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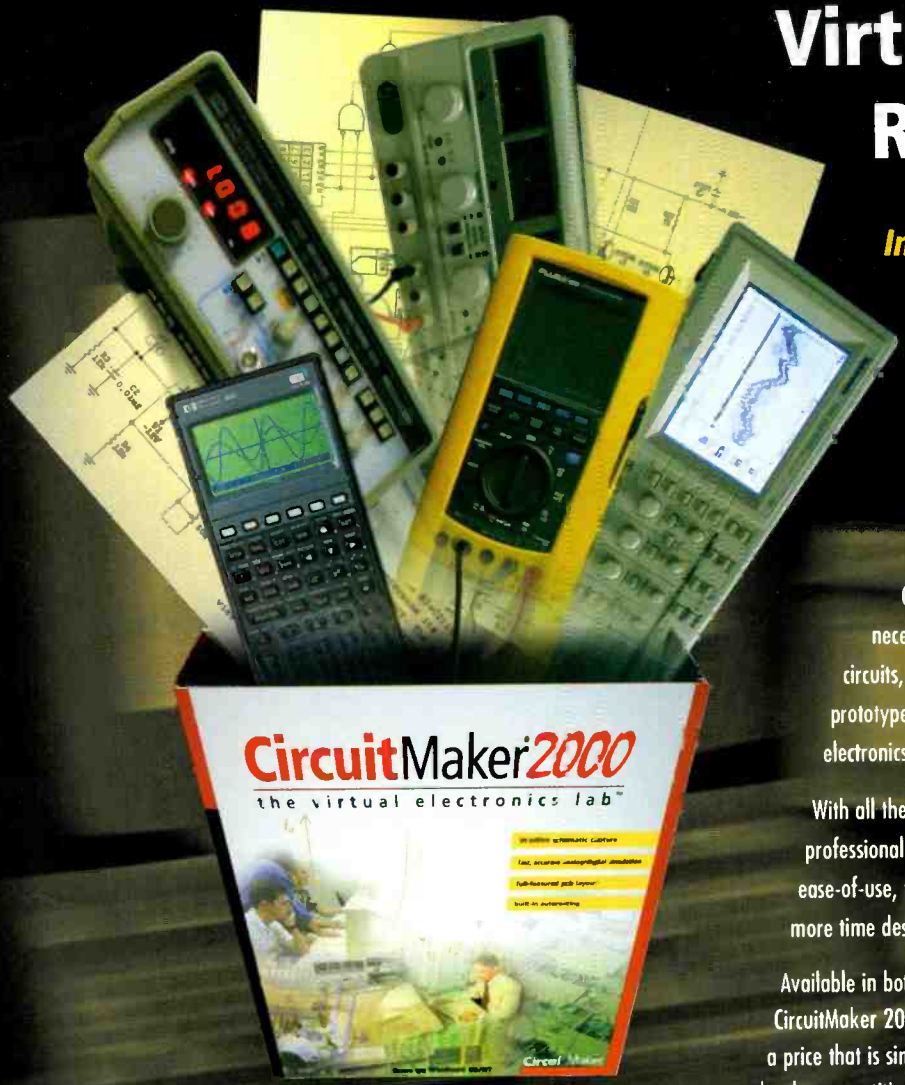

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July 2000, Vol. 1, No. 7
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THE MAGAZINE FOR THE HANDS-ON ELECTRONICS ACTIVIST!

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Editorial

Sharing The Wealth

There's one common trait that everyone—including you and me—shares, regardless of our race, creed, ethnic background, social status, or even educational standing. In his book, *The Dilbert Principle*, Scott Adams (of *Dilbert* fame) said it best:

We're all stupid.

What he meant by that is not as a blanket condemnation, but rather as an assessment of a person's knowledge base *in a particular subject*. For example, I feel that I have a somewhat functional knowledge in terms of the piano from both a technical (how it works) and musical (how to use it) standpoint; I don't consider myself "stupid" in that subject. On the other hand, while I understand the *very general* concepts behind doing a "ring job" on an automobile engine, I have absolutely *no* practical knowledge or experience in performing such a task. When the time comes that I get tired of dumping extra quarts of oil into my old "diesel" Saturn (gasoline goes in the fuel tank, but *boy* does it burn oil!), I'll have a qualified mechanic do the work; at least I'll be comforted in the knowledge that most, if not all, of the parts that are supposed to go back into the engine won't be left behind on the shop floor.

Assuming that the mechanic doesn't know anything about classical music, who's the stupid one?

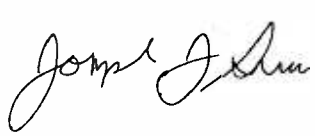
Answer: Both and neither at the same time.

We can't know *everything*; as far as I know, only the Supreme Being's resume has that entry. The best that we can do is to pick up hints, tips, and pointers as we travel through Life. After all, we aren't born with knowledge; someone else has to teach us. As I sometimes respond to the question, "May I ask you a question?", "I can answer every single question in the world. Most of the time, unfortunately, the answer is 'I don't know.'"

We are now living in what has been referred to as the Information Age—where Knowledge is the measure of Power and Wealth. Teaching others can be one of the greatest thrills you can experience when you see the light of understanding fill their eyes as they say, "Oh...*now* I get it!"

Have you picked up a little trick when testing equipment? How about a sneaky shortcut when designing circuits? What have you learned that's useful and practical in the electronics field? Have you read something in one of our magazines that you use in an unusual or novel way? If you think that others would benefit from what you've learned, tell us about it; we'll print the best ones as space and time permits. Through the pages of **Poptronics**, you can teach others.

Help fight stupidity—share the wealth.



Joseph Suda
Managing Editor

GIZMO®

Personal Digital Audio Player

The latest version of Philips' *Rush Model SSA107* digital audio player ($299.99) accepts a 65-megabyte SmartMedia Card that allows it to play up to two hours of CD-quality digital music that's been downloaded from the Internet. Rush is bundled with RealNetworks' *RealJukebox* software, which provides everything needed to acquire, play, manage, and transport your digital music collections, including songs from CDs that have been "ripped" (converted) into digital music files as well as audio files downloaded from the Net. The player is also "AudibleReady"—you can play any of the more than 20,000 hours of spoken-word audio that's available at *audible.com*. The software for Audible's Internet audio service is also bundled with the player.

The Rush player connects to a PC via a parallel-port interface. The included car adapter provides easy connection to a car stereo. The device measures less than three inches square and one inch deep. Because the player has no moving parts, playback is not affected by bumping or jarring. Bookmark functions make it easy to find a desired song or talking book, and extended long play mode provides up to 12 hours of listening.

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

CIRCLE 50 ON FREE INFORMATION CARD

Surfing, Anyone?

Internet-related products such as computers and WebTV are finding their way into the living room, and more homes are adding multiple computers. This fall, to accommodate this new trend, Thomson multimedia is introducing the RCA *WMJ900* wireless modem ($249) that provides access to the phone line from any location in the home.

Consisting of two transceiver units—a base and an extension, the colorful modem has a high-tech look that complements most any room. The base connects to any phone line in the home, while the extension unit is connected to a laptop, PC, or other Internet product. Data is transmitted via RF from the computer to the base unit where the modem connection is made, as well as between PCs at speeds of 115k.

The 56k duplex modem incorporates 900-MHz digital speed spectrum circuitry and is V.90 compatible. The extension unit operates off the power of the laptop or PC, but also comes with two DC power adapters for extended operations. The WMJ900 comes with a three-foot RS232 serial cable, a six-foot phone with RJ-11 plugs, one mini DIN/DC jack with PS/2 connectors for connection to the extension, and a 3.5 disk with setup drivers.

Thomson Consumer Electronics, 10330 N. Meridian St., Indianapolis, IN 46290; *www.rca.com*.

CIRCLE 51 ON FREE INFORMATION CARD

FRS + Forecasts

How can you stay in touch with the other members of your camping (or hiking, or biking, or hunting) party and stay up to the minute on the latest weather conditions? Uniden's *FRS550W* Family Radio Service radios ($99.95 each) provide two-way communications and are equipped to receive all seven NOAA weather frequencies, allowing you to tune in the latest forecasts and warnings. The radios boast a range of up to two miles and offer 14 channels and an automatic channel-scan feature to find an open transmission. A backlit LCD indicates the channel being used, and 38 "privacy codes" (CTCSS tone codes) are available to cut down on chatter from other on-channel conversations. The FRS550W features voice activation as well as a vibration mode that makes the radio vibrate when there is an incoming transmission.

Uniden America Corporation, 4700 Amon Carter Blvd., Ft. Worth, TX 76155; 817-858-3300; *www.uniden.com*.

CIRCLE 52 ON FREE INFORMATION CARD

"This is Your Driver Speaking"

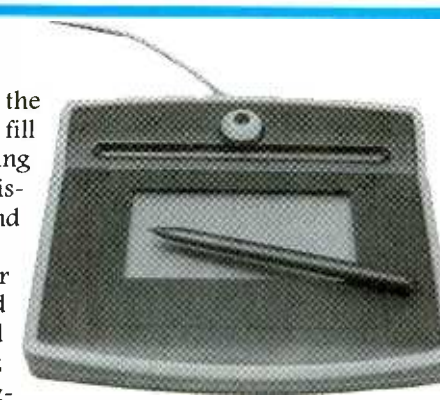
JVC's *ELKameleon KD-LX50* in-dash CD-player/receiver ($429.95) uses proprietary voice-recognition technology that allows the driver to control the system using spoken commands. Without taking his hands off the wheel, the driver can, for example, operate the system by speaking commands such as "CD," to switch the unit from FM to the CD player. The system can recognize and respond to 25 spoken commands. The set includes a microphone, a remote control, and a hideaway unit powered via JVC's J-Link system. A button on the remote is used to activate the voice-recognition system.

The mobile stereo also features JVC's ELKameleon anti-theft system, which automatically retracts the system's controls and switches off the LCD display to make it blend in with the console when the ignition is turned off. The unit's BBE II High-Definition Sound system is said to correct phase delay and distortion to ensure that the output sound (rated at 45 watts×4) remains true to the original recording. Audio Cruise mode automatically adjusts volume levels to offset changing engine, wind, and road noises. CD changer control functions, including Direct Disc Select and two-mode repeat/random play, will provide complete control over a JVC 12-disc changer, which can be connected easily using the company's J-Link connection. For "car theater" applications, full-function VCR control is included. Other features include a large, multi-color LCD and CD Text capability.

JVC Americas Corporation, Mobile Entertainment Division, 1700 Valley Road, Wayne, NJ 07470; 973-315-5000; *www.jvc.com.*

CIRCLE 53 ON FREE INFORMATION CARD

Signature Capture System



An interactive pen and tablet system with LCD graphic display, the *SignatureGem LCD4x3* from Topaz Systems ($495) is used to electronically fill out and sign transactions. The LCD4x3 supports navigation functions, allowing the user to move between computer-guided screens with a tap of the pen, displaying graphics, instructions, text, and logos, while activating checkboxes and capturing handwritten e-signatures.

Featuring a 4- by 2.5-inch LCD screen that displays "electronic ink" under the pen as you sign, the system completely eliminates the paperwork involved with gathering form information and signatures. Organization, storage, and retrieval of signed transactions or documents is instantaneous. Topaz *GemTools* software completes the package, which transfers and binds the signature to an e-document by means of encryption and provides signature verification. All software updates are available free from the Web site.

Topaz Systems, Inc., 650 Cochran St., Unit 6, Simi Valley, CA 93065; 805-520-8282; *www.topazsystems.com.*

CIRCLE 54 ON FREE INFORMATION CARD

You Can Take It With You

Although laptops offer many conveniences, laptop users have had to make do without a solid work platform and writing space when on the road. Until now. The *LapPro* from Quantum Creations ($139) incorporates a versatile one-strap system, work-in-case design, and padded internal frame in a portable desk-top computer case.

It is ergonomically designed for use in vehicles (strapped to passenger seat), in airplanes (slim design fits under seat), and in any type of chair. It also can be used hands free while standing since the back strap allows users to work at their laptop while in line or in the field. Despite its thin profile, the case boasts a large carrying capacity with expandable compartments for peripherals, files, and legal-size documents.

Quantum Creations, P.O. Box 2011, South San Francisco, CA 94083; 800-289-2537; *www.lap-pro.com.*

CIRCLE 55 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.

Mini DV Camcorder

Ready to jump on the digital video bandwagon? Check out Samsung's *Model SCD70* Mini DV camcorder ($1099.99). The compact camera has a flip-out, three-inch color LCD screen and a color viewfinder. It boasts a 22× optical zoom and a digital image stabilization function. The camcorder doubles as a digital still camera and uses a 4-MB SmartMedia Card for storage. Stills are captured with a resolution of up to 640 × 480 pixels. The camcorder comes with all the software and cables needed to interface with a computer through a serial RS-232C port or an IEEE 1394 (Firewire) port.

Samsung Electronics, 105 Challenger Road, Ridgefield Park, NJ 07600-0511; 201-229-4000; *www.sosimple.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Full-Flat Monitor/Receiver

You can view virtually any type of television or computer image on Proton's *WDT-3401 VT* 34-inch Full-Flat high-definition TV monitor/receiver ($6000). The widescreen set offers 16:9 and 4:3 aspect ratios and is fully compatible with all 18 digital TV formats. Dual RGB inputs (one rear and one front-panel RGB-A/V) allow easy connection of computers; the monitor displays standard VGA (640 × 480), SVGA (800 × 600), and XVGA (1024 × 768) images. S-Video and A/V inputs are also conveniently located on the front panel. Dual component inputs are available for connecting a DVD player and an HDTV/SDTV set-top box.

High DC restoration, special three-line digital comb filters, black-level extension, and video noise-reduction technology are said to produce a brilliant, finely detailed picture. The monitor offers parents a channel-block feature and V-chip. The built-in audio system includes dual 10-watt bi-amplified speakers and dual-18-watt subwoofers. The audio-effects switch can be used to select stereo, mono, extra bass, or spatial expansion mode, which uses the Spatializer audio processor to create a three-dimensional surround-sound experience.

Proton U.S.A., 13855 Struikman Road, Cerritos, CA 90703-1031; 562-404-2222; *www.proton-usa.com.*

CIRCLE 57 ON FREE INFORMATION CARD

Cool Boombox

Taking aim at Generation Y, Casio's *CD-312S* CD Boombox offers hip styling in two trendy colors (silver or white) and an appealing $49 price tag. The portable music system includes a CD player with one-key operation, five-second intro play, and one-repeat/all-repeat function. Up to 24 tracks can be programmed into memory for customized playback. The CD-312S also contains a cassette player with automatic record-level control and auto-stop, an AM/FM stereo tuner, and a Bass Boost System

Casio Communications, Inc., 20665 Manhattan Place, Torrance, CA 90501; 310-618-9910; *www.casiocommunications.com.*

CIRCLE 58 ON FREE INFORMATION CARD

Radio From Your Computer

The Broadcast Vision *Netplay Radio FMP3* transmitter ($189) turns PC/MAC computers into personal wireless radio broadcasting stations, enabling the receiving of downloaded music or entertainment files with any FM receiver. The included cable is plugged into the computer's sound-out port, and patch cords connect to the Netplay FMP3 transmitter's right and left stereo input channels. Sound level is controlled by the computer and monitored by an LED readout on the front panel of the FMP3.

Files stored on the computer are then selected, and any open FM stations (from 87.5 to 107.9) is tuned in on the FMP3 transmitter. The transmitter, which is a compact 5fi by 4 by 1/inches, broadcasts clear stereo programming on home stereo systems, Walkman-type receivers, boom boxes, or car radios. The unit includes an adjustment for near and far reception and has a built-in antenna.

Broadcast Vision, 5126 Clareton Dr., Suite 160, Agoura Hills, CA 91301; 800-770-9770.

CIRCLE 59 ON FREE INFORMATION CARD

TED NEEDLEMAN

Film at 11

There are two recurring themes that you'll find in the topics I cover in this column. The first is graphics, which I am fascinated with, but have little actual talent for. The second is organization, such as using the PC to reconfigure and organize my music collection from vinyl LPs to polycarbonate CD-Rs. This emphasis on organization, which this and a few upcoming columns will touch upon, is no coincidence. Aside from calculating ballistics tables for the Army, which many of the earliest computers were developed to do, some of the earliest uses for computers were organizational in nature.

For example, the first large-scale use of tabulating equipment and Hollerith cards (those old 80-column punch cards that many of us grew up with) was by the US Census Bureau. Many of the businesses that purchased the original general-purpose computers did so to store business records, usually on large reels of tape.

EVERYTHING IN ITS PLACE?

I've had computers since they became practical for individuals to own them. Yet I've been able to steadfastly avoid becoming overly organized. To be honest about it, I'm about as far from organized as a person can be and still survive to mention it.

That wouldn't be half-bad, except that I'm also something of a pack rat. It bothers me to get rid of anything. My wife and kids do help, egging me on to dump software that's come for review and will never be looked at again. But not only do I have the photos that were taken on my honeymoon, more than 30 years ago, I still have the negatives as well.

Several issues back, I detailed the great record-to-CD-R project. Once I nailed down the procedure, my 13-year old boys, Bryan and Scott, took over. The artwork is pretty much all scanned, the printable CD-Rs almost finished printing, and about 30 percent of the albums transferred. After all, one of the terrific benefits of having kids is that they can finish the projects you start.

Before you can scan, you must first mount the film into a special holder.

The success of that project, however, has also sparked an expectation that I'll make an effort to organize other areas, such as the boxes of photographic negatives and slides and the 33-gallon tubs that contain magazines and papers with the more than 2000 articles, reviews, and columns I've written. How could I throw those out?

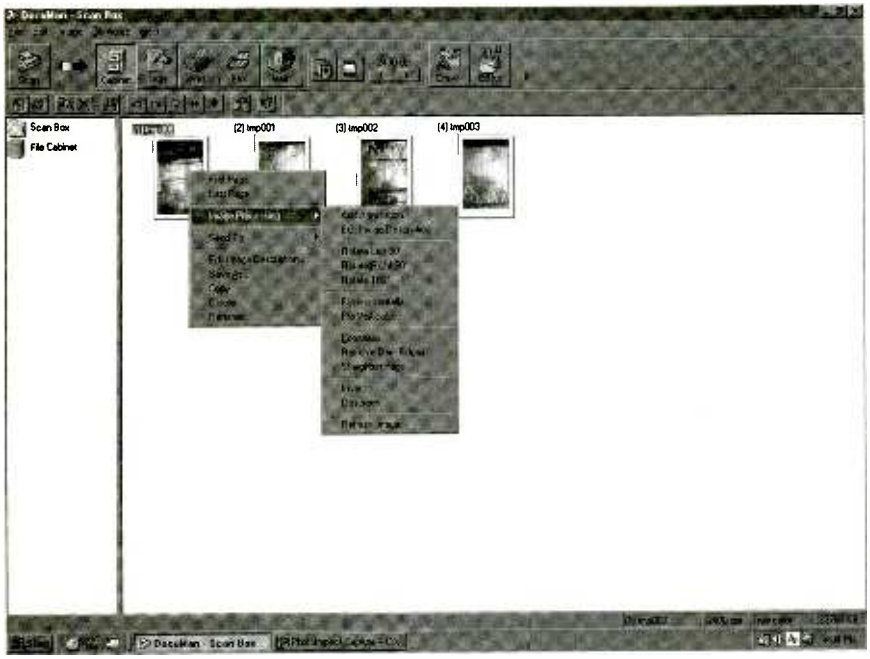
Actually, both problems are pretty similar, at least conceptually. I'll solve the photographic problem this month, the paper problem next month. Both of these problems require a two-step approach. The first step is to convert the media into an electronic digital format. Then, once that has been accomplished, I can apply an out-of-the-box solution to organizing the media.

We've talked about scanners several times in this column. I'm a big fan of flatbed scanners and have several hooked up to various PCs. But a flatbed scanner—even with a transparency adapter that directs the light through the media onto the sensor, rather than reflecting it from the object being scanned—is not really the best way to capture small format (such as 35mm) film, negatives, or slides.

The reason for that has to do with resolution. Normally, most flatbed scanners have a true optical resolution of about 600 dpi. Using a mathematical technique called interpolation, the scanning software can estimate what the scanned image will look like at much higher resolutions, often up to 9600 dpi. The problem is that despite its fancy name, interpolation is just a process of guessing what the unseen pixels actually look like. The guess is made by sampling the pixels around the one that can't be imaged and using a statistical process to estimate the color, shade, and brightness of the unimaged pixel. The big problem is that to get to a decent resolution, such as 4800 dpi, you have to perform multiple interpolations. Doing this results in the software "guessing" pixels based on pixels that it has previously interpolated, rather than imaged.

In many "normal" scans, you'll hardly ever need to interpolate the resolution up. For most image printing,

The film or slide holder is then placed into the slot in the scanner's front panel, and the TWAIN driver is launched to perform the scan.



The AtriScan 2400FS's TWAIN driver provides an easy-to-use interface for capturing film and slide images and making initial adjustments on them.

the rule of thumb is to scan at half the resolution that you'll print with. And except for photographic quality, you can usually get away scanning at even a lower resolution than that.

The exception to this rule is when you are scanning a photograph (or slide, film, or negative) that will be enlarged before printing. In this situation, you need to scan at a very high resolution, as you need as much image data as possible available when you are printing at a size that's larger than the original. If you're just going to scan a couple of slides or negatives, and image quality doesn't need to be that high quality, a transparency-adapter-equipped flatbed scanner is fine. Plenty of vendors, such as Genius and Microtek, offer them at reasonable prices. It's a different story, however, if you have lots of transmissive media that you want to capture at high-quality resolution levels.

The answer to this dilemma is a specialized film scanner. These are especially designed for small-format transmissive media. They also feature denser CCD image arrays, which provide a much higher optical resolution than a flatbed. That allows you to interpolate, when necessary, without introducing multiple generations of inaccuracies into the final file.

Many film scanners, from vendors like Minolta and Polaroid, aren't cheap, with prices up to and over $1000. Olympus, one of my favorite vendors, offers a nice scanner, the ES-10, for about $399. If you also shoot a lot of film in the new APS (advanced photo system) format, the ES-10 is a good scanner to consider, as it offers an APS adapter for $199 that lets you just drop in a cartridge containing developed APS film and scan the film directly into the software.

My needs were a bit more modest and were easily met by the ArtiScan 2400FS scanner from Tamarack Technologies, Inc. The ArtiScan 2400FS handles only 35mm film, negatives, and slides. It offers great 2400 dpi optical resolution, and it is a bargain at $200 for the parallel-port model or about $225 for the model with a USB adapter that I used.

VENDOR INFORMATION

ScanSoft, Inc.
9 Centennial Dr.
Peabody, MA 01960
978-977-2000
www.scansoft.com

Tamarack Technologies, Inc.
1521 W. Orangewood Ave.
Orange, CA 92868
714-744-3979
www.tamarack.net

Ulead Systems, Inc.
970 West 190th St., Suite 520
Torrance, CA 90502
310-523-9393
www.ulead.com

The scanner itself is very compact, measuring only 8 × 4.4 × 4.6 inches (LDH) and weighing about 4.5 pounds. The standard model comes with a parallel-port interface. The one I used also provided a USB adapter that plugs into the parallel-port connector on the scanner and a USB port on the PC. I prefer to use USB wherever possible, as I find that adding peripherals into the printer stream, even when they provide pass-throughs, frequently tends to muck things up. For example, the parallel-port version of Intel's AnyPoint home phoneline network simply doesn't work if you also have a parallel-port Zip drive in the series. USB also tends to provide better performance, as it is a very fast I/O port compared to a parallel-printer connection.

The ArtiScan 2400FS comes with several CD-ROMs-worth of software, including two different imaging and document management applications, *DocMan* and *DocPal*. There's also a very comprehensive TWAIN driver that works with other TWAIN-compatible Windows applications you may have installed.

That's convenient, as I tend to stay with those applications I've grown comfortable with (and facile in) over the years, including Ulead's *PhotoImpact* and Adobe *PhotoShop* for image editing, and ScanSoft's *PaperPort* for image and document management. *ScanSoft* keeps buying other companies in the low-end of the document-management market, and at the current time, now provides *PaperPort*, *Pagis*, and Caere's *PageKeeper*, as well as a host of other software products for OCR (optical character recognition) and image manipulation.

Installing the ArtiScan 2400FS took about five minutes, and I was in business. The scanner comes with two plastic holders. One is for strip film or negatives; the other will hold a bunch of slides. Mount the film (or slides) in the holder and gently place the holder into the slot in the front of the scanner. You can launch the scan process in one of two ways—from a desktop icon, or, the way I usually do, through the Acquire menu choice on a TWAIN-compatible Windows application. This brings up the scanner driver, where you can adjust the settings and scan either the individual images/slide or the entire holder's worth. Scanning

time depends on the resolution you've set, but at the optical maximum of 2400 dpi takes about 90 seconds per image. It really depends on the resolution as well as what type of PC you have the scanner hooked up to. Mine is attached to a real rocket, a Micron Millennium Max 600 (600-MHz) Pentium III.

I'm currently scanning the image into *PaperPort 5.0* first, then using the link at the bottom of the *PaperPort* desktop to launch *PhotoImpact 5.0*, adjusting the brightness and color to try and make up for old film sitting in a box for years. When I'm satisfied with the results, I let *PaperPort* save it into a "filing cabinet" drawer, so it will be easy to find in the future. The great thing about this is that I can get a couple of strips of film scanned and tweaked in 15 minutes or so. I may take a couple of months to finish off, but, at the end, I'll burn some CD-Rs, make up labels that describe the contents, and have the images safely stored on optical media.

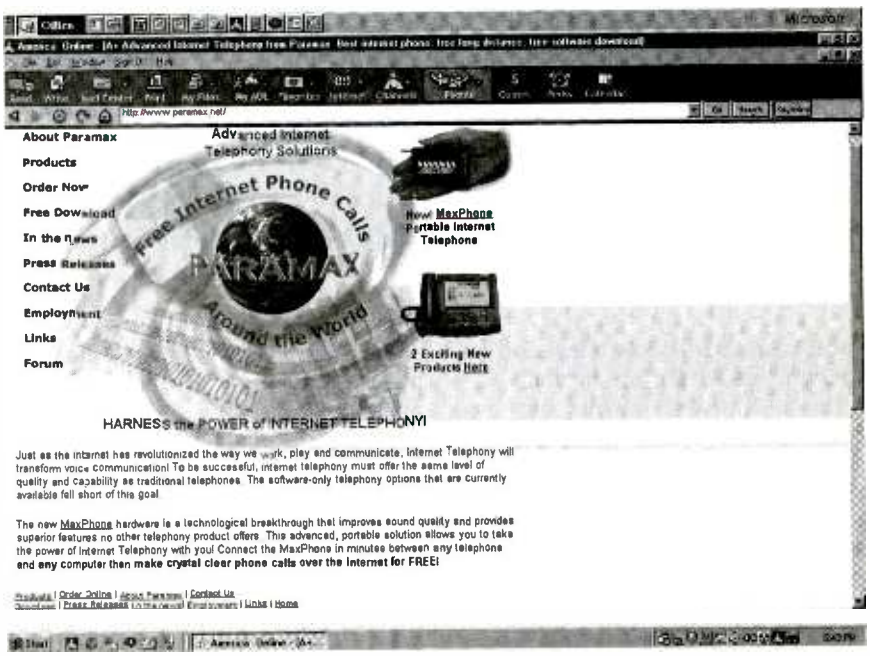
Next time, we'll start to attack the mountains of paper that have built up here over the years. My wife will appreciate that! P

NET WATCH

JOE BLACK

Making Free Phone Calls

The word "free" is a very powerful word. It implies something for nothing, and that is magic to most of us. In real life, however, we find that very little is truly free. There are offers for free merchandise of all sorts—just pay for the shipping. Perhaps it's a free dinner—after you pay for the first one. But now we are all reading about making free long distance phone calls over the Internet. And this time free really means free—sometimes. Of course, you do have to have a computer and an Internet connection; however, if you are reading this column you are likely to already have those, so the phone calls we are talking about here are often, indeed, free!



Paramax's software and hardware solutions to Internet telephony keep you in touch no matter where you are.

WHAT IS INTERNET TELEPHONY?

In its simplest definition, Internet Telephony is a method that uses the Internet to transmit voice communications from one place to another. It is sometimes feasible to transmit video as well, but in this column, this month, we are going to concentrate on voice transmission.

There are two forms of Internet Telephony. One has you talking from computer to computer, with the Internet carrying the voice signal. The two computers can be located anywhere in the world. The only requirement is that they are both connected to the Internet. The second has you talking from your computer and connecting to an ordinary telephone somewhere in the United States or Canada. In some instances you can make international calls as well, but these are not free so they will not be discussed here.

HOT SITES

dialpad
www.dialpad.com

MaxPhone
www.paramax.com

Netphones
home.rochester.rr.con/netphones

zeroplus
www.zeroplus.com

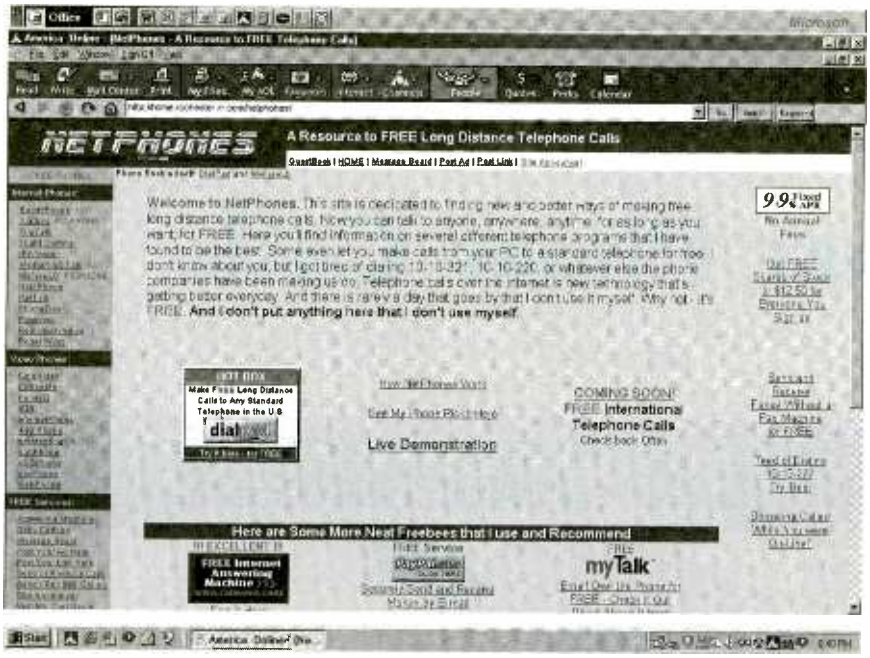
HOW COMPUTER-TO-COMPUTER INTERNET TELEPHONY WORKS

When we place a call over the Internet, we speak into a microphone connected to our multimedia computer. The signals produced by the mike are converted to electronic signals. These signals are then converted into packets of data that are then sent via the Internet to the party we wish to speak with. When the data packets reach this other party, they are reassembled into voice signals and the person you are calling hears your voice through the speakers or headset connected to their computer. It doesn't matter where you are calling; as long as the computer is connected to the Internet, you can speak to whomever you want.

Obviously, along with the computers and the Internet connections, it would be wise if you were both using the same telephony software. While some different software packages are compatible, it works best when both parties are using the same software.

Making an Internet phone call is easy. In most instances, you simply enter the e-mail address or Internet Provider address, and if you and the party you are trying to reach are both online, you'll be speaking to each other—free!

When you make an ordinary telephone call, a connection between you and the person you are calling is made at the telephone exchange for that specific call. Your voice signals are



Netphones collects together many different methods of contacting others through audio or video solutions.

transmitted over a fixed telephone line through a dedicated connection.

In a PC-to-PC Internet call, you simply get your computer up and running, connect to the Internet as you normally would, and start the telephone software. Then you enter the other party's IP or e-mail address and press the call button. The person on the other end will hear their PC phone ring and can press the answer button to respond. Now you can talk to each other just as you would if you made a conventional phone call—except that this call is free.

The compressed data packets that carry your voices are each sent out into the Internet with a destination address. Each data packet makes its own way along various and different routes to their destination. There the computer at that end regroups the data packets and converts them back into the original voice signals, which are played back through the sound card and speakers of that computer. Many PC-to-PC software programs even let you leave a voice-mail message if the person you are calling is not at his computer when you call.

PC VIA INTERNET TO PHONE CALLS

Long distance phone calls have become relatively inexpensive. You have all seen offer after offer with prices from as low as 5 or 6-cents a minute up to—well, you tell me. But no matter how you cut it, they do have a cost—plus monthly fees, minimum charges, etc.

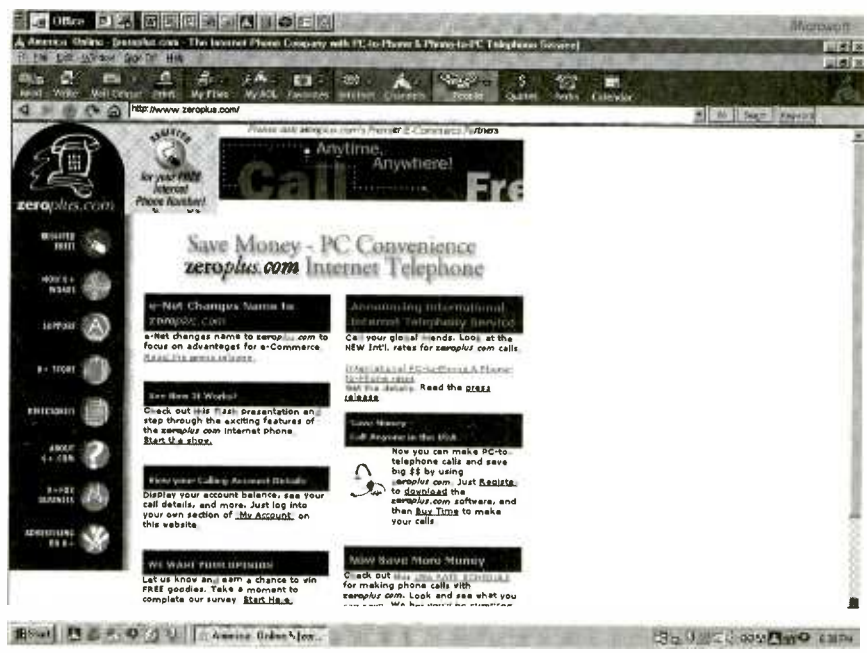
PC via Internet to telephone calls ride partially on the Internet and partially on the existing network of fixed telephone lines. The newest leading-edge technology is used to compress voice signals and take full advantage of the maximum capacity of conventional telephone lines. Data packets from different calls and even different kinds of data can travel simultaneously along the same line at the same time. The way it works is that your voice travels along the Internet for as long as it can before transferring back to conventional telephone systems to complete the call.

SYSTEMS I HAVE TRIED

If you want to find out just how many companies are offering Internet Telephone Call software and systems, log on to the Internet, go to your favorite search engine (I like HotBot.com [Lycos] and Snap.com), and search for "Internet Phone Calls." You will be surprised at how many you will find. Now I can't tell you about each and every one of them, but I have tried a few and can tell you about those.

MaxPhone by Paramax

Paramax Inc. says that their software is a technological breakthrough that improves sound quality and provides superior features no other telephony product offers. Look them up at *www.paramax.com/*. Their advanced portable solution makes it easy for you to take the power of Internet Telephony with you. Connect their MaxPhone in minutes between any telephone and any computer and then make crystal-clear phone calls over the Internet for free!



Another portal for Internet telephony is zeroplus; here, you are charged for your calls.

While free, dialpad restricts you to calls within the US only.

Netphones

This fascinating Internet site at *home.rochester.rr.con/netphones/* states that it is dedicated to finding new and better ways of making long-distance telephone calls. Now you can talk to anyone, anywhere, anytime, for as long as you want for free. Here you will find information about several different telephone systems. Some even let you make calls from your PC to a standard telephone.

zero*plus*.com

Here is another site that offers a way to save money on phone calls. It's at *www.zeroplus.com/* and says Save Money—PC Convenience, zero*plus* Internet Telephone. You can register at this site for your free Intenet Telephone number, but the calls are not totally free. There is a rate schedule for domestic and international calls, and you do have to prepay for your connect time. Maybe this doesn't belong in a column about free phone calls, but I thought that it was worth mentioning.

dialpad.com

This is more like it. Just go to *www.dialpad.com/*. They say you can make unlimited free long-distance phone calls to anyone in the United States. There is nothing to download or install. Your Web browser uses Java-based technology to place calls while you're online. In addition, *dialpad.com* is completely free!

WRAPUP

I've only discussed the systems that I have actually tried for myself. Some work better than others, but they all do work and are far less costly than making conventional long-distance domestic and international calls. The quality may fall a little short of hard-wired telephone communications, but conversations are definitely satisfactory—and the prices are hard to beat.

One last site to look at is *www.deltathree.com.* I did not spend much time here, so I'll let you decide what you think of this one for yourself. Do let me know what other systems you uncover or are currently using and I can do an update sometime later this year. Also send along your comments on any system you are using or have tried—good, bad, or indifferent. Send your comments and suggestions to me at *jblack@gernsback.com.* P

LETTERS

VCR Repair: Can It Be Done?

I enjoyed reading the past few "Service Clinic" columns by Sam Goldwasser. In regard to VCR repair, everything he talks about is true; however, he is about 6 or 7 years too late. Modern-day VCR repair (which almost doesn't exist in terms of business profit) does not relate to most of what is discussed in Mr. Goldwasser's material. Unfortunately, gone forever are those wonderful Panasonic VCRs and their clones from the 80s because too many people believe that newer is better. The material that Mr. Goldwasser talks about, such as belts, idlers and loose guide post, just isn't the case any more. Instead repair men deal with broken nylon or plastic that is molded into the mainframe and cannot be replaced without replacing the entire mechanism.

Other typical problems are tuner-RF breakdowns where surface-mount components are not only nearly impossible to replace, but are not available from manufacturers. How pitiful. I spent over 15 years perfecting VCR repair and now it is all but obsolete—what a shame.

STAN BOGOVICH
Daytona, FL

Yes, It Can

What Mr. Bogovich says is absolutely true for VCRs that are less than a few years old. The consensus of those in the business is generally that these machines are built to last through the warranty and then either be too expensive or simply impossible to repair. They are not designed like the older Panasonics, which could be maintained almost indefinitely with minimal effort and expense.

The "Service Clinic" articles were never intended to apply to those throw-away machines—at least beyond the general cleaning and inspection. There is still a pinch roller, there are still many places where dirt can collect, and video heads still wear out or get damaged. It isn't unknown for lubrication to dry up or never be there in the first place.

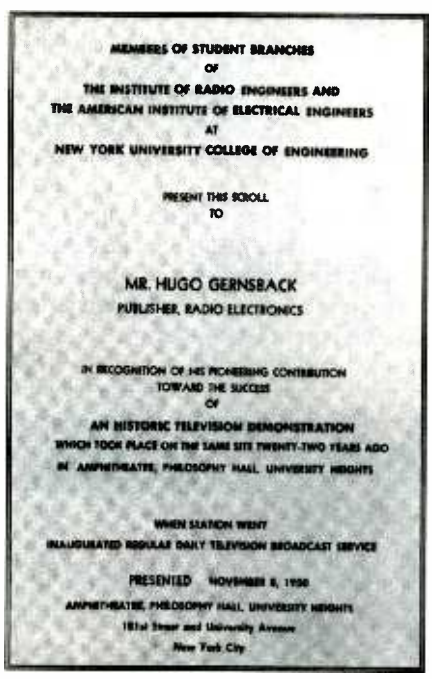
It is perhaps my fault for not making this clear in the introduction. Nor are these columns intended as a course for VCR repair professionals.

However, there are still millions of "middle-aged" to older VCRs out there whose life could be greatly extended with a little tender loving care. If you buy a $79 VCR, you get what you pay for. Don't expect it to last more than a year or so. However, if you have something that is a few years old, it may be worth the effort to keep it going. Newer VCRs don't have significantly better picture or sound quality; they are just more cheaply made to optimize the manufacturer's bottom line.

SAM GOLDWASSER

Hugo's "Hugo Award"

Paul Krueger stated in his letter in the June issue that he witnessed a presentation to Hugo Gernsback at New York University. That certificate of recognition is displayed at our offices and is reproduced below.—Editor



MEMBERS OF STUDENT BRANCHES
OF
THE INSTITUTE OF RADIO ENGINEERS AND
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
AT
NEW YORK UNIVERSITY COLLEGE OF ENGINEERING

PRESENT THIS SCROLL
TO

MR. HUGO GERNSBACK
PUBLISHER, RADIO ELECTRONICS

IN RECOGNITION OF HIS PIONEERING CONTRIBUTION
TOWARD THE SUCCESS
OF
AN HISTORIC TELEVISION DEMONSTRATION
WHICH TOOK PLACE ON THE SAME SITE TWENTY-TWO YEARS AGO
IN AMPHITHEATRE, PHILOSOPHY HALL, UNIVERSITY HEIGHTS

WHEN STATION WENT
INAUGURATED REGULAR DAILY TELEVISION BROADCAST SERVICE

PRESENTED NOVEMBER 8, 1950
AMPHITHEATRE, PHILOSOPHY HALL, UNIVERSITY HEIGHTS
181st Street and University Avenue
New York City

Falling Into a Black Hole? Don't Forget Your Flashlight!

It appears that my article "Measuring Gravity Waves" (**Electronics Now**, October 1999) has stirred up a bit of interest. I am definitely not a physicist. Perhaps this allows me a less "biased" view of Relativity, which is so basic to modern physics. However, I am well read in Relativity and aware of its basic points, such as the relative velocity between two particles is NOT the sum of their velocities. This appears to be true between a particle with mass relative to another particle with mass, and to a particle without mass relative to another particle with mass. The variable factor is, of course, Time.

How this all relates to two particles without mass is (in my eyes) not very clear-cut. Thus, my relativity experiment was born and proposed to postulate that it just might be possible for a particle without mass (the graviton) to exceed light speed. Are gravitons subject to Time variations? How about photons? For a different view, let's look at three other currently "accepted" theories.

- Photons (and thus all electromagnetic radiation) propagate at 1C, the speed of light.
- Gravitons (and thus gravity waves and other gravitational effects) also propagate at 1C.
- Black holes (by definition) have escape velocities within their event horizons greater than 1C.

We know that photons can't escape from a black hole's event horizon—so how do we explain the hole's gravitational effects found external to its event horizon? Can a graviton traveling at 1C escape any easier than a photon? (Please DON'T tell the Particle Physicists that space remains curved without graviton interaction!) Is it possible that gravitons actually propagate faster than 1C, thus escaping the event horizon? If so, might a black hole have a limited lifetime? Perhaps its gravity well collapses below the event horizon, after its escape velocity finally exceeds graviton propagation velocity. Or, perhaps, what we are observing are NOT black holes at all!

Be sure that you don't trip over those unturned stones, folks.

SKIP CAMPISI

Whole Lotta Shakin' Going On

The article "A Seismic Detector" (**Electronics Now**, November 1999) is a credit to your magazine. The electronics/PC portion is a real classic and presents circuitry that will be useful in many data-gathering applications. While its use with a geophone is novel, there are some caveats that should be considered.

First of all, a little about earthquakes and seismographs. There are many similarities between detecting earthquakes and detecting other weak signals, radio signals, for example. One of the most important points is that you have to listen on the right frequency if you want to hear the signal. And you must be mindful of noise and how to deal with it.

The earth is a really noisy planet. We have noise caused by wind, pipelines, tides, coastal waves, automobiles, and the general noise caused by people. Earth noise is maximum at a few frequencies. One is around .167 Hz, better stated as a signal with a period of about 6 seconds. Its primary source is thought to be ocean wave action. Other noisy frequencies are around 10 Hz. Modern seismographs are designed to respond to signals peaked at periods of 1.25 seconds and about 15 to 25 seconds. Geophones, on the other hand, are part of a system designed to "listen" around 20 to 30 Hz.

So, who cares? Well, geophones are intended to listen to the signals from test explosions, sources close at hand. Seismographs are usually designed to listen to signals from distant sources, many thousands of miles away. In order to detect any but the strongest of earthquakes, a seismograph must be operating at the right frequency and must be situated in a quiet location. It is impossible to detect all but a very few earthquakes in a metropolitan environment.

One other point. The detector or a geophone, in the case of the article, must be damped. That is, the response of the electromagnetic transducer must not be oscillatory in nature. This is commonly done by placing an electrical load across the winding of the dynamic coil, although other means are sometimes employed. If steps are not taken to prevent the inertial mass from oscillating like a weight on a spring, the output of the system will be interesting but not meaningful. The value of a seismogram is to determine the origin time and something of the strength of the event. If the system is not properly damped, it will be nearly impossible to use the recorded information for any scientific purpose.

As I said above, the article presents a valuable contribution to the art and science of data recording. The limitations of its use with a geophone in no way diminishes its value.

RICHARD M. SHAPEE
Concord, CA

Confused About Wavetraps

I found the article "Curing Scanner and Shortwave Receiver Overload Problems" (**Poptronics**, March 2000) very interesting. However, I found the text labeled "Wavetraps" (page 78) to be very confusing, and I teach this subject to college students. I suspect there are many readers who could not match this explanation to the graph in Fig. 3B.

The text states that a parallel resonant circuit in series with the signal causes maximum attenuation, which is correct. However, the solid curve in 3B shows minimum attenuation at resonance. In addition, the words tell how a series resonant wavetrap provides a low impedance at resonance, also true, but the dotted curve rises to a maximum attenuation at resonance. Finally, combined with this reversal is the fact that

the series resonant circuit as shown in the schematic (Fig. 3A) is not in series with the signal, but shunts the signal to ground. Thus, at resonance, it actually provides the equivalent of maximum attenuation, since its path to ground is minimum. I assume this is why the dotted curve is drawn the way it is.

The text in Fig. 3 also makes similar unclear statements. When the article refers to "maximum attenuation at the resonant frequency," it should refer to the dotted trace, not the solid trace. One of the reasons this gets a little mixed up is that a series trap does, in fact, present minimum impedance at resonance, but it is referenced to a curve that shows maximum attenuation at resonance. Again, I think the dotted curve was drawn to show the effect of the trap as it is wired in the circuit, not the trap itself.

However, if that is the case, then the solid curve cannot be correct. The parallel tank is wired in series with the signal, and thus presents maximum attenuation as wired in the circuit. Yet, the solid curve shows minimum attenuation. The bottom line is that for the way the two traps are wired in Fig. 3A, both the dotted and the solid curve should be identical. Perhaps most readers won't get deep enough into the article to notice this discrepancy, but I had to read Fig. 3 three times, and then figure out why the picture didn't match the words or my understanding of traps. That notwithstanding, the article was most enjoyable.

CRAIG CRICHTON
via e-mail

[We're glad that the enjoyment you're referring to is the article and not the confusion!—Editor.]

Microphone Swapper Corrections

I'd like to point out that there's an error in my article "PC Microphone Swapper" (**Poptronics**, April 2000). In both the schematic and parts-placement diagrams, J3 is shown wired wrong. The output connection should go to the tip connection, not the ring as shown. While it will work with stereo headphones, plugging in a mono unit will short the output to ground. In the parts-placement diagram (Fig. 3), wire J3 similar to J2. Connect the tip to the pad for the output; the ground pad next to it is for the sleeve connection. The additional ground connection going to the cable shield is for the shield only. You can also (and probably should) use an 1/8-inch jack instead of the 1/4-inch unit specified; most modern headphones and earphones use that size.

Although the magazine doesn't specify such things, the ceramic-disc capacitors should have a 16-WVDC (25-WVDC in the case of C1) rating to prevent damage if they are rated too low. Granted, most ceramic capacitors that you buy today are rated at 25 to 50 volts, but there's always a risk if you're using something from your spare-parts box.

ROBERT OLDS

How Many Metric Æs In A þ?

In the April 2000 issue of **Poptronics** on page 23, the second sentence of the first paragraph beginning in the center column reads, "The board should be about 1fi inches from the front panel." What are "fi inches"? I've seen this several places in **Poptronics**, and in **Popular Electronics** before that.

MARK LLOYD
via e-mail

[The cause of the occasional accidental "fi" is due to how the magazine is prepared for printing. Our production department uses Quark Express for Windows while our printer uses Quark Express for the Macintosh. Normally, you would expect that Quark would have no cross-platform problem when reading files, right?

Unfortunately, the answer is "no." Although the file formats are the same, Quark for the Mac seems to randomly garble anything in a Postscript Type 1 font that's more complex than simple text. The "fi" symbol is usually an accidental TrueType font substitution for the "1/2" symbol.

If you think that's bad, you should see what happens occasionally to sub- and superscripts when we get the galley proofs!—Editor.]

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.

Send e-mail to:

popeditor@gernsback.com

Of course, e-mail is *fast*.

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

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

Don't Misspell My Name

As the publisher of *Bebop to the Boolean Boogie*, we were pleased to note the letter and response in the *Q&A* column (**Poptronics**, February 2000). I suspect that Max, the author, might be a little concerned that neither Rich Joerger nor your editorial staff got his name right. Clive (call me "Max") Maxfield (not Maxwell) has also written *Bebop BYTES Back* and has a Web site called EPE Online: *http://epemag.com*.

HOLLY WADEY
LLH Technology Publishing
Eagle Rock, VA

Haves & Needs

I need help with a question. How can I turn any telephone into a speaker phone? If anyone can help me with this, I would appreciate it. Please reply directly to me at the address below, as I do not get the magazine here.

VICTOR GARCIA
Prado #59 c/Revolucion y
20 De Mayo, Vista Alegre
Holguin, 80300
Cuba

Prototype

Planes That Think for Themselves

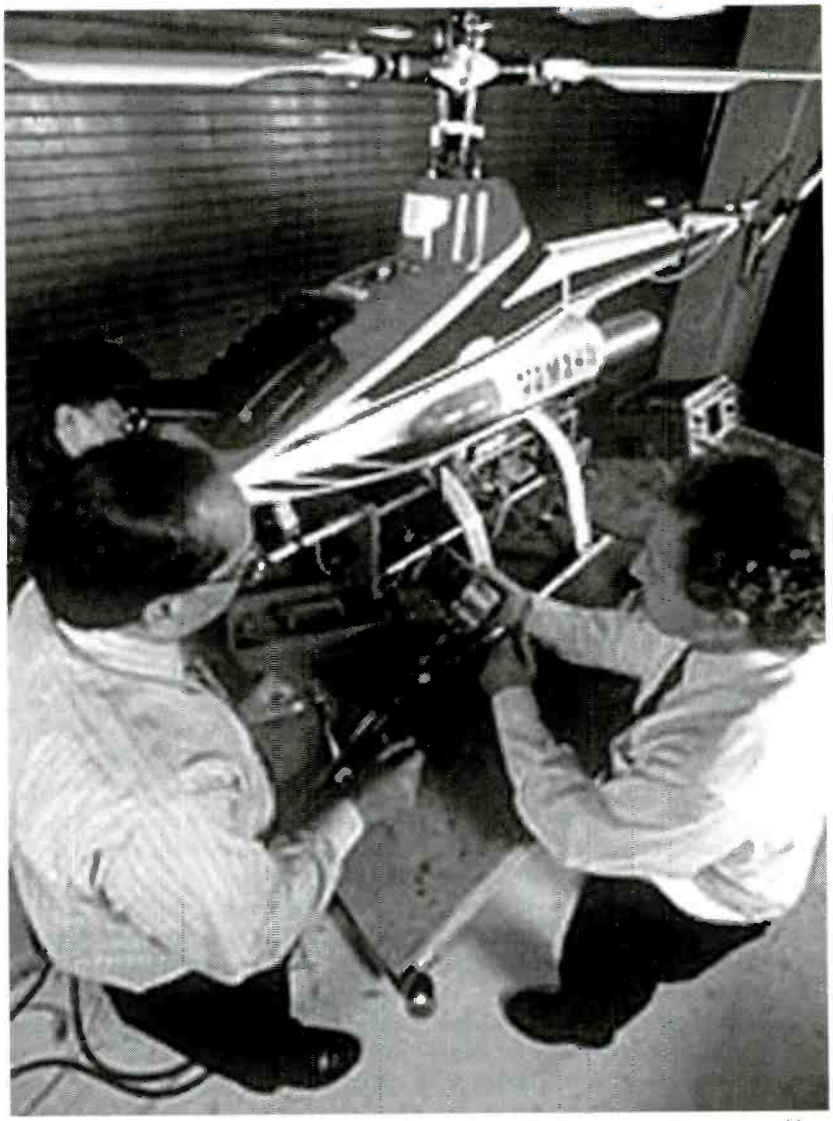
Numerous automatic systems provide support for jetliners and the pilots that fly them. Such systems allow the plane to fly unattended at times, and they kick in quickly if a wind blast destabilizes the airplane or the pilot flies too close to the terrain or other traffic.

What happens if an automatic system, or any of the vital flight surfaces controlled by such systems, alters or fails at a critical moment, requiring major adjustments throughout the plane's flight-control system? In the future, the answer may be "The neural network will take care of it."

Much like the human brain, artificial networks consist of collections of processing elements that are highly interconnected. Each collection transforms a set of inputs to a set of desired outputs. Artificial neural networks, already used for such applications as pattern recognition and process control, are being re-engineered by Georgia Institute of Technology scientists. The redesigned networks will perform a host of monitoring and adjustment functions in aircraft—known as "adaptive control."

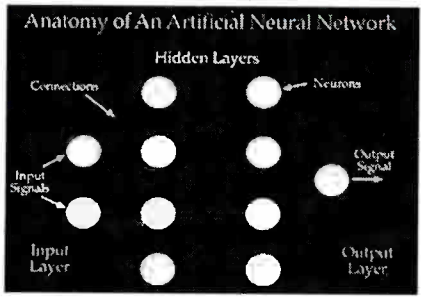
"We're pursuing adaptive control using neural networks on a whole spectrum of aircraft," says Dr. Anthony J. Calise, professor of aerospace engineering. Calise and his colleagues are engaged in seven aircraft-related, neural-network projects, funded by NASA, the Air Force, industry sponsors, and Georgia Tech.

A neural network has been installed aboard an experimental aircraft, the X-36, by Dr. Calise, his colleague Dr. J. V. R. Prasad, and their research team—working closely with Boeing Phantom Works. The X-36 is a one-fifth-size unmanned jet research aircraft that simulates conditions in a full-sized plane. The X-36, developed under NASA auspices by Boeing, was tested recently at Edward Air Force Base. Its neural network functioned successfully, but tests were cut short due to hardware problems.



Artificial neural networks, already used for such applications as pattern recognition and process control, are being re-engineered by Georgia Tech scientists led by Dr. Anthony Calise (right). Redesigned networks will perform a host of monitoring and adjustment functions in aircraft.

At Georgia Tech's Uninhabited Aerial Vehicle Lab, Calise, post-doctoral researcher Dr. Rolf Rysdyk and a team of graduate research assistants are working with Guided Systems Technology



Neural networks are typically organized in layers. Patterns are presented to the network via the "input layer," which communicates to one or more "hidden layers" where the actual processing is done via a system of weighted "connections." The hidden layers then link to an "output layer" where the answer is output as shown in this graphic.

Inc. to test a neural network in a remotely piloted helicopter.

Similar, but Better

For obvious safety reasons, all modern aircraft have redundant controls—backups in case of a primary control failure. However, redundancy alone can't adjust automatically for a major system loss.

Pilots must be trained to manually compensate if an engine should sputter or a rudder fail. During such an emergency, the pilot must explore the remaining options to learn what actions will restore control. In effect, the pilot is quickly retraining himself/herself to fly a degraded vehicle.

The complexities of modern flight control systems makes this process much more difficult. Many of today's aircraft, including military jets, have intrinsically unstable designs and cannot be flown without so-called "feedback systems"—highly sophisticated flight control systems that can sense aircraft performance and angular rates and then feed back a corrective signal that automatically helps stabilize the body.

Neural networks may be able to dramatically alter this process. By focusing on two main areas—how a vehicle flies and the potential failure scenarios for that vehicle—researchers are trying to train the neural network to deal with any system failure.

The neural network system is sufficiently sophisticated that it can even deal with damage to the airframe. Calise says, "The neural network is there to maintain the handling qualities of a well-functioning flight control system—even if you get part of a wing shot off, which is just one of the failures we've mimicked in simulation."

"A neural network is working all the time," Calise says. "When something goes wrong, it adapts just like a human being might adapt to a failure." But, he adds, with one crucial difference: The neural network has the potential to deal with failure more quickly and accurately than any human pilot. Ideally, the recovery process would happen so rapidly it would be virtually transparent to the pilot.

Imitating the Brain

In an aircraft-based system, the neural-network algorithm becomes part of, and works cooperatively with, the flight-control system computer. Like other software, such algorithms have to be tested and refined until they do the job right. As Calise puts it, "The key to using a neural network is to be able to develop efficient algorithms for training neural networks."

A neural network tries, in so far as possible, to mimic human brain functions, Calise explains. The brain's active ingredients, so to speak, are its neurons, which have mechanisms for receiving and sending signals to other neurons.

Neural networks, too, have "neurons" that receive signals from other neurons, process them, and then output a signal. These "neurons" are units of computer code that are mathematical representations of a human neuron's input-output functions. They are linked together by connections called "weights;" changes in these "weights" allow the network to learn by recognizing patterns or configurations.

One well-known approach to neural network training involves "back propagation," where repeated exposure to different objects and patterns is combined with retraining of the weights whenever there is a mistake. In other words, the system learns through experience, by trial and error. But back propagation involves many computations and experiments, Calise notes. Much of the work is done off line in a tedious, time-consuming process, then put on line when the system works correctly.

"In flight control we don't have that luxury," Calise says. Such a system must learn on line in real time as it is exposed to new environments—and be ready to deal with unpredictable failures. To train aircraft networks in real time, the Georgia Tech team has had to bring in new tools. Even formulations used in other cutting-edge neural network research, such as robotics applications and automation, don't apply to aircraft neural networks.

A Software Add-On

Rather than strip out existing flight control software and replacing it with a new system, the Georgia Tech scientists chose to insert the neural network into existing flight control systems.

"That ability, to add on rather than replace, has been a key to our being able to get to where we are today, " Calise says. This integration of neural network function with flight control promises to improve aircraft design and testing, along with enhancing flight and flight safety.

Today, flight control systems are designed for many different operating conditions. As an aircraft moves from one operating condition to another, a flight control system must be adjusted to compensate—a process called "gain scheduling." In today's digital flight control systems, which are implemented in the form of computer code, "gain" means multiplication of an error signal by a number. Gains are varied, either automatically or manually, for speed, altitude, dynamic pressure, payload, and numerous other factors.

Designing a sound gain schedule for a given aircraft is laborious and expensive. Extensive wind tunnel and other tests are necessary to gather data, followed by demonstration of the gain schedule in flight.

Neural networks can alter the entire process by simply removing gain-schedule design, Calise says. Instead, scheduling is done automatically in real time. The neural-networked controller adapts as it flies, automatically rescheduling itself to current flight conditions. For instance, changes in the aircraft's load would not require rescheduling the controller; rather, the neural network would automatically learn the shift in the centers of gravity and the system would reconfigure itself.

Ultimately, Calise says, neural network development may even allow a one-size-fits-all approach throughout

entire aviation areas. A flight control system for one aircraft could be moved to a different aircraft type, and it would reschedule for that vehicle automatically.

"That's kind of like the dream of adaptive control—to be able to do something like that," Calise says. "And I think we're very close to realizing that dream." PT

Quantum Leap

Scientists at the Department of Energy's Los Alamos National Laboratory have made yet another experimental leap forward in the quest for a functional quantum computer capable of solving large mathematical problems or cracking secret codes faster than today's fastest supercomputers. Emanuel Knil, Raymond Laflamme, and Rudy Martinez of Los Alamos and Ching-Hua Tseng of MIT described their results in the March 23 issue of *Nature*.

Using nuclear magnetic resonance techniques, researchers created a seven-qubit quantum computer within a single drop of liquid. The laws of quantum physics allow quantum particles to exist in multiple states: quantum particles can represent both zero and one simultaneously. This concept allows bits, in this case qubits, to be encoded at speeds beyond what is possible in a classical digital computer.

The quantum computer uses nuclear magnetic resonance to manipulate particles in the atomic nuclei of molecules of trans-crotonic acid, a simple fluid consisting of molecules made up of six hydrogen and four carbon atoms. The particles are like tiny bar magnets spinning in a magnetic field that can be "lined up" by applying an electromagnetic pulse from the nuclear magnetic device. The lining up of spinning particles in positions either parallel or counter to the magnetic field allows the quantum computer to mimic the information encoding of bits—zeros and ones in classic digital computers.

Raymond Laflamme and his team used nuclear magnetic resonance to manipulate particles in the atomic nuclei of molecules of trans-crotonic acid—a simple fluid, which he is holding here, consisting of molecules made up of six hydrogen and four carbon atoms. The particles are like tiny bar magnets spinning in a magnetic field that can be "lined up" by applying an electromagnetic pulse from the nuclear magnetic device.

"What we find particularly intriguing," said Laflamme, "is that this latest advance seems to follow Moore's Law." Moore's Law says that density of transistors on integrated circuits, and in turn the calculating speed of the computer, doubles every 18 months. The birth of the three-qubit quantum computer came roughly 18 months prior to this development. "I think it is a bit premature, however, to really assume it follows Moore's Law, but who knows what future technological developments will do. Of course, if Moore's Law is at work here," Laflamme added, "then we could have a 30-qubit quantum computer in less than five years."

A 30-qubit quantum computer would be roughly equivalent to a conventional computer running at 10 teraflops, or trillions of operations per second. The fastest supercomputers in the world have achieved speeds of about two teraflops.

If functional quantum computers can be built, they will be valuable in factoring large numbers and therefore extremely useful for decoding and encoding secret and confidential information. Their arrival could spell trouble for Internet users.

"You realize, of course, that if we had an operational quantum computer today, nothing on the Internet would be safe," Laflamme said. "Our current methods of encrypting secret or personal data, like the RSA public key encryption algorithm currently used in Web browsers would be nearly worthless." PT

➤ Give Me Warp Speed, Mr. Sulu

A two-megabit user-configurable silicon-based search engine, the LN17020, empowers high-end network device manufacturers to design products with unprecedented levels of performance and search intelligence. This full ternary device, which implies a mask bit for every data bit, handles 34-, 68-, 136-, or 272-bit wide operation.

Lara Networks recently introduced the second member of its Search Processor family, the LN17020, a two-megabit user-configurable, variable-width Search Processor for high-performance Internet devices. Up to 31 of Lara's SuperCAM devices can be cascaded without performance penalty to create search tables with unparalleled depths of one million 68-bit addresses.

The LN17020, using 0.18μ copper process technology, sustains throughput of 66 million searches per second. A user-configurable silicon-based search engine, it empowers high-end network device manufacturers to design products with unprecedented levels of performance and search intelligence. This full ternary device, which implies a mask bit for every data bit, handles 34-, 68-, 136-, or 272-bit wide operation.

As the demands on network processors and bit-stream processors have outpaced silicon process technology, new ways are being adopted to supplement the capacity bottlenecks of these processors. Due to its extra-large width, the LN17020 makes possible a broad range of searches within the same cycle.

Also, as demand increases for intelligence in networking, devices need more capacity for searching IP packets and A cells for filtering, routing, handling multiple protocols, and security encryption. SuperCAM technology addresses this high-performance and high-capacity need, providing the hardware acceleration that Internet applications desperately need. PT

Something New Under the Sun

Materials from semiconductors to exotic glasses will be studied by five Alabama scientists who received NASA grants for four years of microgravity material science research. Dr. Don Gillies, Dr. Ching-Hua Su, Dr. Konstantin Mazuruk, and Dr. Edwin Ethridge are leading research teams at NASA's Marshall Space Flight Center (Huntsville, AL) and Dr. Jimmy Mays is conducting research at University of Alabama (Birmingham).

The scientists are using microgravity to examine the properties and structures of materials and the role of processing in creating the materials. "By subtracting gravity from the equation, we are better able to see what is happening as a material is produced," explained Gillies.

Led by Dr. Ching-Hua Su , a team of researchers at several sites is studying density and other critical properties of semiconductors at crucial points during the molten state. The information will be used to improve the quality of semiconductors and the electrical and optical devices made from them.

When semiconductor crystals are melted, convection often creates currents in the molten liquid, resulting in defects in the final crystal. Dr. Mazuruk is researching how to use magnetic fields to control convection and improve semiconductor quality.

Producing a unique glass for fiber optic cables to transmit telephone or Internet signals across continents or oceans is being investigated by Dr. Ethridge. The glass—called ZBLAN—is made from heavy metals such as zinc or lanthanum and metals combined with fluorine. Improved ZBLAN fibers could eliminate the need for expensive signal amplifiers required for today's undersea cables.

Dr. Gillies is leading a team that has modified computed tomography to examine materials during and immediately after processing in space. Similar to CAT scans, computed tomography allows scientists to study samples rapidly and increase the quality of subsequent samples.

Development of smaller and lighter electronic and optical devices is the goal of research by Dr. Mays at the University of Alabama. He is studying how to make nanoparticles—particles smaller than 2 to 20 nanometers—of semiconductor and metallic materials made of polymers.

Microgravity may help enhance the size and shape of these particles. More uniform size and shape will make these semiconductors usable as transistors in microelectric devices and compact lasers. PT

Hackers, Keep Out

Recent hacker attacks launched against major electronic commerce sites have called attention to the need to improve computer network security and to develop systems that detect security breaches rapidly. Researchers at the Applied Research Laboratories at The University of Texas at Austin (ARL:UT) led by Program Manager Sara Matzner developed a new line of defense to help protect e-commerce and other computer-based systems. The Network Exploitation Detection Analyst Assistant (NEDAA) provides a method for detection of computer intrusion and misuse as they occur—significantly faster than the current methods.

The system plugs in various combinations of artificial intelligence techniques coupled with the domain knowledge of human experts. Matzner said NEDAA guards against network intrusions by assisting human analysis to filter through the large volumes of data traveling on computer networks. The program can react while an attack is taking place. It can also detect past attacks through analysis of attack patterns.

"NEDAA employs advanced database access techniques and applies domain knowledge and artificial intelligence to perform that monitoring. At the same time, it can retrieve information about past attacks for forensic off-line analysis," Matzner said. Matzner added that the system "can prevent damage as it occurs. One of the main advantages of the NEDAA system is the speed and efficiency with which it can do this monitoring."

Matzner's group, which is part of ARL:UT's Information Systems Laboratory, is evolving new ways to adapt and deploy NEDAA's plug-and-play implementation. This capability means that the system is ideally suited for adaptation to a wide variety of computer security applications, including those for e-commerce.

"The viability of e-commerce, already a major sector of the U.S. economy, depends upon the security and confidentiality of network transactions, which makes protecting e-business a critical priority," Matzner stated. "Besides commerce, other components of critical infrastructure relying on electronic security include the nation's financial, telecommunications, and military networks." PT

Beware of Lightning Strikes

Now with greater availability in North America, the SAFe system promises to perform without any missed or false warning signals. The system provides advance warning of potential lightning strikes, identifying three hazard levels with appropriate warnings for each level. The pre-warning level indicates thunderstorms, the warning level detects lightning hazards two to three miles from the station, and the alert level indicates imminent risk of a ground-to-lightning strike.

In case of potential lightning strikes, the system warns people so that they can take shelter or interrupts hazardous industrial processes; and it enables sensitive, strategic equipment to be protected against surges or micro-cuts.

The SAFe can detect active thunderstorms as much as 15 miles away and identify incipient thunderstorms at a distance of 6 to 9 miles away. Because the system allows site managers to take appropriate precautions in real time, the level of permanent lightning protection can often be reduced.

The SAFe system, which uses auto-controlled calibration of electric field measurement, is based on a digital electric field sensor with a 10-Hz sampling rate and synchronous demodulation. This sensor, which can operate in temperatures ranging from -13°F to +131°F, is connected to the warning terminal by a fiber-optic cable immune to lightning-induced electrical surges or drop-outs. The warning terminal displays and logs four-color warnings and monitors the status of the entire system. A PC can be used as the central station for a network of up to 16 SAFe systems. In addition to the standard system, DIMENSIONS also offers a small, easily installed detection station. PT

CD ROM based resources for learning and designing

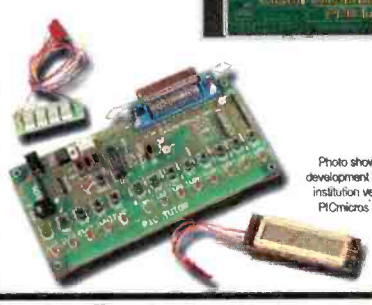


Photo shows PICmicro development kit supplied with institution versions of C for PICmicros and PICtutor

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

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

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

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

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

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

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

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

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

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

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

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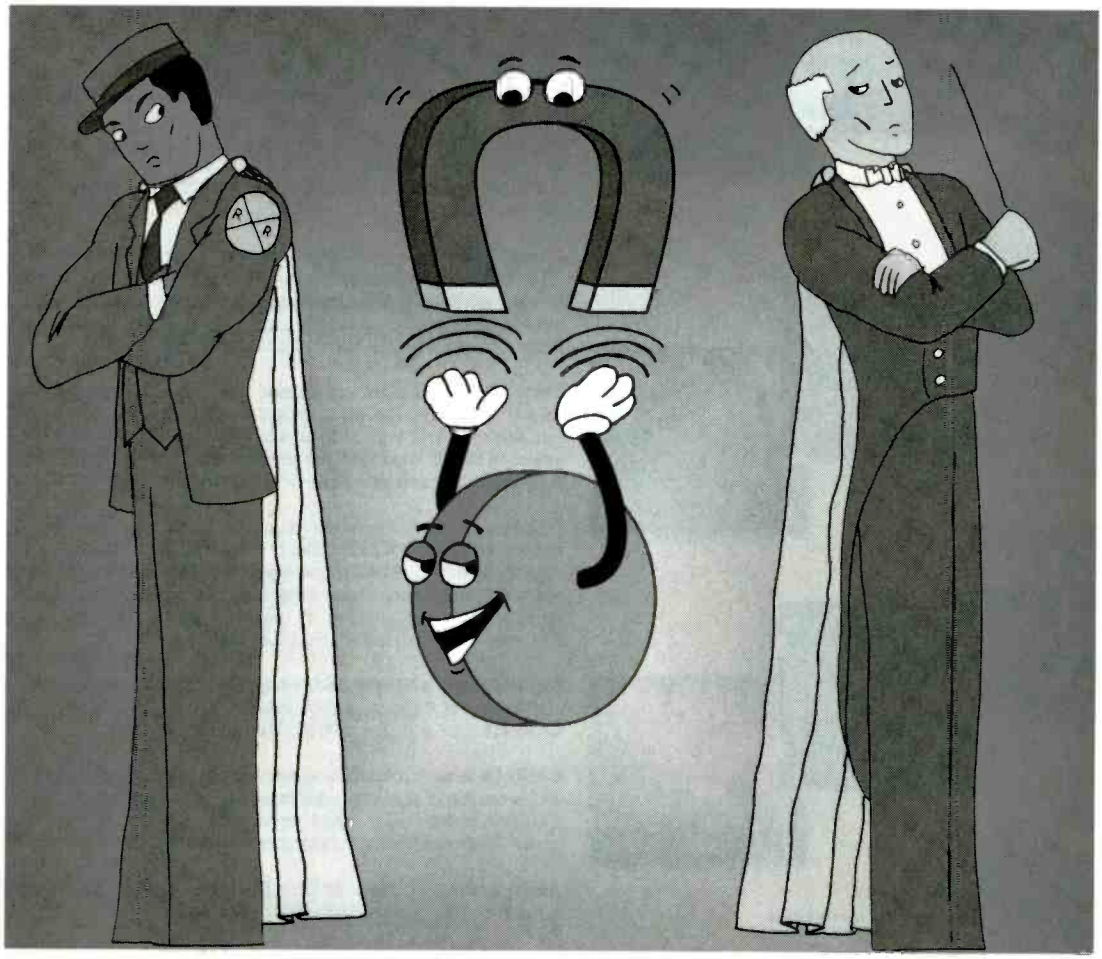
JOHN IOVINE

Superconductors



As you can tell from the title of this month's column, we're going to have some fun with superconductors. Actually, that's not quite the case. This time around, we're going to lay the foundation on superconductor theory and practice; next month will be the actual experiments.

Superconductors, for those few that haven't heard of them, are materials that demonstrate no resistance to the flow of electric current. That's *zero* electrical resistance. Therefore, an electric current initiated inside a perfect superconductor will not dissipate with time and will flow forever. Granted, that probably goes against everything that you were taught in public school, but the phenomenon does occur under special circumstances.

Temperature Scales and Other Definitions

In the realm of superconductivity, temperature plays a big role. Because of the low temperatures involved, the *Kelvin* scale is usually used. You're probably familiar with the Fahrenheit and Celsius scales. In the former, water freezes at 32° and boils at 212°, whereas the latter uses 0° and 100° for those temperatures.

As matter cools, the molecular motion within it slows; it is that motion that gives an object its temperature. At some point, therefore, motion stops completely. Once that happens, you can't make anything colder because there's no more heat to take away. That temperature, called *absolute zero*, occurs at –273.15° C or –459.67° F. Since dealing with all those negative numbers can become quite a mouthful, the *Kelvin* scale is usually used. In that scale, absolute zero is assigned to the 0-degree reference; the "tick marks" on the thermometer follow the Celsius spacing. Water freezes, therefore, at 273.15° K.

The Fahrenheit scale has its equivalent to Kelvin: it's called the *Rankine* scale.

A Short History

The Dutch physicist Heike Onnes

discovered superconductivity in 1911. He observed that mercury, when cooled to within about 4.2° K, lost all of its electrical resistance. Onnes also coined the term *superconductivity* to describe the effect.

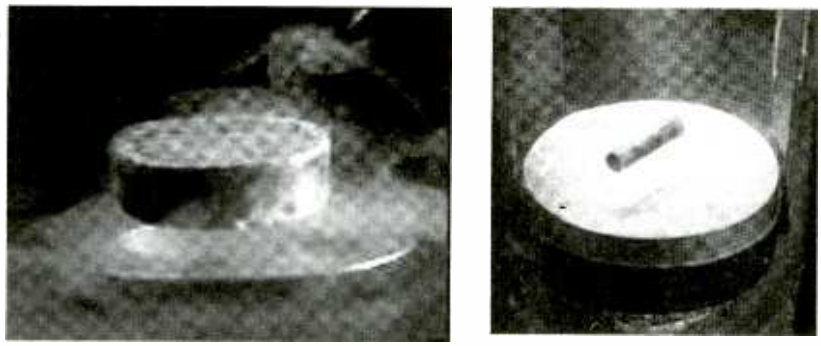
It was known at the time that the resistance of a metal decreases with its temperature. That was certainly the case with mercury. The unexpected part had to do with the non-linearity between temperature and resistance. As the temperature of the mercury decreased, its resistance decreased as expected, but at about 4.2° K, the resistance disappeared: Onnes had found the *critical temperature* of mercury where it suddenly goes superconductive. "Tc" is the notation for the critical temperature in a superconductor. To prove that the metal was truly superconducting, an experiment was set up in which a ring was charged with an electric current. As long as there is no resistance, the electricity would flow with no drop in current. Scientists finally became convinced of Onnes' discovery after seeing that the ring was still conducting the same current after a *year*!

While studying the superconductive state of mercury, Onnes observed that even a weak magnetic field could quench the superconductivity. This sensitivity to magnetic fields limits the amount of current that can pass through a superconductor, since the magnetic field generated by the current itself will extinguish the superconductivity if too great. The *critical magnetic field*, notated as Hc, represents the level at which a magnetic field quenches superconductivity.

Scientists continued to study the superconductivity of elements and compounds. They found 12 superconducting metals. Even common metals like lead and tin became superconductive if sufficiently cooled.

In 1933, K.W. Meissner and R. Ochsenfeld discovered that superconductors are strongly diamagnetic—they are repelled by magnetic fields. In 1945, Russian physicist V. Arkadiev nicely demonstrated this property by levitating a small bar magnet above the surface of a superconductor. This has become the classic experiment demonstrating the *Meissner-Ochsenfeld effect* (MOE); it is usually referred to as simply the Meissner effect.

The largest impediment to the practical use of superconductors is the extremely low temperature needed to make a material superconductive. Since its discovery in 1911, the critical temperature of superconductors was raised only slightly over the next 75 years. By 1986, it had risen only to 23° K for a niobium alloy. That year marked a breakthrough in superconductor research. Researchers K. Mueller and J. Bednorz at IBM Zurich were experimenting with a possible new alloy that required baking at high temperatures to form the compound. When they removed the sample from the oven, they found that the disc was green in color—a sure sign of oxygen contamination. Normally, they would have disposed of the faulty material; oxygen in a metal turns the compound into a ceramic, which is not conductive. For whatever reason, they decided to test it anyway since they would have to wait for a new batch. To their amazement, the sample went superconducting at an amazing 30° K! The race was now on in the quest for high-temperature superconductors. Several other labs began work on ceramic superconductors, and the critical temperature need for superconductivity was soon raised above an important milestone for



One unusual aspect of superconductors is their ability to repel magnetic fields as seen in these classic experiment demonstrating the Meissner effect.

practical use outside the laboratory—the temperature of liquid nitrogen (77° K, –196° C, or –321° F).

Being able to use liquid nitrogen for superconductivity is a tremendous boon to the technology. Liquid nitrogen cools 20 times more effectively than liquid helium, it's 1/10 the cost of liquid helium, and is much safer to transport and handle. Superconductors are now much more economical to use in equipment and experiments.

The ceramic superconductors that we'll be using in our experiments need to be cooled with liquid nitrogen to become superconductive.

More on the Kelvin Scale

As I mentioned before, the critical temperature of superconductors is usually given in degrees Kelvin. The Kelvin scale is named after the 19th Century scientist Lord Kelvin, who suggested that absolute zero become the base of a new temperature scale. This temperature scale makes it easier to use superconductivity formulas because you're plugging positive numbers into an equation rather than the negative numbers encountered in the Celsius and Fahrenheit scales.

Meteorologists also used the Kelvin scale in many calculations to avoid using negative numbers in their computations.

To convert between the different temperature scales is easy using a few simple formulas. To convert Kelvin to Celsius, subtract 273: 100° K is equivalent to –173° C.

Once we have a Celsius temperature, the time-honored formula:

$$F = 9/5\ C + 32$$

converts Fahrenheit to Celsius. Conversely:

$$C = 5/9\ F - 32$$

changes Celsius to Fahrenheit.

Ceramic Superconductors

The ceramic materials used to make superconductors are a class of materials called *perovskites*. The superconductor that we will be experimenting with is an yttrium (Y), barium (Ba), and copper (Cu) composition. The chemical formula is YBa2Cu3O7. This superconductor has a critical transition temperature around 90° K, well above liquid nitrogen's 77° K temperature.

Superconductors are readily available through a number of science supply stores. The YBa2Cu3O7 superconductor material, along with a rare-earth magnet to demonstrate the Meissner effect, is available for $33 from a source given in the sidebar.

Type I and Type II Superconductors

As Onnes discovered, the superconductivity of a material can be quenched when the material is exposed to a strong enough magnetic field, depending upon the material. The first superconductors discovered were easily quenched by relatively weak magnetic fields. These are Type I superconductors.

Type II superconductors are more robust. They have two critical magnetic fields. The first is a low-intensity magnetic field (Hc1) that partially quenches the superconductivity of material. The second is a high-intensity magnetic field (Hc2) that completely extinguishes superconductivity.

The Type II superconductor allows sufficient current to flow to generate strong superconducting magnets. The superconductors that we'll use are Type II.

The Meissner Effect and Flux Pinning

The classic experiment of floating a rare-earth magnet above a superconductor is pretty interesting. This shows that the superconductor is diamagnetic, repelling a magnetic field as stated before. Have you wondered why the magnet doesn't just flip off the superconductor? After all, the magnet's magnetic field is being repelled. Why does the magnet stay levitating above the superconductor?

The answer lies in *flux pinning*. Flux pinning occurs in tiny defects in the crystalline structure of the superconducting material. Imagine the magnetic field around the magnet-like lines of force. The superconductor repels the majority of the magnetic force lines, which support and levitate the magnet. A smaller portion of the lines of force become trapped in the defects in the superconductor matrix and are held in place. These trapped lines of force (flux pinning) are why the magnet doesn't slide or fall off the superconductor.

Doping the superconductor's ceramic formula with silver can enhance flux pinning in superconductors. An enhanced flux-pinning superconductor can not only levitate a magnet above itself but also suspend a rare-earth magnet in mid air beneath itself as well. We will do this experiment next month.

Liquid Nitrogen

Liquid nitrogen is a clear colorless liquid. While liquid nitrogen is nontoxic, it is extremely cold (–321° F); one must exercise care in handling it. You might have seen the experiment where a flower is dipped in liquid nitrogen and then crushed into tiny pieces. The same thing can happen to you if you accidentally come in contact with it. Although the image is extremely gruesome, we'd hate to see you break a finger off after pouring liquid nitrogen on it. We will cover handling procedures next month when we begin to perform our superconductor experiments.

Procuring liquid nitrogen locally will be a more challenging task than obtaining a superconductor for experimenting. Check your local classified telephone directory under "Gas—Compressed, Industrial, and Medical" for suppliers. Call these suppliers and find one who is willing to sell a small quantity (such as a liter) of liquid nitrogen. If you happen to live in the New York Metropolitan area, I've listed a supplier who is willing to sell small quantities of liquid nitrogen.

After finding a suitable company, the next problem is finding a container to bring to the supplier to carry and hold the liquid nitrogen. Most suppliers will

SOURCES FOR SUPERCONDUCTING SUPPLIES

Liquid Nitrogen

TW Smith Co.
885 Meeker Ave.
Brooklyn, NY 11222
718-388-7417

Superconducting Kits and Supplies are available from Images Company, 39 Seneca Loop, Staten Island NY 10314; 718-698-8305: 1-liter Dewar Flask (DEW-1L), $ 89.95; YBa2Cu3O7 Superconductor Kit with 1-inch diameter 90° K superconductor disk, rare-earth magnet, non-magnetic tweezers, and 36-page booklet (S1), $ 33; Bi2Sr2CaCu2O9 Superconductor Kit with 1-inch diameter 110° K superconductor disk, rare-earth magnet, non-magnetic tweezers, and 36-page booklet (S2), $42; YBa2Cu3O7 Superconductor Kit with Flux-Pinning Suspension includes 1-inch diameter 90° K flux-pinning-enhanced superconductor disk, two rare-earth magnets, non-magnetic tweezers, and 36-page booklet (S3), $63.

not sell you liquid nitrogen if you do not have a suitable container. For instance, you would not store liquid nitrogen in a closed vessel because as the nitrogen evaporates into a gas, dangerously high pressures can build that could rupture the container or cause it to explode.

Typically, super-cold fluids are transported in special containers called *Dewar* flasks. Dewar flasks are so well insulated that they can hold a quantity of liquid nitrogen a few days before it evaporates. In an open, non-insulated container, the liquid nitrogen will only last a few hours before evaporating completely into a gas.

Superconductor Experiments

You can perform a wide variety of superconductor experiments. However, complex experiments require the more expensive superconductor kits. I've made available several superconducting kits through my company to help you get started. Available kits include a standard YBa2Cu3O7 superconductor compound with a rare-earth magnet to demonstrate superconductivity and the classic Meissner Effect. If you want to experiment with a higher temperature superconductor, a bismuth compound (Bi2Sr2CaCu2O9) that becomes superconductive at 110° K is also available.

Other kits include a flux-pinning kit that allows a rare earth magnet to be levitated (suspended) underneath a superconductor and electrical conductivity tests that store an electric current in a superconducting toroid.

Next month, we will perform a number of superconductor experiments. In the meantime, locate and secure a liquid nitrogen supplier so you can perform the experiments yourself. P

Non-Functional Function Generators

Q *In regard to the function generator question in the March Q&A, there is an error in this circuit. Capacitors C6 and C7 are not returned to ground. Does this circuit really go out to 1 MHz like the reader wanted? I doubt it.—Anonymous, via e-mail*

I saw your March column and was surprised to see you recommending the ICL8038 as a function generator. Sure, it works, it's available, and it's inexpensive; but it also requires dual voltage supplies, uses lots of power, runs hot, and is difficult to get a good sine wave—especially over a wide frequency range. I think the XR8038 was also mentioned, but as far as I know, Exar no longer produces that part. My current favorite for this application is the MAX038 from Maxim; it works up to 20 MHz. Wouldn't you agree?—R. K., Portland, OR

A Oops! The requirement to function at 1 MHz completely went past me; the circuit shown in the March issue (p. 12) tops out at around 200 kHz. In fact, the original article that I referenced stated that the circuit was designed for a 100-kHz limit. Additionally, there's a mistake in the diagram; the junction of C6 and C7 should be grounded. The circuit requires a split supply (both +12V and –12V). On top of that, Jameco's part number for the 8038 is 51879, not 58179.

Shown in Fig. 1 is a better circuit. This IC, the Maxim MAX038, will reach 20 MHz when the circuit board is laid out carefully for high frequencies. Choose squarewave, triangle wave, or sinewave output by connecting A1 and A2 to ground or +5 volts as shown in the table. In addition to the selected waveform, the oscillator also produces a TTL-level (5-volt) squarewave that can be fed to a frequency counter or other control circuitry. There are even provisions for running it as a phase-locked loop.

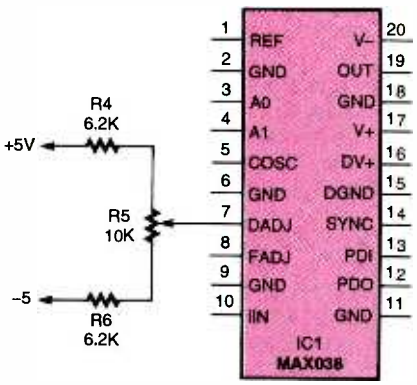


Fig. 2. You can set the duty cycle of the MAX038 by feeding a varying voltage to pin 7.

Even when oscillating at a low frequency, the MAX038 is a high-frequency device and it is prone to parasitic oscillation unless high-frequency wiring precautions are followed. Keep the leads to R1 very short. If possible, use the circuit board in Maxim's evaluation kit (see below) rather than a solderless breadboard.

Figure 2 shows how to adjust the duty cycle of the output. Although really narrow pulses cannot be obtained, this gives you enough control to use the MAX038 as a pulse generator under some conditions. The frequency depends on R1, R2, and C6. For best results, keep the combined value of R1 and R2 in the neighborhood of 10,000 ohms; make large frequency changes by changing C6. The component values shown will give you about 0.3 MHz to 5 MHz, but high-frequency performance may require a carefully laid-out circuit board. You can use much larger capacitors for lower frequencies, down to 0.1 Hz or so.

The MAX038 requires a well-regulated split power supply at +5.0 and -5.0 volts; Fig. 3 shows a suitable power supply circuit and Fig. 4 gives you the pinouts of the chips used in it. Note also C1, C2, C3, and C4, the filter capacitors in Fig. 1. For best high-frequency performance, use 1-µF tantalum electrolytic capacitors in parallel with 0.1-µF ceramic or film capacitors.

You can view the MAX038 data sheet online at *www.maxim-ic.com*. You can order small quantities of the chip for $14.70 each online or by calling 408-

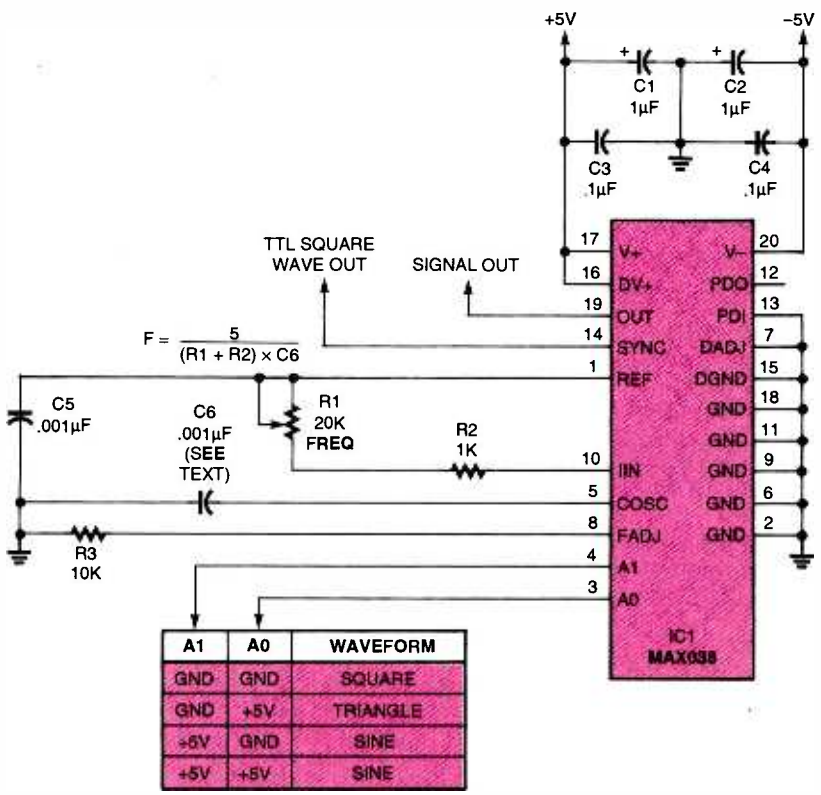


Fig. 1. With careful board layout, this function generator can hit 20 MHz. Note how you can select different waveforms with digital signals on pins 3 and 4.

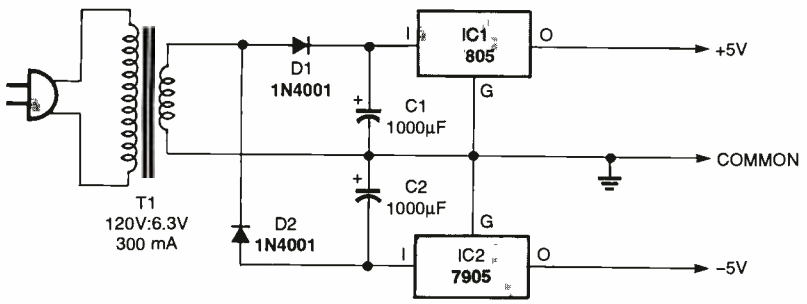


Fig. 3. The MAX038 requires an accurately regulated split power supply.

737-7600, extension 3468. The full designation of the chip in a dual-inline (DIP) package is MAX038CPP. Maxim also sells an evaluation kit with a ready-made circuit board for high-frequency operation; if I wanted to get the most out of the MAX038, I'd probably start with that.

Special thanks go out to Norman Diefenderfer, who also spotted the missing ground connection in the March diagram.

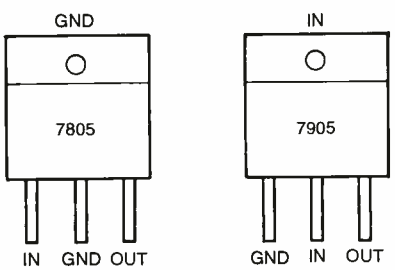


Fig. 4. Note the different pinout arrangements between the 7805 and 7905 regulators. Since one tab is at ground and the other at a negative voltage, don't connect them together. If you use a common heatsink, use mica insulators to isolate the tabs.

Farewell, LM3909 LED Flasher

Q *The LM3909 LED flasher chip has become rare and expensive. Please suggest a circuit that will flash an LED using one or two 1.5-volt cells, have very low current consumption, and offer an adjustable flash rate if possible. I've experimented with a CMOS 555 but battery life has been disappointing. Thanks!—S. H., Montesano, WA*

A The National Semiconductor LM3909 makes a red LED flash about once per second, using only a single 1.5-volt cell for power, and drawing less than 0.4 mA (see Fig. 5). That means that you can power a flashing LED for months or years from a single C cell or the like. This is a particularly neat trick because a red LED requires 1.8 volts. While it doesn't answer your precise question, look in this issue at the "Basic Circuitry" column. There are several LED circuits shown there.

Unfortunately, the LM3909 was discontinued in September 1998. At the time this was written (April), a few units are still available from Jameco Electronics (1355 Shoreway Road, Belmont, CA 94002; 650-592-8097; *www.jameco.com*) for $4.95 each, but they probably won't last long.

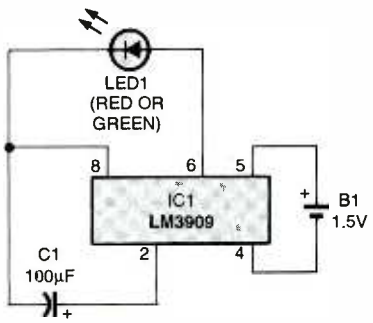


Fig. 5. The LM3909 IC, now discontinued, flashes an LED from a single 1.5-volt cell, drawing only 0.4 mA. A nice trick, considering that the LED requires 1.8 to 2.1 volts to operate!

The LM3909 works its magic by alternately charging a capacitor and then grounding its positive terminal, so that the negative terminal briefly goes below ground voltage, as shown in Fig. 6. That's how it delivers about 2.5 volts to the LED from a 1.5-volt supply.

The low current consumption of the LM3909 is the result of the short duration of the pulses it generates. On each cycle, the LED is on for about 1/1000 second, then off for a full second. Thus, its average current is only 1/1000 of its peak current. Because the pulses are so short and the voltage is relatively low, the LED does not require a series resistor.

Figure 7 shows how to use a CMOS 555 timer chip to get the same effect,

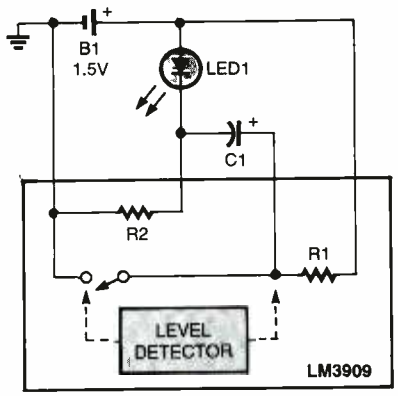


Fig. 6. How the LM3909 worked its magic: When the capacitor charges to 1 volt, its positive terminal is suddenly grounded, bringing its negative terminal to –1 volt. Voltage across the LED is then 2.5 volts, even though you use a 1.5-volt battery as a source.

except that you need a 3-volt source (2.7V from a lithium cell will do). The pulses are very short because R2 is so much smaller than R1, and, as in Fig. 5, the LED does not require a series resistor. Be sure to use a CMOS timer (TLC555, LMC555, or 7555), not the conventional NE555. The flashing rate is set by R1 and C1, which you can vary over a wide range. Figure 8 shows another low-current flasher circuit you can try. This is a relaxation oscillator using two transistors, one NPN and the other PNP, in a latching configuration.

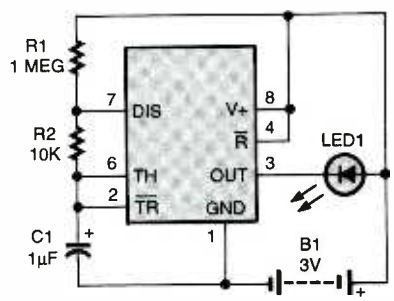


Fig. 7. This CMOS 555 flasher circuit consumes only 0.2 mA but requires 3 volts. No series resistor is needed because the pulses are very short.

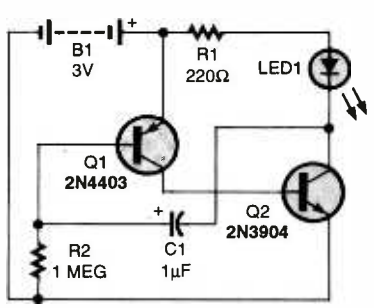


Fig. 8. Here's another low-current LED flasher circuit.

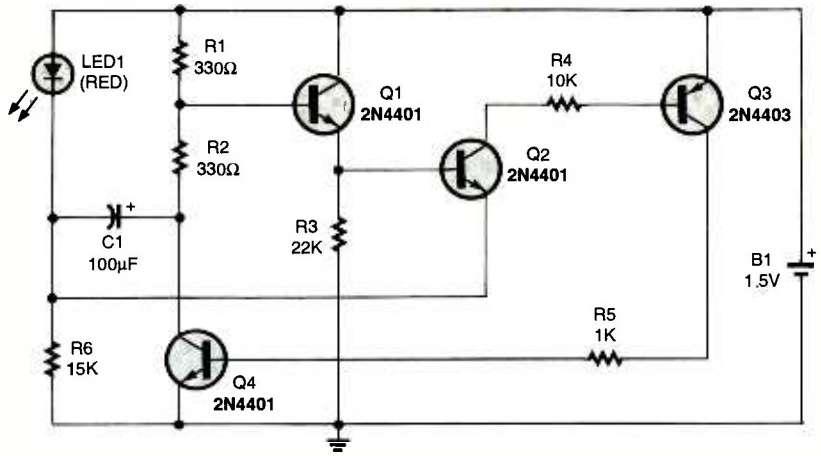


Fig. 9. For the truly determined, here is a discrete-component substitute for the LM3909 LED flasher.

Again, the pulses are very short.

Finally, if you need complete authenticity, the circuit in Fig. 9 actually simulates an LM3909. It is based on the circuitry inside the LM3909 with a few simplifications. Using this circuit commercially might violate National Semiconductor's patent, but you can certainly use it experimentally or as a source of ideas.

Finally, I'd like to challenge our readers. The circuit in Fig. 9 is probably not the simplest one that does the job. Can you simplify it further? Or can you make something similar out of, say, an LM10 low-voltage op-amp? I'd like to hear from anyone who comes up with a better design.

Why Doesn't It Work

Q *I'm having problems with the "Electronic Fuse" in* ***Radio-Electronics****, December 1991, pp. 63—68. I could not get it to work. I've built it two times and made some corrections but am still unable to get it to work. Can you help me with the circuit or recommend a better one?—C. B., Louisville, KY*

A The "Electronic Fuse" is an adjustable unit with a relay that will drop out when excessive current is drawn. You use it in place of a fuse in the AC line supply of equipment you're working on, and you can adjust it to any value from 1/10 amp to 10 amps. For those who are wondering, **Radio-Electronics** was the name of our magazine before the last two name changes.

The article was published before I came on board, so I don't know if any problems were noted with it at the time. Looking at the circuit, I don't see any obvious flaws. It does contain a toroidal transformer, which is probably fairly critical, and of course, it works only on AC. Since you haven't indicated the exact problems you had or the corrections you made, I can't go any further. Since the author's address is given in the article (on page 64), you may want to contact him.

Before you do that, though, follow our general "Why-doesn't-it-work?" troubleshooting strategy. First, *understand the circuit.* If possible, look at the circuit and figure out how it works, rather than just building it blindly.

Second, if possible, *get help locally.* Get another hobbyist to look at what you've built and help you check that it's wired correctly. It's possible that you've overlooked or misunderstood something in the schematic. A simple solder splash on a PC board can remain amazingly invisible for hours on end if you keep looking at the same object. A fresh set of eyes can sometimes spot an obvious and simple error to which you've become accustomed. You can often locate other electronics enthusiasts through a ham-radio club.

Third, *check the wiring.* Maybe something's connected wrong, or maybe there's a bad solder joint. Sometimes you can't tell by just looking.

Fourth, *check the parts,* especially failure-prone components such as ICs and transistors. Take nothing for granted; I have bought surplus NPN transistors that turned out to be PNP!

Fifth and last, *trace the signal.* If the whole circuit doesn't work, find the part that *does* work, and work backward from there.

The "electronic fuse," for instance, is basically an amplifier that takes a small AC signal (from a current transformer) and uses it to pull in a relay. A good strategy would be to remove the transformer and feed an audio-frequency signal (perhaps 1 volt at 60 Hz) from a signal generator into the input of the op-amp. If you can get the relay to pull in, the rest of the circuit is probably OK, and the problem is with the transformer. Otherwise, move toward the relay, stage by stage, until you can get a response; then you can figure out where the signal is being lost.

Optical Illusion?

Q *While trying out a high-brightness LED in a dark room, I was surprised to see a ball of sparkles seemingly hanging in the air around the light source. I thought it was my eyes, but my wife sees them too. The sparkles do not move. What causes them?—F. K., Gold Beach, OR*

A It *is* your eyes—and your wife's eyes, too. To prove it, tilt your head while viewing the phenomenon. The sparkles will tilt with it.

Port Access in Visual BASIC

Q *Some time ago I wrote a QuickBasic program to gather measurement data through parallel port LPT2. I'm trying to convert the program to Visual Basic to run under Windows, but parallel I/O is a major problem. What do I use in place of the INP function and OUT statement of QuickBasic?—R. L., Overland Park, KS*

A In Microsoft BASIC on the original IBM PC, the INP function and OUT statement gave you direct access to port addresses. That is, you could put a port number on the CPU's address bus and read or write data to whatever device happened to respond to the address, if any. This made it easy to do low-level manipulation of parallel and serial ports, and even to build your own ISA cards with their own port addresses (see this column, May 1997, for an example).

All this was possible because DOS was a minimal operating system; basically, all DOS did was load your program into memory, start it running, and get out of the way. As a result, low-level control of the hardware was very easy. Besides, your program is the only one running on the system; it has the hardware all to itself and doesn't have to share with other applications.

Not so with Windows 95 and higher.

HOW TO GET INFORMATION ABOUT ELECTRONICS

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 http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://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.repairfaq.org*

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

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

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

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: 631-293-3751.

Electronics Now 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; (http://www.arrl.org). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

Windows is a multitasking operating system in which several programs run at once and have to be protected from each other. Because of this, all hardware access is supposed to go through device drivers (special operating-system extensions). In reality, for compatibility reasons, Windows 95 and 98 still allow direct port access, but Windows NT and 2000 do not. Programming languages designed for Windows NT and 2000 therefore do not provide for direct port access.

Fortunately, you can get the device drivers you need from Lakeview Research (*www.lvr.com*). That site is run by Jan Axelson, whose books on parallel-, serial-, and USB-port interfacing come in very handy when you're trying to make a PC communicate with test equipment or circuits of your own design.

Thermistors

Q *I recently inherited a bag of components that I'm told are "thermistors." They are little black blobs about 1 to 2-mm across, with two leads. Can you explain how I can test and use them? I'd like to build a device to keep my bread yeast at a good temperature for growing; do you think it's possible?—O.L., Orleans, Ontario, Canada*

A A thermistor is a resistor whose resistance varies with temperature. Most thermistors are NTC (negative temperature coefficient), which means the resistance falls as the temperature rises.

To test them, simply use an ohmmeter to measure the resistance at various temperatures. One of the most common types has a resistance of about 20,000 ohms at room temperature.

A thermistor can indeed serve as the basis of a temperature-control circuit. You'll need to arrange a switching transistor and relay to turn on the heating element when the temperature falls below a certain value.

S-Video to Composite Video

Q *I'm trying to help a friend hook up a computer DVD player with an S-video output to his television set, which has only an RCA connector for composite video. How can I obtain or build a converter?—T. C., Austin, TX*

A "S-video" is video with the color (chrominance) and brightness (luminance) signals on separate wires in the cable; composite video has the two mixed together.

As you noted in subsequent correspondence, an adapter cable is available from VideoWare Inc., 711 E. Main St., Riverton, WY 82501; 307-852-2049; *www.teachcam.com*.

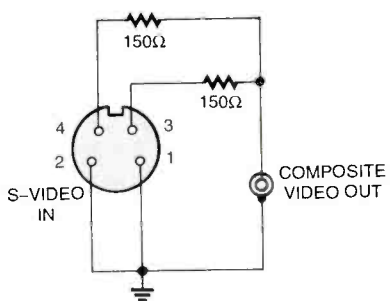


Fig. 10. To convert S-video to composite video, try mixing chrominance (pin 4) and luminance (pin 3) with a pair of 150-ohm resistors.

Although I haven't tried it, it will probably be easy enough to build your own, since all you have to do is mix the two signals. Try the circuit in Fig. 10, and experiment with resistor values until you get good results.

(Continued on page 69)

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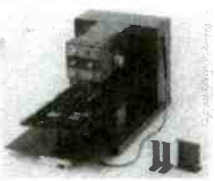

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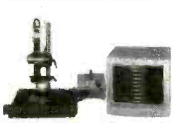

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IMPORTANT WARNING NOTICE

Before we start, there is some important information that must be brought to your attention.

If you decide to build and operate this device, you must place it inside a screen room or Faraday cage to prevent the electromagnetic interference it will produce from disturbing your neighbors.

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

*Tesla coils produce large amounts of electromagnetic energy. **IT CAN WIPE OUT COMPUTER SYSTEMS AND CAUSE DESTRUCTIVE INTERFERENCE TO COMMUNICATIONS AND OTHER SENSITIVE ELECTRICAL AND ELECTRONICS EQUIPMENT.** The system must be operated within a shielded enclosure such as a Faraday cage. All leads going into and out of this enclosure must be properly filtered to attenuate any electromagnetic interference from occurring on the line.*

The Tesla Coil described in this article is a dangerous electrical device for the following reasons:

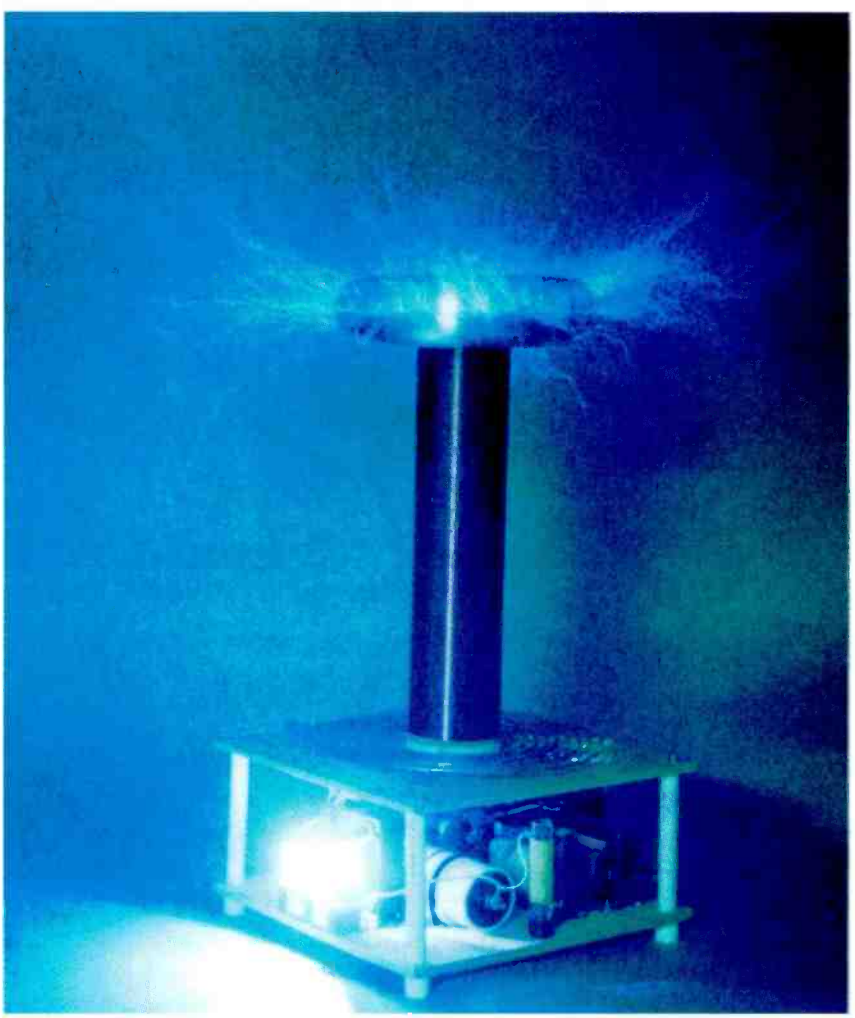
- *The T1–T4 transformer array produces lethal currents.* ***HUMAN CONTACT WITH THESE POINTS WITH THE SYSTEM CONNECTED TO A POWER SOURCE CAN RESULT IN ELECTROCUTION OR SERIOUS BURNS.*** *Never stand on a conductive surface, such as cement, wet ground, etc. when operating this equipment.*
- *Omitting line-bypass capacitors C1 and C2 can create a fire hazard within your house wiring.*
- *Never operate this device in a flammable atmosphere; the sparks can cause ignition. Low overhead wood structures are also prone to be fire hazards.*
- *Always provide adequate ventilation for the large amounts of ozone produced.*
- *It is often a merit of Tesla coil operation to make physical contact with the secondary spark discharge for demonstration purposes. Only a qualified person should do this, and only after verifying proper operation.* ***THE SECONDARY RETURN OF THE OUTPUT COIL MUST BE DIRECTLY GROUNDED TO EARTH.***
- *Never leave the system unattended where children or any other unqualified person might be able to power it up.*
- *The coil should never be energized for longer than 10 to 20 seconds at a time.*
- *This Tesla coil can produce a spark discharge up to 30 inches long. Position the main power switch at some remote point, as sparks may jump to the operator if he/she is standing close to the output coil. Insulate all metal controls as contact can cause irritating burns to the fingers.*
- ***DO NOT USE NEAR PACEMAKERS OR OTHER SIMILAR DEVICES. ALWAYS WARN SPECTATORS AS TO THE DANGER OF BEING NEAR THIS DEVICE IF THEY ARE WEARING OR USING SENSITIVE EQUIPMENT.***
- ***DO NOT OPERATE NEAR COMPUTERS OR ON THE SAME POWER LINES.***

These warnings are serious. It is vital for your health and well being, as well as to those around you, that they are followed.

Tesla coils have been around for a long time. This magazine's predecessors have from time to time published articles about other versions of this device. All of these articles are based on the principles developed some 100 years ago by Nikola Tesla when he conducted his famous experiments with the wireless transmission of energy from a mountaintop research laboratory in Colorado Springs, CO during the late 1890s. Almost all Tesla coils built today use line-operated step-up transformers to generate the high voltages required for the Tesla coil's primary circuit. Our *Tesla Coil* follows that same technique; the difference is in the huge high-voltage output it produces.

How It Works. Tesla coils, when reduced to their basics, are simply high-frequency step-up transformers designed to operate at a resonant frequency. The easiest way to understand how the Tesla Coil works is to jump right in and study the schematic diagram. Follow along with the schematic shown in Fig. 1 during the following discussion.

Transformers T1 through T4 form a bank of step-up transformers connected in a series-parallel arrangement. They take 117-volt AC household current and boost it up to 8000 volts at 60 mA. Connecting the secondaries to a common neutral point



This 14-second time exposure, while graphically showing the Tesla Coil's ability to generate high-voltage streamers, does not do justice to actually watching the bluish-purple discharges emanating from the terminal atop the secondary coil. Note the intense bright light coming from the spark-gap assembly. When running your Tesla Coil, don't stare at that light without adequate UV eye protection.

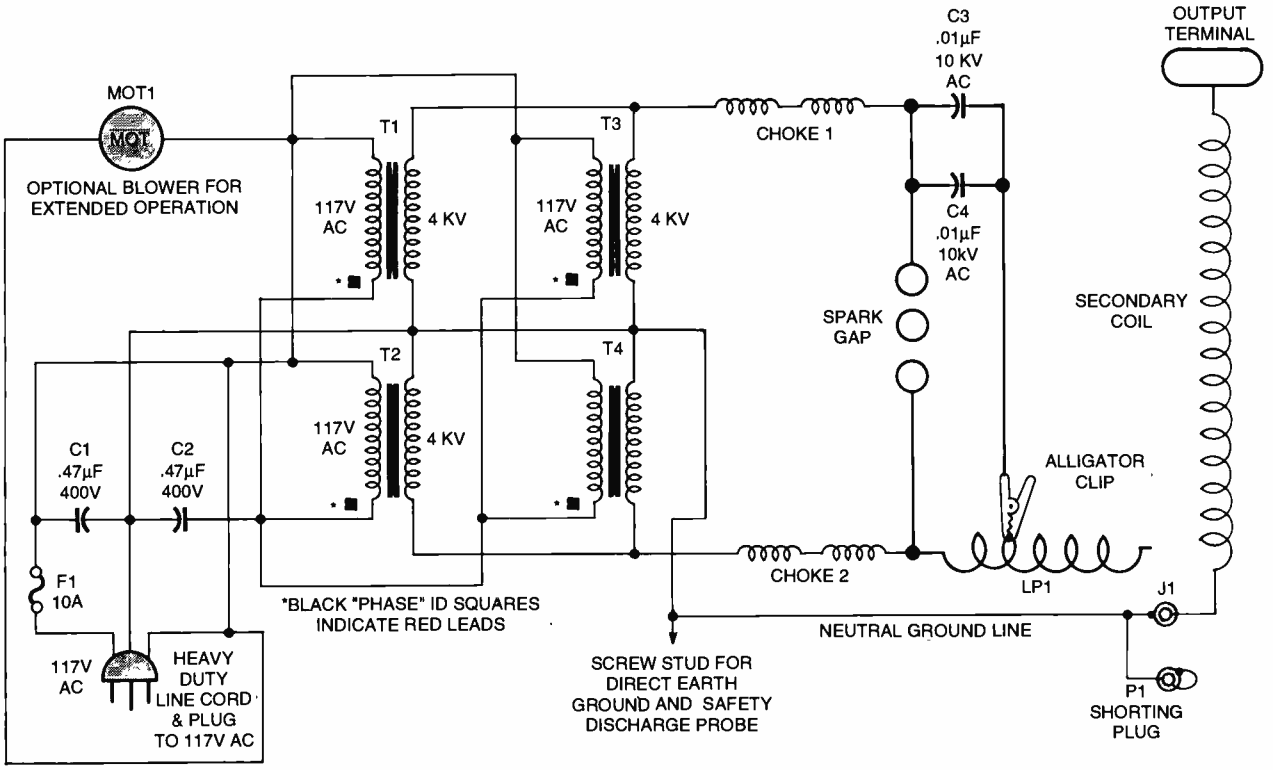


Fig. 1. Full schematic of high-voltage Tesla Coil. Note that C3 and C4 are connected in parallel and can be replaced with one capacitor with a value of 0.02 µF.

creates a midpoint ground. That way, 4000-volt transformers can be used; the outputs are wired in series.

It is important to take a careful look at the phasing dots shown adjacent to the transformer windings. These *must* be followed in both the primary and secondary circuits. While it is easy to do series and parallel connections in a DC circuit, AC circuits require you to think about the *phase* as well as the polarity. Caution: *The primary wiring must be isolated from the secondary.* The secondary coil is connected directly to the ground plate bracket.

Fuse F1 carries a 10-amp rating to protect against any catastrophic damage caused by any faults during operation. If this fuse fails, be sure that you determined the cause before replacing it and operating the Tesla Coil again. The heavy-duty 3-wire line cord has its neutral lead connected to a ground plate that is also used as a connection point for all grounds in the system. It, in turn, must be connected to a dedicated, solid earth ground.

Note that capacitors C1 and C2 are connected across the AC lines to the ground plate. These bypass capacitors prevent any "kickback"

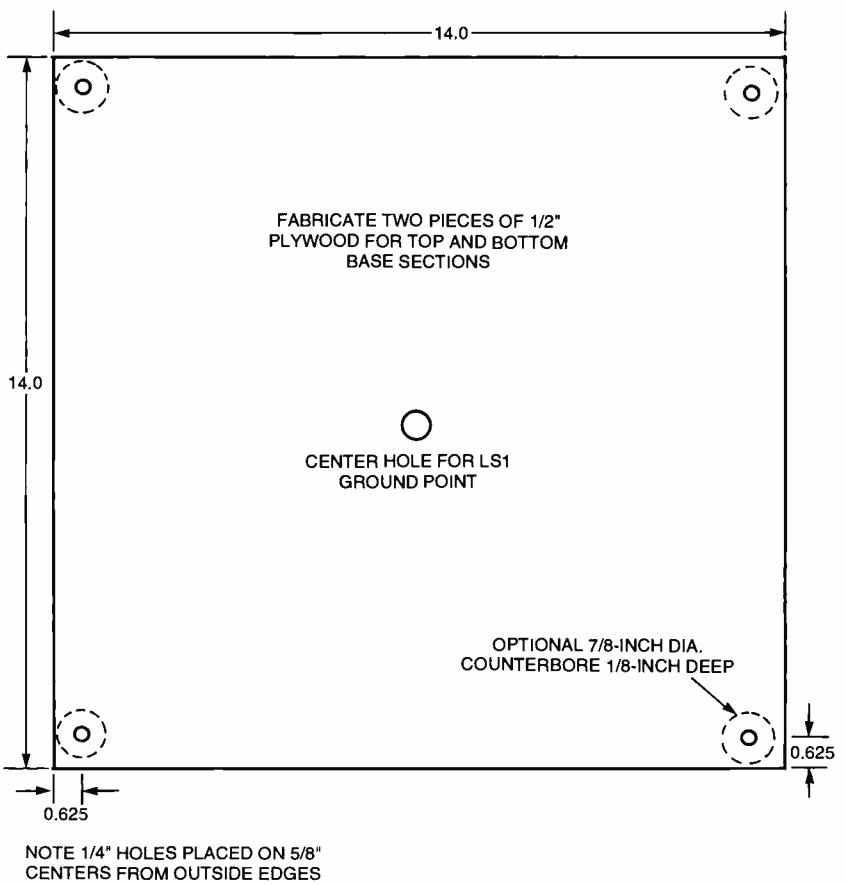


Fig. 2. The top and base sections are made out of plywood following this pattern.

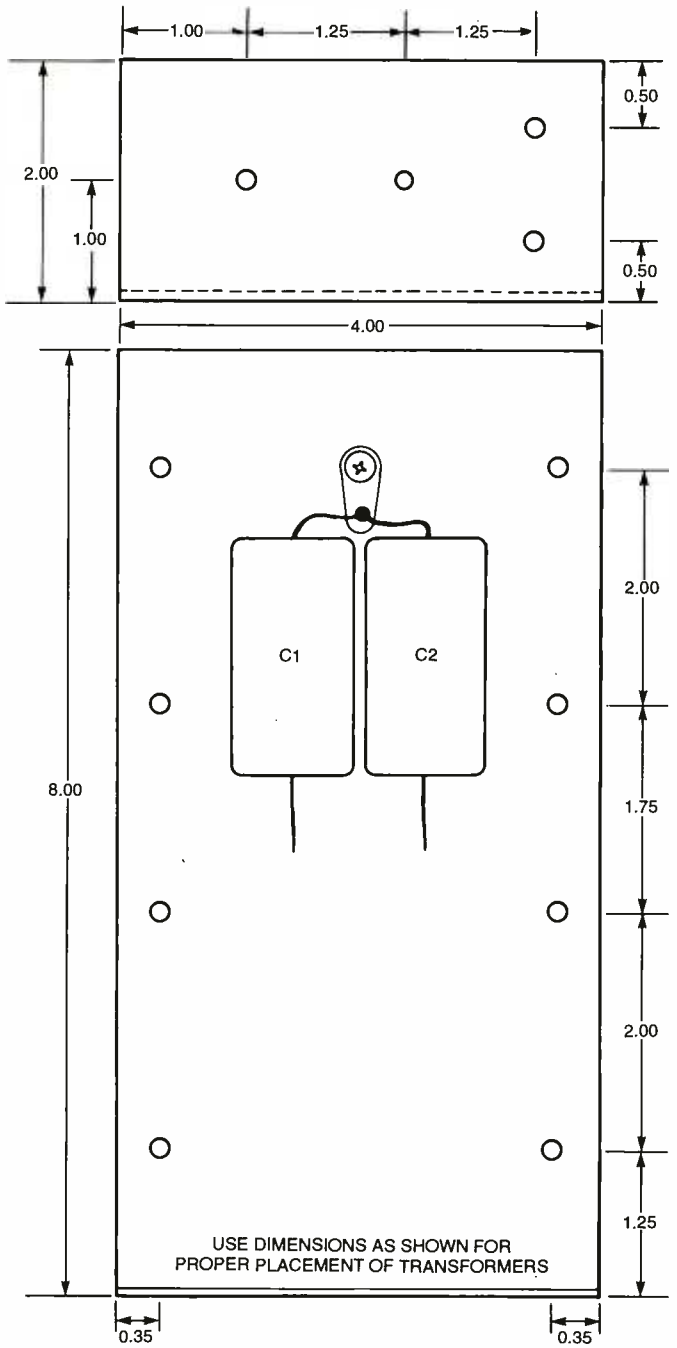


Fig. 3. The ground plate is made from a single piece of aluminum.

PARTS LIST FOR THE TESLA COIL

C1, C2—0.47-µF, 400-WVDC capacitor
C3, C4—0.1-µF, 10-kVAC polypropylene high-current pulse capacitors in parallel (or single 0.02-µF unit)
Choke1, Choke2—see text
F1—10-amp fuse
J1, P1—RCA-style connector, panel-mount
LP1—Primary coil (see text)
MOT1—4 1/2-inch 117-VAC high-output muffin fan (optional—see text)
T1–T4—4000 volts, 30 mA, current-limited, open-core coil transformer
Heavy-duty 3-wire line cord with plug, line-cord strain relief, alligator clip, 3/16-inch OD copper tubing, 12 × 3-inch toroid terminal (or optional stove-pipe bellows—see text), tool-steel or tungsten electrodes, 1/2-inch plywood, PVC pipe, sheet aluminum, wire, hardware, etc.

Note: The following items are available from Information Unlimited, P.O. Box 716, Amherst, NH 03031; 603-673-6493; *info1@stdtl.com*; *www.amazing1.com*: Plans (BTC4), $20; Full kit of all parts with plans (BTC4K), $899.95; Assembled and tested unit (BTC40), $1199.95; Video of setup and operation (BTC4VID), $25. Please add $5 for shipping and handling. NH residents must add appropriate sales tax.

pulses from entering your house wiring to minimize (*not eliminate*) any possible damage to sensitive electronic equipment. The output of the Tesla Coil can cause annoying burns and shocks from contact with metal controls, etc. Operation can be easily controlled by simply inserting and removing the power plug or by adding a control switch, disconnect box, or other control device.

The 8000-volt output charges "tank" capacitors C3 and C4. They are connected in parallel and must have at least a 10,000-volt rating. When the voltage across the capacitors is high enough, they discharge across the spark gap. The spark gap is adjusted so that the discharges occur on each voltage "peak" of the AC-cycle waveform. The discharge "steps" a pulse of current into primary coil LP1. Due to its nature, the spark gap generates many frequencies that set up a resonant voltage in LP1; LP1's inductance and the combined capacitance of C3 and C4 set the resonant frequency of LP1. That resonant energy is coupled into the secondary coil, which is also tuned to the resonant frequency of the primary circuit.

The secondary coil's energy "rings down" with an exponentially decaying waveform. The high-voltage output produced in the secondary is a function of the ratio of the primary and secondary "Q" factors. It is important to point out that, unlike a standard transformer, the voltage is *not* dependent on turns ratios! The spark gap switch must "turn off" to allow the secondary "ring-down" energy to couple back into the primary circuit. The spark gap uses multiple gaps to enhance positive turn off and to prevent ionization from excessive heating. You can use brass or tool steel for the limited-use spark-gap

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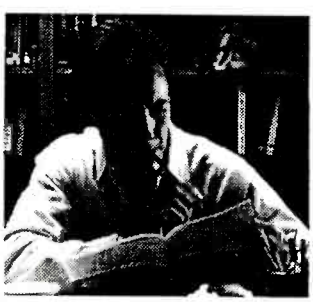

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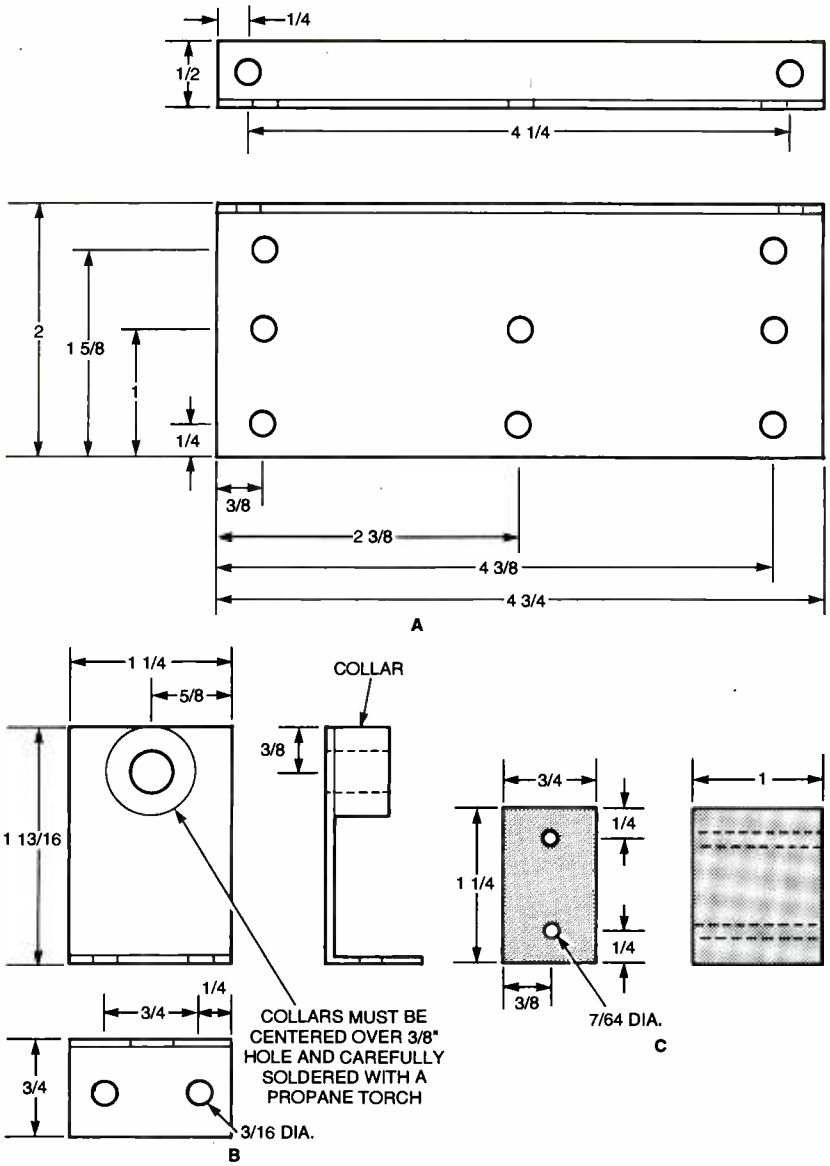


Fig. 4. The spark gap consists of a base bracket (A), a set of three electrode brackets (B), and PVC spacers (C).

electrodes, but for any prolonged operation, tungsten electrodes are necessary.

Major Components. Let's take a closer look at the major components of the Tesla Coil and how they work.

The Secondary Coil: This is where the high voltage is produced. The coil form must be an excellent insulator and have a low dissipation factor to high-frequency currents. Preferably, it should be made from a material that would not readily "carbon track" in case of spark break over, etc. Wiring turns must be even and properly spaced. Turn crossovers or overlaps will always cause serious performance problems and cannot be permitted. If you create a crossover while winding this coil, you must do it all over again.

To calculate the series-resonant frequency of the secondary, consider it as a quarter-wave section of length equal to the actual physical length of the wire used. Although this is an approximation, it's close enough for our needs. A reduction in this figure can be fudged because of extra capacitance resulting from ionization at the top of the coil when it discharges.

The Output Terminal: This is a 12-inch toroidal (donut-shaped) terminal. These are expensive and hard to find. You can use stovepipe elbows as a substitute since sharp corners are not as degrading as they would be if used on a Van de Graaff generator. The terminal has two purposes. First, it electrostatically shields the top winding of the secondary coil from arcing into open air. That situation burns the coil, resulting in degraded performance. Second, adding electrical capacity to the top of a quarter-wave system enhances current flow through the coil. This property increases spark energy at the cost of fewer discharges per time unit.

Mathematically speaking, there is no limit to this capacitance with the exception of the resonant frequency decreasing to an unworkable value. Information Unlimited, the creator of this Tesla coil, is currently working on a computer program for determining that important property when used for voltage magnification and other non-magnetically coupled resonant systems.

The Primary Coil: Together with capacitors C3 and C4, this coil forms a series-resonant circuit equal in frequency to that of the secondary coil with its associated output terminal. A tap that allows a connection anywhere along its spiraling turns tunes the circuit. The windings are heavy, bare copper wire or copper tubing at least $^{3}/_{16}$ inch or thicker to accommodate the high flowing-tank currents.

Coupling: The secondary coil is coupled to primary coil LP1 and must be tuned to the same frequency for efficient operation. Coupling these circuits, however, must not be too tight, as "beat frequencies" can cause hot spots along the secondary coil. Coupling that is too loose, however, will not allow proper energy transfer between the two circuits. You may wish to experiment by changing the position of the secondary coil by placing it on wood blocks.

Spark-Gap Switch: This is where the energy stored in capacitors C3 and C4 is switched into primary inductor LP1. The spark-gap electrodes must allow for clean "makes" and "breaks." Adjustment is critical to allow C3 and C4 to charge sufficiently before breakdown, and therefore switching, occurs. Remember

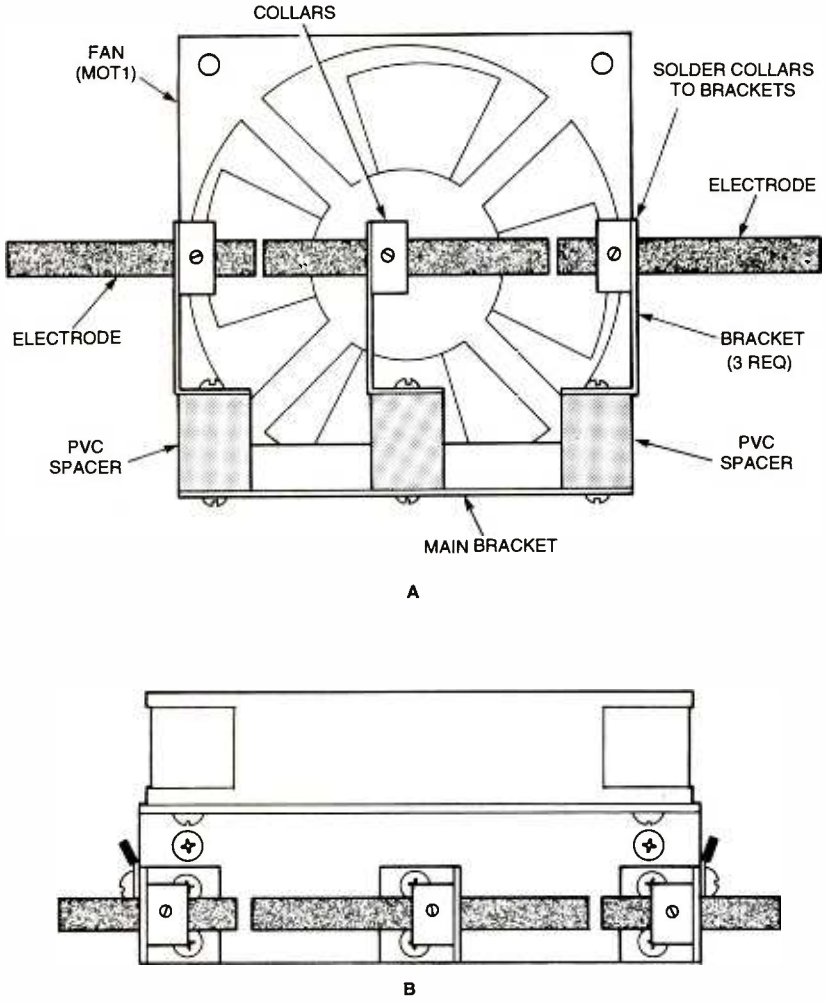


Fig. 5. You can use an optional fan (designated MOT1 in Fig. 1) to air-cool the spark gap for extended runs. The side view (A) and top view (B) are shown here.

Fig. 6. Two choke coils are needed. Here is a close up of how they are assembled. Note the unusual winding of the coil; see the text for details.

that system energy is a function of the square of the charging voltage across the primary capacitor. It is important that the gap shuts down cleanly before the secondary current reaches its maximum value. The energy in the secondary *must not* couple back into the primary; it will cause erratic spark gap operation, destructive voltage nodes, hot spots, etc. If you are going to operate the Tesla coil frequently, use tungsten for the spark-gap-switch electrodes. Additionally, an optional cooling fan (MOT1 in Fig. 1) will help dissipate heat buildup in the spark-gap assembly.

Primary Capacitor: This is where the energy is stored that is exchanged with the primary inductor. The exchange occurs at a rate equal to the resonant frequency. It must be capable of handling high currents and must have a low dissipation factor for efficient operation. ***A special capacitor must be used in this circuit; pay attention to its dissipation factor and REVERSE-CURRENT-HANDLING CAPABILITY.***

RF Choke: This part blocks the high resonant frequency and harmonic voltages and currents from feeding back into the transformers. Those currents can create destructive voltages that will most certainly cause premature failure of these expensive devices.

Putting The Tesla Coil Together. In contrast to the usual electronic project, the Tesla Coil has many mechanical parts to fabricate. If you don't have the facilities for cutting and bending sheet metal, a kit is available from the source given in the Parts List. Rare is the individual who would have in his "junk box" all of the parts necessary to build this Tesla Coil!

Of course, you can implement your own ideas during construction. However, if you do it differently, the performance of your coil may be degraded. The smart approach would be to build the unit *exactly* as shown. Once it's working, try your modifications one at a time. If one of your ideas doesn't work, it's easy to tell which it is with that approach.

Like the "Horatio Alger" stories, we're going to start at the bottom and work our way up. Make the base from a piece of ½-inch plywood cut to the dimensions shown in Fig. 2. Since a second piece of plywood cut to the same dimen-

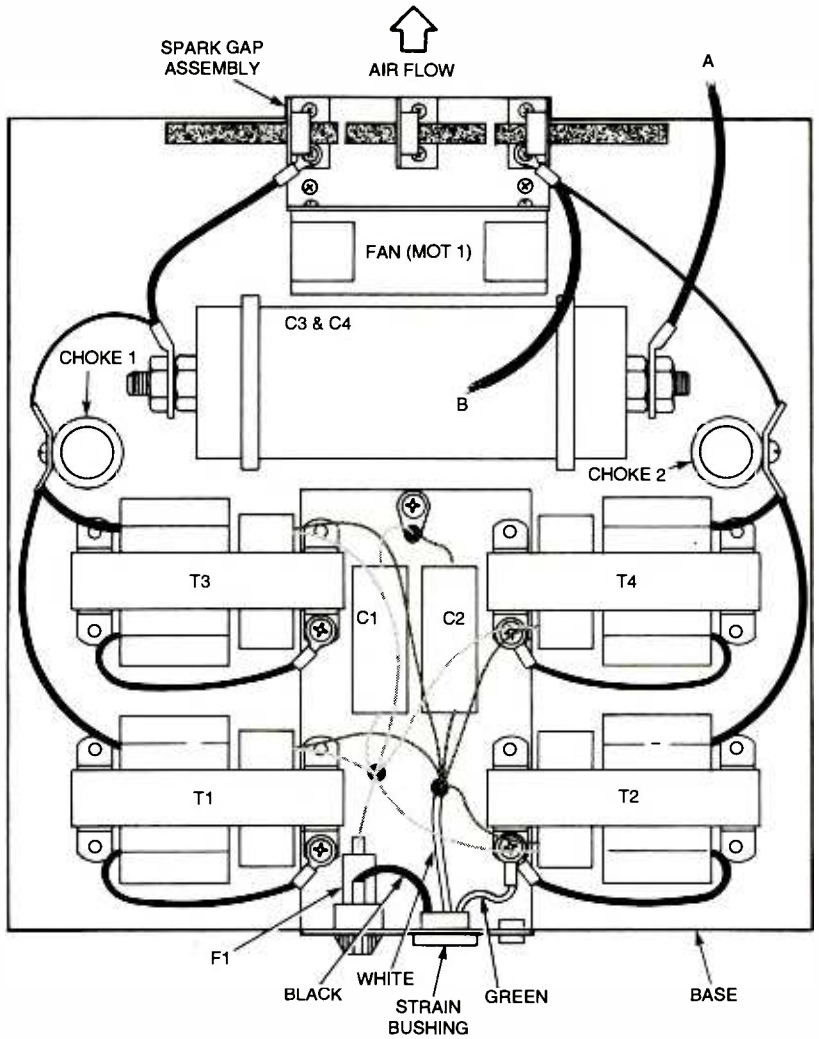


Fig. 7. The base layout shows how the transformers, capacitors, and spark-gap assembly are mounted. Also shown is the high-voltage wiring. Follow this layout precisely.

sions will hold the primary and secondary coils, go ahead and make that piece as well. When it comes time to mount both pieces of plywood together, we'll be using lengths of PCV pipe as spacers with a brass rod running through them. If you want, you can counterbore the holes at the corners so that the spacers "nest" solidly within the counterbore. Drill the counterbore first with a flat-blade wood drill; the pointed center of the drill will mark the location for drilling the actual hole. Only counterbore one side; those two sides will be facing each other in the final assembly.

The ground plate (Fig. 3) is a piece of 0.032-inch-thick aluminum. Bend one end to a right angle; the holes in that part are sized for the fuse holder, a strain relief for the power cord, J1, and P1. Note the position of the holes for mounting the transformers. Bolt a lug to the plate as shown in Fig. 3, and solder C1 and C2 to it. Secure C1 and C2 in place with silicone adhesive. Set the assembly aside while the glue sets.

The parts for the spark gap are shown in Fig. 4. The hole locations on these pieces must be accurate. The base bracket (Fig. 4A) can be made from a piece of aluminum. The collar and bracket in Fig. 4B should be made from brass; that will make it easier to solder the two parts together. The spacer in Fig. 4C is a solid piece of PVC plastic. Although the hole is shown as going all the way through, it might be better to drill shallow holes that don't meet. That way, additional insulating material will keep the screws that will go into the holes from accidentally touching each other.

The spark-gap assembly is shown in Fig. 5. Note that the screws used on the PVC spacer should not touch each other; that would defeat the purpose of the insulated spacers. Those screws should be as short as possible to prevent any arcing. Be sure to mount the fan so that its airflow *blows* across the spark gaps instead of drawing air across it and into the fan blades.

Both chokes are made in accordance with Fig. 6. There should be about 3 inches of free space between the solder lugs.

To wind the coil, solder a length of 26-gauge magnet wire to the upper solder lug. "Space wind" the wire for one inch. To space wind a coil, take a second piece of 26-gauge magnet wire and wind the two wires in parallel—similar to a bifilar winding. When the coil measures one inch long (there should be about two inches of remaining space to the lower solder lug), carefully remove the second wire. You should now have a coil that has a space equal to the wire diameter between each turn. Shellac this coil to fix it in place.

When the shellac is dry, continue winding the coil for the remaining two inches of space with tightly packed turns. Solder the end of the wire to the lower solder lug and shellac these additional windings.

Temporarily put the plastic end cap in place. Using a piece of foam packing material as a spacer, insert the ferrite core as shown and secure it with silicone adhesive. Set both chokes aside while the glue dries.

The Lower Assembly. Now that we have all of the assemblies needed for the base plate, it's time to start putting things together. The arrangement of components and their wiring is shown in Fig. 7.

Install the fuse holder, J1, P1, and a suitable three-conductor power cord into the appropriate holes that you drilled in the Fig. 3 ground plate. Note how the ground screw fits in the hole drilled in the center of the plywood base. Secure the plate with screws that also hold the transformers. Although Fig. 7 only shows one screw per transformer, use screws on all mounting holes.

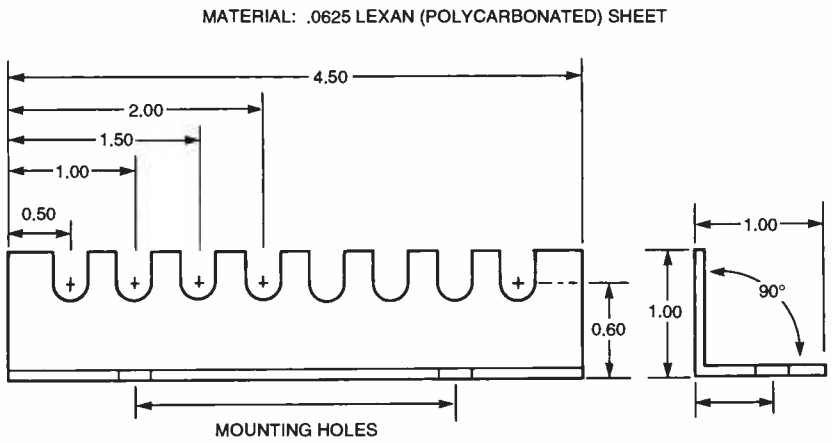


Fig. 8. These Lexan brackets support the primary coil.

Be sure to use a mounting lug from the transformer wires shown to the ground-plate screw that's drawn. It's important to connect the transformers that way to provide a positive earth ground for the transformer frames.

Choke1 and Choke2 are installed above the transformers. Remove the plastic caps from the chokes and attach them to the base plate with a brass screw. Install the choke assembly into the end cap; Fig. 6 shows the details.

Capacitors C3 and C4 can be found as a single unit of the correct value. As we mentioned before, the important consideration is to have a 0.02-μF unit with a 10,000-WVDC rating. If you have two individual components, you can place them in a piece of PVC pipe, attach their leads to suitable threaded brass rod, and seal the unit with high-voltage potting compound. As you can tell from the foregoing description, finding a ready-made device is much less messy. In any event, mount the high-voltage capacitor as shown in Fig. 7.

The spark gap is mounted at the end of the base plate. Note the airflow direction.

Follow the wiring diagram carefully, double-checking it against the schematic diagram. The primaries of T1–T4 are wired using standard 117-volt wiring techniques. While the prototype used wire nuts to collect the various wires together, feel free to use terminal strips and solder the connections. Remember that those points are at line voltage and must support at least 5 amps.

For now, ignore the two wires labeled "A" and "B;" we'll get to them in a moment.

The Primary Winding. In preparation for making LP1, you need to fabricate four supports from polycarbonate sheet; the dimensions and particulars are shown in Fig. 8. Mount them to the other piece of plywood that we prepared using #6 brass wood screws (the use of brass is important for any hardware that's close to the primary or secondary coils); see Fig. 9. Use the side of the plywood that *doesn't* have the counterbores. Note that you'll need to drill two additional holes in the plywood for the wire leads to each end of the coil; they should be large enough to pass 12- or 14-gauge wire.

Strip the end of a 12-inch piece of insulated 12- or 14-gauge wire and insert it into one end of a length of $^3/_{16}$ copper tubing. Solder it in place using a heavy iron or propane torch. Thread the wire into the hole that's closest to the center of the plywood. That is what's considered the "start" of LP1.

Now the "fun" part begins. Carefully bend the copper pipe into a smooth spiral, placing it in each groove of the plastic support brackets. The end of the last (outer)

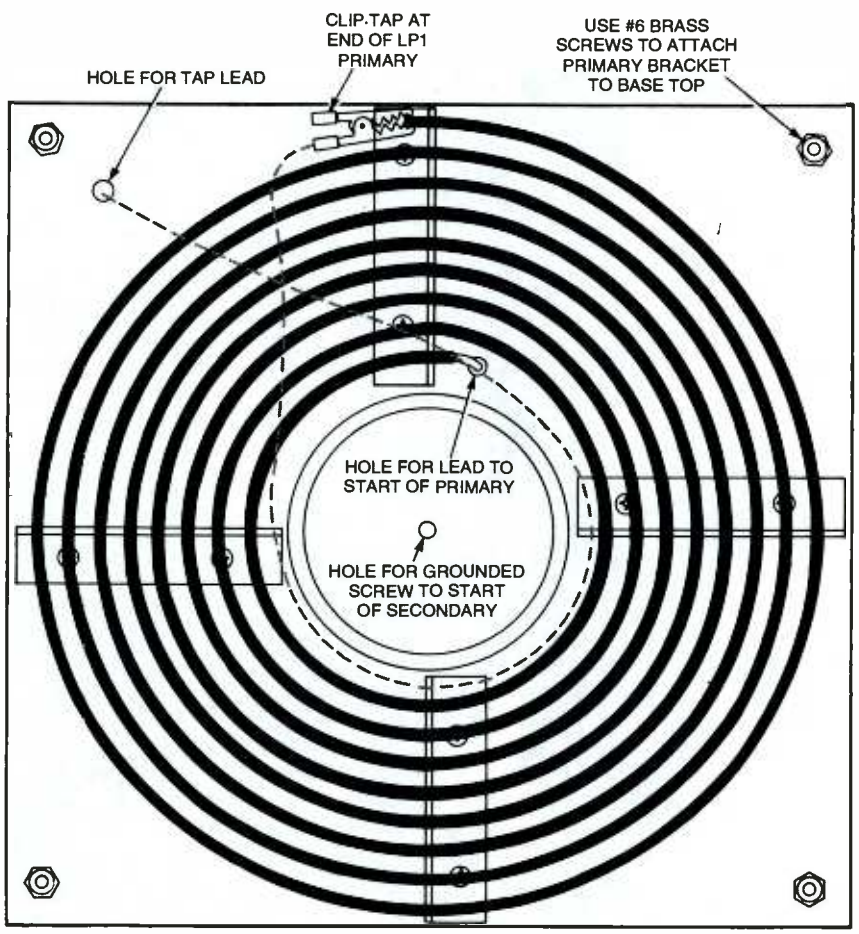


Fig. 9. Follow this pattern to make the primary coil. Remember, you are using copper tubing to wind this coil. Soft tubing from a home-improvement store or plumbing supply is easy to work with; its intended use is for supplying water to a refrigerator's automatic icemaker.

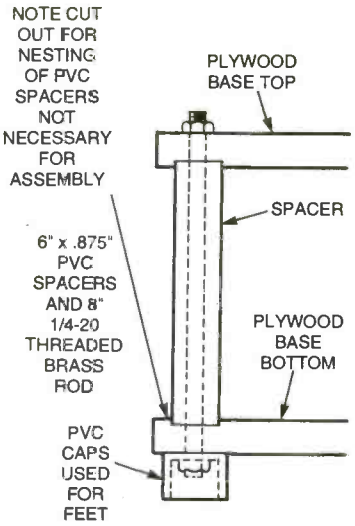


Fig. 10. When mounting the two plywood plates together, follow this arrangement. You can use pipe caps for feet.

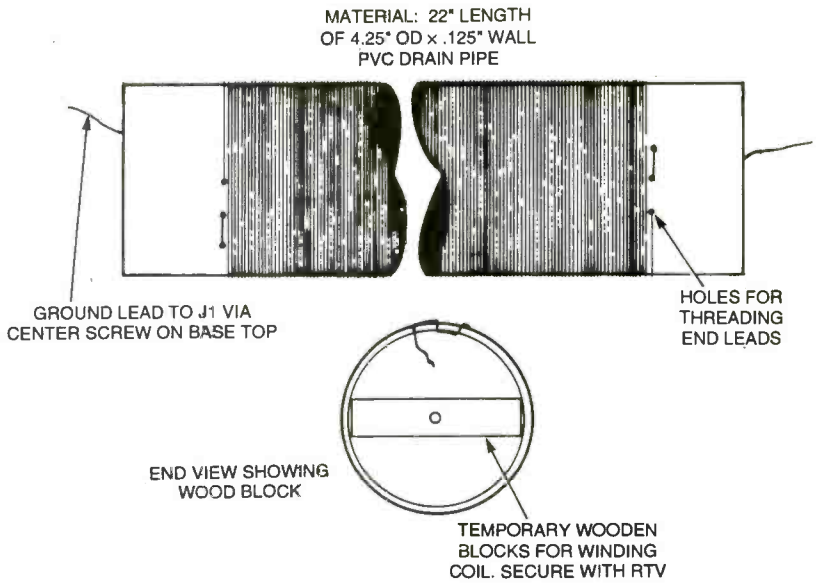
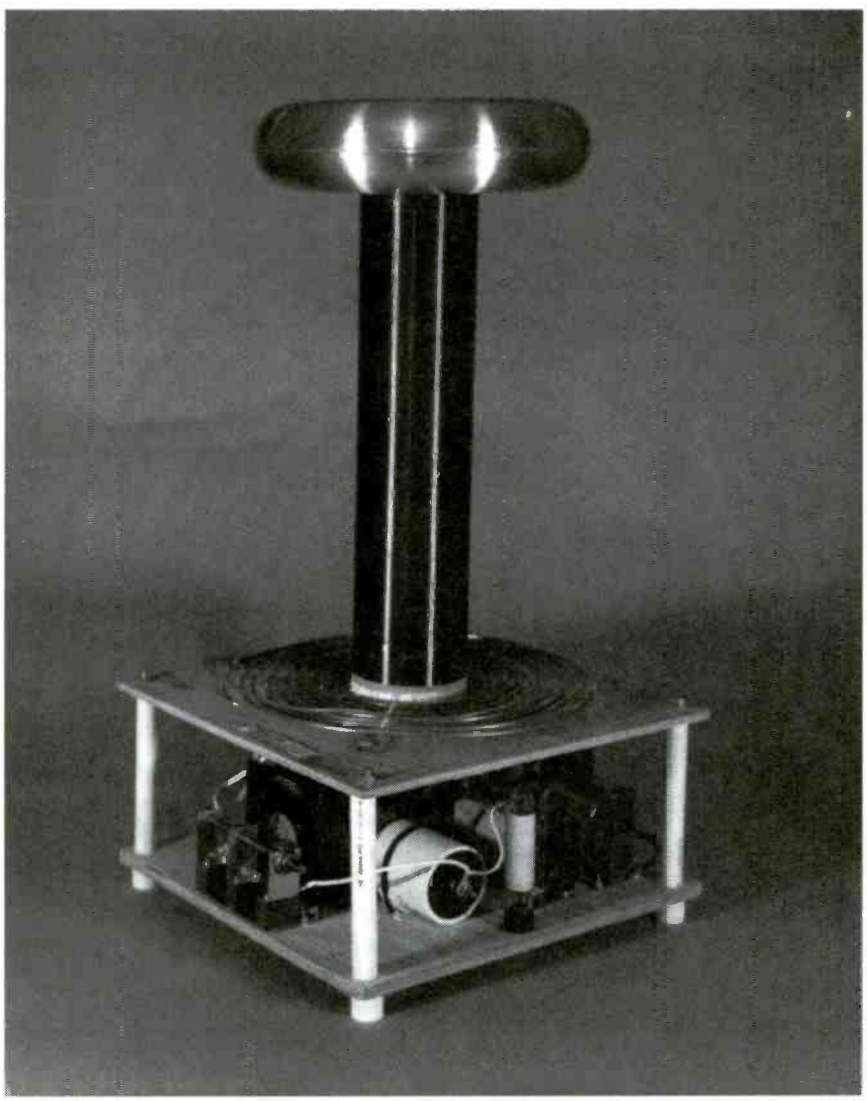


Fig. 11. Construction details for the secondary coil.



The completed Tesla Coil is ready to throw sparks, raise eyebrows, and make hair stand on end!

turn of copper tubing is positioned adjacent to the hole for the tap lead. Using some silicon adhesive, apply a dab at each slot in the brackets to hold the copper tubing in place. Allow 24 hours for the silicon rubber to set completely.

Cut a 3-foot piece of insulated 12- or 14-gauge wire for the coil tap lead and attach an alligator clip to one end. Attach the alligator clip to the end of the copper-tubing coil. Position the wire as shown in Fig. 9 and insert it into the hole in the upper corner of the plate.

Install a brass screw and nut in the center hole with the threads sticking up. A 12-inch length of 12- or 14-gauge wire is connected to the underside of the brass screw (by the screw head) with a lug. The other end of the wire gets a plug that mates with J1.

Using brass rods, nuts, and PVC plastic spacers, mount the upper plate with LP1 to the main assembly. The details of marrying the two assemblies together are given in Fig. 10. The wires dangling from LP1 are connected as follows: The 12-inch "start" lead connects to the spark gap as wire "B" in Fig. 7; wire "A" is the three-foot "end" lead with the alligator clip. Plug the wire from the central ground screw into J1.

The Secondary Coil. If you thought that creating the primary coil was "enjoyable," the secondary coil will be more so! The basic details are

shown in Fig. 11.

The coil form for the secondary needs to be an excellent insulator as well as a relatively lossless dielectric at the operating frequency. A ruby-mica coil form would be ideal if it existed. Thin wall PVC tubing, while not the best, is a good compromise between cost and performance. Unfortunately, PVC is hygroscopic (absorbs moisture). Small amounts of moisture will degrade the performance of the Tesla Coil. The following procedure will help drive out the moisture and seal the PVC form. Pick a dry day to do this.

Start by thoroughly cleaning the PVC pipe inside and out. Let it dry completely in a dehumidified area. Once it is dry, use a heat gun to drive out as much remaining moisture as possible. Apply several coats of orange shellac to seal the plastic surface. Wait until the shellac is completely dry before proceeding.

Cut two pieces of wood to fit across the inside of the pipe and drill a hole in their center. Secure them inside each end of the pipe with silicone adhesive. When the glue is dry, run a shaft through the blocks and secure one end in a bench vice. You should be able to spin the pipe on this "axle."

Drill a set of three holes at each end of the pipe as shown in Fig. 11. The holes should be about 1 inch from the ends of the pipe. In other words, the 22-inch pipe should have a 20-inch area between the holes and centered on the pipe.

Take some 26-gauge magnet wire and thread it through the three holes on one side of the pipe. You should have about 8–10 inches of wire on the inside of the pipe. Secure the wire in place with a piece of tape that has extremely "sticky" properties. If the wire comes loose during winding, you'll have to start all over again!

Start winding the wire about the pipe. Keep the windings tight, close, and free of kinks or crossovers. Don't forget to heed the warnings concerning the secondary coil in the "Major Components" section of this article.

Stop winding about every inch or so and shellac it in place.

When you reach the other set of holes, thread the wire through them in the same manner as the beginning of the coil. Again, leave about 8–10 inches of wire on the inside of the pipe. You should end up with about 1000 turns or so of wire.

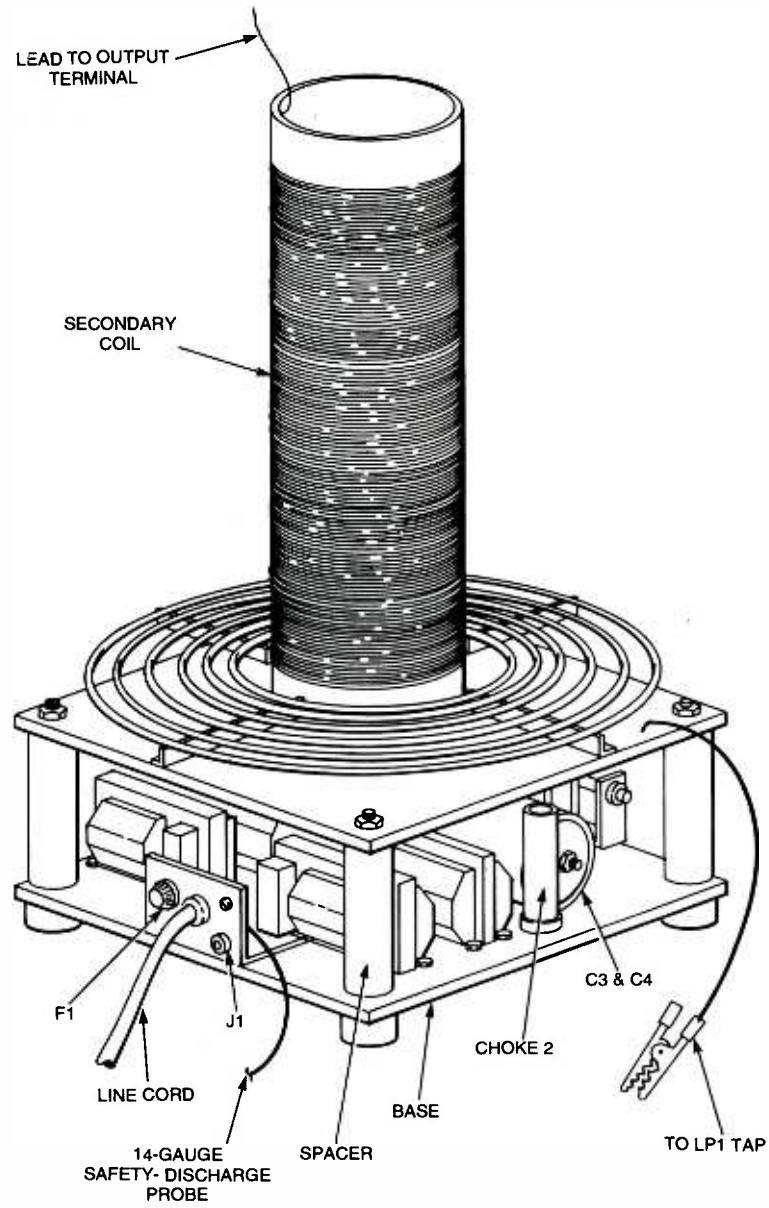


Fig. 12. Overall look at the mechanical assembly of the Tesla Coil.

Remove the wood blocks and install a bracket at each end that has a threaded hole in its center. The thread size should match the brass screw in the center of the upper plywood plate. Bend a set of "ears" on the bracket, and drill holes. Attach the brackets with brass screws and nuts; drill holes in the pipe for the screws. Scrape the insulation from the end of the magnet wire and connect it to one of the screw/nut pairs. The brackets will double as electrical contacts for the secondary coil.

Screw the completed secondary coil onto the brass screw in the upper plywood plate; your Tesla Coil should now look like Fig. 12.

Testing The Tesla Coil. If you live in a heavily populated area, close to an airport, or near computers and other sensitive electronics equipment, you must operate the Tesla Coil within a Faraday cage. It is best to test the system in an area that has wood floors. This will reduce the risk of dangerous ground currents resulting from accidental contact.

After you have verified correct wiring, proper clearance of high-voltage points, and proper ground

connections to the ground plate and from the ground plate to an earth ground, set the two spark gaps to about 1/16 inch. Connect the tap lead alligator clip to the outermost primary turn. Be sure to loop the tap-lead wire around the secondary coil. It is used as a full turn of the primary winding; you can add even more depending upon the position of the tap connection. This is important as the system will not properly tune without this added turn.

Connect a current meter to J1 or short this jack to ground. Next, attach a toroid or other similar terminal to the top of the secondary coil. You can use a metal 13- or 16-ounce coffee can. In a pinch, a metal bowl will suffice. Make sure that there is positive electrical contact. Use your own ingenuity in mechanically securing the terminal to the top of the coil. Place a grounded terminal approximately 8 inches from the toroid and secure it in place. This is your test contact.

Plug the unit into the AC power source briefly and see if there is a spark discharge to the test contact. A word of warning: The spark gap creates blinding amounts of ultraviolet light accompanied by a *very* loud sound. If there is no spark, recheck the entire system. If it is working, separate the test contact until you reach the distance where the spark becomes erratic. Don't forget to turn off the power after each test, and do not leave the power on for periods longer than 15 seconds at a time. With the power off, connect the tap to the next inner winding on primary coil LP1. Reapply power briefly. Keep repeating these steps until you find the tap on the primary that produces maximum output. Now you can slightly open the spark gaps and repeat the entire procedure until you find the maximum settings. Keep in mind that you can place the primary-coil tap at any point on the coil. For example, the prototype device pictured here has its tap about 40° from the end of LP1.

You may also experiment by using different values of coupling by raising the secondary coil on wood blocks and then readjusting all parameters. A round or square wood block that fits inside the secondary coil will position it and secure it in place. Remember, always use brass screws for fastening.

Closing Notes. Safety is the keynote. You are using a device that generates dangerous voltages and amperages. Make sure that the power is off when making adjustments. When the power is on, be sure to keep the time intervals short—15 seconds or less.

The optional current meter connected to J1 can be used as a fine-tuning indicator by adjusting for a maximum reading. However, initial operation where tuning may be way off can result in erroneous current peaks—especially if coupling is too tight.

The secondary coil in this system acts like a quarter-wave antenna with top-loading capacitance. This means that there is a current node at the base that can be measured in amps. If you rely on the green wire of the power cord for grounding, you force your electrical wiring to become a part of the system. This is not a good idea as a voltage gradient can result along the wiring run. ***Ground the coil to earth with the shortest lead possible!***

The two choke coils are designed to provide a relatively high impedance to the resonant operating frequency and any associated harmonics. It is necessary to choke off those high frequencies and to prevent them from reaching the power transformers. If not done, damage to the secondaries of the power transformers is inevitable.

The spark gap is connected across the transformer bank to limit voltage stress on their secondary windings. As we mentioned before, the spark gap releases large amounts of intense ultraviolet light. ***The spark-gap discharges should not be viewed directly. Observe these discharges only through a piece of clear plastic or protective eyegear.***

There you have it. Work carefully and you should have a great time with this project. If you come up with comments or an interesting photo or two, feel free to e-mail them to me in care of the magazine at *feedback@gernsback.com*. P

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CALL ALERT

RAYMOND C. BUCK, III

Stop annoying telephone solicitors and telemarketers from destroying the tranquillity of your home with their relentless sales pitches

One of the most annoying things about the telephone is calls from solicitors and telemarketers. Most people now have answering machines to help screen out such unwanted calls. However, if you leave your telephone plugged in to receive calls from family members, the ringing telephone can still disturb you. That is especially irritating if you are trying to get a little extra sleep on a Saturday morning. The *Call Alert* unit described here is one way to help solve the problem.

Call Alert connects to the telephone line ahead of your answering machine. Calls are received in the usual manner unless you wish to have privacy. In that case, you would turn the telephone ringer off. When the answering machine picks up the call, the caller can still alert you if the caller knows the security code to activate the Call Alert unit. Anyone not privy to the security code can leave a message.

Call Alert has the ability to store three different security codes, which can be changed at will. That allows you keep one code the same at all times so that it could be given to those whom you want to be able to reach you at anytime. The other two codes could be given to different people whenever the need arises, such as when you are expecting a delivery or a service call from the local appliance repairperson. Once you have received that particular call, you can change the security code.

The way it works is that once your answering machine has latched onto the telephone line, the caller enters the security code that you've given him or her. At that point, Call Alert sounds a 30-second tone. If the answering machine disconnects prior to the 30-second period (say, the caller hangs up), the alert tone shuts off. When you hear the alert tone, you'd pick up the telephone to speak to the caller (if you choose to do so). Pressing any Touchtone digit stops the alert tone. The answering machine would probably still be playing its outgoing message at this point. So you'd press "##" on your telephone, causing Call Alert to disconnect the answering machine from the line. That's a handy feature in case yours is not one of the newer answering machines with the disconnect feature built in. When you complete your call and hang up, everything returns to normal and you're ready to receive the next call.

You can install as many Call Alert units as necessary. It has no effect on the normal operation of your telephone line. In addition, it's also possible to program each unit with a different security code. For example, you might install one in the kid's bedroom with a code for their friends that does not match the code(s) programmed into the main unit. That way, your unit would not beep if the call isn't for you. The call can be answered from any telephone. It does not have to be answered from the Call Alert unit that's beeping. In fact, if all of the Call Alert units have the same security codes, they'll all beep when a correct code is entered.

A Look at the Circuit. The Call Alert is comprised of six integrated circuits, four transistors, five diodes, a bridge rectifier, and several support components. A complete schematic diagram of the circuit is shown in Fig. 1. The main functions of the Call Alert unit are controlled by IC5—a PIC 16C54 microcontroller. The microcontroller interprets the DTMF digits received from IC4 and compares them to the security

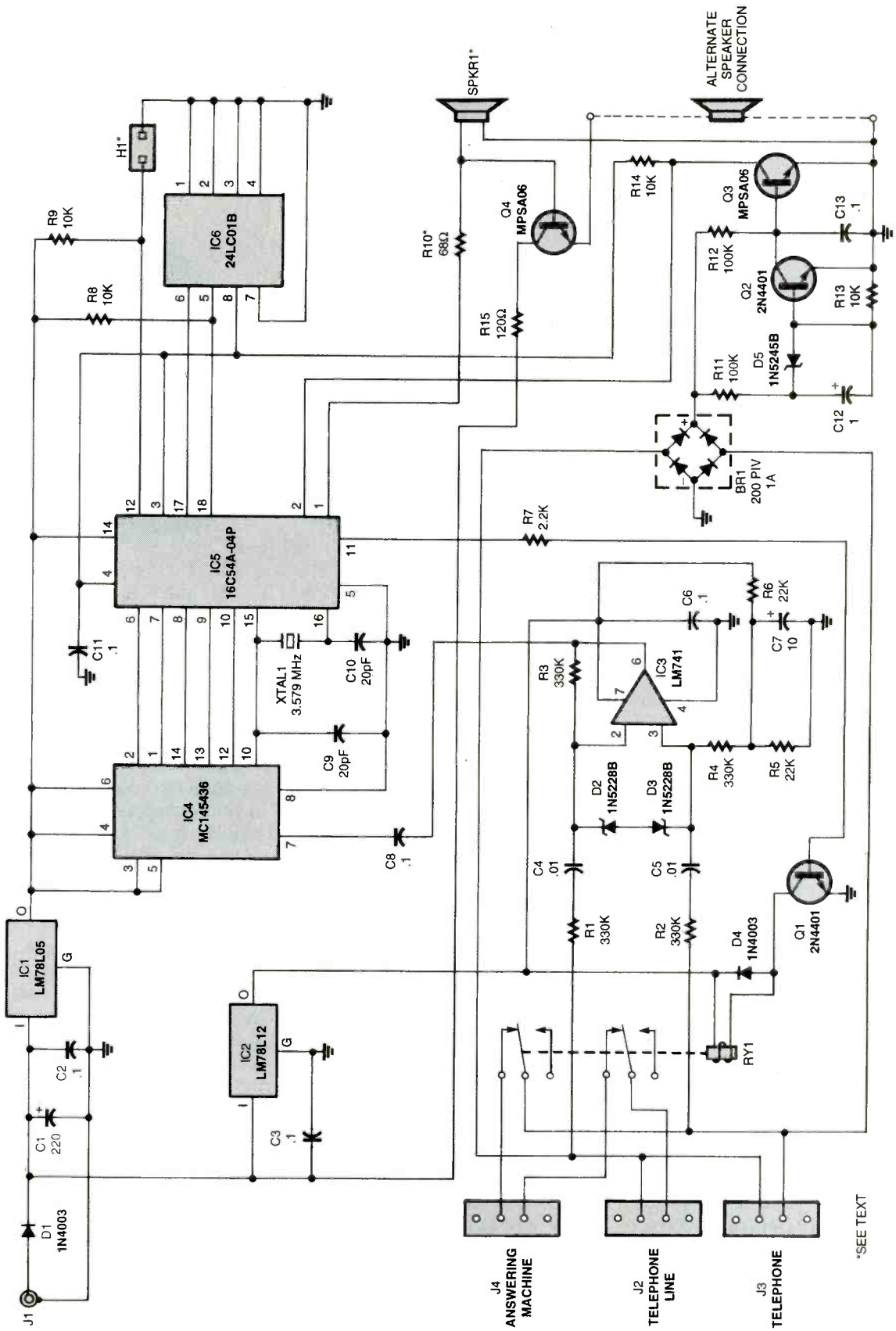


Fig. 1. At the heart of the circuit is IC5—a PIC 16C54 microcontroller that is programmed to interpret DTMF data applied to its inputs and compare them to the security codes stored in IC6 (the EEPROM).

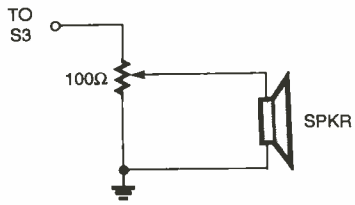


Fig. 2. When configured for the high-volume output, this volume control circuit can be connected to the circuit in front of the speaker to allow sound-level adjustments

codes stored in IC6. If there is a match with one of the three sets, Call Alert sounds an alert tone. If there is no match, Call Alert returns to its idle state and waits for additional DTMF digits to be entered. The security codes consist of four digits. If less than four digits are entered, IC5 continues to wait for additional digits. While IC5 is waiting, it constantly checks the telephone line to see if the answering machine has disconnected. That would indicate that the caller has hung up. If that's the case, Call Alert resets itself and awaits the next call.

Call Alert connects to the telephone line through J2 (LINE). You then connect the telephone to J3 (PHONE) and the answering machine to J4 (ANS MACH). When the answering machine answers an incoming call and the caller enters a security code, DTMF digits entered are routed to IC3, which provides impedance matching between the telephone line and IC4 (the DTMF decoder). Op-amp IC3 also insures that the DTMF digits are at the correct level for IC4 to decode. Diodes D2 and D3 prevent damage to IC3 from the telephone line ring signal. The decoder (IC4) converts the DTMF tone pairs into a binary format that is then sent to IC5 (the PIC microcontroller) for processing.

The 16C54 microcontroller (IC5) is programmed with the software that makes Call Alert perform its functions. Applying power to the unit while H1 is shorted causes it to go into the program mode, which it confirms by emitting two beeps. You can then program the security codes that you've selected. You can program any or all of the codes. As each code is programmed, the unit sounds two beeps to confirm that the code has been accepted. The unit emits three beeps if you make an incorrect entry while trying to program the security codes. If there is a problem with the unit accepting the security codes, you'll hear five beeps, indicating a circuit malfunction, specifically with IC6 (a 24LC01B serial EEPROM).

Once the security codes are programmed, they should be retained in the event of a power loss. A 24LC01B serial EEPROM (IC6) is used to accomplish that task. It is much smaller than a battery, costs less, and never needs to be replaced. Another reason for choosing the serial EEPROM is that there is not enough RAM in the 16C54 for both the security codes and the system-operating code. When a caller enters four digits, the codes in the EEPROM are read and compared to the one the caller entered. Since an EEPROM is similar in operation to a standard EPROM, it will not lose its memory when power fails.

The beeping sound is generated in software and consists of a tone approximately 1 kHz in frequency at quarter-second intervals. Looking at the schematic diagram (Fig. 1), notice that there are two speakers (SPKR1 and an alternate speaker) shown connected to the circuit and that in the same area there is a resistor (R10) marked with an asterisk. Normally the output of the 16C54 at pin 1 will produce sufficient speaker volume for most purposes. In that case, R10 is a 68-ohm resistor (as indicated in the schematic), R15 and Q4 are not used, and SPKR1 is connected as shown.

However, if the normal volume is insufficient, simply replace R10 with a 2.2K resistor, install R15 and Q4, and connect the speaker as indicated by the alternate speaker connection. You can also install an optional 100-ohm volume control as shown in Fig. 2, which would allow you to adjust the output level. In the event you decide to use a volume control, use the higher-powered output option.

The portion of the circuit consisting of BR1, Q2, Q3, and their associated components is used to detect whether or not the telephone line is in use. As was previously stated, if you pick up the telephone when you hear the alert tone and dial "##", the answering machine will be disconnected. That is accom-

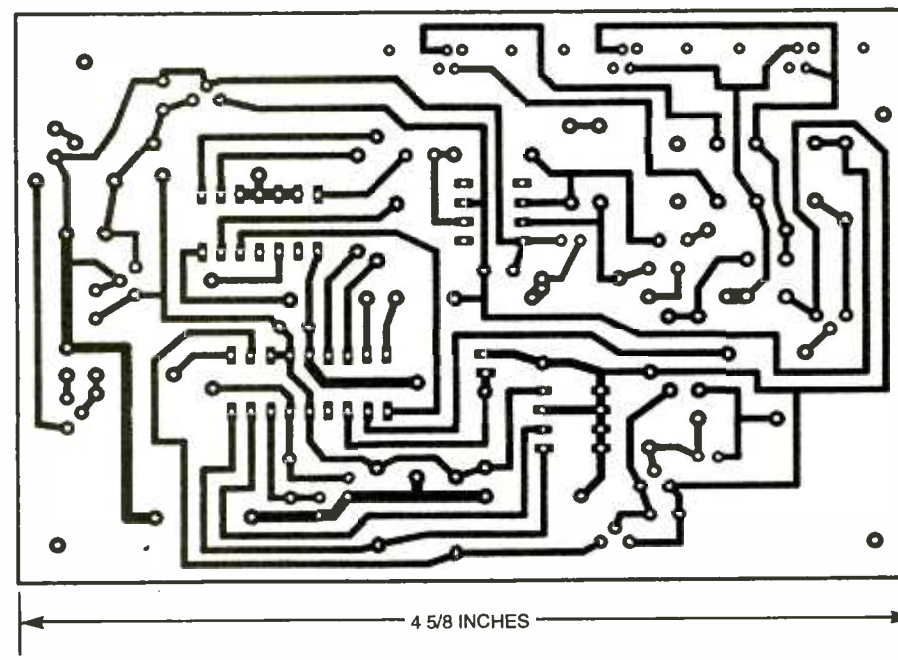


Fig. 3. Call Alert can be assembled using the construction method with which you are most comfortable; for ease of construction, it is recommended that the project be assembled on printed-circuit board. Here is a full-size template of the layout on which the author's unit was assembled.

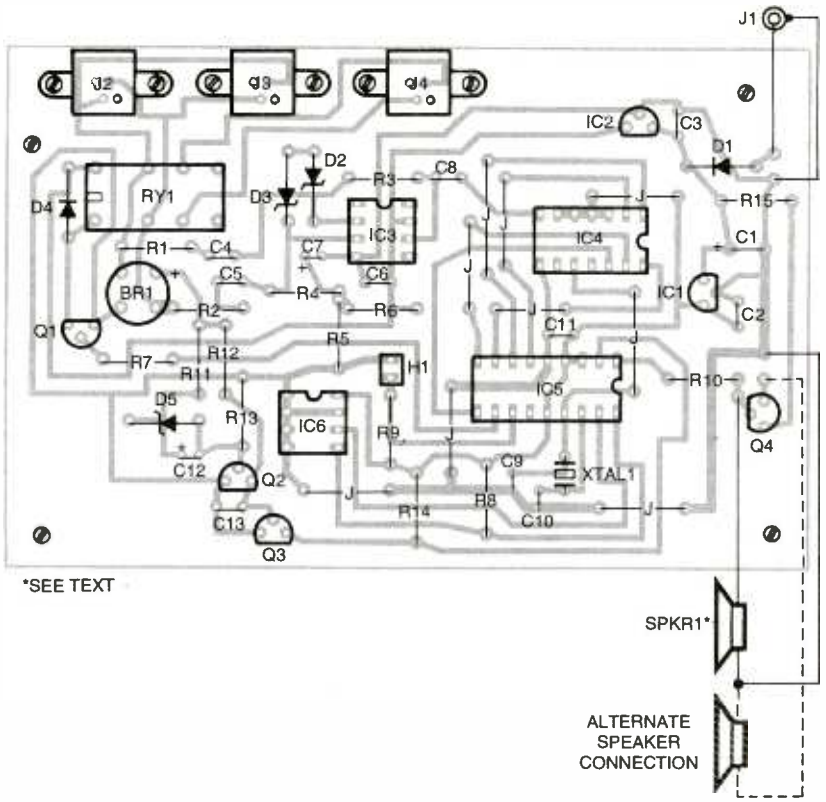


Fig. 4. Assemble Call Alert using this parts-placement diagram as a guide. It's recommended that IC sockets be provided for IC4 and IC5. When assembling the board, pay particular attention to the orientation of Q4 and IC1, as the lead configurations of each must be modified to fit properly into the circuit board (see text for details).

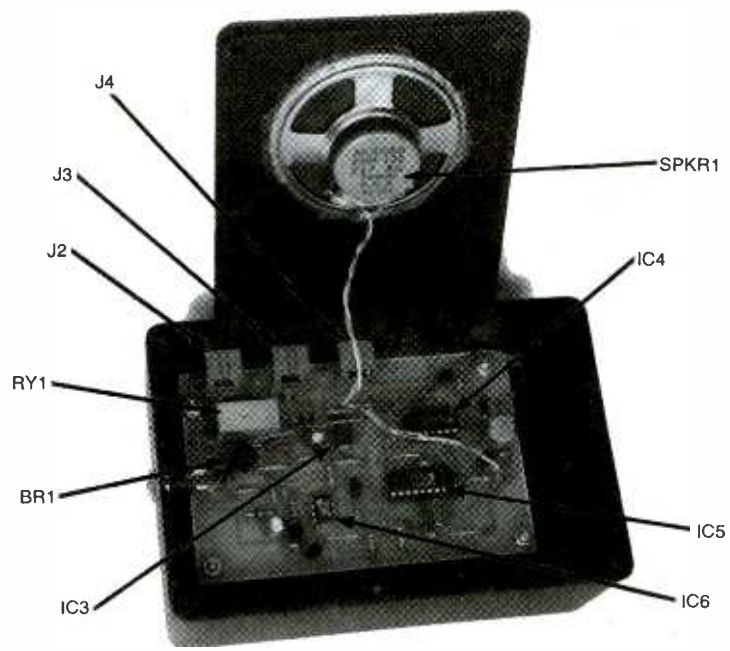
plished by IC5 turning on Q1, which operates RY1. When you hang up the telephone, a disconnect signal is sent to pin 2 of IC5. That causes IC5 to turn Q1 off, thereby releasing RY1 and restoring the answering machine to the telephone line.

Construction. There is nothing particularly critical about the construction of the Call Alert. Thus, the circuit can be assembled on either perfboard or a PC board. However, for ease of assembly, it is recommended that a printed-circuit board be used. You can either etch your own board using the printed-circuit template shown in Fig. 3, or purchase the board from the supplier given in the Parts List. If you prefer perfboard construction, be sure to install XTAL1, C15, and C16 as close to pins 15 and 16 of IC5 as possible. Also, try to keep the wiring between IC3, pin 6 and IC4, pin 7 to a minimum distance.

It is recommended that you use IC sockets for IC4 and IC5, since it is best that they are not installed during initial testing. Sockets are not really needed for IC3 and IC6, but they can be used if you wish. In any event, once you've obtained all of the parts listed in the Parts List, construction can begin.

Assuming that you're using the printed-circuit layout shown in Fig. 3, assemble Call Alert, guided by the parts-placement diagram shown in Fig. 4. When assembling the board, pay particular attention to the orientation of Q4 and IC1. The center lead of each of those devices is bent out toward the front of the body. Also, be sure to observe the correct polarity of the electrolytic capacitors and all diodes. Leave the installation of RY1, J2, J3, and J4 for last, as doing so makes it easier to assemble the unit.

In order for Call Alert to function properly, IC5 (the PIC microcontroller) must be programmed with the correct operating software. A pre-programmed microcontroller is available from the source listed in the Parts List. If you wish to program your own part, the source code is available from the Gernsback FTP site at *ftp.gernsback.com./pub/call_alert.exe*.



The Call Alert prototype was housed in a small plastic enclosure of the type available from most hobby electronics suppliers. Note that SPKR1 is mounted to the lid of the enclosure and connected to the circuit through short lengths of hook-up wire.

Checkout Time. Once construction is complete, it is time to perform the initial tests on the unit. With IC4 and IC5 removed from their

PARTS LIST FOR THE CALL ALERT

SEMICONDUCTORS

IC1—LM78L05 5-volt, 100-mA, fixed-voltage regulator, integrated circuit
IC2—LM78L12 12-volt, 100-mA, fixed-voltage regulator, integrated circuit
IC3—LM741 op-amp, integrated circuit
IC4—MC145436 DTMF decoder integrated circuit (Motorola)
IC5—16C54A-04P microcontroller, integrated circuit
IC6—24LC01B serial EEPROM, integrated circuit
Q1, Q2—2N4401 or 2N3904, general-purpose, NPN silicon transistor
Q3, Q4—MPSA06 or MPSA56, NPN silicon transistor
D1, D4—1N4003 1-amp, 200-PIV silicon rectifier diode
D2, D3—1N5228B, 3.9-volt, 0.5-watt, Zener diode
D5—1N5245B, 15-volt, 0.5-watt, Zener diode
BR1—1-amp 200-PIV, full-wave bridge rectifier

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1–R4—330,000-ohm
R5, R6—22,000-ohm
R7—2200-ohm
R8, R9, R13, R14—10,000-ohm
R10—680- or 2200-ohm (see text)
R11, R12—100,000-ohm
R15—120-ohm

CAPACITORS

C1—220-µF, 25-WVDC, aluminum electrolytic
C2, C3, C6, C8, C11—0.1-µF, monolithic or ceramic-disc
C4, C5—0.01-µF, monolithic or ceramic-disc
C7—10-µF, 25-WVDC, aluminum electrolytic
C9, C10—20-pF, ceramic-disc
C12—1-µF, 50-WVDC, aluminum electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—Wall-adapter compatible power-input jack
J2–J4—Modular telephone jack
H1—2-position header pin
XTAL1—3.579-MHz crystal
RY1—12-volt DPDT relay
SPKR1—2-1/2-inch, 8-ohm speaker
12-volt DC wall adapter, enclosure. IC sockets, volume control (optional, see text), wire, hardware, *etc.*

Note: The following items are available from ATC Electronics, PO Box 43033, Phoenix, AZ 85080: Tel. 602-516-2926; e-mail: *sales@atcelectronics.com*. A complete kit of parts (less enclosure) including all parts for both high and low output option (except the volume control) for $28.50; a preprogrammed PIC16C54 microcontroller for $10; an etched and drilled, printed-circuit board for $6.50; a MC145436 DTMF decoder for $3.50. Please add $4.00 to all orders for shipping and handling. Allow 2 weeks for checks to clear.

sockets, apply power to J1. Measure the voltage at IC4, pin 4 and IC5, pin 14. You should get a reading of approximately 5 volts. Next measure the voltage at pin 7 of IC3, which should be around 12 volts. If those voltages are correct, remove power and install IC4 and IC5. Make sure you have the speaker connected and do not install the shorting header in H1. Apply power to the unit; you should hear one beep from the speaker, indicating that the unit is probably operating correctly. Again remove power from the unit.

To program the security codes into Call Alert, connect the telephone line to J2 and connect a telephone to J3. Install a shorting strip across H1 and apply power; you should hear two beeps, indicating that the unit is in the program mode. The three security codes are accessed by dialing 1, 2, or 3. Pick up your telephone handset (ignore the dial tone) and dial 1-2-3-4-5. The unit should then beep two times, confirming that you have programmed the security code 2345 into location 1.

Hang up the telephone, disconnect power from Call Alert, and remove the jumper from H1. Then reapply power and you should hear the single beep again. Pick up the telephone handset and dial 2345. The speaker should begin beeping. Wait a few seconds and hang up the telephone handset. When you do, the beeping sound should stop. That confirms that the disconnect circuit is functioning properly.

You can now remove power, install a jumper across H1, and program the three security codes that you wish to use. You can program all three codes without having to hang up between the different entries. Just ignore the reorder tone that comes from the telephone company's central office when you press the # key on your telephone. When you have programmed all three codes, hang the telephone up, remove power from Call Alert, and remove the jumper from H1.

Once testing is complete, Call Alert can be installed in a suitable case. The most difficult part of this process is insuring that the cutouts for J2–J4 are in the correct locations. You can use the assembled board to make a paper template for proper spacing and alignment. Be sure to take into account the height of the spacers used to mount the board to the case. Install the PC board into the case and mount J1 and the speaker to the case. Install the cover on the case and it is ready for operation. Connect the telephone line to J2, the telephone to J3, and your answering machine to J4. Power the unit up and if you hear the single beep, your unit is operational.

Have someone call you and dial one of the security codes when the answering machine answers. Call Alert will start beeping. At that point, pick up the telephone, and dial ## to confirm that the beeping stops and that the answering machine disconnects from the line. When you hang up the telephone, the answering machine will be reconnected to the telephone line.

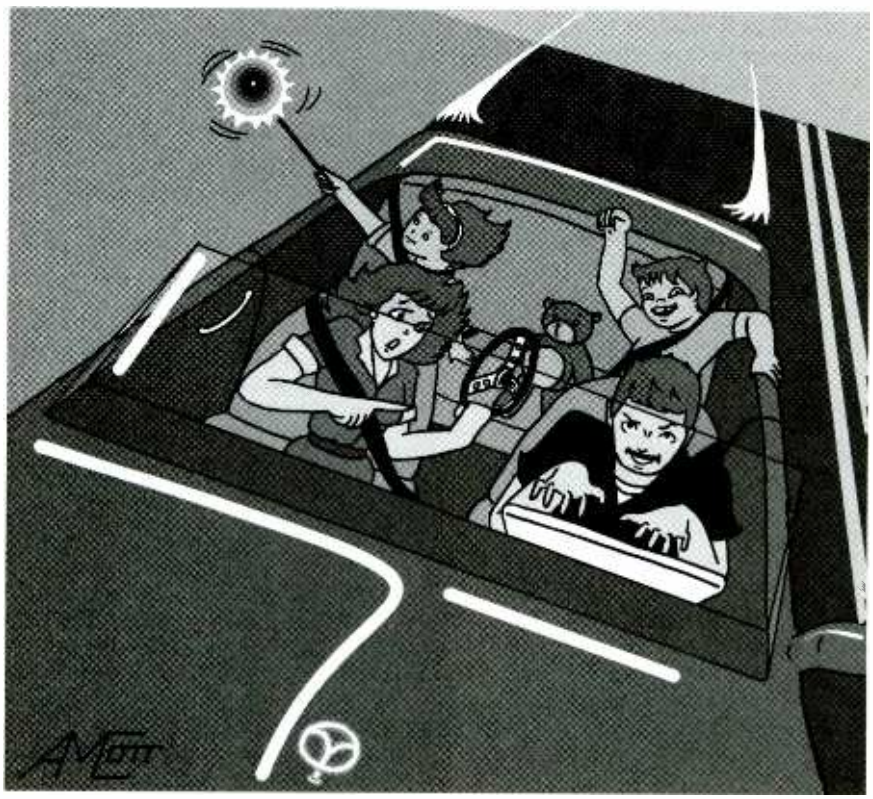
If you think that you will be changing the security codes on a frequent basis, you may want to install a momentary pushbutton switch in place of H1. Mount it so that you have access to it without having to open the unit's case. Then when you need to change a code, disconnect power, hold the switch in, and reapply power. You can release the switch after you hear the two beeps. You do not need to hold the switch in while you are programming the security codes. Once the new codes are programmed, disconnect power, wait about ten seconds and reapply power.

Install several Call Alert units and you will be able to enjoy peace and quiet when you want to. Remember, the sound of silence is golden.

Using A PC Keyboard

Need a cheap keyboard for input on your latest project? Look no farther than that old IBM PC keyboard collecting dust in your closet!

CRAIG PEACOCK



IBM keyboards—not really an interesting topic, one would expect. Why would you want to learn about the keyboard interface? Thanks to the sheer volume of IBM keyboards manufactured each year, they can be a cheap alternative to a keyboard on a microprocessor-development system. Perhaps you want a remote terminal. In that case, it's an easy task to couple a keyboard and an LCD module to a microcontroller.

Learning about the IBM keyboard interface doesn't limit you to using the keyboard itself. Remember, the keyboard is only one half of the system. That keyboard jack on your computer can also be used with devices that appear to be keyboards from the computer's point of view. After all, if it looks like a keyboard, walks like a keyboard, and quacks like a keyboard...

Seriously, though, if you have an RS-232-based device such as a barcode scanner that you want to use with existing software that only allows you to key in numbers or letters, you could design a little box to convert the RS-232 output into keyboard transmission codes. From the software's vantage point, you're not using a scanner, you're just typing on the keyboard at a furious rate!

In this article, we're not only going to teach you about the keyboard interface protocol, we're going to build a test interface so you can see the keyboard protocols in action. This interfacing example uses a 68HC705J1A microcontroller to decode the transmissions from an AT-style keyboard and output the ASCII equivalent of the key pressed at 9600 BPS.

Note that we're only dealing with AT keyboards. If you have any XT-format keyboards, consider placing them in a museum. Since XT keyboards use a different protocol compared to the AT, the code contained here will be incompatible. If you research the protocol on your own, you could apply the knowledge gained here to work with those obsolete devices. Again, if you want to try your hand with XT keyboards, you're on your own.

PC Keyboard Theory. The IBM keyboard uses a serial protocol to send "scan codes" to your computer. The scan codes tell your system what keys you have pressed or released. Take, for example, the "A" key. That key's scan code is 1C in hexadecimal notation (28 in the base 10 counting system favored by humans). When you press the "A" key, your keyboard will send 1C, or 00011100 down its synchronous serial line. If, after a moment, you are still holding the key down, the keyboard keeps track of how long you hold that key. When that time exceeds the "auto-repeat" delay programmed into the keyboard (called the "typematic delay"), another 1C code will be sent. That keeps occurring until either another key is pressed or the "A" key is released.

When the key is released, another code is sent. In our previous example, releasing the "A" key will cause the keyboard to send two scan codes: F0 (hexadecimal), to tell you that the key with the preceding scan code has been released, followed by the scan code of the key that was released—1C in our example.

The keyboard has only one code for each key. It doesn't care if the shift key has been pressed; those keys have their own scan codes as well. It will still send you the same code whether you're typing a capital or a lower-case letter. It's up to your system's BIOS code to keep

track of that and take the appropriate action. In fact, the keyboard doesn't even process the number-lock, caps-lock, and scroll-lock keys. When you press the caps-lock key, for example, the keyboard will send the scan code for the cap-locks key: 58 hexadecimal. Your computer (through the part of its BIOS code that handles the keyboard) then sends a code to the keyboard to turn on the caps lock LED.

Since an AT-style keyboard has 101 keys (up to 107 in the modern variants) and 256 available 8-bit codes, you only need to send one byte per key, right?

Wrong. Unfortunately, a handful of the keys found on your keyboard are "extended" keys, requiring *two* scan codes. Those keys are preceded by an E0 code. To make matters worse, it doesn't stop at two scan codes either. How about the scan code E1, 14, 77, E1, F0, 14, F0, 77! That can't possibly be a valid scan code.

Wrong again. It happens to be the code that's sent when you press the pause/break key. Don't ask me why the designers made it so long; maybe they were having a bad day!

When an extended key is released, you would expect that the release code combination would be F0 to start the release sequence followed by E0 and the scan code of the key being released. Again, for whatever reason or whim the design engineers had all those years ago, E0 is sent first followed by F0 when an extended key has been released.

Commands. Besides scan codes, commands can also be sent to and from the keyboard. See the sidebars for detailed information on the various commands; "Computer-to-Keyboard Commands" lists the commands that you can send to a keyboard while "Keyboard-to-Computer Commands" deals with commands and responses that the keyboard can originate. By no means are those lists complete; only some of the more common and useful commands are mentioned.

We've already talked about one example of sending a command to the keyboard above. Remember when we talked about turning on the status LEDs when a key such as the scroll lock or caps lock is pressed? Now that you understand the basic flow of information between keyboard and computer, the details of what commands are available and how they work will make more sense.

If you've wondered why the keyboard would need to send commands to the computer in addition to keypress scan codes, the descriptions of the keyboard-to-computer commands should clear that up. For example, if the keyboard receives a command that doesn't make sense, it can request a resend of the last command in case electrical noise was interfering with the cable between keyboard and computer.

Scan Codes. As mentioned in the sidebar for the computer-to-keyboard commands, an AT keyboard has two sets of scan codes built into it. The more common scan code set, set number 2, is detailed in Fig. 1. Note that each scan code is listed below the legend that is printed on the key caps. The only exceptions to that are the extra long codes for the "print screen" and "pause/break" keys. As with all other codes listed in this article, the scan codes are in hexadecimal; the scan code for the escape key is 76 hexadecimal, 01110110 binary, or 118 decimal.

As you can see, the scan code assignments are quite random. In many cases, the easiest way to convert the scan code to ASCII is to use a look-up table. However, that's getting a bit ahead of our story; we'll take that up when we talk about a demonstration project and its accompanying software.

Keyboard Connectors. The PC's AT keyboard is connected to external equipment using four wires. Those wires are shown in Fig. 2; Fig. 2A shows the pinout for the older-style 5-pin DIN plug that was borrowed from the XT design. In the early days of the AT, keyboards usually had a switch on the bottom that let you select between the XT and AT protocols. That way, you could use the keyboard with any available computer.

With the advent of the IBM PS/2 system in the late 1980s came the newer style of keyboard plug; its pinout is shown in Fig. 2B. While the original intent was to prevent non-PS/2 keyboards from being attached to PS/2 machines, today's systems are becoming smaller and sleeker. Having a smaller plug for the key-

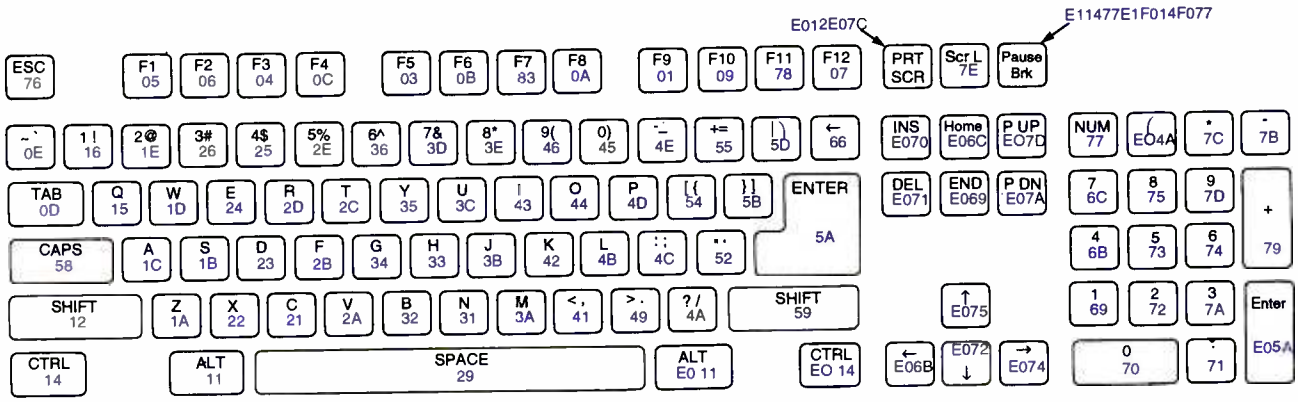


Fig. 1. A binary number is assigned to each key on the AT keyboard; some codes are arranged in a somewhat haphazard manner.

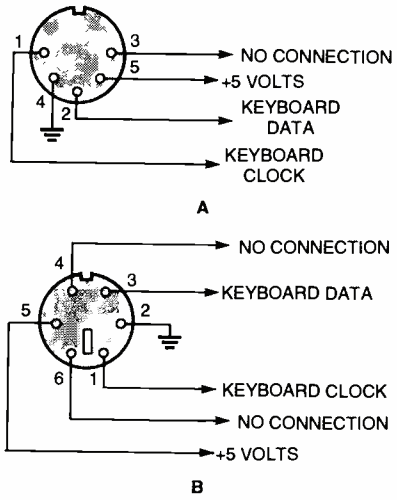


Fig. 2. While the connectors for an older-style DIN (A) and a PS/2-style mini-DIN (B) connector have a different number of pins, the signals that they carry are the same.

board is a definite help in that area. Unfortunately, the downside is that PS/2-style mice have the same plug. Anyone who has accidentally mixed the two connectors will attest to the fact the results, while not catastrophic to the equipment, make troubleshooting annoying and confusing, especially when you're trying to figure out why you're getting the famous error message, "Keyboard Not Found. Press F1 to continue."

A fifth wire can sometimes be found that was once a keyboard reset, but today is left disconnected on AT Keyboards. When we say "keyboard reset," we mean resetting the microcontroller inside the keyboard, not the reset command that you issue to the computer with the "three-finger salute" CRTL-ALT-DELETE. An AT keyboard can be reset by sending the FF hexadecimal software command, making the hard-wired reset line redundant. Both the keyboard-clock and keyboard-data pins are open-collector bi-directional I/O lines. The bi-directional feature lets the host talk to the keyboard using those lines as needed.

Note that most keyboards are specified to draw a maximum current load of 300 mA. That will need to be considered when powering your devices.

Keyboard-to-Computer Transmission. As mentioned before, the PC's keyboard uses a bi-directional scheme on its I/O lines so that either device can send information to the other. The computer has the ultimate priority over direction. At any time, it can send a command to the keyboard, although that isn't recommended.

The keyboard is free to send data to the computer when both the data and clock lines are idle; a logic high (5 volts) represents that state. The clock line can be used as a "clear-to-send" line. If the computer takes the clock line low, the keyboard will buffer any data until the clock is released by going high. Taking the data line low means that the computer is going to send a command to the keyboard.

Data is transmitted from the keyboard to the computer with an 11-bit frame. The first bit is a start bit (Logic 0) followed by eight data bits. The data bits are sent least-significant bit first. An odd parity bit and a stop bit complete the transmission. The falling edge of the clock defines when to read each bit.

Figure 3A shows a one-byte transmission from the keyboard to the computer. Although the diagram shows the keyboard data changing on the rising edge of the clock, that is not necessarily the case. Data can change at any time as long as the next bit is stable before the next falling edge of the clock line. The keyboard generates the clock as well as the data. The frequency of the clock signal typically ranges from 20 to 30 kHz. As we mentioned before, the least-significant bit is always sent first.

Host-to-Keyboard Protocol. The waveform for sending a command to the keyboard is shown in Fig. 3B. The transfer is initiated by taking the keyboard data line low. To prevent the keyboard from sending data at the same time, it is common to take the clock line low for more than 60 microseconds—more than one bit length. Then the data line can be taken low, at which time the clock line is released.

The keyboard responds by generating a clock signal on its clock line. That process can take up to 10 mS. After the first falling edge has been detected, the computer places the first data bit on the data line. The keyboard reads that bit on the next falling edge, after which the data can be replaced with the next bit. This process is repeated for all eight data bits. After the data bits come an odd parity bit.

Once the parity bit has been sent and the data line is in an idle (high) state for the next clock cycle, the keyboard will acknowledge the reception of the new data. The keyboard does that by taking the data line low for the next clock transition. If the data line is not idle after the tenth bit (start bit + 8 data bits + parity bit), the keyboard will continue to send a clock signal until the data line becomes idle.

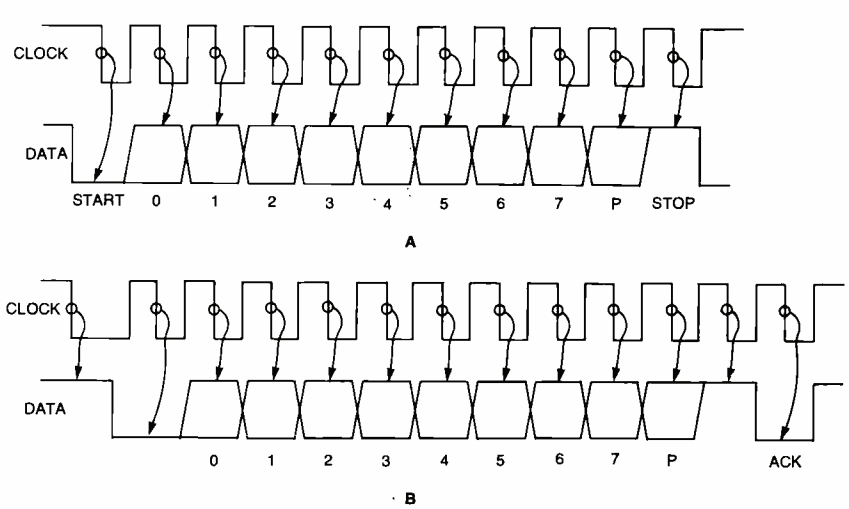


Fig. 3. When the keyboard sends data, the individual bits are to be read on the falling edge of the clock signal (A). The same arrangement is followed when sending a command to the keyboard (B). Note that the keyboard sends the acknowledge signal if the data was properly received.

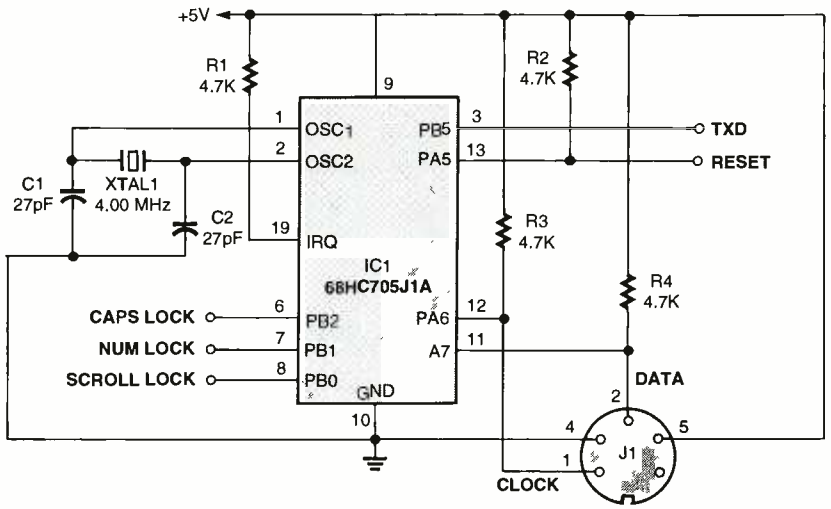


Fig. 4. With a simple single-chip microcontroller, you can interface a keyboard to any project that you want. Note that the interface is small enough to fit inside the keyboard, making it a truly portable interface.

An Example Keyboard-to-ASCII Decoder. To demonstrate the protocols at work, let's build a small microcontroller-based circuit. Using a 68HC705J1A single-chip microcontroller, we'll read data from the keyboard, convert the scan codes into ASCII, and send that out in RS-232 format at 9600 baud. However, we won't stop there. To see the bidirectional use of the clock and data lines, we'll also control the number-lock, caps-lock, and scroll-lock LEDs.

While the circuit is an interesting demonstrator, it can be used for a wide range of purposes. If you team it up with a reasonably sized four-line by 40-character LCD panel, you could have yourself a small portable terminal. You could also use it with a microcontroller development system. The 68HC705J1A in a one-time-programmable (OTP) version is only a fraction of the cost of a 74C922 keyboard decoder chip, which only decodes a 16-key matrix keypad.

The keyboard doesn't need to be expensive either. Most people have old keyboards hidden away in a closet or on a shelf. As long as it's an AT keyboard, it's useful. Remember that XT keyboards will not work with this program. With the introduction of USB keyboards, there will be many redundant AT keyboards waiting to be used.

Circuit Description. The schematic diagram shown in Fig. 4 is our demonstrator circuit. As you can see, the hardware portion is minimal. The software is designed to run at 2 MHz; a 4-MHz crystal is needed for XTAL1 since IC1 divides that frequency by 2 to get the microcontroller's internal bus speed. The timing for the RS-232 transmission is based on the bus speed. If you want to use a different frequency, you'll have to do some heavy reworking of the software.

Serial output is on pin 13 of IC1. Although the signal is in the RS-232 format, it is not at RS-232 voltage levels. If you want to connect it to any true RS-232 devices, you will need some sort of RS-232 level converter circuit; Maxim makes several types of conversion chips that work well for that purpose. If you are familiar with the design of whatever piece of equipment you'll be connecting the circuit to, you might be able to bypass the equipment's RS-232 input circuit that translates the voltage levels back to 5-volt logic. If that's the case, you can connect both devices together directly. However, if you need to have a length of cable between them, you'll need to follow the RS-232 conventions for reliable transmissions.

The keyboard is connected to pins 11 and 12 of IC1 through J1. Since it requires open collector/open drain outputs, IC1's Data Direction Register (DDR) is used to switch between high impedance for receiving signals from the key-

PARTS LIST FOR THE KEYBOARD INTERFACE

IC1—68HC705J1A one-time programmable microcontroller, integrated circuit
XTAL1—4-MHz crystal
C1, C2—27-pF ceramic disc capacitor
R1–R4—4700-ohm, 1/4-watt, 5% resistor
J1—5-pin female DIN or 6-pin female Mini-DIN connector
Socket, wire, hardware, etc.

COMPUTER-TO-KEYBOARD COMMANDS

ED—Set Status LEDs. This command can be used to turn on and off the Num Lock, Caps Lock, and Scroll Lock LEDs. After receiving the ED command, the keyboard will reply with an acknowledge byte (FA) and wait for another byte that determines the LED status. Bit 0 controls the Scroll Lock, bit 1 the Num Lock, and bit 2 the Caps lock. Bits 3 to 7 are ignored.

EE—Echo. Upon sending an Echo command to the keyboard, the keyboard should reply with an echo (EE).

F0—Set Scan Code Set. Upon sending F0, the keyboard will reply with ACK (FA) and wait for another byte, 01–03, which determines the scan code to be used. Sending 00 as the second byte will return the scan code set currently in use. The default scan set is scan set 02. Set 2 scan codes are the set discussed in this article.

F3—Set Typematic Repeat Rate. The keyboard will acknowledge this command with FA and wait for a second byte, which determines the typematic repeat rate.

F4—Keyboard Enable. Clears the keyboard's output buffer, enables keyboard scanning, and returns an acknowledgment.

F5—Keyboard disable. Resets the keyboard, disables keyboard scanning, and returns an acknowledgment.

FE—Resend. Upon receipt of the resend command, the keyboard will retransmit the last byte sent.

FF—Reset. Resets the keyboard.

KEYBOARD-TO-COMPUTER COMMANDS

FA—Acknowledge.

AA—Power-on self-test passed (BAT Completed).

EE—Echo command response (see Echo command in Computer-to-Keyboard Commands sidebar).

FE—Resend—Upon receipt of the resend command, the computer should retransmit the last byte sent.

00—Error or buffer overflow.

FF—Error or buffer overflow.

board and a logic 0 when sending commands to the keyboard; we'll discuss the software details later. Resistors R3 and R4 pull the pins high to create a logic 1 when sending a command.

A "reset" line on pin 13 sends out an active-low pulse whenever the ctrl-alt-delete combination is pressed on the keyboard. That lets you send a hardware reset signal to whatever device you're controlling. In addition, three other output lines on pins 6, 7, and 8 correspond to the caps-lock, number-lock, and scroll-lock keys. With those keys, you can control any on-off function that you want; IC1's software handles turning the keyboard LEDs on and off as needed.

The power supply can create a slight problem. A standard keyboard can drain up to about 300 mA; it's a good idea to use a separate regulator rather than trying to run everything off of one 7805. While decoupling capacitors are not shown in Fig. 4, they are recommended for reliable operation. Consult the MC68HC705J1A data sheet for more information.

Software. The software for the demonstrator circuit, while only 999 bytes long, is over 19 pages when the source code is printed out. For that reason, it can be downloaded from the **Poptronics** FTP site at *ftp.gernsback.com/pub/pop/pc_keyboard.zip*. Most of it (hopefully) is easy to follow. Select bits and pieces are published here; we'll be referring to them as we explore how the software works.

The software has some nice features when used as an interface to a microcomputer development system. Many times, you'll find yourself having to input various numbers when creating or debugging an assembly-language program. If you've worked with programming at

LISTING 1

```
Receive  ldx #08                        ;Number of Bits
         clr PAR                        ;Clear Parity Register
         bclr clk, DDRA                 ;Clear to Send

         brset clk, PORTA,*             ;wait on idle Clock
         brset data, PORTA, Receive     ;False Start Bit, Restart
```

LISTING 2

```
Recdata  ror byte
         jsr highlow                    ;Wait for high to low Transition
         brset data,PORTA,Recset
         bclr 7,byte
         jmp Recnext
Recset   bset 7,byte
         inc PAR
Recnext  decx
         bne Recdata                    ;Loop until 8 bits been received
```

LISTING 3

```
highlow  brclr clk, PORTA,*             ;Loop until Clk High
         brset clk, PORTA,*             ;Loop until Clk Low
         rts
```

LISTING 4

```
         ldaPORTA                       ; Msbit is Parity
         rola                           ; Shift MSbit to LSbit
         rola                           ; thru carry
         eorPAR
         and      #$01
         beq      r_error
```

LISTING 5

```
         jsr highlow
         brclr data,PORTA,r_error       ;Stop Bit Detection
         bset clk,DDRA                  ;Prevent Keyboard from sending data
                                        ;(Clear to Send)
         rts
```

LISTING 6

```
r_error  lda #$FE                       ;Resend
         sta byte
         jsr Transmit
         jmp Receive                    ;Try again
```

LISTING 7

```
transmit ldx #$08                       ;8 Data Bits
         bset clk,DDRA                  ;Set Clock Low
         lda #$13                       ;Delay 64uS
         jsr delay
         clra                           ;Clear Parity Register
         bset data,DDRA                 ;Set Data Low
         bclr clk,DDRA                  ;Release Clock Line
         jsr highlow
```

LISTING 8

```
loop    ror byte
        bcs mark
space   bset data, DDRA      ; Clear Bit
        jmp next
mark    bclr data, DDRA      ; Clear Bit
        inca                 ; Parity Calculation
next    jsr highlow          ; Wait for high to low transition
        decx
        bne loop
```

LISTING 9

```
        and #$01
        bne clr_par
set_par bclr data,DDRA
        jmp tr_ackn
clr_par bset data,DDRA
tr_ackn jsr highlow
```

LISTING 11

```
error   lda #$FF             ;Reset
        sta byte
        jsr transmit
        rts
```

LISTING 10

```
        bclr data, DDRA      ;Release Data Line
        jsr highlow
        brset data, PORTA,error  ;Check for Ack
        brclr clk, PORTA,*   ;Wait for idle line
        bset clk, DDRA       ;Prevent Keyboard from sending data
                             ;(Clear to Send)
        rts
```

that low of a level, you know the annoyance of having to set a particular byte to a certain value. In a Windows environment, you have the option of entering a direct ASCII code into a word processor with the numeric keypad. For example, if I hold down the ALT key while typing "0174" on the keypad, I get the following symbol on the screen: ®. The actual symbol that you get depends on the font that you're using. The point is that you can access any of the 256 characters in a standard font without the need for a special key on the keyboard. In a similar manner, the keyboard-interface software has a similar capability. When you enter a decimal number while holding down one of the ALT keys, the number is sent in binary format to the target system; ALT + 255 results in the value FF (hexadecimal) being sent to the system. I call that feature the "Direct Decimal Enter" routine. Unlike the PC, you can use either the numeric keypad or the numbers along the top of the keyboard.

Since I'm targeting a microcomputer development system, the Direct Decimal Enter routine is complemented with a "Direct Hexadecimal Enter" routine—a function not found in a PC operating system. That feature is accessed in a similar manner, only you press and hold the CTRL key while entering a hexadecimal number.

The software outputs data in ASCII using the RS-232 serial protocol at 9600 bits per second. If you want to use it with a development system, you can tap it in after the RS-232 line transceivers to save you a few dollars on RS-232 level converters.

Reading Keyboard Data. The first section has to do with receiving data from the keyboard. Remember what we learned about stopping the keyboard from sending any data? As it can take considerable time to decode the keys pressed, we must do that or some of the data might be lost or corrupted.

The first part of the program in Listing 1 keeps the keyboard clock line low, unless it is ready to accept data. A loop retrieves the data bits from the keyboard with index register X containing the number of bits to be received. The PAR variable will be used to verify the parity bit at the end of the transmission; we must clear it first. We can then place the keyboard clock line in the idle state so that the keyboard will start transmitting data if a key has been pressed. The program then loops while the clock line is idle. If the keyboard clock goes low, the loop is broken and the keyboard data pin is read. That should be the start bit, which should be low. If it isn't, we branch to the start of the receive routine and try again.

Once the start bit has been detected, the 8 data bits follow (Listing 2). The data is only valid on the falling edge of the clock. The subroutine "HIGHLOW," shown in Listing 3, waits for the falling edge of the clock. After the falling edge, we can read the level of the keyboard data line. If it is high, we set or clear the most significant bit of the byte as needed. Note that if the bit is set, PAR is incremented to keep track of parity for verification when the parity bit is received. Index register X is decremented as we have read a bit. It then repeats the above process, until the entire 8 bits have been read.

After the 8 data bits, comes the dreaded parity bit. We could ignore it if we wanted to, but it's better to do things the right way; see Listing 4. The PAR variable has a tally of the number of 1s. The keyboard uses odd parity, so the parity bit should be the complement of PAR's least significant bit. By EXCLUSIVE-OR-ing PAR with the parity bit, we get a 1 if both the bits are different. That means that the parity bit checks out.

Since we're only interested in the least significant bit, we can exclusive-OR the accumulator with PAR, then single out that bit using the AND function. A zero means that a parity error has occurred and the program branches to the error-handling routine, R_ERROR.

After the parity bit comes the stop-bit routing of Listing 5. Again, we can ignore it if we desire. However, we have chosen to branch to the error routine if the stop bit is clear.

When Something Goes Wrong. What you do for error handling is up to you. In most cases, it will never be executed. In fact, I don't yet know if the error-handling routine shown in Listing 6 works! I've tried it out in close proximity to the washing

(Continued on page 69)

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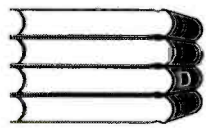

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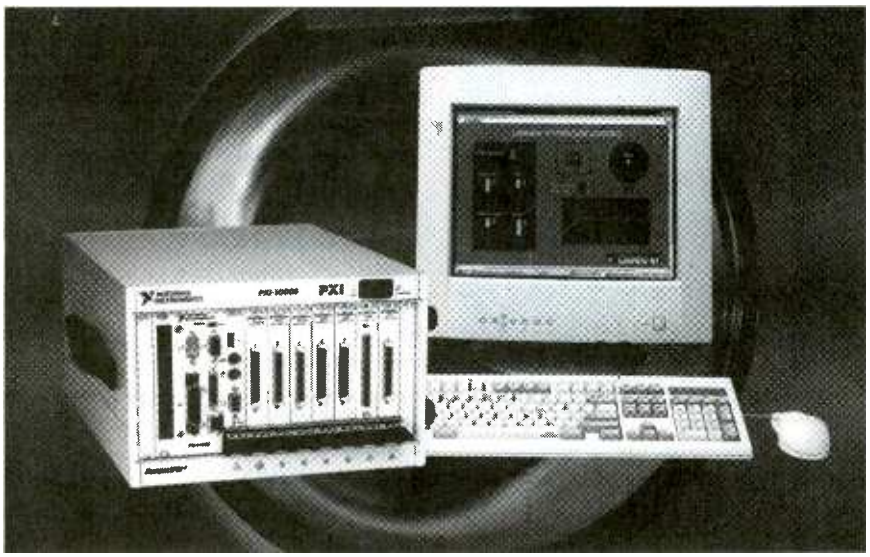

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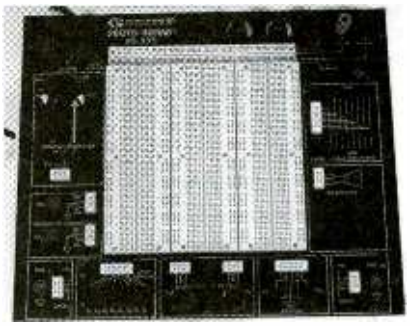

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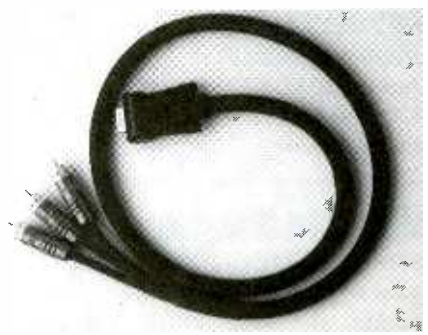

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(Continued on page PS-6)

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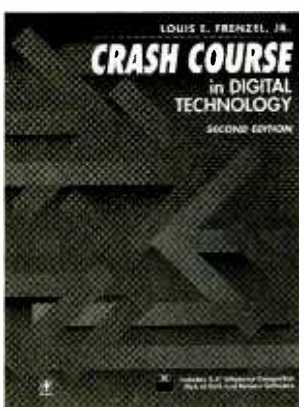
In an easy-to-understand format, this book explains the basics of digital electronics theory and circuits. Combined with the two other titles in the Crash Course series, *Electronics Technology* and *PC and Microcontroller Technology*, this book forms a complete course in electronics and microcomputer technology.



Each chapter includes learning objectives, clear explanations and examples, and a self-quiz. The included drill-and-review software allows students to test themselves. Subjects covered include Programmable Logic Devices; BCD, ASCII, and hex; decoders, multiplexers, and pantry circuits; and troubleshooting methods.

Palm Pilot: The Ultimate Guide, Second Edition

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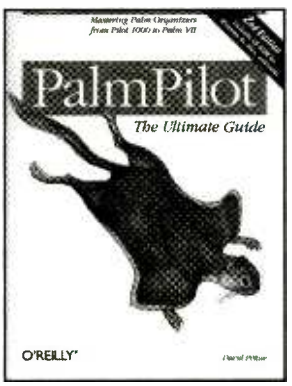

Filled with time-saving tips, surprising tricks, and practical information, the second edition covers all models, including Palm IIIx, Palm IIIe, Palm V, Palm Vx, and Palm VII. It also reviews such clones as the Handspring Visor and IBM Workpad. New chapters show readers how to check Web pages or e-mail with the wireless Palm VII, synchronize Palm database and spreadsheet files with applets, and write Palm VII Web-search applets of your own.

The included CD-ROM contains over 3100 Palm programs, hand-picked from *PalmCentral.com*. The illustrated catalog (for Macintosh or Windows 9x) searches, sorts, and describes each application.

Nikola Tesla's Teleforce & Telegeodynamics Proposals

edited by Leland L. Anderson
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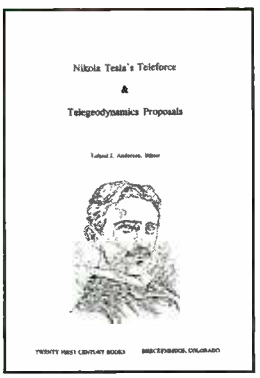
In 1934, the unorthodox inventor Nikola Tesla announced a particle-beam projector intended as an instrument of national defense. He called this system



"teleforce." In 1935, Tesla claimed a method to transmit mechanical energy with minimal loss over any terrestrial distance that he termed "the art of telegeodynamics."

These two important papers, hidden for more than 60 years, are presented here for the first time. This work also includes explanations of the more technical and functional aspects of the two devices, as well as historical background. The bibliography and appendix provide a wealth of related material and information for future research.

Digital Frequency Synthesis Demystified

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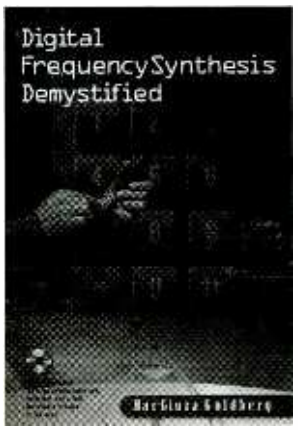

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by Michael DiSpezio
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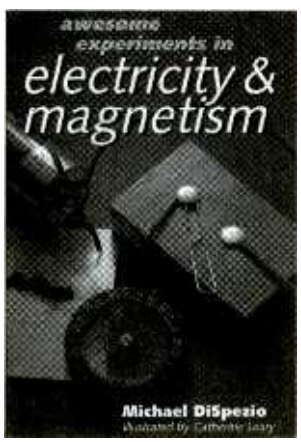
Older electronics enthusiasts begin as little enthusiasts. This kid-centered family introduction to electricity is charmingly illustrated by Catherine Leary and contains instructions for over fifty experiments that can be easily performed with easily purchased items or common household objects.

Experiments in static electricity, current electricity, magnets and magnetism are all found in this book. Among the interesting experiments are constructing a Morse code transmitter, along with information for sending Morse code.



Computational Principles of Mobile Robotics

by Gregory Dudek and Michael Jenkin
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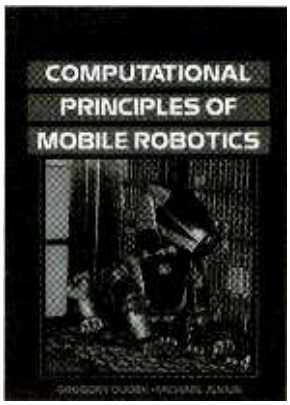
Unlike the robots of Isaac Asimov and other popular science fiction writers, actual autonomous robots must negotiate moving, sensing, and reasoning out the environment. This book describes the way in which existing robotic systems have addressed these three tasks.



The authors emphasize the computational methods of programming robotics rather than the hardware construction methods. Mobile robots of all kinds, vision-based and non-visual sensor technologies, and software architectures used to represent and reason about space are all covered thoroughly.

The Forrest Mims Circuit Scrapbook, Vol. II

by Forrest M. Mims, III
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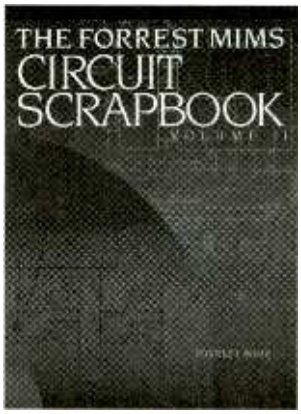

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Selected from circuits previously published in *Modern Electronics*, this collection of classic circuits has something for everyone. In a readable and "user-friendly" style, the author explains how to build and experiment with the circuits. Many of them are optoelectronic in nature, detecting or emitting light.

Hand-drawn schematics, detailed theory of operation, and construction hints are part of each circuit description. Some of the circuits are for audio synthesizers, fiber-optic sensors, laser-diode devices, piezoelectronics, and radio-control systems.

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These articles come from the pages of *Audio Amateur* and numerous other periodicals. They were published during the peak of the technology of the long-playing (LP) record, culminating in the 70s. Although that time has passed, the LP record has never completely disappeared from the music scene.

A useful reference for collectors of both vintage LPs and today's new pressings, the book provides a basic understanding of the current state of LP technology. A continuing mix of theory; information on cleaning, maintenance and storage of disks; and tips on modification of LP and other audio equipment, the articles help both new and experienced collectors achieve the best reproduction possible with this medium. P

SERVICE CLINIC

SAM GOLDWASSER

Optical Sensors in VCRs

I know I promised that this month we would deal with problems like "My VCR totally ignores me," but we're going to take a slight detour from our original plan. Before we tackle that, let's take a look at some of the common types of sensors found in VCRs, the problems that they cause when they fail, and some useful testing techniques that will help you find the fault and fix it.

Tape Start/End Sensors

VHS cassettes have a clear leader and trailer to make it easy for the VCR to detect the beginning and the end of the tape (see Fig. 1). A light source pokes up into the center of the cassette. The light passes through passages in the plastic housing, through the clear portion of the tape as it leaves and enters the cassette, and finally falls on photodetectors that are on either side of the cassette.

A failed light source is common in older VCRs where the light source was an incandescent lamp. It is a rare fault in modern VCRs, because today's breed uses an infrared LED. However, when this light source does fail, it can produce a number of symptoms:

- The VCR may simply shut down and refuse to do anything. VCRs with incandescent lamps were often designed to figure out that the light bulb was burnt out, since it was drawing no current, and then shut down or flash an error code.
- The VCR may go through the motions of playing a pre-recorded tape thinking that a tape is present because the sensors return signals indistinguishable from what it would see if a tape were present. Eventually, it may give up and shut down.
- The VCR may do strange things when you attempt to load a cassette since the microcontroller is receiving conflicting signals—the cassette is out, but the sensors think otherwise.

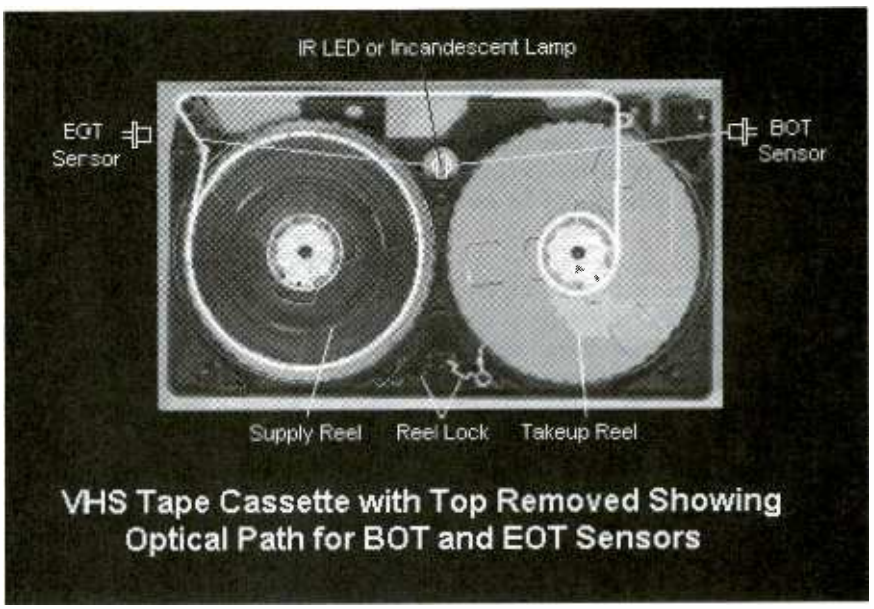

Fig. 1. Optical path of the start/end sensors.

If your VCR uses an incandescent lamp and it is not lit when power is on, then the bulb is most likely burnt out and needs to be replaced. If either one of the light sensors fail open-circuit, you may see similar symptoms. If the sensor on the supply side fails shorted, the VCR will behave as though the tape is at the end. The VCR may refuse to play or go into fast forward, or it might try to rewind as soon as a cassette is inserted. If the sensor on the takeup side fails shorted, the VCR will behave as though the tape is at the beginning; it might refuse to rewind. In both cases, you can sometimes trick the VCR into cooperating and confirming that there is a sensor problem by pulling the connector for the appropriate sensor once the cassette is loaded. If you can get at the connectors, you can test the sensors by monitoring the voltage on their outputs.

One test that you can try if the VCR attempts to play an imaginary pre-recorded tape as soon as power is turned on is to locate the microswitch for record-lockout protection. It will be located near the front (where the record protect tab would be when the cassette is loaded). Press it in while you turn the power on. If the VCR initializes and displays cassette-in without trying to play, then it obviously thinks that there is a cassette in place. This is most likely due to a faulty sensor. In some cases, other problems like a faulty mode switch or microcontroller can produce symptoms that might be mistaken for faulty start/end sensors.

Start/End Sensor Testing

The start and end sensors are usually a combination of a light source (IR LED) and an IR photodiode. With a little effort, these can be tested for functionality.

- *For an incandescent lamp* (older VCRs), check to see if it lights when power is on; if not, the lamp is most likely burnt out. Test it with an ohmmeter.
- *For an IR emitter*, use an IR detector or an IR detector card to determine if the LED is operating. You can also try powering the IR LED with a low-

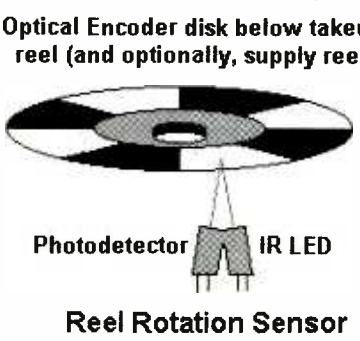

Fig. 2. Reel sensors.

voltage supply through a 500-ohm or so resistor. Then use the IR detector to see if the LED works. Don't forget to disconnect it from the circuitry first! Try both polarities to be sure you got it right.

To test the sensors themselves, disconnect them from the circuitry and shine an IR source on them (an IR remote control or an incandescent lamp) while monitoring the resistance with an ohmmeter. Use the polarity that gives the higher reading (reverse bias). This resistance should drop dramatically if they are functional.

If the start and end sensor assemblies are interchangeable, swap them. If the symptoms shift from play to rewind or vice versa, one of the sensors is bad.

Tape Counters

There are two kinds of tape position counters: *reference* and *real-time*. What I call a reference counter is what all VCRs used up until a few years ago. A sensor counts revolutions of the takeup reel (usually) either directly or with a belt drive. A mechanical or electronic counter displays an arbitrary number that provides some idea of how much tape has been used. Since the rotation rate of the reel is not constant with respect to the actual time of the tape, it is not possible to use this for anything other than a reference. In addition, the tape may slip a bit and be wound tighter or looser depending on whether it was wound in play, fast forward, or rewind. Thus, even the reference is not accurately repeatable.

Common failures are a broken or weak belt for the mechanically operated counter or defective circuitry for the electronic display. A failed sensor would most likely also cause the VCR to shut down and unload the tape. This happens because the sensor confirms that the takeup reel is rotating and that tape is not spilling into the bowels of the VCR.

Real-time counters—which really are a vast improvement—operate off the control track pulses from the control head. Tape location is measured in hours, minutes, and seconds, though it is still a relative indication and must be reset at the beginning of the tape if an absolute location is to be determined. The only disadvantages of real-time counters are that:

- *They do not operate with a new or bulk erased tape* since there is no control track. Consequently, it is not possible to leave a specific length section of such a tape unrecorded by using the counter to space over it. You must lay down a control track first by recording something—anything—for the time you want. However, be sure to use a valid video source so the sync pulses occur with the proper timing.
- *The tape must be in contact with the control head* for all operations. In principle, this results in more head (and tape) wear, though I know of no cases of the head stack requiring replacement because of this design.

Failure of the real-time counter on a VCR that otherwise works normally is quite unlikely and is probably an electronic problem since the control head must be functional for all record/play modes to work properly. However, it is possible that a half-loading arm that fails to fully extract the tape would result in problems in (non-search) fast forward or rewind modes.

Reel-Rotation Sensors

Reel rotation is usually detected by optical sensors that are positioned under the reels (see Fig. 2). Some older VCRs may use mechanical or optical interrupters driven off belts from the reel spindles. There will always be a takeup reel sensor—even on a VCR that has a real-time counter. It serves two functions: (1) confirm that the reel is rotating and that tape is not spilling into the bowels of the machine and (2) operate the (non-real-time) tape counter. If this sensor fails, the VCR will shutdown almost immediately and will result in a stuck tape counter.

Some VCRs have a similar sensor on the supply reel. The output from this sensor can be used to confirm proper rotation of both reels during modes involving tape motion as well as during the tape load and unload operations. Exactly when each is used will vary by design.

If your VCR has identical sensors monitoring both reels, swapping the sensor assemblies may be a useful test. The behavior will change if one is bad. For example, a VCR that would shut down in a couple of seconds in play mode may, after you switch sensors, continue to operate correctly but now have problems with rewind.

Some fancier VCRs will display an estimate of tape remaining using the difference in rotation rates of the supply and takeup reels based on assumptions about tape thickness, hub size, and total length (which you may have to tell it). Sometimes, reel-rotation sensor problems are simply due to accumulated dirt on the reflective surfaces. So always clean them before going further. Sometimes, replacement sensors will be needed. If this happens, replace both sides where appropriate—most of the cost will be your time. The sensors themselves are relatively inexpensive.

Note that on VCRs with real-time counters, the real-time display, as well as possibly the tape movement sensing, operates off the A/C head-control pulses. Failure here could be caused by dirt, a bad A/C head, tape-path alignment problems, or the failure of a half-loading arm to properly extract the tape so that it contacts the A/C head.

Reel-Rotation Sensor Testing

The counters on some VCRs are active at all times; if you rotate the appropriate reel, the counter will change. Counting up or down depends on its default mode; the direction of rotation probably will not matter. If your VCR is of this type, testing is particularly easy. Slowly rotate the takeup reel by hand; some models might use the supply reel instead. The numbers should change several times—probably four—per revolution. There should be no missed counts and there should be no positions where the counter free runs—where the display increments or decrements on its own very quickly. Any of these symptoms could indicate a problem with the sensor or LED, a buffer amplifier, bad connection, or the microcontroller or other IC that actually drives the counter and display.

For electrical tests, first locate the LED and photodiode. You can tell which is which by testing with a meter

on its "diode-test" scale. The LED will have the higher forward-voltage drop. Sometimes, you may even find that the connections are marked.

Momentarily insert and remove a resistor (1000 ohms or so should work) across the sensor leads. If needed, put the VCR in play mode and make the test before it quits. This should make the counter change if the LED is bad or the photodiode is open. Alternately, a remote control may be able to activate it, providing pulses that will look to the counter exactly like reel rotation. If this has no effect, unsolder the sensor (or unplug the sensor assembly from the main board if there is a connector) and try the resistor across the terminals where it was connected. If you now get a response, the sensor was shorted (or the connection was bad).

If you do not get the counter to change in either case, the problem probably lies with an intermediate buffer amplifier, the electronics on the main board, or a bad connection leading to the main board. You will need to obtain the service manual or trace the circuit leading to where the sensor signal is detected to proceed. It is possible that the counter will only change when the microcomputer expects the reel to be moving, so any tests made while the VCR is in its stop mode may not be valid.

An alternative test is to use an ohmmeter set on its high-ohms scale across the photodiode. Use the polarity that gives the higher resistance and shine a light on the sensor. The resistance should drop dramatically when the sensor is exposed to a bright incandescent light (these put out a good amount of IR). If it is infinite in both directions, the photodiode is open. If it is low in both directions, it is shorted. You may be able to make a measurement while the sensor is still in circuit, though other components may mask the resistance change. As noted, the IR sensor/LED combination is often a plug-in assembly. For example, my meter read infinite resistance with no light and 200 ohms with a bright light on a photosensor. Of course, your mileage may vary.

If you have an oscilloscope, use it to monitor the sensor output. If there is a voltage signal at this point (likely), then you should see it go high and low as you rotate the reel or shine light on it. With the reel rotating, the low and high periods should be roughly equal. There might be a buffer amplifier that is driven by the sensor. Check its output as well. The signal there should be a cleaned-up version (low-pass filtered and possibly inverted) of the sensor output. In all cases, the signal should be a DC value without noticeable ripple or noise (block external light as fluorescent lamps in particular may add a 120-Hz ripple to your detected signal). Even at the low-to-high or high-to-low transitions, the level should change smoothly. You might be able to trace the signal to its final destination such as the microcontroller or other large multilegged part and monitor it there as well.

Play a T120 tape recorded at EP speed near the end of the tape. This will result in the slowest takeup reel rotation. If your VCR has the counter active in stop mode with the cassette out, rotate the takeup reel by hand very slowly. If the counter skips or 'free runs' at certain positions of the reel, there may be a problem with the hysteresis circuit. If this is external to the microcontroller, a resistor may have opened or there may be some other easily identified bad component. If it is internal to the microcontroller—either an actual circuit or firmware—replacing the microcontroller may be the best solution. In some cases, you might need to add your own circuit; I have done this to repair a Sears VCR with an erratic counter problem. It is a simple 1- or 2-transistor circuit depending on what external circuits are already present.

Monitor the sensor output when rewinding a T120 tape to the very end—this will be the worst-case test as the pulses will be at the highest rate. There should be no missing pulses and the high and low times should still be similar. A bad sensor might result in unequal high and low times and dropped pulses at high speed.

That's it for now. Next time, I promise we will go on to general control system problems like "My VCR totally ignores me!" 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

ROBOTICS WORKSHOP

GORDON MCCOMB

Running Robots with DC Motors

Direct current (DC) motors are the mainstays of robotics. A surprisingly small motor, when connected to wheels through a gear-reduction system, can power a 25-, 50-, or even a 100-pound robot. A flick of a switch, a click of a relay, or a tick of a transistor, and the motor stops in its tracks and turns the other way. A simple electronic circuit enables quick and easy control over speed—from a slow crawl to a fast sprint.

This column shows you how to apply open-loop continuous (as opposed to stepping or servo) DC motors to power your robots. The emphasis is on using motors to propel a robot across your living room floor, but you can use the same control techniques for any motor application, including gripper closure, elbow flexion, and sensor positioning.

The Fundamentals of DC Motors

There are many ways to build a DC motor. By their nature, all DC motors are powered by direct current—hence the name *DC*. This is as opposed to alternating current (AC), used by most motorized household appliances. By-and-large, AC motors are less expensive to manufacture than DC motors; because their construction is simpler, they tend to last longer than DC motors.

Perhaps the most common form of DC motor is the permanent magnet type, so-called because it uses two or more permanent magnet pole pieces (called the *stator*). The turning shaft of the motor, or the *rotor*, is composed of windings, which are connected to a mechanical commutator. Internally, metal brushes supply the contact point for the current that turns the motor.

Other types of DC motors also exist, including the series-wound (or universal) and shunt-wound DC motor. These differ from the permanent magnet motor in that no magnets are used; instead the stator is composed of windings which, when supplied with current, become electromagnets.

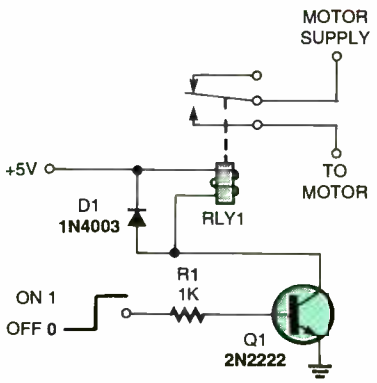

Fig. 1. This basic circuit uses a relay to turn a motor on and off. The input signal is TTL/microprocessor compatible.

One of the prime benefits of most, but not all, DC motors is that they are inherently reversible. Apply current in one direction (the + and - on the battery terminals, for example), and the motor may spin clockwise; apply current in the other direction, and the motor spins counter-clockwise. This capability makes DC motors well suited for robotics, where it is often desirable to have the motors reverse direction.

DC Motor Ratings

Here are some things to keep in mind when considering a DC motor for your robot:

- DC motors can often be effectively operated at voltages above and below their specified rating. If the motor is rated for 12 volts and you run it at 6 volts, odds are the motor will still turn, but at reduced speed and torque. Conversely, if the motor is run at 18 to 24 volts, but run at 12 volts, the motor will turn faster and will have increased torque. This does not mean that you should intentionally under- or over-drive the motors you use. Significantly over-driving a motor may cause it to wear out faster than normal. The motor will heat up more than its design criteria, or its mechanical bearings and bushings may not be able to handle the increased speed. However, it's usually fairly safe to run a 10-volt motor at 12 volts or 6-volt motor at 5 volts.
- DC motors draw the most current when they are "stalled." Stalling occurs if the motor is supplied current, but the shaft does not rotate. Any battery, control electronics, or drive circuitry you use with the motor must be able to deliver the current at stall.
- DC motors vary greatly in efficiency. Many of the least expensive motors you may find are meant to be used in applications (like automotive) where brute strength, rather than conservation of electricity, is the most important trait. As the typical mobile robot is powered by a battery, strive for the most efficient motors you can get. It's best to stay away from automotive starter, windshield wiper, power window, and power seat motors, as these are notoriously inefficient.
- Rotational speed of a DC motor is usually too fast to be directly applied in a robot. Gear reduction of some type is necessary to slow the speed of the motor shaft. Gearing down the output speed has a positive side effect of increasing torque.

Direction Control

As noted above, it's easy to change the rotational direction of a DC motor: simply switch the power lead connections to the battery and the motor turns in reverse. There are a number of ways to accomplish electronic or electrically assisted direction control of motors. All have their advantages and disadvantages. Let's examine the more common approaches.

Perhaps the most straightforward approach to automatic control of DC motors is to use relays. It may seem rather daft to install something as old-

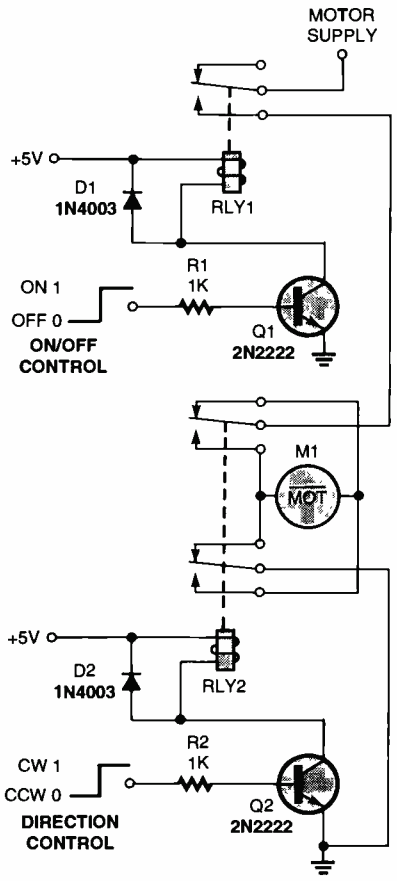

Fig. 2. Both on/off and direction relay controls in one.

fashioned and cumbersome as relays in a hi-tech robot, but it is still a useful technique. You'll find that while relays may wear out in time (after a few hundred thousand switchings), they are fairly inexpensive and easy to use.

Basic on/off motor control can be accomplished with a single-pole relay. Rig up the relay so that current is broken when the relay is not activated. Turn on the relay and the switch closes, thus completing the electrical circuit. The motor turns.

Relays can easily be driven by digital signals. Figure 1 shows a driver circuit for a relay-controlled motor. Logical 0 (LOW) turns the relay off; logical 1 (HIGH) turns it on. The relay can be operated from any digital gate, including a computer or microprocessor port.

Controlling the direction of the motor requires a double-pole, double-throw (DPDT) relay, wired in series after the on/off relay described above. With the contacts in the relay in one position, the motor turns clockwise. Activating the relay changes the contact positions, turning the motor counter clockwise. Again, you can easily control the direction relay with digital signals. Logical 0 makes the motor turn in one direction (let's say forward), and logical 1 makes the motor turn in the other direction. Both on/off and direction relay control is shown combined in Fig. 2.

You can quickly see how to control the operation and direction of a motor using just two data bits from a computer. Since most robot designs incorporate two drive motors, you can control the movement and direction of your robot with just four data bits. When selecting relays, make sure the contacts are rated for the motors you are using. All relays carry contact ratings, and it will vary from a low of about 0.5 amp to over 10 amps, at 125 volts. Higher capacity relays are larger and may require bigger transistors to trigger them (the very small reed relays can often be triggered by digital control without the addition of the transistor).

Bipolar Transistor Control

Bipolar transistors provide true solid-state control of motors. For the purpose of motor control, you use the bipolar transistor as a simple switch. By the way, I'm making the distinction of a *bipolar* transistor, as there are numerous kinds of transistors you can use, including the field-effect transistor, or FET. In fact, we'll talk about FETs in the next section. For the remainder of this section, we'll just drop the "bipolar."

There are several ways to implement transistor control of motors. One common approach is to use the H-bridge network, as shown in Fig. 3. This is a simplified H-bridge; some designs get quite complicated. However, this one will do for most basic hobby-robot applications. The H-bridge is wired in such a way that only two transistors are on at a time. When transistor 1 and 4 are on, the motor turns in one direction. When transistor 2 and 3 are on, the motor spins the other way. When all transistors are off, the motor remains still.

Note the resistor used to bias the base of each transistor. These are necessary to prevent the transistor from pulling excessive current from the gate controlling it (computer port, logic gate, etc.). Without the resistor, the gate would overheat to destruction. The actual value of the bias resistor depends on the voltage and current draw of the motor, as well as the characteristics of the particular transistors used. For ballpark computations, the resistor is usually in the 1K to 3K range. You can calculate the exact value of the resistor using Ohm's Law, taking into consideration the gain and current output of the transistor; you can experiment until you find a resistor value that works. Start high and work down, noting when the controlling electronics seem to get too hot. Don't go below 1K.

The choice of transistors should comply with some general guidelines. First, they must be capable of handing the current draw demanded by the motors, but the final choice of exact transistor to use will largely depend on your application and your design preference. Most large drive motors draw about 1-2 amps continuous, so the transistors you choose should be able to handle this current. This immediately rules out the small signal transistors, which are rated for no more than a few hundred milliamps.

A good NPN transistor for medium-duty applications is the TIP31, which comes in a TO-220 style case. Use it

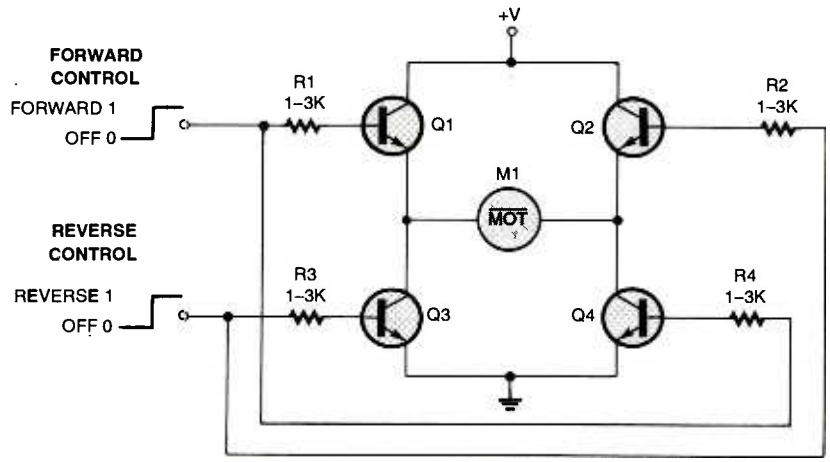

Fig. 3. Four NPN transistors connected in an "H" pattern can be used to control the direction of a motor. The power supply is single ended.

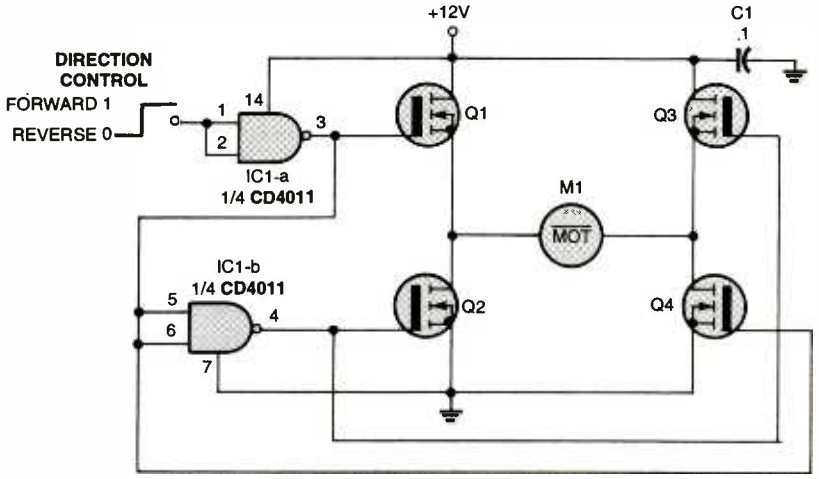

Fig. 4. Four N-channel power MOSFET transistors in an "H" pattern can be used to control the direction of a motor. In a circuit application such as this, MOSFET devices do not strictly require biasing resistors, as do standard transistors.

with a suitable heat sink. For high-power jobs, the NPN transistor that's almost universally used is the 2N3055 in the TO-3 case. Again, mount the transistor on a heat sink.

Another popular transistor to use in H-bridges is the TIP120, which is a Darlington transistor. Internally it's actually two transistors: a smaller "booster" transistor and a larger power transistor. The TIP120 is preferred because it can be easier to interface with control electronics. Some transistors, like the 2N3055, require a hefty amount of current in order to switch, and not all computer ports can supply this current. If not using a Darlington like the TIP120, it's sometimes necessary to use small signal transistors (the 2N2222 is common) between the computer port and the power transistor.

Remember that with most power transistors, the case is the collector terminal. This is particularly important when there is more than one transistor on a common heat sink, and they aren't supposed to have their collectors connected together. It's also important when that heat sink is connected to the grounded metal frame of the robot. You can avoid trouble by using the insulating washer provided in most transistor-mounting kits.

The power leads from the battery and to the motor should be 12- to 16-gauge wires. Use solder lugs or crimp-on connectors to attach the wire to the terminals of T0-3 style transistors. Don't tap off power from the electronics for the driver transistors; get it directly from the battery or main power distribution rail.

Power MOSFET Control

Wouldn't it be nice if you could use a transistor without bothering with bias resistors? Well, you can, as long as you use a special brand of transistor, the power MOSFET. The MOSFET part stands for *m*etal-*o*xide *s*emiconductor *f*ield-*e*ffect *t*ransistor. The power part means you can use them for motor control without worrying about burning them, or the controlling circuitry, up in smoke.

MOSFETs physically look a lot like transistors, but there are a few important differences. First, like many CMOS ICs, it is entirely possible to damage a MOSFET device by zapping it with static electricity. When handling it, keep the protective foam around the terminals. Further, the names of the terminals are different from transistors. Instead of base, emitter, and collector, MOSFETs have a *gate*, *source*, and *drain*. You can easily damage a MOSFET by connecting it in the circuit improperly. Always refer to the pin-out diagram before wiring the circuit, and *double-check* your work.

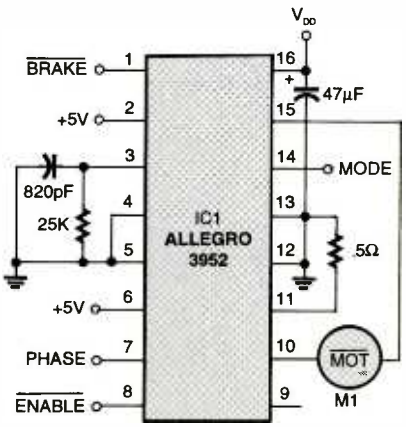

Fig. 5. The Allegro 3952 is one of several all-in-one H-bridge motor-control ICs.

A commonly available power MOSFET is the IRF-5xx series (such as the IRF-520, IRF-530, etc.), from International Rectifier, one of the world's leading manufacturers of power MOSFET components. These *N-channel* MOSFETs come in a T0-220-style transistor case and can control several amps of current (when on a suitable heat sink). A very basic circuit that uses MOSFETs is shown in Fig. 4. Note the similarity between this design and the transistor design on Fig. 3.

An even better H-bridge using power MOSFETs uses two N-channel MOSFETs for the "low-side" of the bridge, and two complementary *P-channel* MOSFETs for the "high side." I won't get into the details about why this is better (the subject is adequately addressed in many books and Web sites). The use of complementary MOSFETs allows all four transistors in the H-bridge to turn completely on, thereby supplying the motor with full voltage.

Motor Bridge Control

Control of motors is big business, and it shouldn't come as a surprise that dozens of companies offer all-in-one solutions for controlling motors via fully electronic means. These products range from inexpensive $2 integrated circuits to sophisticated modules costing tens of thousands of dollars. Of course, we'll confine our discussion to the low end of this scale.

The basic motor control is an H-bridge, as discussed above, all in one integrated circuit package. Bridges for high-current motors tend to be physically large, may come with heat fins, or have connections to a heat sink. A good example of a motor bridge is the Allegro Microsystems 3952, which provides in one single package a much improved version of the H-bridge circuit. A typical working circuit using the 3952 is shown in Fig. 5.

Motor control bridges have two or more pins on them for connection to control electronics. Typical functions for the pins are:

- *Motor enable.* When enabled, the motor turns on. When disabled, the motor turns off. Some bridges let the motor "float" when disabled; that is, the motor coasts to a stop. On other bridges, disabling the motor causes a full or partial short across the motor terminals, which acts as a brake to

(Continued on page 69)

CHARLES D. RAKES

Light-Emitting Diodes For Fun and "Prophet"

Just about every electronic device produced today contains some type of LED indicator. Those solid-state light sources can tell us a lot about what is going on inside a piece of equipment, even if it's just a simple green LED to indicate that the power is on. Many times, LEDs mark other operational functions by the various colors used. The two most popular (as well as least expensive) LED colors are red and green. Other available colors include yellow, orange, blue, and white—the last two being perhaps the most costly. Other LED packages are also available. One type has two or more different color LEDs in a single package; the red/green combination is the most common and the most popular. Many other types are also available including the jumbo, superbright, and blinking varieties.

This month, we're going to look at a number of very basic and simple LED circuits that explore ways to increase the normal light output when they are first turned on. In addition, I will show you some light-sensing circuits. So dig into your scrap box, locate some LEDs to work with, and off we will go!

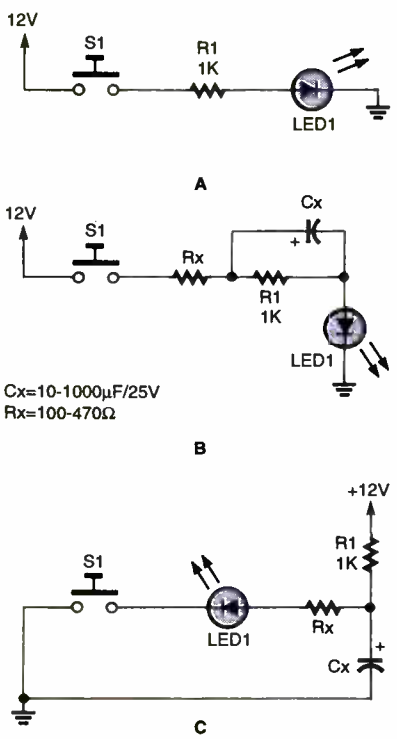

Fig. 1. The most basic circuit for lighting an LED is to simply supply power through a current-limiting resistor (A). To make an LED more noticeable when it first turns on, the circuit shown in (B) will flash the LED once brightly. The circuit in (C) provides a brighter initial flash. In all circuits, the LED remains on as long as power is supplied to it.

Pulse Circuits for a Brighter ON Signal

LEDs that are used as simple on/off indicators are usually connected with a series current-limiting resistor between the LED and the power source, as shown in Fig. 1A. To determine the value of that resistor, use the formula

$$R=E/I$$

where R is the resistance in ohms, E is the voltage, and I is the current in amps. Before doing the math, don't forget to subtract the LED's forward voltage drop (about 2 volts) from the circuit's power-supply voltage.

The LED in Fig. 1A draws 10 mA. That's 12 volts minus the 2-volt forward drop, leaving 10 volts. Divide that by 0.01 (the 10 mA current) for the resistance. Using the formula

$$P=EI$$

we can find the LED's power dissipation (P) in watts. Plug in the voltage and current values of 2 volts and 0.01 amp, and we come up with a power dissipation of 0.2 watts, or 20 mW. This 20-mA is the average current rating of small indicator LEDs. Some of the jumbo LEDs are rated between 40 and 100 mA. You can use these current values as a guide when working with unidentified and unspecified LEDs.

Our first pulse circuit (see Fig. 1B) is created by adding a large electrolytic capacitor in parallel with a 1000-ohm current-limiting resistor. This arrangement feeds the LED a higher initial current pulse when S1 is turned on. The LED's initial current is limited only by the value of Rx. After a short time period—duration depending upon the value of Cx—the LED's current comes down to the value flowing through the series resistance of Rx and R1. If you increase the value of R1, you will decrease the average current flow

PARTS LIST FOR THE SIMPLE LED INDICATORS (FIG. 1)

Cx—10- to 1000-µF, 25-WVDC, electrolytic capacitor
LED1—Light-emitting diode, any color or size
R1—1000-ohm, 1/4-watt, 5% resistor
Rx—100- to 470-ohm, 1/4-watt, 5% resistor
S1—Single-pole, single-throw, normally-open pushbutton switch

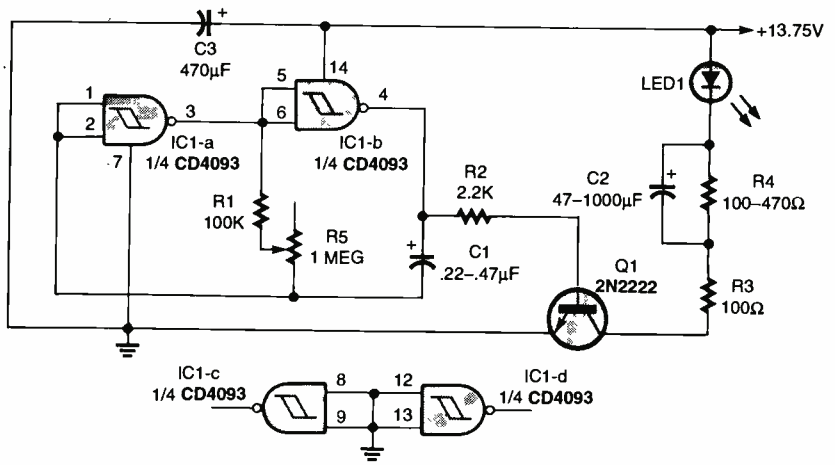

Fig. 2. This flashing LED indicator circuit uses a 4093 CMOS IC to keep the LED pulsing on and off.

PARTS LIST FOR THE FLASHING LED INDICATORS (FIG. 2)

SEMICONDUCTORS

IC1—4093 CMOS, quad two-input NAND Schmitt trigger, integrated circuit
Q1—2N2222 NPN transistor
LED—Light-emitting diode, any type or color

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—100,000-ohm
R2—2200-ohm
R3—100-ohm
R4—100- to 470-ohm
R5—1-megohm potentiometer

CAPACITORS

C1—0.22- to 0.47-µF, ceramic-disc or similar low-leakage
C2—47 to 1000-µF, 25-WVDC, electrolytic
C3—470-µF, 25-WVDC, electrolytic

without affecting the initial current pulse that forces the LED's bright output when it is turned on. Increasing the value of R1 to 10,000 ohms, and paralleling it with a 470-µF, 25-volt electrolytic capacitor produces a bright turn-on effect and a very low average light level.

Our next pulse circuit (Fig. 1C) takes the energy stored in electrolytic capacitor Cx and discharges it through the LED. This produces an initial burst of bright light, and after the capacitor discharges, the current flow through the LED is reduced to the current limited by series resistors R1 and Rx. If we increase the value of R1, the average light output of the LED is reduced. Decreasing the value of R1 will increase the light from the LED. Higher Rx values produce lower current pulses, and lower values produce higher current pulses. If Rx is lowered too far, the LED can draw excess current and might be damaged. Select a value for Rx that allows no more than a 10% increase over the LED's maximum rated current. There is no need or purpose to increase current through the LED once it has reached its maximum light output.

Flashing LED Indicator

Figure 2 shows the circuit of a flashing LED indicator that incorporates a 4093 CMOS quad two-input NAND Schmitt trigger IC and an NPN driver transistor. Two gates of the IC are used; the inputs of the two unused gates are connected to ground. Gates IC1-a and IC1-b form a low-frequency pulse generator whose output drives Q1, a 2N222 transistor. Transistor Q1's collector feeds an LED pulse circuit similar to the one in Fig. 1B, replacing the manual switch we used in Fig. 1B. Each time the output of IC1-b goes positive, Q1's collector pulls to ground, charging C2 and causing the LED to flash.

The LED's flash rate is set by R5. Its frequency varies from less than one cycle per second to several cycles per second. You can change the oscillator's frequency range by changing the value of C1. Increase the value to slow the flashing and decrease its value to speed up the flash rate.

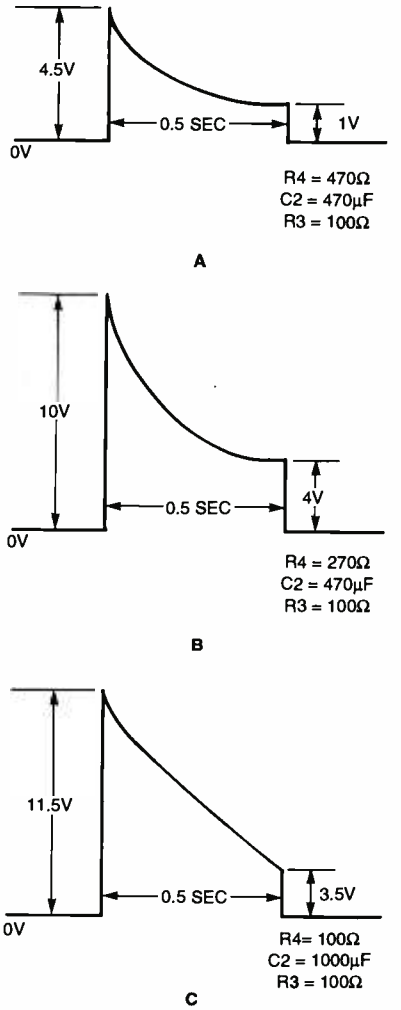

Fig. 3. As you can see from these waveforms, substituting different values for R3, R4, and C2 in Fig. 2 changes the characteristics of the pulse, and therefore the flash pattern, of the LED.

The waveform of the pulse circuit that comes through R3 and the LED is shown in Fig. 3. The values for R4 and C2 in Fig. 3A deliver an LED pulse current of about 45 mA and a sustained current of 10 mA. Use the values in Fig. 3B to increase the pulse current to about 100 mA. If you use the values in Fig. 3C, the pulse current will exceed 110 mA.

If you want to use the capacitor-discharge circuit that we looked at in Fig. 1C, use the circuit in Fig. 4 in place of the output circuit in Fig. 2. Now, when Q1's base is driven positive, its collector switches to ground, discharging C1 through R2 and the LED. This produces an initial bright LED output pulse. The value of R2 sets the maximum output pulse current. The value of C1 sets the length of the pulse.

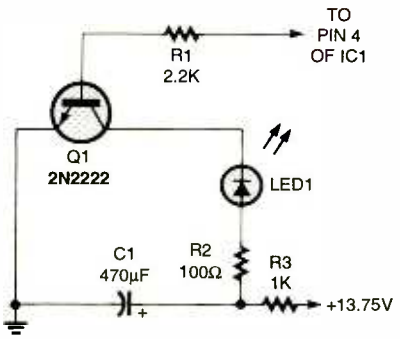

Fig. 4. Adding a capacitor-discharge circuit to the output circuitry of Fig. 2 gives the LED an initially bright flash each time it turns on. This modification only works for low pulse rates.

PARTS LIST FOR THE CAPACITOR-DISCHARGE CIRCUIT (FIG. 4)

C1—470-µF, 25-WVDC, electrolytic capacitor
LED1—Light-emitting diode, any type or color
Q1—2N2222 NPN transistor
R1—2200-ohm, 1/4-watt, 5% resistor
R2—100-ohm, 1/4-watt, 5% resistor
R3—1000-ohm, 1/4-watt, 5% resistor

PARTS LIST FOR THE HIGH-PULSE-RATE LED FLASHER (FIG. 5)

SEMICONDUCTORS

IC1—4093 CMOS quad two-input NAND Schmitt trigger, integrated circuit
Q1—2N2222 NPN transistor
Q2—2N3906 PNP transistor
LED1—Light-emitting diode, any type or color

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—1-megohm
R2—10,000-ohm
R3, R4—2200-ohm
R5, R6—100-ohm
R7—10-megohm potentiometer

CAPACITORS

C1—0.22-µF, ceramic disc or other low-leakage
C2, C3—470-µF, 25-WVDC, electrolytic

Try a Transistor Switch

The circuit in Fig. 2 works fine at low pulse rates. However, if the rate is increased to a point where C2 cannot fully discharge through R4 between pulses, the output cannot reach its maximum output level. To solve this problem we turn to the circuit in Fig. 5. It uses a transistor switch to replace the capacitor's charging/discharging resistor. Here we use three gates of the CMOS 4093. Again, the inputs to the unused gate are connected to ground. In this circuit, one of the unused gates is in a PNP switching transistor driver. The frequency-determining component values are different from those we used in the circuit of Fig. 2, but either set of circuit values will work.

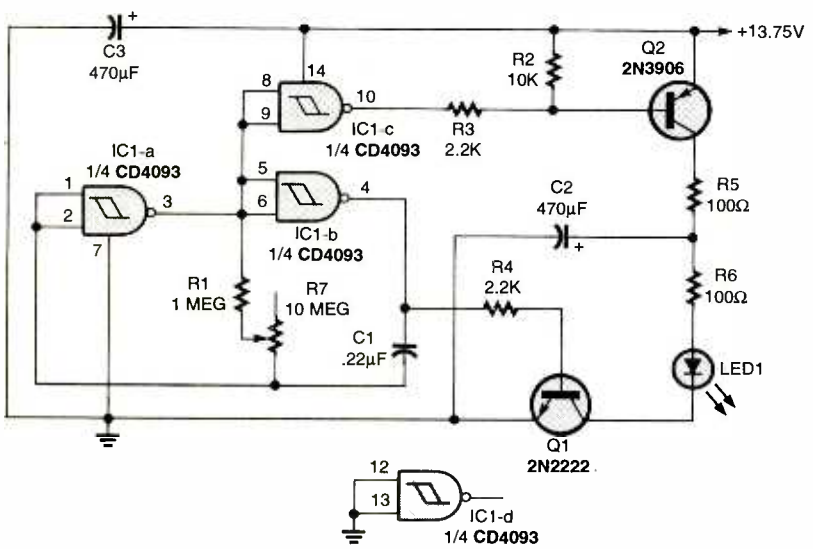

Fig. 5. For higher pulse rates, a transistor switch replaces the capacitor in the output portion of the circuit of Fig. 4.

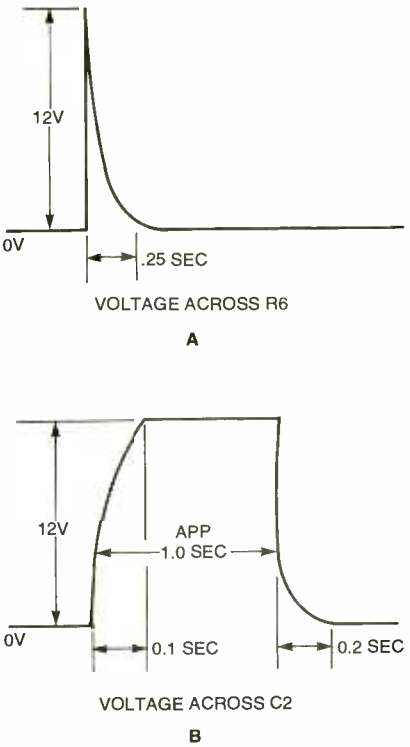

Fig. 6. Here's what the waveforms look like when C2 is discharged across R6 (A). The full charge/discharge waveform for C2 is shown in (B).

Here's how this circuit operates. When the output of IC1-a goes high, the outputs of IC1-b and IC1-c both go low. The low output of IC1-b keeps Q1 turned off, allowing no current to flow though LED1. At the same time, the low output of IC1-c pulls the base of Q2 to near ground, causing it to turn on. This ties C2 to the positive supply through current-limiting resistor R5, charging C2 to near supply level. When the output of IC1-a goes low, the outputs of IC1-b and IC1-c both go high; IC1-c's positive output turns Q2 off and disconnects C2 from the power source. IC1-b's positive output turns Q1 on, discharging C2 through LED1, producing a bright pulsed output. Between pulses, LED1 is turned off, producing no light.

The pulse current waveform is shown in Fig. 6A; Fig. 6B shows the charging voltage waveform across C2. The voltage across R6 reaches 12 volts, producing a pulse current of about 120 mA. The pulse-current level can be adjusted by increasing or decreasing the value of R6. Increasing the value of R6 will decrease the pulse current, while decreasing R6's value will increase the pulse current.

Consider using one of these LED pulse circuits in your next project, or

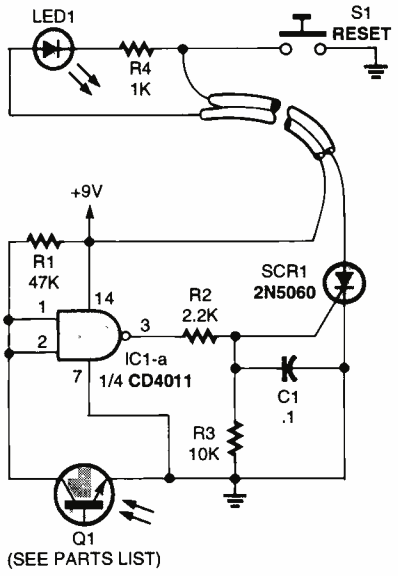

Fig. 7. This light detector turns on a remote LED to warn you of an intruder.

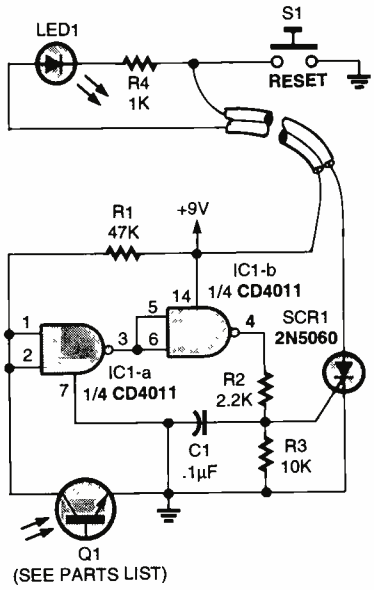

Fig. 8. If you want to know if the lights went out while you weren't around, use this variation of Fig. 6.

PARTS LIST FOR THE LIGHT-DETECTOR CIRCUIT (FIG. 7)

SEMICONDUCTORS

IC1—4011 or 4093 CMOS quad two-input NAND gate, integrated circuit
LED1—Light-emitting diode, any type or color
Q1—Any NPN phototransistor
SCR1—2N5060, 2N5061, or similar 0.8-amp silicon-controlled rectifier

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1—47,000-ohms
R2—2200-ohms
R3—10,000-ohms
R4—1000-ohms

ADDITIONAL PARTS AND MATERIALS

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

PARTS LIST FOR THE LIGHT-ABSENCE DETECTOR CIRCUIT (FIG. 8)

SEMICONDUCTORS

IC1—4011 or 4093 CMOS quad two-input NAND gate, integrated circuit
LED1—Light-emitting diode, any type or color
Q1—Any NPN phototransistor
SCR1—2N5060, 2N5061, or similar 0.8-amp silicon-controlled rectifier

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1—47,000-ohms
R2—2200-ohms
R3—10,000-ohms
R4—1000-ohms

ADDITIONAL PARTS AND MATERIALS

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

build one of the circuits we have discussed just for fun. While you're experimenting, see what improvements you can make.

Snoop Detector

Have you ever wondered if someone has been snooping in your room, closet, desk, or any other private enclosed area? If you answered yes, then you might be able to use one of the following light-detector circuits to alert you when your privacy has been breached. Our first light-detector circuit is in Fig. 7. It is set up to detect light entering a dark room, closet, or whatever. The indicator LED and reset button should be located outside the area being monitored and out of sight. If anyone opens a door, a drawer, or lets light into the monitored area, the circuit turns the LED on, and it remains lit until the circuit is reset. This tattletale will not tell you whom the culprit was, but will tell you that someone was there.

Here's how this circuit works. Transistor Q1 is placed in a dark area. It is turned off as there is no light, and the voltage at the inputs to IC1-a is a positive 9 volts. The inputs of all unused sections of IC1, a CMOS 4093, must be connected to ground. The gate's output is at ground and produces zero bias current to SCR1. As a result, SCR1 remains off. When enough light hits phototransistor Q1, it turns on. This drops IC1-a's gate voltage to near ground. The gate's output goes high and supplies a positive bias current to SCR1, turning it on and illuminating LED1. SCR1 operates as a memory device and keeps LED1 lit until it is reset with switch S1.

Was the Light Turned Off?

Our final detector circuit, shown in Fig. 8, is a modified version of the circuit we saw in Fig. 7. It tells you if the light in a monitored area has been turned off or otherwise interrupted during your absence. This time, we use two of the four available gates in IC1. The inputs to the unused gates must be connected to ground, just as we have done in all the previous applications.

With sufficient light hitting phototransistor Q1, its output, as well as the output of IC1-b, is low. This keeps SCR1 and the LED turned off. If the light does not reach Q1 for any reason, the gates send a positive voltage to SCR1's gate and it goes on, lighting LED1 in turn. The LED will remain on until the reset switch is activated.

Here's hoping that you will try at least one of the circuits we've looked at this visit and make something useful out of it. Send me your comments and suggestions via e-mail at *cdrakes@ipa.net* or the old slow way at Charles D. Rakes, P.O. Box 445, Bentonville, AR 72712. P

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Q & A

(continued from page 27)

Writing To Q&A

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

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

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

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

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

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

PC KEYBOARD

(continued from page 53)

machine, but I really need a controlled source; another 68HC705 to send out a false parity bit might do the trick. If I ever get around to that particular test, I'll be sure to let you know.

When an error occurs in the parity or stop bit, it's a fair assumption that the rest of the byte has errors as well; ignoring the error and processing the received byte could have unexpected results. Instead, we use the keyboard's resend command (FE) to try again.

Note that the error routine transmits a resend command straight away without waiting for the corrupt transmission to finish. This is not a problem as the keyboard considers any transmission successful if the tenth (parity) bit is sent. If we interrupt the transmission before the parity bit is sent, the keyboard will place the current byte in its buffer for later transmission.

Reading a byte doesn't really require bi-directional data and clock lines. If you can process the byte fast enough, then no handshaking (RTS) signal is required. This means that you no longer need to fiddle with the Data Direction Register. I have successfully done this with a 68HC705, outputting only scan codes on a parallel bus. As you can imagine, you must be quick in order to catch the next transmission.

Writing Bytes to the Keyboard. The following routine given here is a generic one that can be used for your own purposes. During normal execution of this program, the keyboard clock line should be low to prevent data from being sent when the system isn't ready for it. In Listing 7, we take the keyboard clock line low and wait for 64 microseconds. Having that delay might be pointless as the line is already low and probably has been for quite some time, at least since the end of the last transmission or reception.

The program segment in Listing 8 initiates the host-to-keyboard transmission by taking the keyboard data line low and releasing the keyboard clock line. We must then wait for a high-to-low transition on the keyboard clock before we load the first bit onto the keyboard data line.

As you can see in Listing 9, putting the individual bits on the keyboard data line is similar to the read cycle. The X register is used to keep track of the number of bits sent. Also similar to the read cycle, we increment the accumulator so that we can calculate the parity bit later.

After the data bits have been sent, Listing 10 sends the parity bit. Unlike the read cycle, we can't ignore the parity bit. If we do, the keyboard will issue a resend (FE) command if the parity bit is incorrect—a 50% probability!

Once the parity bit has been set and the falling edge of the keyboard clock detected, Listing 11 releases the keyboard data line. We then have to wait for another falling edge of the keyboard clock to see if the Keyboard has acknowledged the byte. The keyboard does that by pulling the keyboard data line low. If it is not low, then the program branches to an error handler. If all has been successful, the keyboard clock line goes low to prevent the keyboard from transmitting.

We have taken a rather harsh approach to handing any transmit errors. Ideally, we should wait for the keyboard to request a resend of the last transmitted byte. What we actually do is to issue a reset to the keyboard—very much like smacking someone in the head for making a mistake. So far, I've never had an error. If this starts to become a problem, then a better error handler could be written.

Happy keyboard interfacing and don't wear out your keyboard! P

ROBOTICS WORKSHOP

(continued from page 64)

stop the motor very quickly.

- *Direction*. Setting the direction pin changes the direction of the motor.
- *Brake*. On bridges that allow the motor to float when the enable pin is disengaged, a separate brake input is used to specifically control the braking action of the motor.
- *PWM*. Most H-bridge motor control ICs are used not only to control the direction and power of the motor, but its speed as well. The typical means of varying the speed of a motor is with pulse-width modulation, or PWM.

The better motor control bridges incorporate overcurrent protection circuitry to avoid damage to itself if the motor pulls too much current and overheats the chip. Some even provide for *current sense*, an output that can be fed back to the control electronics in order to monitor the amount of current being drawn from the motor. This can be useful to determine if the robot is stuck. DC motors will draw the most current when stalled. If the robot catches on something and can't budge, the motors will stop, and the current draw will increase.

Because of the ease with which motor control bridges are used and their relatively low cost, we'll gravitate toward using them over the "discrete" methods discussed. Of course, you're free to use whatever motor control methods you wish.

Some available motor control bridges include the L293D and L298N from SGS-Thomson, the 754410, an improved version of the L293 from Texas Instruments, and the LM18293 from National Semiconductor.

Next month: building "wearable robots." Be sure to tune in for the fun! P

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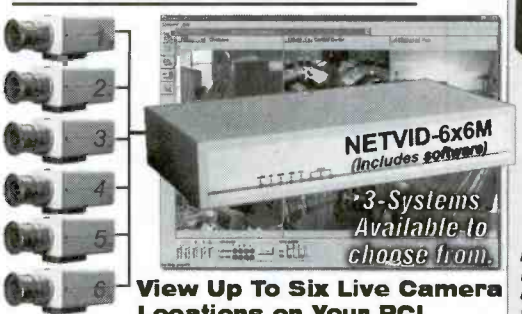

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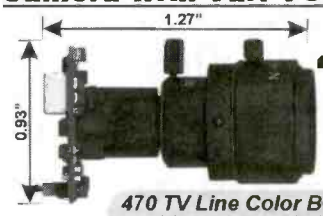
WT-2400 wireless Transmitter $129.95

Camera with Vari-Focal Lens



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- No load current draw: Switch ON : < 0.6 A DC Switch OFF: < 0.2mA DC
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This Power Inverter Handles Temporary High Surge Loads to Start Electric Motors, Water Pumps, TVs and more.

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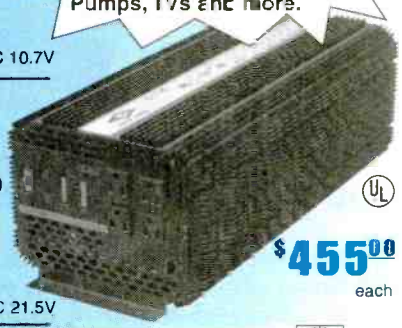
- Output Frequency: 60Hz
- No load current draw: Switch ON : < 0.5 A DC Switch OFF: < 0.2mA DC
- Low battery alarm: audible, DC 21.5V



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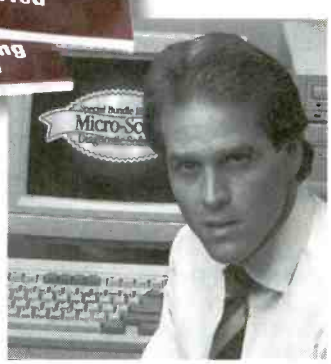

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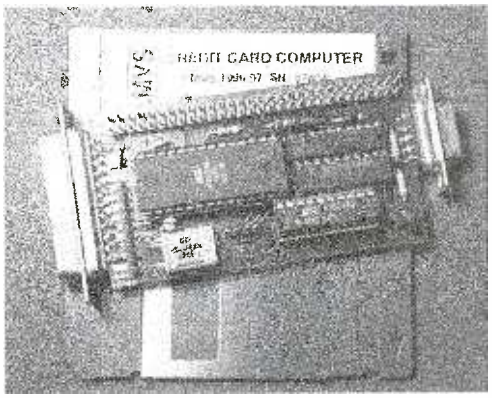

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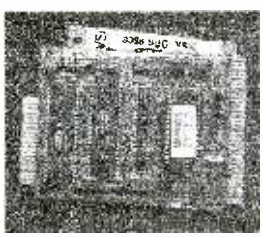

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386 version $42 oem $195 eval

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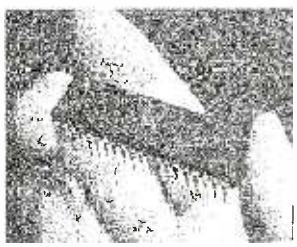

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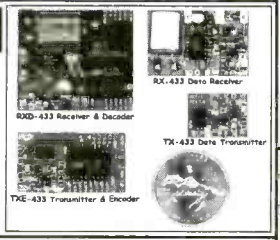
Doppler Direction Finder

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

DDF-1, Doppler Direction Finder Kit $149.95

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

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

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

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!

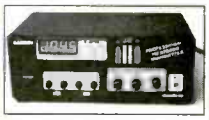
PIC-1, PICPRO PIC Chip Programmer Kit $59.95

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

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

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.

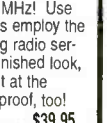
FM-10A, Tunable FM Stereo Transmitter Kit..... $34.95
CFM, Matching Case and Antenna Set $14.95
FMAC, 12 Volt DC Wall Plug Adapter..... $9.95

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

FM Station Antennas



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

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

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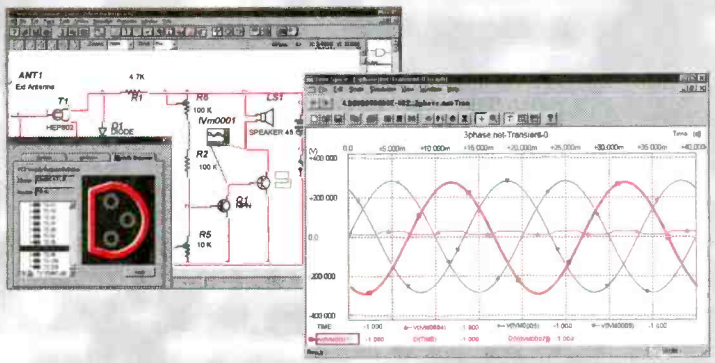

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- Low current - 2.5mA
- Supply 2.5-12Vdc
- 418MHz or 433MHz
- Range up to 300ft
- CMOS/TTL data input
- 7 x 11 x 4mm !

AM-TX1-xxx $12.60

AM Receiver

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- CMOS/TTL output
- Patented Laser Trimmed
- 5Vdc. 0.8mA (HRR6)
- 2kHz data rate
- Sensitivity -105dBm
- 38 x 12 x 2 mm

AM-HRR6-xxx... $16.33

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- Only 23 x 33 x 11mm
- Up to 40,000bps data rate
- Up to 450ft. range.
- 5V operation
- 418MHz or 433MHz FM
- 5V CMOS logic interface
- Fast 1mS enable
- Power saving feature
- Carrier Detect output

BiM-xxx-F $87.36

RS232 Transceiver

- 3wire RS232 interface
- 19.2Kbps half duplex
- 418MHz or 433MHz FM
- 7.5-15Vdc. 20mA
- TX/RX Status LED's
- Up to 400ft. range
- 1/4 wave ant. on board
- User data packetizing
- 58 x 40 x 15mm

CYPHERNET $139.30

AM Transmitter

- Range up to 250ft.
- SAW controlled stability
- Wide supply range 2-14V
- CMOS/TTL input
- Low current. 4mA typ.
- Up to 4kHz data rate
- Small: 17 x 11mm

AM-RT5-xxx $12.10

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- High Withstand Voltage to 400V
- Wide bandwidth & fast sweep
- VERT mode / FIX triggering
- One touch X-Y switching
- Relay attenuator

CS-5355/75 & CS-5370 Features:
- 2% accuracy
- Delay sweep for expanded waveforms
- Reliable relay attenuator
- 3 signals synchronized on V mode

Model	Description	Sale
PCS-4125	20 MHz, 2 ch	$399.00
PCS-4135	40 MHz, 2 ch	$599.00
PCS-5355	50 MHz, 3 ch, delayed sweep	$799.00
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PCS-5370	100 MHz, 3 ch, delayed sweep with readout & cursors	$1,299.00

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FM Transmitters

•Accepts mic level input
•Transmits from 88~108MHz
•Requires single 9~15VDC supply

Description Order #	Mfr. #	Reg.	Sale
FM transmitter 28-4850	FM-1	$14.95	$10.90
High power FM transmitter 28-4851	FM-2	24.95	22.39
Pre-amplifier with compression 28-6230	PM-9	12.50	10.20

Digital Message Recorder

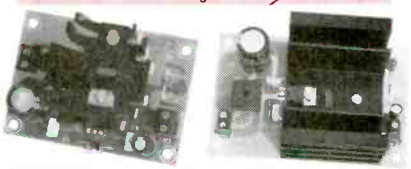
•Records any audio signal •Retains information with power removed •Includes an electret microphone •TR-4 and TR-6 have on-board 5W amplifiers

Description Order #	Mfr. #	Reg.	Sale
16 second 28-4855	TR-1	$34.95	$28.99
16 second with repeat 28-7854	TR-3	39.95	35.90
16 second with repeat 28-7856	TR-4	52.50	47.20
60 second with repeat 28-6245	TR-6	87.95	79.00

Counters

•Up/down count •LED display •Contact closure count and reset input •Requires single 12VDC supply

Order #	Mfr. #	Description	Reg.	Sale
28-5150	CD-3	Three digit	$39.95	$35.50
28-5155	CD-5	Three Digit w/relay output	64.95	58.00
28-4785	CD-9	Two digit	14.95	11.55



DC Power Supplies

•Includes AC transformer •Provides tight voltage regulation •Short circuit protected

Order #	Mfr. #	Output	Reg.	Sale
28-4772	FE-2	12VDC, 300mA	$14.95	$11.85
28-4775	FE-4	12VDC, 1A	19.95	16.70
28-4776	FE-7	24VDC, 1A	24.95	20.65
28-4777	FE-11	12VDC, 2A	34.95	29.95
28-4778	FE-13	12VDC, 5A	49.95	44.50

Audio Pre-Amplifiers

•Use with Cebek or any amplifier with line level input •Operates from a single 6~18VDC supply •Gain adjusted via board-mounted potentiometer

Description Order #	Mfr. #	Reg.	Sale
Microphone preamp, Hi-Z 28-7932	PM-1	$8.39	$6.90
Microphone preamp, Low-Z 28-4805	PM-2	8.95	6.50
Preamp for general use 28-7960	PM-4	8.59	7.09
Electric guitar preamp 28-4815	PM-7	8.95	6.49
Voice activation "VOX" relay 28-4825	PM-11	17.95	13.15

Timer Modules

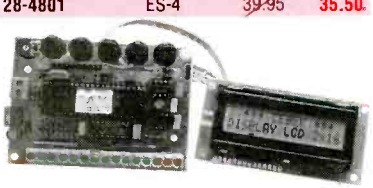
•Operates from a single 12VDC supply •Provides precise time delay for a variety of uses
•SPDT, 5A relay output

Description Order #	Mfr. #	Reg.	Sale
Single event 1~180 second 28-4735	I-1	$17.95	$12.45
Single event 2~45 minute 28-4736	I-2	17.95	12.45
Single event 30~240 minute 28-4737	I-3	18.49	13.85
Repeat cycle 0.3~60 second 28-4740	I-10	18.49	13.85
Repeat cycle 1~30 minute 28-4741	I-11	19.95	17.75
Repeat cycle 20~150 minute 28-4742	I-12	18.95	15.85

Audio Amplifiers

•Perfect for repair and equipment modification •Operates from a single 12VDC supply •Accepts line level input

Description Order #	Mfr. #	Reg.	Sale
0.5W single channel 28-5165	E-13	$7.49	$5.60
1W single channel 28-4795	E-1	7.49	5.60
1W two channel 28-5170	ES-1	14.95	11.25
5W single channel 28-4796	E-2	13.95	10.99
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
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28-6140	EC-2	Two line	99.95	89.95
28-4765	EC-3	Single line	115.00	103.50
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CAT # DCM-154

$2.00 each

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Desktop flip rack keeps all of your important media in one place. CD's 3.5" floppies and ZIP discs all can be stored in the same rack. Outer rails hold 16 CD/CD ROMs. Inner rails hold 20 3.5" floppy discs, or 3 ZIP discs and two M.O. discs. Individually boxed.

CAT# CDB-18M

10 for $30.00

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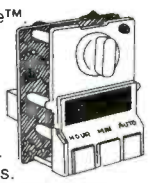
Digital On-Timer



Digital timer from Mr. Coffee™. Small modular design, no brand name or logo. Ideal for use in any product that needs to be turned on automatically at a specific time. Operates on 120 Vac. Switch loads ups to 10 amps. Can be switched manually. White plastic face. 2.48" X 1.77", with four digit LED clock. Overall size: 2.48" X 2.17" X 1.88" deep behind face. 0.25" qc terminals. Easy to connect and operate. Includes instruction sheet.

CAT# MCT-3

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3.15" x 1.41" module size.
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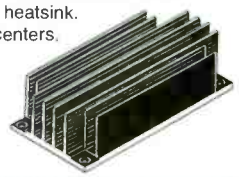

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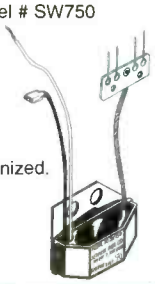

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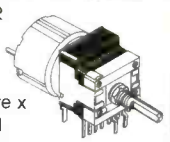

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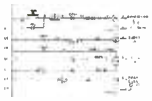

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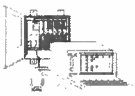

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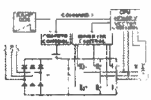

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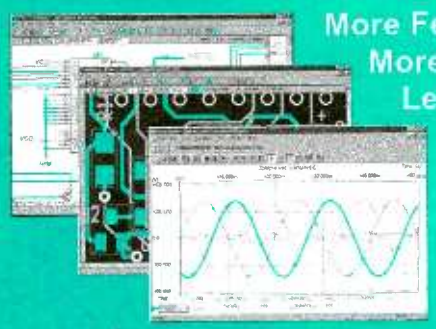

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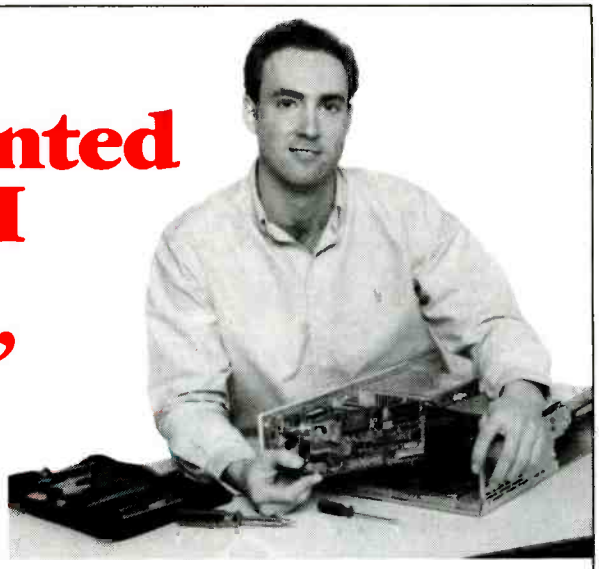

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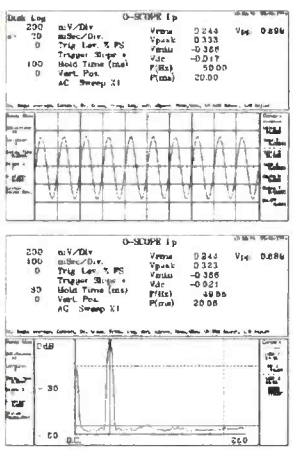

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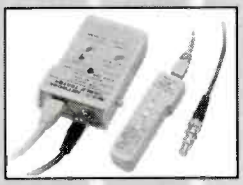

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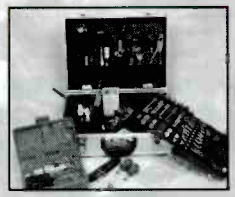

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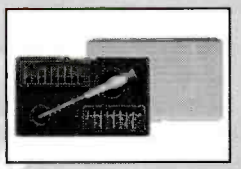

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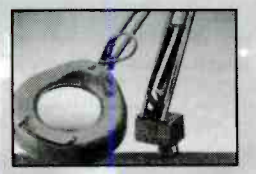

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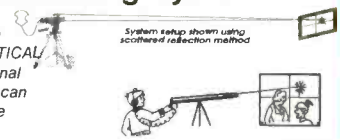

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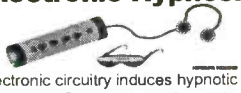

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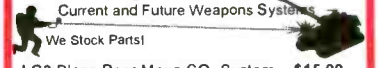

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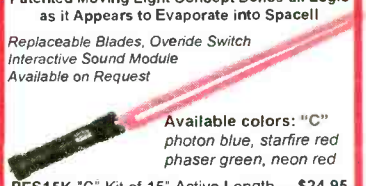

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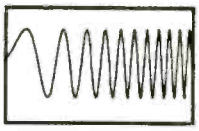
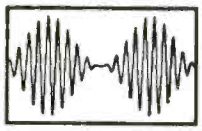


DC to 21.5 MHz linear and log sweeps



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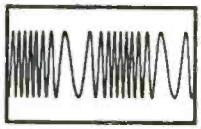
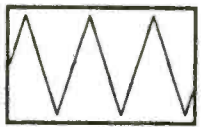


Int/Ext FM, PM, BPSK, Burst



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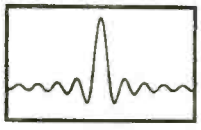
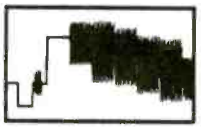
Pulse Generator

Noise



Arbitrary Waveforms



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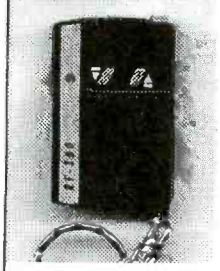

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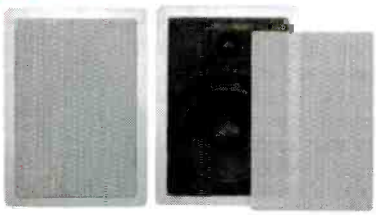

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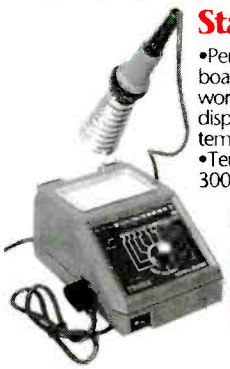

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A great book for project builders. It is quite common to associate the term "Security Devices" with burglar alarms of various types. However in fact it can refer to any piece of equipment that helps to protect people or property. The text is divided into three basic sections: Chapter 1 covers switch-activated burglar alarms and includes exit and entry delays. Chapter 2 discusses other types of burglar alarms and includes Infra-Red, Ultrasonic and Doppler-Shift Systems. Chapter 3 covers other types of security devices such as Smoke and Gas Detectors; Water, Temperature and Baby Alarms; Doorphones, etc. Most circuits are simple, and stripboard layouts are provided.

To order Book BP56 and send $5.99 includes shipping and handling in the U.S. and Canada only to **Electronics Technology Today Inc.**, P.O. Box 240, Massapequa Park, NY 11762-0240. Payment in U.S. funds by U.S. Bank check or International Money Order. Please allow 6-8 weeks for delivery. ET09

ProService Review

July, 2000

LAST ISSUE!

An official journal of NESDA (National Electronics Service Dealers Association), and ISCET (International Society of Certified Electronics Technicians).

VOL. XXVI, NO. 7

PURPOSE

ProService Review, included in each issue of *Poptronics,* is produced by NESDA, the National Electronics Service Dealers Association, 2708 W. Berry St.. Ft. Worth, TX 76109. It is intended for the enlightenment, education and entertainment of the members of NESDA, ISCET, and other ethical professionals engaged in or connected with the appliance, computer, and electronics service industries.

With the exception of official announcements, the statements and opinions expressed herein are those of the authors and not necessarily those of the associations.

Unless otherwise clearly indicated, neither NESDA nor ISCET endorses any company, product or service appearing in any article in this publication.

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Contents

Get Up to Speed with NPSC 2000

The National Professional Service Convention provides up-to-date technical and management training at a more-than-reasonable cost (check the competition). And, in a downsizing profession, it's one place you can get tons of ideas to help keep your service business viable.

by Mary Margaret Merrill

Perhaps you've never heard of the National Professional Service Convention (NPSC). Though this well-kept secret has had a minimum of advertising, it continues to grow in impact each year. NPSC is designed to make technicians more professionally savvy, and service managers get a better handle on their bottom lines.

If you're in the consumer product service industry, NPSC 2000 is a marvelous opportunity to network with others in your profession. Consider this: brainstorming with hundreds of other people with the same business concerns as you. You're bound to get more than a few ideas to help keep your business in the black.

NPSC 2000 will be held August 7-12 at John Ascuaga's Nugget Hotel in Reno, Nevada. There are several different options for registration: (1) you can come on a daily basis; (2) sign up for any three consecutive days and receive a discount; or (3) come for the whole week and get a better discount. Each registration includes admittance to all technical and management seminars, all sponsored meal functions (which actually includes most meals), and entry to the Professional Service Trade Show. This one-of-a-kind exposition offers two full days of exposure to the best in test equipment, service aids, and services for the product servicing professional. You're even invited to have a good time while you're there. And children 17 and under are admitted FREE to all activities (18-year-olds must register as adults).

One of the best values offered to your business by NPSC is the opportunity to exchange ideas with representatives from major manufacturers, as well as with other servicers. Through the Service Information Symposiums, servicers meet with high-level executives to clarify company policies and address other relevant interactive concerns. The Symposiums will be held during the morning hours of Wednesday and Thursday prior to the Trade Show.

Find out from other servicers what works for their businesses and what doesn't. Share ideas for profit potential and the growth of your own business. And, you can always attend the "Best Ideas Panel — The Next Generation," where participants from the audience share their unique business-enhancing strategies. This session has been a hands-down favorite of participants since its inception.

The featured speaker at NPSC 2000 will be Jim Jacobus with Champion Education Resources. Mr. Jacobus will present "Living Life Large — Getting the Most Out of Your Life!" to the General Assembly on Wednesday afternoon. The seminar focuses on "unique, practical and powerful strategies that can help both individuals and organizations reach extraordinary performance levels."

Gerry McCann, McCann Electronics, Metairie LA, is responding to requests for simplified computer usage with his "Cajun Clicker Class 101." Topics will include the internet usage, EDI, printers, scanners, and useful business information for the modern service center operator. Computer experts and Microsoft Engineers may also attend, but are cautioned to sign in and remain silent (and will be heavily fined for any finger pointing or laughing seizures).

A very popular speaker is making an

(continued on PS-4)

National Professional Service Convention2000

and Professional Service Trade Show

John Ascuaga's Nugget Hotel — Sparks (Reno) NV

Register for the Full Convention, Any Three Consecutive Days, or Daily

Complete this form, detach and mail to: NPSC 2000, 2708 W. Berry Street, Fort Worth, TX 76109; 817-921-9061; Fax 817.921.3741; www.nesda.com

Full convention registration includes all programmed meals, banquets, door prize drawings, trade show, dealer/manufacturer meetings, seminars and workshops. Activities may be scheduled for optional participation at an extra cost. There is no convention youth program. However, children 17 and under are free.

NOTE: Special Registration Rates are valid ONLY on registrations ***completed, fully paid and received before the deadlines*** listed. "Three-Day Special" registration is available for any three consecutive days. Children age 17 and under are free. Convention fee schedule per person (ages 18, up):

If registered and fully paid by ...	Full Convention Registration	3-day Special	Daily	Totals:
August 3, 2000	$220	$180	$85	$ _____
At the door	$250	$200	$90	$ _____

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Firm Name _____

Address _____

City _____ State _____

Zip _____ Phone _____

Member of (please check the appropriate boxes below):

☐ NESDA; ☐ ISCET; ☐ PSA; ☐ NARDA/NASD; ☐ Non-Member;
☐ Instructor; ☐ Speaker; ☐ Distributor; ☐ Manufacturer; ☐ Sales Rep;
☐ Press; ☐ Dealer; ☐ Technician; ☐ Other _____

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If registering for a 3-day special, check which 3 days you are registering:

☐ Mon.-Wed. ☐ Tues.-Thurs. ☐ Wed.-Fri. ☐ Thurs.-Sat.

Below, please print legibly ***your*** name, and the names of all other registrants (including nicknames) as they are to appear on the registration badges:

Check box if first NPSC	Full Name *(The one name you want in large letters)*	Badge Name	Youth Ages
☐	_____	_____	_____
☐	_____	_____	_____
☐	_____	_____	_____
☐	_____	_____	_____
☐	_____	_____	_____

Numbers of Participants/Length of Registration

# Adults Full: _____	# Adults 3-Day: _____	# Adults Daily: _____	Total No. of Days: _____
# Children Full: _____	# Children 3-Day: _____	# Children Daily: _____	Total No. of Days: _____

Make your check payable to NESDA

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Special Room Rates: Deluxe room rates at John Ascuaga's Nugget Hotel are $89 single or double; $10 per person over 2 in the same room, max. 4. Children 18 years and under stay free with parents. Rates do not include room tax. Rooms are subject to availability. You may call the Nugget directly to make your reservations at 800-648-1177 (tell them you're reserving under the National Professional Service Convention). ***Due to a city-wide celebration the week prior to NPSC 2000, our room-block does not begin until Sunday, August 6th. Hotel reservations beginning prior to August 6th are on your own. To guarantee a room at John Ascuaga's Nugget Hotel, reservations MUST be made by June 30.***

REFUND POLICY: Register in advance. If find that you have to cancel — any time prior to convention — all money prepaid will be refunded except for a 10% processing fee per registered person.

— Legally Speaking —

Pull Over When Calling

Liability is waiting for you. Company policies should protect your business. One of the featured speakers for NPSC 2000 tells you how.

by Bob Goldberg

The lawyers have found another way to attack your business! An employee, during working hours, is driving his own vehicle but is using his cell phone for company business and is involved in an accident. Is the owner of the business liable?

One Court has said "yes." The employee is working and pursuing company business, thus the employer is responsible for the accident. To protect yourself, it is important to establish a company policy that wireless calls should not be made while driving a vehicle. The employee should park his or her car prior to receiving a call. The following policy should do the trick:

WIRELESS PHONE USAGE WHILE OPERATING A MOTOR VEHICLE
This policy applies to the use of a wireless phone by all employees during working hours.

Any employee who, in the course of performing his or her job functions, finds it necessary to use a wireless phone must do so in a safe and prudent manner. If the employee operates a motor vehicle, the vehicle must be stationary and in "park" before initiating the cellular call. Wireless phone use is never permitted in a moving vehicle. All necessary business calls should be made either before leaving the previous location or after arriving at the next destination. In this regard, the call should be initiated only after the vehicle is stopped and the gear in "park." If a wireless phone call is received while an employee is operating a motor vehicle, the employee should either pull over onto the shoulder of the road and place the vehicle into "park," or preferably, the employee will drive into an appropriate parking location and then place the vehicle in "park" before engaging the phone call. Only business calls are permitted on wireless phones provided to an employee by [COMPANY]. Violation of this policy may result in disciplinary action, up to, and including termination. §

NPSC 2000 Preliminary Schedule

Sunday, August 6
11 am - 5 pm: Registration Desk open
Noon - 6 pm: NESDA Board of Directors meeting

Monday, August 7
8 am - noon, 2 - 6 pm: Registration Desk open
8 am - 8:30 am: First-Timer Orientation
9 am - noon: State/Local Presidents Committee meeting
1 - 5 pm: "PTV Digital Convergence Training," Alvie Rodgers CET, ***Hitachi***
2 - 5 pm: Past Presidents Committee meeting
6:30 - 7:30 pm: Reception, hosted by ***Howard W. Sams Co.***

Tuesday, August 8
7:30 - 8 am, 9:30 - 11 am, 2 - 6 pm: Registration Desk open
7:30 - 8 am: First-Timers Orientation
8 am: Breakfast, hosted by ***NESDA Endorsed Products***
9 am - noon: NESDA Annual Membership meeting
9 am - 12:30 pm: "Multi Audio System Servicing," Gary Backes, ***Philips***
9 am - 12:30 pm: "Digital PTV Convergence Training," George Cawthorne, ***Panasonic***
9:30 am - 4:30 pm: "Digital PTV Convergence Training," Alan Sasaki, ***Pioneer*** *(hands-on, class limited, pre-registration required)*
12:30 pm: Lunch, hosted by ***Wood Technologies, Inc.***
2 - 3:30 pm: "Servicer Summit Symposium," collecting input from NESDA members for discussion at the following Manufacturers/Servicers Summit Meeting.
2 - 6 pm: "Customer Relations for Technicians," Teresa Omar, ***Hitachi***
6:30 pm: Cocktails, hosted by ***Sharp***
7:30 pm: Dinner, hosted by ***Sharp***

Wednesday, August 9
7:30 - 8 am, 4 - 6 pm: Registration Desk open
10:30 am - 3 pm: Registration in Exhibit Area
7:30 - 8 am: First-Timer Orientation
8 am: Breakfast, hosted by ***Pioneer***
9:15 - 10:15 am: Service Information Symposiums *(see separate schedule)*
10:30 am - 3 pm: Trade Show open
3 - 4 pm: NESDA Elections
4 - 5:30 pm: General Assembly; "Living Life Large — Getting the Most Out of *Your* Life!" Featured Speaker: Jim Jacobus, ***Champion Education Resources***
7 pm: Dinner, hosted by ***Sony***

Thursday, August 10
7:30 - 8 am: Registration Desk open
10:30 am - 2 pm: Registration in Exhibit Area
7:30 - 8 am: First-Timer Orientation
8 am: Breakfast, hosted by ***Panasonic***
9:15 - 10:15 am: Service Information Symposiums
10:30 am - 3 pm: Trade Show open
3:15 - 4:15 pm: "Best Ideas Panel — The Next Generation"
4:30 - 5:30 pm: Manufacturer Panel "Addressing Service Concerns," moderated by Glen Finley, *CEA*, VP Member Relations
6:30 - 8:30 pm: Reception, hosted by ***Philips***
9 - 11 pm: NESDA Computer Committee Meeting

Friday, August 11
7:30 - 8 am, 11 am - noon, 3 - 6 pm: Registration Desk open
8 am: Breakfast, hosted by ***Toshiba***
9 am - noon: ISCET Board of Governors meeting
9:30 am - 10:30 am: "Increase Your Profits," Jerry Vogt *(for servicers, mfrs., distributors, elec. claim processors and TPAs.)*
9:30 am - 12:30 pm: CSM Prep Course, Randy Whitehead CSM
9:30 am - 12:30 pm "Digital PTV Convergence Training," John Swendiman, ***Toshiba***
10:30 am - noon: "Cajun Clicker Class 101," Gerry McCann CET/CSM
12:30 pm: Lunch, hosted by ***Thomson***
2 - 3:15 pm: "Customer Service & Relations," Scott Medawar, ***Thomson***
2 - 5 pm: CET/NASTeC/CSM Testing
2 - 6 pm: "Digital PTV Convergence Training," Gary Fadely, ***Thomson***
3:30 - 5 pm: "Stock Trading on the Internet," Bill Kramer, ***Merrill Lynch***
3:45 - 5 pm: "Customer Service & Relations," Scott Medawar, ***Thomson*** *(repeat session)*
7 pm: Dinner, hosted by ***LG/Zenith***

Saturday, August 12
7:30 - 8 am, 11 am - noon, 4 - 6 pm: Registration Desk open
8 am: Breakfast, hosted by ***Hitachi***
9:15 am - 12:15 pm: ISCET Annual Membership meeting
10:30 am - noon: "Negotiate What You Deserve," Bob Goldberg, Attorney
1:30 -3 pm: First-Timer Critique
2 - 3:30 pm: "What Laws Will I Break This Year?" Bob Goldberg, Attorney
2 - 5 pm: NESDA *(New)* Board of Directors meeting
6 pm: Cash Bar Cocktail Party
7 pm: Dinner, "Officers Installation and Awards Banquet"

(NPEC 2000, continued)

encore performance from the 1999 NPSC. Noted attorney Bob Goldberg will begin Saturday morning with "Negotiate What You Deserve." This session is designed to impart the skills needed to fairly get most of what you want in dealings with those whom you must bargain. It will be followed with an afternoon session on "What Laws Will I Break This Year?" Mr. Goldberg reveals many of the "traps" sprung on servicers, how to minimize your exposure to liability, and how to maintain compliance with the law. Managers and owners can also look forward to a session featuring "Stock Trading on the Internet," with Bill Kramer of Merrill Lynch.

Managers who are interested in taking the Certified Service Manager exam will have a morning review session on Friday, August 11, presented by Randy Whitehead CSM. The CSM exam will follow in the afternoon, in conjunction with NASTeC and CET testing. The NASTeC exam is for technicians in appliance repair, while the CET exam is for those in electronics. Both Associate level and Journeyman level tests are available by request, however testing fees are not included in convention registration. For a list of fees, contact NESDA (CSM) at (817) 921-9061, ext. 16, or ISCET (CET and NASTeC) at (817) 921-9101, ext. 19.

For technicians, seminars will be offered on digital convergence by five major manufacturers. "PTV Digital Convergence Training" will be presented by Hitachi's Alvie Rodgers CET on Monday. Then, on Tuesday, George Cawthorne will present the seminar with respect to Panasonic's products. Toshiba's John Swendiman will instruct a product-specific course on Friday, as will Gary Fadely with Thomson. In addition, Pioneer Electronics will feature a "hands-on" course, "HD Projection TV Convergence Procedures," taught by Alan Sasaki. Be sure to pre-register for this class, as space is limited.

Technicians can also look forward to "Multi Audio System Servicing," instructed by Gary Backes of Philips. Many more courses that will be offered had not been confirmed at the time this article was prepared. Be sure to check the NESDA web site, www.nesda.com, for the latest scheduling changes and additions.

THE BIGGEST LITTLE CITY

The stage is being set for NPSC 2000 in Reno, Nevada. Dubbed the "Biggest Little City in the World," Reno was once the site of extensive silver mining fueled by the famous Comstock Lode. Today, Reno is the doorway to the Lake Tahoe area, and home of a substantially good time. There are numerous restaurants, golf and nightly entertainment. Nearby attractions include Wild Island Family Adventure Park, Boomtown Family Fun Center, the Fleishman Planetarium and the National Automobile Museum.

Just a short drive away, in Carson City, you may visit the Nevada State Capital and the Nevada State Railroad Museum. Or, visit Lake Tahoe for a ride on the Paddlewheeler, the Tahoe Gal or the Tahoe Queen for an incredibly scenic view of the area. And, there's the Ponderosa Ranch, a popular movie-set tourist attraction from the TV series "Bonanza."

So even if you come to NPSC 2000 to improve your business, bring your family for some after-hours togetherness. For more information about Sparks, Reno and surrounding areas, contact the Reno-Sparks Convention & Visitors Authority at 775-827-7639; 800-443-1482; or fax 775.827.7666; www.rscva.com.

SAVE MONEY

When it comes to travel, saving money is the name of the game. For convention-goers, this means that you can receive a discount of up to 10% for using either American Airlines or Southwest Airlines, as well as on car rentals through Alamo Rental-A-Car. And, to make the deal a little sweeter, you don't even have to make your own reservations. Just call NPSC's official travel agency, *Conventions in America*, and all your booking needs will be taken care of. For complete details, contact the NESDA office at 817-921-9061, ext. 16. §

Industry Calendar

COMDEX Canada 2000
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— Marketing —

Top Ten Tips on Building a Great Web Site

On the Web, the size of your company is virtual. You can appear as large as you wish, and it all depends on the quality of your web pages, including design and functionality.

by Ed Foster

During the course of an average day, I talk to dozens of web site owners who want to improve their web site's visibility on the search engines. Invariably they will ask the dreaded question "What do you think of my web site?" Sometimes this can be a tough question to answer without hurting somebody's feelings. It's really hard to tell somebody that you've seen better web sites created by ten-year-old girls displaying their Barbie doll collection. This is not the response that they are typically looking for. To prevent others from making the same mistakes I see every day, I created the "Top Ten Tips on Building a Great Web Site." Many of these Tips are very easy and inexpensive to implement and will pay huge dividends down the road.

1. Buy Your Own Domain name and Avoid Virtual Domains.

Buying a domain name for your business is probably the best investment you can ever make in your company's future. Once purchased, this domain will always be the property of your company, and can become a very valuable asset over time. Domains can be obtained through InterNIC (www.internic.net) at a cost of $70 for two years.

On the surface, virtual domains might seem like a "good idea." They are usually much cheaper, or sometimes even free when you sign up your company for web hosting. But their downsides are considerable. Many search engines have trouble adding virtual domains to their databases. This fact alone makes virtual domains a very bad deal. Also, since virtual domains are not internationally registered, your company does not really own a virtual domain.

2. Never use a free web hosting service for your business.

This goes back to the age-old saying, "You get what you pay for." Free web hosting is fine for displaying photos of little Bobby's 2nd birthday party, but if you are really serious about your company's future on the internet, you will need to secure your own domain name and you will need a reputable company to host this domain. Besides who really wants a company URL like http://www.xyzcom.abc/member/123566/shtml/index.html anyway? It doesn't fit on business cards too well. Web hosting prices vary widely but can usually be found in the $10 to $20 per month range for the average business. Do a little research when choosing your web hosting service. In general, I always recommend nationally known companies that specialize in web hosting and that have excellent customer service. Before you sign up, try reaching their technical support personnel during the day. If all you can get is voice mail, then you can be sure that they will not be available when you really need them.

3. Build a Web Site Rich in Content.

The most important thing to remember about first rate web sites is that they are always rich in content. For example, if your site sells Widgets, then include as much relevant information as possible about your widgets on the site. Make it easy to navigate around your site, tell them everything anybody would possibly want to know about why your widgets are best. Finally, make it easy for somebody to buy your widgets online with a minimum of effort.

The first page of your web site is, without question, the most important page of the web site. It should contain enough information so that someone can tell immediately what you do. Make sure that you have a brief paragraph or two that explains your company and products on this crucial page and not just pretty graphics. Your first page should be a concise introduction about your company and products. The details will come in the later pages.

4. Promote Your Site Aggressively.

After you have a great site, tell the world about it. Make sure that your URL is on all your company business cards, letterhead, brochures, phone systems,

(continued on PS-7)

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(Schemes, continued from PS-5)

etc. Start building relationships with other web sites that fit nicely with what you do. For instance, if your site sells the best car wax in the world, locate web sites that sell other non-competing car care products and link to each other's sites. This will build traffic for both sides.

Another way to promote your site is to create an affiliate program for your product. An affiliate program is simply a way of paying a commission to a web site owner that sends you a customer that ends up buying your product. Affiliate programs work very well for products and services that can be bought online with credit cards.

Banner advertising has always been very big on the Internet. When somebody clicks on a banner, they are taken to a web site that tells them more about the product displayed on the banner. Banner ads can work for some products. However, their effectiveness has started to diminish over the last two years. Search Engines are still the best and least expensive way to promote a web site. Most web site owners are completely unaware of how their site is being ranked for the relevant keywords. To generate meaningful traffic, your site must be in the crucial top 20 positions on the major Search Engines for your specific keywords. There are many programs available that will report how your web site ranks on the major search engines for certain keywords. One free program is Tracker 2.0, available at www.top-10.com.

5. Don't Advertise How Small You Are with Web Counters.

Many early web sites used counters that showed how many people had visited the site since a certain date. It was a bad idea then, but I'm still surprised at how many sites still use them. Why in the world would you want to advertise that your site is so poorly marketed that you've only had 362 visitors in the last year? Incredibly, I still see this almost every day.

If your site is doing 1,000,000 hits a day and you really need to advertise this fact, then you should do so. For the rest of you, keep your competition guessing how big you are. Instead of using a web counter, just have your web hosting company provide you with a web statistics page. Web statistics are available from any decent web hosting company, and will provide far more information than you ever wanted to know about the traffic going to your web site.

6. Don't Use Personal Email Addresses on your Web Site.

If you have gone to the trouble of buying your own company domain, why not use this domain in your email? I see so many sites out there that use something like "unclebuck@aol.com" for a contact email address instead of for example a more proper "sales@abc.com" address. This just screams, "I'm an Internet amateur." If you want all the email for a domain to be forwarded to another email address, then simply get your hosting company to forward it. Any good web hosting company will be able to do this and it's usually free!

7. Don't use FrontPage sample web pages for your site.

This causes me to smile every time I see one, because nothing screams "Cheesy" more than a web page that uses the samples from FrontPage. You can spot one of these babies faster than a hooker at an Amish family reunion. Don't get me wrong, there's nothing wrong with designing or maintaining your web site with FrontPage; just don't use the samples that come with it. Spend the time to learn how to either create your own original looking site, or hire a web site designer to design the site using your guidance.

8. Use a reliable web site designer or do it yourself.

(continued on PS-9)

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(Web Design, continued from PS-7)

I'm surprised at how many times customers tell me it will be a while before they can make some changes to their web sites. Most of the time, it's because their niece had originally done their site over a spring break weekend and she's in the middle of finals right now, or some other nonsense. Your web site is very important to your business and should not be created by somebody who will not be immediately available for updates and changes. Make sure that your web site designer will be there for the long haul.

9. Have Good Navigation throughout your site.

Good navigation means using easy to understand menus, and never putting the user into a dead end page. Search engines can send a customer to any page of your site. This is why it is extremely important to make it easy to get back to your home page from any other page on the site.

10. Tell Your Customers How To Reach You.

Great web sites have multiple means for their customers to give them feedback. I remember a distressed web site owner who couldn't understand why he hadn't gotten a single phone call over the last month. After a quick check of his web site, I discovered he didn't have a contact phone number listed on the site. When I clicked on the email link, there was a script error. Apparently he had recently changed his web hosting and never bothered to check his email script. He had a great web site, but no way to make sales or to take customer feedback.

Make sure that your web site has some type of "Contact Us" link that lists your company name, email address, mailing address, phone number, and fax number. People like to be able to talk to somebody on the phone when they have questions. If they can't reach you on the phone, they will move on to a company they can reach.

Always remember that building a successful web site takes time and sustained effort. It is a task that is never quite done because it can always be improved. Following these ten tips is but a first step to making your site stand out from the millions of other web sites.

About the Author: *Ed Foster is the Information Director at Roanoke Technology Corp. He can be reached at 252-537-9222; efoster@top-10.com; www.top-10.com.* §

— Building Your Business —

A Well-Written Business Plan Gives a Sense of Direction

Before you start on a journey, take out the road map and start planning.

by Stephen Wilbers, Ph.D.

If you could look into a crystal ball and see what the future holds for you and your business, what would you see?

Success beyond your wildest dreams? Moderate but sustained growth? Steadily declining sales? Bankruptcy?

Because you can't predict the future, the next best thing is to formulate a carefully considered, thoroughly developed business plan. A plan won't tell you the future. But a plan might give you a hand in shaping that future.

Here are the basic components of a business plan and some tips on how to produce a coherent, effective document:

Executive Summary: Although you will write this overview last, present it first. The purpose of this one-or two-page snapshot is to capture the attention of prospective lenders and investors. Cover in brief the key elements of your plan — a description of your idea, organizational structure, market analysis and strategy, financing, and five-year projection. Make sure your executive summary represents your best, most persuasive writing.

Description of your idea: Your goal in this section is to justify your concept. Explain why the product or service you propose is valuable. Provide technical specifications, list component parts, and describe steps in manufacturing. Identify outside vendors and contractors. Comment on trademarks, copyrights, patents and other aspects involving proprietary protection.

Company structure: Tell who you are, how you are organized and how you operate. In describing the structure of your organization, emphasize the skills of your employees and the experience and expertise of your management team.

Market analysis and marketing strategy: Here is where you convince the reader that your claims are valid. Describe consumer needs and trends, emphasize what makes your product or service unique, link your projection or the market's growth to demographics, point out the advantages of your location, describe your competition, and comment on your strategy for pricing and advertising. Show the reader you've done your homework.

Above all, avoid an error typical among enthusiastic entrepreneurs. As Gustav Berle and Paul Kirschner advise in *The Instant Business Plan,* don't assume that the world is waiting to beat a path to your door. "Sometimes it is; most often it isn't."

Financial planning: Having presented a thorough and realistic assessment of the market, take the same detailed, facts-and-figures approach to describing the financial side of the equation. In this make-or-break section, describe your capital requirements, depreciable assets, projected income and cash flow. Be sure to specify your break-even point.

Five-year projection: Though speculative, your five-year plan provides a sense of long-term expectations. Provide monthly projections of costs and profits for the first two years; provide quarterly projections thereafter.

After you have drafted your plan, take time to revise it. Your plan's effectiveness will be assessed according to four criteria:

1. Soundness of concept. Does your idea seem feasible? Are your market analysis and projected sales realistic?

2. Thoroughness of development. Have you developed each component in sufficient depth? Are there major omissions that will prevent the reader from accepting your assertions?

3. Relevance of detail. Have you demonstrated your knowledge of the market by providing detail that is accurate, specific, relevant and sufficient?

4. Overall quality of presentation. Does everything about your plan convey a commitment to high standards and professionalism?

Together, those four criteria add up to your most powerful persuasive tool: your credibility.

Whether you are planning to start a business or to expand one, think of your business plan as a public declaration of your commitment to making something happen. Without a credible plan, you might find it hard to get people to take you seriously. §

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As the owner of a service business, if you simply *join* NESDA and do *nothing else,* you will benefit from being a member. That's because your national trade association will *still be working* for your professional interests at the national level, behind the scenes — with legislators, manufacturers, distributors, service contract companies and others.

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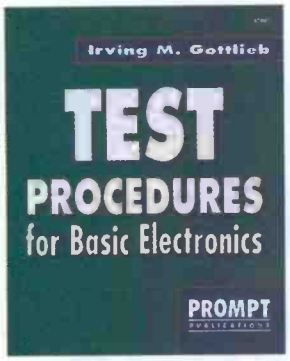

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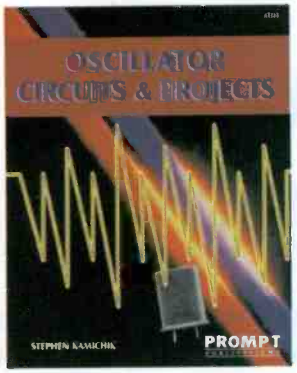

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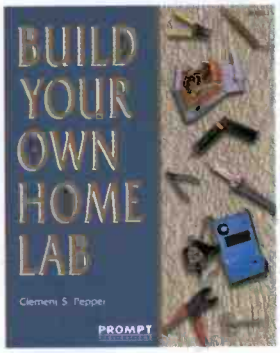

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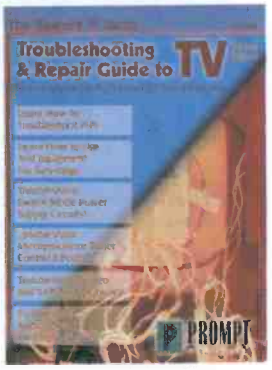

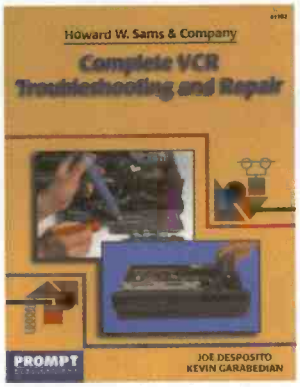

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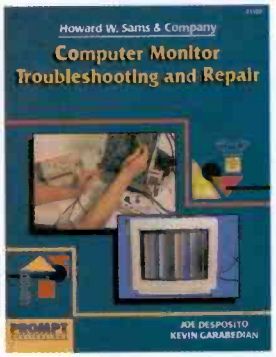

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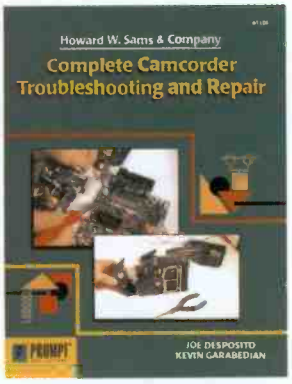

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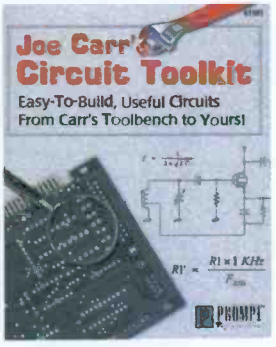

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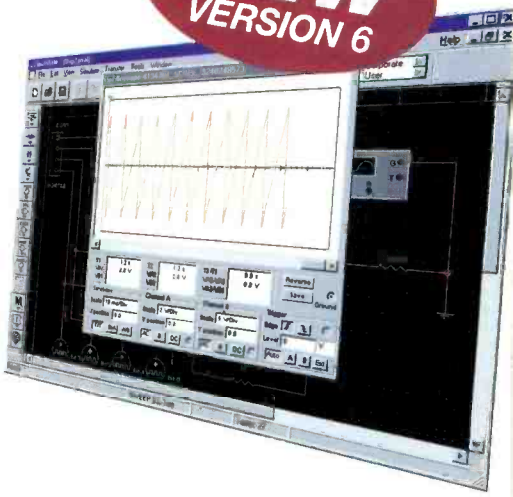

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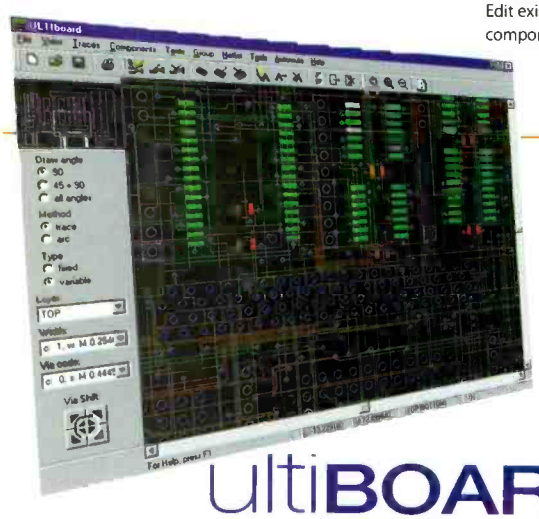

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