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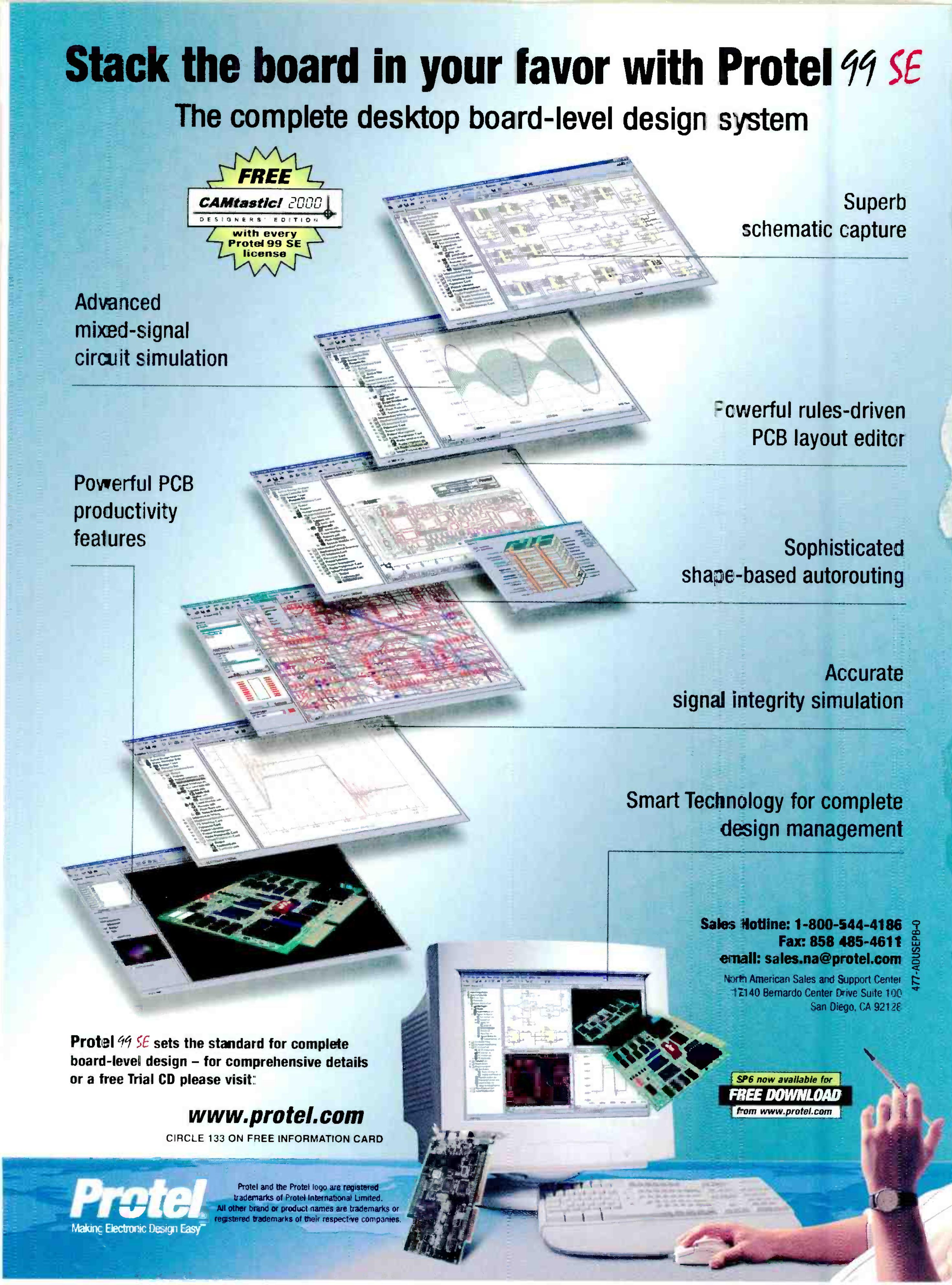
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Electronics Now

August 2001, Vol. 2, No. 8

Popular Electronics®

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THE MAGAZINE FOR THE HANDS-ON ELECTRONICS ACTIVIST!

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PRODUCT REVIEWS

DEPARTMENTS

AND MORE

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Editorial

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The Electronic Renaissance

Hello, again. Seeing that this is only my third editorial, I believe it's time for a prediction. Sure, all the editors make predictions. Fashion editors predict fashion trends, financial editors predict financial trends, and electronics editors predict electronic trends.

My fellow inventors, mad scientists, hackers (both kinds), and buffs…I see a bright future. We are headed straight for AN ELECTRONIC RENAISSANCE! As our world grows more dependent on energy and machines, people will become interested in basic electronics. Just like that famous Renaissance, this one will be a voyage of re-discovery. Already, people around the world are experimenting with theories in latent-energy retrieval that were first dreamt up by the likes of Tesla. Other experimenters are tapping into crystal and rock energy in order to heat and cool homes. Since consumer electronics have become disposable and cheap, many folks have abandoned their benches. Now, it seems as if they will be heading back in hordes.

Part B of my prediction is that the majority of neophytes will be practicing in the discipline of energy creation and storage. Batteries—solar-charged and wind-charged—will be a big hit; as gasoline, oil, and electricity prices climb upwards to the stars. The great part about electronics is that it can be safe, fun, and relatively cheap.

We at **Poptronics** will be here to guide you all through the splendor of the upcoming Electronic Renaissance with the help of well-written features that inform and inspire our readership. Our contributing editors will continue to bring word from the front of breaking technologies and solid theory. There will also be a few surprises along the way.

Happy reading,

Chris La Morte
Managing Editor

LETTERS

mailto: letters@gernsback.com

It Wasn't Me...

Last month's feature, "The MPX 2000," had a few errors contained within the schematic. Capacitors C6, C7, C9, C10, C14, C15, C31–C34, C39–41, and C43 should all be in pico-farads (pF). Transistor Q6's part number is 2N3906. Capacitor C20 is 1 µf and is not labeled (top right of schematic in parralel with D13). Also, North Country Radio has a message recorder that can be used in conjunction with the MPX 2000. Picture a contiuous loop of information being transmitted over the FM band. This could be useful for churches, schools, or even family reunions. Visit www.northcountryradio.com *or send mail to North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804-0053, or call 914-235-6611.—Editor*

Learning Electronics

I just got interested in building electronic circuits about a month ago. I work at a public library and started by picking up some Electronic Theory books. I am 20 years old, and for as long as I can remember, every subject I've put my mind to comes to me pretty easily. Electronics I'm struggling with a bit, but I like that. It's a challenge for me.

Anyway, I picked up an Electronics Learning Lab from RadioShack, to teach myself some of the basics. Things are making more sense, and slowly I'm learning more and more. Back at the library, I found our **Electronics Now** backfile of several years, and I'm slowly working my way through them. I love the magazine.

I am semi-familiar with BASIC programming and slowly learning NQC (thanks to your nod to Lego Mindstorms Robotic Invention System). Programming makes sense to me, and I feel like I can pick up most languages with ease.

Also, I got the idea to shop at thrift stores and pick up old electronic devices, such as computers, phones, radios, etc, and strip them for parts. Is this a worthwhile endeavor, or are electronic components cheap enough to purchase? If nothing else, I figured it would give me training in soldering and de-soldering.

Finally, I'm reading as many electronic texts I can get my hands on, as well as your publication. Do you have any must-reads for the electronic hobbyist beginner? Any input you can give me on any of the above subjects would be greatly appreciated.

Fledgling,
JUSTIN HASSLER
via e-mail

Justin,
Although electronic components are widely available, it is still a learning experience when one salvages parts from old units. An excellent book that can teach you the ropes is Practical Electronics for Inventors, *which is published by McGraw-Hill. This handy reference will have you tinkering along with the rest of us. Would anyone else like to add to the list of references?—Editor*

A Good Turn

The "Basic Circuitry" column, "A Right Turn" in the March issue was very interesting to me as an engineering student. The circuits in there were very helpful and useful. Please include more robotic circuits in future columns.

JASON SLADE
via e-mail

Copy Rights

I have some comments to make on the subject of "Pirates or Patriots," the "Net Watch" column in the May issue. Having had my own writing and programs plagiarized and pirated, I sympathize with the music industry. Yet there is another side to the story as well: the very valid impression on the part of the public that they are being taken for a ride.

It is clearly a LOT cheaper to make a CD than to make a cassette. Blank CD-R disks, complete with jewel case, cost less than blank cassettes with a case. The process of putting music or data on a CD is just a matter of stamping it, whereas putting music on a cassette requires a lengthy recording process—high speed, to be sure, but time consuming.

So why does a music CD cost $15, while the same music on a cassette is half the price?

All this is irrelevant, though. The much larger problem is that the recording industry is bullying Congress and equipment manufacturers, infringing even on legal copying. For example, the price of every blank audio CD includes an extra amount, which goes to record companies to reimburse them for the supposed cost of piracy. But if I use that CD to record my own piano playing, why do I have to contribute to the recording companies? Or if I want to make multiple digital copies of that piano recording, why does the Serial Copy Management System (SCMS) in some recording equipment prevent me from doing that? To protect the big recording companies, Congress and equipment manufacturers have limited the rights of the individual musician.

The trend for the future is even scarier. At this rate, within the next few years, it will become impossible for the small-time musician to make and distribute any of his own work. What a great way for the big companies to kill off the competition!

PETER STARK
via e-mail

No Nightmare

In almost 40 years of reading Gernsback publications, the article "Telemarketer's Nightmare" in the May issue was the most useful and easy to implement idea that I have ever come across. I guess I'll have to implement it with a PIC 16C54 on the first ring.

JACK WALTON
Short Hills, NJ

Improved Memory

Stanley J. York did a nice job on his article, "Analog Memory Module" (**Poptronics**, February 2001).

I have a couple of suggestions for builders of this circuit, which concern C3's operation. Firstly, in my own experience, I've found that typical electrolytic capacitors are so leaky (or soon get that way!) that they do NOT make good storage devices. Using a 1-µF Mylar (non-polarized) unit will give much better performance.

To maintain the author's specified time constant, R13 should then be changed from 47 ohms to 470 ohms. (See. Fig. 1.) This leads us to my second suggestion: If C3 should happen to be holding a significant charge when power to the device is turned off, it's possible that a substrate "SCR" could be triggered in either IC, allowing C3 to discharge into it and possibly damage or destroy the device.

Limiting discharge current will prevent damage, and is done in this way: Replace R13 with a "short" and move R13 so that it's now between Pin 4 of IC2 and the positive terminal of C3, replacing that "short." Replace the "positive" terminal of C3 and Pin 12 of IC1 with a 1k, ¼-watt resistor.

These changes will not degrade circuit performance at all, but significantly enhance and protect it. For those of you concerned with power consumption, switch to only one 9-volt battery and substitute a CMOS quad op-amp for the LM324. A TLC274 would be a good choice, and its much lower current would allow a much longer "hold" time, assuming low leakage across your PC board—but that's another story.

SKIP CAMPISI
Jackson, NJ

Service Suggestions

I have been a loyal reader of "Service Clinic" since the Jack Darr days of the early 1970s when I was in high school, in a really cool electronics technical program that resulted in my first job as a bench tech in a production shop. During those high school years I learned the

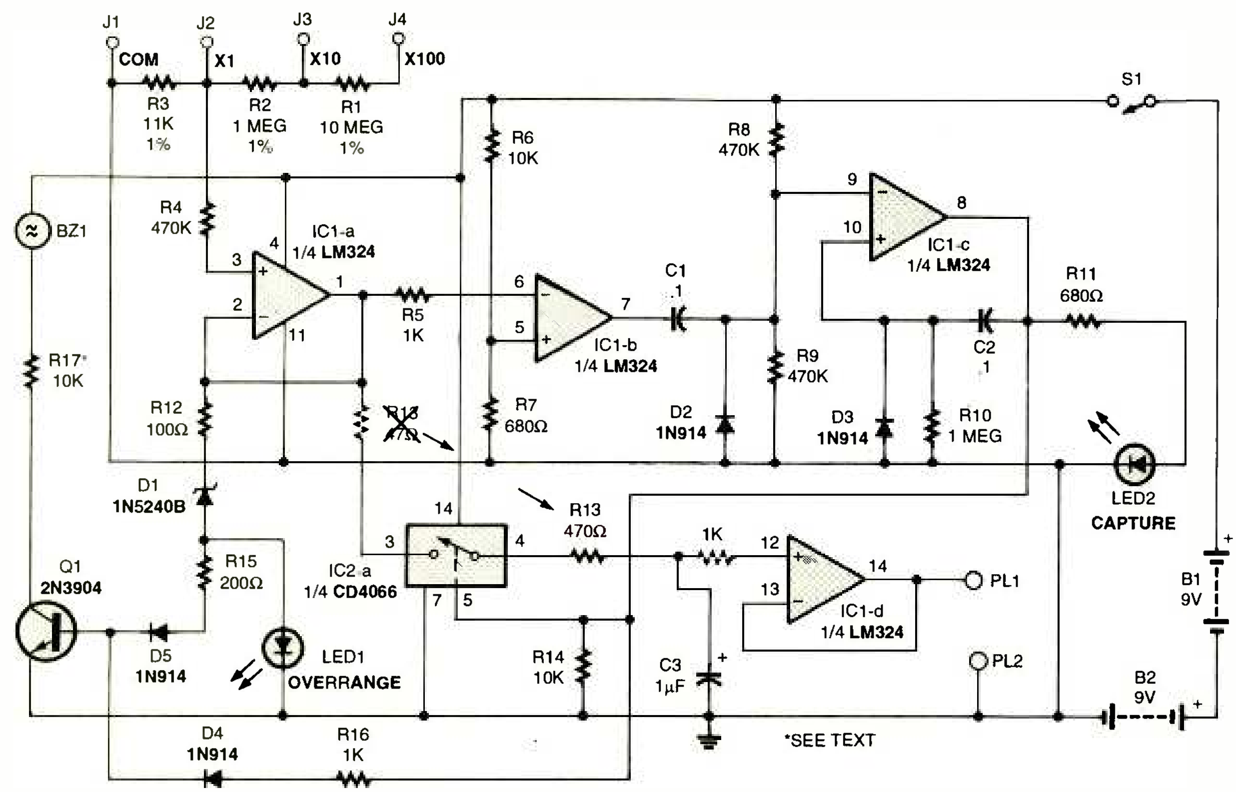

Fig. 1. York's "Analog Memory Module" receives a tune-up—compliments of Campisi.

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.

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value of repairing for fun, with the idea that there were some electronics jobs available that would never make me rich, but whose rewards would be great for me as a fulfillment of my skills and passions.

I stayed with that job for eight great years. Then, I went to work for that famous Seattle builder of tubular things that fly, as a data communications technician. Fifteen years later I am proud to say that I am still there, as a Network Engineer. I have stayed with **Radio Electronics, Popular Electronics, Hands On Electronics,** and everything in between, largely for the service articles, and the construction pieces.

I was thrilled with the return of Service Clinic several years ago under Sam Goldwasser's leadership

I agree it is time for some changes in the column. I think every month should be something different, if possible. Some topics for consideration are:

- Antique electronics servicing. I still miss Marc Ellis, and I'm sure others do, too.

- Appliance repair—major and small. While toasters can be bought for ten bucks, ten bucks is still enough to get a person into Monster Jam in January!!!! Dishwashers are not ten bucks, and there are viable jobs for doing that work as well. The mechanics magazine has abandoned that area. Opportunity strikes.

- Auto electronics—People look at me like I'm crazy when I say I still work on my own vehicles, but it isn't all that hard if you are patient, have the time, and are willing to learn. The manufacturers have modularlized most of the components, so all you have to be is careful. Strange as it may sound, a primer on basic maintenance might help our younger audience get interested in the electronics side of things.

- Context. Your article on "When to service and when to throw away" was great. More context-related stuff perhaps?

- Also articles on component testing, especially the use of ESR meters, and construction articles about ESRs would be good as well.

- Case histories and Q&A are always fun, as you suggested.

- Range of careers in Electronics. The high school program I mentioned to you earlier managed to place 100% of its third year students in entry level jobs with growth potential, until the program ended in 1994.

I work in the networking field, but my perspective is that I don't feel electronics has died as a career choice at all—it has just been overshadowed by software. How permanent are THOSE jobs? Ask the Dot-commers who have had three jobs in the last six months.

WALT ANDERSON
via e-mail

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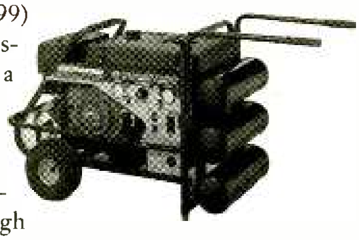

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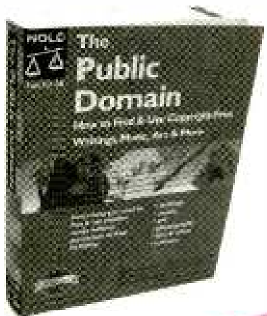

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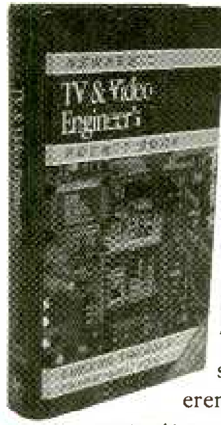

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This book is an essential tool for service engineers and a handy reference for students and hobbyists. It presents a wide range of data and key information in a compact form, covering TV reception, satellite and cable TV, video recorders, color camera technology, and more. This edition had been updated, with new chapters on digital camcorders and VCRs, digital TV, Dolby sound systems, and home theater.

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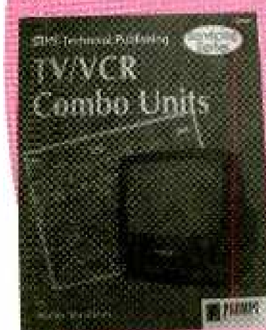
A comprehensive look at the troubleshooting and repair of TV/VCR combinations, this well-illustrated guide offers straightforward troubleshooting tips, theory, and advice on specific models, as well as case histories in each chapter. Typical VCR mechanical assembly schematics for several major brands are included. The first half of the book covers problems with the TV, and the second half deals with VCR problems.



Tab Electronics Guide to Understanding Electricity and Electronics, Second Edition

by G. Randy Slone
McGraw-Hill
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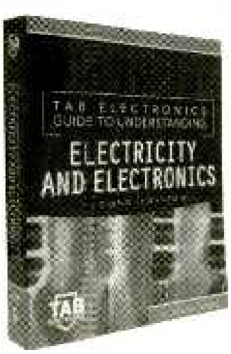
From a pared-down course in quantum physics to suggestions for removing solder, this beginner's guide covers the entire field of electricity and electronics. Readers learn basic electronic concepts, schematic symbols, and commonly used equations. There are instructions for building 25 practical projects.



Beyond Contact: A Guide to SETI and Communicating with Alien Civilizations

by Brian McConnell
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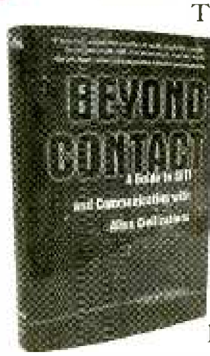

This book explores in-depth the search for intelligent life in the universe and how inter-stellar communications could work. Starting with the history of SETI, the author shows how SETI research has led to technological improvements in astronomy, computers, and wireless communications. He also explains how to build a general-purpose symbolic language.

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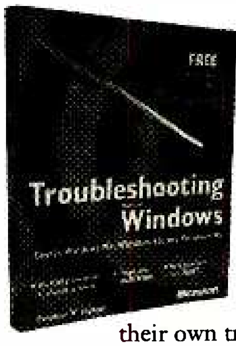

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The Opera 5.x Book: Browsing The Web With Speed And Style

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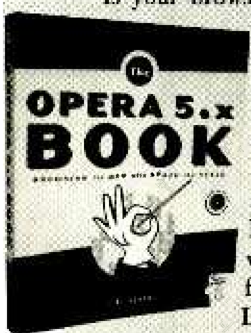

Is your browser slowing you down or taking up too much space? The Opera Web browser is the fastest and smallest available. This book provides inside tips on using this software, and the included CD-ROM contains trial versions of Opera 5.0 for BeOS, EPOC, Linux, and Windows, as well as plug-ins and utilities.

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Business Buzz

RELIABLE STORAGE
White Electronic Designs recently introduced a new family of solid-state Flash IDE Drives with up to 128MB of 100% reliable data storage. The IDE15s are non-volatile, mass-memory devices built with Intel StrataFlash components. Use of the random access memory components is a new approach providing increased data storage reliability. Intel's StrataFlash incorporates Multi Level Cell (MLC) storage techniques, which allows 2 bits of information to be stored in one memory cell. Since there are no moving parts, the IDE drives are inherently shock and vibration resistant, making them ideal for mobile computing and critical data-storage applications.

A SIGN OF THE TIMES
The mm225 videophone from Motion Media Technology has been selected as the communications platform for a new nationwide service providing deaf people with immediate access to an interpreter. The crisp, clear picture of the mm225 videophone makes signing clearly recognizable. CSD (Communication Services for the Deaf), the largest provider of video interpreting services in the US, is in the process of setting up videophone installations in locations such as hospitals, municipal offices, and other key facilities. The service will eventually be available seven days a week, 24 hours a day.

NEW WAVE
The DigiWave Filter has been designed as a solid-state alternative to mechanical filters. Many rear-projection TVs use white light from a lamp that must be filtered into sequential red, green, and blue wavelengths to create a full-color image. The DigiWave Filter relies on a compact laminate of red, green, and blue layers. As each layer is electrically activated in turn, the light is reflected onto a display chip, creating a high-definition, full-color image without the noise or excess bulk of a color wheel. The filter appears like a thick, flat glass element, sandwiching layers of sub-wavelength microdroplets of a unique electro-optic material. This type of photonic technology is expected to contribute to the replacement of the CRTs in televisions and computer monitors.

Active Safety Systems—The Next Step

SensorCar's forward-looking radar can recognize pedestrians and working with a computer can determine if they are in danger.

There are two ways to prevent injuries and fatalities in automobile accidents—provide protection in an accident or prevent the accident in the first place. To date, safety technology has been mostly passive techniques to protect occupants. Ford Motor Co. and its Volvo and Madza divisions are developing active systems to prevent accidents as well as to protect pedestrians.

According to the National Highway Traffic Safety Administration, about a quarter of the crashes result from driver inattention. Other accidents occur because other vehicles or darkness hides dangers, or the driver is distracted by traffic. Nearly all lane-change collisions result when drivers simply do not see the other vehicle. In many parts of the world, pedestrian accidents account for a significant proportion of traffic accidents when drivers do not see the person until it is too late to stop.

CamCar

Drivers may not be able to see pedestrians stepping off the curb or vehicles edging into traffic from either side. Thus, Ford is developing active safety systems to provide complete visibility in all directions in its CamCar program. CamCar technology, which is being demonstrated in a Lincoln Navigator SUV, uses pencil-size cameras, sophisticated computer processing, and three switchable video screens in the instrument panel.

The CamCar's TrafficView uses two forward-facing video cameras—one mounted on either side of the vehicle over the front wheels—providing 22 degrees of coverage to see around obstructions. A driver behind a truck could check for oncoming traffic before making a left turn or could see pedestrians hidden by a large vehicle. Two other TrafficView cameras present a 49-degree view of the adjacent lane area to the rear that is far broader than side mirrors, so drivers could monitor traffic before making lane changes.

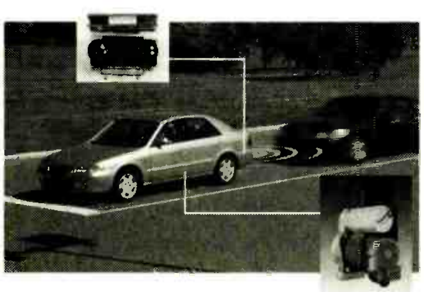
TYPE

A panoramic array of four miniature cameras at the back offers an enhanced, 160-degree rear view in four separate images. These images are fed to a computer program that compares and overlaps them and then combines the result into a single, seamless panoramic view. With a joystick, the driver can pan and zoom the synthesized panoramic image on an instrument panel display.

When the vehicle is put in reverse, the NightEye low-light camera provides a detailed view of the area immediately behind the vehicle, in daylight or even in extremely low light. This NightEye video picture is far more detailed than the typical view through the rear window. A second hitch camera shows where a trail hitch is aligned with respect to the bumper.

The instrument panel houses a central video display with an additional display on either side. The images on these display panels change to provide the most important information to the driver, tailored to the individual situation. For example, normally the two side displays show rear-looking side views, but when the driver needs to see around a forward obstacle, a pushbutton switches the displays to the two forward-looking cameras.

The automotive environment poses unique problems for display panels. TV-type units present too much glare, and some flat-panel screens cannot respond properly in cold weather and have problems with some viewing angles. Thus, Ford is using a new type of display with Candescent Technologies Corporation's ThinCRT technology. These no-glare, thin-screen displays offer fast response time, viewing from any angle, and high tolerance to temperature changes.



A CCD sensor monitors traffic behind the SensorCar. If a rear-end collision is imminent, motorized retractors tighten seat belts.

SensorCar

Another active safety technology that warns the driver of a potential collision with pedestrians is SensorCar technology, which is being demonstrated in a Madza 626. A grille-mounted laser radar scans over a range of 4 degrees in elevation and 23 degrees of azimuth for pedestrians in front of the vehicle. The system can detect a pedestrian entirely dressed in black at nearly 150 feet and a pedestrian clad in white—which offers more reflectivity—at up to almost 200 feet. It can discriminate between people and stationary inanimate objects with a similar profile, such as trees or light poles.

An onboard computer uses the sensor data to determine potential danger with mathematical algorithms comparing the pedestrian's distance and direction of travel. For example, a pedestrian stepping directly in front of the vehicle poses no danger if the vehicle is stopped at a traffic light, so no alarm is needed. If the system determines the pedestrian will enter the vehicle's path and there is potential for an accident, the system sounds a beeping alarm through the front speakers and a lighted icon warning appears on the instrument panel. If the vehicle speed and the distance to the pedestrian indicates that hard braking is required to avert a collision, SensorCar also sounds the vehicle's horn.

It also detects possible rear-end collisions and if one is imminent automatically activates motorized safety belt pretensioners to minimize injury. Two sensors installed in the SensorCar's rear bumper constantly monitor rear vehicle traffic. The computer compares distance, approach angles, and closing rates of the other vehicles to determine whether any of them is about to collide with the SensorCar. If a significant rear impact is probable—contact at a closing

Research Notes

CLEANER ICs

A new technology application called SCORR developed at the DoE's Los Alamos National Laboratory could all but eliminate the use of hazardous corrosives and the production of wastewater in IC fabrication. It focuses on photoresist removal—using carbon dioxide at high temperature and pressure, known as suprercritical carbon dioxide ($SCCO_2$), in place of the hazardous materials. Designed as a closed-loop system, SCORR reuses the carbon dioxide in the process, adding no greenhouse gas to the atmosphere. A key element is a tiny high-pressure sprayer that pulses the $SCCO_2$ /cosolvent onto the silicon wafer to assist in dislodging the photoresist. It's believed that the process has the potential to save hundreds of millions of gallons of water every year even if installed in just one factory.

SUPERCOMPUTERS

What may be the most powerful parallel supercomputer of its kind, the "SGI 512-processor Origin 3000" recently came to life at NASA Ames Research Center. Working with SGI, Ames scientists suggested connecting many computer processor chips in a new way. Since these machines include many CPUs, the suggestion was to modify the computer systems to act as if each one had one large memory unit. To make the prototype 512, Ames and SGI combined two 256-processor machines. The next step is connecting two commercial 512 machines to make a test bed 1024-processor SGI computer, which is expected to be up and running by the time this is published.

FALCON CHIP

Sandia National Laboratories engineer Ken Condreva has built a better stopwatch. It's smaller than a dime, accurate to 125 picoseconds, and can be produced inexpensively. The inspiration for his invention was the need to accurately record critical timing signals in weapon test flights. His invention became the FALCON, an IC that uses his patented "Pulse Stretcher" technique to increase resolution up to 200 times for a low-power electronic clock. The circuitry provides greater resolution by lengthening duration of the output signal making it last 64–200 times longer than the input signal.

The tiny displays for Donnelly's VideoMirror Camera Vision System mount on the rear-view mirror and flip out of the way when not needed.

➤ Now That's Fast

A new electric car has been developed that is capable of 0–100 km/h in 4.1 seconds. AC Propulsion, the San Dimas, CA company that built the electric car (called the t-zero) has spent four years developing the car. Recently they took it for a series of tests with a private Ferrari owner, and the results were nothing short of astounding. The t-zero was clocked at 4.1 seconds, showing unbelievable acceleration for an electric car.

The t-zero is drivable with one pedal, since it brakes as soon as the foot is lifted from the accelerator. This turns the kinetic energy of the tires into chemical energy for the batteries. Its major drawback is its lack of range. It can only go for 145 km before it needs to be recharged, and the recharge lasts for a full hour.

AC Propulsion only expects to sell about 100 cars, but their hope is that major auto manufacturers will adopt their technology in the near future. Co-founder of AC Propulsion, Alan Cocconi says the innovation lies in the drivetrain, because it charges the side-mounted batteries making the engine a lot lighter than other electric cars, which have a separate charger.

"The drivetrain is the innovation," said Cocconi. "We just built the car to show it off." PT

rate of 6 mph or greater—it sounds an alarm from the rear speakers and illuminates a warning icon. If the approaching vehicle speed is great enough that hard braking would be required, a motorized retractor immediately tightens the front-seat lap-and-shoulder safety belts. This positions the driver and front passenger closer to the seat backs and headrests, reducing the distance they will move backward as a result of the rear impact. The system works whether the vehicle is stationary or in motion, as long as the engine is running.

EyeCar

In another move toward improving the driver's field of vision, Volvo's EyeCar technology locates the eyes of each driver and positions the driver at the optimum position for best visibility, regardless of the driver's height. After the sensors locate the driver's eyes, they then trigger motors to automatically raise or lower the seat to the optimum height as well as adjust the steering wheel, pedals, center console and even floor height. An innovative, relocated B-pillar in the concept Volvo car reduces the blind spot in the driver's vision while providing added crash resistance.

Video Mirrors Already Here

While Ford and other companies are working on systems of the future, the Donnelly Corp. is already offering its Donnelly VideoMirror Camera Vision System in several versions, including ReversAid and BabyVue. The ReversAid system features a small flip-down hideaway screen that is mounted on the vehicle's rearview mirror. The screen displays images from tiny cameras mounted in the rear of the vehicle. When the vehicle is shifted into reverse, the driver is provided an enhanced view of what is behind the vehicle. When the small display is not needed, you simply flip the screen up and out of the way. By changing the angle of the camera slightly, ReversAid can be modified to become TowChek to make hitching up a trailer a one-person job. BabyVue uses a similar camera, but mounted in the vehicle's headliner to allow drivers to view infants in reverse-facing infant seats. If you don't have a baby, simply orient the camera to provide the driver with a view of all rear-seated passengers in the vehicle's cabin and thus the system becomes CabinVue. For more information: 800-297-2555 or *www.donnelly.com*.— **by Bill Siuru** PT

Avoiding Collisions

The Port Authority of Allegheny County recently started the largest field test of Intelligent Vehicle Technology by a public transit agency in the United States—a year-long test of the side collision avoidance system installed on 100 Port Authority buses.

The sensors on each bus are spaced approximately six feet apart and mounted between 30 and 50 inches above the road surface. An on-board computer measures the time it takes an emitted sound wave from any or all of the sensors to return after bouncing off a hard object within six feet of the side of the bus, extending to an area four feet beyond the rear of the vehicle. The system is designed to detect typically stationary roadside objects at least 12 inches in diameter when the bus is moving and to detect an automobile while both the bus and the car are in motion.

The sensors are active at all times when the bus engine is running, and the system alerts the operator visually when an object is detected. The visual indicators, one above and to the left of the dashboard and one near the door, are easily seen and mounted in such a way as to be in the operator's field of view when he or she is looking at either of the side mirrors. When the system detects an object while the turn signal is activated, the visual warning will be accompanied by an audio signal.

The second-generation technology will be an integration of the side collision avoidance systems being tested here and front-end collision systems that will be field tested by the San Mateo County Transit District (SamTrans) in San Carlos, California.

"This technology provides transit and other members of the automotive industry with dependable means for reducing accidents from side impacts," said Edward Thomas, Associate Administrator for Research, Demonstration and Innovation for the Federal Transit Administration (FTA). "Furthermore, as we look ahead, the information derived from the Pittsburgh test can be used to help develop pedestrian collision avoidance technology." PT

Are Internet Cars Coming?

These days it seems there is a worldwide race to bring mass appeal to Telematics—an emerging industry that provides "smart" information for drivers. Telematics has been touted as one of the biggest growth areas for the auto industry. Companies have begun offering products and services to drivers such as GPS, traffic updates, remote diagnostics, virtual advisors, multimedia entertainment centers, as well as Internet access. It may sound like something from a science fiction novel, but it is becoming a reality.

The results of a new collaboration between Acunia NV and BMW was shown at the CeBIT 2001 Information Trade Fair in Germany—a live demonstration of the "dynamic downloading" of Telematics services as a part of its "ConnectedDrive" strategy. BMW's "ConnectedDrive" brings together communication devices, Telematic systems, electronic platforms, networking bus systems, intelligent computation through Internet connectivity, and the detection of the driving environment. It accomplishes this daunting task through sensors that are integrated into an innovative and comprehensive concept that assists the driver.

Ericsson, Volvo, and Telia recently announced the formation of WirelessCar Corporation. The company will develop and market complete solutions for mobile e- services to vehicle manufacturers and fleet operators.

Also recently introduced in Europe was a new 152-Kb mobile connection developed by MegaCar. MegaCar, in conjunction with IBM, is developing this Internet access software for Mercedes, but is also expected to begin selling it to other manufacturers this summer. It maintains a stable connection at high driving speeds like those found on the autobahn and is able to download at twice the speed of cable Internet service.

With this service, drivers and passengers have the ability to navigate the Internet on a touch screen with large, easy-to-see and -use buttons. By the end of this year, the company hopes to also include a voice-activated system, which better addresses driver-distraction concerns. If introduced on a mass scale, it is believed that this service would add approximately $2000 to the price of the car.

This high price of innovation has been one of the major deterrents in the mass appeal of Telematics thus far. Other factors leading to the slow adoption of Internet services in the car have included slow connection speeds, the quality of content available, a lack of industry standards, and limited networks for wireless coverage. PT

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San Rafael, CA 94901

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80909

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or e-mail: requests@berkshire-is.com

Taking Control

Get a grip on your gear with the *Home Theater Master MX-500* learning remote control ($189). It's preprogrammed for more than 1000 audio and video components and is capable of learning 530 functions from original remote controls. The MX-500 can operate a total of ten audio and video components and offers three different types of macro functions.

Universal Remote Control, 500 Mamaroneck Ave., Harrison, NY 10528; 914-835-4484; *www.hometheatermaster.com.*

CIRCLE 50 ON FREE INFORMATION CARD

Packing Power

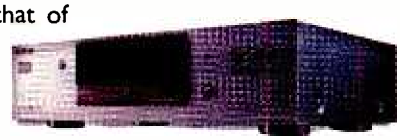
According to Panasonic, its AA-size *1600 mAh nickel-metal hydride* (NiMH) *battery*, when used with the five-hour *Fast Charger* ($29.99 for four batteries and the charger), lasts almost 2½ times longer per charge than standard-capacity AA nickel-cadmium batteries. Developed for use with today's digital consumer electronics, the NiMH batteries can be recharged hundreds of times. Four batteries can be charged simultaneously in just five hours.

Panasonic Industrial Company, Two Panasonic Way, 7A-3, Secaucus, NJ 07094; 877-726-2228; *www.panasonic.com/batteries.*

CIRCLE 52 ON FREE INFORMATION CARD

Multi-channel SACD Player

With full Direct Stream Digital resolution on all six channels, the *SACD1000 Super Audio CD player* ($1999) draws the listener into a three-dimensional listening experience. The format uses a sampling frequency 64 times higher than that of a CD. The SACD1000 can play DVDs, CDs, and VCDs, and supports CD-R and CD-RW playback.

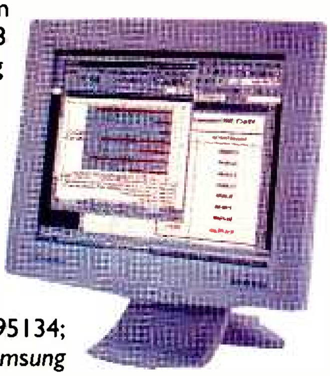


Philips Consumer Electronics North America, 64 Perimeter Center East, Atlanta, GA 30346; 800-531-0039; *www.philips.com.*

CIRCLE 51 ON FREE INFORMATION CARD

Flatly Affordable

Using only a third of the desktop space and about 70% of the energy required by a similarly sized CRT monitor, the *SyncMaster 570vTFT* 15-inch flat-panel monitor ($499) boasts enhanced TFT viewing with 0.297 dot pitch and a maximum resolution of 1024 × 768 pixels. It has built-in Plug and Play capability. The monitor's screen can be detached from the base for wall mounting.



Samsung Electronics America, Digital Information Technology Division, 85 West Tasman Drive, San Jose, CA 95134; 800-SAMSUNG; *www.samsungmonitor.com.*

CIRCLE 53 ON FREE INFORMATION CARD

Home Theater in a Box

The *Cinema ProPack 600* ($1199) is a complete multi-channel home theater in one neat package. It consists of a five-disc DVD changer, a Dolby Digital/DTS receiver, a 5.1-channel speaker system, a full-function remote control, and all interconnection cables. The receiver offers MP3 decoding and Logic 7 digital signal processing. The speakers are said to provide clear, detailed, powerful surround sound from compact enclosures.

JBL Consumer Products, 250 Crossways Park Drive, Woodbury, NY 11797; 516-682-3523; *www.jbl.com.*

CIRCLE 54 ON FREE INFORMATION CARD

Hi8 Camcorder

Canon's *ES8200V Hi8 camcorder* ($449) sports a sleeker look than its predecessors, thanks to a newly designed, lightweight 22X optical zoom lens (700X digital). The camcorder features a 2.5-inch color LCD viewscreen, six auto-exposure functions, an image-stabilization system, and digital special effects in both record and playback modes. A photo mode allows still shots to be recorded on the cassette tape.

Canon U.S.A., Inc., One Canon Plaza, Lake Success, NY 11042-1198; 800-OK-CANON; *www.usa.canon.com.*

CIRCLE 55 ON FREE INFORMATION CARD

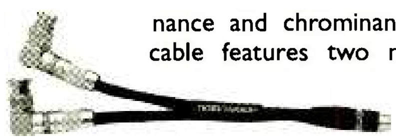
Weather Clock

Royal's *WS44 ThermoSolutions clock* ($69.99) provides at-a-glance temperature readings as well as the date and time. The desktop weather station comes with a remote sensor that allows it to display indoor and outdoor temperature and humidity readings. It also shows a weather forecast and the daily minimum and maximum temperatures and humidity levels.

Royal Consumer Business Products, Olivetti Office USA, 765 U.S. Highway 202, Bridgewater, NJ 08807-0945; 908-526-8200; *www.royal.com.*

CIRCLE 57 ON FREE INFORMATION CARD

For the Long Run



According to *Tributaries*, its *YCS S-Video Separator Cables* allow the highest quality separation of an S-Video signal's luminance and chrominance information. Each cable features two multistranded copper conductors wrapped in aluminum/Mylar, terminated at the combined cable end with a gold-plated brass S-video connector. The cables are available in straight or right-angle BNC ($77.50), straight or right-angle RCA male ($65), or straight RCA female ($65).

Tributaries, 1307 East Landstreet Road, Orlando, FL 32824-7926; 800-521-1596; *www.tributariescable.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Information Age Scanner

Agfa's *SnapScan e50 scanner* ($199) gives consumers an easy way to accurately capture photographs and artwork. The e50 scans originals and automatically formats them for the Internet, word processing, text conversion (OCR), or image-manipulation programs. It provides 42-bit color depth at a resolution of 1200 × 2400 dpi. Slides can also be scanned. The e50 comes with *Corel Print Office 2000* and *ReadIris* software.

Agfa Corp.-CDI, 200 Ballardville St., Wilmington, MA 01877-1069; 978-658-5600; *www.us.agfa.com.*

CIRCLE 59 ON FREE INFORMATION CARD

Pseudo Surround

Want to achieve that home-theater feel in dorm, bedroom, home-office, or kitchen? Add the *Gemini Philips Magnavox Simply Surround system* ($79) to an existing receiver, TV, and stereo VCR to create a surround effect for very little money. The system includes a pair of two-way adjustable bookshelf speakers, a control box, 50 feet of speaker wire, and quick-fit connectors for easy installation.

Gemini Industries, Inc., 215 Entin Road, P.O. Box 1115, Clifton, NJ 07014; 973-471-9050; *gemini-usa.com.*

CIRCLE 58 ON FREE INFORMATION CARD

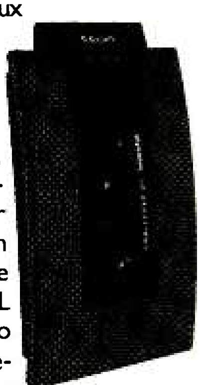
Smart Cards

A *512-MB Compact Flash (CF) Memory Card* ($799)—said to be the world's highest capacity, standard CF Type I card—recently debuted, along with a high-capacity 128-MB SmartMedia Memory card ($189). Designed for three- and four-megapixel, high-resolution digital cameras and Internet music players, these cards can store hundreds of high-quality digital images, MP3 music files, or even video.

SanDisk Corp.; 866-SANDISK; *www.sandisk.com.*

Color Me Blue

BlueDSL ($350), from French company Inventel Systemes, is an ADSL gateway that includes both a Linux router and a Bluetooth radio module. Targeted for both home or SOHO markets, it has an estimated range of over 300 feet and can transmit both voice and data. BlueDSL can handle up to seven simultaneous links and up to sixty-four Bluetooth devices.



Inventel Systemes; *www.inventel.com* or French Technology Press Office; Fax: 312-222-1237.

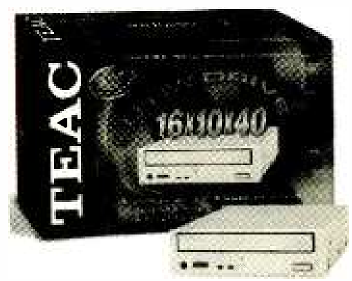
Wireless Networking System Update

New features for the *ORiNOCO* wireless networking system are available for current users as a free download on the Web site below. For the residential gateway product, the RG-1000, the software adds Point-to-Point Protocol over Ethernet (PPPoE), and it implements Dynamic Host Configuration Protocol (DHCP). These two changes mean that the system can be used with almost any broadband connection.

Agere Systems; 866-ORINOCO (US) or 610-712-8081; *www.orinocowireless.com.*

High-Performance CD-RW

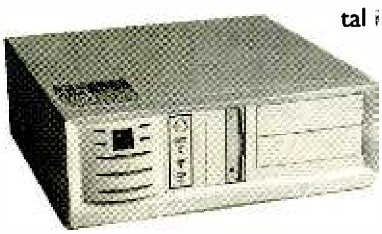
The *TEAC 16×10×40 CD-RW Drive* ($279) writes data or audio files at 16X (CD-R), rewrites at 10X (CD-RW), and can play back at 40X (CD-ROM) speeds. Capable of writing an entire 650-MB CD-R disc in less than five minutes, it stores data and/or audio; and it can also record mixed music CDs using .wav and MP3 files. The 16×10×40 comes bundled with *Easy CD Creator.*



TEAC America, Inc.; 323-726-0303; *www.teac.com.*

Keeping Watch

Designed for business or home security, the *Image Vault DVR 6.0* (Digital Video Recorder) replaces videotape recorders to capture digital images that are saved on a computer hard drive. Models range from four ($2600) to 16 cameras ($9900) and 209- to 240-gigabyte hard drives. Version 6.0 can also be programmed to record audio constantly or just when an alarm is triggered.



Fire King International, Inc.; 888-462-4382; *www.fireking.com.*

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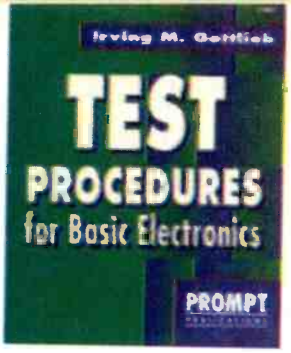

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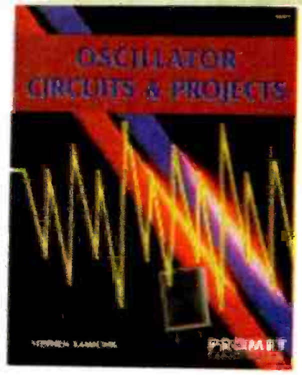

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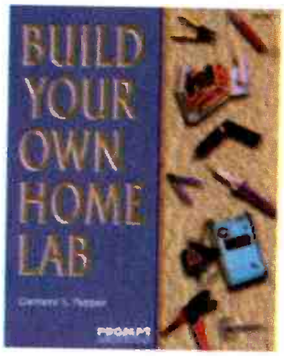
Shows you how to assemble an efficient working home lab, and how to make it pay its own way. Includes projects for creating your own test instruments too. *7 3/8 x 9 1/4", 249 pp. paperback.*



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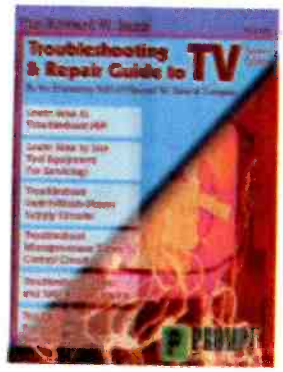

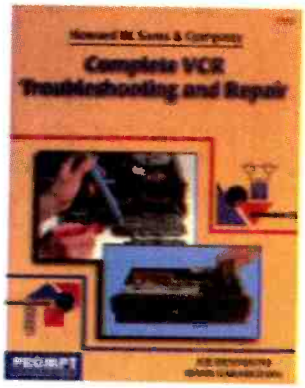

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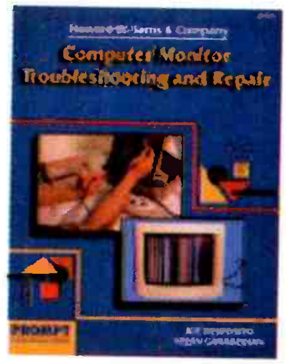

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☐ Wholesale & Discount Buyer's Guide #CP-1. – $19.95
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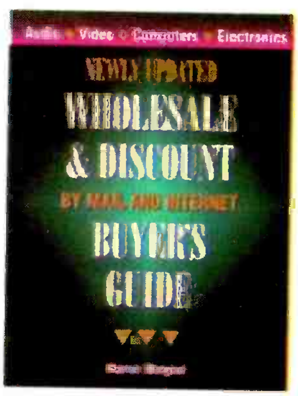
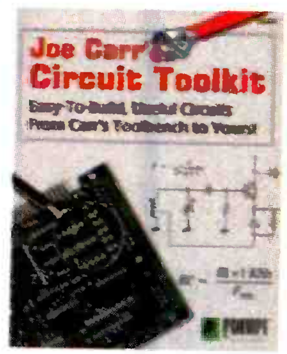


☐ Joe Carr's Circuit Toolkit. #61181. – $29.95
Easy-to-build, useful circuits from Carr's workbench to you. They will spark new ideas in your day-to-day use of circuits and help solve frustrating problems. *256 pp. paperback. Contact Jim Surface.*



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CL04

YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

1900
1910
1930
1940

Dateline: August 1951 (50 years ago)

Radio-Electronics featured General Electric's (then-) new Z-2061 miniature magnetron vacuum tube. This device was a breakthrough in oscillator technology. The Z-2061 was used as a local oscillator in UHF TV receivers, CBs, and RF generators. Also included in this issue was an editorial by Hugo Gernsback entitled "Service Technicians' Trials," in which Mr. Gernsback explored the numerous guises of *nuisance customers* like the *Parts Putterer* and *Suspicious Sue*. (*Tubes are slowly making a comeback in DIY electronics. Audiophiles in particular are re-discovering the warmth of tube-driven amplifiers.*)

1951

1960

1970

Dateline: August 1981 (20 years ago)

"The Incredible Shrinking IC" was the cover story for **Radio-Electronics**, August 1981. This feature told the history of integrated circuitry from its humble beginnings with Kilby's and Noyce's Resistor-Transistor Logic experiments in the first half of the last century to Very Large Scale Integration (VLSI) chips of the late 70s and early 80s. A construction article was also included in the magazine, which instructed the readers on how to build their own eight-foot-tall satellite antenna for television use. (*A driving force behind IC technology has always been the U.S. Department of Defense. Today, scientists are still pushing the envelope to decrease the size and increase the speed and complexity of ICs.*)

1981

Dateline: August 1991 (10 years ago)

Why spend close to $10,000 for a spectrum analyzer, when you can build your own for around $300. **Radio-Electronics** once again provided its readership with plans for building practical and affordable test equipment. The "Spectrum Analyzer" article helped readers construct their very own PC-board-mounted spectrum analyzer that operated from 0.1 to 800 MHz and was able to demodulate FM signals within that range. In another article in the August issue, an author presented plans for an EKG. (*How handy would such gadgets be for the armchair technician?*)

1991

2000

REID GOLDSBOROUGH

mailto: digitaldomain@gernsback.com

Keeping The Net Free

A battle is raging between those who feel Internet users should control their own time online and those trying to wrest that control away. The battlefield is advertising.

The Web can be an ideal medium for putting your message out, with its space flexibility and multimedia possibilities. New developments in Web advertising are making it an equally ideal medium for putting your foot in your mouth.

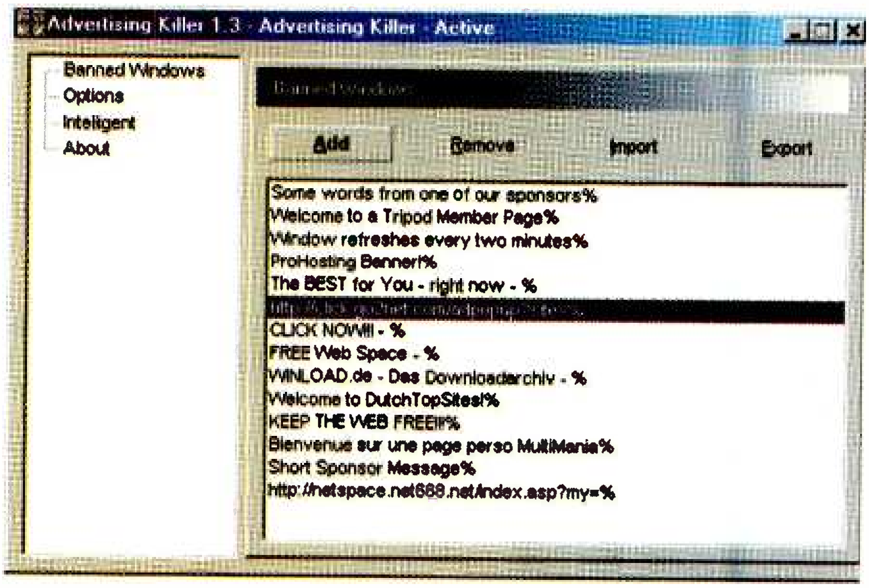
VIRTUAL BILLBOARDS

The Web standard for enticing people to visit your site is the banner ad, the typically small, rectangular box that Web sites place on other Web sites. It's the banner ad that allows the bulk of the Web to be free, just as the TV commercial allows network television to be free.

Banner ads, however, have come under criticism for failing to deliver the promised eyeballs. Fewer people click through banner ads to the promoter's own Web site. According to *The State of Internet Advertising*, a report issued recently by market research company AdRelevance at *www.adrelevance.com*, click-through rates are at their lowest ever.

Web marketers have been scrambling to devise more effective alternatives. They're using TV as a model, reasoning that if annoying TV commercials a la the classic Mr. Whipple's "Please, don't squeeze the Charmin" can be effective marketing gambits, why worry about annoying Web consumers with repetition, intrusiveness, and loss of control.

The stakes are high. Web sites that need ad revenue to survive aren't getting it. As the online ad market falters along with the rest of the cyber economy, established media companies such as CNBC.com are laying off employees and ad-driven Internet sites such as Living.com are shutting down completely.



Advertising Killer quickly deactivates pop-up advertisements. A simple interface allows users to add specific types of windows to the kill list.

You'll likely see larger, flashier, and more intrusive banner ads in the near future. In February the Internet Advertising Bureau, at *www.iab.net*, announced new standards for bigger Web ads. The standards include lengthwise ads called skyscrapers that run down the side of a Web page, large square ads, and pop-up ads that spontaneously appear in a new browser window when you arrive at a Web page.

Pop-ups, sometimes ridiculed as "whack-a-mole" ads, are controversial because they degrade your browsing experience by forcing you to close them to see the content underneath.

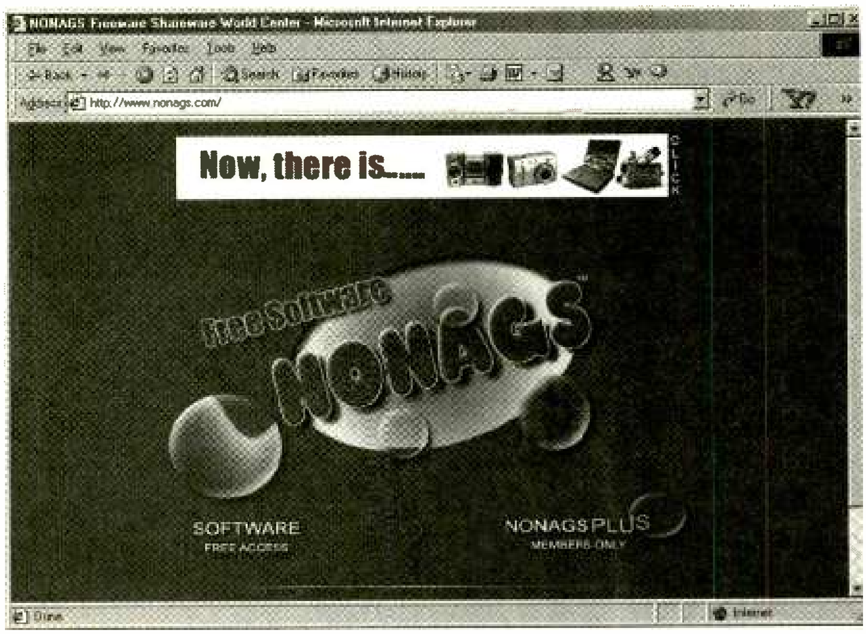
Some Web sites, including computer news site CNET, are experimenting with larger ads offering Flash animations, those in-your-face special effects loved by some and hated by others.

You'll likely see video in banner ads as well. Online advertising technology company Bluestreak, at *www.bluestreak.com*, has recently introduced a technology it's calling StreakingMedia that lets advertisers include streaming audio and video in their Web and e-mail marketing campaigns.

QUESTIONABLE TACTICS

The most vexing Web ad developments involve various techniques that try to prevent you from leaving a Web site. "Mousetrapping" disables your browser's back and forward buttons, requiring you to type in a Web address or go to your Favorites or Bookmarks menu to leave the site.

Another technology, called multiple-window exiting by proponents and browser hijacking by critics, doesn't even let you do this. First appearing with pornographic Web sites, the technology continually throws new browser windows at you when you try to leave a site.



Nonags is a site dedicated to the distribution of freeware. Members and non-members alike can revel in the large inventory of useful applications.

Try backing out of a site, opening another site, or quitting your browser, and another browser window pops up. Try closing that window and still another window pops up. This happens repeatedly, the purpose being to generate mindless "hits" or frustrate you into reading what they're forcing down your throat. The only way to get out is to keep clicking, ad nauseam.

This technology is so obnoxiously intrusive that only those Internet bad boys such as Sanford Wallace, the former self-proclaimed "Spam King," could embrace it. Check out his site, PassThisOn.com at *www.passthison.com*, for a taste, but expect to be left with a bad taste. Woe to mainstream sites that fall for these kinds of shenanigans—beware of the backlash.

Clearly, however, the Internet ad industry needs to improve response rates. The trick, a devilish one, is to do it without alienating Web surfers. Most people will tolerate a reasonable level of advertising in their surfing activities. Most won't stand for getting shoved around.

Ultimately, the personal computer revolution, upon which the consumer Internet is based, is about personally controlling your experience. Fortunately, technology can also come to the rescue here.

Advertising Killer, at *www.buypin.com/akiller.php*, is a free program that automatically closes pop-up ads as soon as they appear, and the similarly named AdKiller, at *www.adkiller.com*, masks banner ads. Commercial software such as Norton Internet Security, at *www.symantec.com*, include controls for banner ads and pop-up windows, as well. While we are on the subject of software applications, let's discuss some alternatives to the commercial products available.

SHARE AND SHARE ALIKE

Whatever you use your PC for, chances are you can do it more productively, whether you're a computer guru or newbie. And you can do it without spending a dime with free software programs and Web services.

Nerds may not all be saints, but there's a long history in the computer world of programmers sharing their work for free.

Today you can still download "freeware" from the Internet. These typically are small programs released by their developers to the public without charge, sometimes out of sheer generosity. Some developers have other no-less-valid motives, such as promoting their consulting business or offering a limited free version of their work in the hope that users will upgrade to a beefed-up pay version.

THE SPLENDOR OF OPEN SOURCE

Typically programmers prohibit you from selling their program or altering its source code. A growing number of "Open Source" adherents, following the example of the Linux operating system, release their program's source code to the public over the Internet without restriction in a worldwide collaborative effort to create the best possible product. The Open Source Initiative at *www.opensource.org* offers further information about this phenomenon.

On the Web, some e-commerce companies are moving beyond the advertising-only model and are now charging for their services in a scramble to survive the dot-com shakeout. Most Web-based services remain free.

All this seems antithetical to our market economy and to the very nature of capitalism, and it flies in the face of common sense notions of how to profit from your labor. How well can you be doing if you're pricing your product at zilch? And, from a consumer perspective, how valuable can something be if doesn't cost anything?

FREEWARE PERILS

It turns out that the best of the free software programs and Web services nullify the notion that there's no such thing as a free lunch. These are excellent tools. As with anything, there is a potential downside here.

One negative with a free program is that you probably won't get the same tech support as with a pay program (though good tech support with pay programs is never a certainty). Another negative, which is true any time you tweak a PC, is the risk that something will go wrong, which in a catch-22 can necessitate tech support.

One way to protect your system with Windows PCs is to make back-up copies of two files that together comprise part of the inner workings of Windows called the "Registry." You can do this with the help of software, though it's simple enough to do it manually.

If you're using Windows 95, 98, or ME, just copy the files *system.dat* and *user.dat* in the Windows folder to a Zip or similar removable drive, a back-up tape, or another folder on your hard disk.

In case your system does get corrupted, which is possible but highly unlikely with any given tweak, you can correct things in most cases by simply copying these Registry files back to the Windows folder.

POINT AND CLICK

AdKiller
www.adkiller.com

AdRelevance
www.adrelevance.com

Advertising Killer
www.buypin.com/akiller.php

Bluestreak
www.bluestreak.com

CNBC.Com
www.cnbc.com

CNET
www.cnet.com

Internet Advertising Bureau
www.iab.net

Living.Com
www.living.com

Norton Internet Security
www.symantec.com

Open Source Initiative
www.opensource.org

PassThisOn.Com
www.passthison.com

If you're using Windows NT or 2000, you should use the Backup utility included to back up the Registry and, if need be, to restore it.

A SAMPLING OF FREEBIES

Here's a sampling of the best free productivity-enhancing computer tools:

- PowerDesk. With this utility, you can copy, move, or otherwise manage files on your hard disk faster than you can with Windows' own tools. PowerDesk also includes built-in tools for handling Zip-compressed files (*www.ontrack.com/powerdesk*).
- JConnect Free. Formerly called JFax, this Internet-based service lets you receive faxes as attachments to e-mail messages, which is much handier than using a fax-modem (*www.j2.com*).
- Tweak UI. This Microsoft utility, which works with Windows 95 and all versions after it, makes it easy to tweak the Windows user interface. There are dozens of options—one of them lets you log on automatically at boot-up, convenient for cable and DSL modem users (*www.microsoft.com/ntworkstation/downloads/powertoys/networking/nttweakui.asp*).
- PC Pitstop. This Web-based service scans your PC for viruses, checks your hard disk for errors and fragmentation, and diagnoses your Internet connection (*www.pcpitstop.com*).
- Atomica. Formerly called GuruNet, this combination utility/Web service is a reference gem. While connected to the Internet, you hold down the ALT key when clicking on a word in any Windows program. Atomica offers a dictionary definition and then the option of reading a concise encyclopedia entry, translating the word into foreign languages, or searching further on the Web (*www.atomica.com*).

THE GOOD, THE BAD, AND THE CHEAP

The above is just a sprinkling of what's out there. You can test out other interesting sounding programs at virus-free download sites such as Nonags at *www.nonags.com* and Download.com at *www.download.cnet.com*. If you could look beyond the barrage of bulk-mail, violent advertising, and sinister programming—the Internet is not that bad. **P**

TED NEEDLEMAN

Motherboard Transplant

Back in the early 70s, there was a TV series called *The Six Million Dollar Man*. It was based on a 60's novel by Martin Caiden called *Cyborg* and detailed the exploits of Steve Austin, an astronaut supposedly the last person to walk on the moon. Gravely injured in a test of a lifting body (this was years before the Space Shuttle was actually in service), Austin has his damaged limbs replaced with bionic ones.

The Steve Austin in the novel wasn't quite the superman that Lee Majors played in the TV series. On the TV series, whenever the Bionic Man (and later the Bionic Woman and even Bionic German Shepherd) needed some additional features, they were simply wheeled into the operating room, and Dr. Rudy Wells "upgraded" them.

It's now about 30 years later, and while we don't have bionic people, we do have PCs. And we can, as the introduction to the TV series intoned, make them "Faster, more powerful..."

KNOWING WHEN TO SAY WHEN

Past columns and feature articles in **Poptronics** have detailed various upgrades that greatly extend the life of a typical PC. We've looked at new sound and video cards, DVD and CD-RW drives, and even processor upgrades. At some point, however, you come to a roadblock when the features and capabilities of your PC's motherboard have reached their limits. For example, one of the earlier upgrades discussed last year was adding a 500-MHz Pentium III to an NEC Dimension PC that originally came with a 333-MHz Pentium II. The Intel motherboard that was installed in the NEC PC supported the upgrade, but just barely. Any faster CPU simply would not work. Nor did the original motherboard provide a fast 133-MHz front-side bus. At the time it was made, 66-MHz was the standard speed for the FSB, and 100-MHz was only for performance PCs.

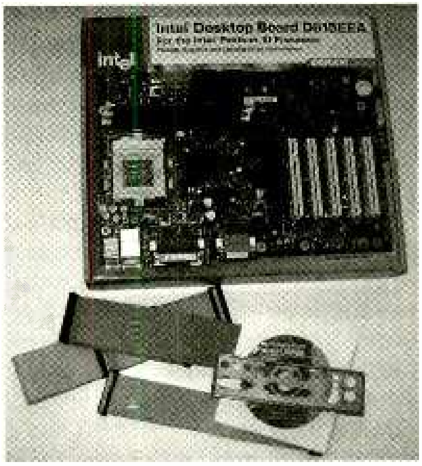
It becomes uneconomical to continue to upgrade an existing PC—it simply makes more sense to relegate the old PC to a task where performance and features are no longer relevant. Where this point is, however, depends a lot on how up-to-date you keep the other components in your PC. In the year that's passed since we bumped the NEC up to a 500-MHz Pentium III, we've added PC133 memory, a faster and larger hard disk, better video card, and a new, fast CD-RW drive. All of these components are still state-of-the-art and very serviceable. It's just the motherboard that's a bit outdated.

The solution, at least in this case, is simple—replace the motherboard. As long as we are replacing the motherboard, we'll swap CPUs as well.

DECIDING ON A REPLACEMENT

The economics of this upgrade are actually quite attractive. The original NEC Dimension makes a good base for this particular upgrade. The case is a mid-tower, with plenty of room and a slide-off side panel design that's found on many of the latest PCs. Even the power supply, 235 watts, is sufficient for what we need, though there are numerous third-party suppliers of ATX power supplies if we wanted one with a heftier rating.

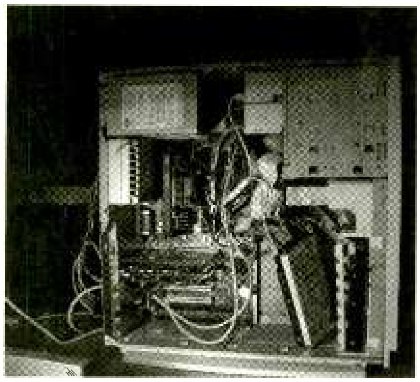
We actually obtained two different motherboards to try for this upgrade, an Intel D815EEA and a Soyo SY-7VCA-E. Each provides a slightly different feature set, though they both are in the same \$130–\$150 price range. For our upgrade, we added a 1-GHz



Most motherboards, such as this Intel, come with accessories, including IDE cables and the proper drivers.

Intel Pentium III CPU. At the time this column is being written, a boxed CPU costs about \$280. If this is a bit rich for your blood, you can perform the motherboard upgrade and go for a less expensive processor. An 850-MHz Pentium III that offers the same *FC-PGA* (*f*lip *c*hip-*p*in *g*rid *a*rray) Socket 370 mounting is about \$100 cheaper than the 1-GHz model. If the motherboard really breaks the bank, consider adding a VIA Cyrix III CPU. It doesn't provide anywhere near the performance of a P3, but at \$70 for the 700-MHz version, it's an affordable way to fill the Socket 370 until you can afford better. Priced in the middle of these two types of CPUs are various iterations of Intel's Celeron processor, which can also be used in the two motherboards detailed here.

Intel and VIA are not the only alternatives, though these two processors do use the same type of socket—a Socket 370. Various processors from AMD are also available. The AMD Athlon is the higher end CPU from this



Here's the inside of the NEC before we started. Notice the Slot 1 CPU and the maze of cables that must all be carefully labeled.

vendor, while the Duron competes with Intel's Celeron processor. The sockets for AMD CPUs are different than those for Intel and VIA processors, so make sure that you choose a motherboard that's compatible with the CPU line that you intend to stay with.

You also need to choose a motherboard that will fit the cutouts at the rear of the case. Some cases come with a removable panel, and the Intel motherboard was supplied with a replacement with the cutouts in the proper placement. If your case does not provide this feature, and you can't find a motherboard with the proper port placements, you will either have to make your own cutouts with a small hacksaw or rotary cutter or deep six this particular project.

TREAD LIGHTLY

One thing to keep in mind as you approach an upgrade like this is that most of the electronic components inside your PC are very sensitive to static electricity. That means that you should pick your work area carefully (no rungs if at all possible), wear non-synthetic clothes, and make sure to use a grounding strap on your wrist. Also, choose your working surface with care. It should be large enough to comfortably accommodate the PC that you're working on with room left over for components.

Before you start, take a nice-sized piece of cardboard, perhaps from an old shipping box, and cover it with aluminum foil. If you can, attach a ground wire to this and place it on the table that you'll be working on. You'll use this as a resting place for the components that you remove from the old motherboard while you're waiting to transfer them. The aluminum foil will keep static charges from damaging the boards and chips.

Before doing anything, unplug all cables and power cords from the PC. Make sure that you have some tape that you can write on to label internal cables before you disconnect them. A digital camera—to take photos of where cables are attached—is also a great idea if you are unfamiliar with how things are connected.

OUT WITH THE OLD...

The most difficult part of a motherboard upgrade is not replacing the boards. That's actually pretty straightforward. The real work is in the details. There are a multitude of cables attached to the motherboard. Most of these (such as the power connectors and cables to the disk drives) are pretty easy to keep track of. The ones that you must be sure to label before removing include: the cables to the internal speaker, reset button, hard disk activity lamp, and any other cable that you aren't certain of its function. Use a piece of masking tape and a permanent marker.

Once you've labeled all of the cables, carefully remove the RAM chips and set them aside on the foil-covered cardboard. If these chips aren't rated for the bus speed you'll be running on the new motherboard, you'll probably have to replace them. Next, remove the peripheral cards and place these on the foil-covered cardboard. Disconnect the cables and then the power supply connector.

At this point, locate all of the places where the motherboard is screwed to the case and carefully unscrew the fasteners, placing them in a container for safekeeping. The motherboard may also be held in place by plastic spacers that either pop off the case and motherboard or move in slots provided in the case. Carefully remove the old motherboard and set it aside.

IN WITH THE NEW

Installing the new motherboard is pretty much the reverse of the process that you just performed. The one difference is that the mounting holes on the new motherboard may not be exactly in the same places as those on the old board. All new motherboards are supplied with new hardware, so carefully examine the hardware supplied, select the appropriate spacers and screws, and carefully install the new motherboard.

When the motherboard is secured, install the RAM chips and new CPU first, then the other cables, and finally the peripheral cards and power connector. Power up, and you should be able to set the BIOS settings on the new motherboard.

SOURCE INFORMATION

Intel Corp.
408-765-8080
http://developer.intel.com

Soyo
510-226-7696
www.soyousa.com

MAKING THE CHOICE

There are plenty of motherboard manufacturers around. While we used an Intel and Soyo motherboard, Abit, ASUS, Gigabyte, MSI, and FIC are among the other vendors that also offer motherboards.

Exactly which one is your best choice depends on what you want and need. The Intel D815EEA provides five PCI slots and will let you use RAM chips up to a maximum of 512 MB of total memory in its three DIMM sockets (one 256-MB DIMM and two 128-MB DIMMs.) It has onboard audio and a 4X AGP slot for a video card, along with a built-in 10/100 BaseT Ethernet adapter.

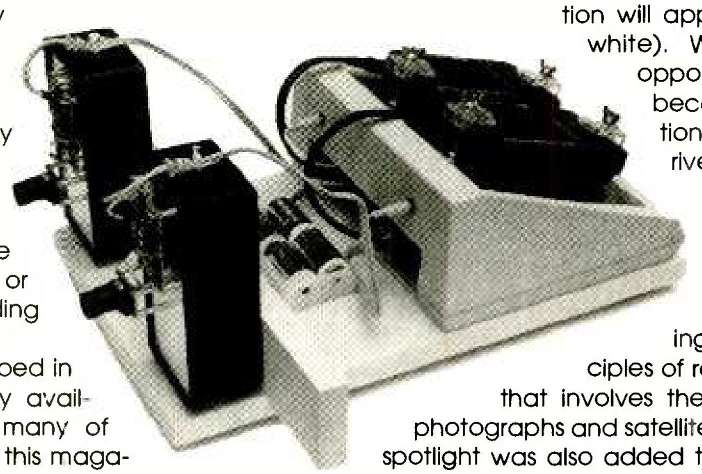
The Soyo SY-7VCA-E also has five PCI slots, but has an ISA slot for older-style peripheral cards, as well. The Soyo lacks the Intel's on-board audio and Ethernet capability, but its three DIMM sockets can each accommodate a 512-MB DIMM module, giving the Soyo an amazing 1.5-GB capacity. Both motherboards offer the latest ATA/100 IDE controller, so you can use the very latest and fastest hard disk drives.

Before you run out to buy a new motherboard, one final word of caution. Not all PC cases have the same holes on the rear panel. Most cases that use a particular style of motherboard (AT, ATX, Micro-ATX, NTX) have the cutouts in the proper place. However, make sure that you match the replacement motherboard form-factor with the one that's being upgraded. Various motherboard vendors maintain a wealth of information on their Web sites, so check those first. P

VIDEO VIEWERS

J. RONALD EYTON

Projects involving video imaging are now relatively easy to undertake because of the availability of low-cost CCD video modules that capture scenes in either black-and-white or color. The audio-visual (A/V) outputs from these modules can be directly connected to the A/V inputs of portable television receivers or to LCD display modules that lately have become much more affordable. Most projects involve only simple connections of the video camera to the TV or LCD display and then adding a power supply.



The two projects described in this article involve readily available components from many of the dealers advertising in this magazine; although configurations and power requirements may vary, the connections are essentially the same. The first project outlines the steps needed to assemble an *Infrared Video Viewer* that allows photographers to preview a black-and-white infrared image of the real world before capturing the scene on infrared black-and-white film. The second project involves the construction of a *Video Stereogram Viewing System* that acquires and displays video images in 3D and allows for experimentation with them.

Infrared Video Viewer. About 44% of the radiation emitted from the sun and arriving at the surface of the earth is in the visible part of the spectrum and is comprised of wavelengths of light from .4 µm through .7 µm (see Fig. 1). About 37% of the emitted solar radiation entering our atmosphere and also arriving at the earth's surface is the invisible infrared radiation slightly longer in wavelength than red visible radiation (beyond .7 µm), but considerably shorter in wavelength than the emitted thermal infrared radiation normally associated with the varying earth's surface temperatures in wavelengths roughly ranging from 9 µm through 13 µm.

See how the world around you looks in black-and-white infrared or color 3D with these two easy-to-build video viewers.

Photographic film is sensitive to the very short wavelengths of incoming solar infrared radiation in the .7-µm through .9-µm range. These wavelengths of radiation are reflected from earth's surface features in a unique manner. Healthy growing deciduous (leafy) vegetation, for example, reflects large amounts of solar infrared radiation. In photographic prints made from black-and-white infrared film, this leafy vegetation will appear light toned (almost white). Water features do the opposite, appearing jet-black because the infrared radiation is quickly absorbed by rivers, lakes, wet soil, etc.

I built the Infrared Video Viewer to demonstrate the environmental interaction of solar infrared radiation to students taking a first course in the principles of remote sensing, a subject that involves the interpretation of aerial photographs and satellite images. An infrared LED spotlight was also added to the system in order to demonstrate the process of infrared viewing in a darkened classroom.

Construction. The viewer (see Fig. 2) consists of a black-and-white video camera module that is infrared sensitive, with an infrared transmission filter attached to the front of the camera lens, that is connected to an LCD display (see Infrared Video Viewer Parts List); these components plus a power supply were then placed in an appropriate housing. A fixed-focus pinhole-lens video module was used to avoid having to continually focus the camera. The infrared-sensitive camera was mounted on a 3- × 2- × 1-inch RadioShack project box. The entire assembly was then attached to a 7- × 5- × 3-inch RadioShack project box that was used to house the LCD video-viewing module.

Wiring simply involved connecting the white wire from the camera to the white wire of the LCD display and the black wire from the camera to the red wire of the LCD display. Both the camera and the LCD display were wired to a 12-volt SPST switch-controlled receptacle mounted on the bottom of the project box. I plugged in an automobile cigarette lighter adapter cord, which I either connected to my car battery (via the cigarette lighter socket) or to a smaller 12-volt sealed lead-acid battery that I placed in sa mall canvas carry-bag.

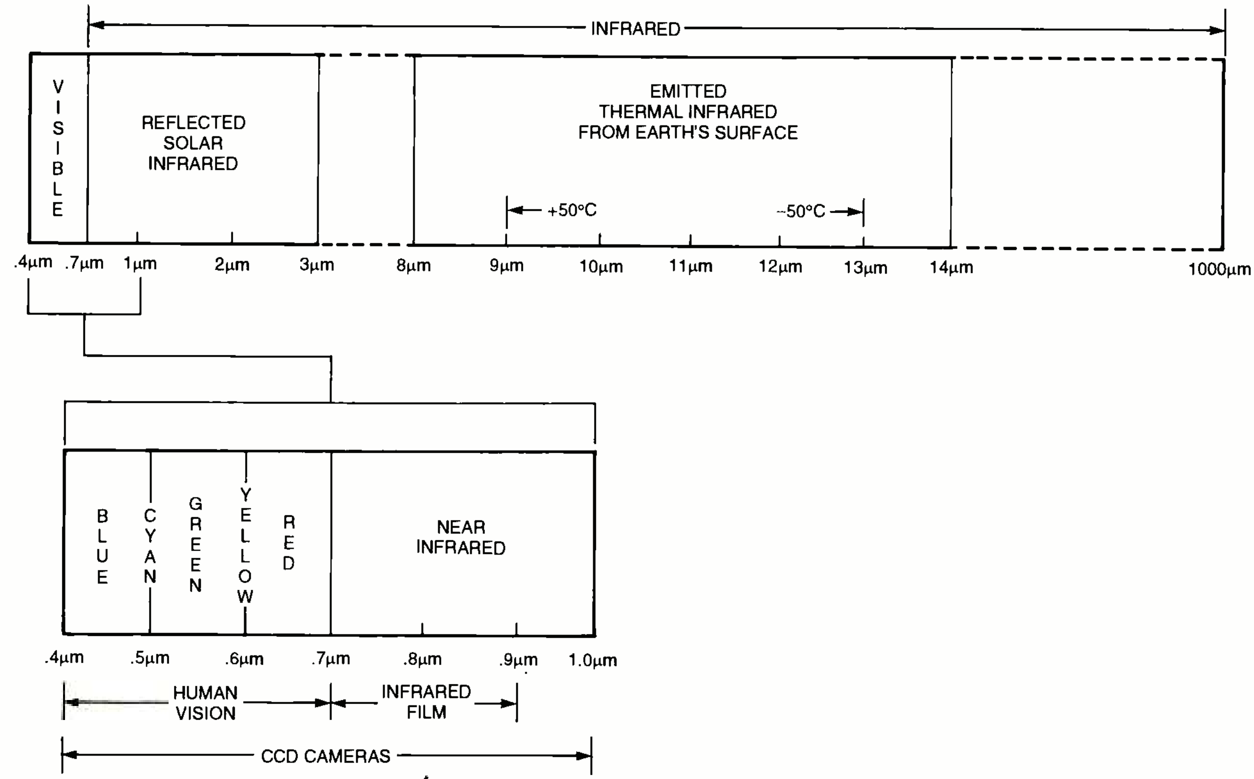


Fig. 1. The above chart illustrates the wavelengths of infrared light. Notice how CCD-cameras are sensitive to both visible and partial infrared sources.

The handles for holding the viewer were plastic drawer-pulls, obtained from a hardware store, which I attached to the sides of the project box. The hardware store also provided the plastic plumbing pipe (see Infrared Video Viewer Parts List) that made up the viewing baffle shown in the picture and diagram. The "plumbing" is necessary to shield the LCD display from direct sunlight when using the viewer outside.

The infrared components are the filter placed in front of the camera lens and the IR-emitting LEDs attached in a cluster to the top of the camera. There are two types of IR filters that can be obtained from the Edmund Scientific Corporation and used in front of the camera—a glass (more expensive) filter and a plastic (less expensive) filter.

Both filters work well—I cannot see any difference in the image rendition even though the filters differ somewhat in how they transmit IR radiation. The glass filter, over time, should probably withstand cleaning and abrasion better than the plastic filter. I found a washer that could be press-fit to the CCD camera lens and cemented the filter to the washer with a few drops of superglue.

The IR LED spotlight was constructed from a kit (see Infrared Video Viewer Parts List) and attached to the top of the camera system, using half of a plastic drawer-pull as the mount. The LED spotlight was wired to the 12-volt power receptacle through a separate SPST switch. A 12-volt LED was added to indicate the on and off state of the spotlight (you can't tell if it is on or off by looking at it!).

I use the IR viewer and LED spotlight in a completely darkened classroom to demonstrate how the system works and I then take students and viewer outside to let them see how the world appears in infrared. The viewer should also be of use to photographers who might want to preview a scene before capturing it on IR black-and-white film, as well as for individuals who are interested in monitoring animals at night using a more intense source of infrared radiation such as an IR filtered sealed-beam flashlight.

An interesting experiment demonstrates that hot objects such as a soldering iron or a stove-top electric element will emit not only heat radiation, but near-infrared radiation, as well. As these objects heat up, they emit shorter and shorter wavelengths going from around 9 μm–13 μm, down to the near-infrared at around 1 μm and finally (at least in the case of the stove) will emit visible radiation as the stove-top element becomes red hot—it now also emits .6 μm–.7 μm visible radiation. A soldering iron or stove-top element (set at medium heat before it glows red) will be visible in the video viewer as a near-infrared emitter and will appear as a bright or white-toned image.

Video Stereograms. Stereograms are usually constructed from two photographs placed side by side that provide a left-perspective view and a right- perspective view to our binocular vision apparatus—a pair of eyes. Specialized stereo cameras using two lenses spaced the same distance apart as our eyes (normally about 2½ to 3 inches) produce the two film negatives from which the stereogram prints are made. Using two video modules to capture a left- and right-

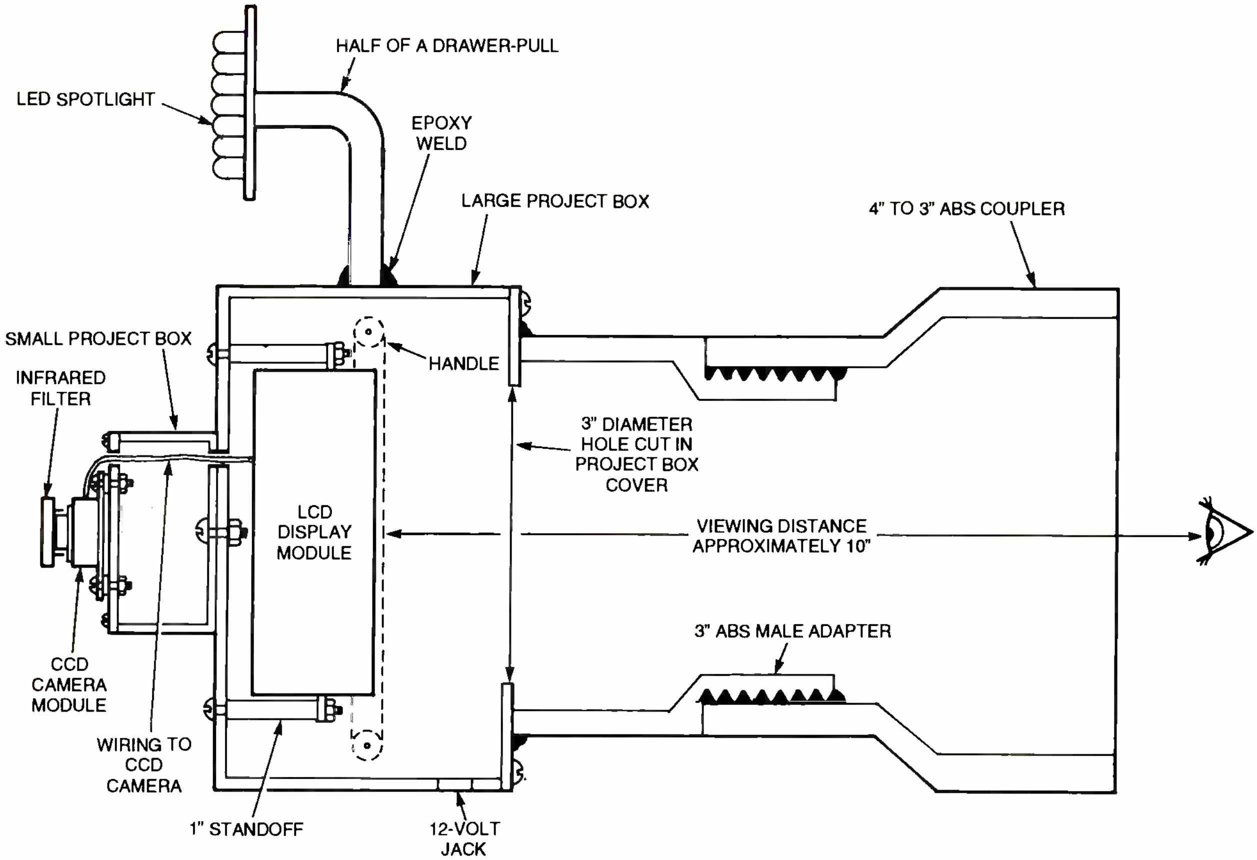


Fig. 2. The Infrared Video Viewer depicted above, although of simple design, can yield remarkable effects. An LED-array is used for illumination and an inexpensive CCD-camera is used for image capture.

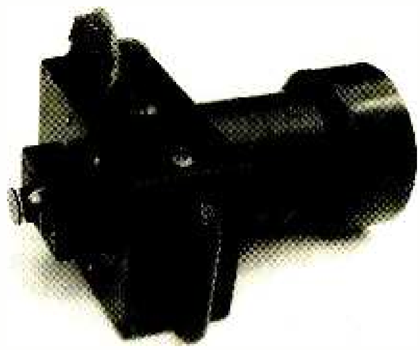
perspective view and then displaying these views on two portable LCD televisions placed side-by-side can duplicate this process.

Because the LCD TVs are a bit larger than the left and right images of a normal photographic stereogram, a set of viewing lenses that incorporate wedge prisms is needed. Inexpensive plastic lens-prism stereoscope viewers can be obtained from Cygnus Graphics (see Video Stereogram Parts List) to facillitate the 3-D viewing process. With all of these parts, a video stereo image acquisition and display system can easily be constucted (see Fig. 3).

What is the value of a video system over a photographic system? The principal advantage is the flexibility for experimentation with different stereo configurations such as close-up stereo (hypostereo) viewing, normal stereo viewing, and distance stereo (hyperstereo) viewing. In addition to demonstrating the stereo viewing process in "real-time," this setup could also be used for the development of a helmet video stereo display—part of a roving video stereo image capture system. This application is discussed briefly at the end of this article.

Building A Stereogram. The Video Stereogram Viewing System was constructed by fastening two RadioShack portable LCD TVs to a RadioShack control console cabinet (8 × 10 × 4 inches), using common plastic mirror wall-mounts or fasteners and wing nuts. The mirror fasteners were used so that the TVs can be easily loosened and moved to access the on/off switch, plug in the appropriate A/V cables, adjust the brightness and contrast, and replace the three AA batteries needed to run each TV set.

The control console cabinet was mounted on a 12-inch × 16-inch × ¾-inch pine board, along with the four C-cell battery holder that is used to supply the power to the video cameras. A 2-inch × 16-inch × ¾-inch strip of pine was glued to the main board and was used to



Here is the completed Infrared Video Viewer. Note the LED-array and the lens of the CCD-camera.

attach the video cameras. Two project boxes (6 × 3 × 2 inches) were used to mount the color video modules on the outside of the box. The video modules were mounted on the left and right side of the project boxes so that the lenses could be as close together as possible when the two boxes were placed side by side.

A bolt was used to attach the project boxes (with video camera modules) to the pine strip that was glued to the main board. Standard cables were used to connect the video modules to the A/V inputs on

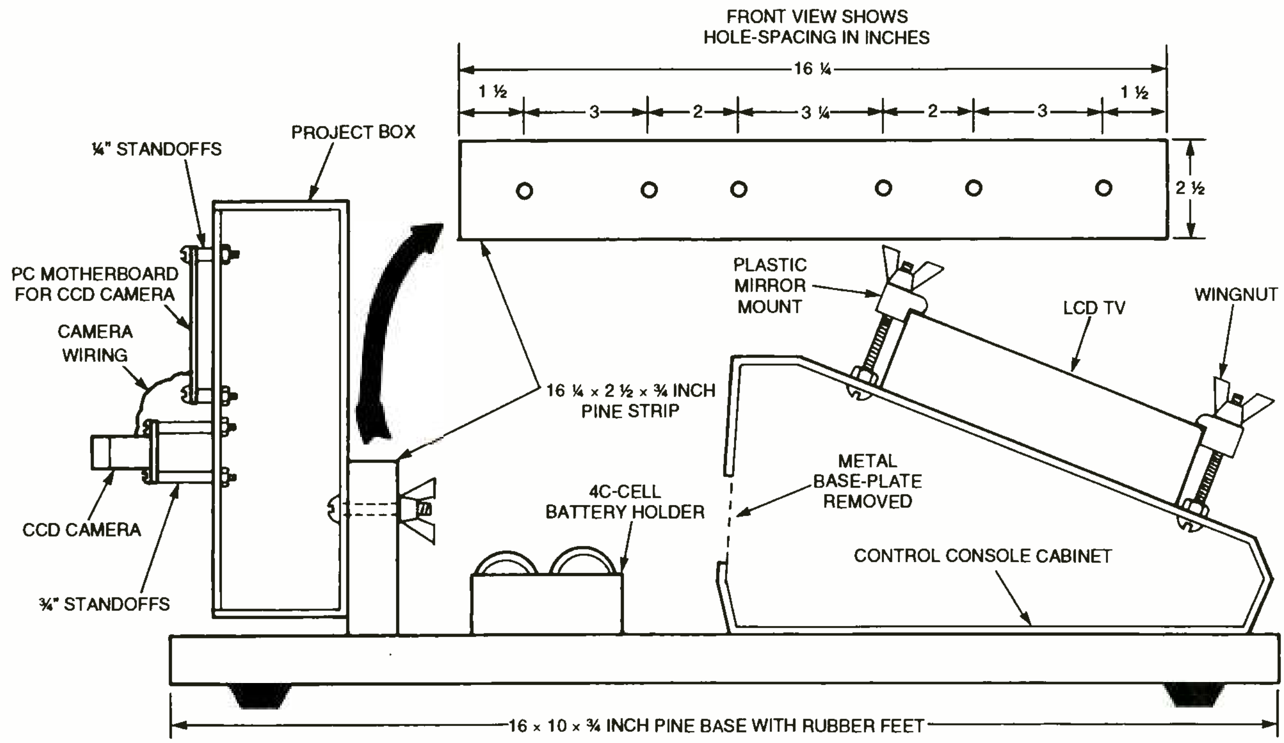


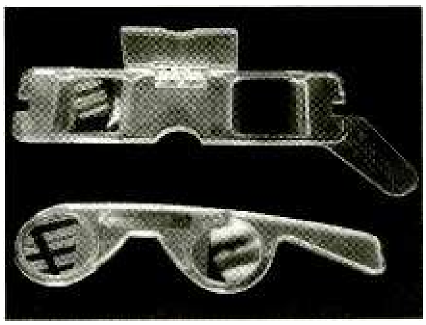
Fig. 3. This Stereogram takes advantage of binocular vision effects in order to produce an apparent three-dimensional image. Two LCD screens provide both a left- and right-perspective image.

the TVs. The extra lengths of cable were "stuffed" into the empty cavity of the control console cabinet that was used to mount the TVs.

Using Lenses. The lenses in the cameras I used are capable of focusing objects as close as ½ inch. When the mounted video modules are placed side-by-side (lenses about two inches apart), objects placed in front of the two lenses at a distance of several inches can be sharply focused. Either of the two stereogram viewers indicated in the parts list can be hand held and used to view the left and right images displayed on the two TVs as a video stereogram. Viewer #1 has about a 10-inch focal-length lens and the strongest prism effect. It is probably the easiest viewer for beginners to use.

Try using the viewer with or without eye glasses (if you wear them) at about a 10-inch distance from the TV images. Viewer #2 has about a 7-inch focal-length and not quite as strong a prism effect as the #1 viewer. However, it does allow for a closer look (7 inches from your eyes to the TV images) and hence produces a slightly magnified image. The stronger prism effect of Viewer #1 makes it easier for individuals to merge the two separate images contained in a stereogram when the distance from the center of the left image to the center of the right image is greater than the normal separation of your two eyes.

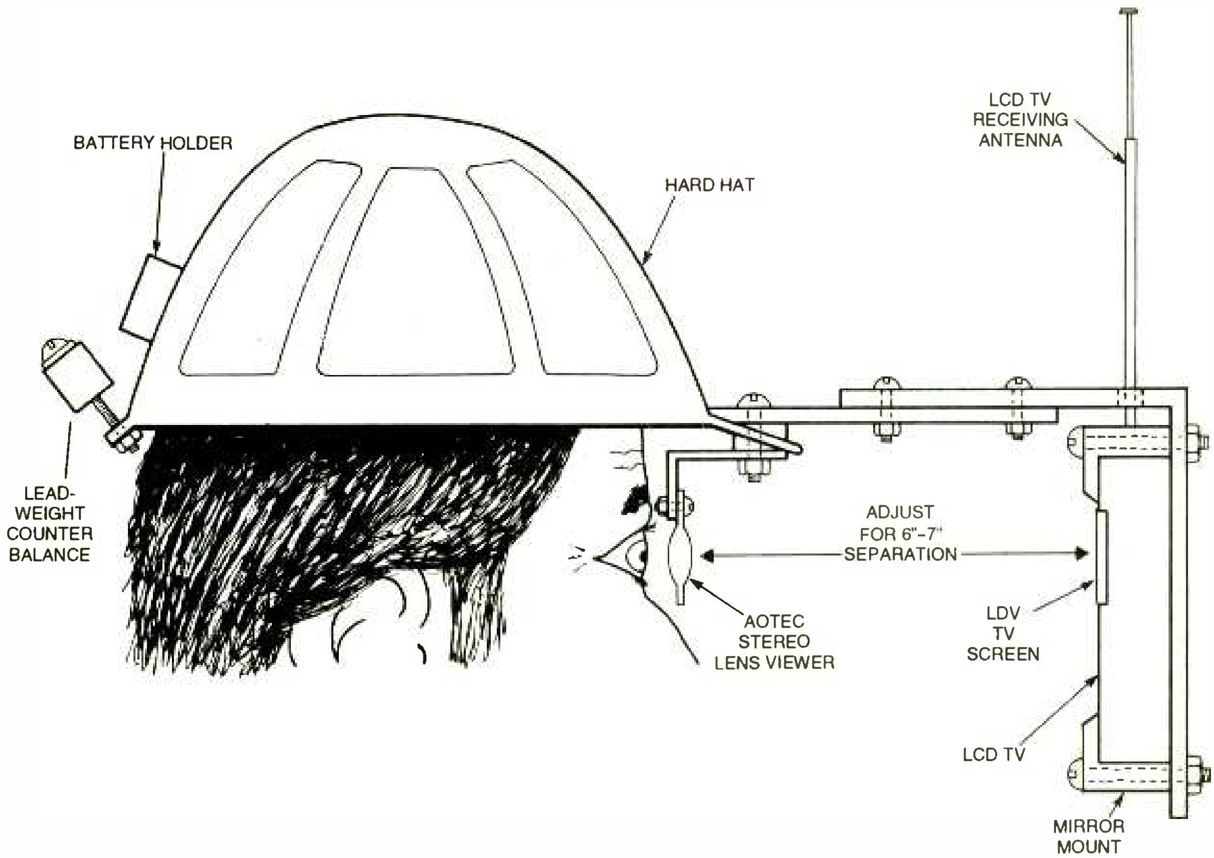
The plastic viewing lens systems (see photo) are inexpensive, and I recommend that you try both. It might also be possible to mount either plastic lens viewer permanently above the two TVs using some sort of side supports connected to the project box. This, however, would make it awkward to turn on or adjust the TVs. Viewing distances with the plastic lens viewers differ slightly between individuals making the fixed distance resulting from mounting the viewer impracticable.



Here are two examples of lenses used for three-dimensional viewing. The added-dimension prism lenses (top) and the Aotec viewer (bottom) are available from Cygnus Graphics for under $5.00.

Visual Gymnastics. Free fusion eliminates the need to use either of the plastic lens viewers and can be accomplished by forcing your left eye to look at the left TV image and, at the same time, forcing your right eye to look at the right TV image. The two images will register, and you will see a 3-D scene without the use of viewing aids. This effect occurs when your eyes are made to diverge or swivel apart. It occurs when you look at far objects, as opposed to looking at near objects, which causes your eyes to swivel in or converge.

One method for achieving free fusion is to focus on a faraway object such as a clock on the opposite side of a room and then quickly look down at the stereogram (the two TV images in our case) and refocus on the images. The argument is that your eyes will still be diverged for a far look and when you refocus on the two TV images in the video stereogram your left eye will still be directed



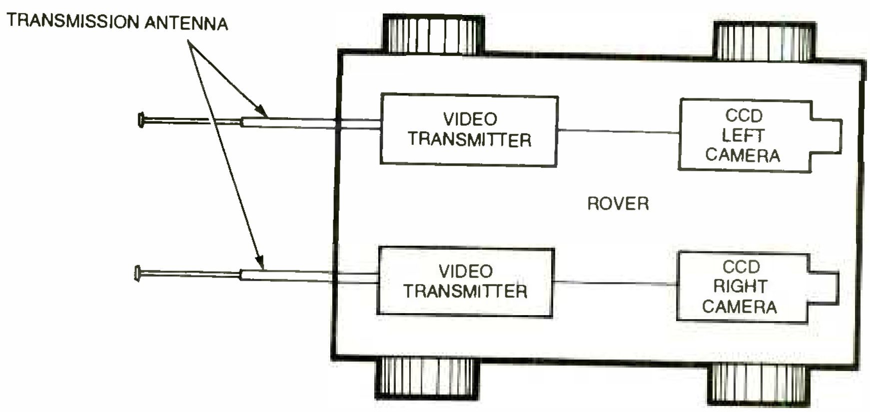


Fig. 4. A good invention has practical applications. Depicted above is a mobile surveillance unit. The observer watches from a helmet-mounted viewer, as a robotic-rover equipped with 3-D imaging sensors scans its environment.

towards the left and view only the left TV (image), and the right eye will still be directed towards the right and view only the right TV (image). Another possibility for free fusion is to view the two TV images by crossing your eyes.

Some individuals can perform this task, involving extreme convergence, much more easily than trying to force a divergent view. If you want to try cross-eyed free fusion, you will have to switch the positions of the two TV images. The easiest way to do this is to interchange the cables so that the left camera is hooked up to the right TV display and the right camera is hooked up to the left TV display.

The stereo depth effect is enhanced with increasing separation of the camera modules. Holes with different spacings in the mounting board for the two cameras allows for placement of the video modules so that the lenses can be set 2 inches apart (from center of one lens to the center of the other lens), 6 inches apart, and 16 inches apart. At 2 inches apart and using close focusing (around 4 inches), small objects can be viewed in stereo. A spacing of 6 inches provides for a slightly exaggerated depth while viewing objects at dis-

(Continued on page 45)

The Tremulous Bear

STEVE DANIELS

Modulation effects—like tremolos and vibratos—are favorites for adding depth and soul to the sound of an electric guitar. However, not all amplifiers have tremolo, and the built-in effects are sometimes not as flexible as you might like. Here's a tremolo pedal that's guaranteed to warm your heart—and your playing. The *Tremulous Bear* can do it all, from slow, throbbing pulsation to machine-gun-like repeat percussion. You can set up lots of weird modulations, and you can easily hack the circuit to drive other effects. If your amp already has tremolo, you can create interesting sounds by using the built-in effect and the Tremulous Bear in series, setting them to different speeds and intensities.

What Is Tremolo And How Is It Produced? Tremolo is amplitude modulation—continuous variation of the volume—of an audio signal. Most circuits for creating it use a *low-frequency oscillator (LFO)* with a range of about 1 to 12 Hz, and the LFO output is made to control the level of the guitar signal. In some circuits, the LFO varies the bias of an amplifier stage through which the guitar signal passes. Other circuits use the LFO to drive a lamp or LED. The pulsing light shines on a photoresistor, and the component's varying resistance controls the amplifier stage. You get different sound qualities depending on the shape of the signal from the LFO and the devices and circuit used in the modulating amplifier.

'Shake Up' Your Guitar Playing With This Versatile Tremolo Pedal!

The heart of the Tremulous Bear is a somewhat unusual setup of the popular 555-timer. The CMOS version is used here for its low current drain. I took advantage of the fact that the 555 generates both square and triangle waves and added switching that allows the use of either. "I knew that the 555 generates square waves," you say, "but where do the triangle waves come from?" To understand this, you have to look at how the 555 works.

Figure 1 shows the internal components of the chip inside the dotted lines, with the external connections and components that make it run as an oscillator. Op-amps U1 and U2 are connected as comparators; the chip's internal resistors bias U2 so that its output will change states if the voltage at the inverting input is greater than $\frac{2}{3}$ of V+. As you can see, this will happen when external capacitor C charges to that level through resistors RA and RB. When U2's output goes low, flip-flop FF toggles and turns on transistor Q. The capacitor now discharges to ground through RB and the drain-source of the transistor. When the voltage on the cap is down to about $\frac{1}{3}$ of V+, comparator U1 changes states. The flip-flop is cleared, the discharge path is closed, and the charging cycle starts again. We get a square wave from the output of the flip-flop, and the triangle wave at pin 2 results from the charging and discharging of the capacitor. What kind of interface can we use to couple that signal to another circuit? After all, any load on the capacitor will keep it from charging properly. Take a look at the Tremulous Bear circuit in Fig. 2.

How It Works. IC2 is wired as the LFO, and a simple toggle switch, S2, lets us choose either the square wave or the triangle wave. The selected signal is coupled to the gate of Q1, a power MOSFET, by diode D2 and the Depth control R10–R11. With S2 in triangle-wave mode, Q1 is controlled by the voltage that charges C7, but its high-input impedance doesn't load the oscillator. The

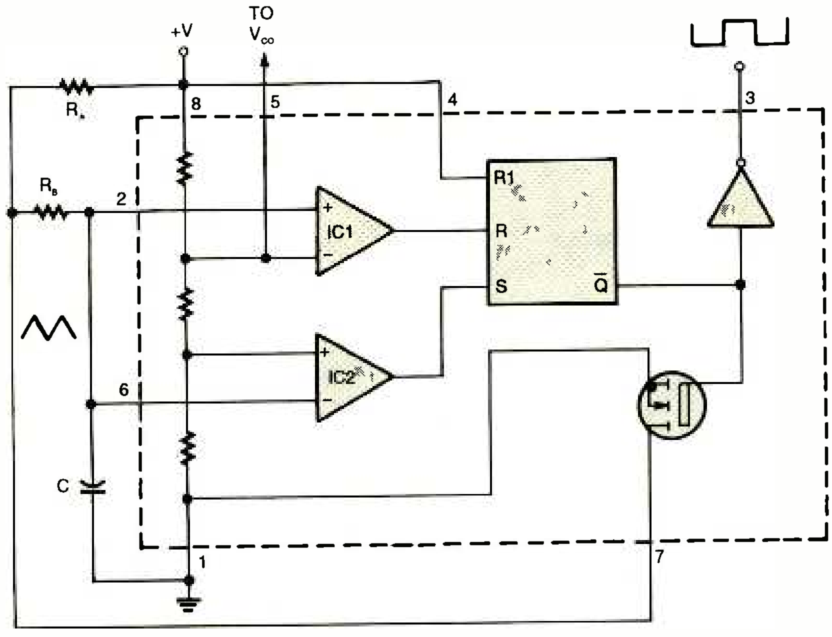
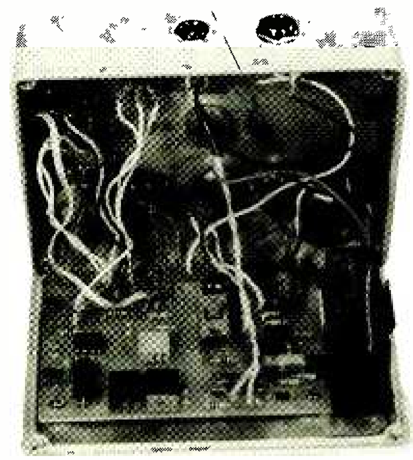


Fig. 1. This schematic shows the internal wiring and operation of the 555 IC. A square wave is obtained from the output of the internal flip-flop, and a triangle wave from the charging of the external timing capacitor.

voltage divider consisting of R12, R13, and R14 sets a bias that just barely illuminates LED1 and LED2 when the voltage of the control signal from IC2 is at minimum. As the voltage of the control signal rises and falls, so does the bias on the gate of Q1 and therefore the brightness of the LEDs. LED1 gives a visual indication that the effect is operating, while LED2 is a high-brightness type that excites photoresistor LDR1. Blocking diode D2 prevents the voltage divider from influencing the charging and discharging of C7. A germanium device is preferred here for its lower forward voltage drop; fortunately, these are still commonly available through RadioShack.

Why use a power device for Q1 when the LEDs only draw a couple of milliamps, and why the voltage regulator? Experienced DIYers will have guessed this: By making Q1 a power device, we can drive an incandescent lamp. The natural time lag resulting from heating and cooling of the filament of a lamp produces a warmer, mellower audio output. The voltage regulator lets us choose either a low-voltage incandescent lamp or an LED without changing the circuit design.

The control signal in a built-in tremolo is usually fixed at a 50% duty cycle—on half the time and off half the time. Modern guitarists sometimes like to set uneven duty cycles to get unusual effects. As it happens, getting an uneven duty cycle from a 555 oscillator is easy; it works this way naturally. Go back to Fig. 1 for a second. We said earlier that the timing capacitor in a 555 circuit charges through two resistances, RA + RB, but only discharges through RB. Because of this, we can't get equal charge and discharge times. This is fine, if we want an odd effect, but now how do we get that *standard* 50% duty cycle? Take a look at Fig. 2 now. Diode D1 is switched in or out



The unit is complete and ready to be closed. An internal battery fits snugly inside the project box.

to take care of this problem. With S1 open (the "Variable" position), C7 charges and discharges through two resistances. With S1 closed (the "50%" position), C7 charges mostly through R1 + R2 because the forward resistance of the diode is much lower than the combination of R3 and R4. Capacitor C7 then discharges entirely through R3 and R4, because the diode blocks in its reverse direction. Since D1 creates separate charge and discharge paths for C7, it is easy to set R1 and R3 for equal on and off times.

The simple amplifier contained in IC1a provides constant input impedance for a guitar. The parallel resistance of LDR1 (a cadmium sulfide/selenide photoresistor) and potentiometer R22 determines the input level to IC1b. By bypassing the photoresistor, R22 acts as a "blend" control; it allows the mixing of an un-modulated signal with the modulated signal coming through LDR1. The blending does two useful things: It helps compensate for the volume loss that results when LDR1 is in its high resistance state, and it lets you set the percussive-ness of the effect. The more un-modulated signal in the mix, the *softer* the resulting sound. A convenient way to match the output level of the circuit to your taste and a low output impedance for easily driving effects chains are both provided by IC1b. Switch S3 is a DPDT alternate-action type. In the position shown in the schematic, it bypasses J1 directly to J2 and also disables the LFO by grounding it through R28. Pressing S3 switches the guitar input to C3 and connects the effect output to J2.

Construction—Beware Of Ticks! Not the six-legged variety...audio ticks! While the Tremulous Bear circuit isn't very complicated, this is a design pitfall that you should know about. Looking at Fig. 3, notice that the PC board layout clearly separates the LFO from the modulator. This also makes it easy to physically separate the leads that go off-board from the modulator from those for the LFO. If you hand-wire or create a different PC board layout, I strongly suggest that you fol-

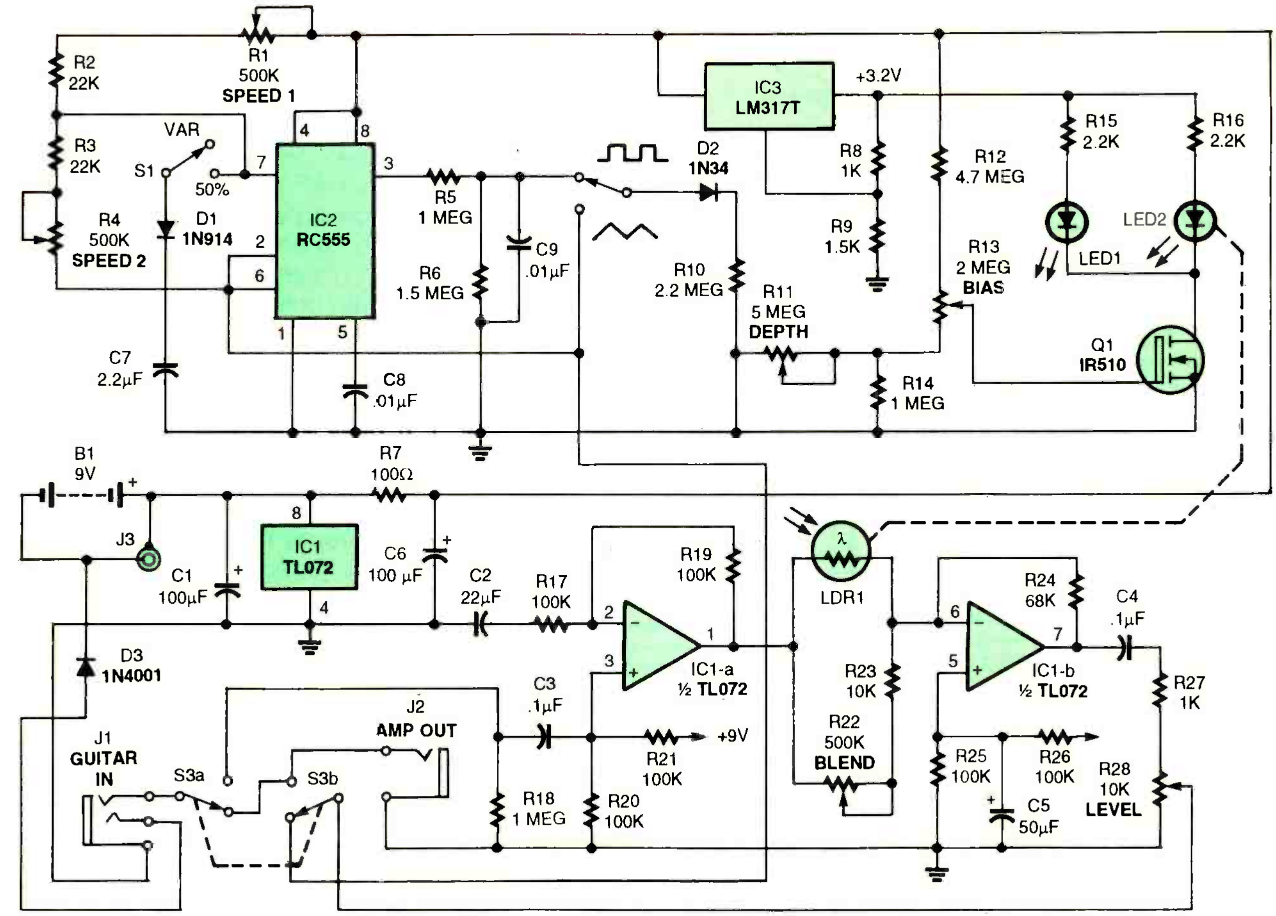
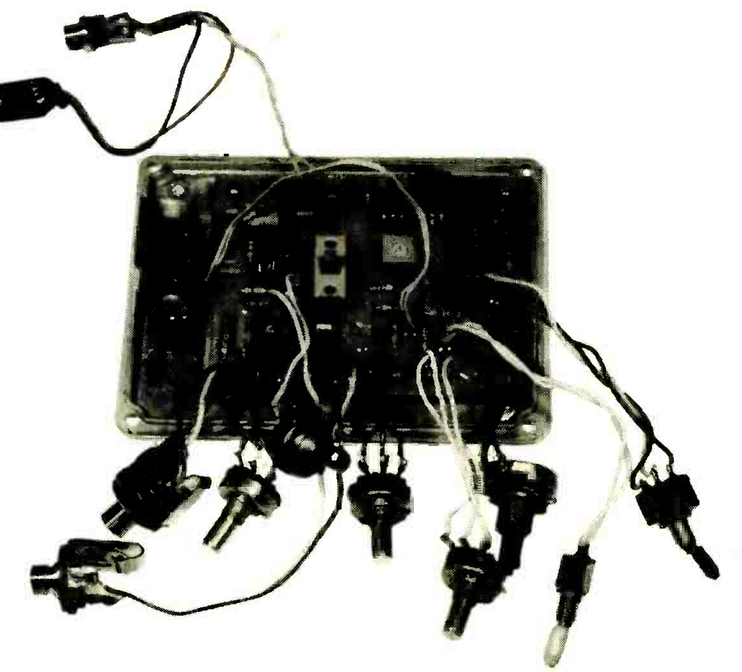


Fig. 2. The chosen waveform from oscillator IC2 varies the bias on Q1, and therefore the brightness of the LEDs. LED1 is a visual indicator, and LED2 varies the resistance of LDR1.

low these guidelines. They help keep the switching action of the 555 from radiating an unpleasant "tick" into the output, which is a common problem with tremolo circuits. If you build the Tremulous Bear as shown here, you'll find that it is tick-free.

To fit everything in the specified Hammond box, it's important to keep the profile of the board low; I used axial-lead electrolytic capacitors rather than radials for C1, C5, and C6, and mounted Q1 and IC3 flat as shown. This leaves as much headroom as possible for the parts that mount on the box. The potentiometers should be miniature types (the part numbers are given in the parts list).

If you make a PC board, you can use any standard method; toner transfer or positive photo-resist will work well. The foil pattern is shown in Fig. 4, or you can order a toner transfer from the author. Drill the holes as shown in the layout drawing. If you expect to use an on-board switch and make your own actuator for bypass switch S3 (see the section on bypass switching below), give particular care to locating and drilling the holes for this component. Since bad PC board traces are the cause of a lot of problems, now is a good time to



The Tremulous Bear is shown here prior to attaching the external components to the top of the case. Switch S3 is in the center of the board.

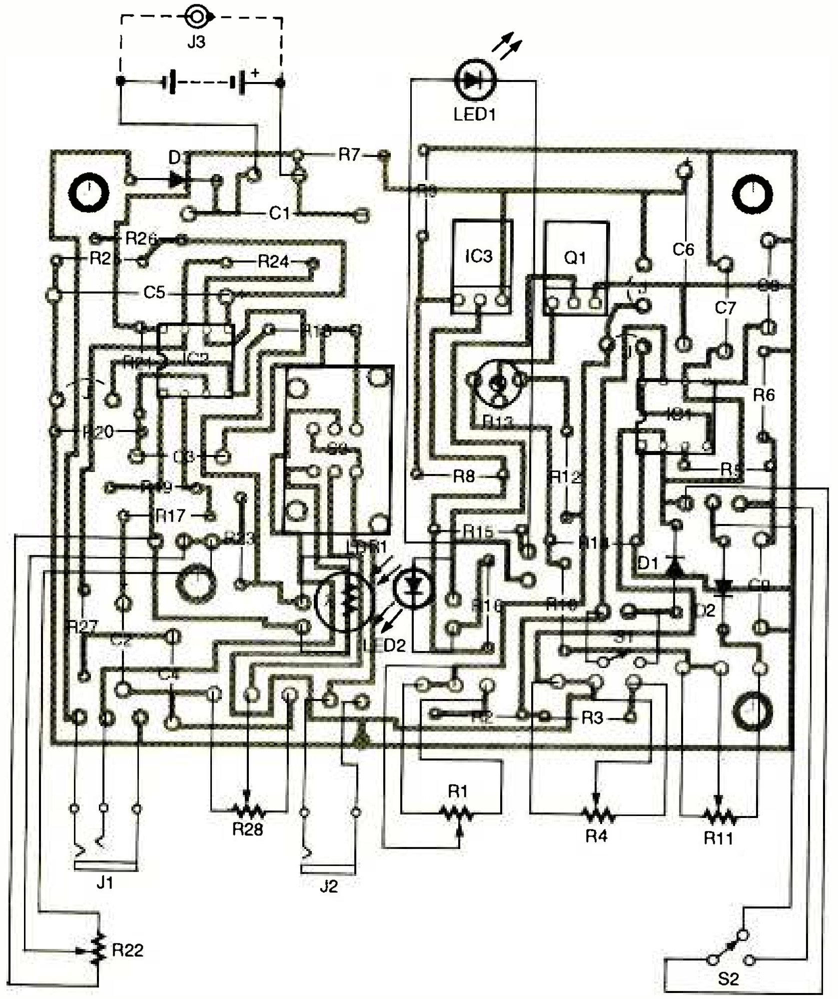


Fig. 3. This component layout keeps oscillator and modulator separate. Don't forget the three jumpers shown in dotted lines.

test every trace for continuity.

Insert the components according to the parts-placement diagram in Fig. 3, starting with the resistors and the capacitors. The jumpers shown in dotted lines are just short pieces of bare copper wire. The ICs and power MOSFET Q1 should be inserted last. You may want to read the next section before you install S3, because it explains how I handled the bypass switching and what your choices are.

Bypass Switching. The switch specified for S3 is usually used in instrumentation applications. It provides double-pole, double-throw switching in a push-on/push-off arrangement and is designed to mount directly on the PC board. It is actuated by a *BOB* (*Bypass-On-Board*) actuator that can be homemade from common hardware (see Fig. 5). The bushing is a hacked-up ¼-inch phone jack, and the plunger is a solid brass rod to which a compression nut has been sweat-soldered. This approach is inexpensive, and it eliminates confusion about how to wire the switch. However, it takes some skill with hand tools to make the actuator. Also, all of your mechanical positioning has to be dead-on to make the plunger of S3 line up with the actuator shaft. I have posted a step-by-step guide to making a BOB actuator on my Web site. If you're not comfortable with rolling your own, use a standard Carling DPDT stomp switch. These are sometimes hard to find locally, but you can order one by mail from the source in the parts list.

Seeing The Light. Using a separate photoresistor and LED for LDR1 and LED2 rather than a pre-assembled photocoupler freed me to experiment with a variety of light sources and sensors. Not just any photoresistor will work for LDR1; you need one that hits the right range of resistance and also shifts quickly between its high and low resistance states. You might find a suitable device in an assortment, but don't count on it. I have successfully used both the Clairex and Silonex types shown in the parts list, and they are readily available by mail-order. When you install the photoresistor on the board, secure it in place with a drop of quick-setting epoxy glue.

The Depth Control. A 10-megohm potentiometer for R11 gives the widest range of control, but 5 megohms is the highest value I've seen in current catalogs. One workaround is to use a 5-megohm potentiometer and increase R10 to 4.7 megohms. Then add an SPST "range" switch wired to short out R10. This arrangement is shown in Fig. 6. If you're really determined, you can create a 10-megohm potentiometer as I did by modifying the 4.7-megohm unit called out in the parts list. Bear in mind that not every make of control will permit this mod; if you want to try it, order the one specified. After you cut the shaft down to ⅝-inch long, remove the resistive element by prying up the tabs that hold the pot together. The element is the semicircle of carbon composition material that has been painted on the phenolic base that also holds the contacts. Measure the resistance of the element by putting an ohmmeter across the outside terminals and then sand the carbon a few strokes—very evenly and gently and from end to end—with 220-grit paper. Repeat the process until you have the maximum resistance you need. Clean the element with a Q-tip moistened with acetone and then re-assemble the control.

At this point, you should have soldered all of the on-board components in place. Before you wire in the external components, locate and glue down the spacers on which the board sits. The spacers are ¼-inch high and tapped for 4-40 screws. To position them, place the board on the lid of the box.

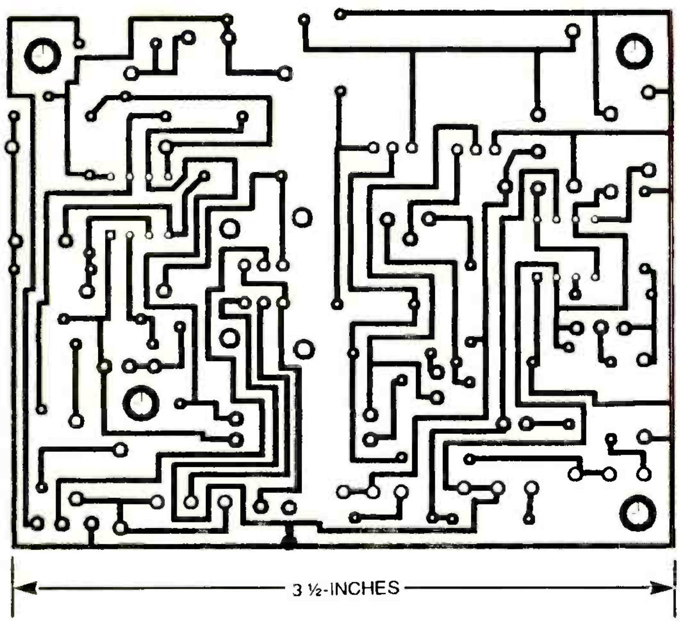


Fig. 4. You can make a PC board by photocopying this actual-size pattern. If you prefer, a toner transfer is available from the author.

Poke a felt-tip pen through each mounting hole and mark the place where each spacer will go. Sand the area of each position mark with 220-grit Carborundum paper and clean up the residue with a Q-tip soaked with acetone. Insert a 4-40 screw in each of the four mounting holes and secure it finger-tight with a threaded spacer. Clean the edges and bottom of each spacer in the same way that you cleaned the mounting areas—sand and clean up with acetone. Mix some quick-setting epoxy cement and apply a small dab to the bottom of each spacer. Carefully place the board down on the lid, centered between the channels and hold it in place until the glue sets. Remove the screws, mix some more epoxy, and add it around each spacer. Now you can also glue the battery holder in place.

Finish the board by soldering leads to it for the off-board parts. I used stranded wire for this and applied a dab of epoxy on each lead as a strain-relief. Then make the connections to the jacks, the pots, and S3 if you are using an off-board stomp switch.

Tooling The Case. This part is fun—once you've been through the pain of learning the ins and outs. The Hammond 1590BB is a popular model for stompboxes; I used it "upside-down," mounting the board to the lid and using the case as a "cover." The layout shown is not cramped, because I sweated a lot of hours to make sure that all the parts would fit. If you don't follow my layout, plan carefully what you are going to do! It is very frustrating to do all the work of making a board and find that something inside the case is in the way of something else. Drilling-templates to locate the holes for the potentiometers, jacks, and switches are essential. You can download copies from my Web site, or make your own with a drawing program if you are using a case other than the Hammond.

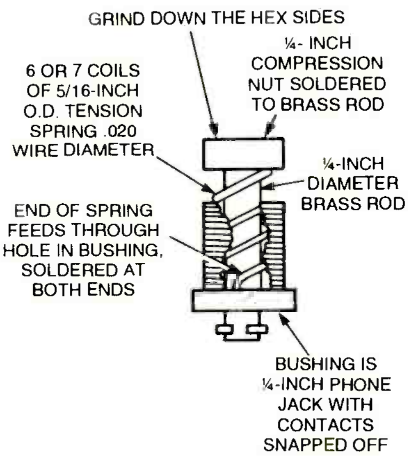


Fig. 5. This is a cut-away view of the Bypass-On-Board switch used in the author's prototype.

Cut the template for the cover to size and fasten it down with double-sided Scotch tape. Use a scratch awl to mark the center of a hole. Drill and de-burr the holes for the pots and switches. Follow the same procedure to drill the holes for the jacks on the side walls.

To get a durable, professional-looking finish, sand the surface thoroughly with 220-grit paper. Then clean up every particle of dirt and grease with acetone. Put down two coats of spray primer and then two coats of enamel. When the paint is dry, put the pieces in a small toaster oven (you can find one for beans at any flea market) at low heat (less than 200 degrees) for about an hour. You can add decals on the resulting finish and then brush on an epoxy sealer.

Setup And Testing. Do this test before you fully assemble the pedal. With the cover open and the room light lowered, connect a 9-volt battery to the battery clips and your guitar and an amplifier to J1 and J2. All of the potentiometers and the bias trimpot R13 should be at about midrange to start. Press S3, and the LED should begin to flash. If you hear the effect when you play, congratulations! You can continue with setup by adjusting the bias trimpot, R13.

To set R13, set Depth control R11 to minimum. Then adjust R13 so that you can just barely see LED2 illuminated. Now set Depth control R11 about ¾ of the way up and play your guitar a bit with the other controls at various settings. Tweak R13 to your taste if necessary. Like the controls in other sophisticated tremolos, the ones in the Tremulous Bear interact with each other; it takes some practice to learn what

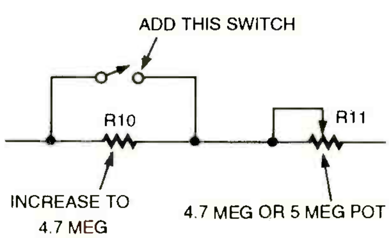


Fig. 6. The schematic above shows the addition of a SPST switch in parallel with R10.

PARTS LIST FOR THE TREMULOUS BEAR

SEMICONDUCTORS

IC1—TL082 dual op-amplifier
IC2—TLC555 or TS555 CMOS timer (RadioShack 900-6262)
IC3—LM317T adjustable voltage regulator
Q1—IRF510 power MOSFET
D1—1N914
D2—1N34 germanium diode (RadioShack 276-1123)
D3—1N4001
LED1—Light-emitting diode, low current (RadioShack 276-310 or similar)
LED2—Light-emitting diode, high-brightness red (RadioShack 276-307)

RESISTORS

(All resistors are ¼-watt 5% units unless otherwise noted.)
R1, R4, R22—500,000-ohm miniature, linear-taper potentiometer (RadioShack 900-7900 or similar)
R2, R3—22,000-ohm
R5, R14, R18—1-megohm
R6—1.5-megohm
R7—100-ohm
R8, R27—1000-ohm
R9—1500-ohm
R10—2.2- or 4.7-megohm (see text)
R11—5- or 10-megohm linear taper potentiometer, see text (RadioShack 900-5979)
R12—4.7-megohm
R13—2-megohm trimmer potentiometer (Mouser 569-72P-2M)
R15, R16—2200-ohm
R17, R19, R20, R21, R25, R26—100,000-ohm
R23—10,000-ohm
R24—68,000-ohm
R28—10,000-ohm miniature, audio- or linear-taper potentiometer (RadioShack 900-7897)

CAPACITORS

C1, C6—100-µF, 15-WVDC, electrolytic
C2—22-µF, 15-WVDC, electrolytic
C3, C4—0.1-µF, mylar or polystyrene
C5—50µF, 15-WVDC, electrolytic
C7—2.2-µF, 15-WVDC, electrolytic, preferably tantalum
C8, C9—0.01-µF, mylar or polystyrene

ADDITIONAL PARTS AND MATERIALS

LDR1—Cadmium sulfide photoresistor, Clairex CL705HL (Mouser 621-CL705HL) or Silonex NSL-5542
B1—9-volt battery
J1—1/4-inch, open-circuit stereo jack
J2—1/4-inch, open-circuit mono jack
J3—external DC-power jack (RadioShack 274-1582 or -1583)
S1—Single-pole, single-throw miniature toggle switch (RadioShack 276-634)
S2—Single-pole, double-throw miniature toggle switch (RadioShack 276-635)
S3—Double-pole, double-throw alternate-action switch (Carling 316-PP or E-Switch 1XJN002UEE [Digi-Key EG-1016-ND])
Case (Hammond 1590BB or equivalent), Knobs (RadioShack 274-415 or similar), 9-volt battery connector, 9-volt battery clip, ¼-inch high × 4-40 threaded spacers, square rubber feet (RadioShack 64-2342 or equivalent)

The RadioShack items whose part numbers start with 900- are available from the RadioShack mail order service, *www.RadioShack.com*, or call 1-800-813-0087.

The following items are available from Small Bear Electronics: Carling DPDT Switch–$9.00, E-Switch 1XJN002UEE (for BOB)–$2.50, toner transfer of PC-board design on Press-N-Peel blue material–$7.00. $ .50 shipping and handling per order to U.S. addresses, $1.00 to non-U.S. addresses. Kit including all parts, unfinished case and Carling switch, toner transfer and blank phenolic board–$64.95 plus postage for 1 lb. U.S. customers pay by personal check, money order or PayPal to smallbearelec@ix.netcom.com. Overseas customers pay by PayPal, International Postal Money Order or bank check, denominated in U.S. Dollars. Checks must be drawn on a U.S. bank. Mail orders to: Small Bear Electronics LLC, 123 Seventh Avenue #156, Brooklyn, NY 11215.

settings you find pleasant for the kind of music you are playing.

When you are happy with the adjustment of R13, finish assembling the pedal by mounting the pots and jacks and closing up the case.

Troubleshooting. If the LED doesn't flash, it's time to break out the multimeter. Remember that the input jack switches the battery voltage, so you have to have a plug in J1 when you take measurements. First, make sure that pin 8 of the 555 has about 8.4 volts on it and that there is about 3.2 volts on the output of the voltage regulator. If you don't see these voltages, review all of the power connections and test the continuity of the associated board traces. When you have the power straightened out, start testing the continuity of every joint and trace in this part of the circuit. Once the oscillator is working, try the effect again.

If there are problems with the sound, first check the supply voltages on the modulator side. You need to have +9 volts at pin 8 of the chip and +4.5 on pin 3 and pin 5. If the voltages are there, see if you can narrow the trouble to one stage by using the guitar amp as a signal tracer. Again, you may have to check each connection with an ohmmeter.

Mods And Substitutions. Without changing the circuit, I substituted a RadioShack miniature 1.5-volt lamp, p/n 272-1139 for the combination of LED2 and R16. By simply readjusting the bias trimpot, I was able to get perfect, slow, up-and-down ramping of the lamp. By increasing R1 and R4 to 1 megohm, I got an even slower rise and fall. The filament lamp adds a beautiful warmth to the sound, but its current drain requires powering the pedal from a wall-wart (AC/DC adapter). You could also use a larger box and build in a small 9-volt supply.

Say that your amplifier doesn't have tremolo, but you want to do some *trem-over-trem* experiments. Take another look at Fig. 1; notice that pin 5 is marked VCO, for Voltage Controlled Oscillator. The chip designers included this function to allow control of the output frequency by an external voltage. I haven't tried it (no time), but I'm sure that applying a varying voltage here from a second LFO (or maybe from a swell pedal?) would do something suitably gnarly.

Obviously, the LFO can also be extracted as a circuit fragment for driving vibratos, choruses, phasers, flangers, and stereo panners. Have a field day...

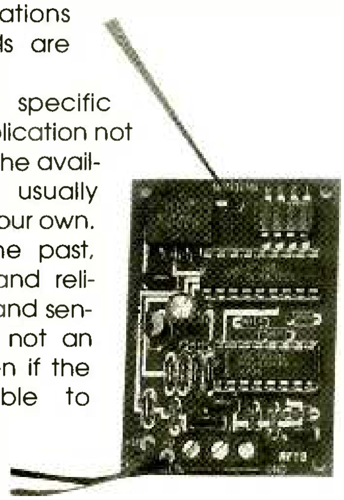
Acknowledgements And References. The idea for using the 555 as a triangle wave source came from a response to a reader question in this magazine. If you don't already subscribe to **Poptronics**, what are you waiting for? Also, the good engineers at Clairex and Silonex were most patient with helping me to find the right photo devices for LDR1. Finally, if you enjoy building your own effects, do check out the

(Continued on page 58)

Wireless Control

FRANK MONTEGARI

Today remote wireless controls of one sort or another are used almost everywhere for almost everything. There are devices available that are designed to transmit audio and video signals or security and computer data from one point to another. They're also used to open garage doors and turn on lights—the applications for wireless controls are infinite.



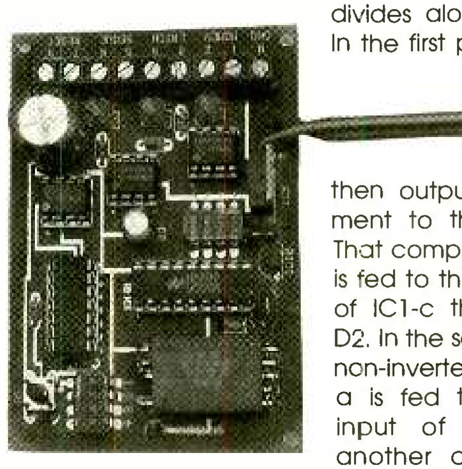
However, for a specific control or pulse application not covered by one of the available devices, it's usually necessary to build your own. Unfortunately, in the past, building a simple and reliable RF transmitter and sensitive receiver was not an easy task. And even if the hobbyist were able to assemble such a system, the circuits required difficult measurements and complicated adjustments in order to set the system's operating frequency, minimize harmonic radiation, and maximize sensitivity. But now, thanks to matched transmitter (TXM-418-LC) and receiver (RXM-418-LC) modules from Linx Technologies, those problems are things of the past. The modules—operating at 418 MHz, with a range of better than 300 feet—are based on surface acoustic wave (SAW) technology for accurate frequency control and have excellent stability and sensitivity.

Build a remote-control transmitter/receiver pair that allows you to control almost any electronic device. Just connect the transmitter to a trigger source and the appropriate output of the receiver to the circuit to be controlled, and you're in business!

Most wireless devices that are not dedicated to or a part of a video, audio, or computer system simply respond to the pressing of a pushbutton or closing of a switch. But the *Wireless Control* system outlined in this article, unlike other such systems, is designed so that the transmitter can accept inputs from mechanical and electronics switches; and other electronic devices—such as phototransistors, microprocessors, computers; as well as other sources.

The matching receiver features three sets of complementary outputs—momentary, latched, and sequential—giving it the versatility to handle almost any application.

The Transmitter. A schematic diagram of the Wireless Control's transmitter circuit is shown in Fig. 1. The circuit is comprised of three integrated circuits, several diodes, the transmit module, and a few additional support components. The signal applied to the transmitter is fed to the circuit through SO1 (a 3-position screw-type terminal block). From there, it travels across C1 and through R3 to the non-inverting input of IC1-a.



The output of IC1-a divides along three paths. In the first path, the output of IC1-a is applied to the inverting input of IC1-b, which then outputs the complement to the input signal. That complementary signal is fed to the inverting input of IC1-c through C3 and D2. In the second path, the non-inverted output of IC1-a is fed to the inverting input of IC1-c through another capacitor/diode combination (C2/D1), making both phases of the input signal available to IC1-c. The output of IC1-c is fed to the inverting input of IC1-d, producing an output signal that is applied to pin 6 of IC2 (a HT680 3^{12} address encoder). That causes IC2 to generate three groups of bits containing data and address information, which is serially transferred to MOD1 (the transmitter module).

While that's going on, the two phases of the input signal (picked up from the outputs of IC1-a and IC1-b) are also fed to IC2 at pins 3 and 4, causing it to generate unique codes for positive and negative transitions at the input. All of that causes MOD1 to produce an RF signal that is transmitted through ANT1.

Encoder IC2 can be programmed via S1 (a 4-position DIP switch) for 16 different addresses so that more than one pair of transmitters and receivers can be used in close proximity without interfering with each other. Resistor R1 (a 100k unit), which is connected between the +5-volt source and the bias terminal of

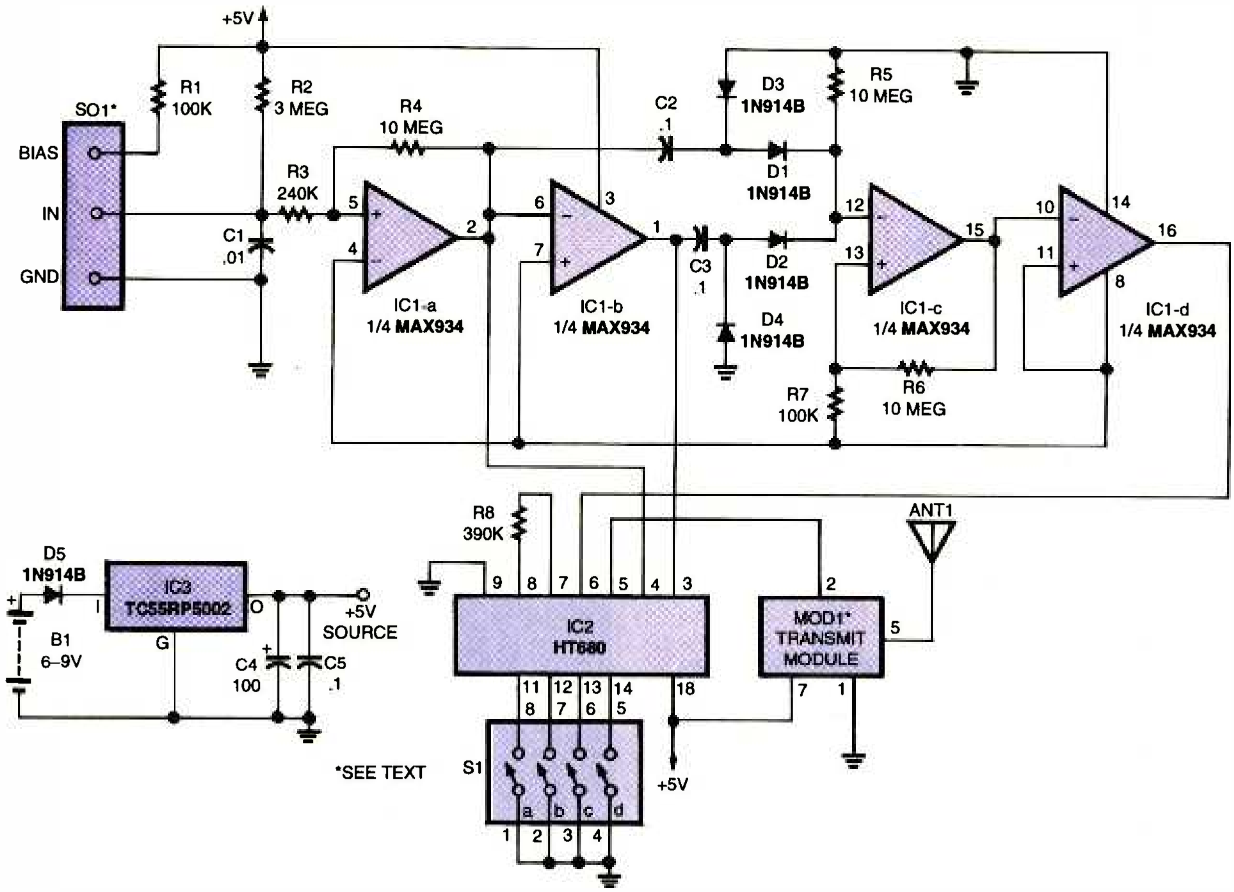


Fig. 1. The Wireless Control's transmitter circuit is comprised of three integrated circuits (IC1–IC3), a proprietary transmit module (MOD1), and a handful of support components.

SO1, allows an external potentiometer or resistor added to the circuit to provide sensitivity and threshold adjustment. The maximum current available from the bias terminal is 50 μA. Component R2 serves as a pull-up resistor, while R4 (which serves as a feedback resistor) provides hysteresis for switch debouncing and noise immunity.

The transmitter circuit is powered from a 9-volt transistor radio battery (B1), whose output is regulated to 5 volts by IC3 (a TC55RP5002EZB low-dropout, micropower regulator). Diode D5 is connected at the input of IC3 to provide reverse-polarity protection. Transmitter standby current is less than 10 μA, and the average transmit current is about 2 mA.

The Receiver. The RF signal output by the transmitter is picked up by ANT2 of the receiver circuit—a schematic diagram of which is shown in Fig. 2. The signal picked up by ANT2 is applied to MOD2 (the receiver module), which extracts the original data and address information from the RF signal and outputs same as a sequential data stream. That information is fed to IC4 (an HT692 3^{10} address decoder), where it is stored and compared with previously programmed data. If a match is detected, one of IC4's data outputs (pins 3 and 4) goes high and remains there as long as a valid data stream is being received. That coding technique ensures that only valid data gets through and random noise pulses are rejected. The decoder can be programmed via S2 (a 4-posiition DIP switch) for 16 different addresses to match the output of the transmitter.

The decoded data outputs of IC4 at pins 3 and 4 are fed along several paths. In one path, the two outputs are fed to IC5—one of three TC4427 dual, level-translating power drivers, which are used to provide complementary 12-volt outputs that can source or sink 200 mA. The three power drivers accept 0- to 5-volt levels and output 0- to 12-volt, push-pull signal levels that can be used to drive external loads. The driver outputs are also applied to three bi-color LEDs, which are used to denote that data is being received; green indicates a low-to-high transition at the transmitter input and red a high-to-low transition. Any driver output that is not high can sink up to 200 mA. The two IC5 power drivers (IC5-a and IC5-b) supply momentary pulses that can be used to trigger whatever load is connected to its output terminals.

In a second path, the two data outputs of IC4 are applied to IC6-a (half of a CD4013 dual D-type flip-flop) through S3 (a 4-position DIP switch). Switch S3 can be used to program IC6-a to be both set and reset by IC4's outputs or to be set by one of the outputs and reset by pushbutton switch S4. It can also be reset by one of the outputs and set

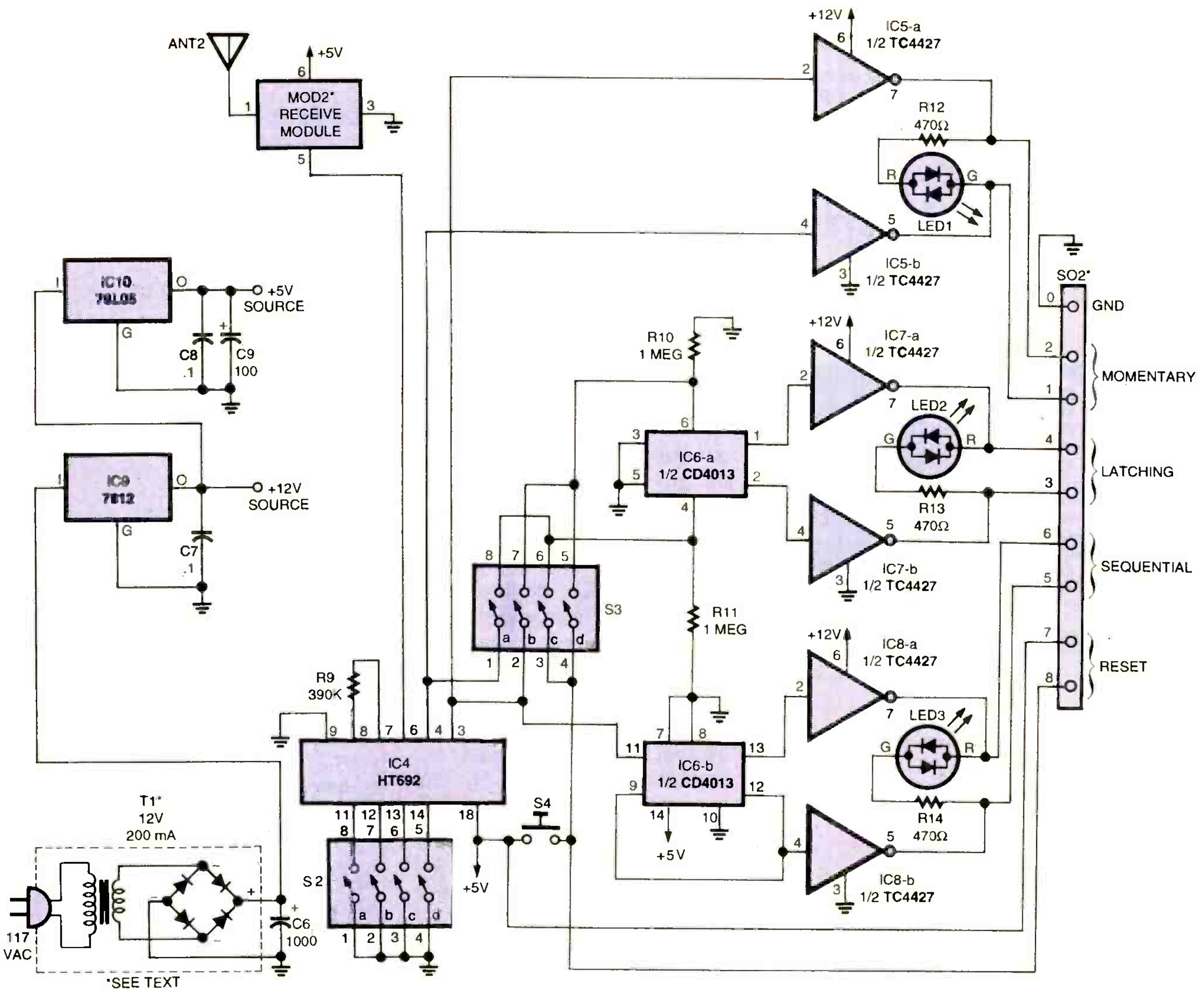


Fig. 2. The Wireless Control's receiver circuit is composed of seven ICs (IC4 through IC10), a proprietary receive module (MOD1), three bi-color light-emitting diodes (LED1–LED3), and several support components.

by S4. The latched outputs of IC6-a are fed to IC7-a and IC7-b, whose outputs are used to drive LED2 (another bi-color LED that indicates IC6-a's output state).

The pin 3 output of IC4, following a third path, is also fed directly to IC6-b at pin 11 (its clock input), causing the flip-flop's outputs (pins 12 and 13) to alternately trigger high or low. The latched outputs of IC6-b are fed to IC8-a and IC8-b, which, like the other power drivers, provides complementary source/sink outputs. LED3 indicates the output state of IC6-b.

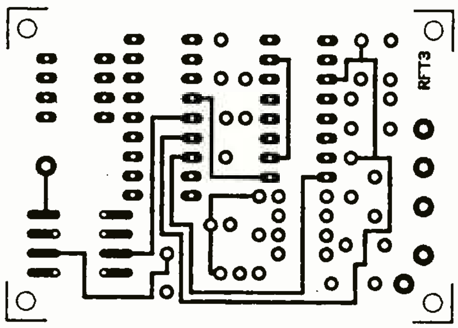
The six power driver outputs are fed to SO2 (a 9-position screw-type terminal block), through which the circuit is connected to the chosen load. The momentary outputs of IC5 at terminals 1 and 2 of SO2 can be used to drive a buzzer. It can indicate a transmitter input closing or opening, or can indicate both if two buzzers are used with different tones.

The outputs of IC7 at SO2 terminals 3 and 4 can be programmed via S4 to latch in different states and thus exactly correspond to an input closing and opening, or they can be programmed to latch on closing only or opening only and be manually set or reset by S4. Doing that is useful to store the results of temporary events, such as a mailbox door being opened by the postman.

The outputs of IC8 at terminals 5 and 6 can be used to sequentially turn a lamp on and off through a relay each time a contact is closed at the transmitter. Since the power drivers supply 12 volts and can source or sink 200 mA continuous and more than 1 amp peak, all sorts of load devices can be driven either directly or through mechanical or solid-state relays.

Power for the circuit is provided by T1 (a 12-volt, 200-mA DC wall transformer), plus a pair of fixed-voltage regulators (IC9 and IC10), along with assorted filter capacitors. Power for MOD2, IC4, and IC6 is provided through IC10 (a 78L05 5-volt, 100-mA fixed voltage regulator), while power for IC5, IC7, and IC8 is provided through IC9 (a 7812 12-volt, 1-amp, fixed-voltage regulator).

Construction. The transmitter and receiver circuits were assembled on a pair of double-sided printed-circuit boards. A set of templates



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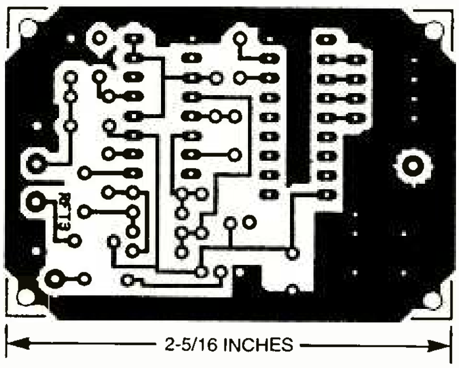

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Fig. 3. The transmitter circuit was assembled on a double-sided printed-circuit board. A set of templates (measuring 2 5/16 by 1 5/8 inches) for the transmitter board is shown here.

(measuring 2 5/16 by 1 5/8 inches) for the transmitter board is shown in Fig. 3, while a pair of templates (measuring 3 3/16 by 2 3/16 inches) for the receiver board is shown in Fig. 4. The double-sided boards provide a good ground plane for the transmit and receive modules.

Note: The transmit and receive modules are surface-mount units that are supplied already mounted to their respective double-sided PC boards. Due to a prior agreement with Linx, the manufacturer of these modules, and their minimum order policy, the supplier listed in the Parts List can not offer the modules separate from the board. However, those who wish can purchase the modules directly from the manufacturer in large quantities. Contact Linx Technologies, Inc. (575 S. E. Ashley Place, Grants Pass, OR 97526; 800-736-6677; Fax: 541-471-6251; Web: *linx technologies. com*) for details.

In addition, the modules are not certified by the Federal Communications Commission (assembled kits cannot be sold as a product without being FCC certified). The kits are intended for personal or experimental use *only*.

Once you've obtained all of the components listed in the Parts Lists, construction can begin. Parts-placement diagrams of the transmitter and receiver boards are shown in Fig. 5 and Fig. 6, respectively. Begin assembly by installing the resistors and capacitors, followed by the non-socketed semiconductor components. The bi-color LEDs (on the receiver board) should be mounted with the long lead connected to point R and the short lead to G on the circuit board.

Next, install appropriate DIP sockets wherever DIP ICs are indicated; **do not** insert the ICs into their respective sockets at this time. Install the terminal blocks, DIP switches, and antennas on both boards. For antennas (ANT1 and ANT2 on the transmitter and receiver boards, respectively), the author used 6.7-inch lengths of stiff wire.

Then connect a 9-volt battery connector to the transmitter board as indicated in Fig. 5. Connect T1 (the wall transformer) to the receiver board, as indicated in Fig. 6. **Note:** S4 and the LEDs of the receiver board should be connected to the receiver board through short lengths of wire so that they can be mounted in a convenient location on the unit's enclosure.

Check the construction workmanship of each board very carefully, looking for cold solder joints, solder bridges, or misoriented or mistakenly placed components; and correct any deficiencies before proceeding. Finally, install the ICs in their respective sockets on the transmitter and receiver boards.

PARTS LIST FOR THE WIRELESS-CONTROL TRANSMITTER

SEMICONDUCTORS

IC1—MAX934 (Maxim) quad ultra-low, single-supply comparator, integrated circuit (Digi-Key MAX934CPE)
IC2—HT680 (Holtek) 3[12] address encoder, integrated circuit (Digi-Key HT-680)
IC3—TC55RP5002EZB (Telcom) +5-volt, fixed-voltage regulator, integrated circuit (Digi-Key 10001)
MOD1—TXM-418-LC transmitter module (see text)
D1–D5—1N914B general-purpose, small-signal, silicon switching diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R7—100,000-ohm
R2—3-megohm
R3—240,000-ohm
R4–R6—10-megohm
R8—390,000-ohm

CAPACITORS

C1—0.01-µF, 50-WVDC, metalized-film
C2, C3, C5—0.1-µF, 50-WVDC, metalized-film
C4—100-µF, 10-WVDC, low-leakage, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—4-position DIP switch
ANT1—6.7-inch antenna wire
SO1—3-position terminal block (see text)
B1—9-volt transistor-radio battery
Printed-circuit board, IC sockets, 9-volt battery connector, wire, solder, hardware, *etc.*

TABLE 1—S3 SWITCH SETTINGS

XMIT	SETTINGS				TERMINAL BLOCK NUMBERS					
INPUT	S3-a	S3-b	S3-c	S3-d	1 *	2 *	3	4	5	6
CLOSED	ON	ON	OFF	OFF		R		R	TOG	TOG
OPEN	ON	ON	OFF	OFF	G		G		NC	NC
CLOSED	OFF	ON	ON	OFF		R		R**	TOG	TOG
OPEN	OFF	ON	ON	OFF	G		NC	NC	NC	NC
CLOSED	ON	OFF	OFF	ON		R	NC	NC	TOG	TOG
OPEN	ON	OFF	OFF	ON	G		G**		NC	NC

CLOSED = Transmitter input at a down level
OPEN = Transmitter input at an up level
R, G = Red or Green LED indicates a terminal at an up level
***** = Momentary - terminal at up level for two seconds
****** = Can be reset to opposite color by pressing SD
TOG = Toggles to opposite color
NC = No change

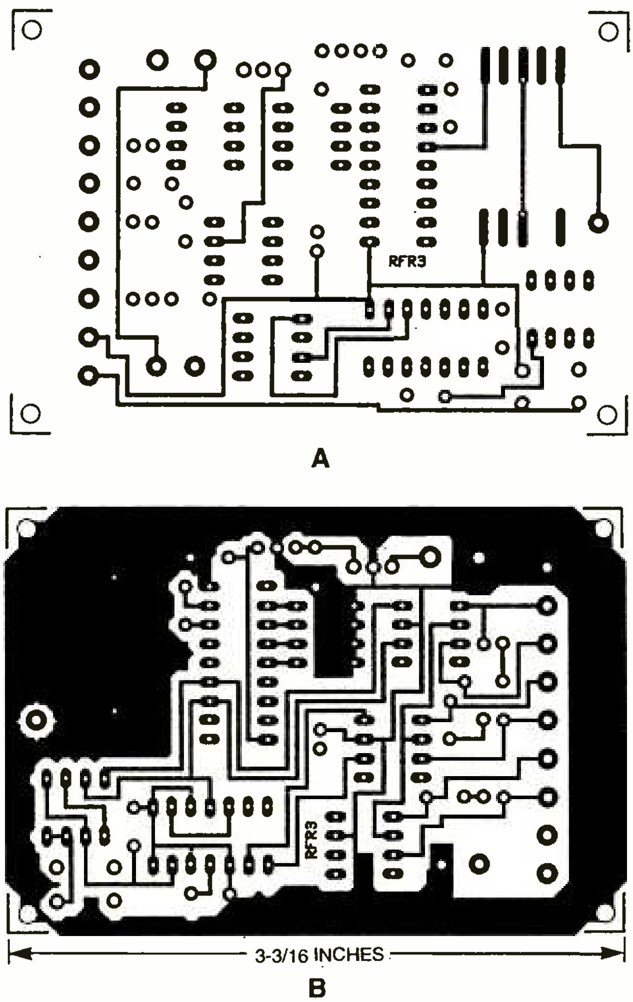


Fig. 4. Like the transmitter, the receiver was assembled on a double-sided printed-circuit board (this one measuring 3³⁄₁₆ by 2⁵⁄₁₆ inches). Both foil patterns are shown here.

Testing. Connect a 9-volt battery to the connector on the transmitter board. Plug the receiver's wall transformer into a receptacle. Set all the individual switches of S1 (on the transmitter board) and S2 (on the receiver board) off, on, or anywhere in between. Just make sure that, however you set the switches, the setting of S1 matches that of S2. Temporarily connect a SPST switch between the input and ground terminals of SO1 on the transmitter board. Next turn your attention to S3 on the receiver board. Set S3-a and S3-b to the "on" position, and S3-c and S3-d to the "off" position. LED1 should be extinguished, while LED2 and LED3 should light either red or green.

Close the test switch connected to SO1 of the transmitter board; LED1 on the receiver board should momentarily light red (blink) for two seconds and then turn off, LED2 should light red and remain lit, and LED3 should change color. Open the input switch, and LED1 should blink green, LED2 should light green and remain lit, and LED3 should remain as it was.

If the two circuits perform as expected, set S3-a and S3-d to the "off" position, and S3-b and S3-c to the "on" position. Press S4 to change LED2 to green (assuming that it is not already green). Close the test switch connected to SO1 of the transmitter board; LED1 of the receiver board should blink red, LED2 should light red and remain lit, and LED3 should change color. Open the input switch; LED1 should blink green, LED2 should remain red, and LED3 should not change. Press S4, and LED2 should change to green.

Set S3-a and S3-d to the "on" position, and S3-b and S3-c to the "off" position. Press S4 to change LED2 to red, assuming that it is not already red. Close the test switch connected to SO1, and LED1 should blink red, LED2 should remain red, and LED3 should change color. Open the test switch; and LED1 should blink green, LED2 should change to green, and LED3 should remain unchanged. Press S4, and LED2 should change to red.

Repeat each of the above tests a few times after changing the S3 switch settings, as some toggling of the latch may occur during the setting of the switches. Table 1 illustrates the functions.

Applications. The transmitter sends a unique digital code when the input toggles from low to high, likewise when it goes from high to low. A low is defined as any voltage below a threshold of +1.2 volts (extending down to −50 volts). A high is defined as any voltage greater than +1.2 volts (up to +50 volts).

The transmitter inputs can be driven from TTL or CMOS devices and circuits, or from a computer, microprocessor, or other logic circuit. In fact, the input device can be something as simple as a pushbutton switch connected between the "IN" and "GND" terminals of SO1. In such an arrangement, when the switch is open, the input is pulled high through R2. Closing the switch grounds the input (pulls it low).

Although a pushbutton switch is used as an example, most any type of switch—magnetic reed, thermostat, a pair of metal probes (in a moisture-detector arrangement), interlaced printed-circuit traces (a homebrew touch-switch arrangement), light-dependent resistor, transistor, *etc.*, to name a few—can be used as the trigger device. In the case of the homebrew touch-switch and other arrangements wherein a bias voltage may be required, a potentiometer can be connected from the "BIAS" terminal to the signal IN terminal of SO1, allowing you to set the transmitter's

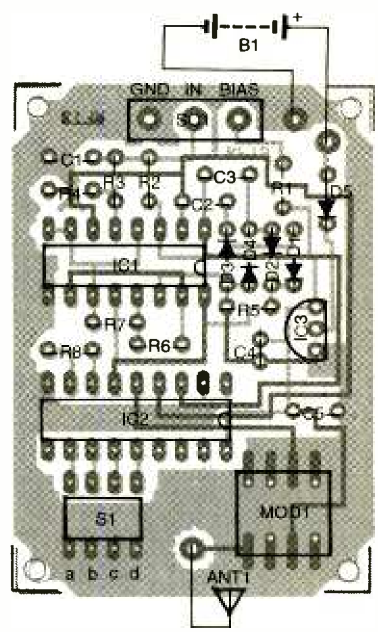


Fig. 5. Use this parts-placement diagram as a guide when assembling the transmitter board.

PARTS LIST FOR THE WIRELESS-CONTROL RECEIVER

SEMICONDUCTORS

IC4—HT692 (Holtek) 3^{10} address decoder, integrated circuit (Digi-Key HT-692)
IC5, IC7, IC8—TC4427 (Telcom) dual 1.5-amp peak, inverting, FET power-driver, integrated circuit (Digi-Key TC4427CPA)
IC6—CD4013 dual D-type, flip-flop, integrated circuit
IC9—7812T 12-volt, 1-amp, fixed-voltage regulator, integrated circuit
IC10—78L05 5-volt, 100-mA, low-power, fixed-voltage regulator, integrated circuit
LED1–LED3—Bi-color light-emitting diode (Mouser 604-L937EGW)
MOD2—RXM-418-LC receiver module (see text)

RESISTORS

(All resistors are ⅛-watt, 5% units.)
R9—390,000-ohm
R10, R11—1-megohm
R12–R14—470-ohm

CAPACITORS

C6—1000-µF, 25-WVDC, electrolytic
C7, C8—0.1-µF, 50-WVDC, metalized film
C9—100-µF, 10-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S2, S3—4-position DIP switch (Jameco 139002)
S4—SPST momentary contact, pushbutton switch (Mouser 101-0461)
T1—12-volt, 200-mA DC, wall transformer (Jameco 114825)
ANT2—6.7-inch antenna wire (American Electromechanical ANT6.7)
SO2—9-position terminal block (see text)
Printed-circuit board, IC sockets, LED standoffs (Mouser 593-STD280), wire, solder, hardware, *etc.*

Note: The following items for the Wireless Control are available from Glolab Corp., 134 Van Voorhis, Wappingers Falls, NY 12590; e-mail: kits@glolab.com; Web: *http://www.glolab.com*: A complete kit of parts for the transmitter—containing an etched, screened, and drilled double-sided printed-circuit board with mounted transmitter module and all resistors, capacitors, ICs, *etc.*; instructions and schematic—for $39 (specify part KT418S2); a complete kit of parts for the receiver—which includes an etched, screened, and drilled double-sided printed-circuit board with mounted receiver module and all resistors, capacitors, ICs, *etc.*; instructions and schematic—for $58 (specify part KR418S2); an etched, screened and drilled double-sided transmitter PC board only with transmitter module mounted, instructions and schematic—for $26 (specify part BT418S2); an etched, screened, and drilled double-sided receiver PC board only with receiver module mounted, instructions and schematic—$35 (specify part BR418S2). Add $5. shipping for all orders. New York State residents please add appropriate sales tax. Please allow 6 to 8 weeks for delivery.

input trigger level.

At the other end of the circuit chain, the output of the receiver can be used to drive any number of devices. For example, a light-emitting diode along with an appropriate current-limiting resistor or a buzzer can be tied between any output and ground to indicated the occurrence of some event detected by the transmitter.

Alternatively, an optoisolator/coupler (with transistor, digital logic, or SCR output) or a relay (mechanical or solid state) could be connected to any output along with a current-limiting resistor and used to trigger some other circuit.

The possible applications for the Wireless Control's transmitter/receiver pair are immense, limited only by your imagination.

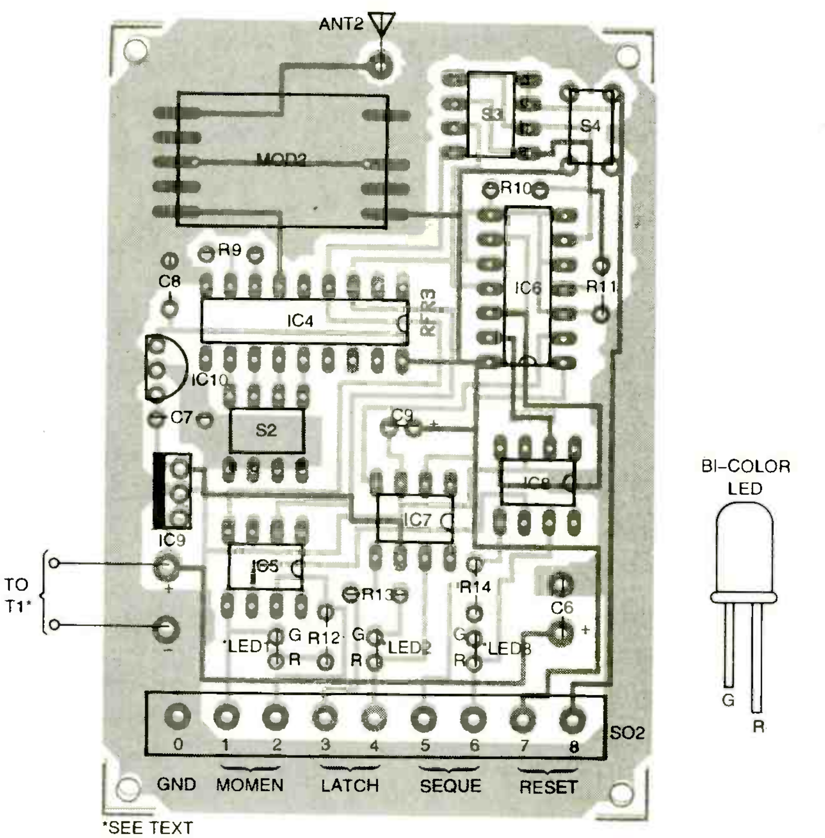
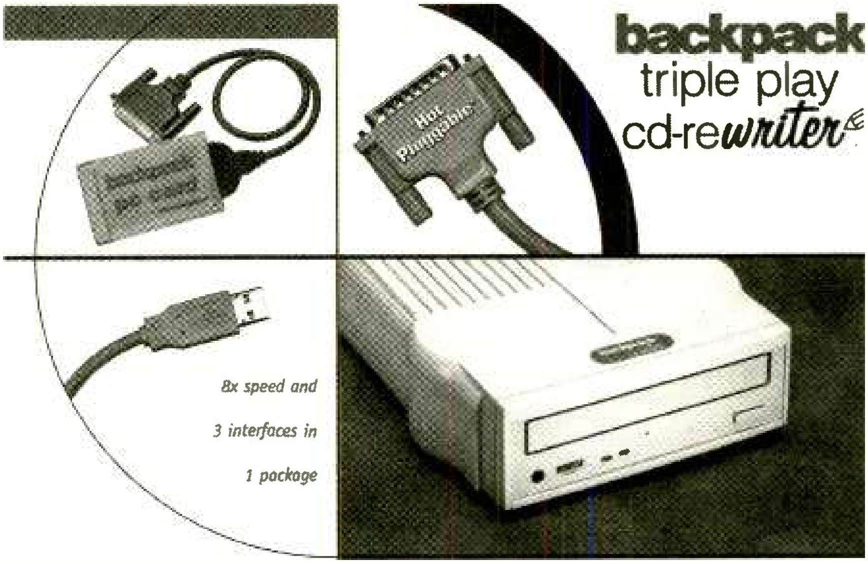


Fig. 6. Guided by this parts-placement diagram, assemble the receiver board, making sure all components are installed in the proper locations and that the polarized components are properly oriented.

A Hands-on Electronics® REPORT

Backpack Triple Play CD-ReWriter

Enjoy mega-storage capability on the go with parallel, PC card, or USB connectivity.



Storage media trends are taking a drastic turn towards optical technology. CDs have become the discs of choice, especially those that have rewriting capability. In the past, people have complained about the price and compatibility of CD-rewriters, but what if you could get a CD-rewriter that is hot pluggable with all three of its included interfaces—parallel port, USB, and PC card—for under $300? Say hello to the new *triple play backpack CD-rewriter* that retails for $269. I recently had the chance to push this box to its limits. Let's take a look at the results.

For The Love Of Mobility. The triple play's PC card interface was the first contender. I slapped the card into a 500-MHz Compaq Presario 1200 laptop while it was running. As advertised, Windows ME automatically detected the unit and led me through the installation. In no time, I was using the packaged Adaptec software for creating data and *.wav* backup discs. After successfully saving and resaving about fifty text files, I disconnected the unit and tried both the parallel port and USB adapters. You can actually witness the difference in data transfer rates between the three interfaces. All three jacks were hot pluggable as claimed and no glitches occurred. Since it's an external unit, the triple play can be swapped between workstations in a snap. As far as complete mobility, you still need an AC power source for the drive (a 14-watt adapter is included).

Platter Production. When people complain that their burner put out a platter, it means that their CD-writer malfunctioned during the recording process. Glitches like this will ruin a single-use disc (rewritable CDs can be recovered from misprints). I had such an experience with the triple play, but it was an acceptable flaw. The media used was a cheaply made discount brand, and the 8X speed was too fast for the disc. The manufacturer told me that they recommend discs that are at least rated at 4X speed. After following their advice, I was pleasantly rewarded with four successful copies from the triple play.

Here is a bit of advice: Don't skimp on your storage media. Sure, discs are available for pennies now, but you always get what you pay for in the marketplace. An investment in high-quality storage media will insure safe and successful backup capability, and you won't have to be afraid of pumping out platter after platter of dysfunctional CDs.

Easy As One, Two, Three. The Adaptec software included with the unit allows users to quickly drag and drop files from their hard drive onto CD-Rs or CD-RWs. File formats like MP3 can be easily converted into *.wav* files for your listening pleasure. The average CD can hold up to 700 MB of data. That's equal to nearly 400 standard 3.5-inch floppies. Some large file formats, such as *T*agged *I*mage *F*ormat *F*ile (TIFF) and *E*ncapsulated *P*ost*S*cript (EPS) can be stored on CD without devouring precious hard drive space.

More and more people are opting to use CD storage because of declining price and easy-to-use software. Owners of the triple play can shop around for the best software applications suited for their needs. The triple play will work with virtually any Windows-based system.

Nifty Options. Weighing in at barely five pounds, the triple play can fit into a modest-sized briefcase or sit unobtrusively upon a desktop. The unit is very quiet and barely puts out any heat. A couple of blank CDs are included—one single-use CD-R and one multi-use CD-RW—in order to get owners started with using the device.

Besides three-way compatibility and hot plugging, the triple play offers pass-through printer capability that allows a printer to share the

backpack triple play
cd-re*writer*

EXTERNAL CD-RW DRIVE

, PARALLEL PORT, PC CARD AND USB

Model Number	Parallel Port Interface	PC Card Interface	USB Interface	Write, Rewrite, Read Speeds
193200	✔	✔	✔	8x4x32
193250	✔	✔	✔	8x8x32

SPECIFICATIONS

Triple Play Performance*	USB Type I — 4X write, 4X rewrite, 6X read (max.) PC Card Type II — 8X write, 4X-8X rewrite, 24X read (max.) EPP/ECP — 4X write, 4X rewrite, 8X read (max.)
Data Buffer	2MB
Typical Access Time	350 milliseconds 12cm disc 1/3 stroke
Supported Media	High Sierra, ISO 9660, CD-ROM XA, Photo CD, MultiRead CD-RW, CD-R and CD-audio format
Recording Media	CD-RW, CD-R
Bundled Software	Adaptec® DirectCD™ and Easy CD Creator™
Write Speeds	1X, 2X, 4X, 8X** (193200) 1X, 2X, 4X, 8X** (193250)
Rewrite Speeds	2X, 4X** (193200) 2X 4X, 8X** (193250)
Read Speed	32X — 1.0MB/s max. with USB Type I 2.5MB/s max. with PC Card Type II 1.2MB/s max. with EPP/ECP
Power Consumption	14 watts, universal power supply included
Line Voltage Range	100 - 240 VAC
Operating Temperature	41°F - 95°F (5°C - 35°C)
MTBF	120,000 POH @ 20% utilization
Approvals	UL, CSA, FCC class B, CE, TÜV, SEMKO
Dimensions	2 3/16"(h) x 7 1/16"(w) x 11 3/4"(l) 5.6cm (h) x 17.9cm (w) x 29.8cm (l)
Weight	4lbs. 8oz. (2067g); power supply - 8oz. (227g); parallel port cable - 5oz. (142g); PC Card and cable - 3.3oz. (95g); USB cable - 2.5oz. (69g)
Warranty	1 year

ADD-ON OPTIONS FOR ALL EXTERNAL CD-RW MODELS

P/N 836	backpack PC Card adapter with attached cable
P/N 839	backpack USB adapter with attached cable
P/N MKT-CASECD	backpack cd-rewriter soft-sided carrying case

PRODUCT FEATURES

- Attach to USB port, PC Card slot and Parallel Port — perfect for desktop and notebook PCs
- Hot Pluggable with USB, PC Card and Parallel Port — attach and detach the drive without restarting your PC under Windows™ 95†, 98, Me and 2000
- Rewrite CD-RW, write CD-R and read CD-ROM discs
- Create your own custom CDs – both audio and data
- Includes CD creation tools software for both audio and data CDs
- Use CD-RW discs for up to 700MB of rewritable storage per disc
- Use CD-R discs for archiving or distributing up to 700MB of data
- Use CD-RW discs to update and rewrite data like a diskette
- MPC 2 compliant with USB, PC Card and EPP/ECP
- Device drivers for Windows™ (95†, 98, Me, 2000 and NT 4†) included
- Includes un-install utility to remove software drivers from Windows™
- Plays both CD-ROM program and audio CDs
- Can be daisy-chained with other backpack drives
- Smart pass-through port (for your printer) allows you to print without disconnecting the drive when attached to the parallel port
- Uses industry standard Universal Serial Bus (USB), PC Card and Micro Solutions' patented parallel port interface technology
- Supports LPT1 - LPT3
- Also available: backpack CD-ROM, hard and diskette drives

SYSTEM REQUIREMENTS

- IBM compatible Pentium
- USB port, PC Card slot or standard EPP/ECP parallel port
- Microsoft Windows™ 95†, 98, Me, 2000 or NT 4†
- 16MB RAM min., 32MB RAM recommended
- 10MB free hard drive space per minute of music to be recorded

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http://www.micro-solutions.com

Specifications subject to change without notice. IBM PC, Windows 95, Windows 98, Windows Me, Windows 2000, Windows NT, Adaptec, DirectCD and Easy CD Creator are registered trademarks of their respective owners.
*Max. transfer speeds. Transfer speeds are dependant on the host PC.
**Recording speeds are not guaranteed. Records at 4x, 2x or 1x speeds on slower Pentiums.
†USB not supported under Windows 95 or Windows NT 4.

LIT-035 02-01

The table above shows the leading particulars for the CD-rewriter. Note, that all data-transfer speeds are dependent upon the host PC.

same LPT port as the CD-rewriter. The days of deciding which peripheral is higher on the food chain or installing arcane A/B switches to incorporate multiple devices are quickly coming to an end. I tried out the pass-through capability by rigging an Epson 740 into the setup. Once again, the product worked as advertised. I was able to print to the printer and scan the CD in the triple play without disconnecting anything and without buggy IRQ conflicts.

A Job Well Done. The triple play receives a hearty handshake of approval from this test bench. The product performed well under test and achieved all published claims. Only one disc was harmed in the lab and that was due to the storage media's incompatibility. Anyone who is shopping for a CD-rewriter should check out the triple play.

MicroSolutions, the corporation responsible for the backpack product line, has a plethora of CD-based products. Starting as low as $149 for a 24X parallel-port CD-ROM and working its way to the triple play, backpack has something for everyone. You can visit *www.micro-solutions.com* for more information or contact their offices at MicroSolutions, 132 West Lincoln Hwy., DeKalb, IL 60115; 800-890-3411; or circle 80 on the Free Information Card. **P**

VIDEO VIEWERS

(continued from page 29)

tances of 3 feet to 30 feet and provides good depth perception for features in the 30- to 100-foot range. Moving the cameras 16 inches apart produces stereo images with greatly exaggerated depths for close objects, but does provide excellent depth perception for features that are hundreds of feet away.

The cameras could also be easily mounted on a long 2-inch × 4-inch piece of lumber with separations of 4 feet, 8 feet, etc. to produce depth sensation in very far away scenes such as the unobscured hills or mountains visible on the far side of a lake. One consequence of this extreme hyperstereo view is that the landscape will appear as a minature model of the real world to the observer of the stereogram. This phenomena, associated with long-base stereo involving a large separation between the camera lenses, is known as the Lilliputian effect and is thought to be the way in which the larger dinosaurs perceived their local landscape as a result of the wide spacing between their eyes.

Conclusion. The 3-D video-viewing system descibed in this article could also be reconfigured as a helmet-display system to be used in conjunction with a roving vehicle/stereo cameras combination. A non-stereo roving video system was discussed by John Iovine (April 2000, **Poptronics**, "Amazing Science - Telepresence", pp. 49-51, 56) and provides the basis for the diagram shown in Fig. 4 for a 3D version. Those of you more capable and ambitious than I might want to give this a go!

PARTS LIST FOR THE VIDEO STEREOGRAM VIEWER

1—Control console cabinet, 8 × 10 × 4 inch, RadioShack Cat. No. 270-216, $16.49

2—LCD color TVs with A/V input jack, OPTIMUS 2.2", RadioShack Cat. No. 16-178, $99.99 each The new RadioShack 2001 catalog shows essentially the same 2.2-inch LCD TV with A/V input jack as Cat. No. 16-3053, $99.95 each.

2—Y-adapter cables, 1/8-inch stereo to 2 RCA plugs, 3 ft., RadioShack Cat. No. 42-2475, $4.49 each

2—Two-phono plugs adapter, back to back RCA jacks needed to connect input plug of Y-adapter to output plug from TV camera module, RadioShack Cat. No. 274-1553, $2.49 each

2—Right-angle adapters, accepts 1/8-inch stereo plug—fits 1/8-inch stereo jack; needed to connect 1/8-inch plug of Y-adapter cable to LCD TVs at right angles (keeps TVs close together), Radioshack Cat. No. 274-372, $2.99 each

1—Battery holder, 4 C-cells, RadioShack Cat. No. 270-390, $1.59

2-Color video cameras—such as:

Ramsey Electronics Inc. (*www.ramseyelectronics.com*) Color CCD Camera with wide-angle 3-mm/f3.6 92-degree lens on three connected PC boards, Cat. No. CCDCC-1 $129.95 each or Jameco Electronics (*www.jameco.com*) Sony Color 2PC Board CCD Camera with a 3.6mm/f2.0 lens focussing from 10mm to infinity, Part No. 139571 $199.95 each

2—Project boxes with aluminum covers, 6 × 3 × 2 inch, used to mount the color video cameras, RadioShack Cat. No. 270-1805 $3.69 each

2—Hand-held stereo lens viewers Added Dimension prism-lens viewer, $3.25 or Aotec Viewer, $1.75 both available from Cygnus Graphic, P.O. Box 32461, Phoenix, AZ 85064-2461

PARTS LIST FOR THE INFRARED VIDEO VIEWER

1—Infrared sensitive CCD camera with pin hole lens, available from Ramsey Electronics (*www.ramseyelectronics.com*), MiniPeeper CCD Video Camera Module, Cat. No. CCDPH-2, $69.95

1—Video display module, available from Parts Express (*www.parts-express.com*), Color 4" LCD Video Module, #205-050, $139.80

1—IR LED spotlight, available from Jameco Electronics (*www.jameco.com*), BG Micro IR Illuminator Kit, Part No. 157964, $14.95

1—Project box, 3 × 2 × 1 inch, RadioShack Cat. No. 270-1801, $1.99

1—Project box, 7 × 5 × 3 inch, RadioShack Cat. No. 270-1807, $5.89

1—LED panel indicator, 12 volt red diffused with holder, RadioShack Cat. No. 276-011, $2.29

2—Toggle switches, Mini SPST, RadioShack Cat. No. 275-634, $2.79 each

1—Jack, metal-panel-mount coaxial DC input 2.1-mm I.D., Radioshack Cat. No. 274-1563, $1.69

1—Cigarette lighter power cord, standard 12 V_{DC} fused 8 ft., RadioShack Cat. No. 270-1533, $4.49 (has tip with a 5.5-mm O.D. and 2.1 mm I.D. to fit jack listed above)

1—Infrared filter, Edmund Scientific (*www.edmundoptics.com*), either 1-inch diameter Optical Cast IR Longpass Filter (plastic), Stock. No. K43-948, $5.25 or 12.5-mm diameter Longpass Glass Color (IR—visually black) Filter, Stock No. K54-662, $11.25

The following items were obtained from a hardware store:

3—Plastic drawer pulls (for handles and attaching IR LED spotlight to infrared video viewer)

1—4-inch × 3-inch ABS coupling (to construct the viewing baffle)

1—3-inch ABS male adapter (to construct the viewing baffle)

1—Unit of Poxy Weld cold-weld-adhesive (metallic gray color) (to construct the viewing baffle and weld it to the large project box)

BUDGET PROJECT AND COMPUTER BOOKS

☐ **BP294—A Concise Introduction to Micro-soft Works $6.99.** You can use the word processor to your advantage to type, edit, print and save documents. This book explains how Works can be used to build up simple spreadsheet examples, edit them, save them, print them and retrieve them. It informs you how to create simple macros, and to simplify long repetitive tasks and to customize the program to your own needs.

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

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

☐ **BP432—Simple Sensor Terminal Block Projects $6.99.** This book is the next logical step from the above book (BP378), by the same author. This is an *open sesame* to the practical world of electronics for youngsters or beginners.

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

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

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

☐ **BP396—Electronic Hobbyists Data Book $7.99.** This book contains details of a modern five-band resistor code or an old color code for a ceramic capacitor, the formula for parallel resistance, and basic data on an NE5534AN operational amplifier.

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

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

☐ **BP298—Concise Intro to the Macintosh System and Finder $5.99.** This book explains: The System and Finder, what they are and what they do; how to use the System and Finder to manipulate disks, files and folders; configuring and printing files from the Finder; getting the most from the system utility programs; and running MultiFinder.

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

☐ **BP345—Getting Started In Practical Electronics $6.99.** This book provides basic essentials for the builder and 30 easy-to-build fun projects with which every experimenter should toy. Printed-circuits designs are included to give your project the professional touch.

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

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

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

☐ **BP317—Practical Electronic Timing $6.99.** This book provides the time measurement theory and backs it with a wide range of practical construction projects. Each project has how-it-works theory and how to check it for correct operation.

☐ **BP325—A concise User's Guide to Windows 3.1 $6.99.** Understand what hardware specification you need to run Windows 3.1 successfully, and how to install, customize, fine-tune and optimize your system. Get into understanding the Program Manager, File Manager and Print Manager. Tips on the word processor, plus how to use Paintbrush. More on the Cardfile database with its auto-dial feature, Windows Calendar, Terminal, Notepad, etc.

☐ **BP327—DOS: One Step at a Time $5.99.** There will be times when you absolutely need to use DOS to carry out 'housekeeping' functions. This book starts with an overview of DOS, and later chapters cover the commands for handling disks, directories and files.

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

☐ **BP404—How To Create Pages for the Web Using HTML $7.99.** HTML is the language used to create documents for Web browsers such as Mosaic, Netscape and Internet Explorer. These programs recognize this language as the method used to format the text, insert images, create hypertext and fill-in forms. HTML is easy to learn and use. This book explains the main features of the language and suggests some principles of style and design. Within a few hours, you can create a personal Home Page, research paper, company profile, questionnaire, etc., for world-wide publication on the Web.

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

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

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

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

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

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ET12

Snow in August?

Q *Because of a recent snow and ice storm, a large number of homes lost their electric power. Needless to say, the generator suppliers did good business selling generators. I would like to see a circuit to indicate the output frequency of these home-type units. Most already have a voltage indicator. Maybe an indicator using LEDs to show over or under safety ranges so as not to damage electric equipment such as freezers and refrigerators.—D.S., Annapolis, MD*

A If you thought time-shifting your TV programming by videotaping was interesting, you should see the time shift in magazine publishing when winter questions get answered in the sweltering heat of summer. But what a perfect time to build the circuits you need for winter!

I had a neat idea for a meter that would allow you to get the frequency in the ballpark and a secondary meter that would zero-in on exactly 60 Hz, much like the old top-end stereo tuners with a signal strength meter and a center-frequency meter. Then I looked at the over-design I was doing, let K.I.S.S. (Keep It Simple, Stupid) take over, and ended up with the design of Fig. 1. Most home generators aren't going to have the ability of precision frequency control anyway.

The basic circuit of Fig. 1(a) uses an LM2917N frequency-to-voltage (F/V) converter, often seen as the spindle speed control on older 5¼-inch disk drives. The output is linear, in that each Hertz change in frequency causes a proportional change in the output voltage, regardless of where that change occurs. This is unusual because circuits involving frequency are usually locked in to a logarithmic scale. The basic circuit is designed to drive one of three output circuits, depending upon whether you want to use a 2-volt digital panel meter (DPM), the 2.5-V_{DC} range of an analog volt-ohm-milliammeter (VOM), or a 1-mA full-scale-deflection analog DC ammeter for your display device. With an input of 60 Hz, my circuit had an output of 4.55 volts, which was the figure used for the calculations of the metering circuits.

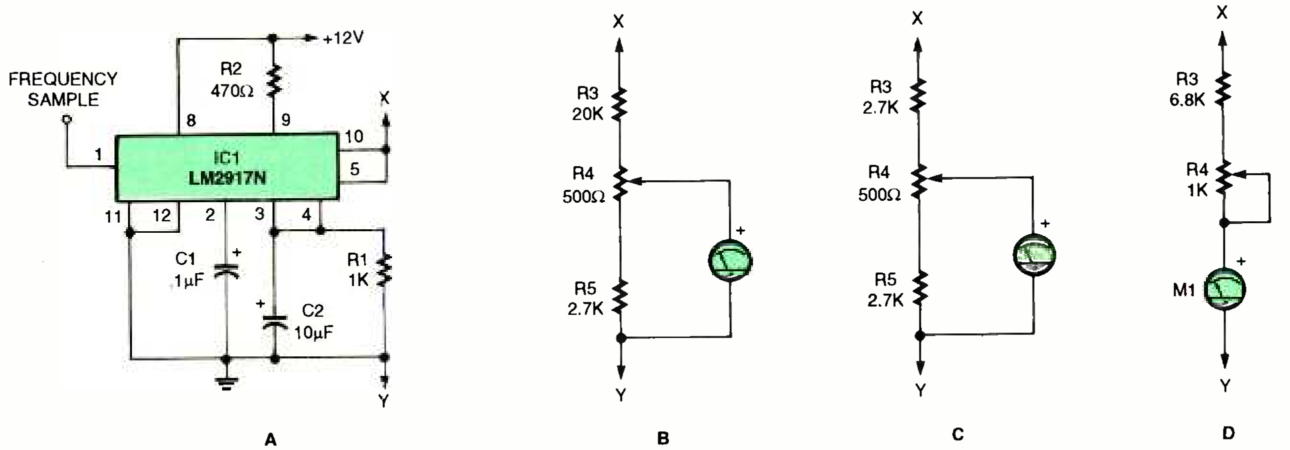

Fig. 1. The LM2917 frequency-to-voltage converter is the core of a frequency meter for monitoring the 60-Hz power mains or an emergency power generator.

Figure 1(b) shows the DPM circuit when you set it for a 2.000-volt range and set the decimal point so that the meter display will appear as "000.0." Resistor R4 is adjusted so that the DPM reads "060.0" with exactly 60 Hz at the input.

Figure 1(c) is the output circuit using a standard VOM such as a Simpson 260 with a 2.5-V_{DC} range. Although you will be using the 2.5-volt range, you'll be reading the frequency from the "10" scale to make things easier. Calibrate this variation by adjusting R4 so that the meter reads "6" when exactly 60 Hz is at the input. In this case, the "10" scale will

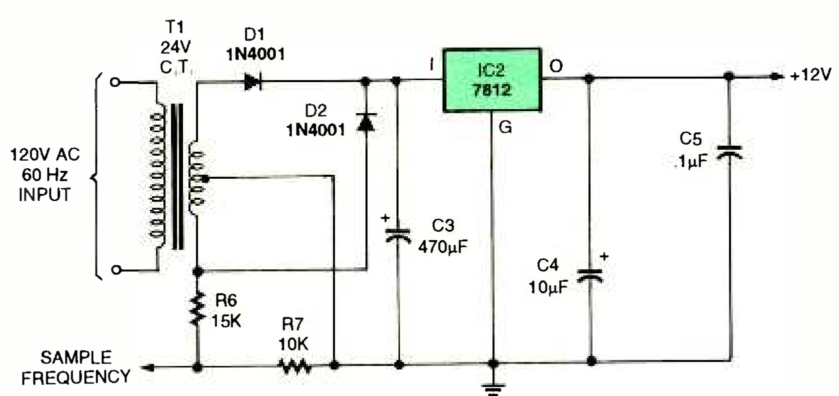

Fig. 2. This simple regulated power supply also provides a sample of the line frequency for use with a frequency meter.

indicate zero to 100 Hz, with the cardinal marks of "5" being 50 Hz and "7" being 70 Hz.

The last variation shown in Fig. 1(d) is for using a standard 1-mA DC analog panel meter for the indicator. The movement I used had a voltage drop of 40.9 mV with 600 microamps flowing through it. These were the numbers used for the Ohm's Law calculations to derive the values for the R3/4 combination. In this circuit, adjust R4 until the meter reads 600 microamps (0.6 mA) with exactly 60 Hz input.

You can get the *exact* 60 Hz input by simply plugging the circuit into a standard wall receptacle and trusting the power company to be on their toes. Californians may want to test the waters on this one.

Figure 2 illustrates a standard regulated power supply for the circuit. Resistors R6 and R7 scale the secondary voltage down a little for use as the frequency input for the F/V converter.

Automated Design

Q *I have been a reader of* ***Radio-Electronics, Electronics Now****, and* ***Poptronics*** *for many years. In the past few years, many software houses made electronics simulation programs available to the professional public, some with the ability to do printed circuit board layout and autorouting. I bought one of these programs and returned it to the manufacturer because the software had numerous bugs. I am in need of a good schematic capture/simulation/PCB layout program and have a feeling that many of your readers are in the same position. It would do a lot of good if* ***Poptronics*** *could publish an article that compared various programs that are available. I realize that such an article would probably be more than just the usual Q&A format. To the best of my knowledge, nobody I know has ever published such a comparison.—H.C., Los Angeles, CA*

A Yes, such an article would be nearly as long as some of my wordy answers. It would appear that in all your reading, you might have missed exactly what you're looking for. T.J. Byers went to quite a bit of work in six issues of **Electronics Now** to review affordable electronics design software packages. In the September and October 1995 issues, he reviewed 13 packages for schematic drawing, printed circuit board (PCB) drawing, and schematic capture. In the January and February 1996 issues, he reviewed 12 packages for PCB layout, both manual layout programs and autorouters that are linked to schematic capture software. T.J. reviewed eight analog and five digital circuit simulation packages in the July and August 1996 issues.

Remember that reviews such as these are very subjective and everyone's tastes are different, so T.J.'s favorite package may be Harrison Ford's least-favorite (actually, Harrison prefers the Ripup II/Design II package). For instance, I can't stand an autorouter for hobby work because it requires you to use predefined components so that it knows physical dimensions for board layout. Hobbyists tend to scrounge their components. If you want to use a transformer, relay, or odd connector that you pulled from your junkbox, you have to describe and define the thing to the program before you can use it. That would not be really awful except that I have one each of 20 different 12-volt DPDT relays! You can't use just *any* electrolytic capacitor, for not only do you have to worry about value and voltage, but the overall physical dimensions and lead spacing are vital factors. Bob Pease of National Semiconductor loathes circuit simulators, feeling that breadboarding is the preferred method of circuit testing, especially since simulators are fraught with bugs and newbie engineers tend to put too much trust into then. So, along with the original articles, you'll find some readers' comments in the April and May 1996 issues.

You have to give T.J. a lot of credit: Testing out bunches of software packages isn't like test-driving cars. Hop into a car, and you can drive it off the lot with no instructions. Load up a software package and your first question is, "OK. Now, how do I get this thing going?" At least, the software manual doesn't have 37 pages of safety belt, child seat, and air bag information.

Technology moves rapidly, and it may be that a 5-year update would be nice, especially because surface-mount technology has really started to skyrocket since the original articles were written. I'd let T.J. take on that chore. It's not for me.

Inedible Ding-Dongs

Q *As a long-time subscriber, let me commend you on your fine magazine. My question pertains to "bell sounds." My car makes various kinds of bell sounds when the key is left in the ignition, lights left on, etc. I would like to experiment with bell sounds using various components. From my electronics training, I know that LC tank circuits "ring" and decay when hit with a voltage spike. I would like to see a circuit that would make a "bell-ringing sound" when struck with a voltage of some kind. Don't print a synthesizer circuit for I'm interested in the most basic LC circuit that we can ring using a 555-timer or such.—D.I., Seattle, WA*

A On behalf of everyone at Gernsback, thank you for the compliment. It so happens that I played with just such a circuit around 34 years ago. It was a construction article titled "Electronic Bongos" as presented in *Electronics Illustrated*, one of the fine electronics hobbyist magazines of that era.

I wouldn't consider using an inductor in a design such as this, although those LC tank circuits are where we learned all about ringing and the "flywheel effect." Today, it's easier to use RC circuits to do the job, and the twin-T oscillator circuit as shown in Fig. 3 is a good route to take. This circuit is set up so that it is on the verge of oscillation. Any external influence will trigger the circuit into a decaying ring. It can be done electronically or by simply using body capacitance as the old "Electronic Bongos" did.

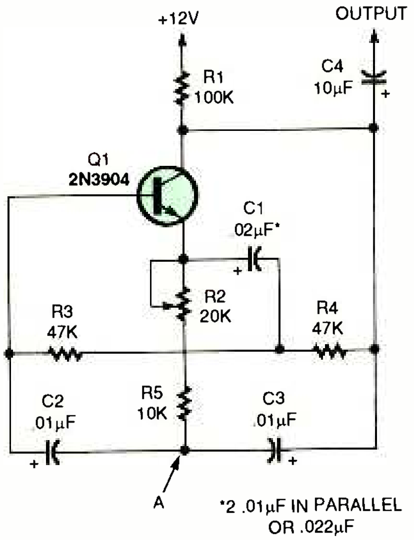

Fig. 3. A twin-T oscillator adjusted until it's on the verge of oscillation will make a very nice ring generator for creating the sounds of a bell or a bongo drum. Note that C1 should be exactly double the value of C2 or C3, if possible. The printed standard value is an approximation.

The output is connected to the input of a utility amplifier. I use a cheap pair of powered computer speakers at my workbench for audio experiments like this. Adjust R2 until the circuit is on the verge of sustained oscillation. The junction marked "A" is the spot where you can add external stimulus to shock the circuit into producing a damped sine wave, the basic sound of a bell. If you attach a plate to this point as a touch pad, striking it with your finger will produce the tone. If you have trouble getting consistent tones, hold a finger of your other hand on the +12-volt line when you strike the pad.

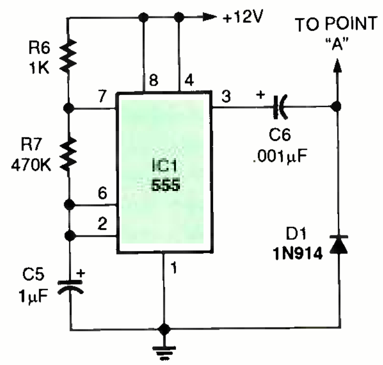

Fig. 4. A low repetition rate 555 pulse-generator circuit coupled to the ring generator allows repetitious "pealing" of the bell.

You could use an op-amp in place of the transistor, but this is one of those circuits where you have to say, "Why?" An op-amp, unless you're using one of the new surface-mount SOT-23 packages, would take up far more space. So, the *old* is better than the *new*.

Alternatively, you can substitute a rectangular-wave generator such as the 555-timer circuit in Fig. 4 and capacitively-couple the output to point "A." Diode D1 has been added to clip positive-going spikes since a positive-going spike creates a slightly different sound than a negative-going spike. DC isolation between the two circuits is provided by C6. With this addition, you will have a sound not unlike the warning chime in your car. Increase the values of the twin-T caps to lower the frequency or decrease their values to increase the frequency. Adjustment of R2 will change the tone from a sustained oscillation to a long ring down to a short, musical "pop."

You could use programmed counters and other circuits such as programmable memory to trigger the rings to create hourly bell strikes for a clock, to mimic a department store employee break chime, an elevator floor annunciator, or game show sound effects. A pair of ringing oscillators could replace the old-fashioned "ding-dong" doorbell chime.

Testing Transistors

Q *Could you tell me how to check transistors with a digital multimeter?—B.L., via e-mail*

A Modern digital multimeters (DMMs) have the normal resistance-measurement ranges and a special "diode test" function, usually noted on the range switch with a diode symbol. The normal resistance ranges have a limited test voltage and often will not forward-bias a semiconductor junction. This can be handy for checking other components in-circuit that are in parallel with semiconductor junctions. The DMM I'm using as I write this does use a test voltage of 3 volts on its lowest resistance range while all the other ranges use less than 0.5 volts. In general, you can't use these meters to test semiconductors using the normal resistance ranges. Instead, you use the "diode test" function.

In this function, the DMM is working

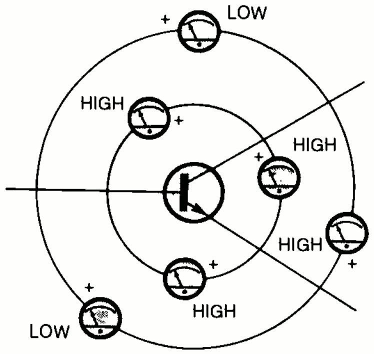

Fig. 5. Checking a bipolar transistor with an ohmmeter. Each little meter symbol represents one of six possible connections of the meter. LOW represents a low resistance value or a junction's forward drop on a DMM "diode test" and HIGH represents a high resistance value and an "open circuit" voltage on a DMM.

as a voltmeter across the junction under test while applying a current-limited voltage to the junction. When a silicon junction is forward-biased in this way, the meter will read around 0.7 volts. When the leads are connected so that it's reverse-biased, the meter will read its maximum voltage, usually around 3 volts. A short will read zero volts. I did notice that the meter I was using gets a little non-linear above 2.4 volts but below that, the voltage indication was accurate. In this function, a 10K ohm resistance gives a 2.4-volt indication and the test current ranges from about 34 microamps up to about 1.3 mA into a dead short. That's the nuts and bolts of the metering system. Let's test some devices.

A typical silicon rectifier or switching diode such as a 1N4001 or 1N914 when forward-biased (red/+ lead on the anode) will read 0.600 volts and 3.1 volts, respectively, when reverse-biased. A 1N751 zener diode reads 0.700 when forward biased and 3.1 volts reverse since its zener voltage is 5.1 volts, well above the maximum voltage of the DMM.

Transistors have two junctions, one between base/emitter and another between base/collector. These two junctions act like diodes. A 2N3904 NPN silicon transistor will show 0.723 volts when the emitter junction is forward-biased (red/+ lead on the base, black/COM lead on the emitter) and 3.1 volts when reverse-biased. When the collector junction is forward-biased (red/+ lead on the base, black/COM lead on the collector), the meter reads 0.715 volts and when reverse-biased, 3.1 volts. You should read 3.1 volts between the collector and emitter no matter which direction you place the leads. A PNP transistor such as a 2N3906 will be similar. Forward-biased conditions are when the black/COM lead is on the base, giving the 0.700 volt reading. I drew the illustration of Fig. 5 to show the relative meter readings for the various measurement points and ohmmeter polarities.

A shorted junction will give nearly zero volts in either direction, and an open junction gives the 3.1-volt reading in either direction. Although we are reading 3.1 volts across the collector and emitter, whether it was an NPN or PNP transistor, it was not an open. In either case, we were looking at two back-to-back diodes where one was always reverse-biased. Had we seen anything below 3 volts on the collector-emitter check, the transistor would have been considered leaky or shorted.

An older analog volt-ohm-milliammeter (VOM) is only a little more difficult to use to check transistors and diodes. Each junction will still have a low resistance in the forward direction and a high resistance in the reverse direction. A VOM can be confusing because the forward resistance will appear to increase as the resistance range is increased. This is because the decreasing current from the ohmmeter circuit causes the resistance of the non-linear junction to increase. Still, the forward resistance will be a lot lower than the reverse resistance, which in most cases will appear infinite or open. Be careful when using older VOMs in solid-state circuits, for their ohmmeter sections often had battery voltages as high as 30 volts and currents on the RX1 range as high as 200mA. Delicate semiconductor junctions could be accidentally destroyed with them.

Recording From an Amplifier

Q *I'd like to connect a cassette recorder to a power amplifier so that we can record the Sunday sermons. Is there some way that I can connect to the speaker outputs to do this? I don't dare try to make a modification or do something to put the amp out of commission. It's a Realistic MPA-80, catalog number 32-2026.—R.T., Midland, MI*

A It just so happens that I had a Realistic MPA-101 in the room with me when I read your question. If the two units are similar except for power output, then you're in luck. The MPA-101 has an RCA jack field in the back. One pair of jacks is for the insertion of an equalizer, and one of those is labeled "OUT." There's a companion switch nearby that allows the equalizer to be switched into or out of the circuit. It doesn't matter which position the switch is in. You'll still get the signal out of the "OUT" jack. However, one position will kill the sound to the rest of the amp, so it might be in your best interests to leave it so that the equalizer is out of the loop. Electrical shock is one hazard of technical work. If fooling around with church equipment, lightning could be another.

Grabbing the signal at the speaker connectors for recording is rarely a good idea. At that point, the volume control and all the tone controls affect the signal going to the recorder as well as the speakers. It's better to record before all the audio control takes place. That way, those listening to the recording can adjust the tone on their playback systems to suit their tastes. You may have some listeners who have lost the high-frequency end of their hearing, and they would have no way of accentuating that portion of the spectrum with their treble boost control if you kill it all in the recording. If the amp's master volume control doesn't affect the recording, then you won't have to ride the recorder's level control all the time. Once set, the record level should always be OK if radical changes to the microphone levels vs. the master level are not made.

Interfacing to 120 V_{AC}

Q *I am replacing a unit which has an output that switches 120 V_{AC} on and off at a 150-ms rate. The replacement unit has an output that is limited to 30 volts at 5 mA. Can I somehow use a relay that can "see" the 150-ms closures of the collector and close, sending the pulses through the load side?—J.G., Hendersonville, NC*

A Assuming that the output of your new unit is simply a transistor in an open collector configuration, you should be able to drive a reed relay directly. A reed relay will have a faster response time than the traditional open-frame relay and will be immune to contamination of dust and dirt.

Figure 6 illustrates the add-on circuit

(Continued on page 58)

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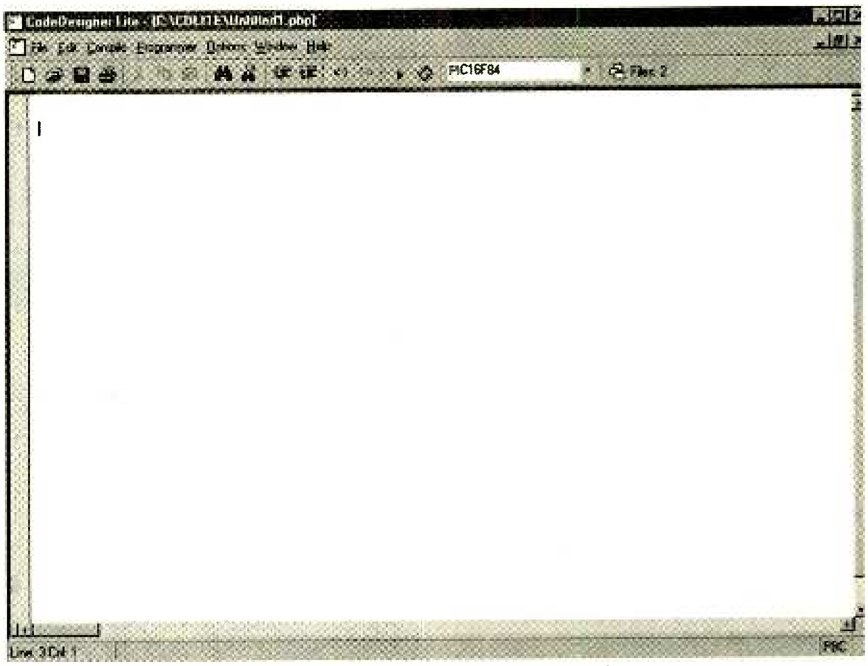
JOHN IOVINE

PicBasic Pro Compiler

Last month, we looked at the PicBasic Compiler; this month, we will look at the PicBasic Professional Compiler. The Pro version compiler is considerably more expensive, retailing for $249.95. Also, the Pro version has a greater number of and much richer basic commands than are in the standard compiler package. A few of the additional commands to be found in the Pro version allow the use of interrupts, direct control of LCD modules, DTMF out, and X-10 commands to name a few.

While a more sophisticated package, the compiler does not handle two of my favorite (and very powerful) basic commands Peek and Poke. While the commands are listed " as functional" in the Pro manual, it is emphasized: "PEEK and POKE should never be used in a PicBasic Pro program." This is unfortunate; personal feeling aside, it destroys upward compatibility of any PicBasic programs that use the peek and poke commands.



CodeDesigner Lite's start-up screen is shown in the screen capture above.

EPIC Programming Board And Software

In addition to the compiler, you will also need the EPIC programming board and software. The EPIC retails for $59.95. However, if you purchase the PICBasic Pro compiler and EPIC programmer at the same time, the cost is $299.95.

The EPIC is bundled with two versions of software; one is for DOS *(epic.exe)* and the other is a 32-bit Windows version *(epicwin.exe)*.

New IDE Features

I didn't have sufficient space last month to mention this, but both the PicBasic and PicBasic Pro compilers are now packaged with an additional diskette that contains a Windows Integrated Development Environment (IDE) interface called *CodeDesigner Lite*. *CodeDesigner Lite* allows one to write and compile PicBasic code in a Windows environment. Each statement is color-coded, making it much easier to spot errors and read through your code. The freebie version allows you to write programs up to 150 lines and open up three source files at once for easy copy and paste.

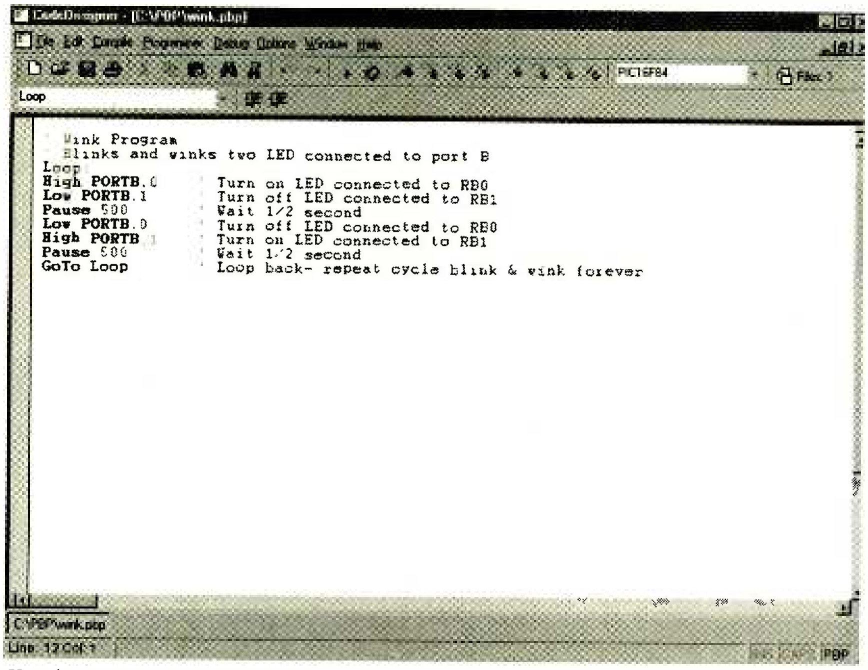
The most important feature of the CodeDesigner IDE interface is that it allows you to first write the program, then compile the program into a hex file, and finally (in theory) program the microcontroller while in the same window. This reduces program development time. Typically I write while in DOS or an MS-DOS Prompt window. I write the program text file using DOS Edit program. When finished, I then exit Edit and manually compile the program. If there was a problem (more times than not), I would then restart Edit and debug the code. When the program is completely debugged, I load the program into the PIC microcontroller using the EPIC software and programming board. At this point, the microcontroller/circuit is tested. If it functions properly, I'm finished; if not, I begin rewriting the program.

So in using *CodeDesigner* productivity increases with the ease with which to write, debug and load PicBasic programs into the microcontroller. My experience is that I can code and debug my programs while in Windows, but to program a microcontroller I still must drop down into DOS. I do believe that this is particular to my computer, and for many others the epicwin.exe program will function perfectly.

While the freebie version (*CodeDesigner Lite*) is functional, you can then upgrade to the full-featured *CodeDesigner*. *CodeDesigner* is available in a hobbyist version for $45.00 and standard version for $75.00.

The hobbyist version of *CodeDesigner* only works with the PicBasic Compiler. The Standard version will work with both the PicBasic and PicBasic Pro compilers. Other features of *CodeDesigner* are as follows:

- Auto Code-Completion
  CodeDesigner makes writing code much easier with smart pop-up list boxes that can automatically fill in statements and parameters for you.



Here is a program written in CodeDesigner ready for compiling and programming.

- Multi-Document Support
- Line-Error Highlighting
  Compile your PicBasic Project, and *CodeDesigner* will read error data and highlight error lines.
- Quick Syntax Help
  The Quick Syntax Help feature displays statement syntax when you type in a valid PicBasic statement.
- Statement Description
  Statement descriptions are displayed in the status bar when you type in a valid PicBasic statement.
- Statement Help
  Simply position your cursor over a PicBasic statement and get statement specific help.
- Label Listbox
  The label listbox displays the current label and allows you to select a label from the list to jump to selected label.
- Colored PicBasic Syntax
  Set colors for Reserved Words, Strings, Numbers, Comments, Defines, etc. Colored PicBasic Syntax makes for easy code reading.
- Bookmarks
  Never lose your place again. CodeDesigner allows you to set bookmarks.
- Multi Undo/Redo
  Didn't want to delete that last line—no problem, simply click on the undo button.
- Multi Views
  Multiple views of your source code allow you to easily edit your code.
- Print Source Code
- Drag- and Drop-Text
- Row/Column-based Insert, Delete, and Copy
- Search and Replace
- Compile and launch device programmer

SOFTWARE INSTALLATION

Load the software on your computer's hard drive according to the instructions given with the software. To complete the instructions, we are going to assume the software, both the PICBasic Pro compiler and EPIC programming software, are saved to a directory called PBasic on your computer's hard drive.

CodeDesigner when it is installed creates a sub-directory in the Program Files directory and installs itself there. It puts a CodeDesigner shortcut on the "Start," "Program" menu in Windows.

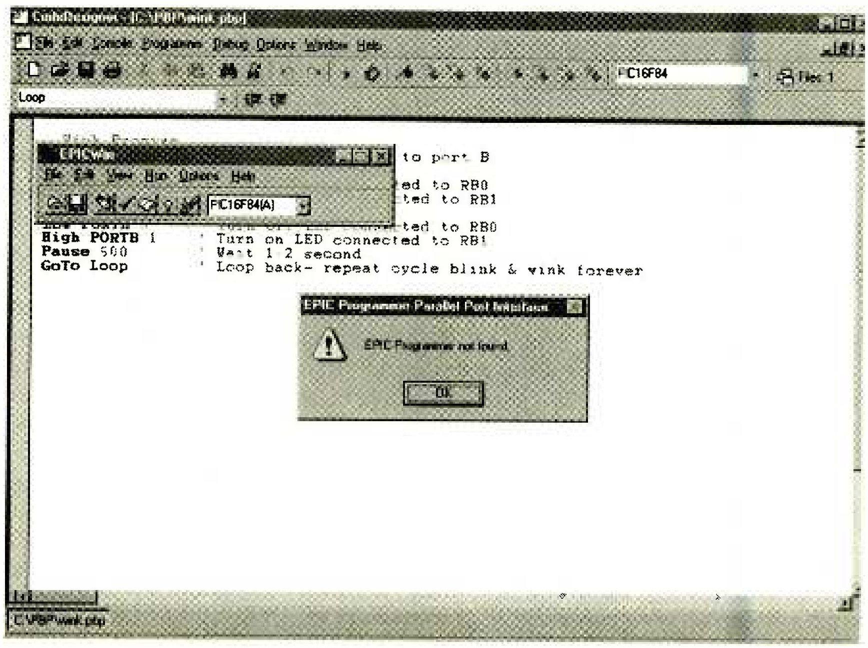
First Program

This program is identical in function (not code) to the PICBasic program from last month. Start CodeDesigner (Lite), and enter the code shown in Listing 1.

CodeDesigner defaults to writing code for the PIC 16F84 microcontroller. This is the microcontroller I recommended to start with; to change the device, simply pull down the device menu and select the appropriate microcontroller.

To compile the program, either select compile under the Compile menu or hit F5. CodeDesigner automatically starts the PicBasic Pro compiler to compile the program. Before you attempt to compile a program, set up the "compiler options" under the Compile menu. CodeDesigner needs you to tell it where (which directory) to find the PicBasic Pro program and where to save the compiled and source files. Once the program is compiled, we can go to the next step of loading the program into a PIC microcontroller chip.

Connect the EPIC programming board to the printer port. If your computer has only one printer port, disconnect the printer, if one is connected, and



An error created when Windows cannot identify the EPIC programmer attached to the printer port.

SOURCE INFORMATION

PICBasic Pro Compiler (includes CodeDesigner Lite) $249.95
EPIC Programmer $ 59.95
PICBasic Pro Compiler & EPIC programmer $299.95
CodeDesigner Hobbyist Version $ 45.00
Code Designer Standard $ 75.00
PIC-LED-02 PIC EXPERIMENTERS KIT $25.50
Consists of:
(1) PIC16F84, (1) 4-MHz crystal *($1.50), (2) 22-pF capacitors *($0.10 ea.), (1) 10K ¼-watt resistor *($0.05), 7805 voltage regulator *($0.90), (1) solderless breadboard, 2.1-inch × 3.6-inch, 270 tie points *($8.95), (8) 470-ohm resistors *($0.05 ea.), (1) 10K-ohm resistor *($0.05), (8) subminiature LEDs *($0.25 ea.), (1) push-button switch, booklet with tutorial on binary number system, logic and I/O of ports A & B.
Available from Images SI Inc., 39 Seneca Loop, Staten Island NY, 10314; 718-698-8305, fax 718-982-6145; *www.imagesco.com.*

*Items marked can be ordered separately.

attach the EPIC programming board using a six-foot DB25 cable.

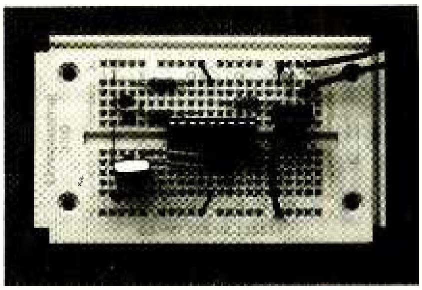
When connecting the programming board to the computer, make sure there are no PIC microcontrollers installed on to the board. If you have an AC adapter for the EPIC programmer board, plug it into the board. If not, attach two fresh nine-volt batteries. Connect the "Batt ON" jumper to apply power. The programming board must be connected to the printer port with power applied to the programming board before starting the programmer. If not, the software will not see the programming board connected to the printer port and give the error message "EPIC programmer Not Found."

The EPIC Programming Board Software

To program the chip from *CodeDesigner*, select "launch programmer" from the Programmer menu or hit F6. *CodeDesigner* automatically starts the *Epicwin.exe* Windows software.

With the EPIC windows software started, set the configuration switches one by one under the options menu item.

Device: Sets the device type. Set it for 16F84 (default).
Memory Size (K): Sets memory size.



The complete circuit can be built on a solderless breadboard, as shown in the photo above.

Choose 1.
OSC: Sets oscillator type. Choose XT for crystal.
Watchdog Timer: Choose On.
Code Protect: Choose Off.
Power Up Timer Enable: Choose High.

After the configuration switches are set, insert the PIC 16F84 microcontroller into the open socket on the EPIC programming board.

If you receive an error message "EPIC Programmer Not Found" when CodeDesigner started the EPIC windows program, you have the option of either troubleshooting the problem or using the EPIC DOS program. For instructions on using EPIC software (DOS version), see last month's column.

The schematic for the circuit is shown in Fig. 1 and is the same schematic used for the PicBasic compiler. The schematic illustrates the minimal components needed to get the 16F84 microcontroller up and running. Primarily you need a pull-up resistor on PIN 4 (MCLR), a 4-MHz crystal with two 22-pF capacitors, and a 5-volt power supply.

The two LEDs and two current limiting resistors connected in series with the LEDs are the outputs. It allows us to see that the microcontroller and program are functioning. I assembled the components on to a solderless breadboard.

WINK

Apply power to the circuit. The LEDs connected to the PIC microcontroller will alternately turn on and off. Next month, we will continue by learning how to use the 16F84 Microcontroller I/O ports, binary number system, and digital logic. **P**

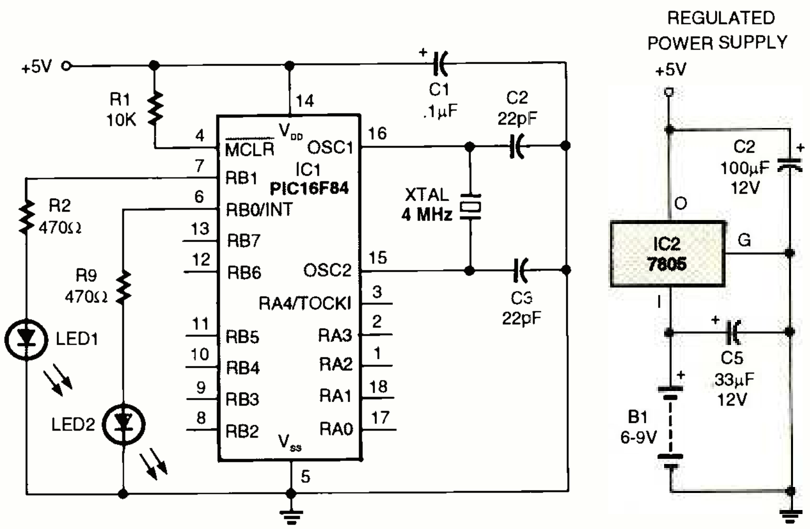


Fig. 1. This is the schematic for the Wink Program.

LISTING 1

```
' WINK PROGRAM
' Blinks and winks two LED connected to port B
Loop:
High PORTB.0        ' Turn on LED connected to RB0
Low PORTB.1         ' Turn off LED connected to RB1
Pause 500           ' Wait 1/2 second
Low PORTB.0         ' Turn off LED connected to RB0
High PORTB.1        ' Turn on LED connected to RB1
Pause 500           ' Wait 1/2 second
GoTo Loop           ' Loop back- repeat cycle blink & wink forever
```

mailto: serviceclinic@gernsback.com

SAM GOLDWASSER

Capacitor Testing and Related Information

Capacitors may not be considered the superstars of electronic equipment (except perhaps in devices like xenon flash units and pulsed lasers), but more like the helpers and extras. However, they play a vital role in virtually everything that uses electrons in some way. A defective two-cent capacitor in a TV or monitor can render it useless.

This Service Clinic deals with techniques for the testing of capacitors using a multimeter without a capacitance test mode. Information on safe discharging of high-value or high-voltage capacitors and a discharge circuit with visual indication of charge and polarity is also included. There is also general information on capacitors, capacitance and ESR meters, and other related topics.

Basic Capacitor Safety

While accidental contact with capacitors on a 3.3-volt logic board isn't going to result in a shocking experience, this is not true of many common types of equipment including TVs, computer and other monitors, and microwave ovens; the switchmode power supplies in some VCRs, laptop computers, and camcorder battery chargers; electronic flash and other xenon strobes; laser power supplies, and many other consumer and industrial devices.

Where equipment is AC-line connected or uses high voltages, special precautions are required both for personal safety and to prevent damage to circuitry from careless actions. In addition to the specific safety issues with respect to capacitors discussed below, read, understand, and follow the recommendations provided in the document.

Capacitor Testing Precautions

WARNING: Make sure the capacitor is discharged! This is both for your safety and the continued health of your multimeter.

A pair of 1N400x diodes in parallel with opposite polarities may help protect the circuitry of a DMM. Since a DMM doesn't supply more than 0.6-volts generally on ohms ranges, the diodes will not affect the readings but will conduct should you accidentally put the meter across a charged cap or power-supply output.

They won't do much with a charged 10-farad capacitor or high-current supply where you forgot to pull the plug but may save your DMM's LSI chip from more modest goof-ups.

This approach cannot be used with a typical analog VOM because they usually supply too much voltage on the ohms ranges. However, my 20-year-old analog VOM has something like this across the meter movement itself, which has saved it more than once.

Testing Capacitors With A Multimeter

Some DMMs have modes for capacitor testing. These work fairly well to determine approximate µF rating. However, for most applications, they do not test at anywhere near the normal working voltage or test for leakage. A VOM or DMM without capacitance ranges can make certain types of tests.

For small caps (like 0.01 µF or less), about all you can really test is for shorts or leakage. However, on an analog multimeter on the high ohms scale you may see a momentary deflection when you touch the probes to the capacitor or reverse them. A DMM may not provide any indication at all.

Any capacitor that measures a few ohms or less is bad. Most should test infinite even on the highest resistance range. For electrolytics in the µF range or above, you should be able to see the cap charge when you use a high ohms scale with the proper polarity—the resistance will increase until it goes to (nearly) infinity. If the capacitor is shorted, then it will never charge. If it is open, the resistance will be infinite immediately and won't change. If the polarity of the probes is reversed, it will not charge properly either—determine the polarity of your meter and mark it—they are not all the same.

Red is usually negative with VOMs, for example. Confirm with a marked diode—a low reading across a good diode (VOM on ohms or DMM on diode test) indicates that the positive lead is on the anode (triangle) and negative lead is on the cathode (bar).

If the resistance never goes very high, the capacitor is leaky. The best way to really test a capacitor is to substitute a known good one. A VOM or DMM will not test the cap under normal operating conditions or at its full rated voltage. However, it is a quick way of finding major faults.

A simple way of determining the capacitance fairly accurately is to build an oscillator using a 555 timer. Substitute the cap in the circuit and then calculate the C value from the frequency. With a few resistor values, this will work over quite a wide range.

Alternatively, using a DC power supply and series resistor, capacitance can be calculated by measuring the rise time to 63% of the power supply voltage from $T = RC$ or $C = T/R$.

What About Capacitance Meters?

Simple capacitance scales on DMMs just measure the capacitance in µF and do not test for leakage, *E*quivalent *S*eries *R*esistance (ESR), or breakdown voltage. If the measurement comes up within a reasonable percentage of the marked value (some capacitors have tolerances that may be as much as +100%/-20% or more), then in many cases, this is all you need to know. However, leakage and ESR frequently change on electrolytics as they age and dry out.

Many capacitance meters don't test anything else but are probably more accurate than a cheap DMM for this purpose. A meter of this type will not guarantee that your capacitor meets all specifications, but if it tests bad—very low—the capacitor is bad. This assumes that the test was made with the capacitor removed (at least one lead from the circuit) otherwise other components in parallel can affect the readings.

To more completely characterize a capacitor, you need to test capacitance, leakage, ESR, and breakdown voltage. Other parameters like inductance aren't likely to change on you.

ESR testers, which are for good for quick troubleshooting, are designed to just measure the Equivalent Series Resistance since this is an excellent indicator of the health of an electrolytic capacitor. Some provide only a go/no go indication, while others actually display a reading (usually between 0.01 and 100 ohms so they can also be used as low-ohms meters for resistors in non-inductive circuits). Substitution is really the best approach for repair unless you have a very sophisticated capacitance meter.

The March 1998 issue of **Popular Electronics** has plans for a digital capacitance tester with a range from 1 pF to 99 µF. The May 1999 issue of **Popular Electronics** has plans for an "Electrolytic Meter," which will accurately measure the capacitance and allow the determination of some of the other characteristic of large value capacitors—up to several hundred thousand µF.

Safe Discharging Of Capacitors In TVs, Video Monitors, And Microwave Ovens

It is essential for your safety and to prevent damage to the device under test, as well as your test equipment, that large or high-voltage capacitors be fully discharged before measurements are made, soldering is attempted, or the circuitry is touched in any way. Some of the large filter capacitors commonly found in line-operated equipment store a potentially lethal charge.

This doesn't mean that every one of the 250 capacitors in your TV needs to be discharged every time you power off and want to make a measurement. However, the large main filter capacitors and other capacitors in the power supplies should be checked and discharged if any significant voltage is found before touching anything—some capacitors (like the high voltage of the CRT in a TV or video monitor) will retain a dangerous or at least painful charge for several days or longer!

A working TV or monitor may discharge its caps fairly completely when it is shut off as there is a significant load on both the low and high-voltage power supplies. However, a TV or monitor that appears dead may hold a charge on both the LV and HV supplies for quite a while—hours in the case of the LV, days or more in the case of the HV as there may be no load on these supplies.

The main filter capacitors in the low-voltage power supply should have bleeder resistors to drain their charge relatively quickly—but resistors can fail. Don't depend on them. There is no discharge path for the high voltage stored on the capacitance of the CRT other than the CRT beam current and reverse leakage through the high voltage rectifiers—which is quite small. In the case of old TV sets using vacuum tube HV rectifiers, the leakage was essentially zero. They would hold their charge almost indefinitely.

Capacitor Discharge Technique

The technique I recommend is to use a high wattage resistor of about 5 to 50 ohms/V of the working voltage of the capacitor. This will prevent the arc-welding associated with screwdriver discharge but will have a short enough time constant so that the capacitor will drop to a low voltage in at most a few seconds (dependent of course on the RC time constant and its original voltage).

Then check with a voltmeter to be double sure. Better yet, monitor while discharging (monitoring is not needed for the CRT—discharge is nearly instantaneous even with multi-megohm resistor). Obviously, make sure that you are well insulated!

When checking the main capacitors in a switching power supply, TV, or monitor, which might be 400 µF at 350 volts, a 2 K ohm 25-watt resistor would be suitable. RC = .8 second. 5RC = 4 seconds. A lower wattage resistor can be used since the total energy stored in the capacitor is not that great.

To test the CRT, use a high wattage (not for power but to hold off the high voltage which could jump across a tiny ¼-watt job) resistor of 1 to 10 megohms discharged to the chassis ground connected to the outside of the CRT—**NOT SIGNAL GROUND ON THE MAIN BOARD**—as you may damage sensitive circuitry. The time constant is very short—a ms or so. However, repeat a few times to be sure. Then, install a shorting clip—these capacitors have been caught regaining a portion of their charge when no one was looking!

When testing the high-voltage capacitor in a microwave oven, use a 100 K ohm 25-watt (or larger resistor with a clip lead to the metal chassis. The reason to use a large (high wattage) resistor is again not so much power dissipation as voltage holdoff. You don't want the HV zapping across the terminals of the resistor.

Clip the ground wire to an unpainted spot on the chassis. Use the discharge probe on each side of the capacitor in turn for a second or two. Since the time constant RC is about 0.1 second, this should drain the charge quickly and safely.

Then, confirm with a WELL-INSULATED screwdriver across the capacitor terminals. If there is a big spark, you will know that somehow, your original attempt was less than entirely successful. At least, there will be no danger.

DO NOT use a DMM for this unless you have a proper high-voltage probe. If your discharging did not work, you may blow everything—including yourself.

Four reasons to use a resistor and not a screwdriver to discharge capacitors:

- It will not destroy screwdrivers and capacitor terminals.
- It will not damage the capacitor (due to the current pulse).
- You will avoid scary snaps and crackles.
- It will reduce your spouse's stress level in not having to hear those.

Capacitor Discharge Tool

A suitable discharge tool for each of these applications can be made quite easily. The capacitor-discharge indicator circuit described below can be built into this tool to provide a visual display of polarity and charge (not really needed for CRTs as the discharge time constant is virtually instantaneous even with a multi-megohm resistor.

Solder one end of the appropriate size resistor (for your application) along with the indicator circuit (if desired) to a well insulated clip lead about 2–3 feet long. For safety reasons, these connections must be properly soldered—not just wrapped.

Solder the other end of the resistor

(and discharge circuit) to a well insulated contact point such as a 2-inch length of bare #14 copper wire mounted on the end of a 2-foot piece of PVC or Plexiglas rod, which will act as an extension handle. Secure everything to the insulating rod with some plastic electrical tape.

Capacitor-Discharge Indicator Circuit

The circuit shown in Fig. 1 provides a visual indication of charge, and polarity is provided from maximum input down to a few volts. **Note:** A different value resistor is needed for each type of application—LV, HV, EHV.

The total discharge time is approximately:

- LV (TV and monitor power supplies, SMPSs, electronic flash units)—up to 1000 µF, 400 volts. Discharge time of 1 second per 100 µF of capacitance (5RC with R = 2 K ohms).
- HV (microwave oven HV capacitors)—up to 5000 volts, 2 µF. Discharge time of 0.5 second per 1 µF of capacitance (5RC with R = 100 K ohms).
- EHV (CRT second anodes)—up to 50,000 volts, 2 nF. Discharge time of 0.01 second per 1 nF of capacitance (5RC with R = 1 megohm). **Note:** Discharge time is so short that the flash of the LED may not be noticed. Adjust the component values for your particular application.

The two sets of 4 diodes will maintain a nearly constant voltage drop of about 2.8–3 volts across the LED and resistor as long as the input is greater than around 20 volts. **Note:** This means that the brightness of the LED is *not* an indication of the value of the voltage on the capacitor until it drops below about 20 volts. The brightness will then decrease until it cuts off totally at around 3 volts. **WARNING:** Always confirm discharge with a voltmeter before touching any high-voltage capacitors!

Equivalent Series Resistance (ESR)

*E*quivalent *S*eries *R*esistance (ESR) is an important parameter of any capacitor. It represents the effective resistance resulting from the combination of wiring, internal connections, plates, and electrolyte (in an electrolytic capacitor).

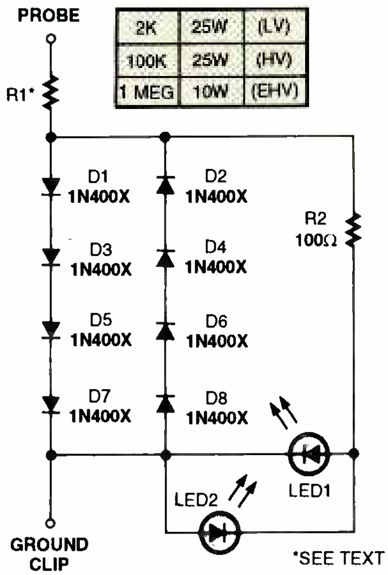


Fig. 1. Here is a simple schematic for a capacitor discharge indicator. Resistor R1's value will depend on the voltage of the capacitor under test. A visual indication is provided for both charge and polarity.

The ESR affects the performance of tuned circuits (high ESR reduces the Q factor) and may result in totally incorrect or unstable operation of devices like switch-mode power supplies and deflection circuits in TVs and monitors. As would be expected, electrolytic capacitors tend to have a high ESR compared to other types—even when new. However, due to the electrochemical nature of an electrolytic capacitor, the ESR may indeed change—and not for the better—with time.

When troubleshooting electronic equipment, electrolytic capacitors, in particular, may degrade resulting in a significant and unacceptable increase in ESR without a similar reduction in µF capacity when measured on a typical DMM's capacitance scale or even a cheap LCR meter.

These devices can generally be used to measure really low resistances of non-inductive devices or circuits as well (they use AC so inductance would result in inaccurate readings). Since their lowest range is at least 10 times better than a typical DMM (1 ohm full scale—0.01 ohm resolution), they can even be used to locate shorted components on printed circuit boards.

What Are These Scored Lines On The Ends Of Electrolytic Capacitors?

They are there to channel the debris in a known direction should the capacitor turn into a bomb. (Really—I'm kidding). However, exploding capacitors aren't all THAT common in properly designed equipment (Well, except for that EPROM programmer that had a tantalum electrolytic installed backwards at the factory. Six months later—POW!)

Making Non-Polarized Capacitors from Normal Electrolytics

You may find non-polarized electrolytic capacitors in some equipment—usually TVs or monitors—though some turn up in VCRs and other devices as well. Large ones may be found in motor-starting applications as well. These usually need to be replaced with non-polarized capacitors. Since polarized types are generally much cheaper, the manufacturer would have used them if it were possible.

In the case of small capacitors—say, 1 µF or less—a non-electrolytic type will very likely be satisfactory if its size—these are usually much larger—is not a problem. There are several approaches to using normal polarized electrolytic capacitors to construct a non-polarized type.

None of these is really great and obtaining a proper replacement would be best. In the discussion below, it is assumed that a 1000-µF, 25-volt, non-polarized capacitor is needed.

Here are three simple approaches: Connect two electrolytic capacitors of twice the µF rating and at least equal voltage rating back-to-back in series It doesn't matter which sign (+ or -) is together as long as they match. The increased leakage in the reverse direction will tend to charge up the center node so that the caps will be biased with the proper polarity. However, some reverse voltage will still be unavoidable at times. For signal circuits, this is probably acceptable, but use with caution in power-supply and high-power applications.

Connect two electrolytic capacitors of twice the µF rating and at least equal voltage rating back-to-back in series. To minimize any significant reverse voltage on the capacitors, add a pair of diodes. Note that initially, the source will see a capacitance equal to the full capacitance (not half). Very quickly, the two caps will charge to the positive and negative peak values of the input across the combination via the diodes. In the steady state, the diodes will not conduct at all; and, therefore, it will be as though they were not in the circuit. However, there will be some non-linearity into the circuit under transient conditions (and due to leakage which will tend to discharge the capacitors), so use with care. The diodes must be capable of passing the peak current without damage.

Connect two capacitors of twice the µF rating in series and bias the center point from a positive or negative DC source greater than the maximum signal expected for the circuit. The resistor value should be high compared to the impedance of the driving circuit but low compared to the leakage of the capacitors. Of course, the voltage ratings of the capacitors need to be greater than the bias plus the peak value of the signal in the opposite direction.

Photoflash Capacitors

These are found not only in electronic flash units and strobes, but pulsed laser power supplies and other fast discharge applications. They are designed for rapid discharge with minimum losses and without self-destructing. Thus, the ESR and inductance are very low and the internal structure is set up to survive very high peak currents (hundreds or thousands of amps). The common ones from photographic flash units are electrolytic capacitors but those in more specialized applications may be other types that can have much shorter pulse durations. Note that photoflash capacitors may have mediocre temperature ratings like 55 degrees C instead of the 70 to 105 degrees C normally found in consumer electronic equipment. Thus, they may not be appropriate for use as service parts replacements for general electronics even though the µF and voltage ratings match.

Wrapup

There is a great deal of additional information on the topics covered above, as well as many additional ones in the docuement: "Capatitor Testing and Safe Discharging" at my Web site, *www.repairfaq.org*.

Next time, we'll deal with one of the major applications of capacitors that earn their reputation—electronic flash units and strobe lights. Until then, feel free to contact me via email at sam@repairfaq.org (I can't reply to snail mail, sorry). Also, for all your repair and laser/optics related questions, check out my Web site at *www.repairfaq.org*. P

TREMULOUS BEAR

(continued from page 36)

Stompbox Forum run by Aron Nelson at *www.soundcorecords. com/stomp box/*. It is geared to beginners, but many of those who respond to questions are experienced hobbyists and professionals who share their knowledge and techniques freely. The design of the Tremulous Bear benefited greatly from tips and suggestions that I picked up there.

I know you'll enjoy building and using the Tremulous Bear, and I welcome comments and questions at smallbear-elec@ix.netcom.com. My URL is *Http://home.netcom.com/~smallbearelec*. P

Q&A

(continued from page 50

that should work. To the left is the open-collector circuit within the unit and to the right is the additional circuitry to drive your 120-V_{AC} load. I'm also assuming that the load is low enough that the reed relay can handle the current. Diode D1 across the reed-relay coil protects the transistor within the replacement unit from the counter-EMF generated by the coil when the transistor in the unit turns off. The last thing you need is to destroy that puppy with something that you've hooked up. I've seen how most of those warranties are written. Select a coil voltage for the reed relay that corresponds to the available DC voltage in your system, making sure that it doesn't exceed the 30-volt rating of your replacement unit.

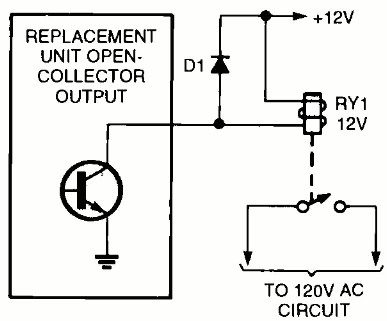


Fig. 6. An add-on circuit for driving an AC load from an open-collector output is useful for many different logic interface applications.

Writing to Q&A

As always, we welcome your questions. Please be sure to include:

(1) plenty of background material,

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

(3) and a complete diagram, if asking about a circuit; and

(4) type your letter or write neatly.

Send questions to Q&A, **Poptronics,** 275-G Marcus Blvd., Hauppauge, NY 11788 or to *q&a@gernsback.com*, but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K. P

BASIC CIRCUITRY

mailto: basiccircuitry@gernsback.com

CHARLES D. RAKES

METAL DETECTION

One of man's greatest challenges throughout history is to see what cannot be seen, to detect what is hidden, and to reap riches from these treasures. This visit we're going to look at some very basic metal-detection circuits. Now don't get me wrong; the circuits we'll share here most likely will never locate a valuable treasure, but they can be put to use performing other more practical applications. However, in the early days of the last century, even the simplest of metal detectors were successful in discovering some very valuable buried treasures. Simplicity often is the best route to take in solving a seemingly difficult task. Never give up on an electronic adventure because you don't have the latest and greatest equipment.

Woolgathering

The first metal detector ever used by man most likely was a chunk of magnetite. This material is nature's rock that is magnetized and attracts other ferrous objects.

House roofers use a modern version of this to pick up wandering nails that just happen to fly off the roof and land on the ground. The roofer's tool is a very strong magnet attached to a long handle. Fallen nails stick like glue as the magnet is scanned across the ground. Very powerful magnets are also useful in retrieving ferrous objects lost in lakes and rivers.

Ferrous Ferrets

Our first example of a ferrous detector is a simple mechanical device shown in Fig. 1. The detector is a modified balanced scale, which indicates ferrous objects and magnetized items. A magnet is attached to one end of the arm and a simple north/south scale is attached at the opposite end. A pivot is located near the magnet end of the arm, and a slide balancing weight is on the opposite end. The magnetic scale should be balanced with no ferrous items near by. Any non-magnetized

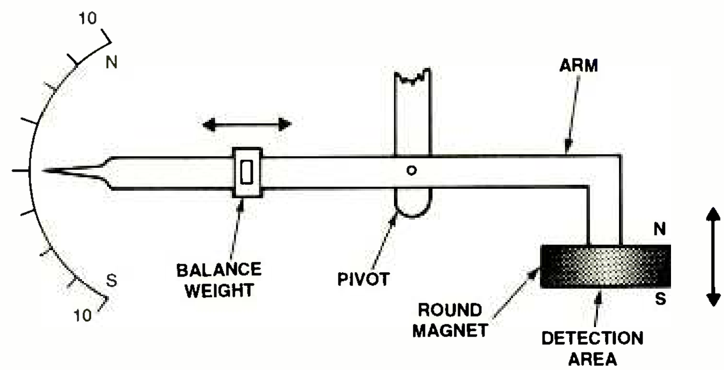


Fig. 1. This basic detector unit uses mechanics and magnetism principles to detect ferrous objects and magnetic fields. No batteries required!

PARTS LIST FOR THE FERROUS FERRETS (FIG. 1)

1 ¾-inch round donut ceramic magnet (RadioShack #64-1888) or similar magnet, misc. wood and metal materials

ferrous object positioned below and close to the magnet will cause the pointer to go up due to the magnetic attraction.

A magnetized object with the south pole facing up will cause the pointer to go down, and when the north pole faces up the pointer will rise. This ultra-simple magnetic detector is very sensitive and will easily determine what objects are ferrous and the polarity of magnets.

Electronic Ferrous Ferret

Our first electronic metal detector circuit, see Fig. 2, uses a Hall Effect sensor to detect weak permanent magnetic fields. Almost all ferrous objects retain

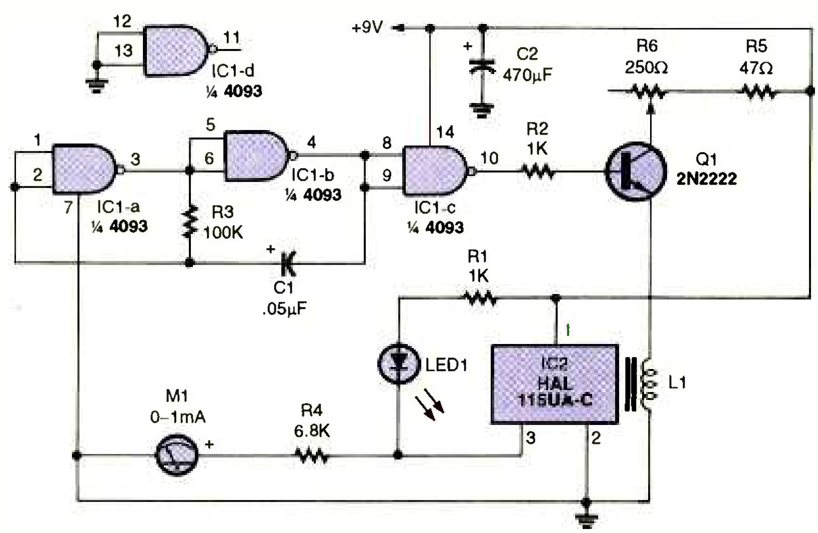


Fig. 2. The electronic version of the Ferrous Ferret uses a simple Hall Effect IC. Weak magnetic fields can be detected with this easy-to-build device.

PARTS LIST FOR THE ELECTRONIC FERROUS FERRET (FIG. 2)

SEMICONDUCTORS

IC1–4093B CMOS quad 2-input Schmitt trigger NAND gate
IC2–HAL 115UA-C Hall Effect IC, Digi-Key part HAL115UA-C-ND
Q1–2N2222 NPN transistor
LED1–Light-emitting diode, any color

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R2–1000-ohm
R3–100,000-ohm
R4–6800-ohm
R5–47-ohm
R6–250-ohm potentiometer

CAPACITORS

C1–.05-µF, ceramic-disc
C2–470-µF, 25-WVDC electrolytic

ADDITIONAL PARTS AND MATERIALS

L1–#32 enamel-covered copper wire, ¼-inch ferrite rod material (see text)
0-1-mA meter, or digital voltmeter

some degree of magnetism, and those that do are easily detected with our Hall Effect ferrous-detector circuit.

The HAL 115UA-C IC Hall Effect sensor is the heart of the weak-field detector circuit and is available for less than a buck from Digi-Key. This Hall Effect sensor is a bipolar device that is sensitive to a magnet's north pole on its branded side and to the south pole on the opposite side. The branded side, see Fig. 3, is the side that displays the part number.

The sensor's output (pin 3) is normally low when no external magnetic field is present. Placing a magnet with its north pole facing the branded side of the sensor will cause the output at pin 3 to go high. Placing a magnet with its south pole facing the non-branded side will also cause the output to go high.

Here's how the circuit operates. Two gates of a 4093 quad-, 2-input, NAND Schmitt trigger IC are connected in a low-frequency square-wave oscillator circuit operating at about 100 Hz. The output of gate "C" drives the base of Q1, which is connected in an emitter-follower circuit supplying the 100-Hz signal to L1. Inductor L1's drive level is set by R6. The output (pin 3) of IC2 is connected

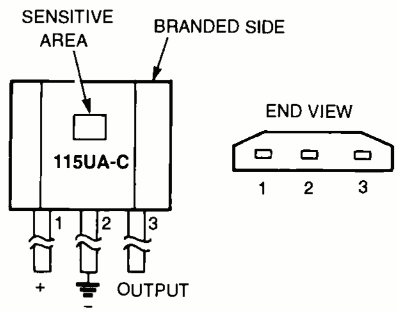


Fig. 3. Let's get up close and personal with our friend—the HAL 115UA-C. The branded side—where the part number is displayed—is sensitive to a magnet's north pole, while the opposite side is sensitive to a magnet's south pole.

to an LED and a metering circuit.

Inductor L1 supplies a low-frequency AC bias to the backside of the Hall Effect sensor, IC2. This AC bias in effect increases the Hall Effect sensitivity many times over and also allows it to detect both north and south pole magnets from the branded side; however, the circuit is much more sensitive to north pole fields. The arrangement of L1 and the Hall Effect sensor is shown in Fig. 5.

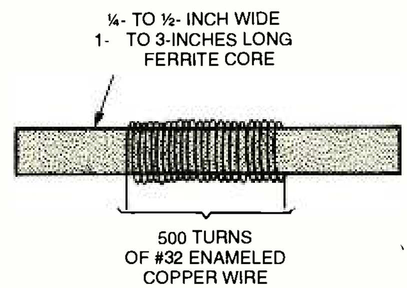


Fig. 4. Utilizing some skill and patience, inductors can be hand-wound. Here is a simple diagram showing the typical inductor needed for metal-detector circuits.

The Hall Effect's output waveforms are shown in Fig. 6. The waveforms are observed at pin 3 of the Hall Effect IC. Output waveform "A" is set by adjusting R6 for a symmetrical output without any ferrous metals in the pick-up area. If a scope is not handy, a DC voltmeter can be used to set the output to about 4.5 volts. This setting will produce an output waveform very close to the one shown in Fig. 6A. The "B" output waveform occurs when the north pole of a magnet is brought in proximity of the Hall Effect sensor. The south pole of a magnet produces the output waveform shown in Fig. 6C.

Winding L1

Inductor L1 (see Fig. 4) is fabricated by jumble winding 500 turns of #32 enamel-covered copper wire on a ¼-inch diameter ferrite rod. The rod's actual diameter and length are not critical, and any size rod material from ¼- to ½-inch in diameter will do. The rod's length can be anything from 1 inch to 3 inches. The type of rod material suitable for this application can be salvaged from an old AM transistor radio or some older TVs.

If the rod material cannot be located, don't give up 'cause there are other paths to take. A relay coil with a resistance of 10 ohms or greater will generally work for L1. Some miniature audio transformers have straight sections of laminations that can be used in place of the rod material. Most of the rod material I've used and have recommended here is actually designed for much higher frequency use. As a last ditch effort, try a number of small nails taped together as a core for L1 and see what happens. Here's a great place to experiment with various coil core materials and windings to improve or vary the circuit performance. Keep me informed on your efforts.

Try This One

Something else came to mind after disassembling the circuit, and due to time restraints I was never able to check it out. I would like to challenge you to do so. What if a second Hall Effect IC sensor was added to the circuit but placed beside IC2 with its branded side facing L1's core?

Duplicate IC2's circuitry with the new IC, but leave out the metering circuit. See Fig. 7 for details. Try to get like waveforms from both circuits by adjusting R6 and positioning the two ICs on the end of L1. Connect one lead of a digital DC voltmeter to pin 3 of IC2 and the other meter lead to pin 3 of the added IC. If I'm correct, the circuit should be as sensitive to the south pole of a magnet as the original circuit was to

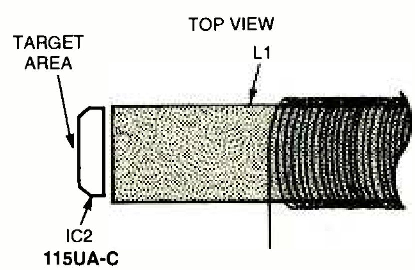


Fig. 5. The Hall Effect IC works in conjunction with the inductor. A low-frequency AC bias is supplied to the backside of the IC via the inductor.

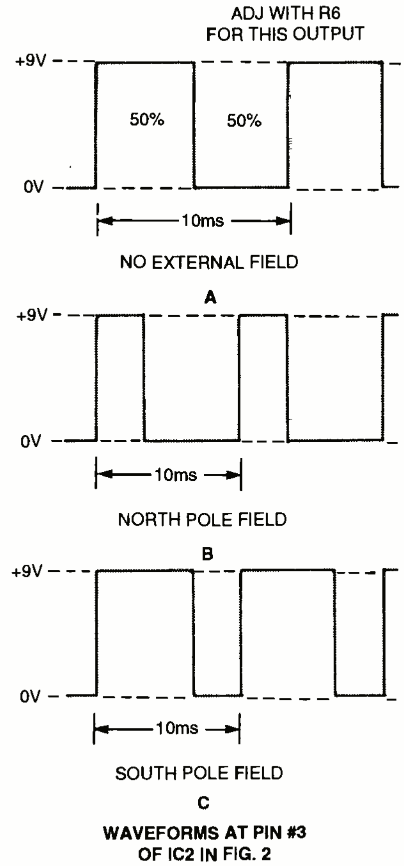


Fig. 6. Here are the waveforms that might come from pin 3 of IC2. Resistor R6 can be adjusted to calibrate the circuit.

the north pole. If not, try connecting a DC voltmeter to the output of IC2 and another voltmeter to the output of the added IC. IC2 should remain more sensitive to the south pole of a magnet, and the added IC should be more sensitive to the north pole.

All Metals Detector Circuit

Our next metal detector circuit takes us back into the early years of the last century where tubes were king and semiconductors were only diodes. It was discovered early on that any metal object placed near the tank circuit of an oscillator would shift its frequency either up or down.

A tank circuit is the combination of an inductor and capacitor that make up a tuned circuit. Ferrous metals near the inductor of a tuned circuit cause the oscillator's frequency to go down and non-ferrous metals cause the frequency to increase. This is the basic effect that the *B*eat *F*requency *O*scillator (BFO) type of metal detector uses to detect all metals.

Figure 8 shows a block diagram of the circuits making up a typical BFO detector. A search loop is usually wound in a circular fashion to serve as the inductor in the search oscillator's tank circuit. The reference oscillator is very similar to the search oscillator with a much smaller inductor, which is usually shielded from the search loop. RF signals are taken from both oscillators and fed to a common mixer, where the sum and difference frequencies of the two oscillators are mixed. The sum frequencies are filtered out, leaving only the audible difference frequencies to pass on to the amplifier and headphones.

As a practical example, we'll set the search oscillator up to operate at a frequency of 100,100 Hz, and the reference oscillator to a frequency of 100,000 Hz. The difference frequency between the two oscillators is an audible 100 Hz that is fed to the headphones. The search coil is then moved over a small ferrous metal object causing the oscillator to drop in frequency to about 100,050 Hz. The audible 100 Hz tone drops to 50 Hz indicating a metal object is located somewhere near the search loop. A non-ferrous object near the loop will cause the oscillator to increase in frequency and produce a higher audio output tone. A carefully adjusted BFO metal detector can be used to discriminate between ferrous and non-ferrous metals.

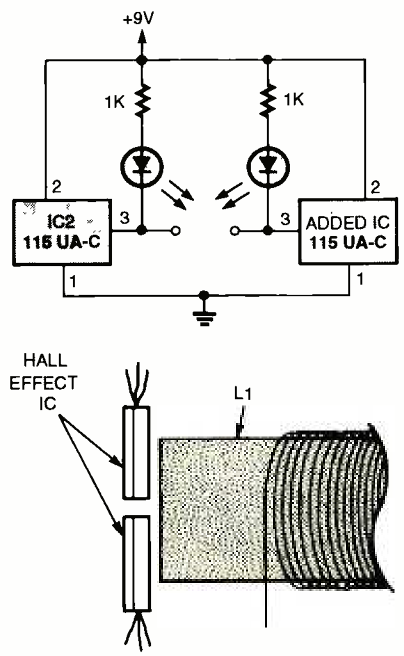


Fig. 7. Increase your odds at detection with this simple modification. An additional Hall Effect IC is added to balance the circuit's sensitivity to the north and south magnetic poles.

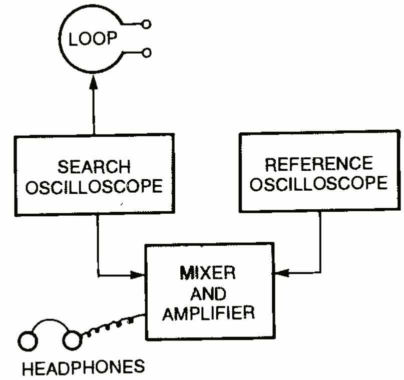


Fig. 8. The popular loop-detector circuit has been a mainstay for many treasure hunters. A set of headphones allows the user to hear an indication of ferrous material and magnetic fields.

Two-Transistor BFO Detector

One of the simplest BFO metal locators to build is the two-transistor circuit shown in Fig. 9. The circuit may be set up to operate on any frequency between 50,000 Hz to over 1 MHz by selecting the tank circuit components. Just about any good general-purpose NPN transistor suitable for low RF applications will work just fine. The search loop can be as small as a dime or three feet or larger in diameter. A small loop works best for small objects buried shallow and a large loop works best for large objects buried at greater depths. The two oscillator circuits should be separated and shielded from each other to reduce frequency pulling between the two. A really well constructed BFO detector will be able to operate with a difference of less than 100 Hz between the two oscillators. The lower the audio output tone the easier it is for the ear to tell a small frequency shift. The detector's maximum sensitivity is obtained when the two oscillators are operating just a few cycles apart. Believe me, this is not an easy task to accomplish, but one well worth the effort.

Here's how the simple BFO detector operates. Transistor Q1 along with its associated components make up a Colpitts oscillator circuit with the search loop, C1 and C2, forming its tuned circuit. Transistor Q2 with its associated components make up another Colpitts oscillator circuit with L2, C2, and C4 forming the tuned circuit. The emitters of Q1 and Q2 are coupled together through R1, R2, and the low-impedance headphones. This circuit arrangement functions as a simple RF mixer circuit. The audio frequencies are fed to the headphones, and the RF frequencies are bypassed to ground through C8.

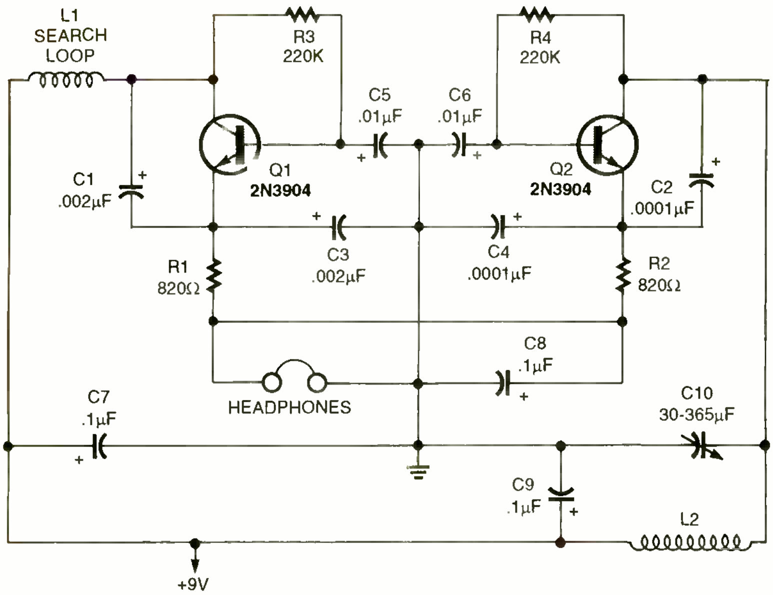


Fig. 9. This is the schematic for a Beat Frequency Oscillator metal-detector. Two transistors are used as the oscillators in this circuit.

PARTS LIST FOR ALL METALS DETECTOR CIRCUIT (FIG. 9)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1, R2–820-ohm
R3, R4–220,000-ohm

CAPACITORS

C1, C3–.002-μF, mylar, or similar type capacitor
C2, C4–.0001-μF, mylar, or similar type capacitor
C5, C6–.01-μF, ceramic-disc
C7, C8, C9–.1-μF, ceramic-disc
C10–365-pf, variable capacitor

ADDITIONAL PARTS AND MATERIALS

Q1, Q2–2N3904 NPN transistor
Low-impedance headphones
Loop form, wire, plastic pill bottle, etc. See text.

Winding And Scrounging

The loop may be wound on almost any round insulated non-metallic form, such as wood or plastic. Inductor L2 can be an old ferrite rod antenna coil removed from an AM transistor radio, or one can be made by winding a coil on a round insulated form. Let me offer the following winding suggestion to get you going on building the BFO circuit. Locate a 10- to 12-inch wood or plastic hoop that's about ¾-inches wide and close wind ten turns of #18 to #22 enamel-covered copper wire evenly around the form. Tape over the wire with plastic electrical tape and connect to the circuit with a length of two-wire zip cord. If an antenna coil cannot be found for L2, then close wind about 80 turns of #22 enamel-covered copper wire on a 1-inch plastic pill bottle or plastic pipe.

One important thing to do in selecting the two inductors is to be sure that the reference oscillator can tune to the same frequency as the search oscillator. If a frequency counter is available then the chore will be super easy. If not, some experimenting with different pairs of capacitors (C1 and C3 or C2 and C4) will be necessary to bring both oscillators to the same frequency.

Fellow Circuiteers, we've just ran out of space and time; so meet me back here next month, and we'll continue on our metal detector journey. I want to thank Ken, in Texas, for suggesting this month's subject. **P**

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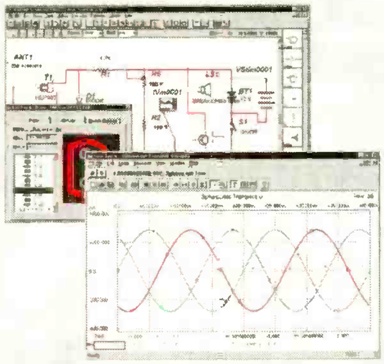

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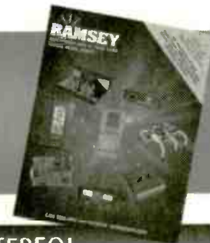

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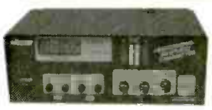

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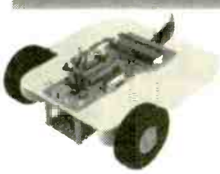
FMAC	12V DC Wall Plug Adapter	$9.95

CARPET ROVER II ROBOT KIT



This advanced kit is an 8 x 8" differentially steered base that is excellent for carpet or tiled floor experimentation. It uses the Next Step microcontroller, a BASIC Stamp 2 controller that can use the BS2 or BS2-E (sold separately). A host PC is required to download programs to the robot. This complete kit includes the Rover, programming cable, IR proximity detector, bumper switch kit, and line follower kit.

RK3000	Carpet Rover II Complete Kit	$185.00

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Build this kit and detect combustible gases and vapors including natural gas, gasoline, propane, and dozens more. Model GLD1000 is a local alarm only, GLD1010 includes a relay to control external alarms.

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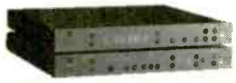

We've got the kit! Our K4500 is a synthesized FM stereo tuner, the K4100 is a matching preamp. Both are fully digitally controlled with an optional IR remote control (kit also). Add our K4020 2 x 155W Class A power amplifier kit to complete your drop-dead stereo. We also have tube amplifier kits. Visit us on the web, or request our new catalog for more information.

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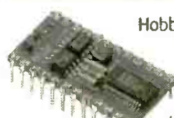
PLAB4	$49.95

RAMSEY NOW CARRIES BASIC STAMPS



Hobbyists and educators have embraced the Basic Stamp family of microcontrollers thanks to their power, ease of programming and simple interface. Ramsey now offers popular BS boards, kits, and trainers. If you've been wanting to learn microcontrollers, or build them into a project, now's the time!

BS1IC	Basic Stamp I Module	$34.00
BS2IC	Basic Stamp II Module	$49.00
27205	Basic Stamp 1 Starter Kit	$109.00
28150	Board of Education Full Kit	$109.00

MINI-KITS

These are easy to build kits that can be used either stand alone or as building blocks for more complex projects.

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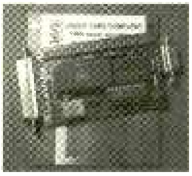

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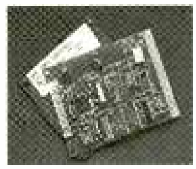

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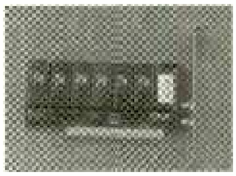

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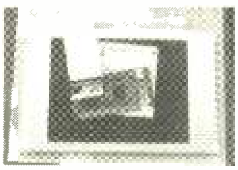

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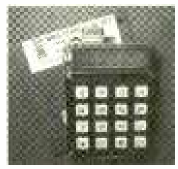

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oem(1k)
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eval kit(1)
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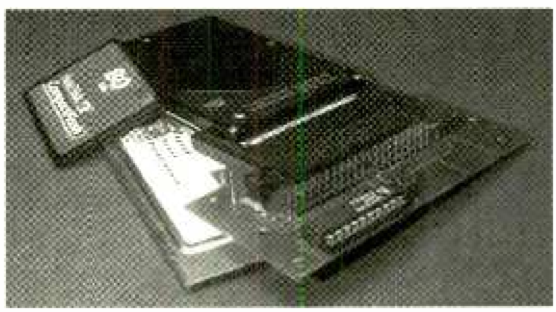

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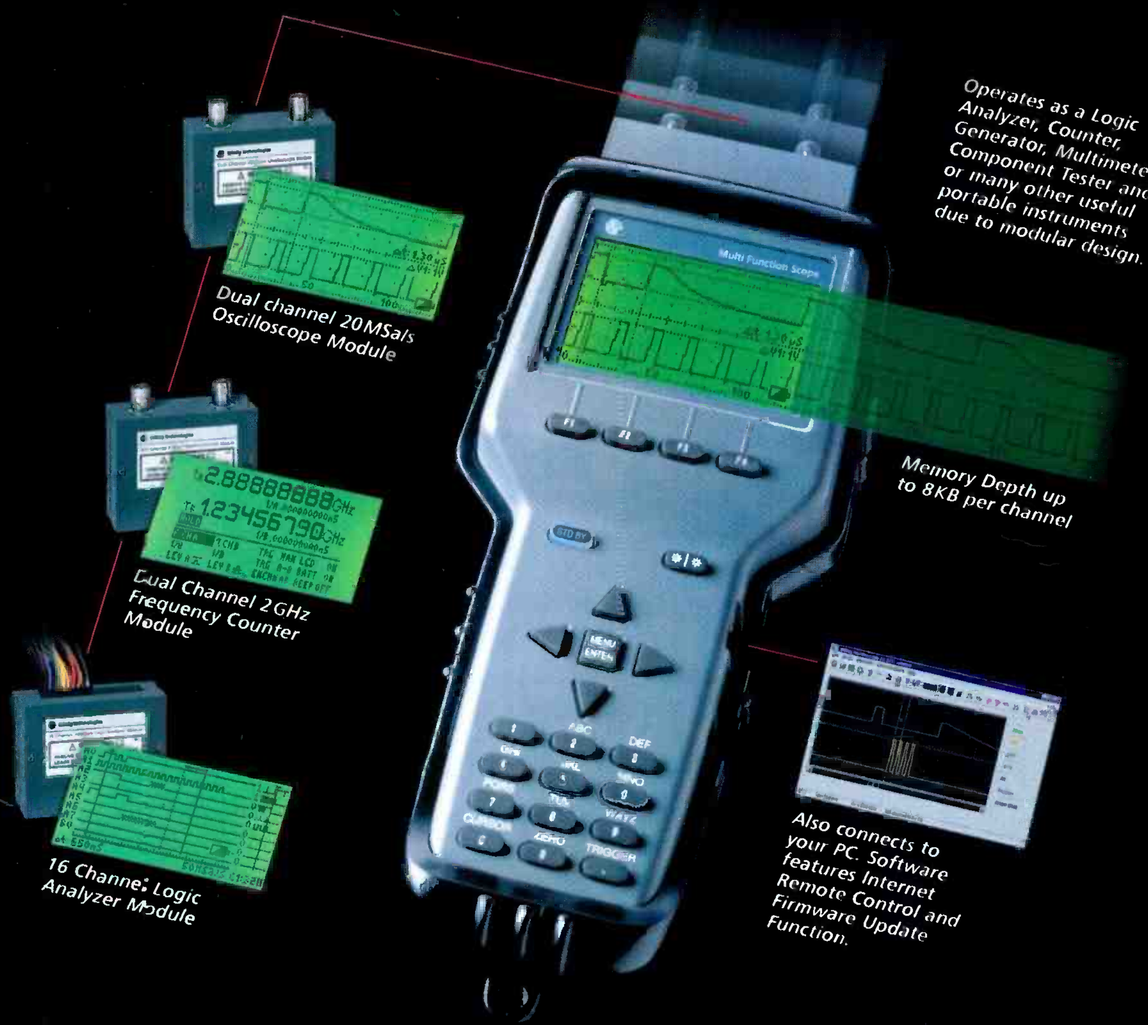

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