681 or similar)
R8—470-ohm
R9—180-ohm

CAPACITORS

C1, C3, C8—0.1-µF, ceramic-disc
C2—10-µF, 16-WVDC, electrolytic
C4—0.002-µF, ceramic-disc
C5—0.01-µF, ceramic-disc
C6—100-µF, 16-WVDC, electrolytic
C7—1000-µF, 35-WVDC, electrolytic
C9—220-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—2-conductor socket to mate with P1
J2—AC-style receptacle, panel-mount
SEN1—Infrared motion detector/alarm (RadioShack 49-425 or similar), modified (see text)
P1—2-conductor plug to mate with J1
PL1—AC line cord with plug
S1—Single-pole, single-throw switch
SPKR1—Piezo-style "tweeter" speaker (RadioShack 40-1383 or similar)
T1—12.6-volt AC, 300-mA transformer (RadioShack 273-1385 or similar)
Circuit boards (RadioShack 276-158 or similar), terminal blocks (RadioShack 276-1388 or similar), heatsink for IC10, mounting hardware for LED1, wire-wrap IC sockets, 9-volt battery, wire, case (RadioShack 270-1809 or similar), hardware, etc.

Get usable solar energy with this
SOLAR–CELL INVERTER

Build this beginner's-level circuit and harness the energy of the sun to power your next electronics project!

FRED NACHBAUR

Solar-cell technology has come a long way in the past decade. It's not uncommon in areas that have strong year-round sunlight to find homes powered primarily by solar energy. One of the spin-offs of large-scale solar-battery manufacture is that several companies are wiring solar-cell fragments together to form inexpensive packages (small solar arrays) for use by hobbyists and experimenters. Those arrays are usually comprised of several odd-sized chunks of solar cells wired in parallel and enclosed in a plastic frame, complete with lenticular cover to help improve output capability when the cell is not exactly at right angles to the Sun.

Such arrays typically are able to provide output voltages ranging from about 0.5 to 12 volts or more at currents of 0.05 amps or more. Unfortunately, with such low energy outputs, the arrays are of little use in powering most electronic devices. That's where the subject of this article—*the Solar-Cell Inverter*—comes in.

The solar array used in our project measures $2\frac{1}{2} \times 3\frac{3}{4}$ inches and can supply up to 500 mA at 0.5 volts in full sunlight, representing a respectable output power (about $\frac{1}{4}$ watt) for such a small package. The half-volt output of the array is adequate to operate low-power DC loads such as small high-efficiency motors. However, there are very few other electronic devices that can be powered by such a low voltage, regardless of the available output current. That's primarily because most electronic devices (such as silicon transistors) require at least 0.6 volts to turn them on, due to the nature of the semiconductor material from which the device(s) are made.

The most common solution to the low-voltage-output dilemma is to place several identical cells in series, effectively multiplying the output voltage by the number of cells in the series string. But taking that route can get very expensive. Another solution is to use semiconductors that, by their very nature, have a lower forward-bias threshold. Devices (*e.g.* transistors and diodes) made from germanium are one possibility. Specially designed silicon diodes called "Schottky diodes" are another. Unfortunately, I'm not aware of any "Schottky transistor;" so if amplification or active switching is required, we're pretty much limited to germanium for our transistors.

Interestingly, germanium was the first material used extensively in the mass-production of soilid-state devices. But, in more recent times, germanium has fallen out of favor because of its high leakage currents, temperature dependence, and the relatively expensive manufacturing processes involved. Even so, there has been renewed interest in germanium devices simply because of their ability to operate at very low voltages. Thankfully, they are still available in "substitute" lines such as NTE and ECG, albeit at a much higher cost than in their heyday.

Another source of germanium

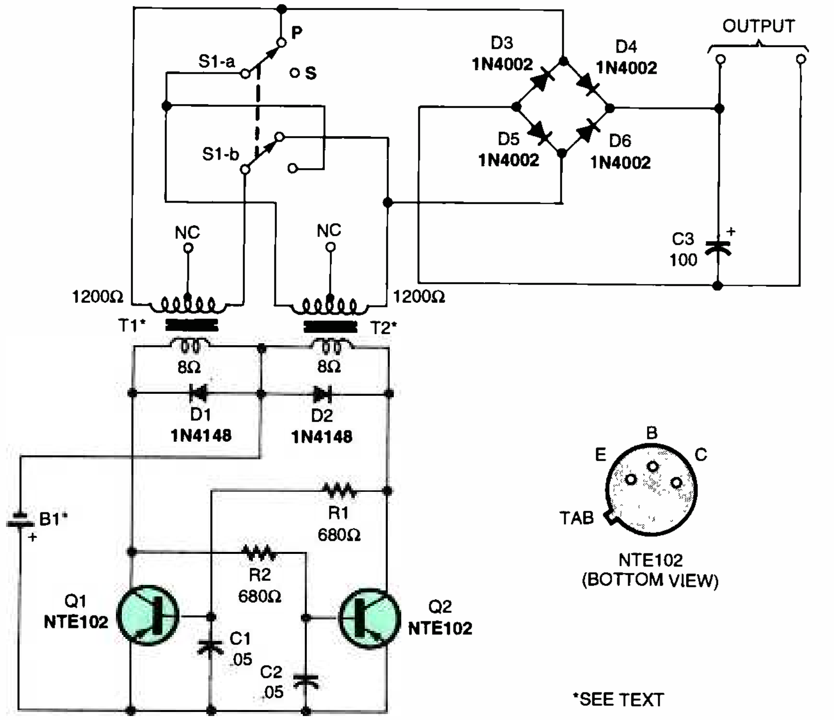


Fig. 1. The Solar-Cell Inverter can take the low-voltage output from a photovoltaic cell and boost it to a usable level. You can switch the output to increase voltage or current.

transistors is your junk box. The junk boxes of many experimenters are chock full of old "transistor radios," small discrete audio amplifiers, and similar bits of circuitry that include germanium transistors and other salvageable parts. Because the great majority of germanium transistors were of the PNP type, most of the gear that used them used a positive-ground system.

A Little Background. The Solar-Cell Inverter is useful for a variety of applications requiring higher voltages than afforded by a single solar cell. The inverter's output voltage can exceed 15 volts in direct sunlight at currents up to several milliamps. That's adequate for powering low-power op-amps and comparators, 555-based timing circuits, and a variety of other devices. With no modifications, the circuit can also be used to directly charge 9-volt NiCd batteries.

The total parts cost of assembling the inverter depends on what you can scrounge from your junk box. The transistors are (or rather, were) very common in the output stages of small audio amplifiers. And it wasn't uncommon to find a pair of them configured for push-pull operation and used to drive an audio-output transformer. Note that, in this application, we're using the same transformers. However, we're reversing the primary and secondary windings to provide the needed voltage boost.

About the Circuit. A schematic diagram of the Solar-Cell Inverter is shown in Fig. 1. The circuit is comprised of a pair of germanium transistors (Q1 and Q2), six diodes (D1-D6), a pair of transformers (T1 and T2), a solar array (B1), and a handful of support components. At the heart of the circuit is an astable multivibrator, better known as a free-running oscillator, formed from germanium transistors—one of the oldest constructs in electronics. To produce an oscillator, the inputs and outputs of the two transistors are cross-wired via two resistor-capacitor (RC) networks, comprised of R1 and C1, and R2 and C2. In that circuit arrangement, a portion of the output voltage of one transistor is diverted to the input of the other—in effect, routing a positive signal (feedback) from the output of one transistor to its counterpart. The result is that one transistor turns on as the other turns off. The time constant (TC) of the RC networks determines the operating frequency of the oscillator.

The oscillator produces a square-wave output that is applied across the series-connected primary windings of T1 and T2. The negative terminal of B1 (the photocell) connects to the junction of the two transformers. Note that there is a diode connected across each transformer's primary winding. Those diodes act as dampers to prevent inductive kickback (voltage spikes generated by the collapsing electromagnetic field that encompasses the coils of the transformer), especially under no-load conditions, from damaging the transistors as they switch off.

It's rather unfortunate that the transformers commonly available generally have a tap on the high-impedance side (which we don't need), but not on the low-impedance side, where we do need it. However, using two transformers, one for each transistor, can circumvent that problem. The advantage to that arrangement is that it allows a double-pole, double-throw switch to be connected to the outputs of the transformers so that their secondaries can be easily switched from "series" to "parallel" connections and *vice versa*. The series connection gives the highest output voltage, whereas the parallel con-

PARTS LIST FOR THE SOLAR-CELL INVERTER

SEMICONDUCTORS

D1, D2—1N4148 general-purpose silicon diode
D3–D6—1N4002 silicon rectifier diode
Q1, Q2—NTE102 or ECG102 general-purpose PNP germanium transistor (see text)

CAPACITORS

C1, C2—0.05-µF, polyester-film
C3—100-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

R1, R2—680-ohm, 1/4-watt, 5% resistor
T1, T2—1200-ohm primary, 8-ohm secondary audio-output transformer
S1—Double-pole, double-throw switch (optional; see text)
Wire, hardware, etc.

Measuring just $2^1/2 \times 3^3/4$ inches, the solar battery shown here can supply up to 500 mA at 0.5 volts in full sunlight.

nection gives a lower voltage, but delivers a higher current to the load.

The output of the transformers is applied to a full-wave bridge rectifier, comprised of four 1N4002 diodes. The resulting pulsating DC output voltage is then filtered by a 100-µF electrolytic capacitor, C3, to remove the ripple from the output voltage.

Building the Inverter. There's nothing critical about the construction of the circuit, so feel free to lay it out in any convenient configuration using the assembly method with which you are most comfortable. The author's prototype was assembled on a small section of perfboard, measuring $1^1/2 \times 2$ inches, with component inter-connection accomplished through point-to-point wiring. When assembling the circuit, be sure to observe the polarity of all polarized components (the transistors, diodes, and filter capacitor). Don't omit the damper diodes; the circuit will not deliver the rated output without them. Besides, leaving out those components could damage the transistors.

Note that in the schematic diagram (Fig. 1), the transformers have polarity marks (dots) at the primaries and secondaries. To help insure that you don't make polarity errors, mark one side of the transformers with a permanent marker. That's done to prevent the transformers from being wired into the circuit with a phasal difference. That's because a phasal difference (in effect, opposing voltages) across the transformer windings can cause the transformers to overheat and prematurely fail.

The primaries and secondaries of the transformers can easily be distinguished by their leads: One side of the transformer (the primary) has two wires, while the other side (the secondary) has three. The center tap of the secondary won't be used in this application.

Switch S1 is included in the circuit for experimenting with the circuit. Once you've established which transformer-output configuration works best for your particular project, you can remove it and hard-wire the transformer secondaries as desired. In the author's prototype, the output has a 9-volt battery clip. That setup allows easy connection of a 9-volt, 50-milliamp-hour (mAh) NiCd battery for charging by the Solar-Cell Inverter.

Testing. Once the circuit assembly is complete, it's time to check the circuit for the usual construction errors—cold-solder joints, incorrectly wired or polarized (with respect to the other circuit elements) components, etc.—correcting each fault as it is encountered. Powering the circuit while construction errors exist could cause damage to the semiconductors (diodes and transistors) or cause a reverse-polarized electrolytic capacitor to explode!

If all checks out OK, connect the solar cell to the input. Note that the polarity is opposite to what you might be used to! Since we're using PNP transistors, the "common" input (emitters of the transistors) is positive. You might be worried at this point if you're going to have to go to a positive-ground system. Short answer: Not at all. Thanks to the transformers, the input and output of the circuit are completely isolated. Your system ground can be either positive or negative, depending only on your preference.

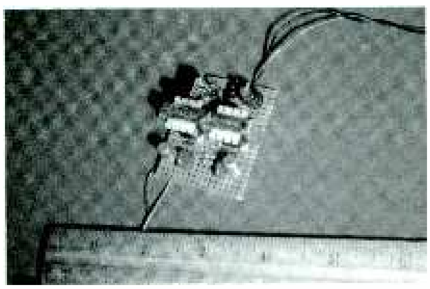
Connect a DVM (or analog equivalent) set to read voltage to the circuit's output terminals and bring the solar cell close to a light source. The meter should indicate an output voltage of up to several volts or more, depending on the distance between the light source and its intensity. You can also use a milliammeter (in the 20-mA or greater scale) to measure "short-circuit output current." With the component values shown, the circuit will tolerate short circuits at the output indefinitely.

Experiment with the two settings of the series-parallel switch. In series mode, the circuit will develop over 15 volts open-circuit and in parallel mode about 8 volts.

Using the Inverter. In full sunlight, the inverter can charge a 9-volt battery at about 4 milliamps, meaning that full charge will be attained in about 16 hours. Note that the series connection is required for this application.

If you're using the inverter to power other circuits, the parallel connection may be preferred for its higher output-current capability. You should have no trouble powering several low-power op-amps (like the LM358) with no changes to the circuit. If you use a resistive voltage divider to derive your "split-supply ground" for op-amps, your circuit should work over a wide variance of supply voltage, and regulators will not be required.

For applications requiring a regulated voltage (such as low-power TTL or CMOS logic), you'll have to follow the inverter with a regulator, since the voltage regulation of the inverter is pretty poor. Lower power TO-92 versions of the 7800- (positive) or 7900- (negative) series fixed three-terminal regulators would be ideal.



Shown here is the author's prototype, which was assembled on a small section of perfboard.

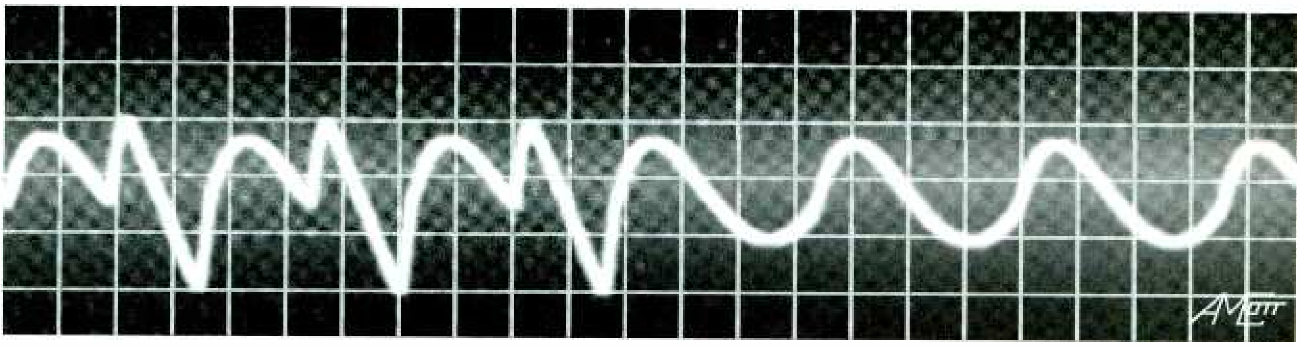
The possibilities are only limited by your imagination. Use, for instance, large-value "super-capacitors" (the one-Farad varieties used as battery backup in some computers) as a "reservoir" instead of a battery. Spy on birds, squirrels, and other local wildlife with a small FM transmitter powered by this combination. You could also use a similar arrangement for short-distance telemetry projects. Yet another use is for powering ancillary control circuits in a

(Continued on page 63)

ALL ABOUT ELECTRONICALLY-TUNABLE ACTIVE FILTERS

Learn about these almost indispensable building blocks of most electronic circuits.

RON TIPTON



Filters—low-pass, band-pass, high-pass, and band-reject—are used everywhere. Whenever we need to enhance the signal-to-noise ratio of a signal or reject a particular frequency or noise signal, we grab a filter.

Filters come in two basic "flavors:" active and passive. Active filters use "active" components such as op-amps or transistors, along with resistors and capacitors, to replace the bulkier passive filters that are built with inductors and capacitors. Besides being smaller, active-filter designs can have voltage gain (of unity or higher) as opposed to the insertion loss inherent in the passive types. Active filters are available as integrated circuits (ICs), encapsulated modules, or units built from discrete components. With that last variety, you have complete control over the circuit's response instead of relying on "off-the-shelf" specifications. Often, a fixed-frequency design will do the job, but sometimes a tunable filter is needed.

We're going to look at five different varieties of tunable filters. The first three use an analog voltage to control the center, or cutoff, frequency; the last two use a digital input for control.

Although simulation is a useful design tool, all of the response curves shown in this article were measured from actual circuits. They work as described! You can incorporate them into your designs "as is" or you can modify them as needed. For easy reference, I've summarized the strong and weak points of each of the five designs in Table 1.

A FET As A Variable Resistor. The first problem that we encounter in designing tunable filters is the limited number of active-filter types that permit independent control of the cutoff frequency, gain, and "Q." State-variable designs are especially suited to tunable filters; we'll use them in four examples. First, however, there is a special case that I want to cover because it's a simple and inexpensive way to make a tunable-band-pass filter.

Look at the multiple-feedback (MFB) filter shown in Fig. 1. The center frequency can be controlled by varying R2 as demonstrated by the formula

$$f_o = 1/(2 \times Q - A) \times (2\pi R2 \times C)$$

where A is the gain at the center frequency (f_o) and both C1 and C2 are the same value (C).

If we replace R2 with a junction-type field-effect transistor (JFET), the result is shown in Fig. 2. This is a band-pass filter with a voltage-tunable center frequency. With the Q set to 5 and the center frequency tuned to about 2000 Hz, the gain-

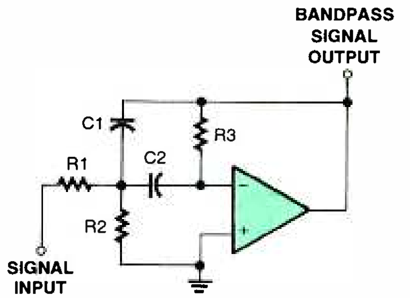


Fig. 1. This multiple-feedback band-pass filter can be tuned for a particular center frequency by varying the value of R2.

TABLE 1

TUNABLE FILTER COMPARISON TABLE

TYPE	TUNING RANGE	STRONG POINTS	WEAK POINTS
Variable-resistor FET	3:1	Simple, inexpensive	Must block DC-operating voltage
Variable-transconductance op-amp	280:1	Fairly wide tuning range; LM3080 cost less than one dollar	Large DC-offset voltage
Analog multiplier	524:1 (practical range)	Linear-cutoff-frequency tuning; Low output noise	Can't think of any!
Digitally-variable resistor	135:1	Easy-to-use serial tuning	Clock noise may be a problem
Multiplying DAC	366:1	Linear-cutoff-frequency tuning	Output noise and DC offset

vs.-frequency response is shown in Fig. 3.

There aren't too many situations where we can use a JFET as a variable resistor because of the necessary DC operating voltage. In this case, however, capacitors C1 and C2 isolate the DC voltage from the op-amp's input as well as participate in setting the frequency response. In the tunable circuit, R2 is the series combination of R3 and the JFET's resistance in parallel with R2. This makes the design a bit tedious to do by hand, so I simulated this circuit in *Spice*. I've included the *Spice* file in a file that can be downloaded from the **Poptronics** FTP site. That file, located at *ftp.gernsback.com/pub/pop/tunable_filter.zip*, includes some other software as well that I'll mention later.

The measured tuning response for this filter is shown in Fig. 4. We can see that it's rather nonlinear, as is the tuning of three of our five examples. The exceptions are the analog and digital multipliers, which we'll get to later. In practice, this nonlinearity isn't much of a problem because we can tailor the control circuit to match the filter's tuning needs.

So how could we use this "beastie" in a real application? One use is in an adaptive filter according to the block diagram shown in Fig. 5. The output voltage varies the filter's center frequency to maximize the output voltage. That is, the filter tracks in input frequency. When applied to a noisy input signal, the output will be much "cleaner."

All equations in this article are stated without formal proof. The example circuits work, so that seems to be proof enough. If you want to see where the equations come from, look at one or both books I've listed in the "Resources" sidebar.

I've already mentioned some "filter-centric" terms that you may already be familiar with or at least be able to figure out from the context of this article; terms like cutoff frequency are somewhat self-explanatory. However, there are probably several "newbies" out there that are scratching their heads wondering, "What, exactly, is a 'Q?'"

That's a good question. Aside from the obvious reference to certain characters that appeared in the *Star Trek* television series, the term Q in electronics refers to the "quality factor" of a filter circuit. It is the relationship between a filter's resonant frequency and band-

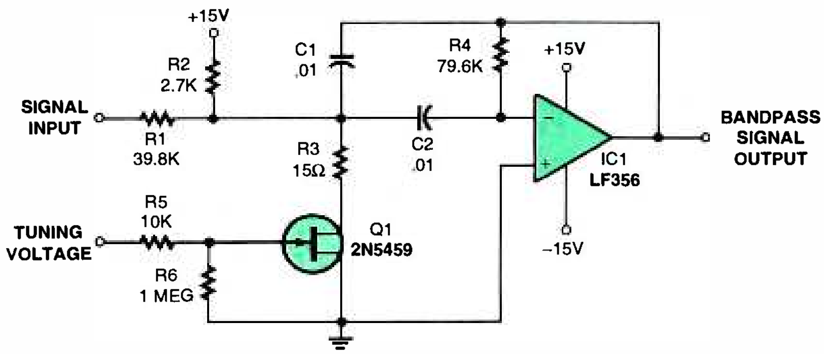


Fig. 2. By substituting a field-effect transistor for R2 of the previous circuit, we get this voltage-tunable band-pass filter. Note that C1 and C2 isolate the FET's supply voltage from the op-amp.

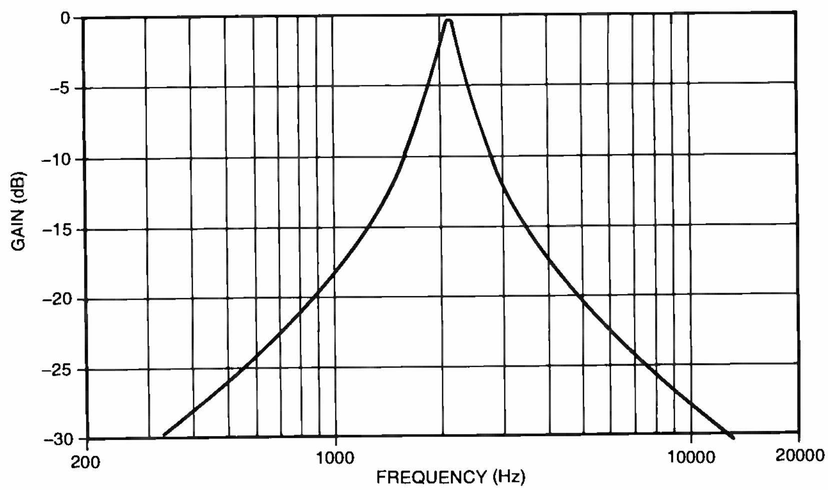


Fig. 3. Here is the response curve of the single-pole voltage-tunable band-pass filter.

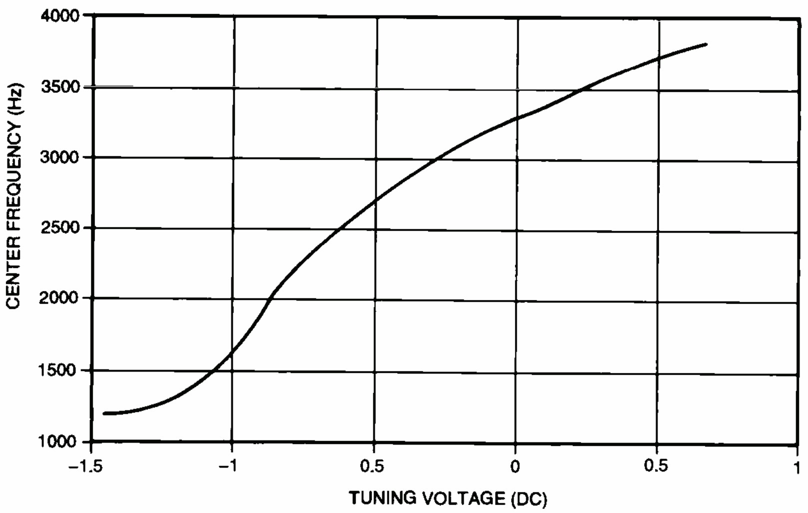


Fig. 4. This graph plots the relationship between the center frequency vs. *the tuning voltage for the single-pole band-pass filter. The tuning is linear over short spans only. For example, it's fairly linear from 1500 to 2500 Hz.*

width. A bandpass filter can be thought of as a combination of a low-pass and a high-pass filter. The frequencies above the low-pass filter's cutoff and below the high-pass filter's cutoff are the ones that are passed. If you plot the response, you'll see that it can represent a peak or a dip, depending on the direction that the plotline goes. The "steepness" of the slopes indicate the Q factor; the more vertical the slope, the higher the Q. The result is a filter that has greater "sharpness" in passing or blocking the target frequencies.

State-Variable Low-Pass Filters. As I've already mentioned, the other four examples use state-variable designs. These come in several slightly different "flavors," and the two that we're going to look at are shown in Fig. 6. These are both basic 2-pole "building blocks." Each one uses four op-amps, eight resistors, and two capacitors. These 2-pole blocks can, of course, be cascaded to create any even-order filter that we might need.

In both circuits, the cutoff frequency, f_c, is given by

$$f_c = 1/(2\pi R3 \times C)$$

where C=C1=C2 and R3=R4.

If we use a component for R3 and R4 whose resistance we can vary, we will have a low-pass filter with a tunable cutoff frequency. The Q and passband gain will be constants unless we choose to make them tunable too. For example, using a variable resistor for R6 in Fig. 6A would make the Q tunable. That's because the Q is set by the ratio of R6 and R7; dividing the first value by the second yields the Q of the circuit. Likewise, the gain is set, the same way as in basic op-amp design, by the ratio of R5 to R1;

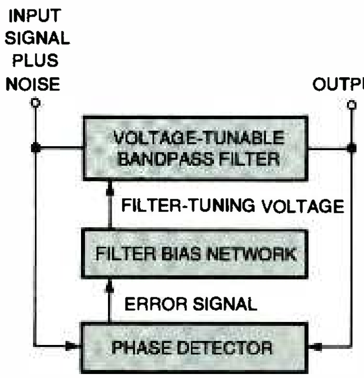


Fig. 5. The block diagram for an input-frequency-tracking filter. When the filter is tuned to the input frequency, there is a 180° phase shift between the input and output signals, resulting in a minimum error signal.

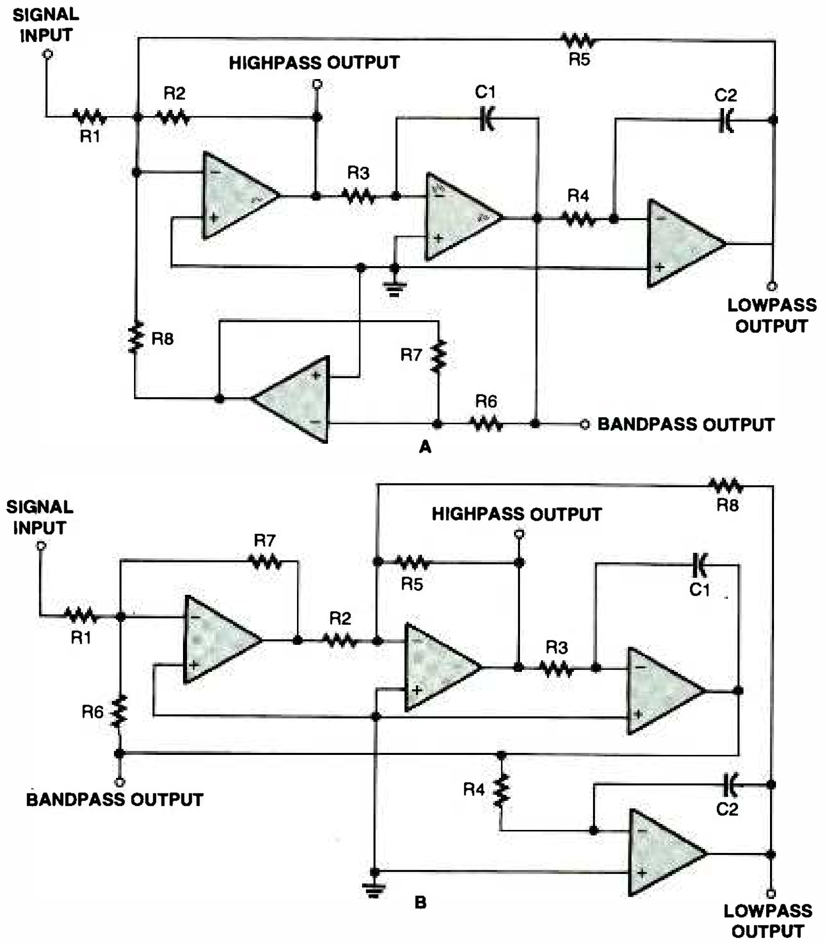


Fig. 6. There is more than one way to design a state-variable 2-pole filter. The circuit shown in (B) is sometimes called a "universal" active filter.

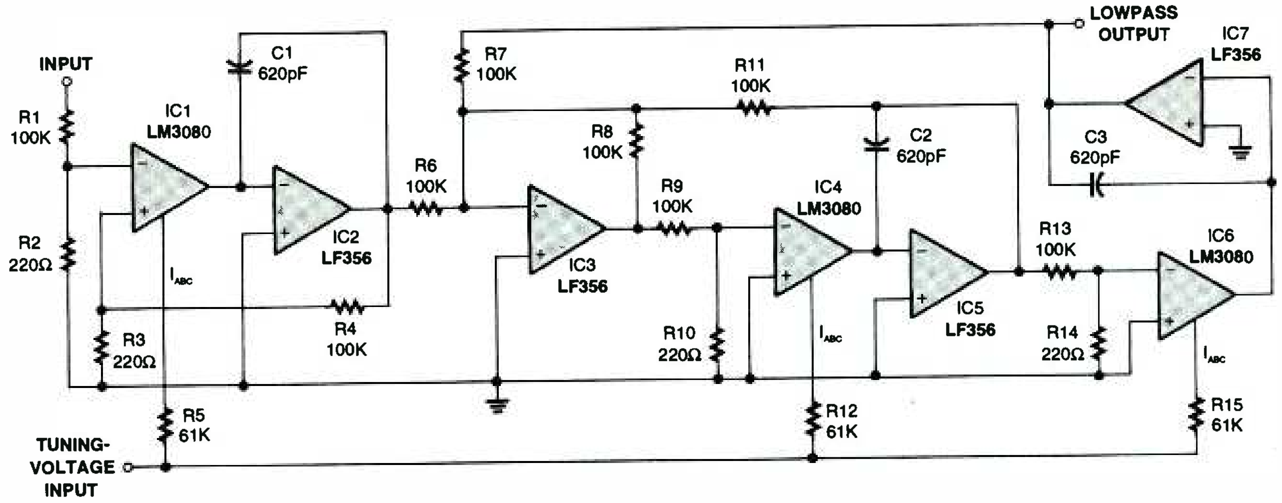


Fig. 7. On this tunable 3-pole Butterworth low-pass filter, the power-supply connections have been omitted for clarity.

again, divide the first by the second for the actual gain value.

The same formulas work for Fig. 6B as well: R5 and R1 set the gain while R6 and R5 set the Q.

One final note: If you want to experiment with the Fig. 6 circuits, you should set R2 and R8 (in Fig. 6A) to the same convenient value; 10K or 100K will do. For Fig. 6B, R2 and R7, and R5 and R8 should match each other in value.

In the following examples, we will look at using variable-transconductance op-amps, analog multipliers, digital potentiometers (VRs), and multiplying digital-to-analog converters (MDACs) as the controlled resistor. We'll start with...

Variable-Transconductance Op-amps. The LM3080 (or CA3080) exhibits variable transconductance that is controlled by the current (I_{abc}) into pin 5. In other words, the resistance of the op-amp from its input to its output appears to vary with the control current. By substituting an LM3080 for both R3 and R4 of the Fig. 6 circuits, we can tune the cut-off frequency.

Although the LM3080 control pin is really a current input, we can use a series resistor as a simple voltage-to-current converter. The 61,000-ohm, 1% resistors in series with pin 5 of each of the LM3080s (as shown in Fig. 7) let us tune the filter with a control voltage between −14.5 volts and +15 volts. Although the circuit uses a dual (plus and minus) 15-volt power supply, we can't drive the control pin all the way to the negative supply voltage. Doing so just turns the LM3080 off, and there will be no signal at the filter output.

I developed this circuit in the mid 1970s to solve a particular design problem. I was developing a piano-tuning aid for the Baldwin Piano and Organ Company, and I used a programmable-frequency divider to generate the tone for each piano key. The divider's output was a squarewave that was "too rich" in harmonics for the application. This called for some low-pass (or band-pass) filtering. I determined that a 3-pole Butterworth (maximally flat amplitude) response with a rolloff of −18 dB per octave was the simplest filter that would do the job.

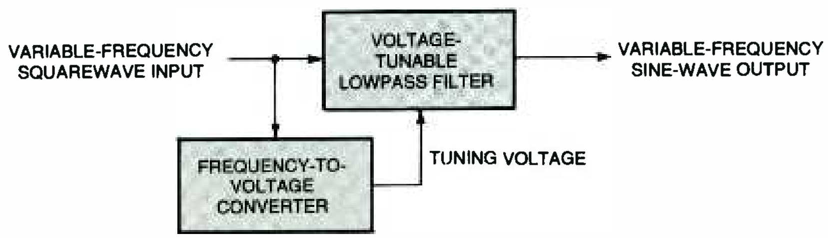


Fig. 8. A voltage-tunable low-pass filter was used to track the input frequency in a piano-tuning aid developed by the author.

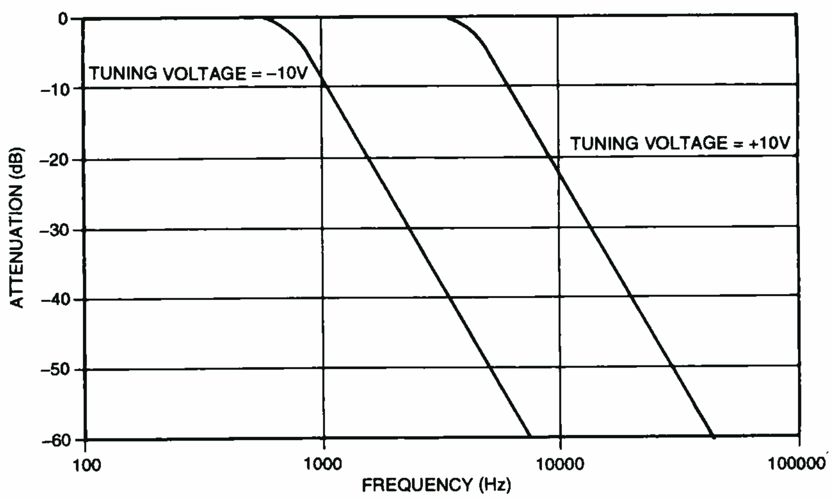


Fig. 9. This graph charts the low-pass frequency response of an LM3080-based 3-pole Butterworth filter. For both tuning-voltage values, there is a −18-dB rolloff per octave.

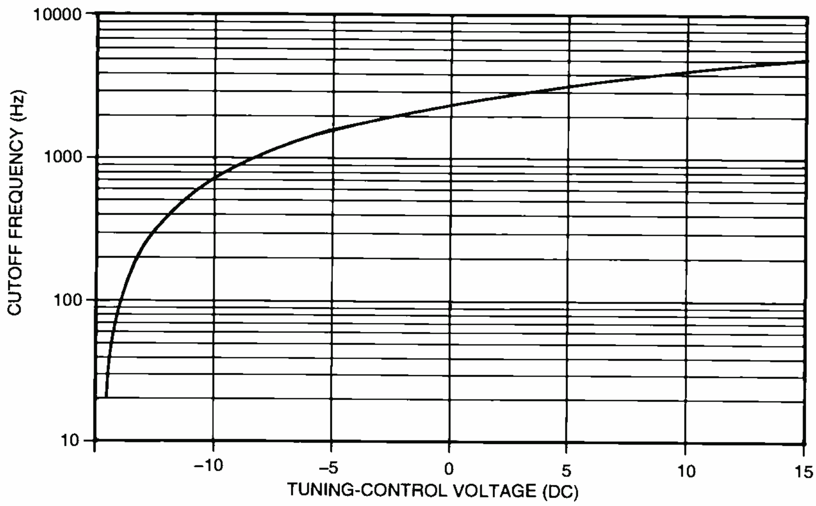


Fig. 10. This cutoff-frequency-tuning curve for the 3-pole Butterworth filter shows how the circuit turns off at tuning voltages below –14.5 volts.

Then I used a frequency-to-voltage converter to tune the filter. This combination, wired in accordance with the Fig. 8 diagram, tracked the divider's output frequency and neatly solved the problem.

Amplifiers IC1 and IC2 form the real (third) pole. The rest of the filter, IC3 through IC7 and associated resistors and capacitors, is just the Fig. 6A circuit; that might not be obvious at first glance. Because the complex pole pair in a 3-pole Butterworth response has a Q of 1, we are able to leave out one op-amp. The 100,000-ohm resistor between the IC7 output and the IC3 input replaces IC4, R6, R7, and R8 in Fig. 6A.

The design equations in Fig. 6 apply here as well, but we need to account for the effective resistance of the LM3080s. At the minimum control current (I_{abc}), this resistance is over 12 megohms, which explains how we are able to get a cutoff frequency of 20 Hz with 620-pF values for C1 and C2. The 100,000-ohm/220-ohm voltage divider is needed at each LM3080 inverting input because the gain becomes nonlinear for inputs larger than about 10 millivolts. Notice that the LM3080s are operating open loop—there is no feedback resistor! This lets us get a useful swing of several volts at the filter's output. As you can see, this filter design includes a couple of "tricks" that you may find worth keeping in mind.

I measured the output noise at less than one millivolt rms with a "true" rms voltmeter (an HP 3400A). That represents broadband random noise with some burst or "popcorn" noise—probably from the LM3080s. The output's DC offset varies with the tuning-control voltage, so the output must be capacitively coupled for most applications.

Response curves for two values of tuning voltage, the tuning voltage vs. cutoff frequency curve, and a photograph of the filter module are included as Figs. 9, 10, and 11.

Analog Multiplier. An analog multiplier produces an output voltage that is the product of two input voltages, so we can use a multiplier as a variable resistor to tune our filter. This is perhaps easier to understand by looking at it this way: The control voltage multiplied by the AC signal changes the voltage of the AC signal; that is, it changes the gain. Nevertheless, a gain change at an op-amp's inverting input appears like a change in the value of the series resistor (for constant-feedback impedance).

If we replace R3 and R4 from Fig. 6A with analog multipliers, we get the circuit shown in Fig. 12. The Analog Devices AD633 is a low-cost multiplier with a 1-MHz small-signal bandwidth. Its transfer function is given by

$$\text{Output Voltage} = (\text{X Input} \times \text{Y Input})/10$$

and the low-pass cutoff frequency is

$$f_c = V_c/(20\pi R3 \times C)$$

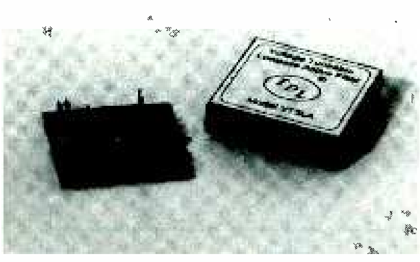


Fig. 11. Here is the author's 3-pole Butterworth low-pass filter module using LM3080s. After the module is potted, it measures 2 × 2 × 1/2 inches.

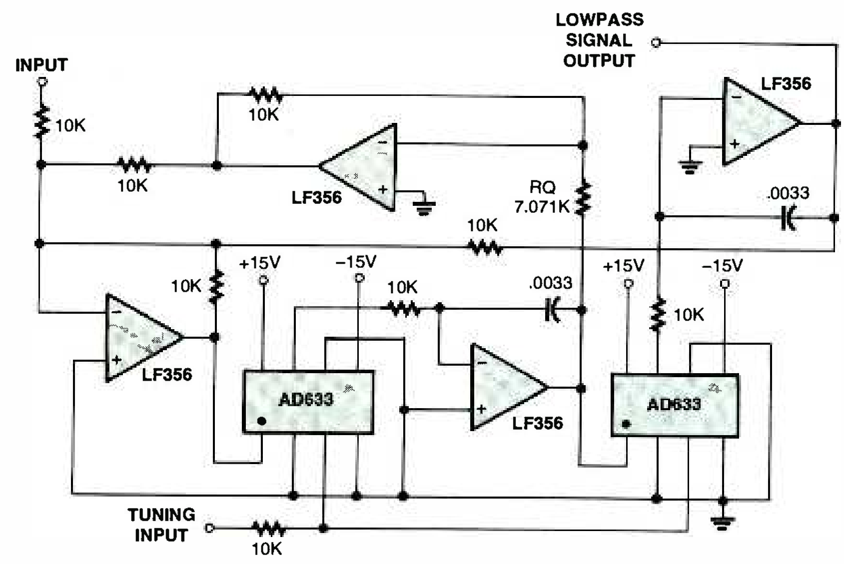


Fig. 12. This 2-pole Butterworth filter uses analog multipliers for cutoff-frequency tuning.

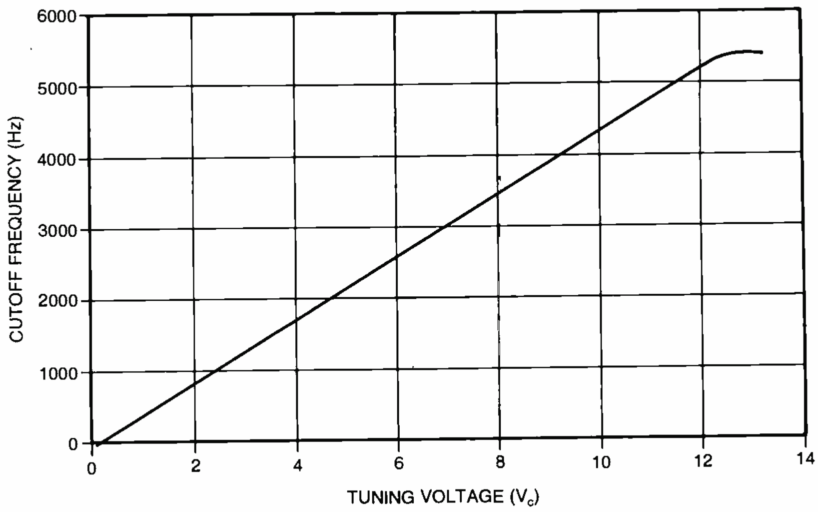


Fig. 13. Here is the measured cutoff-frequency-tuning curve for the 2-pole Butterworth filter using analog multipliers.

where V_c is the tuning-control voltage, R3 = R4, and C = C1 = C2.

Figure 12 is a 2-pole Butterworth low-pass filter; the design equations in Fig. 6A apply here as well. The measured cutoff frequency tunes from 11 Hz to 5766 Hz as shown in Fig. 13. The tuning is linear up to a V_c of 12 volts, just as we would expect from the above equation. We can also see another interesting point from this equation: The filter theoretically tunes all the way to zero frequency as V_c goes to zero. However, the cutoff frequency is 11 Hz at a V_c of 30 millivolts, so very good control-voltage stability is needed to go to lower cutoffs.

This is a "quiet" filter; the output noise is about 300 microvolts rms with the filter's input either open or shorted. That was measured with a wideband true rms voltmeter; the noise is indeed wide-band random noise with no hint of any single-frequency components. The DC offset was less than 5 millivolts and is primarily set by the op-amps.

A measured frequency-response curve is included as Fig. 14.

Digital Potentiometer. A digital potentiometer is ideally a digitally-controlled variable resistor. Real components, such as the 8-bit Analog Devices AD8402 (dual) and AD8403 (quad), are not quite ideal. Their limitations do not really interfere with performance, but they must be kept in mind to assure a successful design.

The variable resistor is easy to understand. It is literally a resistor with 256 different values (8-bit selectable). If we replace R3 and R4 in Fig. 6A with a 10,000-ohm AD8402, we get the circuit diagrammed in Fig. 15. This is again a 2-pole Butterworth design.

The Fig. 6 design equations again apply, but we have to work with the practical limitations I mentioned above. The first of these is "wiper resistance." The variable resistor has some resistance (about 50 ohms) when the digital input is all zeros. Also, this resistor is a "5-volt IC." That is, it is designed to work between +5 volts and ground; and it works best with op-amps using the same power-supply voltage. This requires a +2.5-volt "virtual" ground to bias the op-amps to the power-supply midpoint. This limits the output voltage swing to ±2.5 volts even with

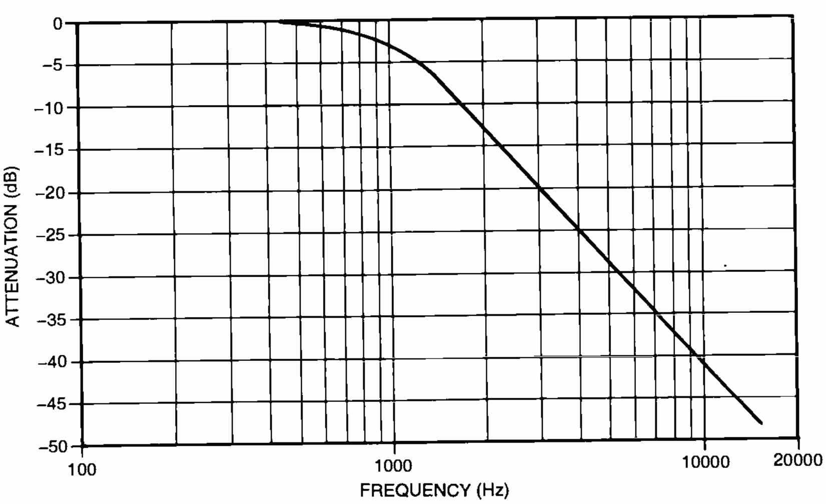


Fig. 14. A plot of the analog-multiplier-based 2-pole Butterworth low-pass filter shows that the rolloff at a tuning voltage of 2.2 volts is –12 dB per octave.

RESOURCES

There's a bunch of books on filter design. Some are more readable (and useful) than others; two in this category are listed below:

Active-Filter Cookbook (D. Lancaster), Synergetics, Thatcher, AZ
Electronic Filter Design Handbook (A.B. Williams and F.J. Taylor), McGraw-Hill

The file mentioned in the text, *tunable_filter.zip*, is available on a $3^1/_2$-inch disk from the author for $5, postpaid. Send check or money order to: TDL Electronics, 5260 Cochise Trail, Las Cruces, NM 88012; 505-382-8175; Fax: 505-382-8810.

All of the components used in the examples are readily available. I've listed some suggested sources below (you should have these catalogs anyway!):

Digi-Key Corporation
701 Brooks Ave. South
Thief River Falls, MN 56701-0677
800-344-4539
www.digikey.com

Jameco Electronic Components
1355 Shoreway Road
Belmont, CA 94002-4100
800-831-4242
www.jameco.com

Mouser Electronics
2401 Hgwy 287 North
Mansfield, TX 76063-4827
800-346-6873
www.mouser.com

"rail-to-rail" op-amps such as the AD484 that I used in the test circuit.

Both the AD8402 and AD8403 have a 3-wire, SPI-compatible, serial-data input and are very easy to program. For this example, I used a PIC microprocessor from Microchip to read a set of eight toggle switches, generate an 8-bit control byte from them, and program the AD8402 with that value. The C program that I wrote for this proved to be too large for a 16C54 with its 512 bytes of EPROM, so I used a 16C71 with its 1K of program memory. This program is included in the *tunable_filter.zip* file mentioned before. An assembly language version could possibly be made to fit the smaller memory of the former microcontroller, but it didn't seem worth the effort for this example.

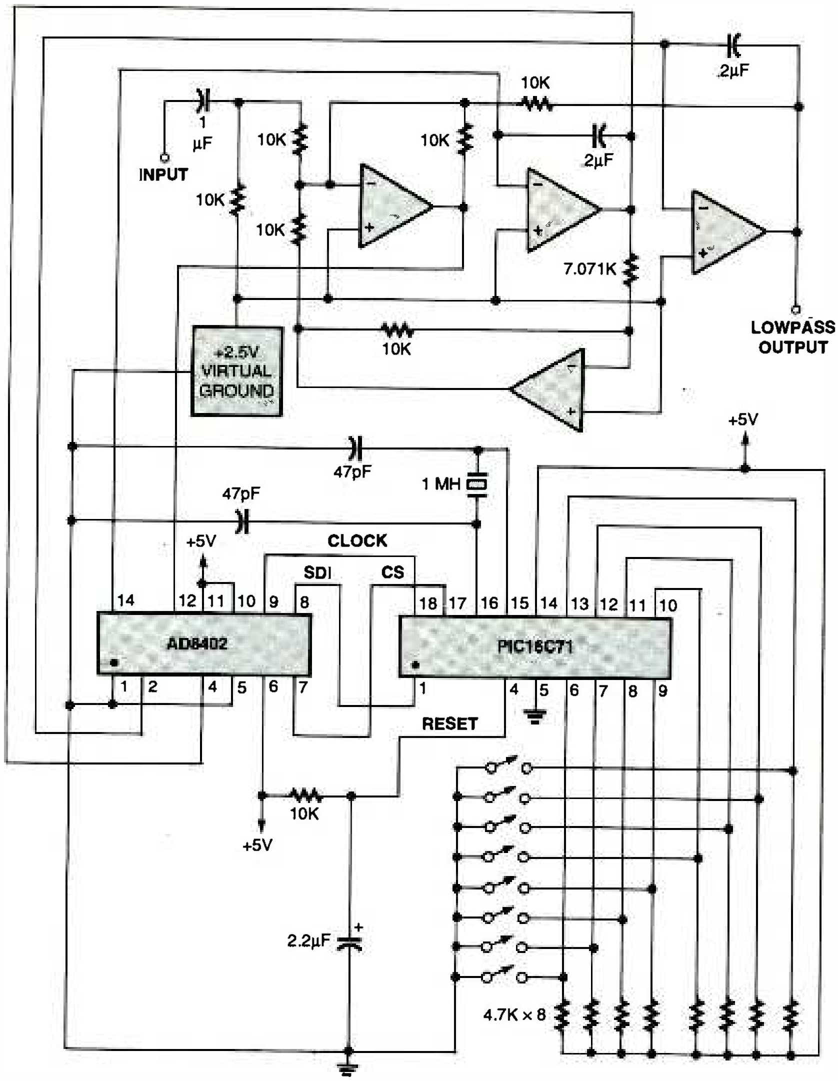


Fig. 15. This 2-pole Butterworth filter uses digital potentiometers to tune the cutoff frequency. Note the use of a "virtual" ground to center the output-voltage swing of the op-amps.

The cutoff-frequency tuning is shown in Fig. 16 as a continuous curve for clarity. It is, of course, a set of 256 discrete frequencies. The frequency response is still the same -12-dB-per-octave rolloff as shown in Fig. 14, so there didn't seem to be any good reason to repeat it.

This filter is somewhat "noisy" because of the microprocessor clock. I measured about 3-millivolts rms output noise that is predominately 1-MHz spikes. If that amount of noise is a problem, one solution would be to put the microprocessor to "sleep" (stopping the clock) except when actually programming the variable resistor. Both the AD8402 and AD8403 have latches that store the last programmed data until it is updated or power is turned off.

The program as written checks the toggle switches every 100 milliseconds and reprograms the variable resistor only if the data has changed, so the 1-MHz spikes are all clock noise.

At first glance, you may think that this filter should have a linear cutoff-frequency-tuning response. After all, each step of the AD8402 is an equal resistance change of about 39 ohms. However, this arrangement doesn't give linear tuning. You can easily verify this by plugging some equal-step resistance values into the cutoff frequency equation from Fig. 6.

Digital-To-Analog Converter. A multiplying digital-to-analog converter

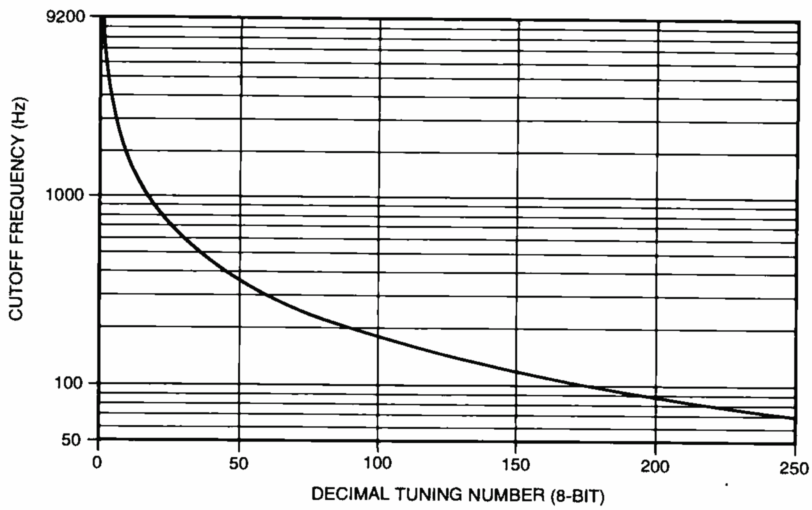


Fig. 16. Although the cutoff-frequency-tuning plot for the 2-pole Butterworth filter using digital potentiometers should have 256 discrete steps, a continuous curve is shown here for clarity.

TABLE 2
4-POLE PAPOULIS FILTER COMPONENT VALUES

Component	Section 1	Section 2
R1	20K	10K
R2	10K	10K
R5	20K	10K
R6	11.9K	21K
R7	10K	10K
R8	20K	10K
C1	42-pF	28-pF
C2	42-pF	28-pF
C_c	-none-	27-pF

(MDAC) is very much like an analog multiplier except the control input is digital data instead of a voltage.

Our final example uses four National Semiconductor 12-bit MDAC's (type DAC1222) to tune the cutoff frequency of a 4-pole low-pass filter. I also decided to use the Fig. 6B "universal" filter this time to show you how to use another response instead of our old, familiar Butterworth.

In 1958, A. Papoulis published a paper in the *Proceedings of the IRE* on a filter response with a steeper rolloff than a Butterworth but with no amplitude ripple in the pass-band such as you get with a Chebychev response. This was apparently the first English-language publication on this "monotonic" pass-band response, so it got the name "Papoulis." The Butterworth has a maximally-flat passband.

The 4-pole Papoulis response is given by

$$(s^2 + 1.0995s + 0.43079)\times(s^2 + 0.46338s + 0.94767)$$

and each quadratic term can be built with one of the 2-pole filters shown in Fig. 6. We can then just cascade them to get the 4-pole response.

Each of the above quadratics corresponds to:

$$S^2 + (s\,\omega\,/Q) + \omega^2$$

so we can equate coefficients and solve for the normalized frequency and Q for each 2-pole filter section. Since it's normalized, we can write frequency as f rather than ω:

$$f_1 = 0.65635,\ Q_1 = 0.5970$$
$$f_2 = 0.97348,\ Q_2 = 2.101$$

You don't have to go through this for Butterworth filters because the cutoff frequency of every section (single-pole or 2-pole) is the same as the overall cutoff frequency. This is true for every order Butterworth filter. But the above method of equating coefficients is general and works for Bessel, Chebychev, etc. as well as for Papoulis.

We can use the design equations in Fig. 6B to find the resistances and capacitances, but first we need to look at one characteristic of a practical MDAC. The data book for this chip says the V_{ref} (voltage-reference) input resistance has a typical value of 15,000 ohms, but can vary from 10,000 to 20,000 ohms. That is too large of a range to get the filter response that we want using four unmatched, off-the-shelf MDACs. The solution is to use a large enough resistor in series with each V_{ref} input to "pad" out most of the input-resistance difference. Making R_{pad} equal to ten times the resistance variation ($10 \times 10{,}000 = 100{,}000$ ohms) should do it.

Let's design the filter for a maximum cutoff frequency of 50 kHz. At that frequency, R3 will equal R_{pad} plus the typical V_{ref} input resistance, that is, 115,000 ohms. Using

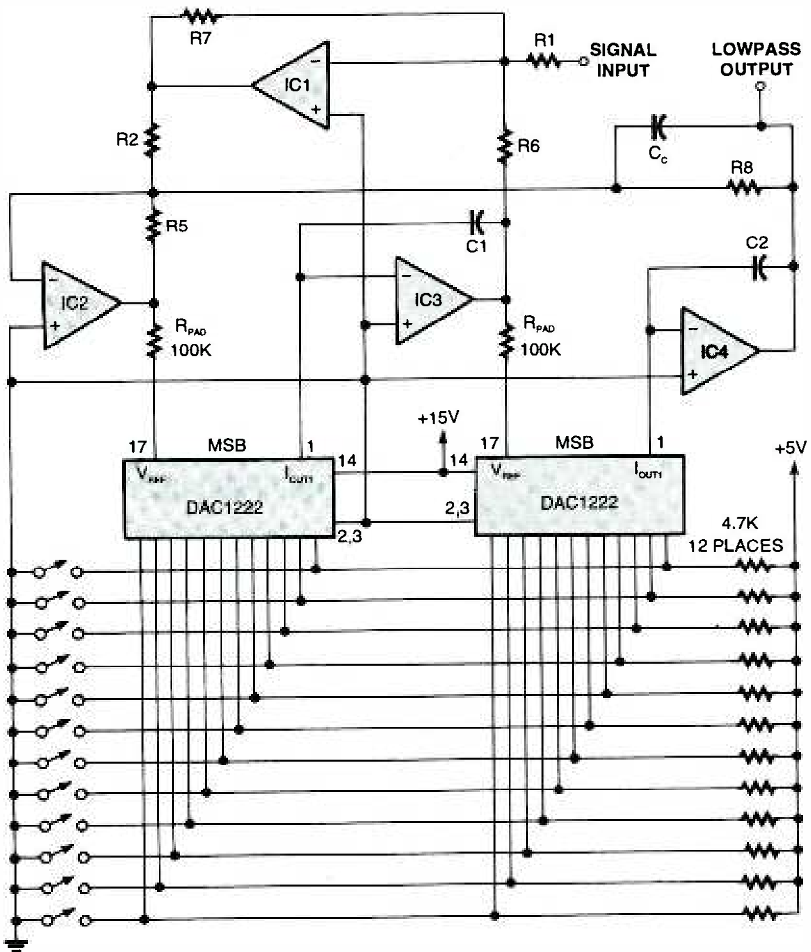


Fig. 17. This 2-pole section of a 4-pole Papoulis filter uses digital-to-analog converters for cutoff-frequency tuning. The second section cascades onto the output of the first.

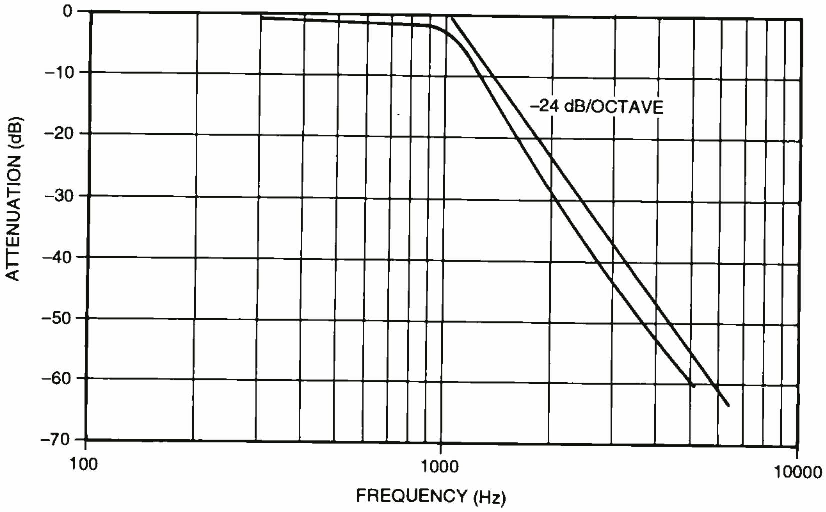


Fig. 18. This plot of the 4-pole Papoulis low-pass filter shows a –24-dB per octave with a DAC setting of 79 (decimal).

the Fig. 6 equations, we get the component values shown in Table 2; those values can be plugged into the Fig. 17 filter-circuit diagram. I used LM318 op-amps, which have a gain-to-bandwidth product of 15 MHz, a pretty fast amplifier. Even so, the second filter section has a Q of a little over 2, so compensation capacitor C_c is needed in parallel with R8 to "tweak up" the bandwidth. Twenty-seven picofarads worked fine in my circuit, but the value will depend on physical layout. If C_c is too small, the passband at the maximum cutoff frequency won't be flat—it will have a peak greater than unity gain in it. If C_c is too large, the filter will oscillate at some high frequency—probably about 1 to 2 MHz—so it's fairly easy to find the right value.

I used one set of pull-up resistors and one set of toggle switches to control all four MDACs. With a digital input of 4095, I measured the maximum cutoff frequency as 55,636 Hz, so the calculated capacitors are a bit too small. I found the minimum cutoff frequency to be 152 Hz at a digital input of 11 (decimal). For inputs of 0 through 10, the filter simply stops working; the MDAC resistance is huge (it's about 38 megohms at an f_c of 152 Hz).

Figure 18 shows the measured frequency response at a 1-kHz cutoff. The straight line is what we would expect from a 4-pole Butterworth (-24 dB per octave), so the Papoulis is better if we don't need a maximally-flat passband.

The cutoff-frequency tuning is graphed in Fig. 19; you can see that it looks pretty linear. The tuning averages about 13 Hz per digital step, but there is some variation that would probably be improved by using MDACs with better linearity. The DAC1222 has a maximum nonlinearity of 0.2%, while it's only 0.05% in the more expensive DAC1220 (which has the same pin-out).

We pay a price for the wide tuning range and good tuning resolution both in output noise and DC-offset level. Both of these vary with the cutoff frequency; that is, they vary with the equivalent resistance of the MDACs. At the minimum fc (maximum resistance), the noise is about 6 millivolts rms with 4.3 volts of offset. At an fc of 1000 Hz, this decreases to 2 millivolts rms of noise and a 1.6-volts offset. At the maximum fc (minimum resistance), the noise is still about 2 millivolts rms, but the offset is down to 60 millivolts.

The MDAC resistance (R3) is so large and the capacitors so small that I built a PC board for this example. This minimizes stray capacitance and other variations. I also simulated the circuit in *SPICE* to get a "warm, fuzzy feeling" that it would really work! The *SPICE* model is included in *tunable_filter.zip*.

These examples will, I think, give you some valuable tools the next time you need a tunable filter! **P**

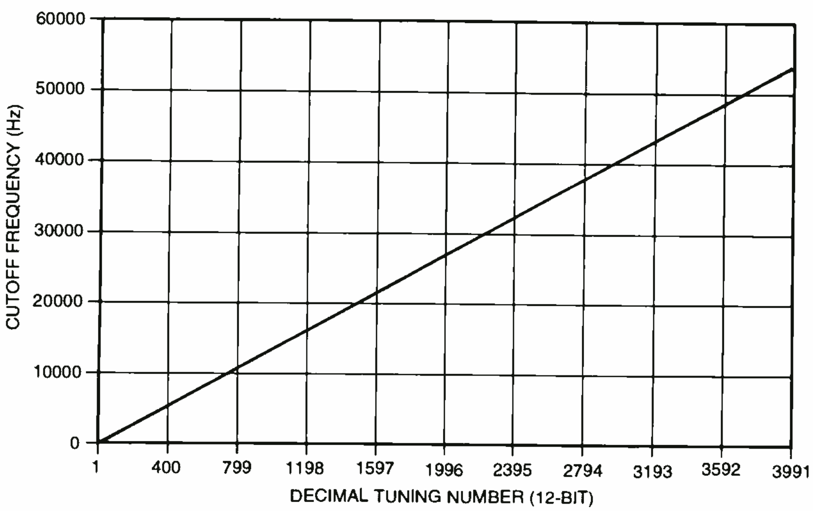


Fig. 19. Note the linearity of the 4-pole Papoulis filter when digital-to-analog converters are used. Although there should be discrete steps, a continuous curve is shown for clarity.

NEW GEAR

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Mobile E-Mail Device

CIRCLE 60 ON FREE INFORMATION CARD

USERS OF PALM COMPUTING platform-based devices now have the *PocketMail Back Flip* available. It allows them to send and receive e-mail or fax messages from any land-line or wireless phone, without having to connect to a computer. No phone jack, cradle, or cable is needed.

It provides a fast, inexpensive, and easy-to-use mobile e-mail solution. Simply dial a toll-free number, hold the device against a telephone handset, and push the PocketMail button. There is no limit to the number of toll-free calls to access the service or to the volume of e-mail messages sent and received. (Unlimited PocketMail service is $9.95 a month.)

The BackFlip consists of a small keyboard and a screen that will display eight lines of text. About the size of a calculator, the device measures 3¹/4 by 6 by 1 inches and weighs only 5.5 ounces. It snaps on to the back of the Palm organizer, transferring e-mail messages directly to the Palm device where they can be read, stored, replied to, or forwarded to another address.

This small device offers many convenient features for the e-mail user on the go. Personalized mailboxes store incoming and outgoing messages. There are nine customizable folders to manage PocketMail messages. Users can access their Palm Address Book to look up previously stored e-mail addresses and fax numbers. The BackFlip handles attachments, sendi°ng and receiving vCard and vCalendar attachments. Additional features in-clude SPAM and PocketRules filters and fax functionality.

The PocketMail BackFlip, only available for purchase from the PocketMail Web site, sells for $99.

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www.pocketmail.com

Desoldering Station

FEATURING A CERAMIC HEATER inside the iron, the *Model 17.510 Digital Soldering Station* maintains the heat at a consistent temperature at all times. This ceramic heating element also enables the iron to heat up and cool down very quickly with less stress on the element than conventional units. It also has a "set" feature that accurately holds the desired temperature.

CIRCLE 61 ON FREE INFORMATION CARD

The unit is ideal for most soldering applications, including surface-mount components. Available with six different tips as accessories, and with a temperature range of 160 to 480 degrees Celsius, the soldering station comes in an ESD-Safe housing.

The 17.510 Digital Soldering Station has a list price of $132.65.

AVEN TOOLS, INC.
4595 Platt Road
Ann Arbor, MI 48108
800-624-8170 or 734-973-0099
www.aventools.com

Piercing Probe

DESIGNED TO ACCURATELY PIERCE wires from .030 to ¹/4-inch in diameter, the *Wire-Tap* piercing probe from Precision Instruments, Co. comes in two lengths: 10-inch and 15-inch. Long enough to get into deep crevices, this probe is also small enough to get into those tight spots for isolating one wire in a bundle. Rather than plunging a needle into a wire, the Wire-Tap uses a threading action to precisely control the amount of penetration. Its silver-plated beryllium copper needle can be removed and resharpened.

CIRCLE 62 ON FREE INFORMATION CARD

The Wire-Tap is meant to be used with multimeters, lab scopes, and graphing multimeters to test automotive, consumer, and industrial electronics. The probe accepts all standard and 4-mm banana plugs, including sheathed and retractable ones.

The Wire-Tap 10-inch probe sells for $84 and the 15-inch sells for $89.

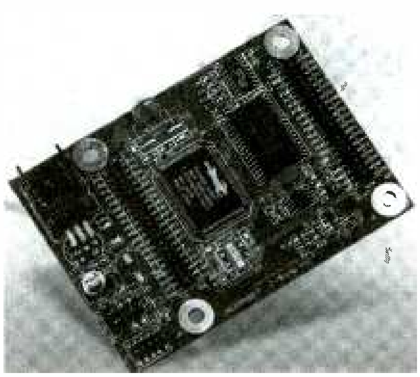
AUTOMOTIVE ELECTRONICS SYSTEM (AES)
3849 N. Fine Ave. #102
Fresno, CA 93727
559-292-7851
www.aeswave.com

Single-Board Computer

IDEAL FOR MACHINE CONTROL and for applications that typically call for a BASIC STAMP or PIC controller, the *Jackrabbit (BL1800 series)* is a high-performance single-board computer stocked with I/O, memory, and communication ports. Measuring just 2.5 by 3.5 inches, the Jackrabbit is perfect for embedded control, providing over 40 multifunctional I/O pins that include digital I/O, RS-232/485 serial ports, A/D and D/A converters, and high-voltage outputs. At its core, the Rabbit 2000 microprocessor performs fast number crunching.

Software for the Jackrabbit is developed using Dynamic C, an integrated C-language development package that includes an interactive compiler, editor, and debugger. The complete development kit includes the Jackrabbit model BL1810 controller, Dynamic C/Rabbit software, manual, schematics, AC adapter prototyping board, programming cable, documentation CD ROM, and additional parts.

The Jackrabbit itself is priced from only $49 and the complete development kit sells for $139.



CIRCLE 63 ON FREE INFORMATION CARD

Z-WORLD
2900 Spafford St.
Davis, CA 95616
888-362-3387 or 530-757-3737
www.zworld.com

Paperless File System

EASILY ADAPTED FOR USE BY any type of business that needs to manage, store, and retrieve documents, the *Virtual Paperless 2000* document-storage program is an electronic format for archives and for distribution on a CD or to hard disk. Each CD can store thousands of $8^1/_2$ by 11 sheets and/or drawings, and all files can be stored as images. The CDs contain their own viewer software, the *Virtual Viewer*, that allows the recipient to find, view, or print files.

The program is easy to implement. Stored files can be viewed in the application's viewer, or a launch button appears to launch the file in its native application. The image-editing tools allow users to edit and clean up the image files using de-speckle, de-skew, and crop, among others.

The Virtual Paperless 2000 storage program sells for $495.

SIMPLE SOFTWARE, INC.
P.O. Box 68
Mogadore, OH 44260
800-839-9260
www.simple-software.com

CIRCLE 64 ON FREE INFORMATION CARD

Remote-Control Car

FUN AND EDUCATIONAL TO build, the *RCC7L Radio-Controlled Car Kit* is a complete 7-function R/C car. The RCC7L is fast and has a remote-control range of at least 50 ft. The finished car measures 4.7 by 4 by 1.5 inches and requires one 9-volt and four AA batteries.

Designed as a learning experience in electronics, the kit comes with a manual of well-illustrated step-by-step assembly instructions that are easy to follow. It teaches proper soldering techniques;

CIRCLE 65 ON FREE INFORMATION CARD

and has a theory section, block diagrams, and schematics and other technical information. After every assembly section, there is a simple test to help builders troubleshoot only a small section if problems occur. There is also a master troubleshooting section.

The RCC7L Radio-Controlled Car Kit has a list price of $33.25.

ELENCO ELECTRONICS, INC.
150 W. Carpenter Ave.
Wheeling, IL 60090
847-541-3800
www.elenco.com

Inductance Analyzer

COMBINED INTO A 20-HZ TO 1-MHz tester, the *1910 Inductance Analyzer* features 0.1% measurement accuracy, DC resistance measurements, sequential testing, and internal DC current biasing. The 1910 provides over 27,000 user-programmable test frequencies for inductance measurements up to 1MHz. Within the instrument's internal memory, the tester has the ability to store and recall up to 30 single test setups and 10 sequential setups. Up to six tests can be linked and executed in sequence.

CIRCLE 66 ON FREE INFORMATION CARD

The unit's internal DC bias current source of 0 to 1 Amp allows components to be tested under real operating conditions. Additionally, the unit can display the current through or voltage across the test device, which guarantees the real test conditions.

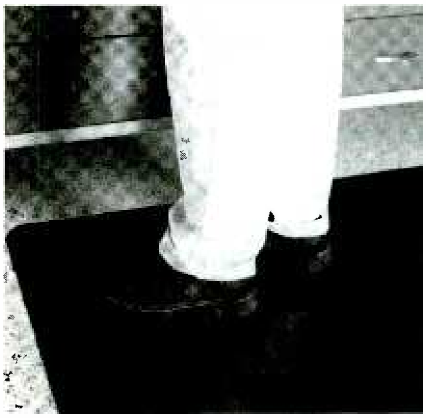
The 1910 Inductance Analyzer has a list price of $4995.

QUADTECH, INC.
5 Clock Tower Place

210 East
Maynard, MA 01754
800-253-1230 or 978-461-2100
www.quadtech.com

Grounding Straps

THE *SERIES 2050 HEEL GROUNDING Assemblies* in combination with a conductive or dissipative floor offer personnel a way to move between work areas while staying properly grounded. To meet customers' varied needs, the 2056 contains a one-megohm resistor, the 2056-M2 has a two-megohm resistor, and the 2057 comes with a 240k-ohms resistor.



CIRCLE 67 ON FREE INFORMATION CARD

One size fits most shoes. After trimming the conductive ribbon to a desired length, the user inserts the extra-long ribbon between the shoe and sock to complete the ground path.

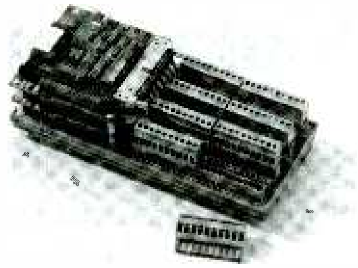
Prices for the Series 2050 Heel Grounding Assemblies range between $4.95 and $9.45.

3M ELECTRONIC HANDLING & PROTECTION DIVISION
2892 Cleveland Ave. North
Roseville, MN 55113
800-814-8709
www.3M.com

Ethernet for Smart A/D

THE *MODEL 2518/19* IS A COMBINATION of a Smart A/D for sensors with a 10-base-T interface. The combination allows data acquisition of eight or sixteen channels via an Ethernet connection. Each channel is software programmable for a different sensor type.

The Smart A/Ds that are attached to the Ethernet board provide sensor excitation, linearization, software filtering, auto standardization, and alarm monitoring. The unit accepts a wide range of



CIRCLE 68 ON FREE INFORMATION CARD

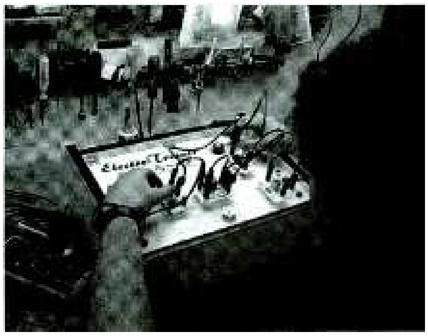
input power from 12 to 24 VDC. A temperature sensor for each group of eight channels is used as a cold reference for thermocouples.

The prices are $653 for eight channels and $949 for sixteen channels.

SENSORAY
7337 SW Tech Center Drive
Tigard, OR 97223
503-684-8005
www.sensoray.com

Electronics Trainer

HELPING STUDENTS LEARN how to follow schematic diagrams and make them into working circuits, the *Electro-Trainer* is designed for any electronics, electricity, or automotive vocational course. A wide range of electronics training is available from creating series and parallel circuits; measuring voltage, current, and resistance in series or parallel; working with Ohm's Law; and performing voltage drop calculations.



CIRCLE 69 ON FREE INFORMATION CARD

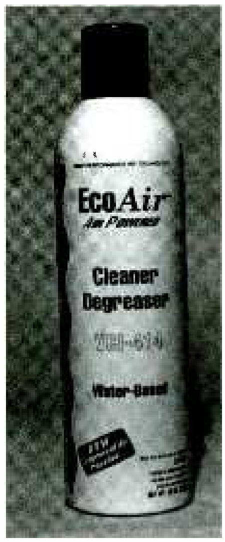
The panel has 64 milled holes for inserting individual modules during training as well as 7 red and 7 black holes for test leads. All the modules are mounted on white acrylic plastic with silk-screened schematic diagrams and labeling, and they all have banana plugs mounted on the back for inserting and removing from the test board. The unit has a locking top that lifts for convenient storage of the training components and test leads. An illustrated guidebook is included with explanations, examples, and questions.

The complete Electro-Trainer system sells for $495 plus shipping and handling.

IDAHO INSTRUMENTS
624 4th Avenue West
Twin Falls, ID 83301
208-733-5636
www.idahoinstrument.com

Biodegradable Cleaner

A SAFE REPLACEMENT TO aerosol, the *EcoAir VCI-414* water-based, biodegradable, heavy-duty cleaner comes with the convenience of a handy power spray application in a recyclable can. The user can spray the liquid concentrate in any direction, even upside down, to clean and degrease metal and painted surfaces. It clings to ceilings and vertical surfaces, effectively removing dirt, oils, and greases in hard-



CIRCLE 70 ON FREE INFORMATION CARD

to-reach areas

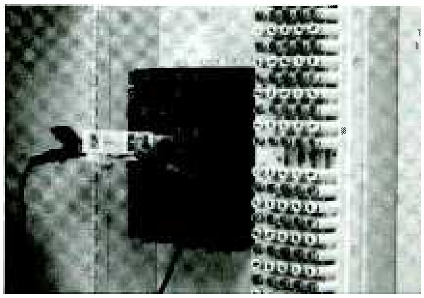
For cleanup of heavily greased or soiled equipment, engine blocks, and tools, the air-powered spray, which provides 100 pounds of compressed air force, penetrates crevices and recessed areas to remove oily residue and dirt. EcoAir cleans and protects both ferrous and non-ferrous metals.

A single spray can of EcoAir VCI-414 sells for $10.99.

CORTEC CORP.
4119 White Bear Parkway
St. Paul, MN 55110
800-4-CORTEC or 651-429-1100
www.cortecvci.com

Telephone Cable Tester

OFFERING TECHNICIANS A QUICK means of troubleshooting telephone cable problems, the *Model 6332 Tel-Line Tester* automatically splits the central office from the field, allowing for fast identification of the problem line. Ideally suited for cable installation and repair, the tester eliminates the need for cutting, stripping, disconnecting, and reconnecting cable pairs.

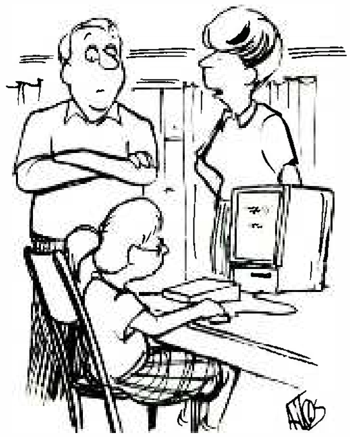


CIRCLE 71 ON FREE INFORMATION CARD

The Tel-Line Tester plugs into any 5-pin connector block located at a building entrance or central office. To troubleshoot, the technician simply clips a buttset or voltmeter to the appropriate metal tabs and checks the switch to determine whether the problem is located in the field or at the central office. The Tel-Line Test Kit comes complete with tester, looping tool, and craft access wall cord.

The Model 6332 Tel-Line Tester sells for $555.

POMONA ELECTRONICS
1500 E. Ninth St.
Pomona, CA 91766
909-623-3463
www.pomonaelectronics.com



"Like I told you over the phone, Mr. Rolland, your daughter, Kathy, decided to major in computer games."

Books that Bridge Theory & Practice

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

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

PRACTICAL INTRODUCTION TO SURFACE MOUNT DEVICES—A technology that spun off the automated assembly line into the grasp of experimenters and project builders. **Order BP411- $9.99 Includes S & H**

THE PRE-COMPUTER BOOK—Aimed at the absolute beginner with little or no knowledge of computing. A non-technical discussion of computer bits and pieces and programming. **Order BP115- $2.99 Plus $2.00 S & H**

PRACTICAL OSCILLATOR CIRCUITS—If your budding project requires an oscillator, you can design it and build it from the many types described here in a hobbyist-friendly style. **Order BP393- $9.99 Includes S & H**

PRACTICAL PIC MICROCONTROLLER PROJECTS—This book covers a wide range of PIC based projects. In most cases the circuits are very simple and they are easily constructed. **Order BP444- $7.99 Includes S & H**

BP396 BP411 BP115 BP393 BP444

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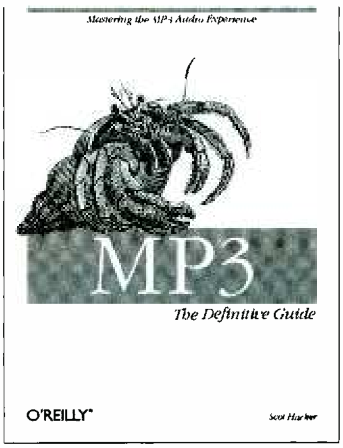
NEW LITERATURE

MP3: The Definitive Guide

by Scott Hacker
O'Reilly & Associates
101 Morris St.
Sebastopol, CA 95472
800-998-9938 or 707-829-0515
www.oreilly.com
$29.95

A complicated, digital, music-encoding algorithm, MP3 has changed the dynamics of music distribution. According to the author, MP3 "could radically restructure the way we select music." Hacker states "For the first time in history, artists and musicians can potentially be heard by anyone on the planet with Web access, and those artists don't need any part of the recording industry to make it happen."



His book introduces the power-user to all aspects of MP3 technology. It delves into detail on obtaining, recording, and optimizing MP3 files using both commercial and Open Source methods; and it covers four platforms: Windows, Macintosh, Linux, and BeOS. In addition, readers will learn all about the complex legal issues surrounding MP3 files.

2000 Technical Library CD-ROM

from Microchip Technology Inc.
2355 W. Chandler Blvd.
Chandler, AZ 85224-6199
480-786-7668
www.microchip.com
Free

This CD-ROM contains a complete selection of technical documentation on Microchip's PICmicro microcontrollers and associated development tools, analog/interface products, non-volatile memory devices, and related microperipheral products. Giving users the flexibility to edit, compile, emulate, and program PICmicro microcontroller devices from a single user interface, the library includes the most current release of Microchip's popular *MPLAB Integrated Development Environment* software.

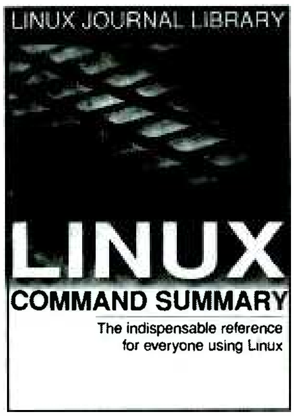
All documents are readable in Adobe Acrobat Portable Document Format (.pdf) and run under Adobe Acrobat Reader 3.0 or higher, and WinZip may be used to access the very large files. Copies of these programs can be downloaded from the Web site, which offers both text search and parametric search capabilities.

Linux Command Summary

by Clarica Grove and Phil Hughes
Specialized Systems Consultants, Inc.
P.O. Box 55549
Seattle, WA 98155-0549
206-782-7733
www.linuxjournal.com
$8

Linux is a free, UNIX-like operating system used by millions of people around the world. The operating system excels in many areas—from end-user concerns, such as stability, speed, and ease of use, to development and networking. A comprehensive reference and learning tool, this book summarizes over 500 Linux commands.

Informative for every level of Linux user, the pocket-sized reference guide

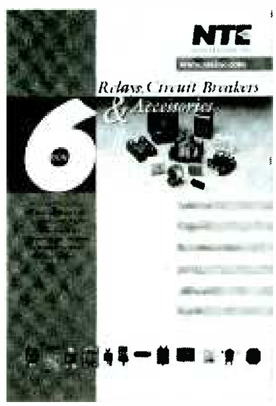


contains the same information as large manuals. Sections of the book cover User Commands, System Administration, Configuration Files, and AWK.

Relay, Circuit Breakers, and Accessories Catalog

from NTE Electronics Inc.
44 Farrand St.
Bloomfield, NJ 07003
800-631-1250 or 973-748-5089
www.nteinc.com
Free

This cross-reference and technical catalog features updated NTE replacements for over 44,000 industry part numbers. Seven new series of relays have been added to their line of U.L. and C.S.A. listed relays and circuit breakers. These include plug-in, multifunctional time-delay, voltage-monitoring, and phase-monitoring relays, as well as alternating relays, solid-state relays, and AC buzzers.

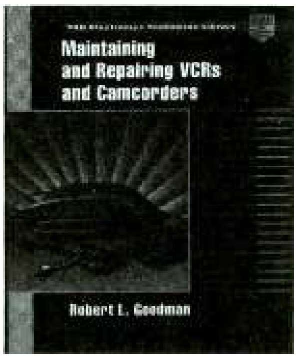


All NTE catalogs, technical specs, and a complete distributor list are available at the Web site.

Maintaining and Repairing VCRs and Camcorders

by Robert L. Goodman
McGraw-Hill
1221 Avenue of the Americas
New York, NY 10020
800-2MCGRAW
www.books.mcgraw-hill.com
$34.95

Written and illustrated with the technician or advanced hobbyist in mind, this book is designed to eliminate guesswork from VCR and camcorder troubleshooting and repair. An all-in-one resource, this manual shows readers how to perform every type of VCR repair and analysis. All the major brands are covered, including Sony, GE/RCA, Toshiba, JVC, 3M, Magnavox, VCR Plus, Philips, Sencore, RadioShack, and Matsushita. It has all the features to help readers troubleshoot, pinpoint problems, and handle repairs.

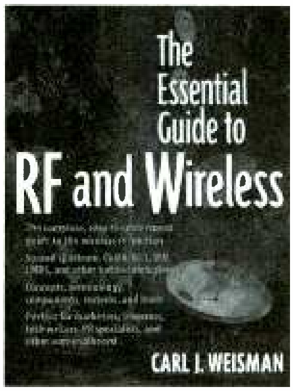


There are practical techniques for repairing the latest 8-mm and stereo VHS technologies. The clear, well-illustrated steps make every job easier, as do the case histories that provide solutions to frequently encountered malfunctions.

The Essential Guide to RF and Wireless

by Carl J. Weisman
Prentice Hall
One Lake Street
Upper Saddle River, NJ 07458
800-282-0693
www.phptr.com
$34.99

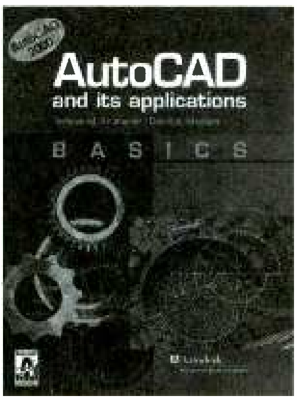
Whether you're a customer, investor, hobbyist, professional, or student, this complete guide presents wireless and RF technology at every level. Everything from fundamental concepts, basic terminology, components, and system building blocks to complete systems are all covered.



Topics include spread spectrum and CDMA: how they work and where they're used; wireless local loop (WLL); and ISM-based LANs. The author also looks at Local Multipoint Distribution Service (LMDS): a new alternative for broadband wireless and RF technology. Dozens of charts, diagrams, and photographs make advanced wireless and RF technology easier to understand.

AutoCAD and Its Applications: Basics, AutoCAD 2000

by Terence M. Shumaker
and David A. Madsen
Goodheart-Willcox Co.
18604 W. Creek Drive
Tinley Park, IL 60477-6243
800-323-0440 or 707-687-5000
www.goodheartwillcox.com
$43.96



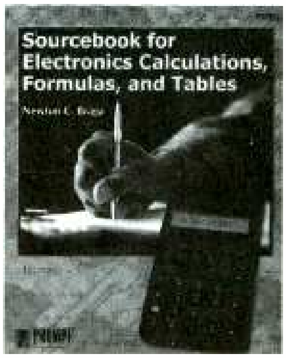
This edition provides comprehensive coverage of introductory and two-dimensional AutoCAD drafting. Organized in an easy-to-understand sequence, the text allows students to progress at a pace that makes them comfortable with the commands and drawing techniques.

There are discussions of every major feature, command, and option. Topics are keyed to the AutoCAD User Guide, and Professional Tips explain how to use AutoCAD efficiently. Hundreds of exercises, questions, and drawing problems help students master AutoCAD.

Sourcebook for Electronics Calculations, Formulas, and Tables

by Newton C. Braga
Prompt Publications
Howard W. Sams & Company
2647 Waterfront Parkway, East Drive
Indianapolis, IN 46214-2041
800-428-7267
www.hwsams.com
$34.95

This book is written for the engineer, student, technician, or hobbyist who designs or needs to understand more about electronic circuits. It contains an assortment of all the basic information necessary to make calculations when designing new projects—a one-stop guide.



Arranged by subject, the information ranges from the simplest elementary operation to the more complex trigonometric and calculus functions. Physical property tables of circuits and materials are included, and many of the formulas are accompanied by application examples. Units, conversions, reduced formulas, and "non-conventional" notations are also included to make design work easier and less frustrating.

2000 Communications Catalog

from Universal Radio, Inc.
6830 Americana Parkway
Reynoldsburg, OH 43068-4113
800-431-3939 or 614-866-4267
www.universal-radio.com
Free

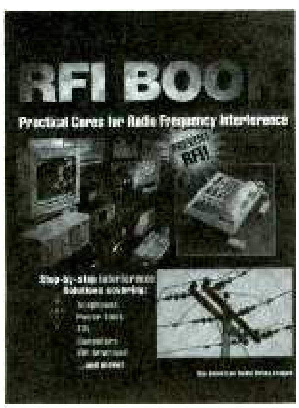
This catalog (#00-33) covers equipment for the amateur, shortwave, and scanner enthusiast. An extensive selection of antennas, headphones, books, and accessories is also featured.

Among the new items are the TEN-TEC RX-340 and Palstar R30 Communications Receivers, the ICOM IC-R3 and Yaesu VR-500 Wideband Portable Receivers, the Sangean CC Radio, and ICOM 756 Pro HF Amateur Transceiver.

The ARRL RFI Book

Edited by Ed Hare, W1RFI
American Radio Relay League
225 Main Street
Newington, CT 06111-1494
888-277-5289 or 860-594-0200
www.arrl.org.
$20

There are two kinds of hams: those who don't have interference problems and



those who actually get on the air. The latter type of enthusiast needs the tips in this book. The author and a team of RFI experts have compiled the best advice available on every type of interference, from automotive to TVI, from computers to lamps, from VCRs to stereos, and from intermodes to telephones. If it's a device that can be affected by interference, including the station receiver, readers will find practical cures here.

This extensively rewritten material brings hams and anyone else interested in this subject the most up-to-date and proven techniques for curing all kinds of interference problems. All the chapters from a previous ARRL interference book have been either revised or rewritten. The latest RFI regulations are covered, and the list of suppliers and the bibliography have been updated and expanded.

Relay & Accessory Guide, 9th Edition (ET-2700-2)

from Philips ECG
1001 Snapps Ferry Road
Greeneville, TN 37744
800-526-9354
www.ecgproducts.com
Free

This complete and comprehensive reference guide contains 102 different series, including over 800 types of relays, proximity switches, photoelectric sensors, and accessories. It's an easy-to-use reference with its pictorial/tabular selector guide. The two-part replacement directory cross-references over 64,000 U.S., Asian, and European industry part numbers and 281 brand names to ECG replacements.

Complete specifications are provided for new products, with detailed electrical and mechanical data. Among the new series are miniature and sub-miniature gullwings, inside "L" and through-hole PC mounts, industrial 12-pin plug-ins, and 2-coil motor-reversing contractors. The guide is also available on CD: *Microsoft Windows Cross-Reference Disc Version 2.0* (ET-2604W2.0). **P**

SCATCAT

(continued from page 38)

After mounting the stand-alone items (J1, J2, LED1, S1, and SPKR1), connect suitable lengths of wire to them. After the boards are mounted using screws and threaded standoffs, it is a simple matter to make the appropriate connections to the screw-type terminals on the boards.

Drill a hole in the rear of the case for the line cord. Use a rubber grommet to protect the cord from chafing; wall-socket current will be passing through these wires. Add a cable tie or tie a strain-relief knot in the line cord inside the box.

As an alternative, you could have the line cord pass through the front panel in one corner. While that might not look as attractive, it does make working with the completed unit a breeze; everything comes out when the front panel is removed without worrying about dangling wires being yanked.

The completed ScatCat is ready to teach your pet a lesson about where they shouldn't go!

When you've completed wiring the ScatCat, double-check your work again for any mistakes such as miswirings, wrong components, polarized semiconductors or capacitors installed backwards, and the like. A good approach is to inspect everything and set it aside. Go do something else not related to electronics: Watch television, play a recreational sport, or visit with friends. The idea is to let your mind shift mental gears for a while. After a day or so, go back to the ScatCat and inspect it again. You'd be amazed how many seemingly "simple" errors can be overlooked when you've been staring at them for hours at a stretch. After taking a break as outlined above, you can approach the unit as if it is new to you.

Setup and Operation. If a motion sensor with a relay-contact output is being used, Fig. 8 shows a suggested setup arrangement. Power from the 12-volt supply is connected to J1's "shield" side. That goes to one side of the motion sensor's relay. The other side of the relay feeds back to J1, as well as to the anode of LED1.

If the specified RadioShack unit is being used, insure it has a 9-volt battery installed. Plug P1 into J1 on the control unit's front panel. Turn the incandescent-lamp fixture (with I1) on and plug it into J2. Without turning on the ScatCat, switch SEN1 to its "chime" position; the system won't work in the alarm" position. Wave your hand in front of it; LED1 should light whenever SEN1 is activated, which is handy when setting up and aiming SEN1.

Position the sensor horizontally and aim it toward the area that you want to protect from animal intrusion. Observing LED1 while waving your hand will allow it to be set up to go off exactly where necessary. The sensor should be near the control unit so that the controls can be accessed, and the intrusion counter read, without setting it off yourself.

With LED1 off (no intrusion), turn on the ScatCat with S1. The "Intrusion Count" display on DISP1 should light, indicating "0." Set off the motion sensor. Four one-second high frequency sound bursts will occur, synchronized with four lamp flashes. The "Intrusion Count" display will increment by one count.

Effectiveness. Dogs are easy...and trainable. After a few incidents, they don't go there anymore. Cats, as any cat owner will tell you, are not trainable; they can, however, be conditioned. It just takes a little longer. Fred took about four or five days to convince. During this period, the intrusion counts grew fewer and less often. The first night, the counter showed two intrusions. After he stopped, the ScatCat was left set up for a few more days, just to be sure.

A few weeks later, there was evidence of a cat on the counter again. The unit was set up again to give a little positive reinforcement. After one more intrusion count, he was apparently convinced, and hasn't been back since. Several friends and relatives borrowed the unit, and it has been successful in all cases.

The ScatCat will give pet-owning techies an opportunity to finally outwit their cats! Happy hunting! P

"What high-pitched sound, KA2GUN? Your signal sounds fine to me."

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES

Marathon of Simple Circuits

This month, we're going to sponsor a marathon of simple circuits that hopefully will be the catalyst needed to turn a stalled project into a completed device or to spark an interest in starting a new project. We'll start out by looking at three basic audio circuits and see where that leads us.

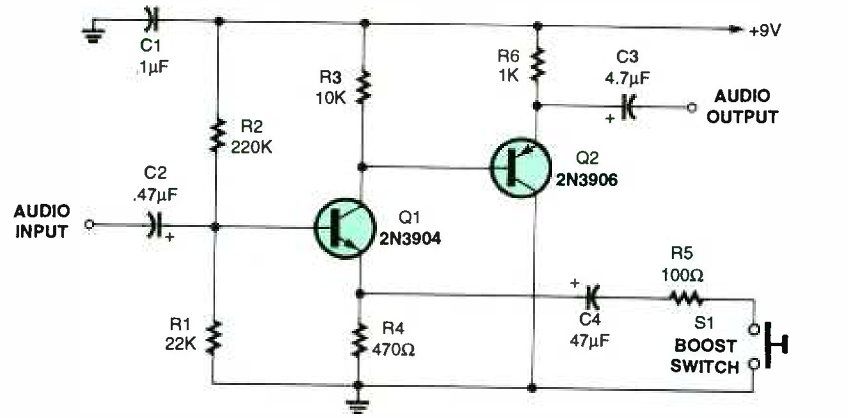


Fig. 1. A simple audio amplifier can be used to drive a low-impedance headphone or to supply a 2-volt peak-to-peak output to an external 1000-ohm load.

Broadband Audio Amplifier

Our first audio circuit (see Fig. 1) is a two-transistor broadband audio amplifier. The amplifier circuit has a voltage gain of about 60 in the boost position and 15 in the non-boost position. In both gain positions, the amplifier's frequency response is almost flat from 200 Hz to over 100 kHz. Transistor Q1 is connected as a common-emitter amplifier, with resistors R1, R2, and R3 setting the transistor's operating bias. The amplifier's AC voltage gain increases from 15 to 60, when Q1's emitter impedance is lowered by paralleling R5 with R4. Capacitor C4 couples the AC signal through resistor R5, when the boost switch is closed, without changing the transistor's biasing arrangement. The amplifier's output is isolated from external loading by transistor Q2, an emitter-follower amplifier. Almost any NPN audio transistor with a minimum hfe gain of 100 can be used for Q1, and Q2 can be any PNP audio transistor.

This amplifier can supply a 2-volt peak-to-peak output to an external 1000-ohm load or can be used to drive a low-impedance headphone pair if we add a 470-ohm resistor in series with the output.

Audio-Signal Tracer

Troubleshooting audio equipment or tracing audio signals is as difficult today as it was when grandpa spent his youth working on tube- and early transistor-audio gear. Long before the oscilloscope became an affordable test instrument, the audio-signal tracer was one of the most often used and probably the most valuable test instrument available for the serious-minded technician or home experimenter. Even in today's high-tech world of microelectronics, a modern solid-state version of the time-proven audio tracer is still a useful tool. Our version uses that ever-popular low-voltage audio power amplifier IC, the LM386. This little 8-pin mini-dip IC is designed for battery-powered operation between 4 and 15 volts; the quiescent current is less than 10 mA. The amp's voltage gain can be as high as 200. Best of all, the LM386 is very affordable, going at most electronic retail stores for about a buck-twenty. If the few remaining parts can be salvaged from discarded electronic gear, the audio tracer can be built for less than the cost of a street hot dog.

Sinusoidal Transistor Phase-Shift Oscillator

Our next circuit is a great companion for the audio tracer. If you are going to be a signal scout, you've got to have a signal to track or you'll go nowhere at all. If your troubleshooting takes you down the path where no signals flow, then build the sinusoidal transistor phase-shift oscillator shown in Fig. 3 and use it to produce your own signal to trace.

PARTS LIST FOR THE BROADBAND AUDIO AMPLIFIER (FIG. 1)

SEMICONDUCTORS
Q1—2N3904 NPN silicon transistor
Q2—2N3906 PNP silicon transistor

RESISTORS
(All resistors are $^{1}/_{4}$-watt, 5% units.)
R1—22,000-ohm
R2—220,000-ohm
R3—10,000-ohm
R4—470-ohm
R5—100-ohm
R6—1000-ohm

CAPACITORS
C1—0.1-µF, ceramic-disc
C2—0.47-µF, 25-WVDC, electrolytic
C3—4.7-µF, 25-WVDC, electrolytic
C4—47-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1—Single-pole, single-throw, normally-open pushbutton switch

The heart of the oscillator circuit is the RC phase shift network that connects between Q1's base and collector. The network is made up of C1, C2, C3, R1, R2, and R5. Those components

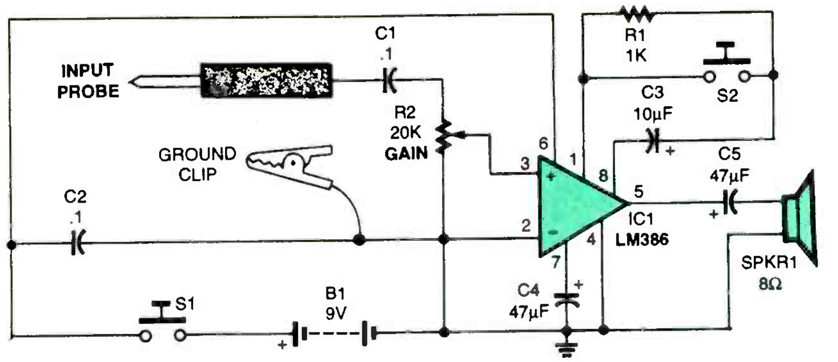


Fig. 2. An audio-signal tracer can be a valuable tool when troubleshooting all kinds of audio circuitry.

PARTS LIST FOR THE AUDIO-SIGNAL TRACER (FIG. 2)

RESISTORS

(All fixed resistors are ¼-watt, 5% units unless otherwise noted.)

R1—1000-ohm

R2—20,000-ohm potentiometer

CAPACITORS

C1, C2—0.1-µF, ceramic-disc

C3—10-µF, 25-WVDC, electrolytic

C4, C5—47-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

IC1—LM386 audio power amp, integrated circuit

S1, S2— Single-pole, single-throw, normally-open pushbutton switch

SPKR1—8-ohm speaker

9-volt battery, case, ground clip, etc.

determine the oscillator's frequency. Resistor R5 serves as the frequency-control potentiometer, which gives the oscillator a tunable frequency range of about 500 to 1000 Hz. Transistor Q1's gain can be adjusted with R6 for maximum output signal with minimum distortion. Transistor Q2 operates as a non-inverting buffer amplifier with R7 acting as a variable output control. The maximum output is about 6 volts peak-to-peak when powered by a 9-volt source.

Turn-Signal Reminder

Moving right along to our next entry, we find ourselves far away from the world of audio and into the world of road rage. Often as I travel the highways, I'll find myself following a vehicle that has the turn signal stuck in the ON position flashing for miles and miles. I don't know if it is the constant distraction or just not knowing what that person is going to do next, but in either case it sure can increase the blood pressure and take the fun out of the journey. We may not be able to make the other drivers more attentive to their driving habits, but we can build the turn-signal-reminder circuit in Fig. 4 and become a positive role model for other travelers.

A single CD4049 CMOS hex-inverting-buffer IC is the heart of the reminder circuit. Two of the inverters, IC1-a and IC1-b, are connected in a simple variable-frequency squarewave audio-oscillator circuit. The oscillator drives the remaining four paralleled inverters, which in turn drive the piezoelectric sounder. The anodes of the two diodes, D1 and D2, are connected to the left and right turn-signal outputs, which is normally at zero volts when neither signal is activated. Operating either of the turn signals supplies a pulsing positive voltage to the anode of one of the diodes, powering the circuit and making it emit a beeping audio tone.

Most piezo speakers or sounders produce maximum output power when they are operated at their natural resonant fre-

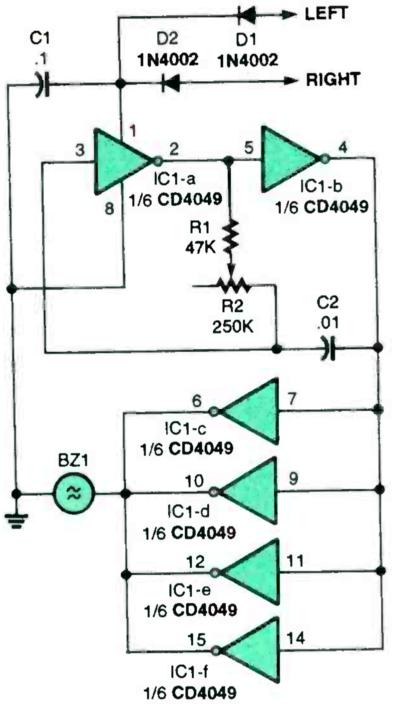


Fig. 4. You won't forget to disengage your car's turn signal if you install this warning device.

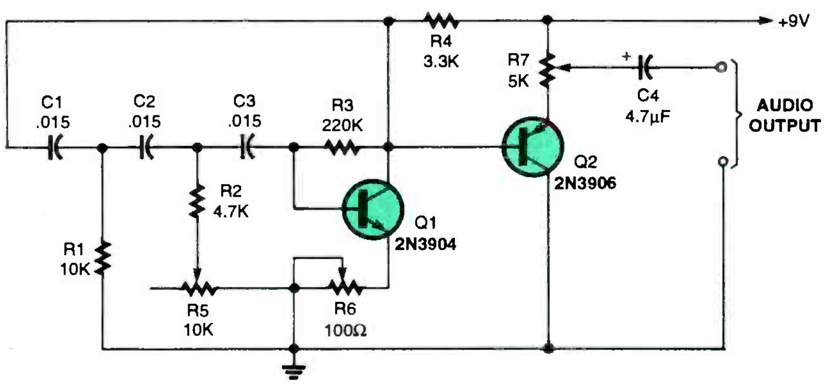


Fig. 3. Signal injectors like this one work hand-in-hand with the audio tracer in Fig. 2.

PARTS LIST FOR THE PHASE-SHIFT OSCILLATOR (FIG. 3)

SEMICONDUCTORS

Q1—2N3904 NPN silicon transistor

Q2—2N3906 PNP silicon transistor

RESISTORS

(All fixed resistors are ¼-watt, 5% units unless otherwise noted.)

R1—10,000-ohm

R2—4700-ohm

R3—220,000-ohm

R4—3300-ohm

R5—10,000-ohm potentiometer

R6—100-ohm potentiometer

R7—5000-ohm potentiometer

CAPACITORS

C1–C3—0.015-µF Mylar

C4—4.7-µF, 25-WVDC, electrolytic

PARTS LIST FOR THE TURN-SIGNAL REMINDER (FIG. 4)

SEMICONDUCTORS

IC1—CD4049 hex-inverting-buffer
D1, D2—1N4002 1-amp silicon diode

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—47,000-ohm
R2—250,000-ohm potentiometer

CAPACITORS

C1—0.1-µF, ceramic-disc
C2—0.01-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

BZ1—Piezo speaker

quency. Adjust R2 for the loudest output tone. If the natural resonant frequency cannot be reached, try changing the value of C2. Smaller capacitance values will give higher output frequencies, and larger values will produce lower frequencies. Have fun and build one of these for yourself or a forgetful friend.

Positive-Voltage Booster Circuit

Our next entry, shown in Fig. 5, is a positive-voltage booster circuit. This handy little circuit can increase your operating voltage by as much as 175% with an output current capacity of 10 to 20 mA. Gates IC1-a and IC1-b of a CD4093 dual-input NAND Schmitt-trigger CMOS IC are connected in a squarewave-oscillator circuit with the output buffered by gate IC1-c. The buffered output drives a complementary transistor pair, Q1 and Q2. The squarewave output at the emitters drives the voltage-doubler circuit made up of D1, D2, C2, and C3 to produce a boost output. With a 12-volt supply, the boost circuit will output 21.5 volts at about 10 mA and about 18.5 volts with an output current of 20 mA. Be sure to tie the inputs of the unused gate to circuit ground.

Variable DC Power Converter

Our next entry in the circuit marathon is a simple variable 5- to 9-volt DC power converter that requires only a single IC and two resistors. Its schematic is shown in Fig. 6. Best of all, with some parts scrounging, the cost should be only a buck or two. The circuit is ideal for use in an automobile or at home with a 12-volt bench supply. The converter can be used to power gadgets that require no more than 1 amp at any voltage between 5 and 9. If the converter were going to be used at or

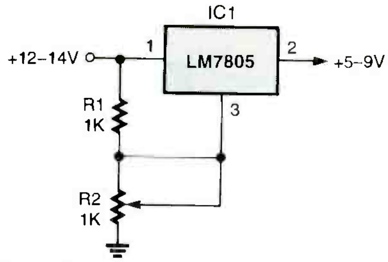


Fig. 6. This DC power converter makes it easy to operate AC devices from a 12-volt car battery.

PARTS LIST FOR THE VARIABLE DC POWER CONVERTER (FIG. 6)

IC1—LM7805 5-volt voltage regulator, integrated circuit
R1—1000-ohm, 1/4-watt, 5% resistor
R2—1000-ohm potentiometer

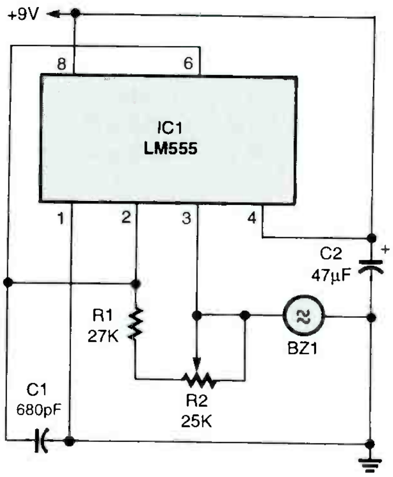


Fig. 7. Here's an ultrasonic "whistle" to help you train your dog.

PARTS LIST FOR THE ULTRASONIC DOG TRAINER (FIG. 7)

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—27,000-ohm
R2—25,000-ohm potentiometer

CAPACITORS

C1—680-pF, ceramic-disc
C2—47-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

IC1—LM555 timer, integrated circuit
BZ1—Piezo speaker (RadioShack 40-1383 or similar)

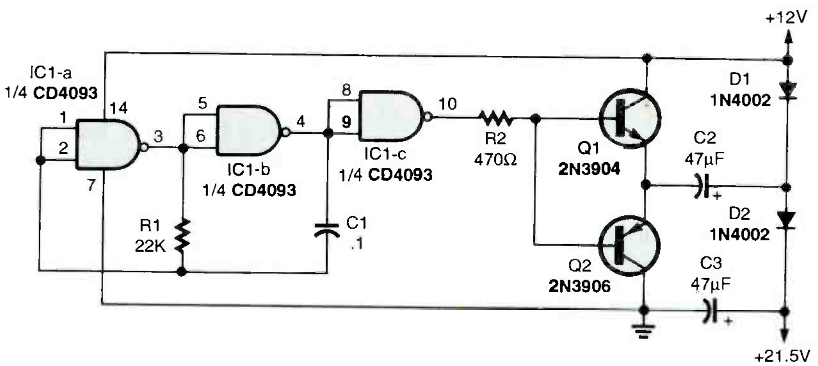


Fig. 5. A positive-voltage booster can increase your operating voltage by as much as 175% and still deliver an output current capacity of 10 to 20 mA.

PARTS LIST FOR THE POSITIVE-VOLTAGE BOOSTER (FIG. 5)

SEMICONDUCTORS

IC1—CD4093 CMOS quad 2-input NAND Schmitt trigger, integrated circuit
Q1—2N3904 NPN silicon transistor
Q2—2N3906 PNP silicon transistor
D1, D2—1N4002 1-amp silicon diode

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1—22,000-ohm
R2—470-ohm

CAPACITORS

C1—0.1-µF, ceramic-disc
C2, C3—47-µF, 25-WVDC, electrolytic

near its maximum current capacity, it wouldn't hurt to bolt the IC to a piece of aluminum and keep the operation running cool.

Ultrasonic Dog Trainer

Our next circuit is an interesting and fun device that can be used to confuse, irritate, and hopefully help train your four-legged, tail-wagging friends. Of course, I can't guarantee that Fido will agree with the training part.

When it comes to the sense of smell and hearing, our best friends have us beat hands down. Just about where our hearing drops off the chart, Fido's is still going strong. The circuit in Fig. 7 will generate ultrasonic frequencies from about 15 kHz to about 45 kHz. The lower frequency end of the range is an excellent area to use in experimenting with training your dog. Your pet's hearing is very sensitive to the high-frequency output so be sure that you keep the exposure time to a minimum.

The heart of the ultrasonic generator is a 555 IC. It is connected in a variable-frequency square-wave oscillator circuit with its output, at pin 3, driving a 2-inch piezo speaker. The oscillator is tuned to the desired frequency by R2, a 25K potentiometer. A standard 9-volt transistor battery powers the circuit.

That is about all we have time for this month. Between now and our next visit, put some of these basic circuits to work. Revive an old project, or, better yet, create a new one and let me know how it turned out. I can be reached via snail mail at Charles D. Rakes, P.O. Box 445, Bentonville, AR 72712, or via e-mail as listed at the top of the column. P

PEAK COMPUTING

(continued from page 15)

two external IEEE-1394 connectors rather than three. With IEEE-1394's daisy-chaining capability, it doesn't much matter.

Once installed, *Studio DV* operates very much like most video-editing applications. You need to capture the video to your hard disk, select clips from the captured video, arrange them, and add in transition and special effects to make a complete video. When finished, you either save the video in one of the common video formats, perhaps burning it to a CD-R, or output the completed video back to tape.

As with all video-editing applications that provide IEEE-1394 support, using *Studio DV* is a blast. The IEEE-1394 support lets you use the software to control most digital camcorders, such as the Canon Optura that we used for testing. There's no going back and forth between the camcorder and the PC's keyboard, which makes the whole process a lot smoother. Down-loading the video from camcorde to PC is a whole different experience, as well. Many of the other video capture solutions we've tried over the years have trouble moving full-motion 30-fps video and audio into a PC without dropping frames or losing synchronization with the audio track. That simply didn't happen with *Studio DV*.

However, the way that *Studio DV* differs most from other lower-end editing products is how it handles the capture process. While most other editing programs capture video at full-resolution, *Studio DV* performs the initial video capture at a lower resolution, saving lots of hard disk space. You mark the clips that you want to actually work with, which can be done even over several different tapes. When you're finished, *Studio DV* will go back to the tapes and recapture only those segments that you actually want to include at a much higher resolution. Therefore, when you are capturing at preview resolution, the video takes up only about 50 MB of space for 20 minutes of captured video. At "real" finished resolution, you'll need about 4 GB of space for the same 20 minutes of high-quality video.

Pinnacle's *Studio DV* provides an easy and complete solution to adding both IEEE-1394 and digital-video-editing capabilities to your PC. Don't be afraid to go a different route if your needs are different. IEEE-1394 interfaces are inexpensive enough and easy to install and run; you should consider one if only to add a high-performance external disk drive. P

SOLAR-CELL INVERTER

(continued from page 41)

"BEAM" robot; see the June, 1997 issue of **Electronics Now** for more information on BEAM robots.

Modifications. You can get even higher output voltages by putting two solar cells in series at the input to provide a one-volt source voltage, which would yield an output of up to 30 volts. The inverter hasn't been tested with voltages greater than one volt, so you're on your own beyond the one-volt mark.

You might want to experiment with the values for the coupling resistors and capacitors. The resistors control the maximum drive available at the bases of the transistors, and the capacitors control the frequency of oscillation. The trade-offs involved here are a bit too complex to easily lend themselves to a theoretical treatment, so the empirical approach is the best here. Be cautious about choosing resistor values too low, however, especially if you are using more than one cell in series at the input.

If you want to experiment with two or more cells in series, you can switch to silicon transistors such as 2N3904 or 2N4401 NPN units, or 2N3906 or 2N4403 PNP units. If you use NPN transistors, don't forget to reverse your input voltage; the negative side goes to the emitters of the transistors. Don't get too carried away; beyond a certain point, you won't get any higher voltage at the output because of saturation of the transformer cores.

Have fun! P

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28-4777	FE-11	12VDC, 2A	34.95	29.95
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•Perfect for repair and equipment modification •Operates from a single 12VDC supply •Accepts line level input

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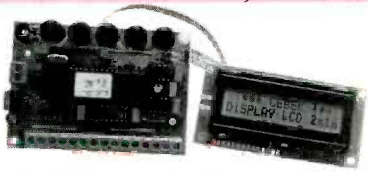
5W two channel 28-4800	ES-2	24.95	20.65
15W single channel 28-4797	E-4	19.95	17.20
15W two channel 28-4801	ES-4	39.95	35.50



Programmable LCD Displays

•Provides one or two line x 16 character display •Fully programmable with easy menu programming •Stores up to 14 alpha numeric messages •EC-3 and EC-4 are backlit

Order #	Mfr. #	Description	Reg.	Sale
28-6135	EC-1	Single line	$89.95	$79.95
28-6140	EC-2	Two line	99.95	89.95
28-4765	EC-3	Single line	115.00	103.50
28-4766	EC-4	Two line	140.00	126.00

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Elenco Model XK-150

$89.95

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

Soldering Stations

Weller Low Cost Soldering Iron
Model WLC-100

$34.95

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

Weller Soldering Station
Model WES50

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

$119

Deluxe Electronic Soldering Station

Elenco SL-5 Series

Electronically controlled, ideal for professionals, students, and hobbyists. Available in kit form or assembled.

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

As Low As $29.95

Ordering Information:

Model SL-5 - No iron. (Kit SL-5K)	$29.95
Model SL-5-40 - Includes 40W UL iron. (Kit SL-5K-40)	$35.95
Model SL-5-60 - Includes 60W UL iron. (Kit SL-5K-60)	$36.95

*** Limited Time Offer ***
FREE SP-1A Solder Practice Kit w/ Kit Order!

Features:
- Cushion Grip Handle Soldering Iron (optional) with Grounded Tip for Soldering Static-Sensitive Devices. Easily Replacable. Uses Long-Life, Plated Conical Tip.
- Heavy Steel, Non-Slip Base.
- Iron Holder Funnel - Reversible, left or right side.
- Steel Tray for Sponge Pad.
- Sponge Pad.

Generators & Counters

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

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

$445

21.5MHz Model 4070	$1295
10MHz Model 4017	$319
5MHz Model 4011	$249

BK PRECISION

Four Functions in One
Elenco Model MX-9300B

$450

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

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

$99

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

Includes antenna, NiCad battery, and AC adapter.

C-2800 Case with Belt Clip $14.95

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

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

$225

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

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

$195.95

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

GF-8025 - Without Counter $139.95

Kit Corner

over 100 kits available

Quantity Discounts Available

Model RCC-7K
Radio Control Car Kit

$29.95

- Fun & Easy to Assemble
- 7 Functions
- Radio Control Transmitter Included
- Also available as Model AK-870 (No Soldering) $24.95

Model AK-700
Pulse/Tone Telephone Kit

$15.95

Ideal School Project

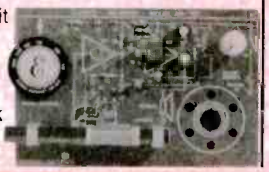
Action Lab Kit
Model MX-902

- Safe, Solderless, Educational, and Fun!
- Easy-to-read, Illustrated, Lab-Style Manual Included.
- Requires 2 "AA" Batteries
- Build your own operating motor - It's easy, it's fun, it's Safe!
- For Ages 10 and up.

$24.95

Model AM-780K
Two IC Radio Kit

$11.95



Also available:
Model AM/FM-108K
AM/FM Radio Kit
$29.95

Model OWI-007
Robotic Arm
(Wired Control)

Teaches the basic robotic sensing and locomotion principles while testing motor skills.

$55.95

300-in-1 Experiment Kit
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- Requires 6 "AA" Batteries
- For Ages 10 and up.

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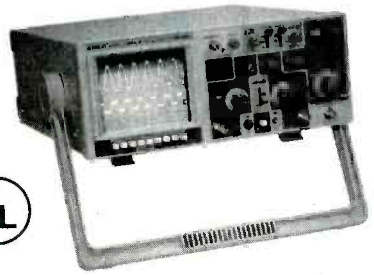


S-1325	25MHz	Dual Trace	$325
S-1330	25MHz	Delayed Sweep	$439
S-1340	40MHz	Dual Trace	$475
S-1345	40MHz	Delayed Sweep	$569
S-1360	60MHz	Delayed Sweep	$725
S-1390	100MHz	Delayed Sweep	$895

DIGITAL SCOPE SUPER SPECIALS

DS-203	20MHz/10Ms/s Analog/Digital	$695
DS-303	40MHz/20Ms/s Analog/Digital	$850
DS-603	60MHz/20Ms/s Analog/Digital	$950

Quantity Discounts Available

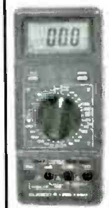
Digital Multimeters

Fluke 87III

$319

Features high performance AC/DC voltage and current measurement, frequency, duty cycle, resistance, conductance, and capacitance measurement.

Elenco LCR & DMM Model LCM-1950



$69

- Large 1", 3 3/4 digit LCD
- Autoranging frequency to 4MHz
- Capacitance to 400μF
- Inductance to 40H
- Resistance to 4000MΩ
- Logic Test
- Diode & Transistor Test
- Audible Continuity Test

Elenco Model M-1740

$34.95

- 11 Functions
- Freq. to 20MHz
- Cap. to 20μF
- AC/DC Voltage
- AC/DC Current
- Beeper
- Diode Test
- Transistor Test
- Meets UL-1244 safety specs

Model M-2760 - $19.95 (9 functions)

Dual-Display LCR Meter w/ Stat Functions B&K Model 878

$225

Auto/manual range

Many features with Q factor

High Accuracy

Elenco LCR Meter Model LCR-1810

$99.95

- Capacitance .1pF to 20,000μF
- Inductance 1μH to 20H
- Resistance .01Ω to 2000MΩ
- Temperature to 750°C
- DC Volts 0 - 20V
- Frequency up to 15MHz
- Diode/Audible Continuity Test
- Signal Output Function
- 3 1/2 Digit Display

Elenco DMM Kit Model M-1005K

$19.95

- 18 Ranges
- 3 1/2 Digit LCD
- Transistor Test
- Diode Test
- Training Course

M-1000B (Assembled) $15.95

B&K Testers

Deluxe Multi-Network Cable Tester Model 231

$75

- Tests 10BaseT, 100BaseTx, 10Base2, RJ45, RJ11, 356A, TIA-568A, TIA-568B, and Token Ring cables.
- Detects open, short, cross, and continuity.
- Tests Point-to-Point, rather than Pair-to-Pair
- Quick and easy-to-use.
- Tests cables on wall plate or patch panel up to 1,000 ft. away with the remote kit.
- Easy-to-read LED display.

Multi-Network Cable Tester Model 230

$69

- Auto scans thin Ethernet (BNC), 10BaseT (UTP/STP), 100BaseTx, RJ45, 356A, TIA-568A, TIA-568B, and Token Ring cables in seconds.
- Detects miswiring, polarization, and continuity.
- Also tests the ground of shielded twisted pair cables.
- Tests cables before or after installation with the remote unit.
- LED display for clear indication of problems.

Remote Network Cable Tester Model 235

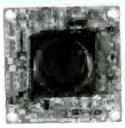
$195

- Detects open, short, reversed, crossed, and split.
- Clear LED display for the fault status.
- Simple and easy-to-use.
- Test cable length: Minimum - 4 ft. (1.2m) Maximum - 492 ft. (150m).
- Identify up to 4 different cables at one end by provided remote identifiers.
- Tests: 10BaseT, 100BaseTx, 10Base2 (coax), RJ45, 356A, TIA-568A, TIA-568B, Token Ring, etc.

CCTV Cameras

Cameras have 420 lines (360 color) of resolution, 0.08 Lux, 3.6mm/F2 90° field of view. Power requirement is 12VDC @ 100mA (order SC-1).

MONOCHROME CAMERAS



SC-12 - 35mm Lens (1.25"x1.25") $69
SC-15 - Pin Lens (1.25"x1.25") $69

Add $10 for lens • Add $10 for audio

Accessories:

SC-1 - 12V 100mA adapter $6.95
SC-2 - 50' cable with connectors $19.95

COLOR CAMERAS

SC-20 Pin Lens
SC-21 3.6mm Lens
360 Lines 1.25" x 1.25"
Infrared Sensitive, Audio Included

$109

Add $10 for case
Call for complete catalog.

Power Supplies

Elenco Quad Power Supply Model XP-581

$79.95

4 Fully Regulated DC Power Supplies in 1 Unit
4 DC voltages: 3 fixed - +5V @ 3A, +12V @ 1A, -12V @ 1A
1 Variable - 2.5 - 20V @ 2A

Elenco Power Supply Kit Model XP-720K

- 1.5VDC - 15VDC @ 1A
- -1.5VDC - -15VDC
- 5VDC @ 3A
- 6.3VAC @ 1A & 12.6VAC center tapped @ 1A

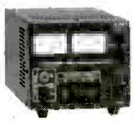
$54.95

XP-720 Fully Assembled **$85**

B&K High Current DC Power Supply

- Variable 3-14VDC
- Thermal Function
- Current Limiting

Model 1686 12A **$169**
Model 1688 28A **$249**



B&K 13.8V Fixed DC Power Supplies
Model 1680 6A $42
Model 1682 15A $75

Elenco DC Power Supply Model SPL-603 3A 0-30VDC

$79.95

The SPL-603 is a solid-state DC power supply providing the exact output voltage no matter what current you use. Output fully protected from overload.

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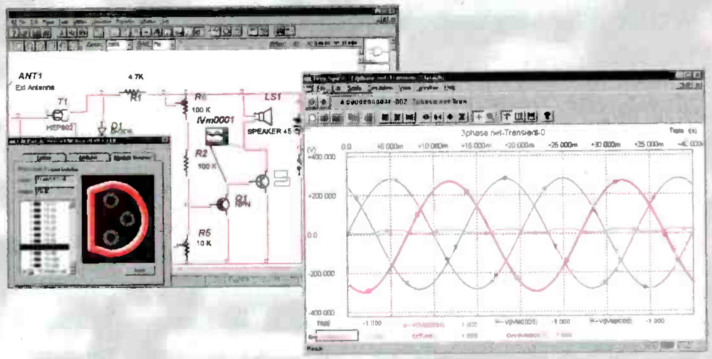

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- Common netlist formats: (Accel, Protel, Pads, wirelist, Spice 3f5, & more.)
- Import Orcad/SDT files/parts
- Visual PCB footprint browser
- Over 12,000 parts included

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Analog Simulation **$99**

The Standard Edition includes:
- Multi channel display
- Over 3,000 models
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The Advanced Edition has all the features of the Standard Edition, with these additional analysis types:

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RAMSEY

Doppler Direction Finder

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

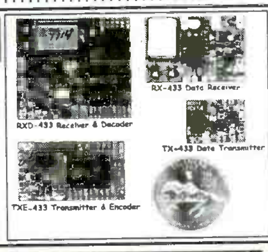
DDF-1, Doppler Direction Finder Kit $149.95

1 GHz RF Signal Generator

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

RSG-1000B RF Signal Generator $1995.00

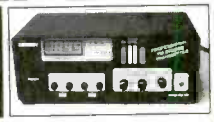
Wireless RF Data Link Modules



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

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

Super Pro FM Stereo Transmitter



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

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

World's Smallest TV Transmitters

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

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

CCD Video Cameras

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

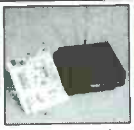
CCDWA-2, B&W CCD Camera, wide-angle lens $69.95
CCDPH-2, B&W CCD Camera, slim fit pin-hole lens.. $69.95
CCDCC-1, Color CCD Camera, wide-angle lens $129.95
IR-1, IR Illuminator Kit for B&W cameras $24.95
IB-1, Interface Board Kit $14.95

AM Radio Transmitter

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

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

FM Stereo Radio Transmitters



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

FM-25, Synthesized Stereo Transmitter Kit $129.95

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

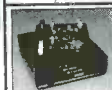
FM-10A, Tunable FM Stereo Transmitter Kit................ $34.95
CFM, Matching Case and Antenna Set $14.95
FMAC, 12 Volt DC Wall Plug Adapter........................ $9.95

Mini Radio Receivers

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

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

RF Power Booster



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

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

PIC-Pro Pic Chip Programmer

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

PIC-1, PICPRO PIC Chip Programmer Kit $59.95

FM Station Antennas

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

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

Order Toll-free: 800-446-2295

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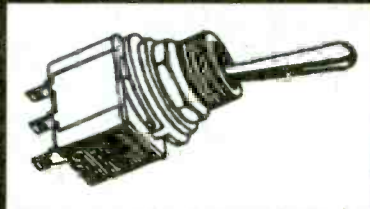

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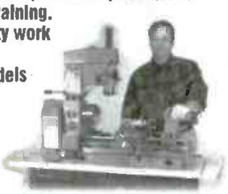

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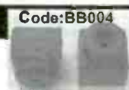

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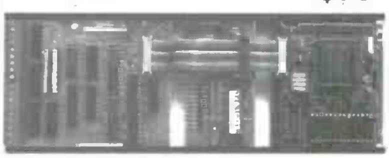

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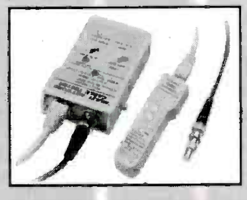

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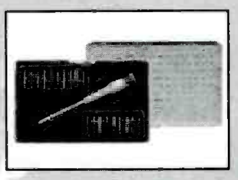

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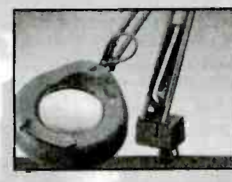

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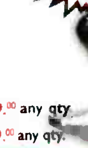

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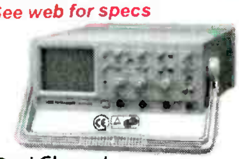

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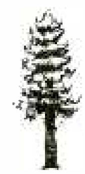

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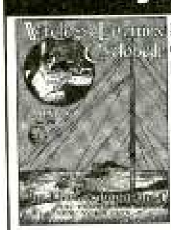

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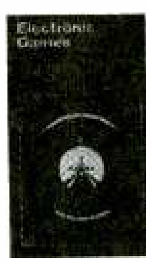

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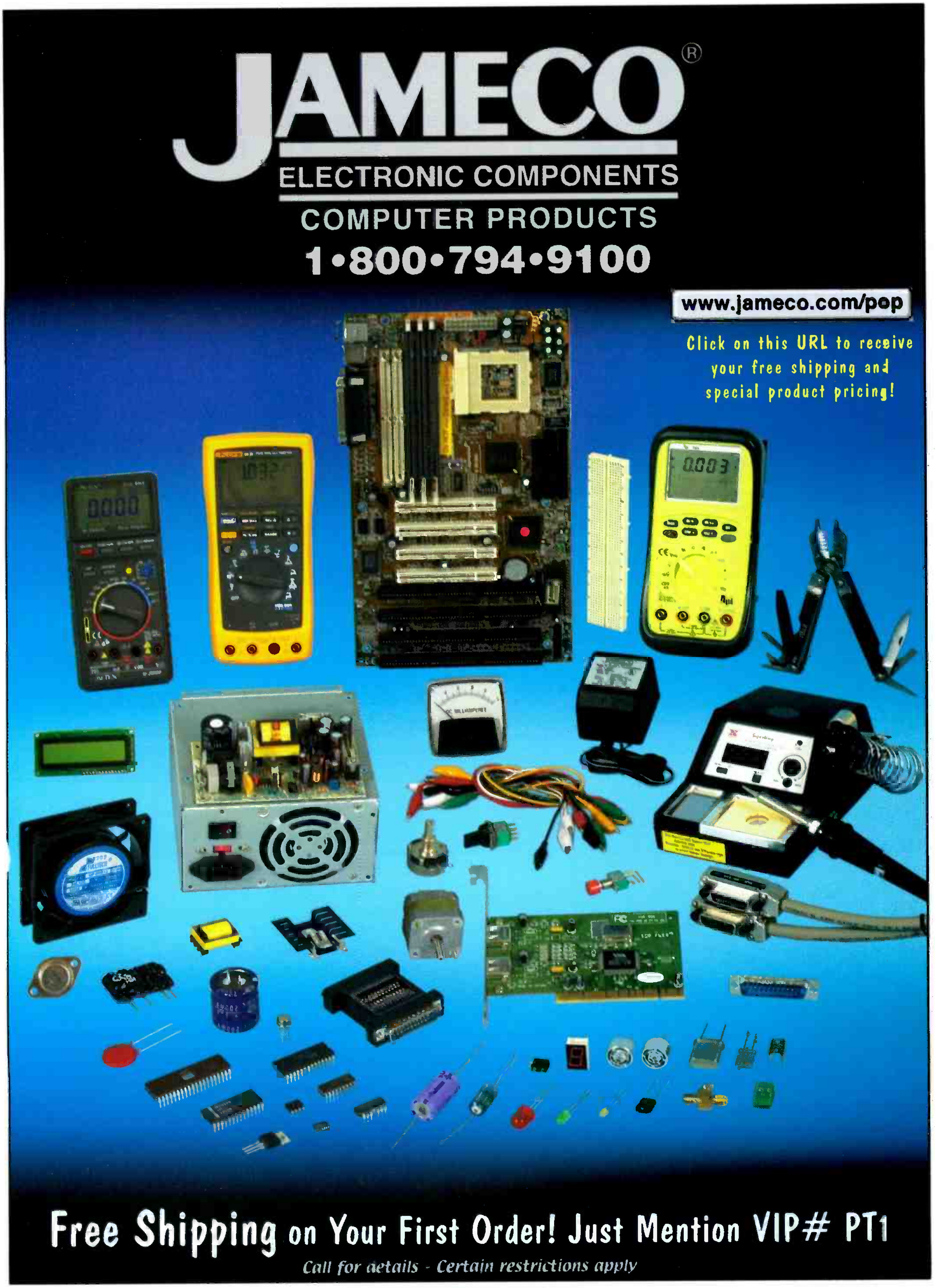
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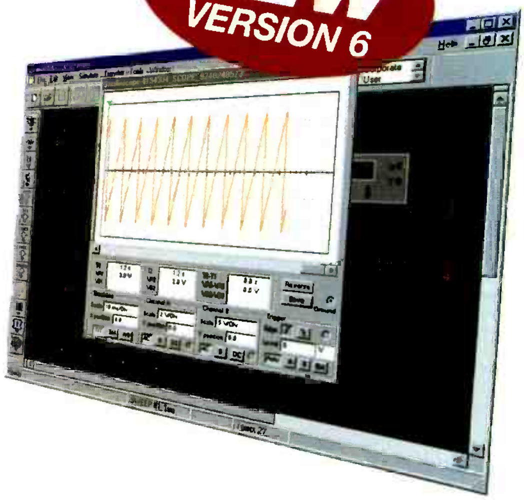

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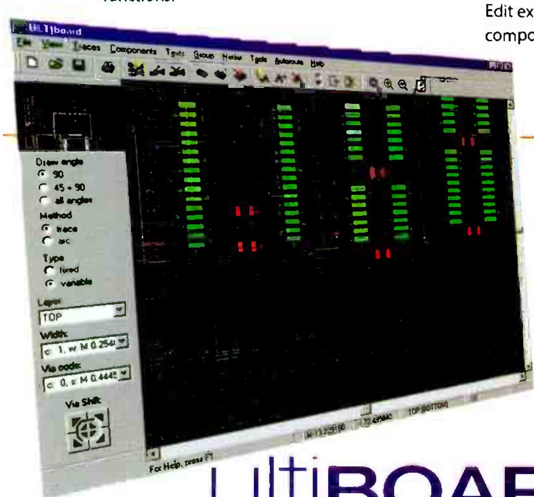

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