DRIVERLESS CARS ON INTELLIGENT ROADS

DECEMBER 1997

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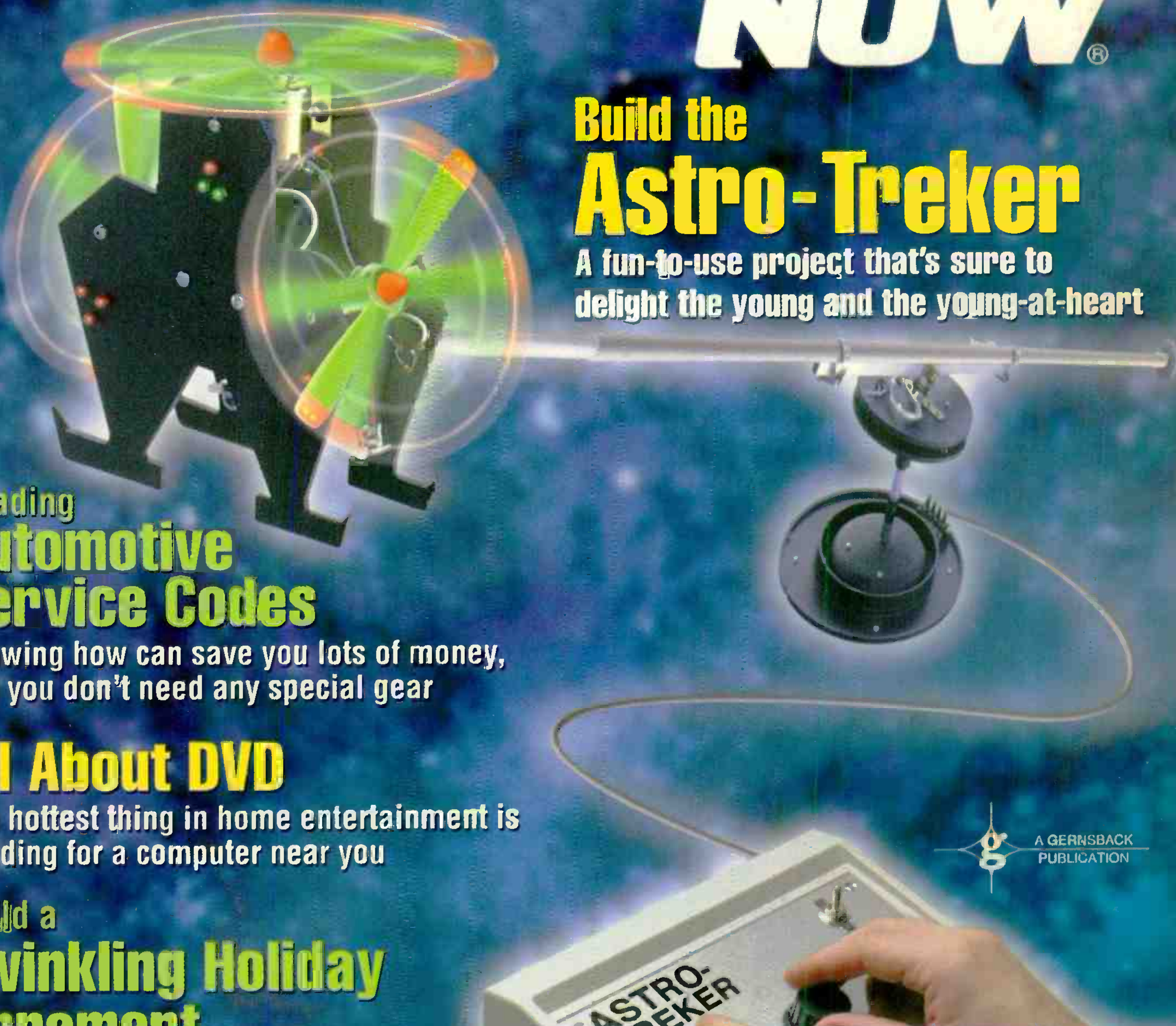

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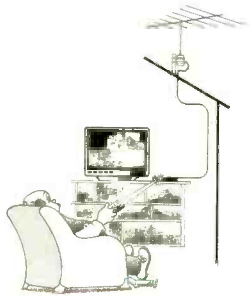

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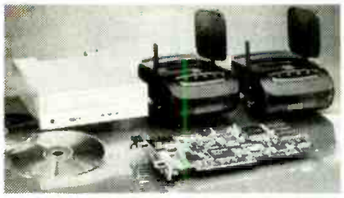

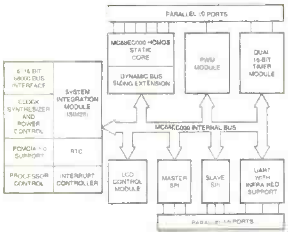

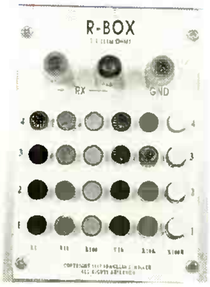

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EDITORIAL

Trouble for DVD?

Were you planning to get yourself one of those hot, state-of-the-art DVD players for your home-entertainment system for Christmas? Or are you one of those early adopters who had to be the first on your block with the hottest development in home video in years? Well, I'm afraid I've got some bad news for you.

Just as things seemed to be looking up for DVD, with a strong holiday selling season poised to firmly establish the standard and the medium, a consortium made up of several major consumer-electronics manufacturers (Zenith, Matsushita, and Thomson), several top Hollywood studios (Disney, Paramount, Universal, and DreamWorks), and one of the biggest consumer-electronics retailers in the country (Circuit City) announced a new disc format for home entertainment. And, of course, it won't work with existing DVD players.

Called Divx, the key to the system is low-cost titles that will run about $5 each. The catch is that they can be viewed only for 48 hours, after which they will no longer work. At that point they can be thrown away or unlocked again for an additional fee. The discs can only be viewed on a Divx-compatible DVD player, which will require a telephone connection to a central Divx computer and is expected to cost about $100 more than a standard DVD player. The Divx player will also play standard DVD discs.

Just lovely. As you might imagine, the reaction within the DVD community has been akin to someone shouting fire inside a crowded theater. The home-video rental industry is also appalled as this could easily spell the end of their business. And how about consumers who have spent hundreds, or even thousands of dollars on technology that might soon be obsolete? Let's just say that most of their reactions can't be reprinted in a magazine that might be viewed by minors.

If you are wondering what the impetus behind Divx might be, the answer is simply money—lots and lots of money. The system gives its proponents a direct line into the lucrative home-video rental market. The studios also like the extra layer of protection that the system gives their copyrighted works. The first Divx players and discs are expected to be available in

Continued on page 98

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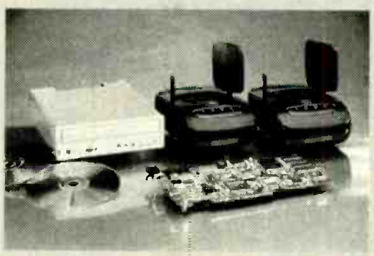
EQUIPMENT REPORT

A COMBINATION DVD-ROM AND DVD VIDEO PLAYER FROM HI-VAL

Can't decide between a DVD video player for your living room or a DVD-ROM for your PC? Why not get both?



CIRCLE 15 ON FREE INFORMATION CARD

As most undoubtedly know, DVD (digital versatile disc) is the hottest new "must-have" technology in both the consumer-electronics and computer fields. At least it's a "must-have" until you take a look at current retail prices. As with most new technologies, initial pricing has been largely aimed at the so-called "early adopters;" those with the desires and finances to be the first on their block with the "latest and greatest." And if you are looking to equip both a home-entertainment system and a PC with this new technology, the sticker shock is doubled.

However, while the advantages offered by DVD in the home-entertainment field could perhaps be debated, there is little doubt that in short time the DVD will largely replace the CD-ROM in PCs everywhere. Their greatly expanded storage capabilities make that a cinch in these days of bloatware applications and bigger, better, and louder computer games.

Here's an idea: Wouldn't it be great to be able to equip your PC with a DVD drive and be able to use that same drive as a DVD player for your home-entertainment system? Well, dream no more, as that's now a reality thanks to an innovative DVD upgrade bundle put together by Hi-Val, Inc. That bundle, which retails for $799, includes a Toshiba DVD-ROM drive, which is a DVD player and 8× CD-ROM drive all in one unit, and an AC-3/MPEG2/MPEG1 audio-decoder card that works in conjunction with an existing sound card. The DVD-ROM drive can play DVD movies and DVD games and is backward-compatible with music CDs and CD-ROMs.

The Hi-Val package also includes RF Link's Wavecom Sr., a wireless transmitter for audio, video, and infrared-remote signals. It transmits DVD movies up to 300 feet through walls, floors, and ceilings to a cable or composite video input on a TV or VCR. An infrared receiver on the Wavecom transmitter transfers any remote-control signals to an infrared retransmitter on the Wavecom receiver. Unfortunately that particular feature is of little use with the DVD kit because the DVD-ROM drive does not offer remote control. Still, with the wireless transmitter, DVD movies can be viewed on a TV in another room while someone works on the computer doing other things. For more information on the Wavecom Sr., see Equipment Reports in the October, 1997 issue of **Electronics Now**.

To use the DVD system, you need Windows 95 and a minimum of a Pentium 133 with 8 MB of RAM, 4 MB of hard disk space, PCI bus mastering, one vacant PCI slot, and a PCI video card that supports DirectX (Direct Draw) at 16-bit color. However, it is recommended that you have a Pentium 166 or higher with 16 MB of memory. The DVD-ROM drive supports DVD-Video, CD-Extra, Video CD, Photo CD, Orange book, multi-session, CD-Audio, CD-ROM, CD-I, and CD-ROM XA, but not CD-R recordable media.

DVD

DVD is based on the Compact Disc and the industry-standard MPEG-2 bit rate reduction. In its most basic form, a DVD disc can hold 4.7 GB of data, which is the equivalent of seven CD-ROMs; multi-layer and/or double-sided discs can hold up to four times as much (more on that in a moment) That's enough storage for over two hours of high-quality full-motion video, additional data tracks, and surround-sound audio. DVD is backward-compatible with CD-ROM. The data-transfer rate for DVD movies is about 600 kilobytes-per-second and for data applications, rates of 1.3 megabytes-per-second or more are typical.

MPEG-2 compression identifies portions of a video segment that are unchanged from frame to frame and stores only the data describing the differences between them. Other technologies that make use of MPEG-2 compression technology includes DSS satellite TV.

DVD supports two audio-encoding systems: Dolby Surround AC-3 and MPEG-2 Audio. The Dolby AC-3 standard has five signal channels plus a non-directional subwoofer channel. Dolby AC-3 gives each of the five audio channels (left, center, and right speakers in the front, and left and right surround in the rear) its own data stream. MPEG-2 Audio can do the same arrangement plus add left-center and right-center channels.

The initial DVD specification calls for a single-sided, single-layer disc with 4.75 GB of storage. To squeeze that much onto a disc, DVD-ROM uses a shorter-wavelength laser than standard CD-ROM, and can read smaller data pits on a tighter spiral track. And because the data layer is only half as thick as on a conventional CD, manufacturers can make double-sided DVD discs with the same thickness as conventional CDs (1.2 mm). Double-sided discs must be turned over to access the data on the other side. By sandwiching a semitransparent layer on top of a reflective layer, a DVD disc can have two layers of data on one side.

A drive equipped with a variable-power laser beam can read the data on both layers. A double-sided DVD disc with dual layers has a capacity of 17 GB.

The DVD-ROM drive included in the Hi-Val bundle has an ATAPI interface and a transfer rate of 1350 kilobytes-per-second for DVD and 1200 kilobytes-per-second for CD-ROM. It has a seek time of 140 milliseconds for DVD, and 110 milliseconds for CD-ROM. The front panel has a built-in headphone jack, volume control, and eject button, plus separate DVD, CD, and Busy indicator lights. The drive features 4× sampling and digital filtering for CD audio.

The Hi-Val Cinemaster DVD card is a PCI-based, bus-mastering plug-and-play card for a PC. Using Quadrant International's VideoInlay technology, digital video is transferred directly over the PCI bus to the graphics card. The video signal is also output on external composite and S-Video connectors for transferring DVD video to a TV (unfortunately, the Wavecom Sr. wireless transmitter cannot transmit the S-Video). Dolby AC-3 audio is decoded on-board and down mixed to 2-channel Dolby Pro Logic, available for external amplification or Pro Logic decoding. The AC-3/MPEG2/MPEG1 audio decoder card works in conjunction with an existing sound card.

Installing The Bundle

Installing the Hi-Val DVD upgrade kit is very easy, as the DVD-ROM drive behaves basically like an IDE CD-ROM drive and the Cinemaster AC-3 card features plug-and-play operation. The plug-and-play card installed in minutes in a vacant PCI slot with the drivers loading flawlessly from diskette. The 5.25-inch internal DVD-ROM drive installs in a standard-size drive bay. It has the familiar master/slave/cable select jumper on the back as well as the ATAPI interface and audio output. An audio cable connects from the back of the DVD drive to the AC-3 card and another goes from the AC-3 card to the original sound card's audio input.

Despite the above, we did encounter some problems. Although there's no reason why the DVD drive can't work off the same IDE controller as the original CD-ROM drive in a system, our test-bed system was fussy—it didn't like two drives connected to the same IDE controller no matter what the combination was. We had to settle for the hard drive on the primary IDE controller and the DVD drive on the secondary IDE controller with its jumper set to the cable-select position. To accommodate the new drive, the original CD-ROM drive had to be removed from the system; that could be a problem for some since, while the DVD drive also is an 8× CD-ROM drive, it can't read CD-R, which most CD-ROM drives can handle.

Some Final Thoughts

For the meantime, DVD-ROM games and resource discs provide the same basic features as current CD-ROMs, but with greatly expanded content. However, enhanced DVD features such as multiple camera angles and languages will soon be put to use in a new generation of multimedia entertainment software. The Hi-Val bundle includes Spycraft, The Daedelus Encounter, Silent Steel, Muppets Treasure Island, Encyclopedia Electronica, and Wing Commander IV DVD software.

The quality of DVD video has been hailed as spectacular, and now that we've had some hands-on experience we must concur. Everything we've sampled to date has provided a crystal-clear picture with CD-quality audio comparable to what's available via laserdisc or DSS satellite TV. For those who can't decide whether they prefer letterbox or traditional pan-and-scan versions of movies, the discs generally offer both versions. Video can be viewed on the computer monitor, or, even better, on a large-screen TV with the wireless transmitter. All in all the Hi-Val bundle is a terrific package.

We've made the jump to DVD, PC-first. If you think DVD is for you and your PC, then contact Hi-Val directly (Hi-Val, Inc., 1300 East Wakeham Avenue, Santa Ana, CA 92705; Tel: 714-953-3000; Web: http://www.hival.com) today, visit your local computer store, or circle 15 on the Free Information Card. EN

Q & A

READERS' QUESTIONS, EDITORS' ANSWERS

Who's On First?

Q *I need a switch arrangement to use in my church's Sunday School class. When a teacher asks a question, the first of the five or six students who knows the answer will activate his or her switch. This will turn on a light to identify the student and also disable all the others' switches. Can you give me any ideas? — A. N. M, San Antonio, TX*

A This kind of circuit is sometimes called a "game-show timer," and over the years, several designs have been published that handle two or three contestants using relays or flip-flops. With six contestants, though, the traditional circuit gets rather complicated, so we decided to start from scratch and do it a new way.

Figure 1 shows our solution, which relies on timing rather than relay logic. The 74HC573 is a latching 8-bit buffer; pin 11 tells it how to behave. When pin 11 is high (+5V), the input signals are transmitted unchanged to the outputs; when pin 11 is low (0V), the outputs are latched and remain unchanged regardless of the inputs.

Initially, pin 11 is high and so are all the inputs and outputs. When a contestant presses a button, the appropriate input and the corresponding output go low. When any output goes low, the diodes ensure that pin 11 will also go low and the 74HC573 will latch. Further inputs are then ignored until the reset button is pressed.

The 74HC540 serves as an output buffer. It inverts the output signals (so that you get one output high and the rest low, not the other way around) and keeps the load, such as LEDs, from affecting the 74HC573. Figure 2 shows how to connect LEDs and lamps to the output. If you need a buzzer to sound when a button is pressed, add the circuit in Fig. 3.

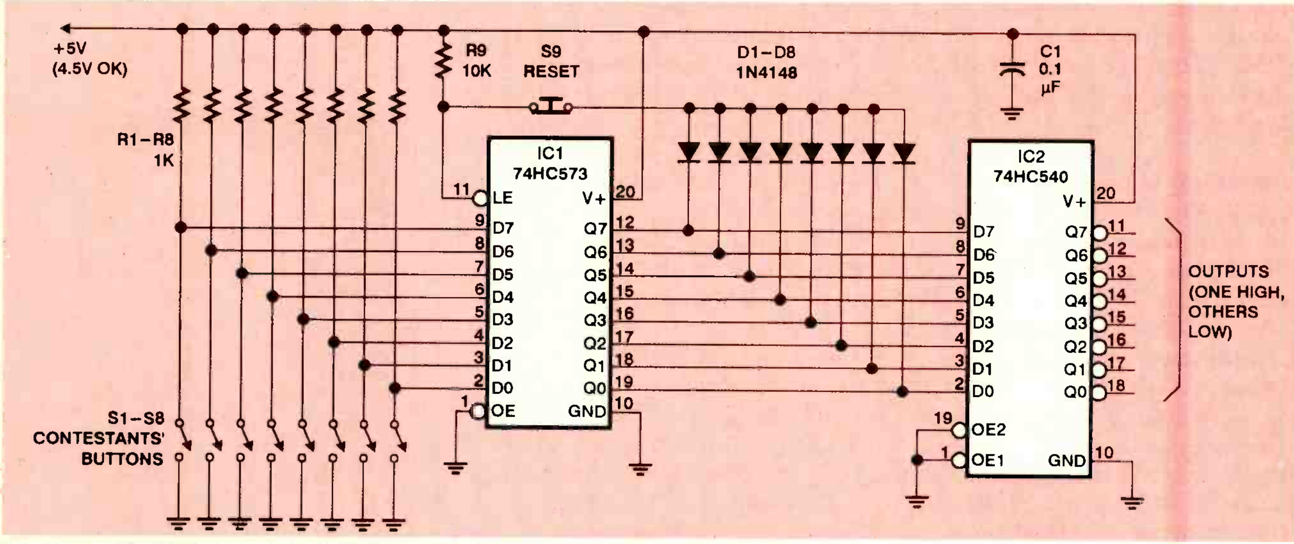


FIG. 1—HERE'S A GAME SHOW TIMER that can be used for up to 8 contestants. The first switch closure latches IC1, locking out the other switches. If you wish, you can substitute 74HCT chips for the 74HC chips shown here.

Note that this circuit doesn't actually contain any logic to keep two buttons from being actuated at the same time. Theoretically, two contestants could press their buttons simultaneously and turn on both of their lights. But they'd have to do it within about 20 nanoseconds of the exact same instant—which is extremely unlikely, and if it happened, you'd be justified in calling it a tie.

How Autofocusing Is Done

Q *I was wondering how the auto-focus feature works on modern cameras. Could you provide the basic theory and maybe an illustrative circuit? — E.L.H., U.S. Armed Forces, Germany*

A Certainly. Consider an auto-focusing video camera first. High frequencies in the video signal correspond to fine detail in the image. So in order to focus the lens, all you have to do is position it so that the high frequencies in the signal are as strong as possible. (It's a lot like aligning an audio-tape head for the best treble.) Figure 4 shows a block diagram of how it's done: The video signal is fed to a control circuit, which moves the focusing motor back and forth until it finds the maximum.

Autofocus SLRs work the same way, but the video signal comes from one or

Continued on page 15

Prototype

Intelligent Roads for Driverless Vehicles

BY BILL SIURU

While driverless cars gliding accident-free down automated roads remain years—or more likely decades—away, test tracks and roads now in use or being built are making use of technologies and techniques that might well find their way into tomorrow's intelligent roads and vehicles.

One such test facility is the 1.8 mile oval WesTrack at the Nevada Automotive Test Center near Carson City, NV. A visitor to that track would see four Navistar tractors pulling triple trailer combinations around the track virtually around the clock. That is part of a project to test 26 different experimental asphalt pavement formulations as part of the Federal Highway Administration "Accelerated Field Test of Performance-Related Specifications for Hot-Mix Asphalt Construction" project. Using accelerated testing, 10 years and 1.7 million total vehicle miles of pavement testing can be accomplished in only two years. The test speed is 40 mph.

What's different here is that to eliminate the monotony of up to 22 hours-per-day, 7 days-per-week driving, the trucks are driverless. The autonomous tractors are equipped with electronically controlled Detroit Diesel turbocharged engines and Twin Disc automatic transmissions. Braking is done with Midland-Grau Anti-Lock Brake System (ABS) on the tractors and all trailers, plus an electronic brake valve for brake control.

AN AERIAL VIEW OF WesTrack at the Nevada Automotive Test Center (Nevada Automotive Test Center).

Redundant guide-by-wire systems buried under the asphalt are used to laterally and longitudinally control the trucks. For added safety, all systems are connected to uninterruptible power supplies. Each tractor is equipped with guidance antennas mounted to the front bumper. Those are used to acquire the guide tones emitted by either primary or alternate wire paths, which are powered by audio amplifiers. The antennas, reading either the primary or alternate wire paths, provide a continuous feedback signal to the steering controller. Steering is accomplished by a robust stepper motor connected directly to a steering gearbox. Steering commands are based on the error signal generated from displacements from the center of the wire. The throttle, engine and transmission are controlled by advanced electronics on the engine and automatic-transmission electronic control unit.

The trucks are controlled and monitored from a control room located beside the test track. Computers within the control room start and stop the vehicles, as well as regulate spacing and speed. Radio-frequency modems on each truck are used for communications for traffic and longitudinal control. Different frequencies are used to distinguish between the vehicles that are on the track at the same time.

As a fail-safe measure, the Differential Global Positioning System (DGPS) independently monitors the truck position and provides an input to the traffic control computer. Each vehicle has two computers shock mounted in the truck's sleeper, one for vehicle control and

FOR MORE INFORMATION

Chrysler Corporation
CIMS 485-06-48
1000 Chrysler Drive
Auburn Hills, MI 48326-2766

Nevada Automotive Test Center
PO Box 234
Carson City, NV 89702
www.WesTrack.com

ONE OF THE DRIVERLESS TRUCKS circling the WesTrack for pavement testing (Nevada Automotive Test Center).

one for monitoring more than 160 parameters on the truck's "health" that would be normally evaluated by a driver. The control room operator has one computer for each truck—with a display showing status of the truck in an easy-to-read format. There are diagnostic programs to aid in monitoring and correcting critical control parameters. If a critical parameter is out of bounds, the vehicle monitoring computer transmits a shut-down signal to the control computer.

The bottom line is that the longitudinal location of the trucks can be kept to within 50 mm (2 in.) of any measurement sensor installed in the pavement. There is a grid of five longitudinal and five transverse pavement strain gauges precisely installed in each of the 26 experimental pavement test sections located in the track. Automation insures the wheels hit the pavement at precisely the right locations.

Chrysler's Automated Durability Road

The Automated Durability Road at the Chrysler Proving Ground in Chelsea, MI is used to test vehicles to see how well they will hold up under the very worst road conditions. The 1.3 mile course replicates rough roads with large potholes, bumpy railroad crossings, and cobblestones. The track is so brutal on vehicles that it only takes about 2,000 miles of driving to equal the effects of driving about 100,000 miles on normal roads.

Chrysler's test drivers dread this driving assignment and can only tolerate about four hours a day on a road where they hit a head-tossing pothole every five feet. However, since a robot can take this kind of punishment all day long, in all kinds of weather, and will not be tempted to avoid any of the potholes, Chrysler engineers have developed a robotic driver that "sits" in the front seat of the test vehicles and actually steers, shifts gears, brakes, and accelerates. Levers that are attached to the robot act like feet and hands, pushing on the brake and accelerator pedals as well as shifting gears. A motor is connected to the steering wheel hub via a short driveshaft with universal joints.

The driverless vehicle is guided using a guide wire embedded in the track. Two inductive coil sensors mounted on the front of the vehicle receive signals from the wires and relay the information to a computer placed on the passenger seat. The closer the coil gets to one or the other guide wire, the greater the voltage. For example, when the signal in the right coil is too strong, it means the vehicle is drifting too far to the left. The computer, or vehicle controller, "steers" the vehicle by balancing the voltages at the coils so they are equal and the vehicle is thus on course.

Transponders, about the size of a roll of quarters, are buried in the road at 100-foot intervals. An antenna placed near the rear license plate keeps track of the vehicle's location at all times. The antenna emits a power burst that is

THE CHRYSLER AUTOMATED DURABILITY ROAD has a guidance wire embedded in the road. Twin inductive coil sensors temporarily mounted on the front of the vehicle measure pick up frequencies from the wire (Chrysler Corporation).

received by the transponders. The transponder sends back a signal to indicate its exact location. If the information does not match up, all vehicles sharing the track are immediately stopped. As a backup safety system, video cameras constantly monitor the track so the human traffic controllers in a "flight tower" can monitor the operation and stop the vehicles if there is a problem.

The vehicles are radio controlled using military radio-communications technology. Spread-spectrum transmissions are used to prevent messages from becoming scrambled or diverted by electronic interference, clouds, buildings, trees, etc., without any delay in response time. Five radio towers located strategically around the track relay instructions from the control tower to the vehicles. Vehicle speed, engine rpm, shock-absorber and coolant temperatures, oil pressure, and the electrical system are all monitored.

Three cars or vehicles are usually tested simultaneously, which greatly complicates the operation. The vehicles typically travel between 25–30 mph and have reached top speeds of 45 mph. Installing and removing the robot, control unit, antenna and sensors takes less than four hours so the system can be used to test many vehicles quite easily.

Besides relieving human drivers from fatigue and punishment of rough road durability testing, Chrysler says the robotic system saves four weeks in the development of a new vehicle because testing can be done around the clock in all kinds of weather. Finally, it improves the quality and repeatability of the testing by eliminating any driver variation.

Test Tracks Vs. Real Roads

While, as you've seen above, driverless vehicles are already being used on the test track, automated cars traveling down public highways are still quite far in the future for a variety of reasons. Indeed, vehicles may never be completely robotic. While the techniques and equipment already being used might be conceptually similar, operating automated vehicles on regular highways is a much greater challenge than ones that only have to circle a closed track.

For instance, clouds, trees, buildings, other vehicles, and any number of other variables make electronic interference a much more significant problem on highways compared to the highly controlled environment of the test track. Extremely reliable and redundant systems are required to prevent accidents. For example, in the Chrysler system, current technology requires that the vehicles be spaced at least 200 feet apart, hardly practical on real roads.

Furthermore, major and expensive changes to the infrastructure—such as guidance wiring embedded in the road—and to individual vehicles would be required. Chrysler estimates it could cost as much as $50,000 to equip each vehicle with robotic equipment with currently available technology. Finally, the in-vehicle equipment has to be made much smaller. For instance, Chrysler's robot, computer, and associated hardware occupy both front seats.

That said, the state of the art continues to evolve. Should driverless cars and intelligent roads eventually move out of the realm of science fiction, the techniques being developed today could well show the way. EN

Remote-Control Robot—Planetary Explorer

A hardy traveler, named "Nomad," set a new record by traveling farther than any remotely controlled robot has ever gone over rough territory. The four-wheeled robot logged more than 133 miles (215 km) across Chile's rugged Atacama Desert, a cold, arid region above 7,000 feet altitude. The field experiments this past summer were designed to prepare for future missions to Antarctica, the Moon, and Mars.

Scientists from NASA's Ames Research Center (Moffett Field, CA), and Carnegie Mellon University's Robotics Institute (Pittsburgh, PA) performed experiments with Nomad for 45 days, from June 15 to July 31. Nomad avoided obstacles on its own and recognized meteorites planted in the desert as a test. The robot, developed at Carnegie Mellon, validated the use of color stereo video cameras with human-eye resolution for geology.

"The Atacama trek is a quantum leap for the planetary robotics culture, where the historical standard of travel has been yards, not miles," said principal investigator Dr. William L. "Red" Whittaker of Carnegie Mellon. "Although the 'straight-line' distance on a map was only about 13 miles, Nomad had to weave through very difficult terrain, and it made numerous sidetrips for science and to test the meteorite sensors."

Nomad is about the size of a small car. To maneuver through rough terrain, the robot has four-wheel drive and four-wheel steering with a chassis that expands to improve travel and stability over various terrain conditions. Four aluminum wheels with cleats provide traction in soft sand. For this terrestrial experiment, power was supplied by a gasoline generator that permitted travel speeds up to one mile per hour.

"Nomad drove itself through about 12 miles (20 km) of the 133 miles it traveled," said Dr. Mark Maimone, Nomad software and navigation leader at Carnegie Mellon. "Autonomous driving is critical for planetary exploration because the communications delay between Earth and planets can be many minutes. With autonomous driving, a robot can explore a much greater distance because it doesn't have to wait for a person to decide a safe route. The

THE NOMAD remote-controlled robot.

rover is able to see obstacles and recognize them on its own."

Nomad's unique onboard panospheric camera, separate from the color video stereo cameras, returned more than a million live video-based panoramas of the robot's surroundings from the Atacama. The camera takes a 360-degree picture—one frame per second—and did so throughout the mission. The high-resolution video camera focuses up into a hemispheric mirror similar to a store security camera. The video view includes all of the ground up to the horizon in the circle surrounding the Nomad.

"Nomad met or exceeded all of our objectives for this project," said Dave Lavery, telerobotics program manager at NASA headquarters (Washington, DC).

The total cost of developing Nomad and conducting the desert trek is $1.6 million. The project is funded by NASA with in-kind support from corporate sponsors and educational foundations. NASA and Carnegie Mellon are formulating plans to look for meteorites in Antarctica in 1998 and 1999. EN

Biology Lab on A Microchip

University of Michigan (UM) biomedical engineering researchers have developed a technology that may one day eliminate much of the uncertainty and expense involved in current medical diagnostic and genetic testing procedures. With just a small blood sample, your doctor may be able to scan your DNA using the UM device to get immediate answers to questions as serious as "Will my baby be born healthy?" or as simple as "Will an antibiotic help my sore throat?"

Currently, DNA analysis is time-consuming, and requires a complete molecular biology laboratory, and at least ten individual procedures performed by highly skilled technicians. "Our goal is to automate the process by, in essence, shrinking the lab to fit on one silicon microchip," said David Burke, assistant professor of human genetics. Cutting the cost, time, and technical skill required for DNA analysis also could lead to wider applications in genetic studies, self-testing kits, forensics testing, water analysis, agriculture, and biology, Burke adds.

In the *Proceedings of the National Academy of Sciences*, Burke and his colleagues reported initial test results on five microfabricated components and their preliminary integration into a DNA-analyzing chip just 3-cm (about 1-inch) long and ½-cm wide. According to Mark Burns, associate professor of chemical engineering, the device relies on a thermocapillary pump to mix drops of pure DNA with an enzyme solution and drive the DNA through five different components on the microchip.

Because the device is fabricated with conventional techniques, it should be inexpensive and easy to produce in large quantities. However, significant technical problems still have to be solved regarding handling such small amounts of liquids, and the interactions between liquids and materials in the chip. EN

Low-Visibility Airport Operations

At Hartsfield-Atlanta International Airport, NASA recently demonstrated an aircraft technology to keep commercial aircraft moving safely on runways and taxiways, regardless of visibility. A total of 53 flight tests were performed for airline and industry executives, and officials of the FAA and other government agencies.

The technology is actually many technologies rolled into one system, on the ground and in the aircraft. Onboard NASA's Boeing 757 research aircraft, were two integrated subsystems: The Roll-Out Turn-Off Guidance subsystem was developed at NASA's Langley Research Center (Hampton, VA) and the Taxiway Navigation & Situation Awareness (T-NASA) display subsystem was developed by NASA's Ames Research Center, (Moffett Field, CA). The airborne systems and displays aid the pilot in touchdown, on the runway, in exiting the runway on to the taxiway, and during taxiing.

As the B757 approaches the airport, computer-generated graphics outline the correct runway and its precise location on a glass visor mounted between the pilot and the cockpit windshield. Once on the ground, the plane's position, as well as the position of other aircraft, is shown on an electronic moving map of the airport on the instrument panel. Using Global Positioning System and an airport layout database, displays are updated in real-time.

The glass visor, or heads-up display, shows the edges of the runway and taxiway with a series of computer-generated "cones." During taxiing, a turn is indicated by virtual cones and signs showing the angle and direction of the turn. As the pilot taxis down the runway, the cones and signs move and change. The pilot's cleared route looks like a virtual highway on the ground.

On the ground is a system of surveillance sensors and other equipment developed by the FAA. This system provides traffic positions to the aircraft via a computer datalink. A controller interface allows air traffic controllers to transmit instructions to the pilot by computer in parallel with normal voice communications, decreasing the chance for miscommunication. This computer link automatically reports if the 757 deviates from its approved path. A combined ground and airborne system can reduce the growing number of ground accidents and close calls.

The research is part of NASA's Terminal Area Productivity Program, led by the Ames Research Center. The program is expected to substantially increase aviation system capacity and safety in all weather conditions. EN

➤ Roboshop

The first fully-automated convenience store, Robot Shop Super 24, opened in Tokyo this past spring. The store has 85 square meters of selling space, and offers 2,500 items, but there's nary a clerk in sight—robots deliver the items you select. Shelf space is rented by the month to companies who want their products on display. And it's the distributor or manufacturer, not the store, that sets the prices. (BY CHARLES WHIPPLE, COURTESY *LOOK JAPAN*, AUGUST 1997.)

Q & A

continued from page 8

more linear CCD arrays that are in the light path only during focusing. Their performance is often enhanced by microlens arrays or other optical devices to exaggerate the difference between correct and incorrect focus.

"Point-and-shoot" cameras often use rangefinder autofocusing; that is, they view the same object from two different positions and measure the angular difference between the two views. Again, an electronic circuit operates the rangefinder and detects when the two images coincide. A block diagram of the system is shown in Fig. 5.

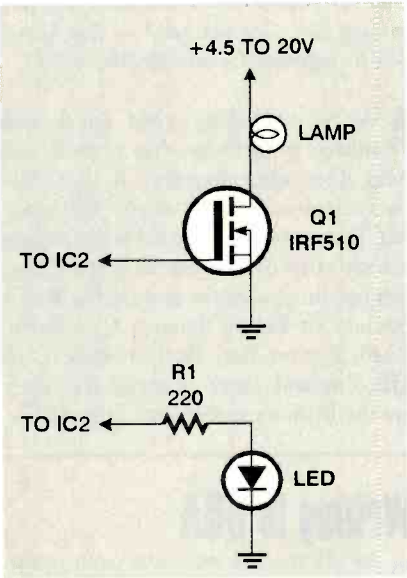


FIG. 2—THE OUTPUTS OF IC2 in Fig. 1 can be used to drive LEDs or lamps using the circuits shown here.

Several other methods of autofocusing have been tried over the years, including Polaroid's sonar system, which sends out an ultrasonic pulse and measures the time taken for it to echo back.

On slide projectors, "autofocus" means something quite different—all it means is that the projector focuses all slides alike, compensating for differences in the frames in which they are mounted. That is done by reflecting an infrared light beam off the surface of the slide and using two photocells to detect whether it is in the correct position.

Two good reference books on autofocusing are Sidney F. Ray, *Applied Photographic Optics* (Focal Press, 1994), and Norman Goldberg, *Camera Technology* (Academic Press, 1992).

HOW TO GET INFORMATION ABOUT ELECTRONICS

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

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

Many electronic component manufacturers have Web pages; see the directory at http://www.hitex.com/chipdir/, or try addresses such as http://www.ti.com and http://www.motorola.com (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online.

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

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 1-800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

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

Copies of past articles: Copies of past articles in **Electronics Now** and **Popular Electronics** (post 1992 only) are available from our Claggk, Inc., Reprint Department, P.O Box 4099, Farmingdale, NY 11735; Tel: 516-293-3751.

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

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214 (1-800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

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

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

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

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

Sewing-Machine Controller Found

Spurred by reader A. R. Baker, who prodded us to look again at SCR and Triac speed controls, we've found the sewing-machine controller circuit requested by W. B. in our August issue. Here it is in Fig. 6. This is a true constant-speed controller because it uses feedback; as the motor slows down under load, the circuit responds to the increased current flow by raising the voltage. However, the motor never gets more than half the incoming AC voltage; with a sewing machine this is presumably not a problem, since you don't run it at full speed anyhow.

This circuit appears in John Markus' *Electronic Circuits Manual* (McGraw-Hill, 1971), which credits it to a General Electric application note. Building it today, you can use RadioShack 276-1114 diodes and a RadioShack 276-1020 SCR. Be sure to use this circuit only

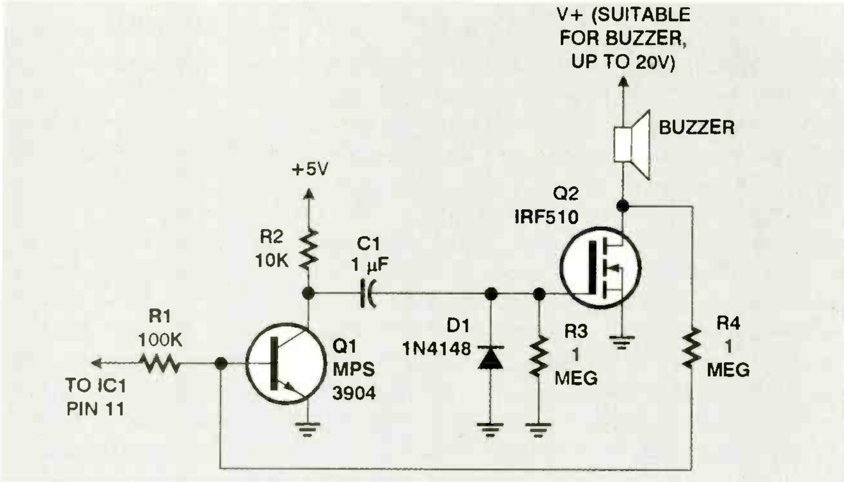


FIG. 3—THIS BUZZER CIRCUIT SOUNDS for one second when IC1 (in Fig. 1) latches. Diode D1 is included for fast recycling, but is optional.

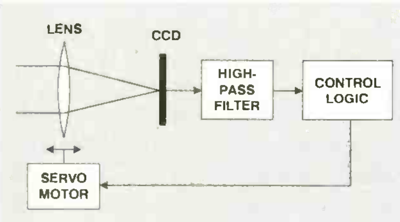


FIG. 4—IN A VIDEO CAMERA, the autofocus system positions the lens to maximize the high frequencies, which correspond to the fine details in an image.

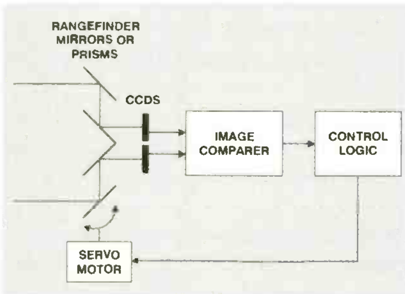


FIG. 5—A RANGEFINDER AUTOFOCUS SYSTEM measures distance by measuring the angle between two mirrors or prisms when they have been adjusted so that the images from both coincide.

with universal motors, not AC induction motors.

Wide-Range Cordless Phone?

Q *I hear that there is a cordless phone that runs on ordinary phone lines and has a range of 30 km (18 miles) or more. Can you supply any information? — H. A., Dasma, Kuwait*

A It's probably not feasible, and here's why. A cordless phone is a radio transmitter, and it emits radio waves in all directions. So does its base. Do you really want your phone conversations to be vulnerable to interception, accidental or deliberate, by everyone within 30 km of you? In any case, a powerful radio transmitter would be required, and since each user would blanket a 60-km circle, there would only be enough frequencies available for a few people in each region.

What you probably need is a cellular or satellite phone that communicates with the telephone company's master antenna (on earth or in space) rather than with a base unit in your home. The range of a cellular phone is only a few miles, but the system automatically transfers you from one "cell" to another as you move around. Satellite phones work much the same way but use satellites in space rather than towers on the ground.

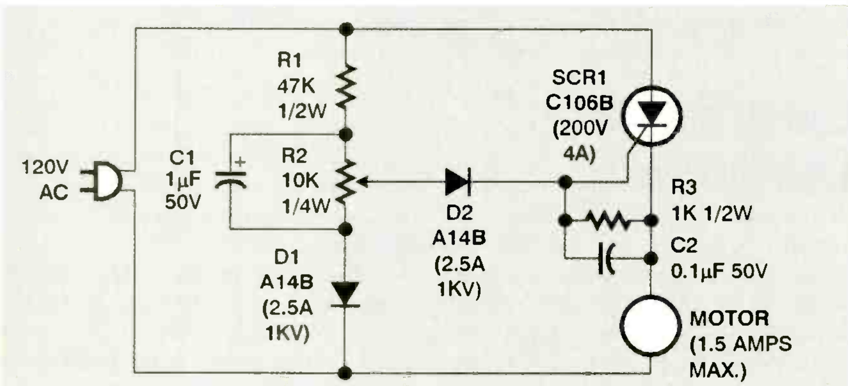


FIG. 6—THIS SEWING-MACHINE SPEED CONTROL circuit is based on one originally published in a General Electric application note in 1969.

Telequipment Scope

Q *I am trying to find the operator or service manual for an old oscilloscope I have. The scope was made in England in 1969 by Telequipment. The model is Type D53A.*

I have already contacted Howard W. Sams, Hi Manuals, and Manuals Plus without any luck. Can you help? — Ron Shaw, 403 S. Jefferson, Carterville, MO 64835

A We're publishing your name and address in the hope that a reader can help. Our understanding is that Telequipment was bought out by Tektronix, but Tektronix does not normally supply manuals that old. Given the scope's English origin, you might also try the Radio Society of Great Britain, Cranborne Road, Potters Bar, Hertfordshire EN6 3JE, England, *http://www.rsgb.org*. They are the British counterpart of the ARRL.

Writing to Q&A

As always, we welcome your questions. Write to Q&A, **Electronics Now** Magazine, 500 Bi-County Blvd., Farmingdale, NY 11735. The most interesting ones are answered in print. Please be sure to include plenty of background information (we'll shorten your letter for publication). *If you are asking about a circuit, please include a complete diagram.* Due to the volume of mail, we regret that we cannot give personal replies. EN

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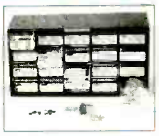
LeadingEDGE Fortiva 3000 Slim Desktop Computer

- 486DX2-66 motherboard
- IDE controller
- One 5.25", half height accessible bay
- 4MB RAM, expandable to 48MB
- 1.44MB floppy disk drive
- 8KB internal cache
- SVGA on-board monitor port
- Two serial ports (16450) and one parallel port
- Vertical riser with 3 ISA 8 or 16-bit expansion slots
- 101-key keyboard • Weight: 23.4 lbs.

Part No.	Product No.	Price
140468	486DX2-66 dsktp comp. Special	$199.95

Jameco Electronic Component Cabinet Kits



Kits include the most popular components with extra space for your customized expansion. Each kit includes a 20 drawer component cabinet.

More kits available – call for details!

Part No.	Description	Price
84953	330 pc. 7400 series IC kit	$152.95
84961	420 pc. 74LS series IC kit	119.95
84970	300 pc. CD4000 series IC kit	84.95
84988	385 pc. Linear series IC kit	159.95
108329	540 pc. 1/8 watt Resistor kit	29.95
81832	540 pc. 1/4 watt Resistor kit	28.95
107879	540 pc. 1/2 watt Resistor kit	31.95
108433	2200 pc. Electr. Hardware kit	39.95
81867	110 pc. Radial Capacitor kit	34.95
81859	320 pc. Ceramic Capacitor kit	29.95
81883	160 pc. Mylar Capacitor kit	34.95
81841	129 pc. Tantalum Capac. kit	49.95
82587	270 pc. Diode kit	39.95
82595	180 pc. Transistor kit	49.95

PARALLAX Basic Stamps

127693

130892

Basic Stamps are small computers using a variation of Basic, called PBASIC to control execution of many applications. The BS1-IC has 8 I/O lines, while the BS2-IC has 16 I/O lines which can be connected directly to buttons, LEDs, registers, and many other TTL level devices. • One-year warranty

Part No.	Description	Price
127693	Basic stamp BS1-IC	$34.95
130892	Basic stamp BS2-IC	49.95

Muscle Wires Project Book

Get the facts behind the unusual properties of Muscle Wires. These unique nickel-titanium alloy Muscle Wires actually shorten in length when electrically powered, and can lift thousands of times their weight.

Part No.	Description	1-4	5-9
141330	Muscle Wires Proj. Bk.	$19.95	$17.95

Muscle Wires Book & Deluxe Kit

- Includes Flexinol, crimps and instructions

Part No.	Description	1-4	5-9
141348	Muscle Wires deluxe kit	$59.95	$53.95

METEX® 3½-Digit Digital Multimeter

- 3½-digit LCD (.5" high digits)
- AC voltage: 200mV, 2V, 20V, 200V, 700V
- DC voltage: 200mV, 2V, 20V, 200V, 1000V
- AC & DC current: 20µA, 200µA, 2mA, 20mA, 200mA, 2A, 20A
- Resistance: 200Ω, 2KΩ, 20KΩ, 200KΩ, 2MΩ, 20MΩ • Input impedance: 10MΩ
- Auto zeroing • One-year warranty

Part No.	Product No.	1-4	5-9
27115	M3800	$39.95	$35.95

EDWin NC (CAD/CAE) Software

The first truly seamlessly integrated suite of software running in all Windows® formats...simulation, schematics, and PCB design.

Part No.	Description	1-4	5-9
141680	EDWin NC	$149.95	$134.95

Jameco 66 Piece Tool Kit

A comprehensive set of tools for field technicians, engineers and lab personnel. Aluminum case features removable pallets, surface-type locks, a black plastic handle, side buckles and strap.

- Size: 18.0"L x 14.0"W x 6.0"H • Wt: 18.2 lbs.

Part No.	Description	Price
105646	66 piece tool kit Special	$149.95

Jameco 54 Watt Switching Power Supply

- Input: 110/220VAC @ 47/63Hz
- Output: +5VDC @ 5.0A, +12VDC @ 1.0A, -5VDC @ 1.0A, -12VDC @ 1.0A
- Overcurrent protection: 110-130% automatic current limiting
- Minimum load: all outputs at 10% of rated load • Data sheet included
- Size: 6.3"L x 3.9"W x 1.5"H
- Weight: 1.2 lbs. • One-year warranty

Part No.	Product No.	1-9	10-24
17056	FCS604A	$44.95	$39.95

Jameco ABS Cases w/ Clear Top

Case is made of a gray ABS plastic body with a clear polycarbonate top cover. It comes with screws of mounting boards or electronic part/component, rubber gasket for a tight seal on your equipment, drilled holes for mounting and enclosure.

Part No.	Size (L x W x D)	1-9	10-49	50-99
141823	2.3" x 2.2" x 1.2"	$3.95	$3.49	$2.95
141831	4.6" x 3.2" x 1.8"	6.95	6.25	5.59
141840	6.3" x 3.2" x 1.8"	7.95	7.15	6.49
141858	7.0" x 5.5" x 2.5"	11.95	10.95	9.95

Digital Hand-held 5MHz Oscilloscope

This compact scope is perfect for the technician on-the-go or for students and lab technicians as well! The display is high contrast LCD with wide angle for visibility, and all functions are done from easy to use keypad.

- Size: 9.0"L x 4.9"W x 1.5"H
- Weight: 2.4 lbs. • One-year warranty

Part No.	Description	Price
135941	5MHz oscillosc.	$269.95

High Luminous Intensity White LEDs OPTIC

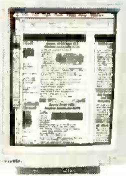
Part No.	Size	1-9	10-99	100	1000
142885	T1	$4.95	$4.49	$3.95	$3.49
142893	T1¾	4.95	4.49	3.95	3.49

JAMECO IC Function Tester/Emulator

- Any DIP type IC up to 40-pins can be inserted into the universal TEST TOOL socket for function emulation
- A 360 tie point solderless bread-board provides free wiring space for any additional circuits
- Size: 10.0"L x 6.5"W x 1.5"H
- Weight: 1.5 lbs. • One-year warranty

Part No.	Description	Price
111907	Tester/emulator Special	$39.95

Hyundai Full Page Monitor



- PC/XT/AT and compatibles
- 15", portrait-oriented, monochrome display
- Works with any IBM-compatible VGA system – no special video controller needed
- Size: 11.7"W x 15.0"D x 13.9"H
- Weight: 26.0 lbs.

Part No.	Description	Price
127909	Full page monochrome Closeout	$59.95

AVerKey Computer-TV Converter

- For PC/Macintosh

Part No.	Description	Price
126800	AVerKey3 Closeout	$249.95

Front Flip Down Plastic Case

- Drawers open and close simultaneously
- Case color: black; drawer color: red
- Size: 13.5"L x 3.8"W x 14.3"H
- Weight: 2.8 lbs.

Part No.	Description	1-9	10-99	100+
142990	Flip Down Case	$19.95	$17.95	$15.95

Hyper Peppy Robot Kit

- Changes course when it comes in contact with an object or hears a loud sound

Part No.	Description	Price
140863	Robot kit Special	$19.95

Making Your Own Printed Circuit Board Book

Design and create your own printed circuit board inexpensively and reliably. (37 pages)

- Size: 8.5" x 11" • Weight: .05 lbs.

Part No.	Description	1-4	5-9
141524	Making PCBs Book	$14.95	$13.49

U.S.Robotics 14.4 kbps Data/Fax Internal Modem SPECIAL

- Supports 14.4 down to 300 bps of data
- Compatible with ITU-T standard
- System requirements: 486 or Pentium®, Windows® 3.xx to Win® 95, 4MB RAM, 2MB hard disk space • One-year warranty

Part No.	Description	Price
139871	14.4 int. modem Special	$34.95
124476	28.8 int. modem Special	59.95
137998	14.4 int. modem (w/voice)	44.95
141292	28.8 ext. modem	79.95
136864	33.6 int. modem (SAVD)	79.95
145015	33.6 int. modem	59.95
136872	33.6 ext. modem (SAVD)	119.95
145023	K56 Flex int. modem	149.95
145031	K56 Flex ext. modem	169.95

Jameco Solderless Breadboards

20773

- Low static plastic body – CMOS safe
- Nickel plated clips designed to withstand up to 5,000 insertion cycles

Part Number	Contact Points	Size L x W	Pricing 1-9	10-49
94457	100	6.5 x 0.4	$2.49	$2.25
20600	400	3.3 x 2.1	4.95	4.49
136901	1,600	5.5 x 2.3	21.95	19.95
20669	630	6.5 x 1.4	5.49	4.95
20722	830	6.5 x 2.1	7.95	6.95
20757	1,360	6.5 x 3.1	11.95	10.95
20773	1,660	6.5 x 4.3	17.95	15.95
20790	2,390	6.9 x 5.8	22.95	20.49
20811	3,220	7.3 x 7.5	30.95	27.95

SOLTEK Cordless Phone by AT&T

AT&T Model 5200

- Two channel operation
- Tone/pulse dialing
- Redial, speed dial and mute buttons
- Factory reconditioned • UL approved
- Operating range 100 yards
- Weight: 1.3 lbs. • 90-day warranty

Part No.	Description	Price
133743	Cordless phone Special	$34.95

Internal CD-ROM Drives FTP

133031

- 5.25" half-height design
- Include software
- Include audio cable
- One-year warranty

Part No.	Mfg.	Speed	Interface/Type	Price
131342	NEC	4X	EIDE	$59.95
133031	Philips	6X	ATA/EIDE Closeout	69.95
140679	IBM	6X	ATA/EIDE	69.95
134244	Mitsumi	8X	ATAPI/EIDE	89.95
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BY SAM GOLDWASSER

On-Line Tech Tips, Tools, and Test Gear for the Troubleshooter

LAST TIME WE INTRODUCED YOU TO THE BASICS OF TROUBLESHOOTING JUST ABOUT ANYTHING ELECTRONIC. THIS TIME, WE'RE GOING TO PICK UP RIGHT WHERE WE LEFT OFF AND TAKE A CLOSE LOOK AT ON-LINE TECH-TIP DATABASES, AND THEN go on to look at the kinds of tools you really ought to have. But first, we need to deal with some old business.

It has come to our attention that due to production problems, several errors crept into the September, 1997 installment of Service Clinic. In Fig. 2, which also re-ran as Fig. 1 in October, the black and green wires on the AC plug are shown reversed; the green wire, of course, should go to the chassis ground. Also in that figure, the ground on the Magnatron should be to the chassis, and a dot is missing at the intersection between the anode of the HV diode and FA. Finally, in the middle of page 25, the value of the capacitor is given in °F; it should of course be in µF. We are sorry for any inconvenience that might have been caused by these errors and have taken steps to help prevent similar ones from cropping up in the future. Now that that's out of the way, let's move on to this month's topics.

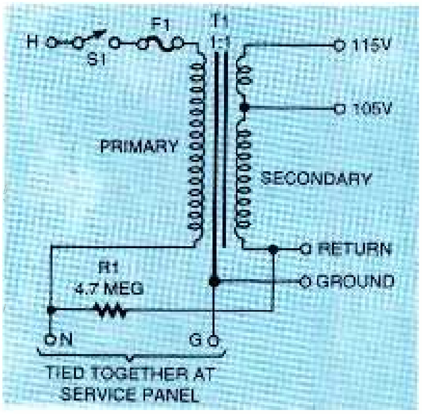

FIG. 1—HERE'S THE SCHEMATIC FOR A TYPICAL ISOLATION TRANSFORMER. It protects you against shock hazards when working on "hot chassis" equipment.

Tech-Tips Databases

A number of organizations have compiled databases covering thousands of common problems with VCRs, TVs, computer monitors, and other electronic equipment. Most charge for their information but a few, accessible via the Internet, are either free or have a very minimal monthly or per-case fee. In other cases, a limited but still useful subset of the for-fee database is freely available.

A tech-tips database is a collection of problems and solutions accumulated by the organization providing the information or other sources based on actual repair experiences and case histories. Since identical failures often occur at some point in a large percentage of a given model or product line, checking out a tech-tips database might quickly identify your problem and solution.

By using a tech-tips database, you can often simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech-tips databases in general—and this has nothing to do with any one in particular—is that symptoms can sometimes be deceiving. A solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old-fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad. In simpler words, use these databases as an assistant, not as a replacement for logical troubleshooting techniques.

Another disadvantage to the databases is that you do not learn much by just following a procedure developed by others. There is no explanation of how the original diagnosis was determined, or what might have caused the failure in the first place. Nor is there likely to be any list of other components that might have been over-stressed by the original problem, and that might fail in the future because of it. Knowing that you need to replace "Q701" and "C725" to get this specific piece of gear going again in this specific instance is fine for now, but that "knowledge" won't help you to repair a different model or a different problem in the future.

One alternative to tech-tips databases is to search at http://www.dejanews.com/ or the sci.electronics.repair Usenet news group for postings with keywords matching your model and problem. Having said that, here are three tech-tip sites for computer monitors, TVs, and VCRs:

- http://www.anatekcorp.com/techforum.htm (Free)
- http://www.electronix.com/elexcorp/techsweb.html ($8/month)
- http://elmswood.guernsey.net/ (Free, currently very limited)

The following source is just for monitors. Some portions are free but others require a $5 charge; however, that charge could get you a personal reply from a technician experienced with your monitor, so it could be well worth it.

•http://www.netis.com/members/bcollins/monitor.htm

Some free monitor repair tips are also available at:

•http://www.kmrtech.com/

Tech-tips of the month and "ask a wizard" options are available at:

•http://members.tripod.com/~ADCC/ — (Home page)

•http://members.tripod.com/~ADCC/tips.htm — (Tech-tips of the month)

The following is specifically for microwave ovens. In addition to a large database of specific repairs, there is a great deal of useful information and links to other sites:

•http://www.vup.com/microtech/

Hand Tools

Invest in good tools. If you are into garage sales, you can often pick up excellent, well-maintained tools very inexpensively, but be selective—there's a lot of junk out there. In the end, substandard tools will slow you down and prove extremely frustrating to use. Keep your tools healthy—learn to use a whetstone or grinding wheel where appropriate (screwdrivers, drill bits, etc.) and put a light film of oil (*e.g.*, WD40) on steel tools to prevent rust.

Some of the basic hand tools you will need to accumulate include:

•Standard screwdrivers of all types and sizes including straight, Philips, Torx. You'll also need a notched straight blade for VCR mechanical tracking adjustment—you can make one out of a standard screwdriver or buy one.

•Jewelers' screwdrivers—both straight and Philips. These are generally inexpensive but quality usually varies in direct proportion to the price.

•Small socket driver set.

•Security bits for some video games, PS2s, etc.

•Hex key wrenches or hex drivers. You'll need miniature metric sizes for VCRs.

•Pliers—long nose, round nose, curved. Both smooth and serrated types are useful.

•Adjustable wrench (small).

•Cutters—diagonal and flush.

• Linesman's pliers.

•Wire strippers—fixed and adjustable.

•Crimp tool.

•Alignment tools—at least a standard RCA type for coils.

•Files—small set of assorted types including flat, round, square, and triangular.

•Dental picks—useful for poking and prodding in restricted areas (but you knew that).

•Locking clamps and or hemostats—for securing small parts while soldering, etc.

•Magnetic pickup tool—you can never tell when you will drop something deep inside a VCR. If you keep a strong magnet stuck to your workbench, you can use it to magnetize most steel tools such as screwdrivers. Just keep anything magnetized away from the tape path and magnetic heads (and magnetic media!).

•Hand drill, electric drill, drill press—one or all. A small bench-top drill press (about 8 inches) is invaluable for many tasks. A good set of high-speed bits (avoid the 1000 bits for $9.95 variety). Also, miniature bits for PCB and small plastic repairs are likely to be needed.

•Soldering and de-soldering equipment. You don't need a fancy rework station; a 25-watt iron and hand de-soldering pump will be adequate for most tasks.

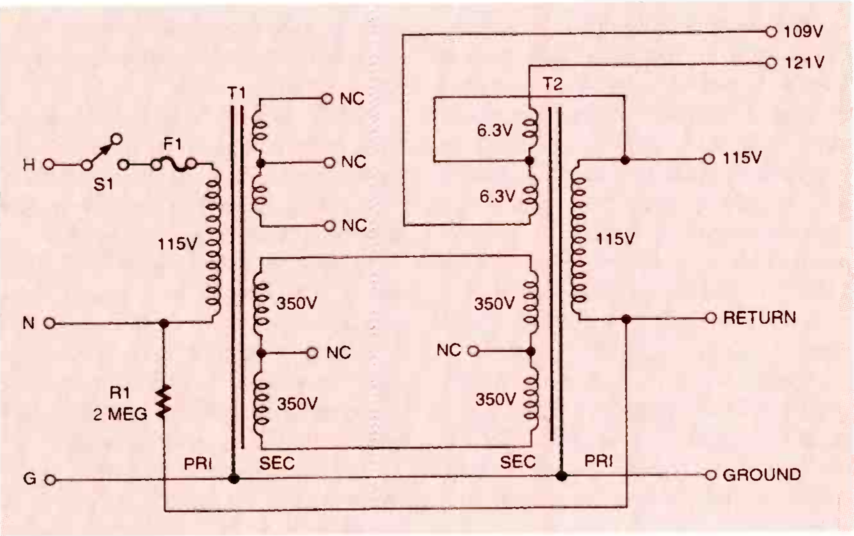

FIG. 2—YOU CAN BUILD YOUR OWN ISOLATION TRANSFORMER using back-to-back power transformers salvaged from old tube-type TV receivers.

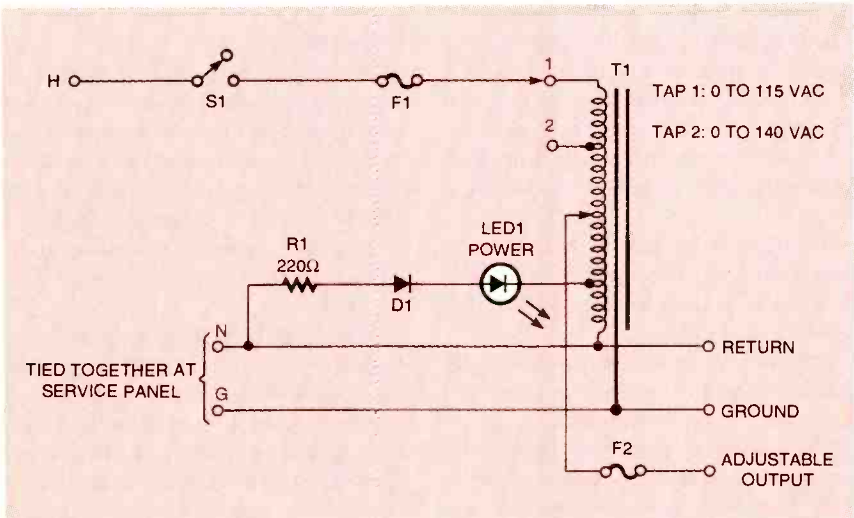

FIG. 3—THE INTERNAL WIRING OF A TYPICAL VARIAC is shown here. A VARIAC lets you vary the AC line voltage that is input to a piece of equipment, something that is a very helpful asset when troubleshooting.

Basic Test Equipment

Obviously, you can load up on exotic test equipment, but it is far from required. What's listed here are those instruments that are most used. You might at first not consider all of what follows to fit the category of test equipment, but an old TV, for example, can often provide as much or more useful information about a video signal than a fancy waveform analyzer:

•DMM and/or VOM—I prefer to have both. A good old Simpson 260 analog meter is better in many ways than a cheap digital multimeter. For most measurements, I still use a 25-year-old Lafayette (remember them?) VOM. I only go for the DMM when I need to measure really low resistances or where better accuracy is needed (though that can be deceptive). Just because a DMM has $3^{1}/_{2}$ digits does not mean it is that accurate. Check the manual, it may prove enlightening. The Simpson 260 also has a nice 5000-volt AC/DC scale that many newer digital instruments lack.

Scales for transistors, capacitors, a frequency counter, *etc.* are not really essential. A diode-test function on a DMM is needed, however, to properly bias semiconductor junctions. However, even that is not useful for in-circuit tests or for some power transistors or transistors with built-in damper diodes and/or base resistors.

Make sure you have a good well-insulated set of test probes. This is for your own safety as you may be measuring relatively high voltages. Periodically inspect those for damage and repair or replace as needed. If the probes that came with your multimeter are substandard—flimsy connectors or very thin insulation—replace them as well.

A high-impedance high-voltage probe is sometimes useful for TVs and monitors. You can build one that will suffice for most consumer-electronics work.

•AC clamp-on ammeter—This tool permits the measurement of currents in appliances or electrical wiring without having to cut any wires. At most, you will need an easily constructed adapter to permit access to a single conductor of a line cord. Some multimeters offer this as an option.

•Oscilloscope—You'll need a dual trace, 10- to 20-MHz minimum vertical bandwidth unit; also one with delayed sweep is desirable, but not essential. Make sure you obtain a good set of proper 10×/1× probes. High vertical bandwidth is desirable but most consumer electronics work can be done with a 10-MHz scope. If you get into digital debugging, that is another story—bandwidths of 100 MHz and up will be required. If money is no object, buy a good digital storage scope. You can even get relatively inexpensive scope cards for PCs, but unless you are into PC-controlled instrumentation, a stand-alone scope is much more useful.

If money is a concern (or perhaps even if it isn't) consider one of the old "war horses" you often see on the surplus/used market. You will usually get more scope for your money and these things last almost forever. My "good" scope is the militarized version (AN/USM-281A) of the Hewlett-Packard 180 lab scope. It has a dual-channel 50-MHz vertical plug-in and a delayed-sweep horizontal plug-in. I have seen these going for under $300 from surplus outfits. Other types of plug-ins are available as well. For a little more money ($400-$700 on the surplus/used market), you can get a Tektronix 465 100-MHz scope that will handle all but the most demanding tasks.

You don't absolutely need an oscilloscope when you are just starting out in electronics, but it would help a great deal. It need not be a fancy one at first, especially if you are not sure if electronics is for you. However, being able to see what is going on can make all the difference in your early understanding of much of what is being discussed in the textbooks and the newsgroups. You can probably find something used that will get you through a couple of years for less than $100. An oldie but goodie is much better than nothing at all even if it isn't a dual channel or high-bandwidth model.

•Logic probe—These are used for quick checks of digital circuitry for activity. A logic pulser can be used to force a momentary 1 or 0. Some people swear by these. I consider them of marginal value at best.

•TV set and/or video monitor—One of these, and preferably a color unit, is needed for testing video equipment like VCRs, camcorders, laserdisc players, etc. I have an old CGA monitor that includes an NTSC input as well on my bench. A great deal of information can be gathered more quickly by examining the picture on a TV or monitor than can be learned by examining the video waveform on a scope.

•VCR or other video-signal source—You'll need this for testing video monitors and TVs. Look for one with both RF and baseband outputs.

•Stereo tuner or other audio-signal source—This one is, obviously enough, for testing audio equipment.

•Audio signal generator—A function generator (sine, square, triangle) is nice as well. The usual audio generator will output from a few Hz to about 1 MHz.

•Audio amplifier—The input should be selectible between line level and mic level, and be brought out through a shielded-cable to a test probe and ground clip. This is useful for tracing an audio circuit to determine where a signal is getting lost. The amplifier's output should be connected to a loudspeaker

•Signal injector—A readily accessible portable source of a test tone or other signal (depending on application) that can be introduced into the intermediate or early stages of a multistage electronic system. For audio, a simple transistor or 555 timer based battery-powered oscillator can be built into a hand-held probe. Similar devices can be built for RF or video testing.

•RF signal generator—This is needed for serious debugging of radio and tuner front-ends. These generators can get quite sophisticated (and expensive) with various modulation/sweep functions. For most work, such extravagance is unnecessary.

•LCR meter—While a capacitor tester is desirable, I prefer to substitute a known good capacitor rather than trusting a meter that will not test under the same conditions as exist in-circuit.

•Adjustable power supplies—At least one of these should be a totally indestructible type—one you can accidentally short out without fear of damage. Mine is a simple 1 amp 0–40-volt transformer and rectifier/filter capacitor affair with a little Variac for adjustment.

If you would like to try building your own test gear, *Test Equipment Projects You Can Build*, by Delton T. Horn, published by Tab Books, a division of McGraw-Hill, Inc., 1992 has a number of simple projects you can try.

Transformers

Isolation transformers are essential to safely work on many types of equipment with exposed AC line connections or that have a live (hot) chassis. Variable transformers provide a convenient way to control the input voltage to equipment to determine whether a fault still exists or to evaluate performance at low or high line voltage.

Make it a habit to use an isolation transformer to power the equipment you are troubleshooting whenever possible. Portions of TVs, monitors, switch-mode power supplies, and many other types of equipment are frequently fed from a direct connection to the AC line without a power transformer (which would provide the isolation function). The DC power rails will typically be between 150 and 300 volts and can deliver momentary current of potentially lethal multiple amps!

Since earth ground and the power line neutral are connected together at your service panel (fuse or circuit-breaker box), grounds like cold water pipes, test equipment chassis, and even a damp concrete floor make suitable returns for the line voltage (hot or live wire). Since this is equally true whether the conductor is a wire or your body, such a situation is very dangerous. An isolation transformer as its name implies provides a barrier that protects against accidental contact with an earth ground. With the transformer in place, such contact results in negligible current flow (mainly due to the parasitic capacitance of the transformer)—a slight tingle at worst. That also protects your test equipment as well as the device you are troubleshooting, since without an isolation transformer, a similar accidental contact could result in a short circuit, sparks, destroyed parts, etc.

Figure 1 shows the schematic of a typical isolation transformer. Note that the ground is included on the secondary side. That is actually needed for safety with certain types of equipment like microwave ovens where the HV return is to the chassis. Most other consumer gear will only have a 2-wire cord and do not use the ground.

Even though the power line neutral and ground wires are tied together at the main service panel (fuse or circuit-breaker box), the transformer prevents any significant current flow between any of its outputs and earth ground should a fault occur. The resistor in Fig. 1 permits any static charge to leak off to ground. Since it is quite large—several megohms—no perceptible current flows between the secondary and primary sides, but that value is still low enough to dissipate any static charge. **CAUTION:** The resistor must be a high-voltage rated type (as in 4200 volts, isolation, large-size, light-blue color) to assure that arc over will not result due to voltage differences that may be present when the isolation transformer is being used in its normal manner.

Isolation transformers can be purchased or you can make your own out of a pair of similar power transformers connected back to back. I built mine from a couple of old tube-type TV power transformers mounted on a board with an outlet box. Their high-voltage secondary windings were connected together. The unused low-voltage secondary windings can be put in series with the primary or output windings to adjust voltage. The schematic is shown in Fig. 2. Note that there should be a fuse in the primary to protect against faults in the transformer as well as the load. Use a slow-blow type. The inrush current of the transformer will depend on the part of the cycle when the switch is closed (worst is actually near the zero crossing) as well as the secondary load. Though not shown in the schematic, it is a good idea to also place a fast-blow fuse in series with the secondary to protect the load. However, the inrush current of the degaussing coils in TV sets and monitors will often pop a normal or fast-blow fuse when no actual problems exist. (It is probably a good idea to disconnect the degaussing coils while testing unless they are suspected of being the source of the problem.)

A variable autotransformer (also known as a Variac, which is the trade name of one manufacturer) doesn't need to be large—a 2-amp unit mounted with a switch, outlet and fuse will suffice for most tasks. However, a 5-amp or larger Variac is desirable. If you will be troubleshooting 220-VAC equipment in the US, there are Variacs that will output 0 to 240 VAC from a 115-VAC line. As valuable as a Variac can be, it is important to remember that a **Variac is NOT an isolation transformer!** Don't make the mistake of using one in place of an isolation transformer. Note that there are combination units, also known as variable isolation transformers. If you have one, great; but if not, there is no need to buy such a combination unit. A Variac followed by a normal isolation transformer will work fine.

Figure 3 shows the internal wiring of a typical Variac. Note that there is no isolation as the power-line neutral and ground are tied together at the main service panel (fuse or circuit-breaker box)! Also note that the "Power-LED circuit" in Fig. 3 is soldered directly to a winding location that has been determined to produce about 6 VAC.

Next time I'll continue this discussion by presenting my thoughts on some basic ancillary equipment every troubleshooter ought to have, as well as some hints on where and how to get service literature including schematics. In the meantime, why not visit my sci.electronics.repair FAQ site on the Internet at www.repairfaq.org. You can reach me directly via e-mail at sam@stdavids.picker.com. EN

NEW PRODUCTS

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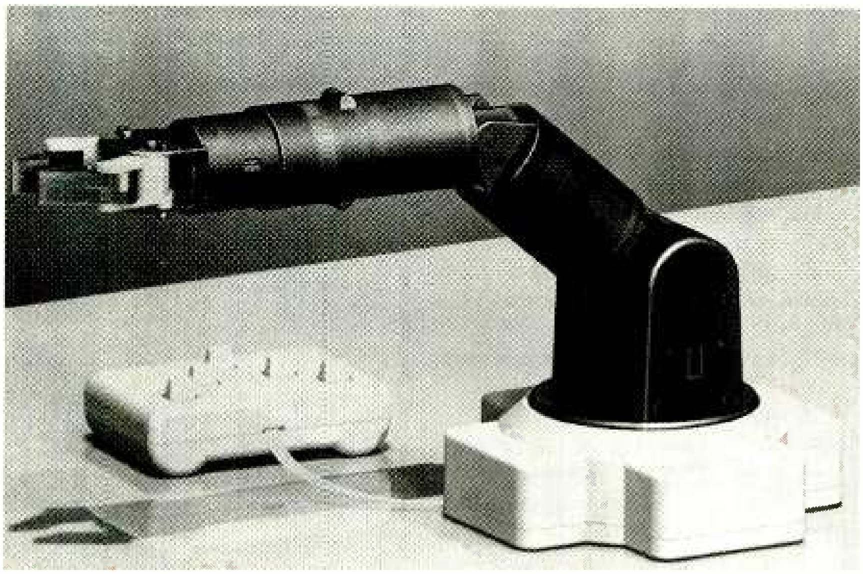
Robotic Arm Trainer Kit



CIRCLE 20 ON FREE INFORMATION CARD

The Robotic Arm Trainer Kit from OWI teaches the basic principles of robotic sensing and locomotion. It includes a five-switch wired controller that permits the arm to grab and release, lift, lower, rotate both the wrist and the base, and pivot sideways 120 degrees. Five motors and five joints allow for flexibility and fun.

After the robotic kit is assembled, the dynamics of the gear assembly can be observed through the transparent arm. The state-of-the-art gear mechanism is a combination of link-mechanism with a motor gear-box control.

The robotic arm has a maximum length of 18 inches outwards and a maximum height upwards of 14 inches. It uses 4 "D" batteries (not included) as a power source and has a suggested selling price of $69.95

OWI Incorporated
1160 Mahalo Place
Compton, CA 90220-5443
Tel: 310-638-4732
Fax: 310-638-8437

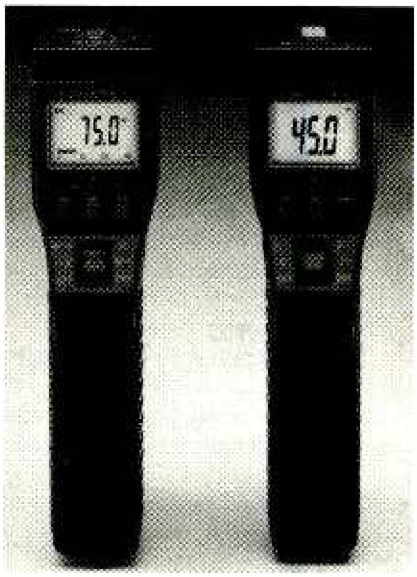
Mini-Stick Meters

Wavetek has introduced two uniquely shaped digital multimeters, the ST75 and TM45. Traditional handheld DMMs must be put down by the technician while holding the test leads. The "mini-stick" design of these meters, however, allows the user to simultaneously hold the meter safely and read the display.

Designed especially for electricians, plant and maintenance engineers, and others who need a compact tool, the small thin style of the meters makes it easy to carry in tool belts and helps it fit easily in tool boxes (it measures approximately $6^3/_4$-inches high by $1^5/_8$-inches wide at its widest). Wavetek's ST75 and TM45 are very useful for applications where space is tight, for quick tracing on wiring panels and circuits, and for blower and motor circuit troubleshooting.

The ST75 is a complete volt/ohm stick DMM, featuring digital and analog bargraph display, 3200-count resolution, autoranging, data hold, quick continuity checking, and diode testing. It measures DC and AC voltage up to 600 volts and resistance up to 32 megohms.

The TM45 is a digital thermometer, geared to commercial and industrial applications, with a wide temperature range up to 2000° Fahrenheit and 1300° Celsius. Features include temperature measurement that is switchable between Fahrenheit and Celsius, compatibility with Type K-thermocouples, and data and maximum display hold.



CIRCLE 21 ON FREE INFORMATION CARD

Priced at $99.95 each, both meters are available from local distributors and national catalogs.

Wavetek Corporation
Instrument Division
9045 Balboa Avenue
San Diego, CA 92123
Tel: 619-279-2200
Fax: 619-565-9558

In-Circuit Capacitance Checker

The CapAnalyzer 88 from Electronic Design Specialists (EDS) is an electrolytic capacitor checker that automatically discharges the capacitor, measures DC resistance and equivalent series resistance (ESR), and looks for shorts in circuit—all in one step.

CIRCLE 22 ON FREE INFORMATION CARD

It measures values from 0.47 µF to 2200 µF in-circuit with complete accuracy. (All signals are under 50 mV with a 5-ohm test impedance to prevent false readings.) Since it take only 2.5 seconds to test each capacitor, an entire PC board can be checked in minutes.

The beeper on the CapAnalyzer 88 allows the technician to look at the circuit being checked rather than having to keep his eyes on the instrument. A slider control sets the value of DC resistance at which the alarm beeper goes off. When the equivalent series resistance is being read, the beeper will also sound—from one to five beeps—depending on the actual ESR reading and the quality of the capacitor.

The state-of-the-art design uses a microprocessor and a two-color, 20-segment, LED meter that reads ESR with a resolution down to 0.1 ohm. A handy, three-color chart on the front panel shows typical ESR readings for good and bad capacitors. Included is a one-handed, gold-plated tweezer probe that can check both conventional and surface-mount capacitors.

The CapAnalyzer 88 has a suggested retail price of $169.

Electronic Design Specialists
4647 Appalachian Street
Boca Raton, FL 33428
Tel: 561-487-6103

Auto-Ranging Automotive Multimeter

HC Protek's Model D-688, a hand-held diagnostic test instrument, helps speed automotive repairs by providing fast, thorough, on-the-job analysis of systems and components found in automobiles. Applications include testing of sensors, solenoids, and components; coils, diodes and alternators; ignition and engine systems; cooling heating, and lighting systems; and charging systems in an automobile.

CIRCLE 23 ON FREE INFORMATION CARD

This auto-ranging multimeter has a 4000-count, 3¾-digit LCD readout with a 42-segment bargraph. The instrument can measure, memorize, and recall both duty cycle and dwell, as well as tach (RPM) settings for fast, curb, and base-line idle specifications on vehicles with or without distributors. It also measures AC/DC current up to 15 amps and monitors changing trends in throttle position and other output sensors. The Model D-688 gives minimum/maximum average readings, as well as temperature readings in both Fahrenheit and Celsius. A 0- to 2000-kHz frequency counter is built-in. Other features include data hold, a continuity buzzer, and overload protection.

The Model D-688 costs $249.95.

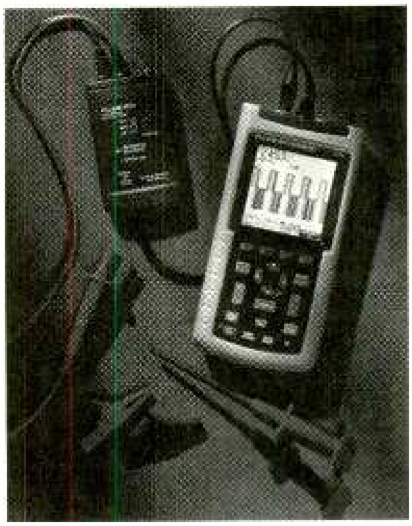
HC PROTEK
154 Veterans Drive
Northvale, NJ 07647
Tel: 201-767-7242
Fax: 201-767-7343
E-mail: HC protek@aol.com
Web: http://www.techexpo.com./WWW/hcprotek

Differential Voltage Probe

Floating measurements are often required on electrical and industrial power systems. The Fluke DP120 Differential Voltage Probe for oscilloscopes allows users to safely make such measurements. It is designed for use with Fluke's range of ScopeMeter test tools, CombiScope instruments, and with analog oscilloscopes and accessories.

The DP120 has a 20 MHz bandwidth and selectable 20× or 200× attenuation. Each instrument channel used with a DP120 probe can be connected to a different ground potential. When used with a battery-operated test instrument, a single DP120 provides a dual-channel measurement capability on systems with two different ground potentials.

Typical situations for which the voltage probe offers solutions include measurements on variable-speed motor controls, uninterruptible power supplies, process controllers, and other systems with multiple ground levels. In many industrial installations, control electronics are connected to PLCs, and measurements need to be referenced to earth ground. However, in power circuits, the output devices are usually floating. Therefore, measurements on the grounded and power sides may be necessary in a single session, which can be easily accomplished with DP120 Differential Voltage Probe.



CIRCLE 24 ON FREE INFORMATION CARD

Included with the DP120 are shrouded 4mm banana-probe tips, sets of pin-grabber test clips, and large-jaw alligator clips. Also provided is a 9-volt battery that allows up to eight hours of operation. The DP120 probe is priced at $395.

Fluke Corporation
P.O. Box 9090
Everett, WA 98206
Tel: 800-FLUKE
Fax: 800-FLUKE-FAX
E-mail: fluke-info@tc.fluke.com
Web: http://www.fluke.com

LETTERS

SEND YOUR COMMENTS TO THE EDITORS OF ELECTRONICS NOW MAGAZINE

Shielded From the Truth

It has come to our attention that the schematic diagram (Fig. 1) for the Quick Tester that appeared on page 53 of the October 1997 issue of **Electronics Now** *was reproduced incorrectly. The connection between J2 and J4 should only connect to the shield of J2. With that connection wired through J2 as originally shown, R1, R2, and S2 have a direct short across them, making that portion of the circuit ineffective. We are sorry for any inconvenience that might have been caused.—Editor*

"Smartbox" Updates

I recently built Anthony Caristi's "Smartbox" (**Electronics Now**, July 1997). I encountered two problems with the project. First, the IRF9Z30 P-channel MOSFET no longer exists. An IRF9Z34, which has a higher current rating, can be substituted, according to the manufacturer. The second problem is with the foil pattern itself. IC3 pin 8 (V_{CC}) is not connected. The problem can be fixed by soldering a jumper from the V_{CC} side of R5 to IC3 pin 8.
DAVID WASILKO
Mililani, HI

Bring Back Fips

I've been a loyal subscriber to **Electronics Now** (and its predecessor, **Radio-Electronics**) since about 1962, when I was about 12. Now I'm a senior EE at a high-tech company, and I'm still a subscriber. Why? Because your magazine fills the gap between the world of industrial applications, which I live in, and commercial products (audio, video, etc.). You have enough basic things for the newcomers, and enough details and interesting things for the oldtimers. That must be a difficult balance to keep.

My only wish is that someday you'd reprint (maybe as PDF files on your Web site) the April Fools' articles published in the 1950s and 1960s under the pen name "Mohammed Ulysses Fips." Looking back, it is remarkable how many of those humorous articles accurately predicted future advances or technology. For example, your September 1997 issue contained an article on noise-canceling earphones. The April 1964 issue contained an article titled "Snorekill" on a noise-canceling system for the bedroom. Other April Fools' articles that I remember and that were equally predictive include Paperthin Radio (1960), Teleyeglasses (1963), and Three-dimensional Television (1965).
FRANK DEMAREST
via e-mail

Northwest Missouri Winter Hamfest

The eighth annual Northwest Missouri Winter Hamfest will be held on January 17, 1998 from 9 a.m. to 4 p.m. at the Ramada Inn, located right off I-29, in St. Joseph, Missouri. Special room rates are available for Hamfest participants.

Major exhibitors, an indoor flea market, and a swap fest are all part of this event. Talk-ins will take place on 146.85 and 444.925. FCC exams will be given. Admission fee is $2 for pre-registration and $3 at the door.

For further information, contact Northwest Missouri Winter Hamfest, c/o Jean Pearson, KC0GB, P.O. Box 8547, St. Joseph, MO 64508.
JEAN PEARSON
Hamfest Secretary

Write To:
Letters,
Electronics Now Magazine,
500 Bi-County Blvd.,
Farmingdale, NY 11735

Due to the volume of mail we receive, not all letters can be answered personally. All letters are subject to editing for clarity and length.

Mars On The Rocks

I strongly disagree with your editorial in the October, 1997 issue of **Electronics Now**. That $1.00 each you mentioned as our contribution to the Mars Lander project has been taken and spent without our permission. And further more, it is taken from our grandchildren and, at the rate we're going, maybe our great-grandchildren.

I am a scientifically-oriented person—a retired technical writer and programmer—and I do not approve of the way we spend money on the space program in general. If sending a robo-cart to Mars to photograph rocks (yeah, I know much more than that) is so important, and if it seems to be entertaining, why can't such exploits be privately sponsored? I can just see the Sojourner coming down its ramp, and deploying a banner with Tide or Coca-Cola on it.

When you consider the money that is spent on commercials with high-paid entertainers, we could have had a colony on the Moon and maybe even on Mars by now.
JOHN P. LYMAN
Casselberry, FL

Dim Future for Technicians?

I read with much interest Dr. Joel Goldberg's article, "Recruiting Tomorrow's Electronics Technicians" in **Electronics Now**, October 1997. I might just be able to give him a reason for the current lack of qualified technicians. I can't say much for the rest of the country, but salaries for technicians here in New Jersey are just plain pathetic.

Since the huge layoffs by Hewlett-Packard, Lockheed, and others in the late 1980s and early 1990s, thousands of fully-qualified technicians have flooded the job market. With this glut of highly-skilled people, employers got smart in a hurry!

Even though the economy is "boom

Continued on page 27

BY JEFF HOLTZMAN

Penetrating the Pilot

THE PALMPILOT FROM 3COM IS THE HOTTEST COMPUTER DEVICE TO HIT THE MARKET IN YEARS. I RECENTLY ATTENDED A DEVELOPER'S CONFERENCE AND AM NOW MORE CONVINCED OF THAT THAN EVER. ESTIMATES AT THE SHOW WERE that sales would top one million units by October. That's after 1.5 years and two product generations.

Market research (DataQuest) shows that the Pilot has in that time grabbed 51% of the market for hand-held computers. The product category itself is vaguely defined and under constant revision—basically, every time someone releases a new device, the categorization scheme must be revamped. Windows CE ("Consumer Electronics") appears to be the big loser here; shrinking Windows to run on a tiny screen and keyboard does not work.

At the conference, a 3Com employee stated that the Pilot's growth correlates with that of every large consumer electronics success (except audio CD), including VCRs, cell phones, and more. That person also exclaimed that the Pilot market has the feel of the early years of the PC industry, before "Wintel" swallowed everything. Everyone I talked to seemed to feel that excitement—even the young'uns who weren't there the first time around. No one company owns the market, nor has competition reduced it to low-profit commodity status where cost-cutting is more important than innovation.

For years, many people (including me) have been predicting the advent of something like the Pilot. The early 1990s saw a spate of such offerings, all of which flopped. Then R&D money became hard to get, because PDAs were viewed as a losing proposition. The Pilot has single-handedly changed that perception once and for all. The Pilot has legitimized the PDA market.

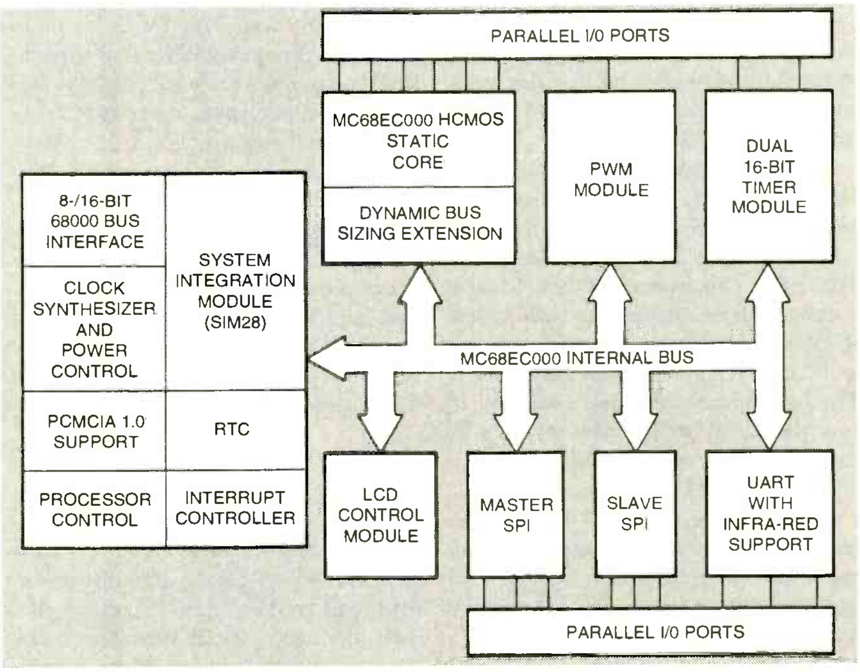


FIG 1—MOTOROLA'S DRAGONBALL CPU is an MC68000-family compatible device with lots of built-in peripheral support, including LCD controller, UART, clock, timers, and more.

Competition is heating up. Windows CE 1.0 has flopped, and CE2 is due this fall. There's an old adage that it takes Microsoft three times to do anything right. Perhaps CE3 will follow in another year. Meanwhile, Sharp and some of the other existing PDA vendors have released and/or are working on Pilot knockoffs. It will be interesting to see whether anything will seriously eat into the Pilot's market before Microsoft does get it right. In the meantime, I believe that there is lots of opportunity for software and hardware add-ons.

To catch up on what's hot, see the Resources sidebar elsewhere in this article. In particular, two Web sites—Adam's (http://www.inforamp.net/~adam/pilot/) and Stingersoft (http://198.70.114.128/stinger/stingersoft.cfm)—will link you to just about all current products and other major Web sites. You'll also want to check out the Pilot news groups. Both hardware and software developers will want to look at Darrin Massena's site (http://www.massena.com/darrin/pilot/index.html).

For my part, I'm going to be investing some time in Pilot development, and I'm going to share some of what I learn with you here. To get started, I'm going to talk about the overall Pilot architecture, and focus in on the underlying CPU. In coming months, I plan to talk about hardware interfacing, and programming in assembly, C, and possibly other languages. I've got several ideas for what I think will make interesting projects. Please feel free to contribute suggestions, or to submit projects of your own. So, let's get started already!

The Basics

In case you missed my earlier columns, here's a quick synopsis. The Pilot is a handheld computer that runs on two AAA cells. It has a 160 × 160 pixel screen measuring 56 cm on a side, yielding a 0.35mm dot pitch. It has no keyboard; rather, it depends on an easy-to-learn (basics in minutes, fluency in hours) and effective handwriting-recognition system called Graffiti. You can stroke directly on the 56 × 56 screen area; there is also a dedicated 60 × 20 mm area directly beneath the screen where you enter Graffiti strokes, and that also has a set of pseudo-dedicated buttons for performing specific functions.

Various models come with 128K to 1MB of memory, and third parties can bump it to 2MB and 3MB (voiding the warranty). The high-end model, the PalmPilot Pro, comes with a backlit screen, 1MB of memory, and additional ROM-based software—primarily a built-in TCP/IP stack. It lists for about $400. The backlight is extremely nice, and if you download many add-ons, you'll almost certainly want the extra memory. If you only use it for its intended purpose, a standard 512K model could probably keep you happy for a long time—and you can always upgrade (memory, not the backlight). For serious work, you should pretty much forget the 128K model.

What can you do with a Pilot? It's primarily an organizer. Sound boring? Not really. I have literally sat in restaurants and been approached by waiters who after a short demo walk away saying, "Cool!"

An anecdote I heard at the conference has it that a little old lady, initially a total skeptic, ended up being converted by the ability to have her address list with her at all times. I could see old-timers using the alarm function as a medication reminder. And with a little interface work, it could be used as an add-on to any number of biomedical devices for measuring and displaying current conditions. More on that later.

It, of course, offers the type of functions you would expect in an organizer: datebook, telephone/address list, to-do list, and memos. A fifth built-in function is a calculator. The Pro version also comes with e-mail and expense applications. Shareware and commercial add-ons include a (poor) spreadsheet; several outliners; Internet applications; fax, draw and paint programs; games (of course); and lots more.

A key component of Pilot's success is its one-button "sync" process, which synchronizes all added, modified, and deleted data, in both directions, between the Pilot and a desktop application, either Pilot's own Pilot Desktop, or any of a number of leading PIMs (Personal Information Managers). Synching normally occurs via the built-in RS-232 port, but there are now options to perform remote synching via modem, and most recently via a LAN. Synchs occur via conduits, essentially DLLs for moving data between the Pilot and applications programs. Custom conduits and TCP/IP applications represent a big market opportunity.

You can buy Pilots at major consumer-electronics and office-supply outlets, Egghead, and the larger computer catalogs. The Pilot news group frequently has sale offers from various companies. Last summer, one company briefly sold the full Pro model for $299, or $100 below list. Check www.pdapage.com to find current best prices.

Inside

For our purposes, there are three points of interest about the Pilot's hardware architecture. One, it is built around a 68000-family microprocessor, Motorola's MC68328 "Dragonball." Two, the only official interface to the device is an RS-232 port. Third, it has a switching power supply, which generates 3.3 volts for the CPU, as well as the RS-232 voltages. The remainder of this column will provide a quick capabilities overview of Dragonball. Next time, we'll start seeing how this richness can be put to use.

Dragonball is 144-pin flat-pack device. It contains a CPU that is claimed to be 100% compatible with the MC68000 family. The CPU itself has a 16-bit data bus (which can operate in both 8- and 16-bit modes for I/O purposes), and a 24-bit address bus. Internally it contains eight address registers, eight data registers, a condition-code register, a stack pointer, and a program counter.

Dragonball also contains a System Integration Module (SIM28) with an incredible set of capabilities, only some of which are used in the Pilot. Highlights include support for static RAM, EPROM, and flash memory; hardware and software watchdog timers; 77 individually programmable I/O pins; PCMCIA 1.0 support; a UART with IRDA support; a dual-channel 16-bit counter/timer; a PWM (pulse width modulation) output for tone generation; a real-time clock with one programmable alarm; a power-management module; an LCD control module; pager interface; and a full CMOS implementation that allows clock operation from DC to 16.7 MHz. A block diagram of the CPU appears in Fig. 1.

The clock is normally driven by a 32.768-kHz crystal, which in turn drives an internal phase-locked loop (PLL). The PLL can multiply the crystal frequency by a number of programmable factors, yielding CPU clocks ranging from about 10 MHz to 16.7 MHz. To implement power saving, the system is normally off. An interrupt to the PLL causes the system to wake up within two milliseconds. There is an extremely sophisticated software-controlled power-

RESOURCES

Shareware

http://www.inforamp.net/~adam/pilot/
http://207.112.193.10/pilotgear/index.html
http://198.70.114.128/stinger/stingersoft.cfm

Developer Information

http://www.massena.com/darrin/pilot/index.html
http://www.sls.lcs.mit.edu/raylau/pilot/
http://www.usr.com/palm/pilotlinks.html
http://www.roadcoders.com/pilot/index.html
http://www.shoppersmart.com/jlehett/gccwin32.html
http://www.usr.com/palm/dresources.html

Newsgroups

alt.comp.sys.palmtops.pilot
news.massena.com/pilot.programmer
news.massena.com/pilot.programmer.codewarrior
news.massena.com/pilot.programmer.gcc
news.massena.com/pilot.programmer.jump
news.massena.com/pilot.programmer.pila

control module that, for example, lets the CPU sleep while DMA operations keep an LCD screen refreshed. The screen itself may be up to 240 rows × 1024 columns in sixteen shades of gray. The Pilot OS directly supports only bi-level tonality, but several apps are experimenting with the gray scaling. (Unfortunately, the results are pretty disappointing from what I've seen. The screen is definitely the Pilot's weakest link.)

The real-time clock provides hours, minutes, and seconds data. It has an n-minute countdown timer that can generate an interrupt after n minutes. The RTC also has programmable one-second, one-minute, and one-day interrupts. The counter-timers provide a maximum period of 524 seconds and resolution of 240 ns (at the 16.7 MHz clock). The two timers can be cascaded for 32-bit operation.

Dragonball contains ten general-purpose parallel I/O ports, several of which are multiplexed with internal CPU functions. For example, Dragonball directly exposes the lower 24 address lines. However, parallel port A also exposes address lines 24-31, providing a full 32-bit address space. Port B multiplexes with the low-order data bus lines (D0-D7). Port C multiplexes with various CPU control signals. Port D has special features for interfacing a matrix keyboard. Ports G, K, and M multiplex interrupt, timer, PCMCIA, and serial I/O signals.

The serial interface provides four standard signals (TSD, RXD, CTS, and RTS), and may be programmed to run at rates of 300-115,200 bps. Pilots usually run their Synchs at 57,600 bps.

Wrapping Up

That's it for now. Next time we'll discuss software development tools, and start looking at ways of getting data in and out of the Pilot via the RS-232 port. Until then, you can stay in touch with me via e-mail at jkh@acm.org. **EN**

"...check to see if Tommy has my PDA in his toy chest..."

LETTERS

continued from page 24

ing" according to the low unemployment rates, what is not mentioned is the fact that underemployment is also booming—people settling for wages only 1/2 to 2/3 of what they were getting, just to survive. Ad after ad reads "entry level; minimum 5-10 years of experience."

A Field Service Technician of the 1980s would be furnished with a company vehicle, uniforms, tools and instruments, and training as required. A good technician then earned between $50 and $75 per hour. However, a recent ad wanted a fully-experienced technician with 5+ years of experience. He was to supply his own vehicle (with his own insurance!), and his own equipment and tools for field servicing. Starting salary: low $20,000s!!! That's about $10 an hour, folks. Pretty sad, no?

If that is all new recruits have to look forward to, I can see why they would NOT want to waste their time with any additional schooling. Stocking shelves at the local supermarket is competitive in salary. I can vouch for this in NJ, as I've been in the same boat since 1989. Pathmark looks good!

SKIP CAMPISI
S. Bound Brook, NJ

Free Circuit Encyclopedia

Just a quick note to let everyone know that a free, downloadable program that is an encyclopedia of electronic circuits, formulas, charts, graphs, etc. is available on the Web at our site (http://members.aol.com/cybercir/index.html). It provides a wealth of electronics information for the hobbyist or professional. The program is not time-limited or de-featured in any way, although it does contains fewer items than the retail version that's available.

Also at our Web site is a "Circuit du Jour" that is changed periodically. This is a specially selected circuit (or other electronics information) that visitors will find useful.

DAMIAN BONICATTO, PTM
via e-mail **EN**

BY FRANKLIN J. MILLER

Building a Resistor Substitution Box

NOW THAT YOU'VE COMPLETED YOUR AUDIO GENERATOR, YOU'RE ALMOST READY TO START DOING SOME REAL TESTING. BUT FIRST, SINCE MOST OF THE TESTS YOU ARE GOING TO WANT TO PERFORM WILL REQUIRE SOME SORT OF TEST fixture or related device, we'll build a unit that will make your testing chores easier.

A Resistor Substitution Box

Last time we discussed building load resistors so we could test amplifier outputs. This time I am going to show you a neat little resistor substitution box (R-Box) that has an almost endless list of applications. It can provide resistance outputs of 1 ohm to 11.11 megohms just by pushing the appropriate combination of buttons on the front panel. If you decide to build this box, be sure to use only precision components; close resistor tolerances—I use only 1% devices here—helps make a very accurate box.

Our assembled unit is shown in Fig. 1. To select values, you merely punch in the resistance you need using the pushbutton pad and it appears across the terminals labeled RX at the top of the unit. For example, if you needed 7300 ohms you would push the 4 key and the 3 key in the row above X1K—that will give you 7000 ohms at the terminals. Then you would depress the 3 key in the X100 row. That adds 300 ohms to the 7000 ohms. The switches stay down and the selected value is available across the RX terminals. For 570 ohms, push the 4 and 1 buttons in the X100 row, and the 3 and 4 buttons in X10 row. It's just that easy.

Construction

The complete schematic for the substitution box is shown in Fig. 2. For easiest construction, a PC board is recommended. An appropriate pattern is provided here, and the corresponding parts-placement diagram is shown in Fig. 3. Note that, as indicated in that figure, the resistors are all mounted on the foil side of the board. The switches are mounted on the component box in the usual fashion.

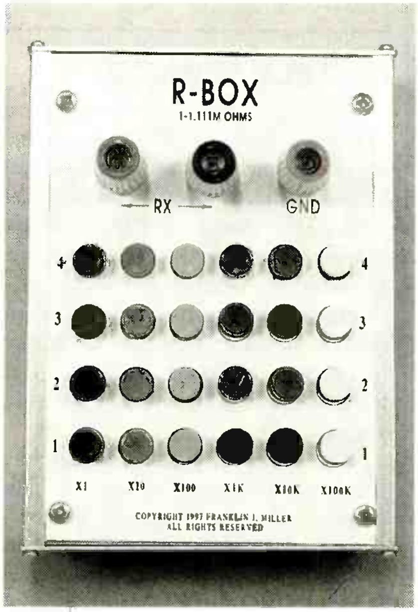


FIG. 1—HERE'S THE FINISHED resistance substitution box (R-Box). It's small, easy to assemble, and has many uses on any electronics bench.

Note that the PC pattern and schematic indicate the use of DPDT switches, though only one section of each is used. Those switches are used because they are included in the available kit (see Parts List) and they are easier to find (in the author's experience) than latching SPDT pushbuttons.

Construction is very simple. The 24 switches are all mounted right on the board. Make sure that you insert them so that they fit flat and tight against the board. This is important! If you don't get it right, the knobs will not fit properly onto the top plate. (Note: If you elect not to use the available kit, make sure you select an enclosure that's a suitable depth for the switches you use. The critical dimension here is the depth of the box; it should be selected so that, when the board is mounted inside, the switch buttons protrude suitably through the top plate.) Do not install J1–J3 at this time.

Once you have mounted all of the components (except J1–J3) and you have carefully inspected the PC-board assembly, put it aside. The next step is applying the top-panel overlay. If you choose to buy the kit, an overlay and pre-punched enclosure is provided. If you elect to build your own, you'll have to create your own overlay; the appropriate panel markings are shown in Fig. 1. A drilling guide is shown in Fig. 4.

The overlay supplied with the kit comes with an adhesive backing. To ensure that it will adhere properly, you must first make sure that the top panel is very clean. A small amount of acetone, which can be purchased at any paint store, will do the job nicely. Since its vapors can be hazardous, make sure you are working in a well-ventilated area.

Now you need a small bottle of water with a spray attachment. It will allow you to move the overlay around for precise placement. Place both the top panel

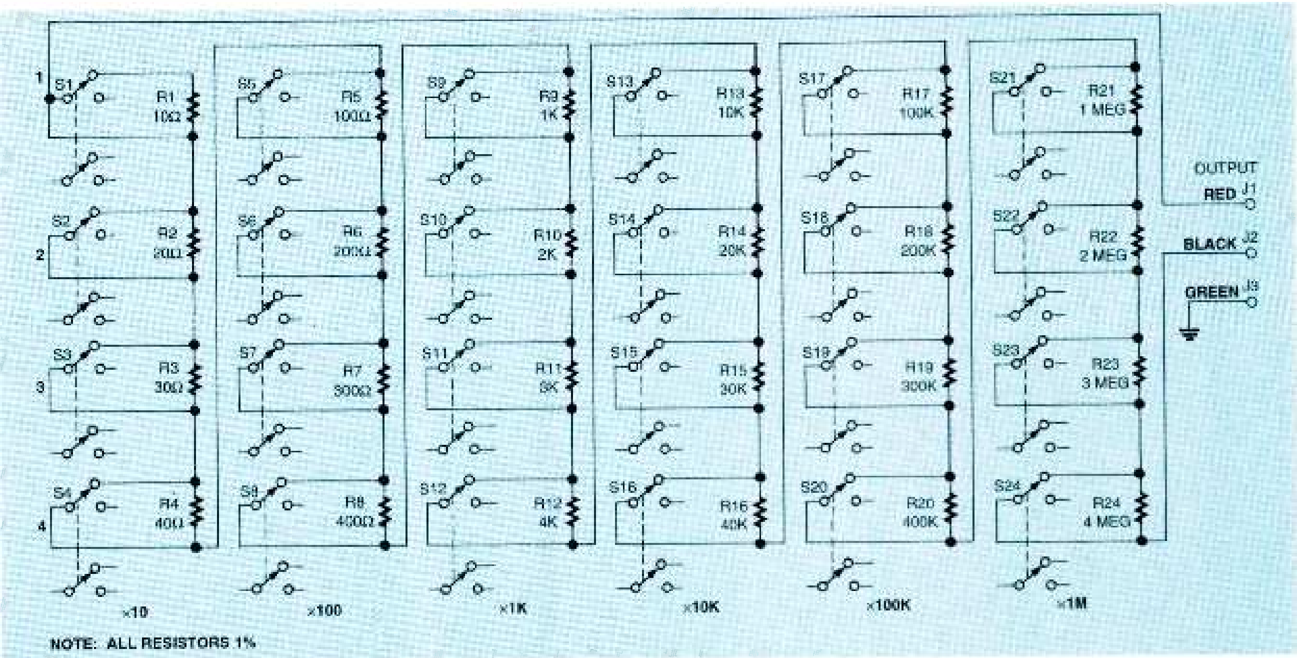


FIG. 2—THIS COMPLETE SCHEMATIC OF THE R-BOX shows that it's essentially an assembly of resistors and switches mounted on a small PC board.

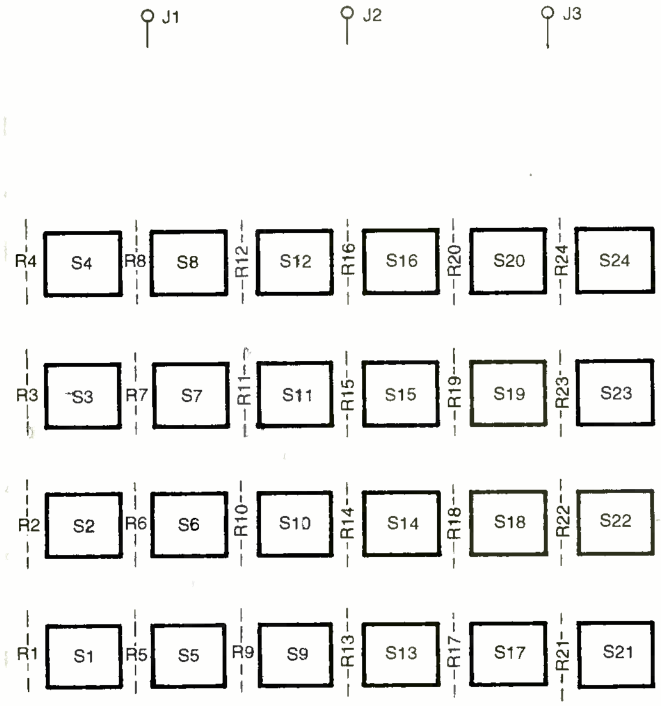


FIG. 3—AS SHOWN IN THIS PARTS-PLACEMENT DIAGRAM, all of the resistors mount on the foil side of the board. That was done to make the R-Box small and convenient to use.

and the overlay in front of you, with the three holes at the top. Remove the overlay backing and align the top upper left corner of both pieces. Once the label is aligned, gradually smooth the balance of the overlay down using the side of your hand. Once this is done, use an orange stick (available in the beauty section of any supermarket) as a rolling device to get out all the bubbles. Let the top panel dry overnight to be sure all of the water has evaporated.

The next step is to put the knobs (supplied with the kit) on the switches. Position the PC board in front of you, with the three pads for J1–J3 toward the top. There are four rows and six columns. Use black buttons for the first column, located on the far left. As you go to your right, use the red, yellow, green, and blue buttons. The white buttons, on the extreme right, complete the chore. They will just snap on.

Now install the banana jacks through the top panel. Go from left to right and insert red, black, and green, in order, tightening the nuts that hold them in place as you go. There are four 2.5-mm × 10-mm long screws and ⅞-inch long spacers with nuts and lock washers that insert in the four corners of the top panel. Insert the four screws and turn the assembly over. Slip the spacers over the screws. Now the printed-circuit board should fit onto the spacers. Place a ground-lug washer over the spacer at the upper left-hand corner of the board;

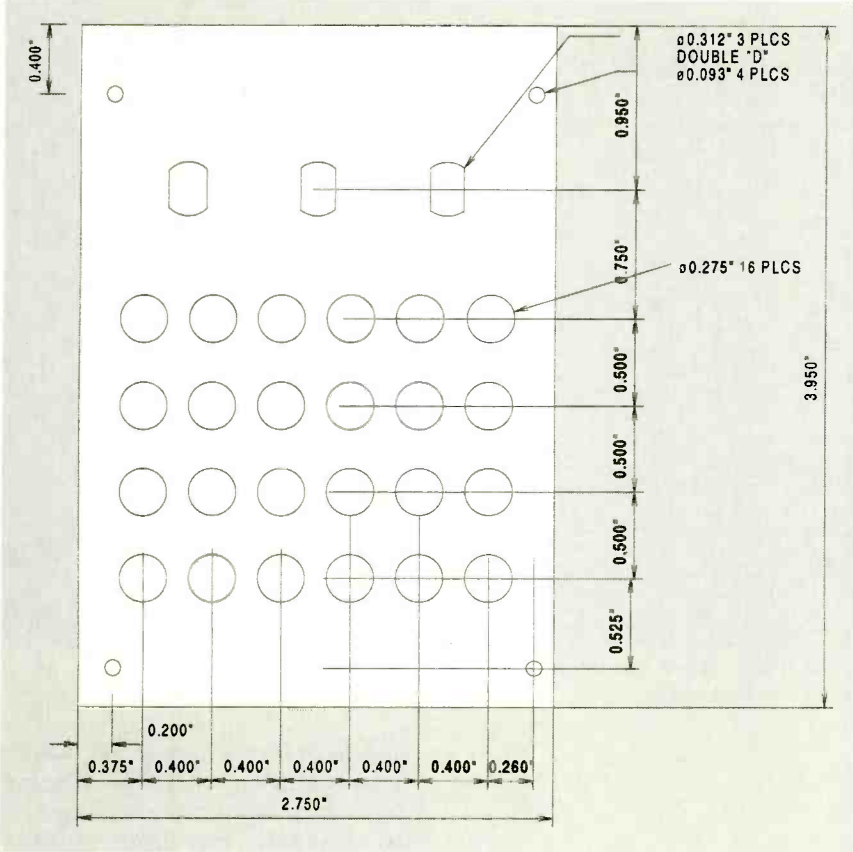
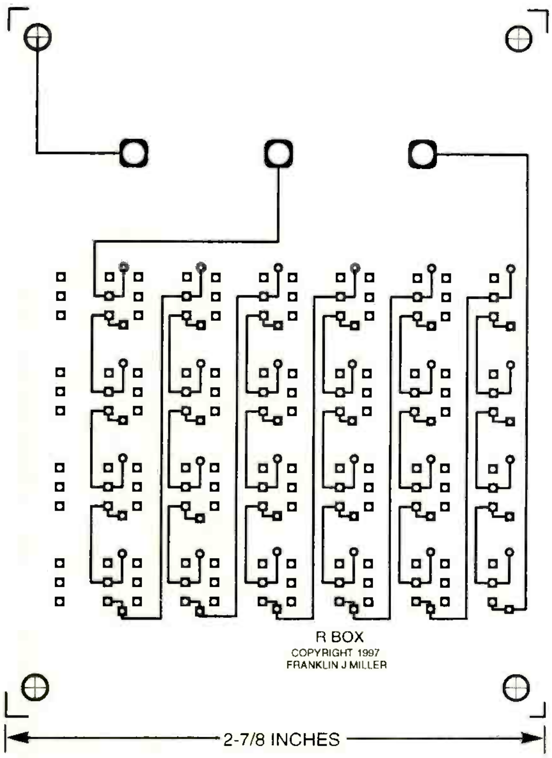


FIG. 4—YOU'LL NEED THIS DRILLING GUIDE for the top panel if you chose to build the R-Box without the benefit of the kit. Follow it closely to get a really attractive unit.



HERE'S THE FOIL PATTERN for the R-Box. It is shown full sized.

PARTS LIST

RESISTORS

(All resistors are ⅛-watt 1%, metal-film units.)

R1—10-ohms
R2—20-ohms
R3—30-ohms
R4—40-ohms
R5—100-ohms
R6—200-ohms
R7—300-ohms
R8—400-ohms
R9—1000-ohms
R10—2000-ohms
R11—3000-ohms
R12—4000-ohms
R13—10,000-ohms
R14—20,000-ohms
R15—30,000-ohms
R16—40,000-ohms
R17—100,000-ohms
R18—200,000-ohms
R19—300,000-ohms
R20—400,000-ohms
R21—1-megohm
R22—2-megohms
R23—3-megohms
R24—4-megohms

ADDITIONAL PARTS AND MATERIALS

S1–S23—DPDT pushbutton switch, latching, see text
J1—Banana jack, red
J2—Banana jack, black
J3—Banana jack, green
PC board, cabinet (see text), front-panel decal, pushbutton knobs, mounting hardware, solder, etc.

Note: The following items are available from Franklin J. Miller, 2100 Ward Drive, Henderson, NV89015: A complete kit, includingpre-drilled aluminum case, front-panel label, push button knobs, PC board, and all components; $70. Price includes shipping inside the continental United States.

the mounting hole there has a trace leading to the pad for J3. Then install all of the lock washers and nuts. Tighten the nuts only finger tight. Turn the unit over to be sure that all of the push buttons work without any problems. Then tighten the four screws and nuts to the final fit.

Now you can solder the banana jacks to the PC board. The last step is to assemble the rest of the case. EN

BUILD THE ASTRO-TREKER

Here's a simple-to-build toy that can provide hours of fun and enjoyment.

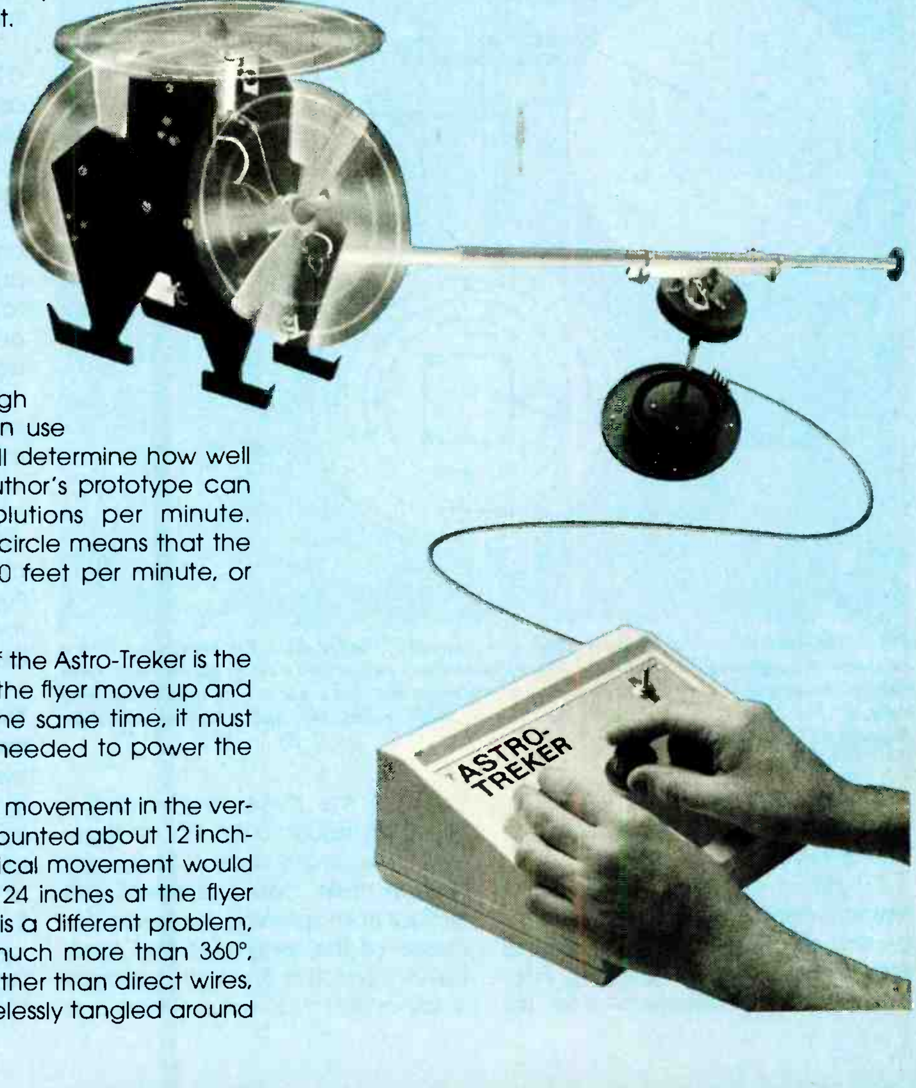
G. RANDY SLONE

When was the last time you built a project that was truly impressive to almost everyone regardless of their age group or technical background? The Astro-Treker presented here is just such a project. It places the operator in the pilot's seat of a simulated hovercraft. To fly it properly takes all of the skill needed in real interactive flight. Depending on the maneuvers being attempted, the Astro-Treker is simple and safe enough for entertaining small children. It also has the capability of challenging the most serious game player.

Like most good video games, speed and skill levels on the Astro-Treker will automatically increase with experience. Since it is a real electromechanical device, all of the laws of physics are obeyed all the time. Inertia, centripetal force, weight, and gyroscopic action continuously interact to give the operator the feeling of literally flying a lunar lander or helicopter.

The Astro-Treker is inexpensive, durable, and will not wear out even with a lot of abuse.

Counterbalanced Flight. Reduced to basics, the Astro-Treker is a gimbaled arm that acts much like a seesaw. On one end of the arm is a "flyer" that consists of some electric-motor-driven propellers; a counterweight is located at the other end. The balance of the arm is adjusted such that the flyer will always fall to the ground when it is at rest.



There are three electric motors in the flyer. Each one has a propeller mounted to it. The propeller of the center motor points straight up; its function is to lift the flyer straight up. The other two motors point away from the center motor at about a 45° angle. Those motors will provide some lift, but they will also drive the flyer in the direction they are pointing.

Choosing a motor with enough torque and a propeller that can use that torque to produce thrust will determine how well the Astro-Treker performs. The author's prototype can easily achieve about 50 revolutions per minute. Traveling in a 6-½-foot-diameter circle means that the Astro-Treker can move over 1000 feet per minute, or almost 12 miles per hour!

The Central Gimbal. The heart of the Astro-Treker is the gimbal that it rides on. It must let the flyer move up and down as well as in a circle. At the same time, it must provide the electrical contacts needed to power the electric motors.

Simple wires can easily handle movement in the vertical direction. With the gimbal mounted about 12 inches above the floor, the total vertical movement would not be much more than about 24 inches at the flyer itself. Spinning around in a circle is a different problem, however. If you want to travel much more than 360°, you have to use some method other than direct wires, which would soon become hopelessly tangled around

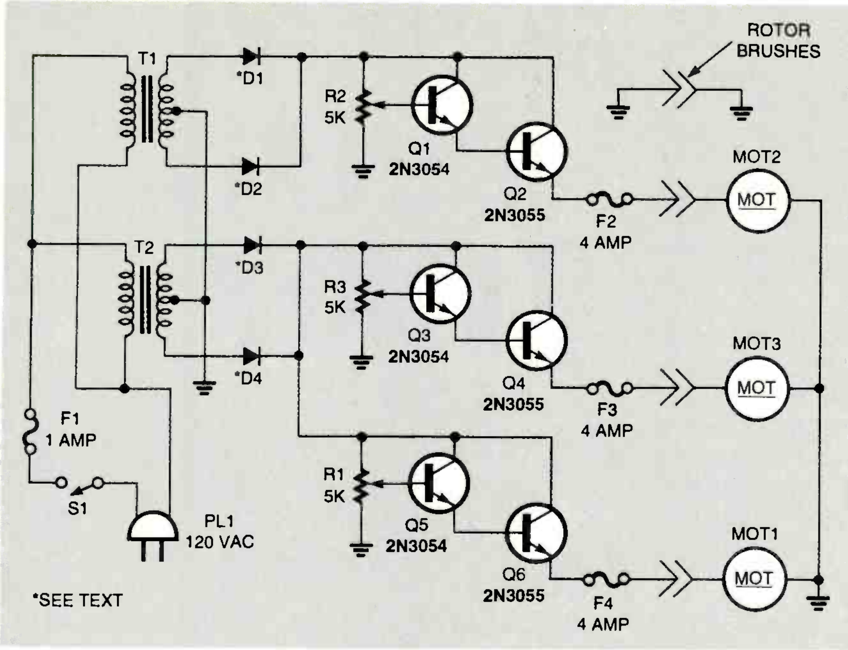


Fig. 1. The Astro-Treker uses a very simple current-amplifier circuit to control the three motors. Diodes D1–D4 are inexpensive high-current units that are readily available at RadioShack.

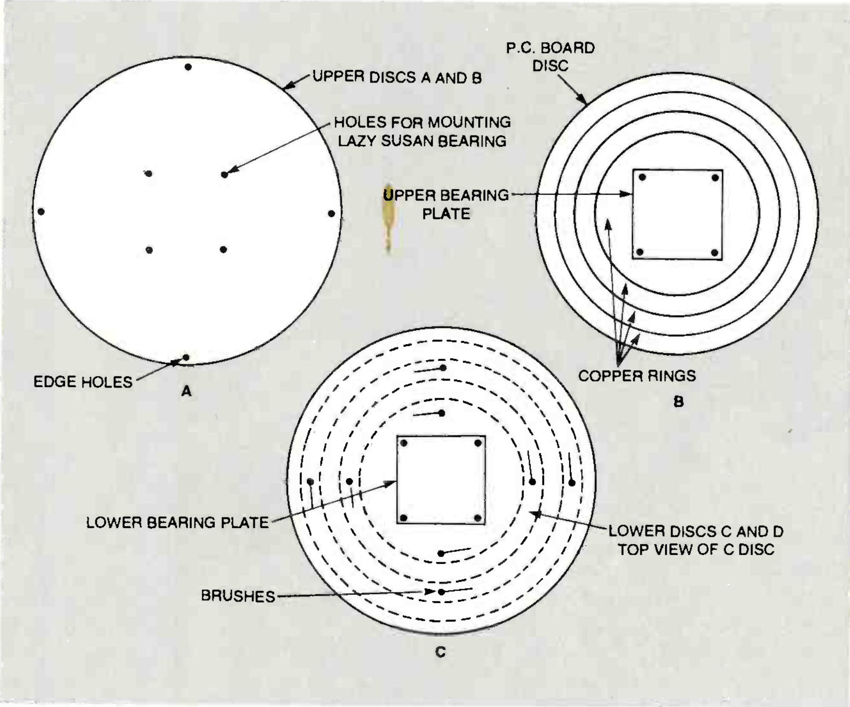


Fig. 2. The Astro-Treker's gimbal is a simple arrangement of stacked discs. The upper disc (A) is a sandwich of 2 stiffening discs and a PC board that has been etched with a series of concentric rings (B). The lower disc (C) is a sandwich similar to the upper disc, but it has a set of brushes mounted on it that make electrical contact with the rings on the PC board. The central bearing is used for additional electrical contact.

the base. You would also have to travel back the same distance to return to your starting point.

Electrical contact in the Astro-Treker is made by a series of concentric slip rings mounted around the gimbal's rotation bearing. Four contacts are needed—one for each of the three motors plus a common return. Such an arrangement will create a bit of drag and friction that could prevent the gimbal from spinning. However, because of the length of the Astro-Treker's arm, the flyer can generate a fair amount of torque that can easily overcome any drag caused by the slip rings. Put another way, with a 3-foot arm, the flyer can travel 18 feet while the slip rings will only move 17 inches.

While only one brush would be needed for each contact, two brushes are used. Each brush is mounted 180° from its companion. That way, continuous and reliable contact can be maintained between the motors and the controller. Having reliable electrical contact will prevent electrical arcing—a prime cause of contact erosion and "pitting" that would roughen the surface of the slip rings.

The Control Panel. The control panel contains the power supply and the circuit that adjusts the power supplied to the three electric motors. It is a very simple design as can be seen in the schematic diagram of Fig. 1. Since each circuit is identical, we will only discuss one circuit—the other circuits work the same.

A full-wave rectifier is formed by D1 and D2 with the center tap of T1 as a ground reference. The unfiltered direct current is applied to R2 and a Darlington-pair amplifier stage formed by Q1 and Q2. As R2 is rotated, a variable current is applied to the base of Q1. The output current from Q1 is then applied to the base of Q2. The much higher output current from Q2 is then applied to MOT2.

Short-circuit protection is provided by F2. Using the suggested motor and propeller, each circuit will have to supply about 1.2 amps. However, any sudden surges will cause the motors to draw much more current for very brief periods. Fuses with a rating much less that the suggested 4 amps will tend to blow out if R2 is spun rapidly.

There is nothing special about the particular choice of transistors for Q1 and Q2—they just happened to be readily available in the author's "junk box." The only important design point is that Q1 be able to supply enough current to let Q2 supply enough current to the motor.

In developing the control circuit for the Astro-Treker, the old saying that "simpler is better" certainly applies. Pulse-width modulation controls would certainly improve the low-speed torque of a DC motor, but at low speeds, the propellers will not develop enough thrust to move the Astro-Treker. Even including filter capacitors to remove the ripples from the rectified power is not needed for electric motors. If a short circuit occurs between F2 and ground, the impedance of T1's secondary will limit current to a level that is less than the maximum level that Q2 can pass. If a filter capacitor was used in the circuit, additional short-circuit protection would be needed to prevent the charge on the capacitor from burning out the transistor before the fuse pops. With the Astro-Treker, simply replace the fuse—and the fun is ready to begin again.

It was also found that using a regulated power source tended to detract from the overall enjoyment of the Astro-Treker. Although any fluctuations in the line current will change the motor speed for any particular throttle setting, that "feature" adds to the realism of piloting the Astro-Treker. In the real world, aviators have to deal with such problems as air pockets, winds, and storms.

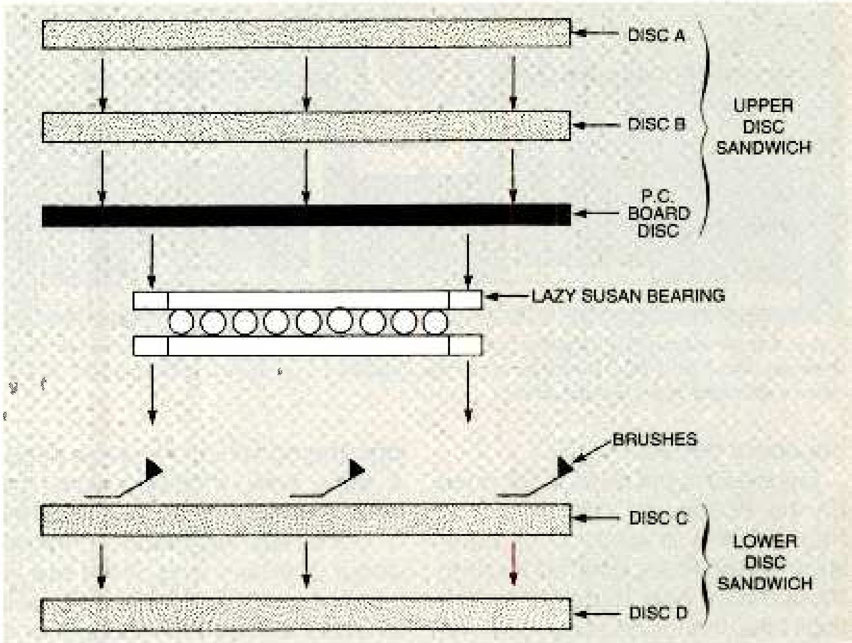


Fig. 3. When building the central gimbal, mount two discs and the PC board together to form the upper sandwich. The lower sandwich is the same, only with brushes instead of the PC board.

Building the Rotor. Building the Astro-Treker is easy and forgiving. Most of the parts and materials that are needed are likely to be found in your "junk box" or readily available from a variety of local suppliers. A broad range of parts substitutions or modifications can be incorporated to bring the construction cost down to fit almost any project builder's budget. In addition, the performance of the finished product primarily depends upon the basic laws of physics rather than construction variables, programs, or calibration techniques

The rotor is made from five discs as shown in Fig. 2A. Each disc is 7 inches in diameter. The upper discs ("A" and "B") and the lower discs ("C" and "D") are made from 1/8-inch-thick plastic sheet. A suggested material is the textured ABS plastic that is used for custom automobile stereo-component installations. That material is inexpensive, easy to work with, attractive, and extremely durable. However, other non-conductive materials, such as Plexiglas or particleboard will work equally well. The combined discs A-B and C-D are used only to strengthen the entire assembly. Therefore, if you wanted to use ¼-inch-thick particleboard, plywood, or some other rigid material, only two discs might be needed.

The PC board disc is 6½-inches in diameter and constructed from any quality type of single-sided PC-board material. It is best not to use a fiberglass-based PC board. The copper surface on those types of boards tends to have a textured surface caused by the fiberglass strands. Some electrical arcing problems could result from the rough surface. Three grooves are cut with a grinding tool or etched on the disc as shown in Fig. 2B. Those rings form the contact rings that pass current to the motors. The width of those rings can vary, depending on the size of the brushes you decide to use. The innermost ring is actually a solid circular plate of copper foil.

A "lazy susan" bearing connects the two disc sandwiches together. It also serves as an additional contact for the innermost contact ring (the circle) on the PC board. That contact will be used for the common return for each of the three motors. Since that contact will be carrying up to three times the current of any one of the other brushes, having additional metal contact area will help prevent arcing in the return brushes.

The rotor brushes are made from the movable contact arms of old relays or leaf-type switches. They are mounted on the lower disc sandwich, sliding against the rings on the upper disc sandwich.

After the discs are cut to size, drill holes at the edges of the discs in the approximate locations shown in Fig. 2A. Those holes will take screws and nuts to bolt the disc sandwiches together. When drilling the holes, it is a good idea to align the discs in a stack and drill all of the holes at the same time. That way, the holes will line up correctly. Screws and nuts will also be used to bolt the lazy susan bearing to the disc sandwiches. The size and locations of those holes will depend upon the actual bearing you will be using.

Bolt the upper disc sandwich together first. Position the PC board on the sandwich so that it is centered as closely as possible about the bearing. Mark the holes where the bearing screws will go through the PC board and drill them out. The bearing is then mounted on

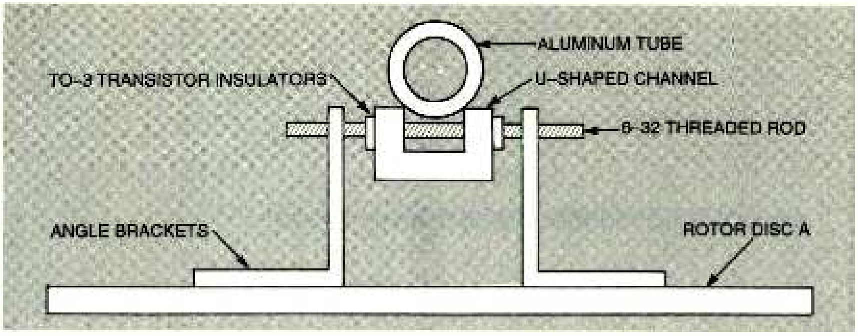


Fig. 4. The pivot bearing is simply a threaded rod that runs through an aluminum channel. Nylon screw insulators for a TO-3 transistor act as the actual bearings. Angle brackets support the pivot channel above the upper disc sandwich.

the upper disc sandwich.

Locate and drill three small holes on the PC board. They should be near the rims of each of the outer rings. Wires will be inserted through those holes and soldered to the rings later. The locations of the holes are not critical. The only points to keep in mind is that the brushes should not ride over any solder joint and that keeping the holes next to each other makes for a neater and more professional-looking job.

Position the brushes on the lower disc sandwich as shown in Fig. 2C. There should be two brushes per ring. The brushes should also ride close to the center of each ring. Temporarily mounting the lower disc sandwich to the lazy susan bearing will help to locate the exact positions of the brushes. Once the locations are found, drill the holes and mount the brushes with screws and nuts. After the brushes are mounted, the lower disc can be bolted to the lazy susan bearing.

Bend the brushes into a slight curve so that the contact points rest flat on the PC board rings. Very little upward pressure from the brushes is needed for good contact. If the contacts are flat, there should be the same mechanical resistance to rotational movement regardless of which direction the rotor is turned. Apply a thin film of non-conductive lubricant on the PC board ring surface to reduce friction and wear. The final assembly goes together as shown in Fig. 3.

Building the Pivot Arm. The pivot arm that is mounted to the top of the rotor lets the Astro-Treker move up and down for takeoffs and landings. The construction details in Fig. 4 show how straightforward the mechanism is. The pivot arm itself is a U-shaped aluminum channel about 20 inches long. Drill a pair of holes across the channel walls at its midpoint so that a short length of 6-32 threaded rod can be used as a pivot point. A pair of screw insulators for a TO-3 transistor are used for the pivot bushings. It might be necessary to place locking nuts on the ends of the threaded rod in order to hold it in place. You might also need to place spacer washers between the angle brackets and the transistor insulators in case the channel tends to "wobble."

An additional hole will be needed at the bottom of the channel near the center pivot. A grommet will be inserted in that hole. The grommet should be large enough to let four 22-gauge wires pass through.

The pivot is mounted to the upper disc sandwich with a pair of 1½-inch angle brackets. Locate the brackets in such a way that the pivot is as centered as possible on the disc. Just remember to keep the bottom of the aluminum channel at least 1 inch above the top of the rotor to allow sufficient clearance for full vertical movement of the flyer.

Building the Base. A simple and convenient way to make a solid base for the Astro-Treker is to use a small desktop-microphone stand. To increase the stability of the base, mount the stand to a piece of ½-inch-thick plywood about 11 inches in diameter. Mounting four rubber feet to the underside of the plywood will keep the Astro-Treker from sliding around on a slick floor.

An easy way to mount the microphone stand to the bottom of the gimbal is by using the microphone holder that comes with the microphone stand. The top section of the plastic holder is a U-shaped piece with two holes near the top. Using a pair of 1½-inch angle brackets, place two of their faces together. Slide the bottom section of the T-shaped structure down into the U-shaped top of the microphone holder. Align the holes from the two angle brackets with the two holes in the microphone holder. Insert an appropriate size bolt through the holes, and tighten the assembly together with a nut and washer. You might have to insert a few washers in between the angle brackets and the microphone holder for a snug fit. The flat surface formed by the top of the two angle brackets can then be mounted to the bottom of the gimbal with bolts or screws the same way that the pivot was mounted to the top of the gimbal. The finished base will look like Fig. 5.

Building the Flyer. The flyer itself is a very simple design. Begin by cutting out two identical sides from some ⅛-inch plastic sheet or similar material. The pattern for the flyer is shown in Fig. 6.

The suggested motors have two tapped mounting holes in the front end of their case. Using two 1-inch angle brackets for each motor, mount one angle bracket to each motor mounting hole. The opposite end of the angle bracket should be pointing toward the rear of the motor.

The pattern for the flyer has three flat areas—one at the top center of the pattern and two that face at 45° angles at the upper corners. The motors will be mounted at those locations. Starting with one pre-cut side, mark a drilling location for one of the angle brackets that are attached to a motor. The motor should be centered within the flat edge, and the end of the motor that the brackets are attached to should be even with the edge of the side. Mark drilling locations for the other two motor locations.

Holding both patterns together, drill through the marked locations.

Both sides will now be exact mirror images of each other. Mount the motors to the sides with appropriate screws and nuts. Tighten the motors down securely.

The shape of the flyer was designed with the recommended motors and propellers in mind. If you want to use a different shape or different hardware, there are several design points to keep in mind. The motors should be mounted at equal distances from each other, the two outer motors should face outward at a 45° angle, and the propellers should not strike anything on the flyer—including other propellers!

The suggested propellers are excellent for the Astro-Treker. They are well balanced, flexible to the point of being almost unbreakable, rubber-tipped for additional safety (an important consideration if little children will be around), and they press-fit very tightly onto the motor shafts without any modification.

The balance rod is a 6½-foot length of ¾-inch o.d. aluminum tube. The Astro-Treker's travel path will be about 6-feet 8½-inches in diameter including the flyer. If you don't have the available floor space for something that large, simply reduce the length of the balance rod. The actual length of the balance rod will not affect the operation of the Astro-Treker. However, a longer rod will make for a more impressive device. Drill a hole in the balance rod large enough to pass four wires. Locate the hole at about the center of the balance rod.

The flyer is mounted to one end of the balance rod with two small angle brackets using similar techniques that were used for the pivot and the gimbal. It is a good idea to place a few rubber grommets between the angle brackets and the flyer in order to reduce any vibration that might be generated by the motors and propellers. Make sure that the hole that was drilled in the center of the balance rod faces down. That way, the wires for the motors will be hidden when the balance rod rests on the channel. Before mounting the flyer permanently to the balance rod, a hole is needed in the side of the flyer where the balance rod meets the flyer. That hole will be passing the wires between the motors and the gimbal.

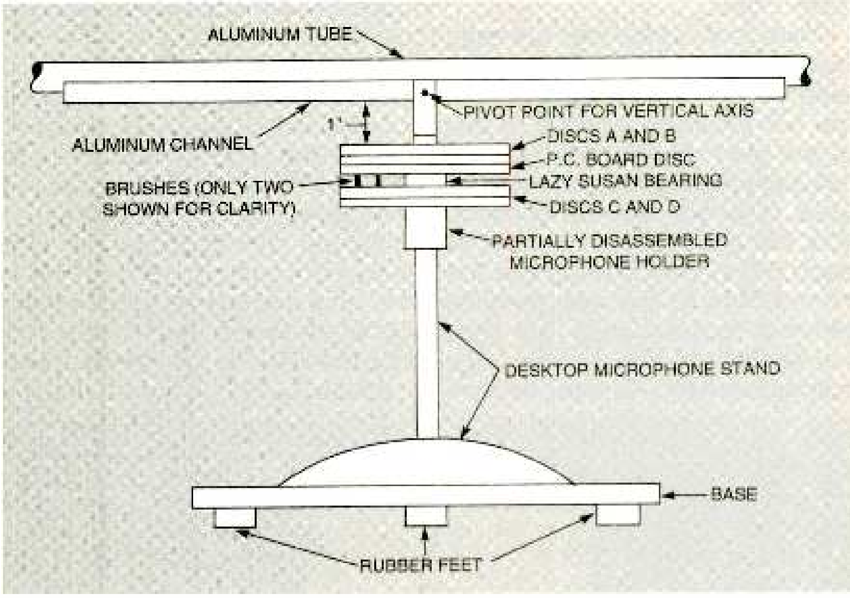


Fig. 5. The Astro-Treker's base is built around a desktop microphone stand.

A counterweight is mounted to the opposite end of the balance rod. It should be a little heavier than the flyer and can be constructed from any convenient weight that can be mounted on the end of the rod. One example is to use a set of large washers mounted on a bolt or scrap piece of threaded rod. One end of the bolt is then inserted into the hollow end of the balance rod and attached in any convenient manner.

Test the balance of the flyer and the counterweight by placing the balance rod on the pivot arm. Slide the balance rod back and forth on the aluminum channel until the counterweight and shuttle are balanced horizontally. If the balance is correct, the distance from the pivot center to the outside face of the shuttle will be about 2 inches longer than the distance from the pivot center to the outside face of the counter-weight. If the balance is wrong, add or remove washers from the counterweight as needed until the correct balance is achieved.

Building the Control Panel. The control panel is very simple from both a design and a construction standpoint. Since there are very few components that can be mounted on a PC board, one is not used; the entire unit is hand wired. Simply follow the schematic diagram in Fig. 1.

If you want, you can use a single 24-volt center-tapped transformer that can supply at least 3 amps. That would eliminate the need for two additional diodes. Unfortunately, a single transformer of that size will not fit inside the suggested enclosure. The transistors need to dissipate about 13 watts each under the worst-case conditions. Those components need to have adequate heat sinking.

Wiring and Final Assembly. The final wiring simply consists of connecting the outputs from the control panel to the individual motors. A good choice for the wire is 22-gauge stranded wire used for alarm systems. It is very flexible, durable, and can easily handle the current loads of the Astro-Treker.

A four-wire cable about eight feet long runs from the control panel to the base of the gimbal. The length can be adjusted to your own preference; however a longer cable will let the operator sit on a nearby chair while using the Astro-Treker. A way to disconnect the control panel might be a good idea, so that the Astro-Treker can be disassembled and stored away. A spring-loaded stereo-speaker terminal strip mounted on either the control panel or the microphone base is ideal.

The bottom of the rotor has eight bolts for the eight brushes and four bolts for the center bearing. Wire the two innermost brushes to one of the bolts used for the bearing. Suitably-sized lug terminals can be used to make the connections. Wire the other pairs of brushes for each ring in the same manner. The control wires (or the wires from the optional terminal strip) are then connected to the brushes. The common return wire must be connected to the innermost brushes that are connected to the bearing. The other connections can be made in any order.

Cut four 22-inch lengths of wire. Strip a small length of insulation from one end of each wire. Insert the wires into the holes that were drilled in the upper disc sandwich. Solder them to the outside edge of each ring. If done properly, the brushes have been adjusted to ride in the center of each ring, so they won't hit the solder joints. When completed, the three wires can be glued permanently in place with caulk or epoxy filler, which acts as a strain relief. The fourth wire (circuit common) is connected to the most convenient one of the four bolts used to mount the upper disc to the upper plate of the bearing.

Bundle the wires together and feed them through the grommet in the channel. Enough slack should be left to form a loop for flexibility. Lay the wires in the channel and run them out to the closest end.

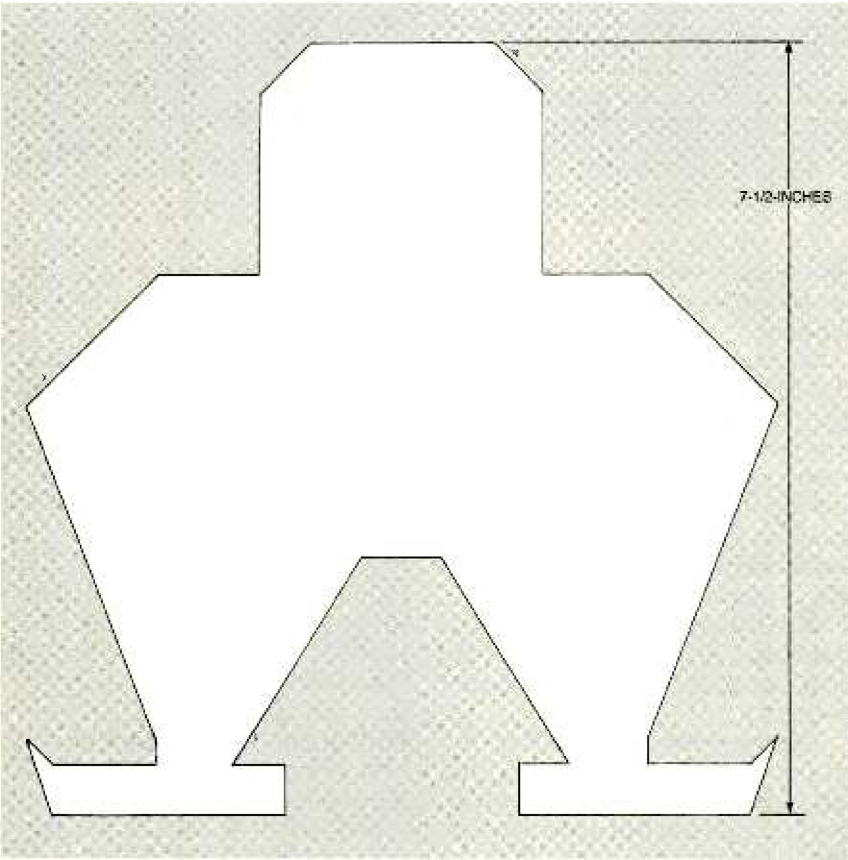


Fig. 6. Here is a suggested pattern for the flyer's body, drawn half-size. The landing feet are shaped like hooks so that the flyer can be used to pick up and move objects that have wire loops in them. The three flat surfaces at the top show where the three motors are to be mounted. The locations are designed to prevent the propellers from striking each other.

Each terminal on the flyer motors is marked with a "+" and "-" symbol. The "-" terminals on all three motors are soldered together with lengths of wire. Estimate the length of wire needed to run from the flyer motors, through the balance rod, out the hole in the center of the balance rod, and out to the end of the pivot channel. That end of the pivot channel will be the end closest to the counterweight, so the wire lengths running from the shuttle will have to be longer than you might think. Add about a foot or so to the estimated length and cut four wires. One wire is attached to the common negative terminals of the three motors. The remaining three wires attach to the positive terminals.

Route the four motor wires through the hole in the side of the flyer and into the balance rod. Feed them through the hole in the center of the balance rod, lay the balance rod on top of the pivot channel, and route the wires out to the same end of the channel as the four wires coming from the top of the rotor.

Connect the common wire to the innermost brush wire. The other wires are to be connected to their respective control wires as shown in the schematic diagram of Fig. 1. If you lose track as to which wire goes where, a simple continuity test with an ohmmeter will identify the individual wires. For example, the wire connected to F2 should connect to the "+" terminal of the center motor.

The balance rod can be attached to the pivot channel by several methods. Tie wraps can be used for a permanent mount, with the wires soldered together. To make the Astro-Treker easy to dismantle and store, you could use rubber bands or small hose clamps instead of tie wraps. Very little pressure is needed to hold the balance rod in place. For that arrangement, a four-conductor plug is needed for the wiring connections.

Testing and Set-Up. Electrical testing of the Astro-Treker is simply a matter of rotating the three speed control potentiometers on the control panel and verifying smooth, minimum-to-maximum speed control of each associated motor/propeller. At maximum speed, a DC voltmeter should indicate about 10.5 volts DC applied to each motor. Maneuvering action of the flyer largely depends upon the position of the balance rod. As the balance rod is moved forward, the apparent weight of the flyer is increased. That will increase the response time and maneuverability. Sliding the balance rod back will have the opposite effect on the

Astro-Treker. A little experimental operation will provide a good feel for where the best position for the balance rod should be.

Using the Astro-Treker. With three simple controls, flying the Astro-Treker is somewhat self-explanatory. For vertical flight, the obvious choice is to activate the center propeller. A less obvious method is to use both outboard propellers at equal thrust. Since they are mounted at an angle, they will provide both upward and sideways movement. If one motor is running faster than the other is, the flyer will start drifting sideways in one direction.

Moving sideways can become a bit trickier, especially if you are attempting to move in a straight line without losing or gaining altitude. As one of the outboard motors is activated and begins to add thrust to the flyer, the thrust from the center motor should be cut. That will compensate for the additional vertical thrust from the outboard motor.

To slow down over a target without changing altitude, increase the thrust on the motor facing the "rear" of the flyer while cutting power to the motor at the "front". That way, reverse-thrust "brakes" can be applied while maintaining the overall balance of vertical thrust.

The bottom-line effect is one of actual interactive flight. With a little practice, the operator can precisely control the flyer position for a variety of skilled maneuvers, including landings, takeoffs, hovering, transportation of "cargo" objects, or even "space war" games.

Games. "Cargo" objects can be devised that can be hooked with the flyer's landing feet. Space toys or other objects can be modified for that purpose by placing a loop of wire through them. The weight of the objects will have a profound effect on lift, speed, and inertia of the Astro-Treker. In addition, the size of the wire loop placed through the cargo object will affect the degree of difficulty in pick-up and release. By varying the weight and loop-size of the cargo, the skill level of game play can be infinitely altered by the operator as his or her skill increases with experience.

While small children can be entertained for hours by just "flying" the shuttle, older children and adults enjoy challenging themselves and each other to the skill required picking up and transporting objects. Inexpensive plastic dining-table place mats make excellent imaginary "planets" for landing and targeting purposes. Depending on the acquired skill level of the game player, maneuvering action and control response can be very rapid.

Options and Modifications. While the Astro-Treker itself is visually impressive, various modifications and additions can add to the visual effects and enhance the games that can be played. For example, LEDs in various colors can be placed on the flyer and can be wired in parallel with the motors. One particularly striking effect is to use three high-brightness LEDs, such as RadioShack 276-206s. Put one wired in parallel with each motor, and mount them so that they are pointing down toward the landing feet of the flyer. A 33-ohm resistor should be connected in series with each LED to provide the necessary current limiting. The effect is an illusion of orange fire exhausting from the bottom of the flyer that varies in intensity as the motor speed changes. Flashing lights or other lighting that is more dramatic is possible, limited only to your imagination.

Another option is to connect an electromagnet, such as the coil from a small 12-volt DC relay, in parallel with the center motor. The electromagnet is mounted to one of the landing feet of the flyer and is used for picking up and dropping iron-bearing metal objects. Since both directional motors provide substantial lift as well as direction, the shuttle can be maneuvered without the use of the center motor. The goal in that case would be to fly over a small metal object, pick it up with the electromagnet by starting the center motor, transporting it to a target location, and drop it on the target by stopping the center motor. Such a maneuver can be quite tricky because

Continued on page 44

PARTS LIST FOR THE ASTRO-TREKER

CONTROL PANEL

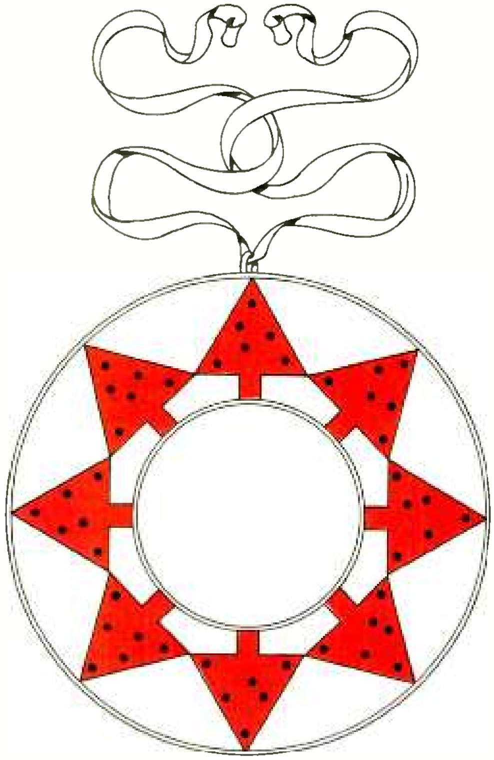
T1, T2—24-volt, 2-amp center-tapped transformer (RadioShack 273-1512 or similar)
D1–D4—6-amp, 50-volt PIV diodes (RadioShack 276-1661 or similar)
R1–R3—5000-ohm, ½-watt potentiometer (RadioShack 271-1714 or similar)
Q1, Q3, Q5—2N3054 transistor
Q2, Q4, Q6—2N3055 transistor
F1—1-amp fuse
F2–F4—4-amp fuse
S1—Single-pole, single-throw switch, 5 amp
PL1—2-conductor line cord

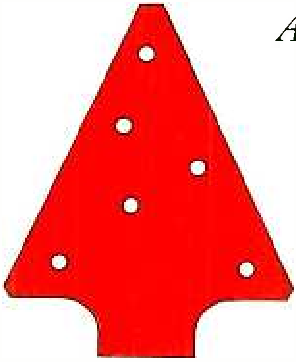
ADDITIONAL PARTS AND MATERIALS

MOT1–MOT3—18-volt DC high-speed motor (RadioShack 273-256 or similar)
Heatsink, cabinet (RadioShack 270-216 or similar), fuse holders (RadioShack 270-739 or similar), knobs (RadioShack 274-402 or similar), strain relief, transistor-mounting hardware, ⅛-inch plastic sheet (Parts Express 265-948 or similar), 5-inch propellers ("PROPSHOT" toys No. 9159, distributed by Lanard Toys, 101 S. Sterling Terrace, Sugar Creek, MO 64054, or similar), 1-inch angle brackets, 1½-inch angle brackets, ½-inch × ⅜-inch aluminum channel, ¾-inch o.d. aluminum tube, washers, 6-32 threaded rod, TO-3 nylon transistor screw insulators, PC board, 3-inch lazy susan bearing, microphone stand (RadioShack 33-370 or similar), microphone stand adapter (RadioShack 33-4005 or similar), ½-inch plywood, rubber feet, 4-position speaker terminal (RadioShack 274-622 or similar), 22-gauge stranded wire (RadioShack 278-862 or similar), brushes, etc.

NOTE: The following items are available from SEAL ELECTRONICS, P.O. Box 268, 3898 Kentucky Rt. 466, Weeksbury, KY 41667-0268, Tel: 606-452-4135: Set of 3 propellers, $12.00 plus $4.50 shipping and handling charge; Transistor-Heatsink Assembly with Q1–Q6 and three fuse holders pre-mounted to a 4 × 9 × ¾-inch heatsink with instructions, $15.50 plus $5.00 shipping and handling charge; pre-fabricated Gimbal Assembly includes all parts, hardware, and 20-inch channel pivot lever with instructions (minor assembly required), $38.50 plus $5.50 shipping and handling charge.

BUILD THIS TWINKLING HOLIDAY ORNAMENT





An electronic Christmas ornament is just the thing to brighten the tree this Holiday!

DAVID WILLIAMS

A great way to get into the spirit of the Holidays is by building this electronic Christmas ornament. This project makes a great conversation piece that also gives you practice working with surface-mount components. The ornament is shaped like a miniature tree with multi-colored flashing LEDs that twinkle just like the real thing! The entire circuit is powered by a coin-cell battery. The ornament is small enough to be hung on your Christmas tree or around your neck at your favorite holiday party. Either way, it's guaranteed to attract lots of attention!

Circuit Description. The schematic diagram in Fig. 1 shows the simplicity of the Twinkling Ornament. The circuit is based on the HT2030 CMOS LED-driver chip from Holtek Microelectronics Inc. That surface-mount chip contains a built-in oscillator, sequencing logic, and output drivers for three LEDs. Two chips (IC1 and IC2) are used to get a twinkling effect from six LEDs.

The circuit is powered by B1, a single 3-volt lithium coin-cell battery. Resistors R1 and R2 limit the current drawn by the LEDs. Momentary push-button switch S1 toggles the display on and off. Each HT2030 draws less than 1 microamp of current when in the standby mode.

Working with Surface-Mount Components. Working with surface-mount components requires proper tools and materials. You will need a soldering iron, a vise, tweezers, and a magnifying glass. The soldering iron should have a rating of 25 to 35

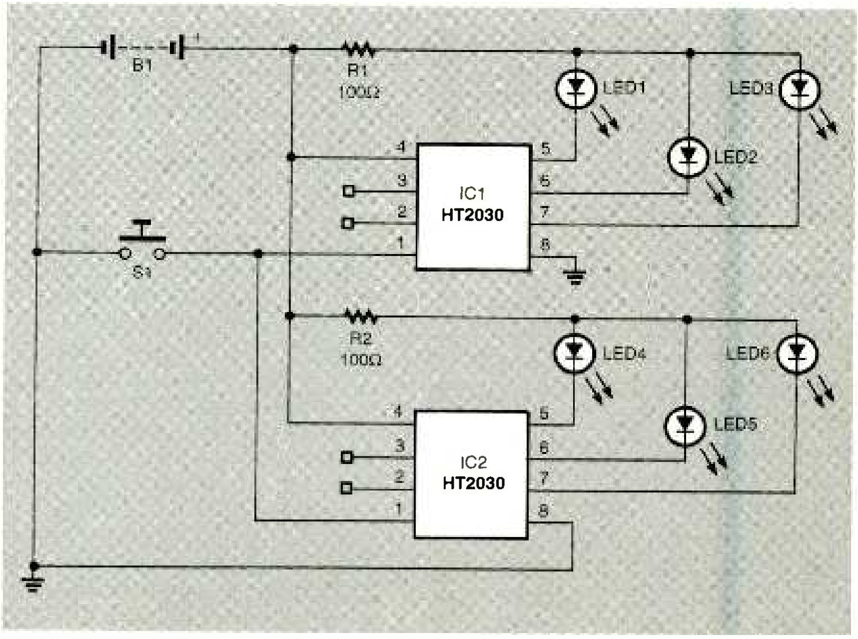


Fig. 1. The Twinkling Ornament is built around the Holtek HT2030. That surface-mount device contains all of the circuitry needed to flash three LEDs in sequence.

watts with a fine conical tip about 1/16 inch in diameter. The materials required are solder, a drop dispenser, liquid flux, and a flux remover.

The solder should be a very fine wire type (no thicker than 0.02 inches in diameter) and should have a 63/37 tin-lead mixture for best results. Tin-lead solders that are made up of 63% tin and 37% lead are called *eutectic* solders. Normally, when solder is melting, it has what is called a *pasty range* in which it is part solid and part liquid—very much like the slush formed by melting snow. Eutectic solders do not have a pasty range—they go from liquid to solid and back all at once. The big advantage to eutectic solders is that it is almost impossible to make a cold-solder or disturbed joint—one in which the lead has been moved while the solder was solidifying. Those types of joints are usually a dull gray in appearance. They have not made a good chemical bond between the lead and the PC board, and will soon fail to conduct electricity.

The best way to solder a surface-mount component to a PC board is to first apply a tiny amount of liquid flux to one PC board pad using the drop dispenser. Then, using the soldering iron and solder, "tin" the pad by creating a small pool of solder on the pad. Let the solder solidify.

Pick up the surface-mount component with a pair of tweezers and position it in the proper location over the pad. Next, use the soldering iron to reflow the solder so that the component sinks into the solder pool. Remove the iron and let the solder cool. The component will be held in place on the board. The rest of the part can then be soldered in the traditional manner.

The process might sound difficult, but with the aid of a magnifying glass and a little patience, things should go smoothly.

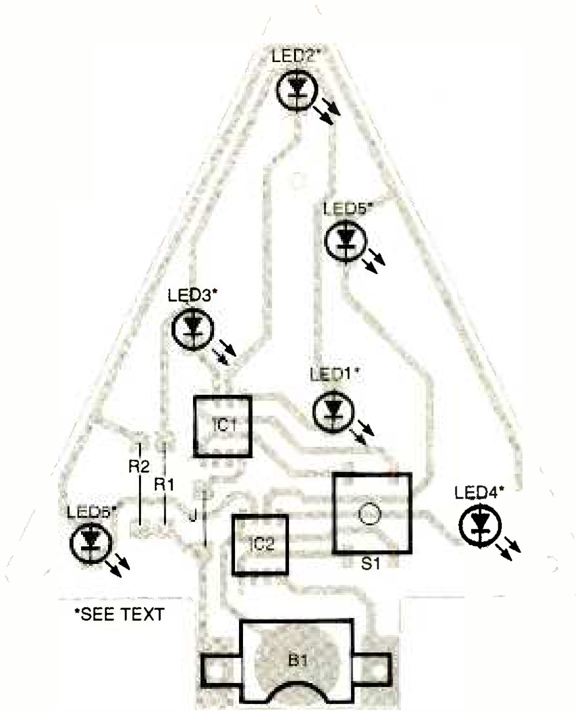


Fig. 2. The Twinkling Ornament uses a combination of surface-mount and through-hole components. Since all components except the LEDs mount on the foil side of the board, a foil-side view is shown in this parts-placement diagram.

PARTS LIST FOR THE TWINKLING HOLIDAY ORNAMENT

R1, R2—100-ohm, 5%, 1/8-watt, surface-mount resistor
IC1, IC2—HT2030 3-LED Flash Driver IC, surface-mount (Holtek)
LED1–LED6—Light-emitting diodes, size T-1, various colors (see text)
S1—Push-button switch, surface-mount (Digi-Key SW416-ND or similar)
B1—3-volt lithium coin-cell battery, size CR1220 (RadioShack 23-188 or similar)
Printed-circuit board, 12-millimeter coin-cell battery holder (Digi-Key 3000K-ND or similar), solder, etc.

Note: The following items are available from LNS Technologies, 20993 Foothill Blvd, Suite 307R, Hayward, CA 94541-1511; Tel: 800-886-7150: Complete kit of parts including etched and drilled printed circuit board, switch, battery holder, ICs, and all other components listed above (XMASTREE-KIT), $18.00; IC1, IC2, (ICHT2030), $4.00 each; PC board only (XMASTREE-PCB), $7.00. Please add $5.00 for shipping and handling. California residents add appropriate sales tax. MasterCard and Visa orders are accepted. No C.O.D. orders will be accepted.

The HT2030 IC is also available from Alltronics, 2300 Zanker Rd., San Jose, CA 95131, Tel 408-934-9773.

Surface-Mount PC Board Fabrication. Since the Twinkling Ornament uses a combination of through-hole and surface-mount components, an etched circuit board is a must. Fabricating an SMT circuit board is identical to making a traditional single-sided board; however, since the component pads and traces on an SMT board are smaller and more delicate, etching must be done very carefully. Check the etching process frequently to avoid any over-etching that could damage the copper traces and check each trace for continuity after the board is finished.

If you don't want to fabricate your own board, a pre-etched one can be purchased from the source given in the Parts List.

Construction. Now that you know how to work with surface-mount components, it's time to start building the Twinkling Ornament. The parts-placement diagram for the twinkling ornament is shown in Fig. 2. With the exception of the LEDs, all of the components will be mounted on the foil side of the board. For that reason, the parts-placement diagram that is shown here is a view of the board from the foil side.

Begin by using a piece of insulated solid wire for the jumper wire. The jumper wire is installed on the foil side of the board. After soldering it in place, clip the excess leads flush with the opposite side of the board. Install and solder R1 and R2 in the same way. Then attach IC1 and IC2, making sure to orient pin 1 of each IC as shown in Fig. 2, using the surface-mount technique described earlier in this article.

You'll also use surface-mount techniques to attach the battery holder to the PC board. Make sure that the open end of the battery holder is facing away from the top of the tree so the battery can be inserted from the bottom. Next, mount push-button switch S1. The LEDs are mounted on the component side of the PC board in the conventional manner. You can use LEDs of various colors for a more realistic effect. Since LEDs are polarized, make sure to observe the proper orientation.

Here's the completed ornament. Whether hung on a tree, worn around your neck, or used in some other decorative way, it can add a touch of electronic sparkle to your holidays.

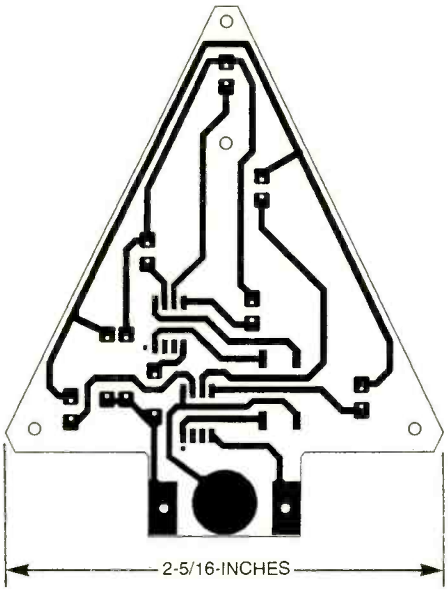
The finished Twinkling Ornament will only have the LEDs visible from the front of the unit—the rest of the circuit will be hidden on the back of the board.

Checkout and Use. Before testing the Twinkling Ornament, clean any flux from the foil side of the board with a flux remover or alcohol. Examine the assembled board to make sure that there are no solder bridges or cold joints. Install the battery by sliding it into the holder with the negative side against the PC board. Turn the Twinkling Ornament on by pressing S1. If all is well, the six LEDs on the unit should begin blinking at once.

If some LEDs blink but others do not, check to see if the LEDs are installed correctly. If all three LEDs on one of the ICs do not work, check the connections around that IC. The resistor for that IC should also be checked. It is also possible that the IC is defective. When replacing an IC, be careful not to overheat the chip. Semiconductors—especially surface-mount ICs—are very sensitive to heat.

If neither circuit is working, there might be a problem with the battery or its holder. It is also possible that both ICs are defective—especially if they were overheated. It could also be that ALL of the LEDs were installed backwards—a fairly common thing to do if the polarity markings were misidentified to begin with!

The PC board has a small hole at the top that can be used to attach the Twinkling Ornament to a hook or necklace loop. You can use your imagination to decorate the component side of the board. Try paint, glitter or perhaps a dark green plastic or cardboard overlay. No matter how you decide to decorate it, your holiday ornament will probably be so popular that you will need to build extras for your family and friends! Ω



The tree-shaped Twinkling Ornament uses a single-sided PC board to hold both the surface-mount and through-hole components.

ASTRO-TREKER

(continued from page 41)

the center motor will speed up as the electromagnet is energized. If the metal object is of sufficient weight, the additional lift provided by the center motor will be canceled out by the weight of the object. It can be more fun and challenging to choose items whose weight is not proportional to the lift generated by the center motor. That would need rapid compensation from the directional motors. With the addition of another brush/ring contact, the electromagnet can be powered independantly of the motors.

The basic concept of the Astro-Treker can be used for constructing a variety of action games and toys. The easy-to-build rotor can also be used in robotics, displays, rotating signs, and science projects. However, you'll probably be having way too much fun with the Astro-Treker to worry too much about practical applications. Ω

BUILD A REMOTE CONTROL FOR YOUR ANTENNA

Program your antenna direction to pick up any TV station just by selecting the channel number on your remote control!

WILLIAM G. GRIMM

TV antennas are directional. They receive strongly from one direction and reflect signals from other directions. The direction an antenna receives best from is the direction closest to the shortest element of the antenna. If you live in an area where TV stations are scattered all around you, you probably have a motorized antenna rotator that lets you point your antenna in the direction of the TV station that you're watching.

You've probably also noticed something annoying about antenna rotators. Although the TV, VCR, stereo, and everything else in your home-entertainment system can be operated by remote control, the antenna rotator requires a trip to the control box to get the picture right. It's almost impossible to remember where all the "sweet spots" are for each station. Televisions might be using the latest 1990s technology, but antenna rotators are still technologically back in the 1950s. What would be great is to have an antenna rotator control that can be operated by the remote control.

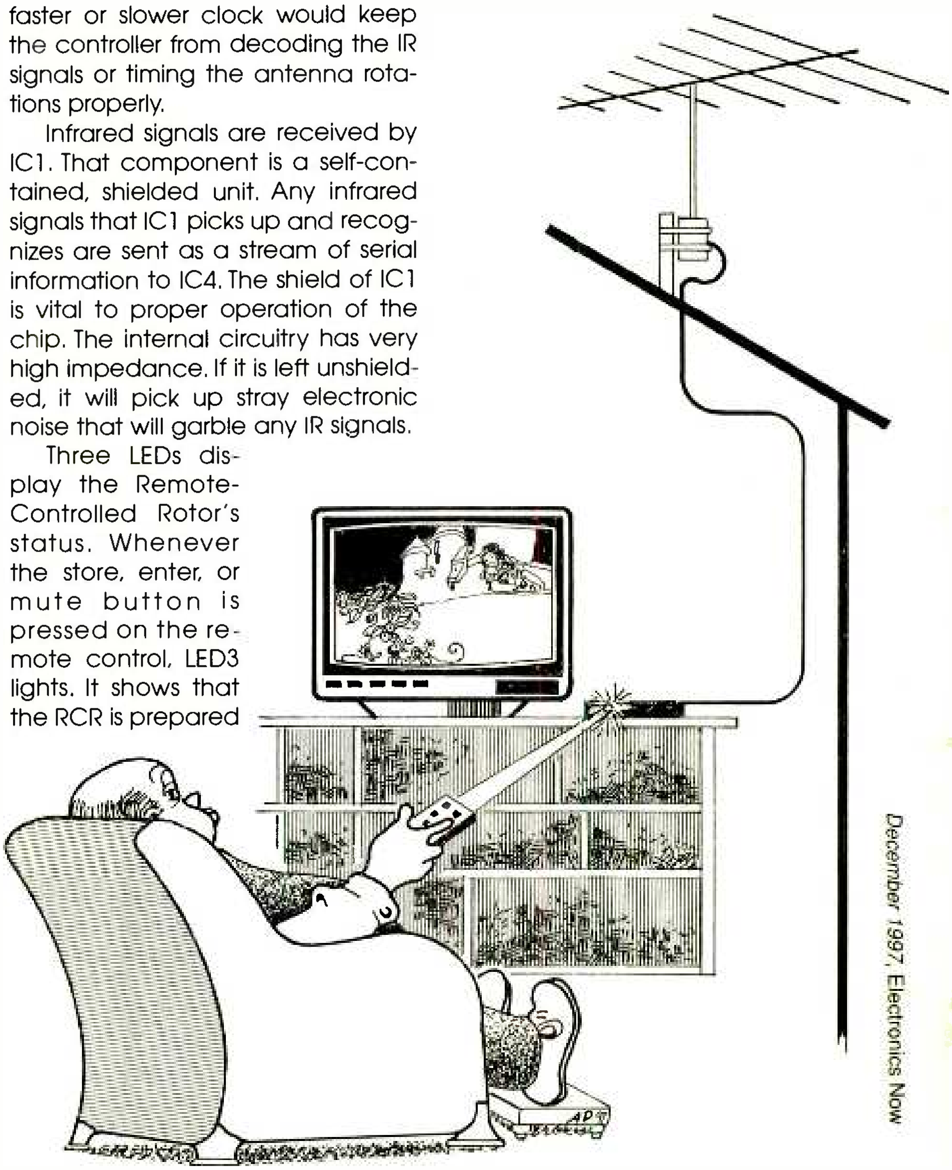
The Remote-Controlled Rotor (RCR) is just such a device. It brings the control of your antenna to your fingertips with the use of a programmable-infrared remote control. It substitutes for the mechanical controllers typically used in the home. It has the added feature of channel-direction memory. Channel directions can be taught to the RCR so that a particular direction can be recovered whenever you want to tune a channel in again.

Based on microcontroller technology, the Remote-Controlled Rotor is small enough to be tucked among a collection of videotapes. It has been tested with Channel Master, Alliance, and RadioShack rotators. It has also been tested with various "universal"-type programmable remote control.

Circuit Description. The schematic diagram of the RCR is shown in Fig. 1. It is built around IC4, a PIC16C56 microcontroller. The program burned into it decodes the infrared signals and decides how to respond to them. The controller is clocked by XTAL1, a 4-MHz ceramic resonator. Since the software is designed around that exact clock speed, a faster or slower clock would keep the controller from decoding the IR signals or timing the antenna rotations properly.

Infrared signals are received by IC1. That component is a self-contained, shielded unit. Any infrared signals that IC1 picks up and recognizes are sent as a stream of serial information to IC4. The shield of IC1 is vital to proper operation of the chip. The internal circuitry has very high impedance. If it is left unshielded, it will pick up stray electronic noise that will garble any IR signals.

Three LEDs display the Remote-Controlled Rotor's status. Whenever the store, enter, or mute button is pressed on the remote control, LED3 lights. It shows that the RCR is prepared



The author would like to express his appreciation to Bruce Jones for his help and assistance in the testing of this project.

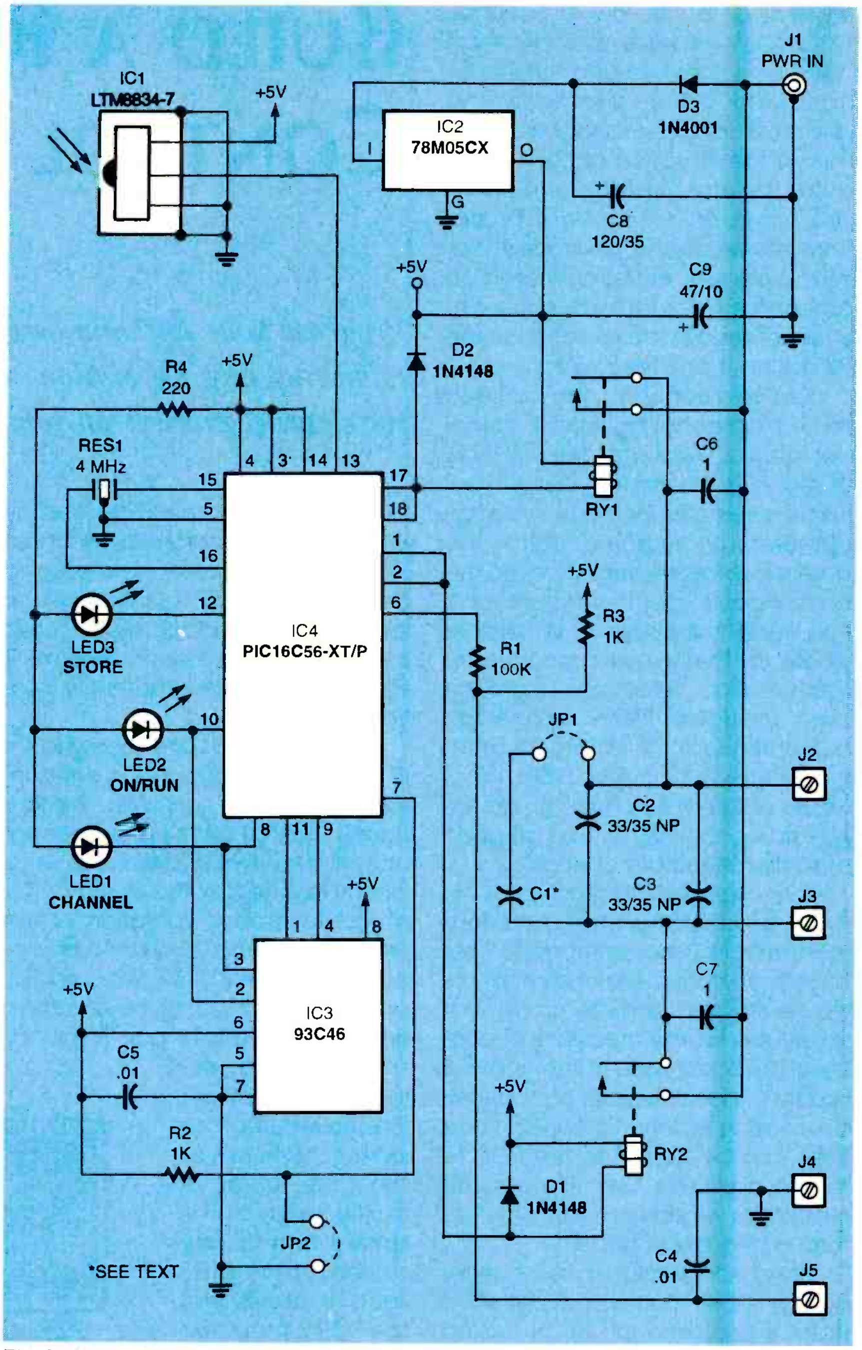


Fig. 1. The Remote-Controlled Rotator lets you control your antenna rotator with a remote control. A microcontroller chip reads the infrared pulses with an infrared sensor module and spins the antenna as needed. Individual settings for channels 2 to 69 can be stored and recalled. You can also set the antenna to point directly North, South, East, or West.

to store an antenna position. The On/Run LED, LED2, is on as long as the RCR is on and flashes when the rotator is turning. It can be shut off by pressing the On/Off button of the remote control. The Channel LED, LED1, lights whenever the first digit of a two-digit channel number has been pressed on the remote control.

The LEDs are lit one at a time. If more than one is lit at the same time, they are flashed in sequence at a high rate so that the flicker is not noticeable. That allows them to share R5 as a single pull-up resistor.

Sharing some of the PIC control lines with the LEDs is IC3, a serial EEPROM. It is used to store channel directions and the current direction of the antenna. Storing the current antenna position lets the RCR recover gracefully from any power outages without having to recalibrate the system all over again. The EEPROM is only used when its select line (pin 1) is high. The data transfers and clock pulses to the EEPROM will also light the LED, but since those signals are hidden within the LED multiplexing, any disturbance in the LEDs will be very hard to notice.

The RCR is designed to work with two types of rotators—those that have feedback and those that are synchronous. If the RCR is connected to a synchronous rotator, it measures the amount of time that the rotator is energized. A synchronous rotator turns a set amount per second. Knowing how long the rotator has been running makes it easy to figure out how far it has turned.

The other type of rotator that the RCR can work with is one that puts out feedback pulses. With that type of rotator, it is a simple task to count the number of pulses. The pulses from a feedback rotator are connected to the RCR through J5. An R–C noise filter (R3 and C4) removes noise from the feedback signal. Valid pulses are buffered by R1 into IC4. If you are using a 3-wire synchronous rotator such as those from Channel Master or Radio-Shack, the feedback circuit is obviously not used. However, it will be needed if a feedback-type four-wire system such as older Alliance rotators will be used with the RCR.

Actual rotator control is handled by RY1 and RY2. The higher-current output pins of IC4 are used to drive the relays. Two lines are wired in parallel. That will supply enough drive current for the relays. Any inductive "kick" from the relays when they are turned off is shunted by D1 and D2. Transients from the relay coils are absorbed by C6 and C7. Without them, the processor would reset itself each time a relay turns off. Capacitors C1, C2, and C3 are an arrangement of motor-run capacitors. Their operation and selection will be discussed later.

The power supply uses an 18-volt 1-amp transformer. Note that the rotators will run hot if 24 volts is applied. Half-wave rectification is used so that a common ground can be maintained with the rotator. The rectified voltage is regulated for the logic circuits and relays by IC2, a 5-volt regulator. Any low frequencies in the supply are filtered by C8 and C9, with C5 filtering the high frequencies.

Construction. The method chosen to build the RCR is not critical. No space- or frequency-sensitive components are involved. The easiest method is to use a single-sided circuit board. A foil pattern has been provided should you wish to etch your own board. Pre-etched boards are available from the source given in the Parts List, as are several of the more unusual items, such as a pre-programmed microcontroller chip and an infrared-transparent bezel for the case.

If you use a pre-etched board or fabricate one from the foil pattern, the parts-placement diagram in Fig. 2 will show you where the components are located. The board has a breakaway portion. That breakaway portion will form a back panel that will fit into a PacTec JM-42 project box. Start by breaking the back panel off the board at the perforations. Solder all of the components to the board.

When soldering the components onto the board, it is easiest to start with the smallest parts first. A jumper wire between IC3 and LED3 is a good starting point, followed by the resistors and diodes. If you have difficulty finding the regulator specified for IC2, you can use a standard LM7805, but you'll have to bend the IC over a bit in order to make it fit within the suggested enclosure. A larger enclosure can also be used, but you'll then have to design a different back panel that will fit around the connectors.

Microcontroller IC4 needs to be programmed with the RCR instructions before it is installed in the board. As mentioned, a pre-programmed part is available from the source given in the Parts List. If you are able to program a PIC chip, the source and object codes are both available from the **Electronics Now** FTP site (ftp://ftp.gernsback.com/pub/EN/rcr.zip).

Jumper JP2 selects the type of infrared commands to which the RCR will respond. If JP2 is shorted, the unit will respond to Teknika TV commands. With JP2 left open, the commands will be for a M/A-COM cable-converter box. The choice depends upon the type of universal remote control you will be using. Once you decide what type of arrangement will be best for your setup, set JP2 accordingly.

Jumper JP1, on the other hand, simply connects C1 into the motor-run capacitors. Its use, along with C1, will be discussed in the section on motor-run capacitors. It is only needed if you have to use the optional C1 capacitor in order to create a custom motor-run capacitor value. For now, leave C1 out and do not short JP1.

Once all of the parts have been soldered to the board, inspect your work carefully. Place the back panel over the connectors and mount the board and back panel into the enclosure. If you are using the suggested enclosure or another enclosure that the back panel will fit into, you might have to file or sand the edges of the panel in order to get it to fit.

Place the infrared-transparent bezel in the front of the enclosure and close the unit. The Remote-Controlled Rotator is now ready for testing and setup.

Testing and Setup. Follow your programmable remote control's instructions to set it up as a M/A-COM cable converter or the oldest type of Teknika TV. The choice depends upon how you set JP2.

The RCR takes the place of the old rotator-control box. Simply disconnect the control wires from the old box and connect them to the RCR. Typically, the wires on most rotators are numbered from 1 to 3 or 4, and are connected the same way. On the RCR, wire 1 goes to J2, wire 2 goes to J3, wire 3 goes to J4, and wire 4 (if present) goes to J5.

Connect the wall transformer to J1. Plug the transformer into the most convenient outlet. The On/Run LED should come on.

If you have a 4-wire rotator (such as Alliance), you might need to press the channel-up and then the channel-down buttons. That will get the RCR to figure out that a 4-wire motor is connected to it.

Press "9" then "1" (referred to as

PARTS LIST FOR THE REMOTE-CONTROLLED ROTATOR

SEMICONDUCTORS

IC1—LTM8834-7 (LiteOn) or GP1U521Y (Sharp) 40-KHz-carrier infrared module (Digi-Key LT1060-ND or similar)
IC2—L78M05CX 5-volt voltage regulator, integrated circuit (Mouser 511-L78M05CX or similar)
IC3—93C46 serial EEPROM, integrated circuit
IC4—PIC16C56-XT/P programmed microcontroller, integrated circuit
D1, D2—1N4148, silicon diode
D3—1N4001, silicon diode
LED1–LED3—Light-emitting diode, red, right-angle mount

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—100,000-ohm
R2, R3—1000-ohm
R4—220-ohm

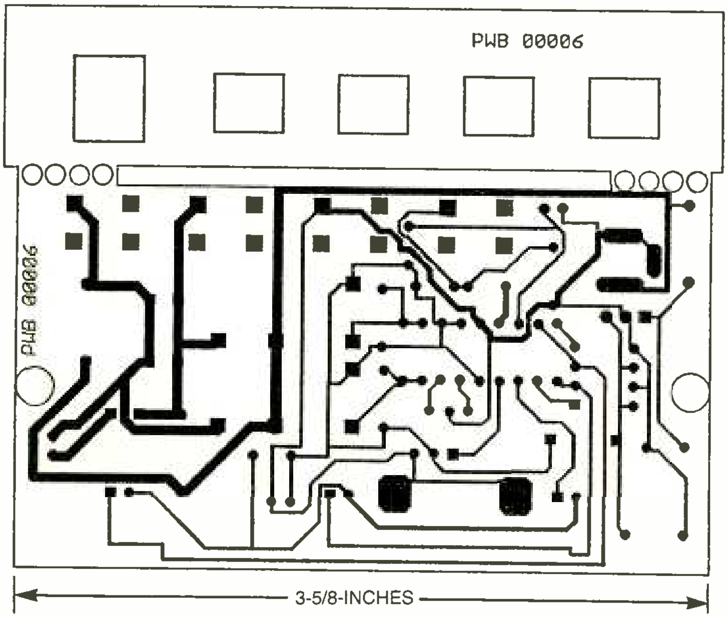
CAPACITORS

C1—optional, see text
C2, C3—33-µF, 35-WVDC, non-polarized, electrolytic
C4, C5—0.01-µF, ceramic-disc
C6, C7—1-µF, metalized polyester
C8—120-µF, 35-WVDC, electrolytic
C9—47-µF, 10-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—Power connector for transformer
J2–J5—Right-angle screw terminals (Mouser 534-8190 or similar)
JP1, JP2—2-pin jumper posts
RES1—4-MHz ceramic resonator (Panasonic EFO-EC4004A4 or similar)
RY1, RY2—5-volt single-pole, single-throw relay (Omron G6B-1114P-US-5VDC or similar)
19-volt, 1-amp AC wall-mounted transformer, enclosure (PacTec JM-42 or similar), infrared-transparent lens, jumper blocks, PC board, solder, hardware, etc.

Note: The following items are available from: Remote Control Rotator, 12811 Bluhill Road, Silver Springs, MD 20906: full kit (not including remote control or rotator), $55.99; printed-circuit board with back plate, $21.27; pre-programmed IC4, $9.00. A limited number of remote controls are also available for $3.49. Please add $5.00 shipping and handling. Maryland residents please add appropriate sales tax.



The foil pattern for the Remote-Controlled Rotator also has a back panel that can be snapped off and used on the case. The square holes in that part of the board will match up with connectors J1–J5.

"91" from here on) on the remote. The LEDs should start blinking, indicating that the rotator is moving. The RCR and the rotator are synchronizing themselves. That should last for about a minute or so.

If the unit does not work, check your work carefully. Polarized components must be inserted correctly. If the RCR seems to work but the rotator doesn't spin the antenna, check that the wires are connected properly. There is also a possibility that one or more of the control wires has broken, especially on an older installation. Old wire might work OK as long as it is not disturbed, but brittle insulation could crumble, resulting in a short.

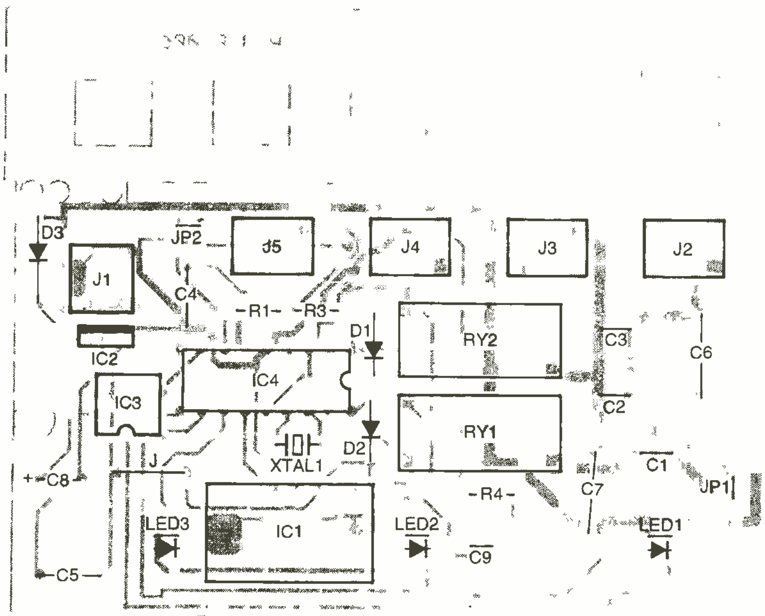


Fig. 2. Here's the parts-placement diagram for the Remote-Controlled Rotator. The entire circuit fits onto a single-sided board with only one jumper needed.

Don't be in too much of a hurry to get on the roof to replace the old rotator motor. The motors are designed for extended exposure to the elements, and are far more durable than the control boxes. If the motor does need replacement, you can check with a local TV-repair shop or electronic-appliance store for new motors. You could also contact the original manufacturer if you do not want to try a different brand.

Installation and Use. The RCR can sit near the television, tucked into any unobtrusive location. The only important thing to remember is that IC1 must be able to "see" the infrared pulses from the remote control. Depending on the RCR's location and the room itself, direct line-of-sight might not be necessary. Sometimes the infrared pulses will reflect strongly off a white ceiling and still be bright enough for the RCR to successfully detect them. Simply connect it up and press "91" to synchronize the rotator to the RCR.

By pressing "70," "71," "72," "73," or "74," you can aim the antenna counter clockwise North, East, South, West, and clockwise North respectively. Those preset directions can be used to find the best reception for a particular TV station. Those special channel directions are:

70—counter-clockwise North
71—East
72—South
73—West
74—clockwise North

If you know that a particular station comes from a city to the east, for instance, press "71". Using the channel up and channel down buttons, adjust the antenna position for the best picture.

With the Teknika TV-set arrangement, the "Mute" button acts as the command to store a channel direction. With the M/A-COM cable-converter option, the "Enter" button is used to store the channel-direction information. To store the direction of a TV station, press the "Enter" or "Mute" button and the two digits for the station number. Alternately, you can also press "99" plus the two-

Continued on page 62

ALL ABOUT DVD

The new, hot consumer-electronics product, the power of DVD is really unleashed when used in a personal computer. Here's why, and how easy it is to harness that power in your own set up.

STEPHEN J. BIGELOW

The compact disc (CD) opened up a whole new world of possibilities for the PC. Those simple, mass-produced plastic discs could hold up to an hour of stereo music, or as much as 650MB of data. Software makers quickly found the CD-ROM to be an outstanding medium for all types of multimedia applications, large databases, and interactive games. But today, the CD-ROM is showing its age, and a single CD no longer provides enough storage for the increasing demands of data-intensive applications. Fortunately, a new generation of high-density optical storage media, called DVD, is now appearing. The home-entertainment applications of DVD, which alternately has been defined as "Digital Video Disc" and "Digital Versatile Disc," have been well publicized. But more important to computer users is that DVD technology promises to supply up to 17GB of removable storage for your desktop PC. This article explores the background and workings of DVD, particularly for computer applications; shows you the steps for installing a DVD package in your own PC; and offers some basic troubleshooting that can keep you out of trouble.

Lots of Promise. The argument for DVD is a compelling one because having gigabytes of removable storage to work with opens up some exciting possibilities for entertainment and software development. As DVD works its way into the marketplace, you're going to see designations such as DVD-Video, DVD-Audio, and DVD-ROM. DVD-Video is the approach used to store movies on the disc (analogous to the way audio is placed on CDs). DVD-Audio (not currently available but expected within a couple of years) is the audio format that might someday replace today's audio CDs. In addition to offering much higher storage capacity, which, among other things, will allow special effects such as surround, these discs will also allow some video or photographs to be displayed on a TV. DVD-ROM refers to computer-based software and data recorded on the disc. Where audio CDs can be played on CD-ROM drives, DVD-Video and eventually DVD-Audio discs will be playable on DVD-ROM drives in your PC.

Understandably, there are a lot of players looking to make the most of what DVD has to offer. Hollywood has been a major factor in the development of DVD-Video—placing full-length movies, sound tracks, and even multi-lingual sub-titling on a single disc. Since all DVD discs are read by laser, there is no physical contact between the disc and its player. The result is that the disc won't wear out like VHS video tapes.

Business presentations, education, and professional training will also benefit from DVD technology. Animations, charts, and interactive applets can be integrated with real-time video. This offers a truly immersive training experience that CD-ROM technology has only approached.

Applications for archiving are limitless. Mapping programs, telephone directories, encyclopedias—any software that now spans several CDs can be concentrated on one DVD disc, and dramatically expanded to offer unprecedented detail. Any data-intensive computer software (especially 3D and other interactive games) will get a real boost from the sheer storage volume offered by DVD-ROM.

Specifications and Standards. The next steps in exploring DVD are to understand the various specifications "on the box," and to become familiar with the specifications that make DVD work and what a DVD will support. You don't need a lot of technical details, but you should recognize the most important points that you'll probably run across while reading documentation.

The *access time* is the time required for the drive to locate the required information on a disc. Optical drives like CD and DVD are relatively slow and can demand up to several hundred milliseconds to access information. In fact, because of the massive amount of data and the greater density, DVDs are actually slower than ordinary CD-ROMs. For example, access time for a normal CD is 180ms, while currently available DVD kits sport access times that range between 200 and 470ms.

Once data has been accessed, it must be transferred from the disc to the system. The *data transfer rate* measures how fast data can be read from the disc. There are two typical means of measuring the data rate; the speed at which data is read into the drive's on-board buffer (the *"sequential"* data transfer rate), and the speed at which data is transferred across the interface to the drive controller (the *"buffered"* data transfer rate). As an example, one currently available DVD drive offers a *sequential* data transfer rate of 1.35MB/s, and 900KB/s for an ordinary CD (about equal to a 6X CD-ROM drive). By comparison the drive can support *buffered* data transfer rates of 8.3MB/s (DMA Mode 2), 13.3MB/s (DMA Mode 1), or 11.1MB/s (PIO Mode 3). As a result, the DVD-ROM drive is compatible with most EIDE drive controllers.

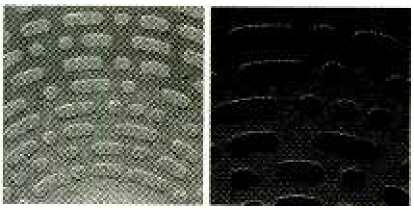


Fig. 1 One way that DVDs squeeze more data on a disk is to space the lands and pits that contain the data much tighter. The spacing for a DVD disk is shown on the left; that for a standard CD on the right.

CD technology is defined by a set of accepted standards—we have come to know these as "books." Since each CD "book" was bound in a different color jacket, each standard is dubbed by color. For example, the standard that defines CD audio is called Red Book. Similarly, DVD technology is defined by a set of "books". There are five books (labeled A through E) which relate to different applications: *Book A* defines the format and approach used for DVD-ROM (programs and data); *Book B* defines DVD-Video; *Book C* defines DVD-Audio (this specification is still under development); *Book D* defines DVD-WO (write once); and *Book E* defines DVD-E (erasable or re-writeable) and DVD-RAM.

All DVD discs must use a data format that describes how data is laid out. Data formats are critical because they outline data structures on the disc such as volumes, files, blocks, sectors, CRCs, paths, records, file-allocation tables, partitions, character sets, time stamps, as well as methods for reading and writing. The format used by books A, B, and C is called the *UDF Bridge*. The UDF Bridge is a combination of the UDF (Universal Disk Format created by OSTA—the Optical Storage Technology Association) and the established ISO-9660 format used for CDs. You may see the UDF referred to as standard ISO/IEC 13346. The UDF is a very flexible format that has been adapted to DVD, and made backward-compatible to existing ISO-9660 operating-system software (such as Windows 95). Actual use of this disk system on DVD discs will depend in large part on what Microsoft dictates as the future operating system standard. Stand-alone DVD movie players are supposed to use UDF, while computer applications will use the UDF Bridge until UDF support becomes universal (possibly as early as Windows 98).

Even with the huge data capacities offered by DVD, an entire movie's worth of real-time audio and video would never fit on a DVD without some form of compression. Both audio and video must be extensively compressed, and MPEG (Motion Pictures Experts Group) compression has been the scheme of choice. Video compression uses fixed-data-rate MPEG-1 (ISO/IEC 1117-2) at 30 frames-per-second with resolutions of 352 × 240, or variable-data-rate MPEG-2 (ISO/IEC 13818-2) at 60 frames-per-second with resolutions of 720 × 480. Audio compression uses MPEG-1 (ISO/IEC 1117-3) stereo, MPEG-2 (ISO/IEC 13818-3) 5.1 and 7.1 surround sound, or Dolby AC-3 5.1 surround and stereo (the audio designations "5.1" and "7.1" indicate five—or seven—signal channels, plus one subwoofer channel). MPEG-2 and AC-3 audio compression allow 48 thousand samples-per-second, where MPEG-1 allows only 44.1 thousand samples per second. MPEG-2 compression is typically regarded as the preferred scheme for DVD.

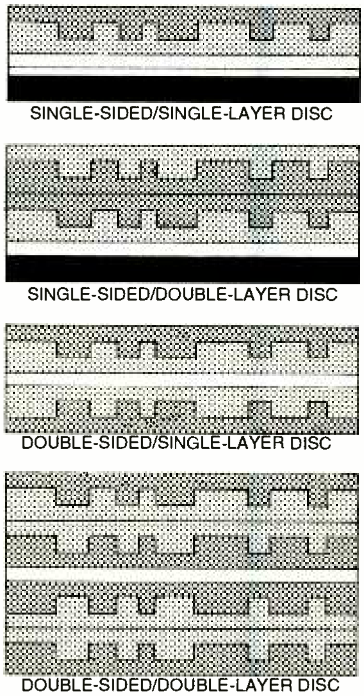


Fig. 2. Each side of a DVD can contain two layers of information, and both sides of the disk can be used.

One of the most important aspects of any technology is "backward compatibility"—how well will the new device support your existing media. The same issue is true for DVD drives. Since DVD technology is designed as an improvement over existing CD-ROMs, the DVD was designed to *replace* the CD-ROM rather than co-exist with it. Ideally, you'd remove your CD-ROM and replace it with a DVD-ROM drive. This means that the DVD must be compatible with as many existing CD-ROM standards as possible. A typical DVD-ROM drive will support CD audio, CD-ROM, CD-I, CD Extra, CD-ROM/XA, and Video-CD formats. Multi-session formats such as Photo CD are not yet supported on all DVD drives. One format that is not supported by any DVD drive yet is the CD-R (recordable CD) format. The laser used in a DVD cannot read

TABLE 1—SPECIFICATIONS OF DVD AND CD MEDIA

Specification	DVD	CD-ROM
Diameter (mm)	120	120
Disc Thickness (mm)	1.2	1.2
Substrate Thickness (mm)	0.6	1.2
Track Pitch (µm)	0.74	1.6
Minimum Pit Size (µm)	0.4	0.83
Wavelength (nm)	635/650	780
Single Layer Capacity (GB)	4.7	0.65

the CD-R, and in some cases, may even damage the CD-R disc. However, new CD-R blanks are being developed that should overcome this problem.

DVD Media. At its core, DVD technology is identical to classical CD-ROMs—data is recorded in a spiral pattern as a series of pits and lands pressed into a plastic substrate. The actual size and dimensions of a DVD are identical to our current compact discs. However, there are some key differences which give DVD its advantages.

First, the data pits themselves are highly compressed on the disc—where classical CDs use spiral tracks that are 1.6 µm apart, DVD tracks are only 0.74 µm apart. A typical pit on a classic CD is 0.83 µm, but DVD pits are just 0.4 µm. Table 1 lists the specifications for DVD and CD media. In short, the data on a DVD is *much* denser than on a regular CD. Figure 1 compares the data densities of DVD's and CDs. In order to detect the DVD's smaller geometries, the laser used in a DVD operates at a much shorter wavelength (a short-wavelength red laser is used).

Second, DVD can use two "layers" of pits and lands (each in their own reflective layer). The laser focus control can select which layer to read.

Finally, a regular CD only uses one side of the disc, but both sides of the DVD can be used. Combined with the multi-layer technique, the DVD can supply up to four layers of data to a DVD drive (see Fig. 2). In actual practice, DVD-ROM discs will likely only use one side of the disc—at least for a while. What all this means is that a DVD can offer up to 8.5GB of storage for a single-sided DVD, or up to 17GB of storage for a double-sided DVD.

Caring For a DVD Disc. As with CDs, a DVD disc is a remarkably reliable long-term storage media (conservative expectations place the life estimates of a DVD disc at about 100 years). However, the longevity of an optical disc is affected by its storage and handling—a faulty CD can cause file and data errors that you might otherwise interpret as a defect in the drive itself. You can get the most life out of your optical disc by obeying the following rules:

Don't bend the disc. Polycarbonate is a forgiving material, but you risk cracking or snapping (and thus ruining) the disc.

Don't heat the disk. Remember, the disc is plastic. Leaving it by a heater or on the dashboard of your car will cause melting.

Don't scratch the disc. Laser wavelengths have a tendency to "look past" minor scratches, but a major scratch can cause problems. Be especially careful of circular scratches (one that follows the spiral track). A circular scratch can easily wipe out entire segments of data that would be unrecoverable.

Don't use chemicals on the disc. That especially includes chemicals containing solvents such as ammonia, benzene, acetone, carbon tetrachloride, or chlorinated cleaning solvents. Such chemicals damage the plastic surface.

Eventually, a buildup of excessive dust or fingerprints can interfere with the laser beam enough to cause disc errors. When this happens, the disc can be cleaned easily using a dry, soft, lint-free cloth. Hold the disc from its edges and wipe radially (from hub to edge). Do not wipe in a circular motion. For stubborn stains, moisten the cloth in a bit of fresh isopropyl alcohol (do not use water). Place the cleaned disc in a caddie or jewel case for transport and storage. Contrary to popular belief, DVD discs are not more sensitive to scratches or dust than ordinary CDs.

DVD Drives. A DVD drive looks almost identical to a CD-ROM drive in size, shape, and layout. In fact, if not for the "DVD" logo on the tray, you'll probably mistake a DVD-ROM drive for a CD-ROM drive. The front of a DVD drive (see Fig. 3) carries all of the standard features that you'd find on any CD-ROM. A motorized disc tray loads and unloads the disc. You can close or open the tray by toggling the Eject button. It's interesting to note that a DVD-ROM won't eject a disc that is "locked" by a software application (such as a running movie). You will need to close your DVD application before ejecting the "locked" disc. The Busy indicator lights whenever data is being read from the drive. Since the DVD drive also supports CD audio, you can connect headphones to the headphone jack, and adjust volume right from the front panel.

Much of the rear of a DVD-ROM may also look familiar (see Fig. 4). Power is connected through a 4-pin

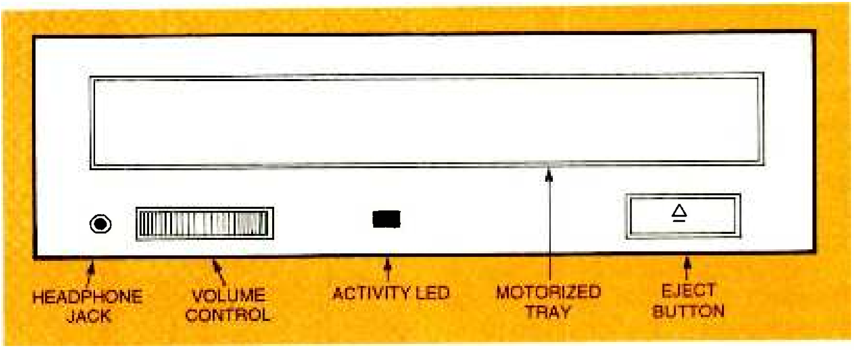


Fig. 3. The front of a DVD drive will be familiar to users of CD-ROM drives as it has the same look and controls.

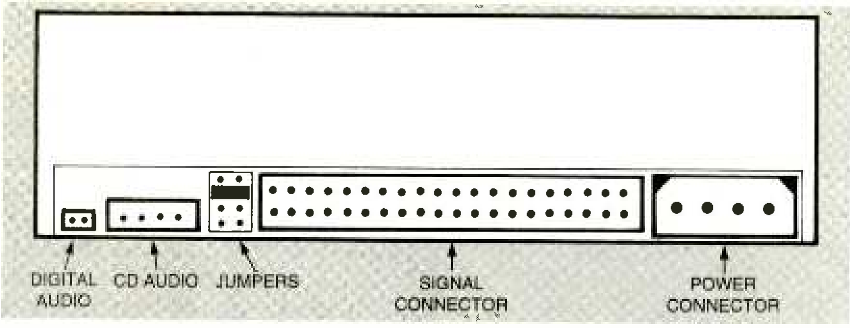


Fig. 4. The rear of a DVD drive sports the connectors needed to interface it with the rest of the system.

Molex connector, so you can use any suitable power connector from your power supply. The signal connector is typically either EIDE (40-pin) or SCSI (50-pin), and connects the drive directly to your existing controller. Unlike early CD-ROM drives, DVD-ROM drives do not use "proprietary" drive controllers. A series of small jumpers allows you to set the drive's identity. For SCSI-type drives, you can set the SCSI ID (usually ID2 through ID6). For EIDE-type drives, you will set the drive as either a primary ("master") or secondary ("slave") drive. If you're running an EIDE DVD-ROM along with a hard drive, the hard drive would typically be the "master" device, and the DVD-ROM drive would be the "slave" device. If you're running the DVD-ROM drive alone, set it as the "master" device. Finally, there are two audio output connectors; a 4-pin CD audio connector which attaches to a sound board, and a 2-pin digital audio connector which supplies sound to a digital audio tape (DAT) or other digital recording system.

Things get a little more interesting when you look inside the DVD-ROM drive (see Fig. 5). Looking in from the top of the drive, you'll see the major sub-assemblies needed to operate the drive. That black circular wheel near the tray is the spindle motor which turns the disc. You can also see the laser assembly, and the laser sled that the laser rides back and forth on. A small motor drives a screw which runs the sled. The load/unload mechanics are obscured below the plastic tray.

The main electronics deck is mounted on the underside of the drive (see Fig. 6). This is a single printed-circuit board that contains all of the circuitry needed to run the drive interface, load/unload motor, audio amplifiers, spindle motor, laser, and laser sled.

One item of particular interest in Fig. 6 is the removable IC. That chip contains firmware for the drive, as well as the "region codes" for the drive. Motion picture studios want to control the home release of movies in different countries because theater releases are not simultaneous. Therefore, they have required that the DVD standard include codes that can be used to prevent playback of certain discs in certain geographical regions. Each player is given a code for the region in which it's sold. The player will refuse to play discs that are not allowed in that region. This means that discs bought in one country might not play on players bought in another country. Table 2 lists the code numbers, and the regions each number covers. Keep in mind that region codes are entirely optional, and discs without codes will play on any player in any country.

The MPEG-2 Decoder Board. Although the DVD drive requires a SCSI or EIDE drive controller for normal program data, DVD video and audio do not use that data path. There are two reasons for this. First, the data required to reproduce real-time video and audio would bog down even the fastest PC. Second, video and audio data are highly compressed using MPEG standards, so even if the PC bus wasn't bogged down by the compressed data, the decompression process would load down the system with processing overhead. In order to play DVD audio and video, DVD-ROM drives require a stand-alone, hardware-based MPEG-2 decoder board such as the one in Fig. 7. That MPEG-2 decoder board works independently of the drive controller system, video system, and sound system.

When the original video source is recorded for DVD, MPEG-2 analyzes the video picture for redundant data. In fact, over 95% of the digital data that represents a video signal is redundant, and can be compressed without visibly harming the picture quality (also referred to as "loss-less compression"). By eliminating redundant data, MPEG-2 achieves excellent video quality at far lower bit rates.

MPEG-2 encoding for DVD is a two-stage process. The original signal is first evaluated for complexity,

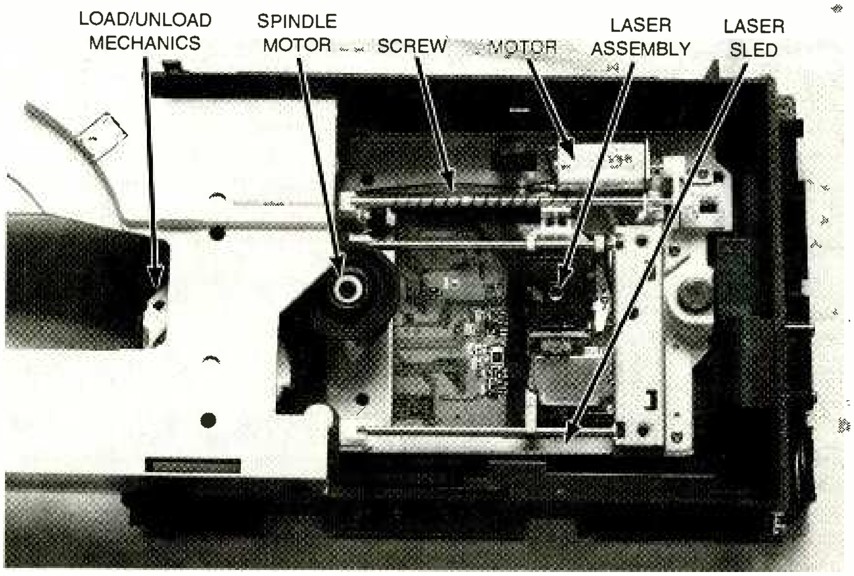


Fig. 5. Inside a DVD drive. This top view shows most of the drive's mechanics.

then higher bit rates are assigned to complex pictures, and lower bit rates are assigned to simple pictures. This allows for an "adaptive" variable bit-rate process. The DVD video format uses compressed bit rates with a range of up to 10Mbits/s. Although the "average" bit rate for digital video is often quoted as 3.5Mbits/s, the actual figure will vary according to movie length, picture complexity, and the

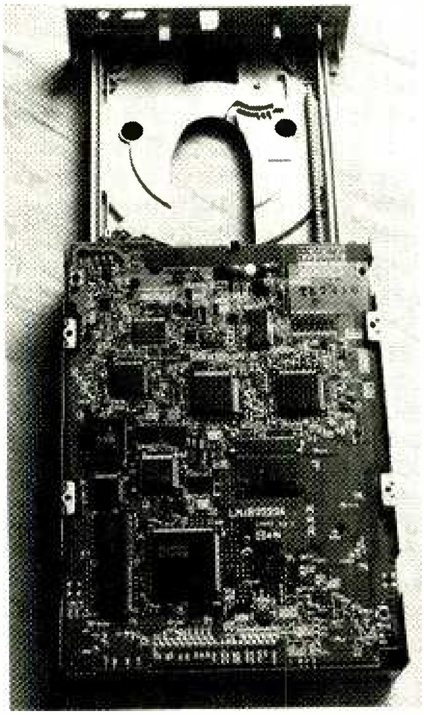


Fig. 6. The drive's main circuit board is mounted on the underside of the drive.

number of audio channels required. With MPEG-2 compression, a single-layer, single-sided DVD has enough capacity to hold two hours and 13 minutes of video and audio on a 12cm disc. At the nominal average data rate of 3.5Mbits/s, that still leaves enough capacity for discrete 5.1 channel digital sound in three languages, plus subtitles in four additional languages.

In addition to MPEG-2, audio can be encoded using Dolby AC-3 (also called "Dolby Surround AC-3" or "Dolby Digital"). With five channels and a common sub-woofer channel (5.1), you get the effects of 3D surround sound with right, left, center, left ear, right ear, and common sub-woofer speakers. AC-3 runs at 384Kbits/s.

In actual practice, DVD products sold in North America and Japan will include Dolby AC-3 sound on the accompanying MPEG-2 board, while DVD products sold in Europe will likely use the MPEG-2 audio standard.

As shown in Fig. 8, there are five major connections on the MPEG-2 decoder board. Those are an Analog Input jack, an Analog Output jack, a Digital Output jack, a Monitor connector, and a Video Input connector. The Analog Input is rarely (if ever) used in normal operations, but it may be handy for mixing in an auxiliary audio signal to the decoder board. The Analog Output signal provides the master audio signal, which is fed to the Line Input of your existing sound board. The advantage of using a Line Input is that you don't need a volume control on the decoder board. Instead, you can set the Line Input volume through your sound board's "mixer" applet. When you play a DVD video, any audio will continue to play through your sound board and speakers. The Digital Output is intended to drive an external Dolby Digital device, so you will probably not be using the Digital Output in most basic PC setups.

The MPEG-2 decoder board will now drive your VGA/SVGA monitor through the Monitor connector. This is important because the decoded video stream is converted to RGB information, and fed to the monitor directly—that avoids having to pass the video data across the PCI bus to your video card. The normal output from your video card is looped from your video board to the decoder card, so while the decoder board is idle, your normal video signal is just "passed through" the MPEG-2 board and then on to the monitor.

Installing a DVD Drive System. Now that you've got a handle on the essentials of DVD, we can get to the fun part—a complete installation of a typical system, the Creative Labs PC-DVD package (retail $500). The kit comes complete with a Matsushita EIDE DVD-ROM drive, MPEG-2 Decoder board, video loop-back cable, CD audio cable, Line Input audio cable, and IDE (40-pin) data cable. The actual installation process took this author under an hour, but your installation may take longer depending on how much hardware you need to or want to re-arrange. (Note: Before you attempt any new drive installation on your PC, be sure to perform a complete system backup of your entire system first, and keep a bootable floppy diskette handy in case of emergencies.)

Before you start any DVD installation, you'll need to make sure your system meets some basic requirements. DVD installation requires a 90MHz Pentium PC with at least 16MB of RAM running Windows 95. At least 4MB of hard-drive space will be needed for DVD drivers and application software, and your system's motherboard must have at least one PCI bus slot available for the MPEG-2 decoder board. Finally, there should be one open external drive bay available for the DVD-ROM drive itself.

There are two other issues that you need to consider before starting the installation. First, consider your existing CD-ROM drive (there's almost certainly one in your sys-

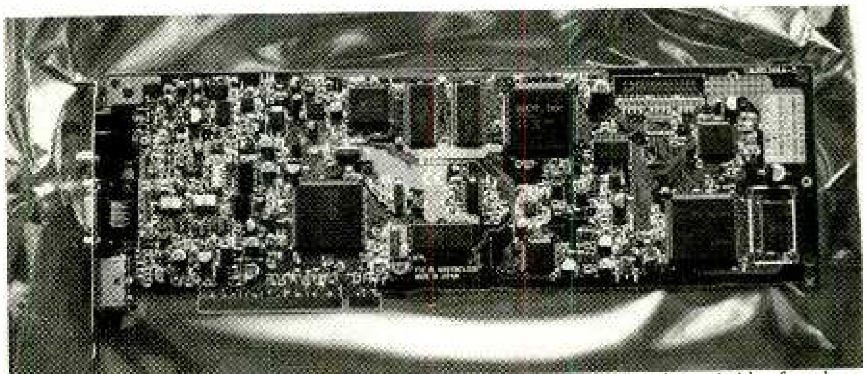


Fig. 7. The use of a MPEG-2 board like this one prevents the compressed audio and video from bogging down a PC.

TABLE 2—REGION CODES

Code	Region
1	Canada, US, and US territories
2	Japan, Europe, South Africa, Middle East (including Egypt)
3	Southeast Asia, East Asia (including Hong Kong)
4	Australia, New Zealand, Pacific Islands, Central America, South America, Caribbean
5	Former Soviet Union, Indian Subcontinent, Africa (also North Korea, Mongolia)
6	China

tem). Ideally, you'd like to remove the CD-ROM and install the DVD-ROM in its place. However, you may want to keep the CD-ROM in place if; (1) you use CDs (such as Photo CDs) that you know the DVD-ROM drive will not support, or (2) if you want to continue using DOS-based CDs. The DVD software and drivers do not support DOS, so you would lose all CD capability under DOS by removing the CD-ROM (that's one point that the DVD documentation leaves out).

Second, consider your DVD drive's interface. SCSI drives are rather straightforward since you can simply set the drive ID, then connect the drive directly to the SCSI cable (you may need to re-terminate the SCSI cable). EIDE drives are a bit tricky—most PCs today offer two IDE ports—a primary EIDE port which can support two EIDE devices, and a secondary IDE port that can also support two devices. If you can, install the EIDE DVD-ROM as the "slave" device on the EIDE port (alongside your hard drive). However, if you have two EIDE hard drives in the system, you should make the DVD drive the "master" device on the secondary IDE port. You may recall that older CD-ROM drives could present problems when used with hard drives, but DVD-drives use more current interfaces, and should not interfere with an existing hard drive's operation.

The hardware process basically consisted of four steps; install the drive, cable the drive, install the decoder board, and cable the decoder board. Once the hardware is in place, you can then install the drivers and application software. If you've ever installed standard "multimedia kits" (consisting of a CD-ROM drive and sound card), then installing a DVD-ROM kit should be a snap. (Note: When working inside your PC, remember to keep the system turned off and unplugged. You should use a properly grounded anti-static wrist strap to remove any electrostatic charges from your body, but you should at least touch the PC's metal chassis regularly during the installation process.). Let's walk through the procedure:

Install the drive. Mount the DVD-ROM drive in an open drive bay, and secure it into place with four screws. As with all drives, be sure not to over-tighten the screws—that could warp the drive just slightly and throw it out of alignment. Also check the jumpers on the rear of the drive. If the drive is SCSI, set the jumpers for the proper SCSI ID. For EIDE drives, set the drive as either "master" or "slave". If you plan to run the drive alongside a hard drive, set the DVD drive as "slave". If you plan to run the DVD drive on its own controller port, set the DVD drive as "master".

Cable the drive. There are typically three cables that need to be connected to the DVD-ROM drive: A drive power cable, a data cable, and a CD audio cable. You can use any four-pin drive power cable, but do not use a power cable from a "Y-splitter". Splitting your power that way can sometimes cause erratic drive behavior. For "slave" drive configurations, you can connect the existing 40-pin signal cable to the data connector on the back of the drive (one end of the cable connects to the drive controller, one end connects to the hard drive, and the third unused connector attaches to the DVD drive). For "master" drive configurations, you can use the 40-pin cable that came with the DVD package. Finally, connect the CD audio cable between the DVD drive and the CD audio connector on your sound board. If you plan on leaving your existing CD-ROM in place, and playing any CD audio from the CD-ROM drive, don't connect the DVD drive's CD audio connector. (Note: Remember to align pin 1 on the signal cable with pin 1 on the DVD drive. You can tell pin 1 on a ribbon cable by the red or blue stripe that

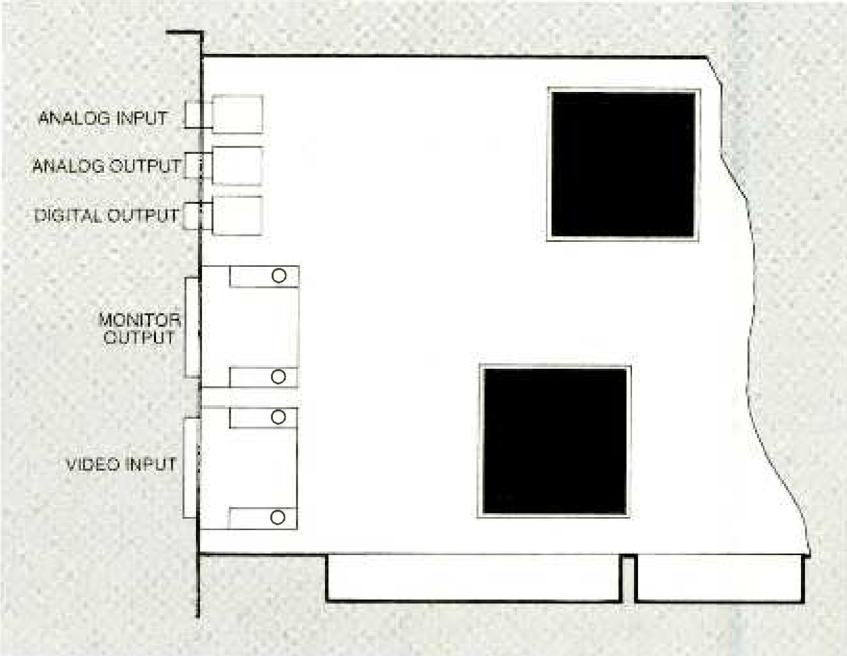


Fig. 8. These are the five connectors found on the rear of an MPEG decoder card. Their functions are described in the text.

runs along the cable.)

Install the decoder board. Once the drive is in place, your next step is to install the MPEG-2 decoder board. You do not need to configure the decoder board first—rather than jumpers, the decoder is configured through software. Find an unused PCI bus slot, and mount the board—you might need to remove one of those little metal plates from the expansion slot opening first. You can use the little screw from that metal plate to secure the decoder board into place. Make sure that the board sits evenly and completely in its bus slot, and *never* force an expansion board.

Cable the decoder board. The last step is to interconnect the MPEG-2 decoder board with the other devices in your system. In general, there are three connections that you have to make. Disconnect the monitor from your video board, and attach it to the decoder's Monitor connector. Use the loop-back cable to attach the video signal from your video board to the decoder's Video Input connector. Then use the sound cable to connect the decoder's Audio Output to the Line Input jack of your sound board.

Software Installation. As noted above, the MPEG-2 decoder board packaged with the Creative Labs PC-DVD kit lacks jumpers. Instead, the decoder is configured exclusively through software—that simplifies the hardware-installation process and reduces the chances of hardware conflicts due to incorrectly set jumpers. The software installation process involves three phases; installing the decoder drivers, installing the DVD-ROM drivers, and installing the DVD applications.

The first time you reboot your PC after the hardware installation, Windows 95 will automatically detect the new hardware. It won't identify the hardware exactly, but it will identify the hardware as a "PCI Multimedia Device". Insert the driver diskette into your floppy drive, and select the *diskette provided by the manufacturer* option when prompted. Windows 95 will install the decoder board drivers, and configure the board. When Windows 95 asks you to restart the system, choose *NO*.

The next step is to install the DVD-ROM drivers. Choose *Start*, then *Run*, then type *A:/SETUP*. Click *OK*. The setup routine will install the drivers for your DVD drive, and configure it appropriately. When the installation is complete, Windows 95 will ask you again to restart the computer. This time, remove the driver diskette and select *OK* to restart the computer. The next time Windows 95 starts, your DVD drive and decoder board should be active.

The last step is to install any DVD applications (such as a DVD control panel or DVD-Video player). The applications will usually be on a separate floppy disk. Insert the floppy disk, Click *Start*, then *Run*, then type *A:/SETUP*. Then all you need to do is follow the instructions. (Note: This section describes the installation of one DVD kit—your own software installation requirements may be different. Always read through your installation instructions thoroughly.)

Optimizing Video for DVD. DVD works best using a resolution of at least 800 × 600, and a "High Color" (16-bit or 65K-color) mode. If your video card will support even higher resolutions or color depths, feel free to use them. Use your Display icon under your Control Panel to adjust the video configuration as needed.

Basic DVD/MPEG-2 Troubleshooting. Even though a DVD package should install with an absolute minimum of muss and fuss, there are times when things just don't go according to plan. Software and hardware problems can both interrupt your DVD system. The following symptoms cover some of the most common troubleshooting issues.

Symptom 1: *The DVD drivers refuse to install.* This is almost always because Windows 95 is having a problem with one or more .INF files on your driver installation disk(s). Check with your DVD vendor to confirm whether you need to delete one or more entries in your OEMxx.INF file(s) (where "xx" is any suffix). You may also need to delete one or more entries from a MKEDVD.INF file. The .INF files are typically contained in the C:\WINDOWS\ INF\OTHER directory. Once you've corrected the appropriate .INF file(s), you can

DVD GLOSSARY

CD (Compact Disc)—removable optical storage capable of holding up to 650MB of data using 12cm optical discs.

CD Audio—the original "red book" format adopted by Sony and Philips in 1980 used to record music and voice audio. Also called compact disc digital audio (CD-DA).

CD Bridge—a "bridge" disc adds information to a CD-ROM/XA track which allows the track to be played on a CD-I player. The bridge disc can be played on a CD-I player connected to a TV, or a CD-ROM/XA player connected to a computer. Typical examples of CD bridge discs are Photo CDs and Video CDs.

CD-I (Compact Disc Interactive)—a 1996 standard which extends CD-ROM capabilities by adding search and "navigation" features to the disc.

CD Extra—also called CD Plus or Enhanced CD. A two-session disc which stores audio tracks on one "session", and CD-ROM data on another "session".

CD-R (Compact Disc Recorder)—a drive capable of writing data or audio information to blank CD media.

CD-ROM (Compact Disc Read Only Memory)—the classic "yellow book" standard for recording programs and data to a CD.

CD-ROM/XA (CD-ROM Extended Architecture)—a disc format developed in 1988 which greatly improves the synchronization of audio and video data on a CD for playing multimedia titles.

DVD (Digital Video Disc or Digital Versatile Disc)—the generic term used to describe the next generation of high-density optical storage discs capable of holding up to 17GB of data.

MPEG (Motion Pictures Experts Group)—the industry group responsible for developing compression standards for multimedia content (primarily audio and video).

PCI (Peripheral Component Interconnect)—the current high-performance 32/64-bit expansion bus architecture used in today's Pentium-based PCs.

Photo CD—a type of CD bridge disc based on CD-ROM/XA. A standard released by Kodak in 1990 designed for storing high-quality photographic images.

Video CD—a type of CD bridge disc based on CD-I designed for playing movies and other commercial multimedia presentations.

re-install the DVD drivers:

- Click *Start*, select *Settings*, then click on *Control Panel*. Double-click on the *System* icon.
- Click on the *Device Manager* tab, then select *"Sound, Video, and Game Controllers"*.
- Select the DVD driver(s), then click *Remove*.
- Exit the *Device Manager* and reinstall the drivers again.

Symptom 2: *The DVD drive isn't detected.* There are several possible reasons why the DVD drive would not be detected. Check the power connector attached to the drive, and make sure that the drive isn't being powered from a "Y splitter" power cable. Check the signal cable next. Both SCSI and EIDE signal cables must be attached securely to the drive. SCSI interfaces are complicated a bit by termination. Make sure that the drive is jumpered properly for its SCSI ID or EIDE "master" or "slave" relationship. Finally, make sure that the DVD drivers are installed and running. Check the drivers under the *"Sound, Video, and Game Controllers"* entry of the *Device Manager*.

Symptom 3: *The DVD motorized tray won't open or close.* The most common issue here is the DVD application itself. Some DVD applications (such as DVD-Video player applications) will "lock" the disc tray closed. Try closing all open applications. If the tray still won't open, try restarting the PC. That should clear any "software lock". If the tray still refuses to open or close, the drive itself may be defective—you can "force" the tray open using a straightened paper clip in the emergency eject hole in the front of the drive.

Symptom 4: *There is no audio when playing an audio CD.* This is a common problem—especially during new DVD-drive installations. Chances are that you did not connect the CD audio cable between the DVD drive and the sound board. If so, the cable may be reversed (or defective). Of course, if you're still using your original CD-ROM drive, and the CD-ROM is connected to the sound board, there will be no CD audio from the DVD drive—there is no way to "parallel" the sound cable.

ABOUT THE AUTHOR

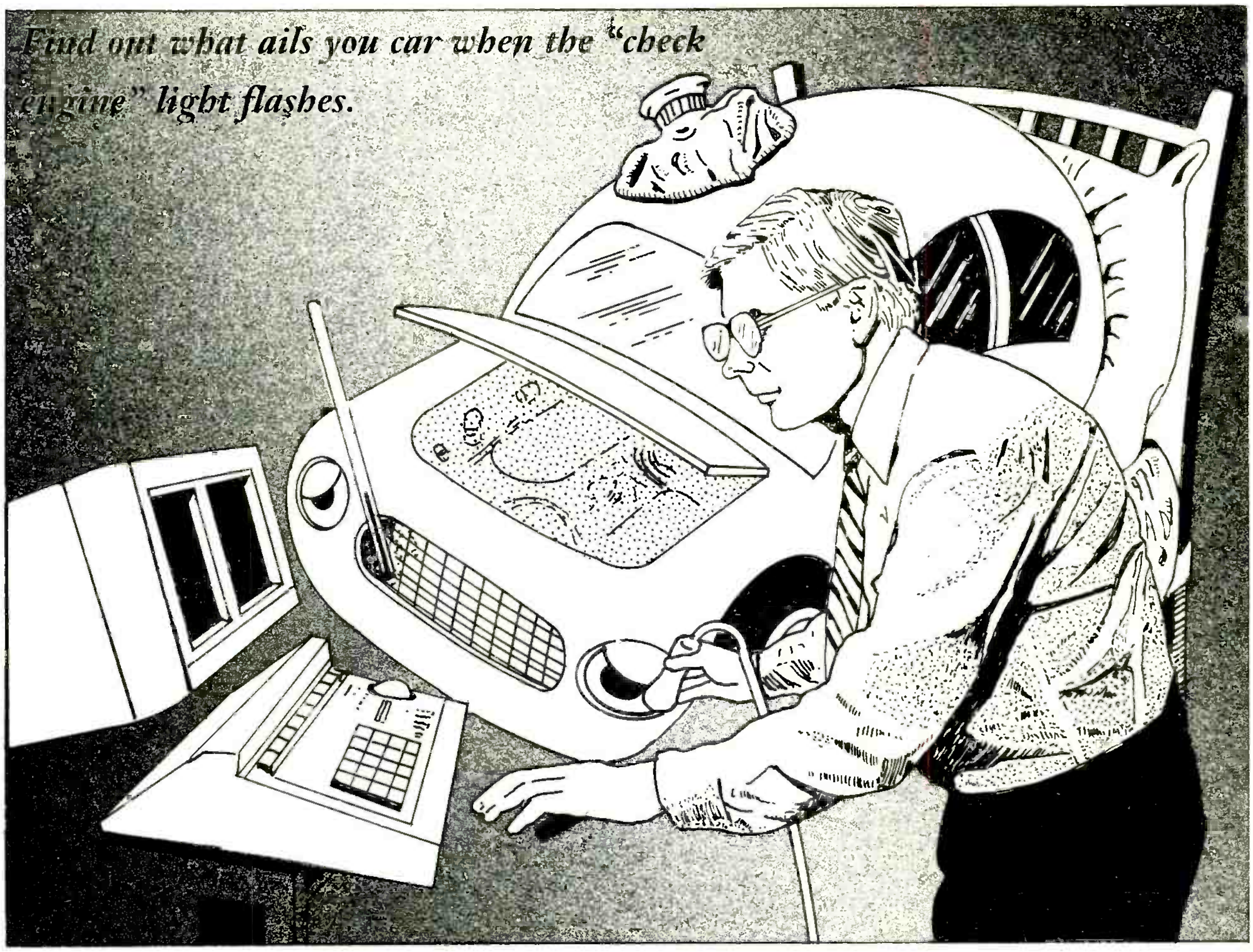
Stephen J. Bigelow is the author of *"Troubleshooting, Maintaining, and Repairing Personal Computers: A Technician's Guide"* (published by McGraw-Hill). He can be reached by e-mail at sbigelow@cerfnet.com. You may also visit the Dynamic Learning Systems world wide web site at http://www.dlspubs.com. Comments and questions about this article are welcome at any time.

Symptom 5: *There is no DVD audio while playing a movie or other presentation.* Here's another common oversight during new DVD installations. Check the external audio cable attached between the MPEG-2 decoder board and the Line Input jack of your sound board. The cable might be plugged into the wrong jack(s), or the cable might be defective. Also check the sound board's "mixer" applet and see that the Line Input volume control setting is turned up to an acceptable level.

Symptom 6: *Video quality appears poor.* MPEG-2 compression is well-respected for its ability to reproduce high-quality images. The problem with "poor" image quality is almost always because of your video configuration—your color depth or resolution are too low. DVD-Video playback is best at resolutions of 800 × 600 or higher, and color depths of 16-bits (High Color) or higher (*i.e.* 24-bit True Color). In most cases, 256 colors will result in a "dithered" appearance.

Symptom 7: *You see an error message that says "Disk playback unauthorized".* The region code on the DVD disc does not match the code embedded into the drive. There isn't much that can be done when this error occurs. Note that region code limitations are only applied to DVD-Video movie releases—computer-software programs and data discs are not marked with region codes.

Conclusion. DVD offers advantages that CD-ROM never had—tremendous storage space, and high-quality audio and video playback. Coupled with the fact that most CDs will work with DVD drives, it seems that the DVD is poised to replace the CD-ROM over the next few years. Ω



Reading Automobile Computer-Service Codes

THOMAS FOX

Almost all late-model cars on the road today have some form of computer control for their engines. Sometimes those control computers are referred to as ECUs (for *E*lectronic *C*ontrol *U*nit), ECMs (*E*lectronic *C*ontrol *M*odule), or ECAs (*E*lectronic *C*ontrol *A*ssembly). Those systems have made the automotive industry the number one user of microcontroller chips. The demand the auto manufacturers have for computer chips appears to be insatiable. Automotive engineers are writing the specifications for a large number of new designs—including some of the so-called "general purpose" devices. One example of that is the Motorola 68HC11. While that chip started out as one specifically designed for cars, today it is used in a variety of applications, many of which aren't related to automotive electronics at all!

Facing a computerized engine can send a chill up the spine of many shade-tree mechanics—including those that are desktop-computer "experts." Even if they can swap out a motherboard quicker than they can replace a new battery in a car, some of them cringe in fear that some day the CHECK ENGINE or SERVICE ENGINE SOON warning light will go on in their computerized chariot. What do they do then?

Thanks to the foresight of automotive designers, the solution is relatively simple—check out the computer's service code. Those service codes are also referred to as "trouble codes." However, before you can find out what the code is, the computer system's self-diagnostic feature must be enabled.

Entering the Diagnostic Mode. In order to read the trouble codes stored in an engine computer, the computer must be told to reveal what it found. That is done by placing the unit in a "diagnostic mode."

Depending on the manufacturer, there are different procedures for doing that. While the descriptions presented here will work with most American cars, you should always make sure that the procedure you are about to follow is correct for your particular vehicle. If you don't follow the manufacturer's directions exactly, you could damage the engine computer. Replacing that device is very expensive. In the words of the old saying—look before you leap.

Of the major American automobile manufacturers, Chrysler has the simplest way of entering the computer's diagnostic mode. Put the car's ignition key in the ignition switch. You should not start the car at any time during this procedure. Within a 5-second time frame, turn the ignition switch ON-OFF-ON-OFF-ON. Remember, do not try to actually start the car.

In General Motors cars, first find the diagnostic connector. It usually is in an easy-to-reach spot under the dash and near the steering column. A typical GM diagnostic connector is shown in Fig. 1. With the ignition in the OFF position, connect together points A and B of the diagnostic connector with a short length of a solid 22-gauge hookup wire. A paper clip bent into an appropriate shape will also work. **Be careful—if you connect the wrong terminals together, you can damage the computer.** Once points A and B are jumped, put the ignition switch in the "on" position but do not attempt to start the vehicle.

As with the other auto manufacturers, no expensive equipment is needed to enter the diagnostic mode with many Ford cars. However, Ford-built cars have a slightly more confusing way of getting the computer into its diagnostic mode. Because of that, details will not be given since a wrong connection could damage the vehicle's computer system. An overview of the process is nevertheless interesting to those that will be working on Ford cars. As with any vehicle, a decent service manual will be valuable to anyone attempting to fix any modern auto.

Ford locates its diagnostic connector in the engine compartment. Also located in the engine compartment is the diagnostic test lead. In order to enter the diagnostic mode, a connection must be made from the diagnostic test lead to the upper right hand connection (looking at its front) of the diagnostic terminal. Since both connectors are female, an appropriate jumper wire must be used. For details, consult the service manual or a book on electronic ignition systems.

By the way, Ford cars that don't have a "check engine" light require some additional equipment, such as an analog VOM, to display service codes.

Reading and Interpreting the Code. Now that the computer is in diagnostic mode, you're probably thinking, "What now? Some sort of 'trouble codes' were mentioned, but how do I read them? There isn't a video monitor or even a LCD or LED display in my car!"

The automotive designers have already thought of that. The trouble codes are flashed out on the "check engine" light. Once in the diagnostic mode, that warning light will flash the appropriate code or codes that have been stored in the computer that caused the "check engine" light to light up in the first place! For instance, if a GM car flashes a code of 55 (five rapid flashes, a pause, and five more rapid flashes), that indicates that the oxygen sensor might be faulty. With Chrysler cars, that same code indicates the end of the test and on Ford cars it means that there is either a charging system problem or that there is no ignition-key-switched power being applied to the processor.

A short table of General Motors service codes is given in Table 1. The information in that table only mentions some general codes that are used on most GM vehicles. Newer codes are added to specific models that use new engine technology. As mentioned previously, you should always use a code table for your specific make, model, and year vehicle.

TABLE 1—Selected General Motors Service Codes

This table is a general listing of selected codes for GM cars and light trucks that have the CHECK ENGINE or SERVICE ENGINE SOON light. Most late model cars have many more codes than those listed here. For detailed listings and more information for individual vehicles, refer to the specific service manual. The information for this table was taken from Wells Mfg. Corp's booklet "Sure You Can Work on Electronic Ignition."

CODE	WHAT CODE INDICATES IN GM VEHICLES
12	System Test Code; Also no RPM Pulses to Electronic Control Module
13	Oxygen Sensor Circuit
14	Shorted Coolant Sensor Circuit
15	Open Coolant Sensor Circuit
21	Throttle Position High
23	Mixture Control Solenoid Low
24	Vehicle Speed Sensor Circuit—Park/Neutral Circuit Failure
31	Canister Purge Solenoid
32	Baro Sensor Circuit Low
34	Differential Pressure Vacuum
42	Electronic Spark Control
44	Lean Exhaust Indication
45	Rich Exhaust Indication
51	Bad PROM
55	Faulty Oxygen Sensor, Electronic Control Module
56	Add Coolant, Port Throttle System Vacuum Sensor
88	Electronic Control Module Circuit (1985 and later)

Low-Cost Diagnostic Equipment. Today, there is a variety of low-cost diagnostic equipment available. Some of it is quite useful. Other items are of questionable value. One example of the latter is the "code readers" for GM cars. It usually consists of a small device that plugs into the diagnostic connector and a booklet of codes. Many of those inexpensive "code readers" don't have a readout—they depend solely on the CHECK ENGINE or SERVICE ENGINE SOON light. Those types of readers appear to be nothing more than a fancy "paper clip" that puts the computer into its diagnostic mode. While that type of tester comes with a booklet that includes code listings, several reference books are available that contain the same information plus a wealth of additional information concerning your car's electrical, computer, and emissions systems. One example of that type of book is "Sure You Can Work On Electronic Ignition," published by Wells Manufacturing Corporation, Fond du Lac, WI 54936.

Understand that we are not saying that those low-cost code readers don't do what they claim. The main point is that there are other less expensive ways to do the same thing. It is also important not to confuse code readers with automotive diagnostic scanners. Diagnostic scanners, some of which can cost upwards of $250, have their own built-in display. Any error codes are indicated on the display in plain English. They also have several additional features that are sure to be useful to the professional automotive-repair technician.

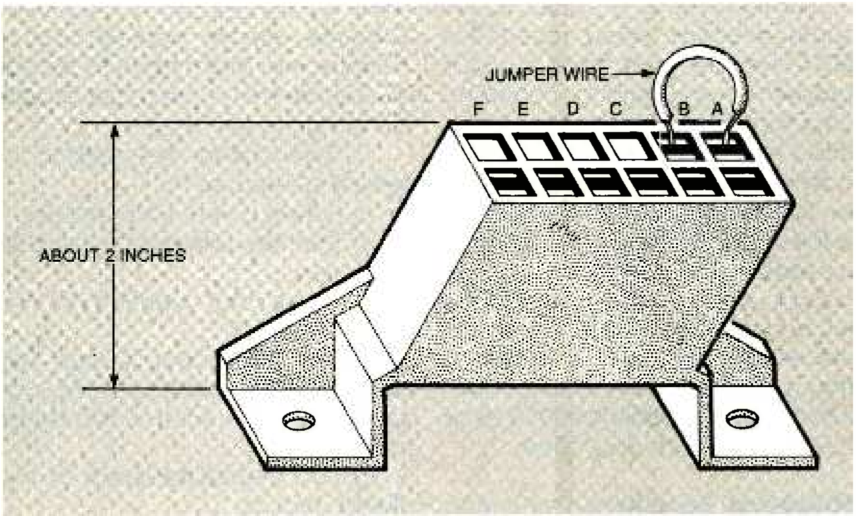


Fig. 1. A typical diagnostic connector for a General Motors vehicle looks like this. To put the computer into its diagnostic mode, simply jumper the two terminals shown with a short length of wire or a bent paper clip.

Clearing Codes. With computers controlling and monitoring more automotive systems, the behavior of those systems can sometimes confuse the average person who has had plenty of experience with older, "pre-intelligent" systems.

Once, a few years back, the author was driving his 1988 Chevrolet pickup truck up a hill. The wheels spun wildly on some wet leaves trying to grip the road. Once the truck got to the top of the hill, I noticed that the brake light was on. The parking brake was off and the brake-fluid level was OK. A quick check of the truck's electrical circuit diagram showed that three things could turn on the light—the parking brake, a low brake fluid level, and a problem with the anti-lock-brake (ABS) system!

After having visions of an expensive repair job come to mind, I realized that perhaps the ABS computer became confused because of the spinning wheels. In an anti-lock-brake system, each wheel has a speed sensor to measure the rotation of each tire. If some wheels are spinning much faster then the others, the brakes are pumped electrically to prevent the wheels from locking up and skidding. It could be that the ABS saw the drive wheels spinning so fast that the calculated spin rate went beyond the computer's ability to keep track of the spin.

The positive battery terminal was disconnected for a few minutes and then reconnected. The trouble code in the ABS system cleared, and everything worked fine after that.

Shortly after that incident, a friend of the author related a similar experience. He, however, was so worried about the brake light that he rushed his truck to a garage. Luckily, the people there were honest and competent. Instead of replacing the ABS system's computer, they also disconnected and reconnected the battery. He was lucky—his repair bill was only $25.

Disconnecting the Battery—A Miracle Cure? While the solution to the brake light problem was correct, the reasoning behind it was not the best course of action. Disconnecting the battery might have erased the error messages stored in the ABS's memory, but that doesn't mean that all problems will go away that easily. Automotive computers can store and remember several trouble codes—even if the immediate cause of the trouble clears itself. Capturing an intermittent problem can be as useful as tracing a "hard" failure.

CAUTION: It isn't wise to neglect any BRAKE warning light—even if it is generated by the ABS system for some frivolous reason. When that light is on, the ABS system will not assist in panic stops. While some recent research has indicated that ABS systems aren't as great as they were first believed to be, they nonetheless are a valuable addition to any vehicle.

If you have fixed a problem with your engine and it is running perfectly, do not forget to disconnect the battery for a minute or so. That will erase the error codes that were stored in the computer's memory.

Hard Failures. What if you are faced with a trouble code that seems to be a real failure? Replace the part indicated by the code? That type of repair job might be beyond the capability of the novice or "shade-tree" mechanic. However, there is a good chance that the problem is not a faulty component. Probably the biggest cause of failures in cars today is a bad, dirty, or corroded connector, or a broken wire. To test for that, use an ohmmeter to run a continuity check on the wires leading to the sensor or other electrical part indicated by the service code. If you're not sure what goes where, check all suspected wires and connections. Continuity checks should only be done when the ignition switch is in the "OFF" position.

Another option is to run a "wiggle test." Just as its name indicates, a suspect wire or connection is tested by wiggling it back and forth. A meter with an audible continuity tester is useful if you don't have someone else available to watch the meter while you're working in the engine compartment.

A variation of the wiggle test is to perform it with the engine running. That method is quite a bit more dangerous because of the running engine. The first thing to do is to clear the trouble codes by temporarily disconnecting the battery. After reconnecting the battery, start the vehicle and wiggle the wires or connectors one at a time. Have someone watch the warning light on the dash to see when it goes on.

WARNING: USE EXTRA CAUTION HERE! Remember that you are poking around in the engine compartment while the engine is running. If you put your hand near something that is moving you could be injured. Also, make sure you don't wear loose fitting clothing.

Combining a continuity check along with a power-off wiggle test is often more effective than the standard continuity test or the power-on wiggle test.

If a wire or connector flunks either test, first clean or replace the connector. If it still flunks, replace the wire. If the vehicle passes the wiggle test and continuity check, and the "warning light" doesn't light, the problem may have been "just one of those things"—perhaps caused by an electrical surge from a nearby lightning bolt. Most computer systems clear the service codes after 20 to 50 car starts. Therefore, if the warning light was caused by "just one of those things," it might clear itself up in a week or so of normal operation. Ω

REMOTE CONTROL ANTENNA

(continued from page 48)

digit station number if your remote does not have or does not support an "enter" button. Don't forget to press "zero" for a single-digit channel (channel 2 is "02"). When the "Enter" or "Mute" button is pressed, the Store LED should come on. When the first digit of the channel number is pressed, the Channel LED should come on as well, lighting all three LEDs. When the second digit of the channel number is pressed the Store and Channel LEDs will go out. If you want to return to the position of any particular channel, simply press its two-digit number without any other buttons.

Only channels 02 to 69 can be stored. Channels 70 to 74 are preset for the North-South-East-West directions and cannot be changed.

For the RCR to go back to the same direction when asked, the RCR memory must have a value properly representing antenna direction. To remove any accumulated errors, the RCR will automatically re-synchronize itself periodically. Synchronization can also be forced by pressing "91". Synchronization, as described before, consists of the rotator turning to the full counter clockwise position and establishing that position as the one from which all others will be calculated. This will enable the RCR to hit the right direction each time.

Motor-Run Capacitors. The motors used in antenna rotators are two-phase AC motors. They use motor-run capacitors to create the second phase. Between the inductance and reactance of an L–C circuit, the current on one leg of the motor is advanced ahead of the voltage.

The motor-run capacitors between screw terminals J2 and J3, as shown in Fig. 1 are C1, C2, and C3. It is important that they be bipolar electrolytic capacitors, commonly used in audio equipment. Because AC is present, a polarized capacitor will boil and explode due to the reversing voltages. Do not substitute regular polarized capacitors for those devices.

The value of the capacitors must be tuned to the rotator being used. Channel Master, Alliance, and RadioShack units work best with 66-µF capacitors. Since that value is not a standard value that is commonly available, connecting two 33-µF capacitors in parallel is an easy way to get the desired values. Since capacitors in parallel add their values together, C2 and C3 create the 66-µF motor-run capacitor. If you are experimenting with another type of rotator, C1 has been included as a blank socket for experimentation with capacitor values.

Using the wrong capacitor value will cause the rotor to "creep." In that situation, the rotator will not come back to the same place in its rotation each time it is moved. The antenna direction will tend to stay clockwise or counterclockwise of the correct alignment. If you are using a rotator other then Channel Master, RadioShack, or Alliance, you might have to test for the proper motor run capacitance by doing the following:

1) Synchronize the rotator by selecting channel 91.

2) Tune in a very weak station.

3) Spin the antenna for the best reception.

4) Store that position in the RCR's memory.

5) Turn the rotator at least 180 degrees away, using the pre programmed North, South, East, or West commands.

6) Turn the rotator back to the stored position.

7) Repeat steps 5 and 6 several times.

If after several times the rotator has come back to the weak station properly, the capacitor value is correct. If the rotator must be moved clockwise (as viewed from above) by pressing channel up on the remote to tune in the weak station, less capacitance is needed. If the rotator must be moved counter clockwise by pressing channel down to tune in the weak station, more capacitance is needed.

Once the Remote-Controlled Rotator is set up, you will be ready to explore the VHF and UHF to store all of those hard-to-get stations in memory. Ω

NEW LITERATURE

USE THE FREE INFORMATION CARD FOR FAST RESPONSE

Web Site Source Book 1997: 2nd Edition

Edited by Darren L. Smith
Omnigraphics, Inc.
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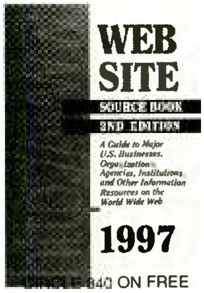
Detroit, MI 48226
Tel: 800-234-1340
Fax: 800-875-1340
$78



CIRCLE 340 ON FREE INFORMATION CARD

Designed especially for business and professional users, this updated and expanded 904-page book provides key information for more than 12,600 Web sites of major businesses, organizations, agencies, and institutions throughout the U.S. The second edition has added over 6,000 new entries, and two new categories: Counties and Real Estate. The listings include the name of the company or organization, mailing address, telephone and fax numbers, and Web and e-mail addresses.

Each entry appears twice: alphabetically arranged by the name of the company, agency or organization; and then in the classified section under approximately 100 subject headings. Users can find contact information for sources under categories, such as arts and entertainment, banking, colleges and universities, government agencies, hotels and resorts, magazines and newsletters, publishers, retailers, science and technology, and travel.

Programmable Logic Controllers: An Introduction

by W. Bolton
Newnes, Butterworth-Heinemann
225 Wildwood Avenue, Unit B
P.O. Box 4500
Woburn, MA 01801-2041
Tel: 617-928-2500
Fax: 617-933-6333
Web: http://www.bh.com/bh
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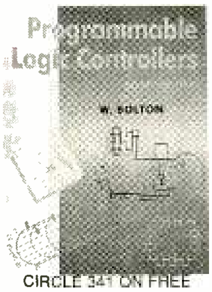

CIRCLE 341 ON FREE INFORMATION CARD

Rapid technological advances have made the PLC (programmable logic controller) an important part of many industries, from petrochemicals to food production. This book provides an accessible introduction to PLCs for students, and for engineers who want a working knowledge of PLCs.

Readers are shown how to identify the main design characteristics and internal architecture of PLCs, as well as the characteristics of commonly used input and output devices. Methods for writing programs for the logic functions, and programs involving relays, timers, counters, shift registers, sequencers, and data handling are explained. Testing and debugging methods are also completely discussed in the text.

The book includes numerous examples and programming problems that cover technology from a range of manufacturers. There are illustrations throughout the text to help the reader understand the concepts.

Catalog 104

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Milford, CT 06460
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Fax: 800-792-5877 or 203-876-7285
Web: www.switchesplus.com
Free

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New encoders that allow keypads to directly interface with PCs are highlighted. The catalog features detailed specifications on each type of product. Most switches are oil-and water-tight, and they can withstand hazardous environmental conditions. Installation hints are also included.

The Web site noted above offers pricing, dimensions, technical details and monthly specials.

Catalog AV97

Aven Tools Inc.
4676 Freedom Drive
Ann Arbor, MI 48108
Tel: 313-073-0099
Fax: 313-973-0097
Free

CIRCLE 343 ON FREE INFORMATION CARD

Aven's 1997/1998 catalog features 105 pages of tools for the electronics, electrical, engineering and industrial markets. Tools from Aven and other manufacturers, such as Accu-Tek, Niptec, Technik, and Klein, are included. Tips on selecting the right tool for the job are found throughout the catalog. A helpful table of contents and an index by product number are included.

The catalog offers a broad selection of tweezers, pliers and cutters, screwdrivers and screwdriver bits, knives and blades, scissors, files, ceramic tools, wrenches, magnifiers and magnifying lamps, ultrasonic cleaners, static control products, and magnetic tools. EN

BY DON LANCASTER

Radio Astronomy, The Enigma of the Faraday Disc, and more

THIS MONTH, WE HAVE A FASCINATING COLLECTION OF BOTH PSEUDOSCIENCE AND REAL SCIENCE TOPICS. LET'S START OFF THIS MONTH'S VISIT WITH A LITTLE BIT OF THE REAL STUFF.

Radio Astronomy

A world-class Henrich Hertz SMT (submillimeter telescope) lies on a small hill in front of my driveway. I recently wrangled a special insider tour; because it was our monsoon season and the staff there was between experiments, I even got to get a real close look at what's happening inside the receiver pods. There is some amazing stuff coming down here.

A radio telescope is just a big radio receiver, but one that's extremely directional, low in noise, and quite sensitive. They are sometimes used singly, but could be grouped together into arrays using a process called interferometry.

Some radio telescopes investigate solar and planetary phenomena in the high-frequency range. Others use ordinary microwaves in the 300-MHz to 150-GHz microwave range. A 300-GHz signal has a wavelength of one millimeter. The latest specialized radio telescopes can deal with signals with much lower bandwidths than that, and can explore the Terahertz mystery band that we looked at in HACK84.PDF and EMERGOP4.PDF (available on my www.tinaja.com Web site).

Things get especially challenging in the 100 to 1000 GHz range. First, you must have a quite dry and very high site, hence the location on the 10,700-foot high hill that blocks my view to the south. Water vapor severely absorbs submillimeter signals. The receiving dish has to exceptionally conform to its parabolic shape; deviations must be kept to say a thousandth-of-an-inch or better over thirty five feet at all times.

You also have to work around all the restrictive atmospheric windows that get in your way, and the receiving electronics often has to be chilled to nearly absolute zero.

And, oh yeah, nobody yet knows how to construct decent mystery-band amplifiers or even power sources. So you are still stuck with a highly noisy and "klutzy" electronics technology that today is roughly comparable to microwaves before 1940; in other words, it's practically the equivalent of a crystal set.

And therein lies a few of the SMT challenges. If you ever want to make friends with a radio astronomer, offer him stable one-Terahertz amplifiers with 20 decibels of gain, a 0.8-decibel noise figure, and at a price of $4.98 per dozen.

Although the new millimeter and submillimeter telescopes can be used for SETI extraterrestrial-intelligence searches, most traditional researchers distance themselves from anything related to "E.T. phone home." Instead, they concern themselves primarily with mapping apparently natural instances of extraterrestrial radio-noise sources.

One important source for those signals is known as molecular resonance. Two of the most popular are the 21-centimeter hydrogen line at 1420 MHz and the 18-centimeter hydroxyl line at 1681

Deuterium	327.384 MHz	Carbon Monosulphide	48.991 GHz
Hydrogen	1420.406 MHz	Hydrogen Cyanide	88.632 GHz
Hydroxyl	1612.231 MHz	Carbon Monosulphide	97.981 GHz
Hydroxyl	1665.402 MHz	Carbon Monoxide	109.782 GHz
Hydroxyl	1667.359 MHz	Carbon Monoxide	110.201 GHz
Hydroxyl	1720.530 MHz	Carbon Monoxide	115.271 GHz
CH Radical	3263.794 MHz	Formaldehyde	140.840 GHz
CH Radical	3335.481 MHz	Duterated H Cyanide	144.827 GHz
CH Radical	3349.193 MHz	Formaldehyde	140.840 GHz
Formaldehyde	4829.660 MHz	Carbon Monosulphide	146.969 GHz
Water Vapor	22.235 GHz	Formaldehyde	150.498 GHz
Ammonia	23.694 GHz	Carbon Monoxide	219.560 GHz
Ammonia	23.723 GHz	Carbon Monoxide	220.399 GHz
Ammonia	23.870 GHz	Carbon Monoxide	230.538 GHz
Excited Hydrogen	36.466 GHz	Methanol	258.507 GHz
Silicon Monoxide	42.821 GHz	Hydrogen Cyanide	265.886 GHz
Silicon Monoxide	43.122 GHz	Carbonyl Sulfide	461.907 GHz

FIG. 1—SOME MOLECULAR RESONANCE FREQUENCIES of interest to centimeter, millimeter, and submillimeter radio astronomers.

MHz. The area between those two makes up a transparent window that's nicknamed the "water hole."

The presence of energy at or near a molecular resonance usually reveals the presence of that molecule. Because of a "red shift" Doppler effect, modest frequency differences from what is expected can tell you whether an energy source is moving towards you or away from you. Other radio-energy sources are associated with pulsars, quasars, black holes, and supernovas. They often paint a wildly different picture of the universe than optical telescopes do.

I've summarized some other key molecular resonance frequencies for you in Fig. 1.

The SMT

The particular SMT I visited handles radio-astronomy wavelengths from 0.3 to 2 millimeters, or frequencies from 150 GHz to 1000 GHz, the latter being a full Terahertz. Thus, this scope starts where older millimeter instruments have left off.

The 35-foot dish is in fact accurate to a mil or so. Specifically, their goal was 15 microns of rms error (there's about 18 microns in a thousandth of an inch) and currently they are under twenty microns or so and improving. At present, this is the finest SMT dish anywhere in the world.

The dish is set up as an AZ-EL mount, which is an abbreviation for azimuth and elevation. Most of the azimuth part is handled by rotating the entire building! Special "windup" cables and flexible pipes let their building spin 270 degrees in either direction, at a clip of 60 degrees per minute. Elevation is handled by tilting the dish over a −2- to 91-degree range.

There is a secondary Cassegranian reflector way out in front, near the parabolic-dish focus. It can only be reached by a scary circus-tightrope platform. The secondary reflector redirects their received beam down through the middle of the main dish. At that point, a flippable mirror deflects the beam out a chosen end of the middle of the elevation axle. The beam then goes to one of two receiver pod rooms.

The neat thing about this setup is that the intended receivers can be bolted down onto fixed optical benches in more or less ordinary rooms. With use of beam splitters, up to six experiments (three on each side) could be conducted nearly at once.

The secondary reflector also is used for minor tracking (ever try to smoothly move a building by a few microns at a time?), as well as to purposely switch on and off axis, modulating the beam for better detectability. The latter is an update of the ancient astronomical "blink comparator" technique. Their typical chopping frequencies are 10 or 25 Hz, depending on need.

I'm also told that you can hang a dipole on the secondary to make a dandy two-meter ham receiver. Their 200 mile line-of-site visibility does not hurt DX all that much, either.

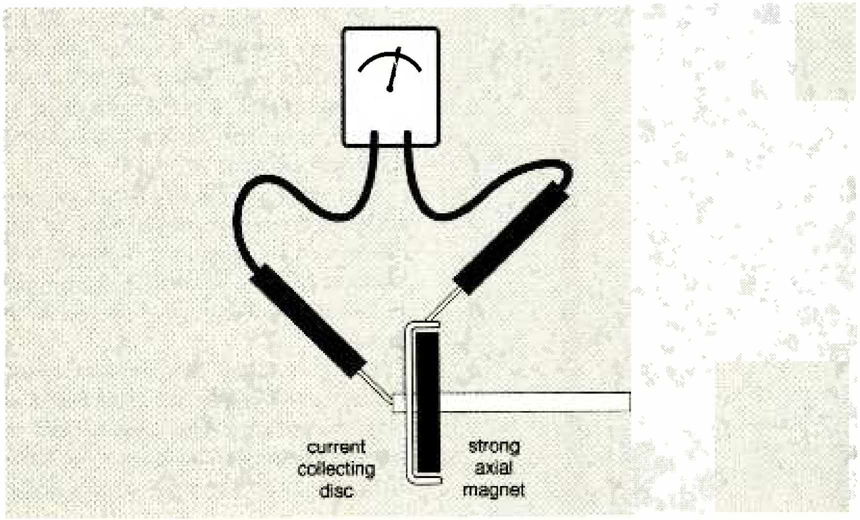

FIG. 2—"FREE ENERGY" ENTHUSIASTS claim to see a homopolar voltage with zero relative motion between a spinning magnet and collecting disc. Sure enough, you can easily convince yourself you are measuring some disc voltage or current, if you are careless enough about your bad lab work.

Back in the receiver rooms, two different technologies can be used at one of the six selectable focal points. Several frequencies can be monitored at once. A bolometer, which is a broadband heat detector, can be used to determine the overall energy being received.

The other option is a tunable superhetrodyne receiver. In that, a Gunn-diode oscillator and multiplier chain generates a frequency near that of the intended reception frequency. That local oscillator frequency is beamed together with the received signals through a window onto a supercooled SIS tunnel-junction diode. The two beams interact with the diode's nonlinearity, producing sum and difference signals. The difference signal is routed to a microwave intermediate-frequency amplifier chain. From there, the received signal is further downconverted, then is amplified, filtered, and undergoes digital signal processing. The usual output is in the form of an intensity map, often in pretty false colors.

Oh yes, the cooling. Much of the universe lies at a "night sky" temperature of 4.5 degrees Kelvin, which is four degrees above absolute zero. Ideally, your detector should be at a temperature that is substantially less than that. To accomplish that, critical portions of the receiver electronics are placed in special Dewars, which are related to plain old thermos bottles, but might be the size of a commercial soft-drink supply canister.

Liquid nitrogen is first used as an intermediate cooler. It turns out that ordinary liquid helium-4 boils at 4.22 degrees Kelvin. But there is a magic and stupendously expensive helium-3 isotope that boils at a significantly lower temperature. By evaporatively diffusing helium-3 into helium-4, a special cryogenic-refrigeration device offers cooling to within a fraction of a degree of absolute zero. Since there is only one naturally occurring helium atom out of 10,000 that is this magic helium-3, special and elaborate recycling compressors recover and reuse this elixir.

For lots more information, you can visit the SMT's Web site at maisel.as.arizona.edu:8080. Seasonal Saturday tours are available through the folks at Discovery Park. All day tour costs are around $30. More details on tours and their amateur astronomy club can be found on the Web at www.discovery-park.com.

Some Resources

A superb collection of state-of-the-art submillimeter receiver papers is available for your free downloading at cfarx1.harvard.edu.ix_lab/papers. For lots more, just search the Web under "submillimeter". I have gathered a few additional radio telescope names and numbers for you as this month's resource sidebar.

One good starting point is the NRAO at info.aoc.nrao.edu. The VLA astronomy site, which is just outside of Magdalena, New Mexico, is certainly worth your visit. If you do go, the little-known, secret, Langmuir thunderstorm lab is on the next mountain over; even less known is that summer visitors are welcome to that remote site.

An individual by the name of Jeffrey Lightman now publishes *Amateur Radio Astronomy: Systems, Procedures and Products*. It is sold through his Radio Astronomy Supplies. Cost is $40. He also carries the *Robert Sickels Radio Astronomy Handbook* at the same price, as well as lots of other books, videos, hardware, and software.

One good journal I've found on submillimeter receiver technology is the *International Journal of Infrared and Millimeter Waves*. The *IEEE Transactions on Microwave Theory and Techniques* is also useful.

Many hundreds of radio astronomy books are stocked by Amazon Books at www.amazon.com One pricey title is *Instrumentation and Techniques for Radio Astronomy* from the folks at the IEEE Press.

As to amateur astronomy resources in general, I have just posted a hot linked download as RESBN67.PDF on my http://www.tinaja.com.

SOME RADIO ASTRONOMY RESOURCES

Caltech Submillimeter Observatory
111 Nowelo St.
Hilo, HI 96720
(808) 935-1909

Discovery Park
1651 32nd St.
Safford, AZ 85546
(520) 428-6260

Harvard Submillimeter Array
60 Garden St.
Cambridge, MA 02138
(617) 495-7489

Hat Creek Observatory
42231 Bidwell Road
Hat Creek, CA 96040
(916) 335-2364

IEEE Press
445 Hoes Lane
Piscataway, NJ 08855
(908) 981-0060

IEEE Transactions on Microwave Theory and Techniques
445 Hoes Lane
Piscataway, NJ 08855
(908) 981-0060

International Journal of Infrared & Millimeter Waves
233 Spring St.
New York, NY 10013
(212) 620-8000

Jet Propulsion Laboratory
NASA
Pasadena, CA 91109
(818) 354-5011

NRAO Observatory
PO Box 2
Greenbank. WV 24944
(304) 456-2011

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Roswell, GA 30075
(770) 992-4959

Radio Sky Publishing
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www.win.net/~radiosky

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Mountain View, CA 94043
(415) 961-6633

SETIQuest
174 Concord St.
Peterborough, NH 03458
(603) 924-9631

SMT Telescope
University of Arizona
Tucson, AZ 85721
(520) 621-5290

Society of Amateur Radio Astronomers
247 N Linden St.
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VLA Astronomy Site
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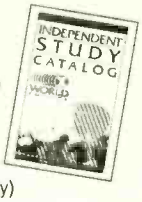

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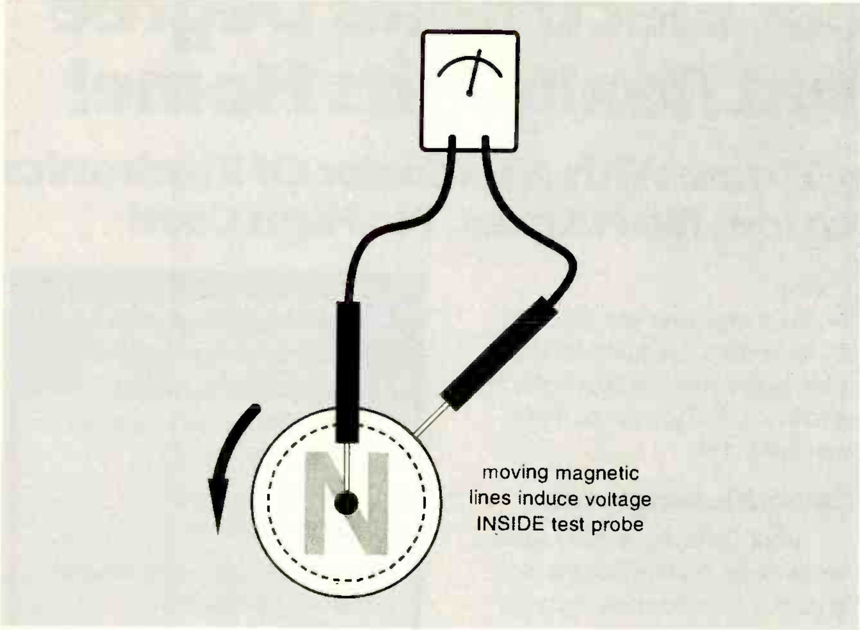

FIG. 3—AN END VIEW clearly shows what is really happening: The voltage or current you see is generated inside of the test lead by simple induction. In essence, the test leads form a one-turn stator winding loop.

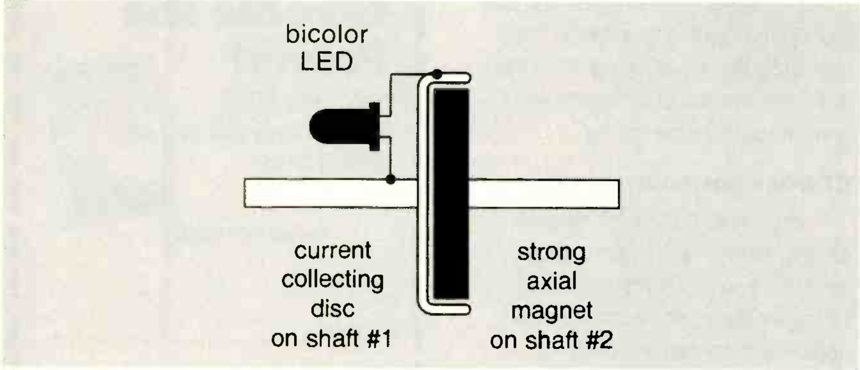

FIG. 4—A "STATORLESS" TEST SETUP to search for mythical homopolar currents. I would expect the LED to light to one color given enough positive relative rotation, and light to the other color on enough negative relative rotation. Brightness should be independent of absolute magnet speed.

The Enigma of The Faraday Disc

There is a cute variation on the homopolar generators we looked at last month that is newly kicking around the Web. Some pseudoscience enthusiasts may show you a "simple experiment" that "proves" you get homopolar energy when there is zero relative motion between the moving magnet and its collecting disc.

Naturally, I believe that claim lies somewhere between "a useful adjunct for porcine whole body cleanliness" and total hogwash. Figure 2 shows the scheme. A strong axially polarized disc magnet is placed on a shaft next to a fixed collecting disc or cup. Spin both with an electric drill, and sure enough, you could easily convince yourself you are measuring voltage and current from shaft to the edge of the disc despite there being zero relative motion between the two. Too bad it ain't so.

Take a close look at the bottom inch of the shaft test probe in Fig. 3. It shows that in this set up, you have moving magnetic flux lines cutting a conductor (the probe itself). *Ergo*, classic physics tells us you'll get an induced voltage. In other words, the voltage you see is generated inside of the test probe, not across the collecting disc!

To prove this to yourself, just move your probes around. In particular, I'd certainly expect the polarity would reverse if you put the probe on the other side of the magnet.

One more time: The voltage is being induced inside of your test probe! In essence what you have is a one-turn stator coil formed by your test probes and leads.

The voltages and currents claimed suggest hundreds of microwatts of power, which is about the usual measurement-error "fumes" you'll probably find in almost any lab. I'd expect a modern magnet at high speeds to produce watts to tens of watts in a real generator. I'd also be wary of measurements that are one-millionth of the field energy present in the nearby electric drill.

It seems that Faraday himself also felt he observed a homopolar output with a zero relative motion between rotating collector and magnets. Was Faraday right, in which case nobody's bothered to commercially develop an obviously powerful new generator in the last 162 years, or was he wrong, making a subtle but simple lab error in which all of the observed voltages were generated inside of his test leads?

I feel the elegantly simple test of Fig. 4 can easily sort this out. The trick is to eliminate any "stator" on your machine and get rid of all measurement wires. Instead, you'll immediately convert your generated electricity to light. Do this by soldering a two-color LED between the center and the edge of your collecting disc. Then arrange for the disc and your magnet to be separately rotatable.

Here's what I'd expect to happen: Keep the magnet stationary and then rotate the disc fast enough to light the LED to normal brightness. Now, start spinning the magnet in the same direction as the collecting disc. As the magnet speed increases, I'd expect your LED to dim. When the magnet speed is zero relative to the collecting disc, I'd certainly expect zero light output. And as the magnet speeds up I'd expect a brighter light of the opposite color. The results should depend only on the relative speeds between your disc and the magnet and not upon the absolute speed of the magnet.

If I am wrong on the results of this simple experiment, I will be most happy to publicly apologize. But then again, you won't be worrying about that, because your picture will be on the cover of *Science* magazine. Many thanks go to Bill Beatty of www.eskimo.com/~billb for all his "look at the stator" comments on this. Visit his great Web site, which covers both real science and pseudoscience in depth. Details on the experiment itself can be found lurking around www.keelynet.com, and much more on pseudoscience is at www.tinaja.com/pseudo01.html.

A Clarification or Two

Uh, whoops. The energy density figures in my recent hydrogen story (Tech Musings, **Electronics Now**, September 1997) were high by 1000. In reality, hydrogen has an energy density of around 38,000 watt-hours-per-liter or 38 kilowatt-hours-per-liter. All these values have been corrected in MUSE115.PDF, which is on my www.tinaja.com Web site. Sorry about that.

Continuing with our discussion of that column, one individual was critical of my failing to include Brown's Gas. Brown's Gas is a stochiometric mix of two parts of hydrogen to one part of oxygen. It sees some limited commercial use in specialized welding torches. But unquestioning Brown's Gas enthusiasts make outrageous claims, such as over-unity energy production, radioactive-waste neutralization, and even negative pressure generation, all without credible and verifiable proof to any acceptable standards; at least none that I've seen.

I strongly feel that Brown's Gas clearly passes my subjective "looks like a duck; quacks like a duck; is gonna lay some eggs" pseudoscience test, if for no other reason than the outlandish claims and nature of the totally clue-challenged denizens it attracts to the Web.

Pseudoscience is a field I closely monitor because it includes such mesmerizingly awful fiction; stuff that is not even wrong. If I ever do discover any credible evidence to the contrary, I'll be most happy to research Brown's Gas in more depth and thoroughly report it, though I do not expect that to happen until after a certain warm place freezes over. You can find more on tinaja.com/pseudo01.html.

New Tech Lit

There's a whole flock of new and free CD-ROM data disks this month: From Texas Instruments, there's the *Logic Selection Guide and Data Book*; from Hitachi, their *H8/ 300 Series Embedded Microprocessors* disk; from Sharp, *a Flash Memory Data Book*; and from Ricoh, full details on *CD Recording Media*.

Home Power magazine offers their new *Solar 2* CD-ROM. It uses the latest version of Acrobat for totally searchable and full color images of 3900 pages of *Home Power* from Issue 1 through 42. Topics include everything from photovoltaic cells on up through electric vehicles to solar cooking to water pumping and more. It costs $29, including US shipping.

Several exciting new laser printer-repair instruments are newly offered from Laser Wizard. Those calculator-size units plug into popular Canon engines and give you all sorts of newfound diagnostic and control powers. Their PIC-based SX30 runs $295 and is the basic unit for SX engines. Add-on $99 adaptors are available for the NX and BX engines. These can let you manually control the printer at the engine level while overriding cover switches and reading error messages.

Laser-printer training and repair parts still remain available from Don Thompson, while cartridge refilling opportunities abound in *Recharger* mag-

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azine ads and stories. More on the neat things you can do with toner in RESBN68.PDF on www.tinaja.com.

Free samples of a new ultra-tough Softouch leather-like coating is available from Alsa.

New books from Newnes include *Inside PC Card Design* by Faisal Haque and *Cellular Telephones and Pagers Overview* by Steve Gibson. The latest of "new" old titles from Lindsay Publications include *I.C. Engines Volume I*, which is a collection of patents on early internal combustion engines, and new books on lathes, saw blades, and milling machines. Lindsay's Web page is at keynet.net/~lindsay.

Innovation is a brand new publication for you users of high-end graphics computers. It is apparently a continuation of an older *IRIS Universe* magazine. Free subscriptions are available to those with a genuine interest. Two useful wireless trade journals are *Applied Microwaves & Wireless* and *Wireless Design & Development*.

For the insider secrets of starting up your own technical venture, see my *Incredible Secret Money Machine II*, which is available as mentioned in my nearby Synergetics ad. You can also preview the introduction at www.tinaja.com/ismm01.html. Also check my new Infopack service, which quickly gives you custom and cost-effective research solutions. As usual, most of the mentioned items should appear in the "Names & Numbers" or in the "Radio Astronomy Resources" sidebars. Always do check here before you call our US technical helpline shown in the "Need Help?" box you'll find nearby. Let's hear from you. EN

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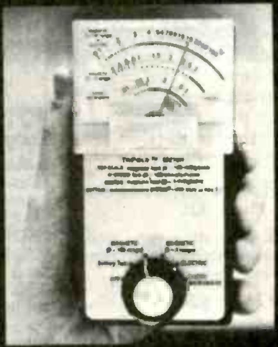

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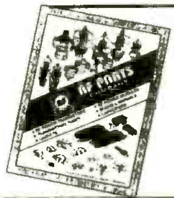

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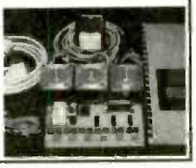

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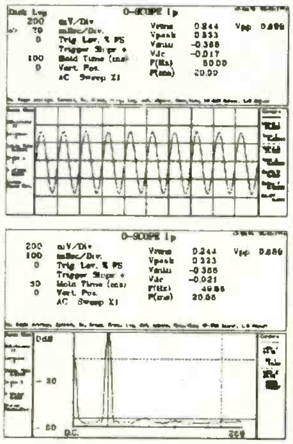

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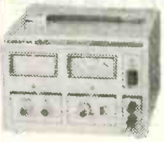

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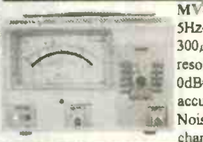

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DM-3104A $799.95 *MEASUREMENT*: *Range*: 0.01%-30%, 0.1/0.3/1/3/10/30% full scale. *Freq*.: 400Hz±10%, 1000Hz±10%(HPF). *Input*: 3mV-100V, ratio measuring 20dB. *Auto. Switching Ranges*. Fundamental Freq. = (fo)±10%; *Fund. Rejection*: >-80dB at (fo)±5%; >-70dB at (fo)±10%. *Harmonic Accuracy*: ±0.5dB, 1.8(fo)-20KHz. **DM-3204 $1,599.00** dual channels

FREQUENCY COUNTER

FC-5250C $119.95 *Freq. Range*: 10Hz-220MHz: (HF)10Hz-20MHz, (VHF)10MHz-200MHz *Gate Time*: 0.1 & 1sec. *Max. Input*: 10Vp-p. *Input Sensitivity*: 35mV 10Hz-200MHz. *Display*: 7-digit LEDs. *Input Impedance*: (HF) 1MΩ, (VHF) 50Ω.

FC-5260A ~~$146.00~~ **$129.95** 10Hz-600MHz. 7-digit LEDs. **FC-5270 $149.95** 10Hz-1.2GHz. 8-digit LEDs. **FC-5600B** ~~$321.00~~ **$299.95** 10Hz-600MHz. 10-digit LEDs. **(FC)5700 $329.95** 10Hz ~ 1.3GHz, 10-digit LEDs.

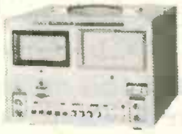
SIGNAL TRACER/INJECTOR

SE-6100 $134.95 **TRACER:** Gain Max. 60dB *Attenuation*: 0/20/40/60dB *Input Impedance*: 100KΩ; *Output Imped*.: 600Ω; *Speaker*: 8 Ω. **INJECTOR:** *Freq*.: 1KHz Squarewave, *Output Level*: Continuously variable 0 - 4.5Vp-p

AUTO. CAPACITANCE METER

CM3300A $139.00 10 ranges, 99.9pF ~ 99.9mF, fully automatic. *Resolution*: 0.1pF lowest, 0.1% full scale. *Accuracy*: 0.5% of full scale±1 digit to 99.9μF, 1% of full scale±1 digit to 99.9μF. *Display*: 3 digit LED. *Unit indicator*: pF, nF, μF, mF. Overrange indicator.

WOW-FLUTTER METER



WF-3103A $699.95 *Freq. Range*: 3KHz±10% JIS/CCIR; 3.15KHz±10% DIN. *Range*: 0.03/.1/.3/3% full scale. *Accuracy*: ±5%. **WF-3105A $799.95**, digital; *Function*: LIN/WOW/Flutter/WTD. *Freq Counter*: 10Hz-9.99MHz. *Indication*: CCIR/DIN/JIS.

ELECTRONIC/PC TOOL KITS

9Z45 $29.99 U.S. Patented, 45-pcs. Contents: IC Inserter, IC Extractor with securers & Bows, 3-prong part Retriever, #0 Phillips Screwdriver, 1/8" Flat Screwdriver, Self-hold Tweezers, Metal Tweezers, Extra Parts Tube, Soldering Iron, Solder, Crimping Tool, Long-nose Plier, Cutting Plier, Zipper vinyl Case. Bits include: *Phillips*: #0, #1, #2, & #3; *Flat*: 1/8", 3/16", 1/4", 9/32"; PZ1, PZ2; T8, T9, T10, T15, T20, T25, T27, T30, T40, T45; *Hex*: 5/64", 3/32", 1/8", 5/32", 3/16"; *Sockets*: 3/16" (5mm), 7/32" (5.5mm), 1/4" (6mm), 9/32" (7mm), 5/16" (8mm). **8G23 $34.99** U.S. Patented, 23-pcs. Contents: IC Inserter, IC Tweezers, IC Extractor with securers & Bows, 3-prong part Retriever. 3/16" Nutdriver, 1/4" Nutdriver, 3/16" Slotted Screwdriver, 1/8" Slotted Screwdriver, #0 & #1 Phillips, Reversible T10/T15 Bits, Reversible #2 Phillips/¼" Slotted Bits, Tweezers, Long-nose Plier. Cutting Plier, 6" adj. Wrench, Soldering Iron, Solder, Crimping Tool, Zipper vinyl Case, Manual. **8088 Microprocessor Trainer $699.00** BGC-8088, teach yourself 8088 based hardware design and software programming.

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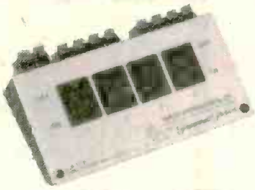
4 Way Speaker Switch



Control up to 4 pairs of speakers with this compact speaker selector switch. Features circuit protector, heavy duty rocker switches, spring loaded terminals, and silver plated switch connectors. Includes one pair of amplifier inputs. Load to amplifier is minimum 4 ohms (with 8 ohm speakers) or 220 ohms with all speakers switched off. Net weight: 1 lb.

#EN-309-030 .... WAS $22.50 EACH NOW $15.00 EACH

"The Sound Bridge" FM Stereo Wireless Transmitter

HOT NEW ITEM!

The Sound Bridge is a mini FM wireless transmitter that can be used to broadcast stereo sound from any audio source like portable CD players, TVs, electronic games, CD-ROM, even computer soundcards, to your home stereo receiver! Adjustable from 89 to 95.5 MHz.

#EN-249-220 .... $14.95 EACH

Weller Professional Irons

Weller

Perfect for a variety of electronic soldering work, this top quality iron features a long life, double coated tip and a quick change, plug-in heater element. Lightweight handle includes a comfortable cushioned grip. Net weight: 1/2 lb.

#EN-372-110 (25 Watt) $30.90 (1-3) $28.50 (4-UP)

#EN-372-112 (35 Watt) $38.90 (1-3) $34.95 (4-UP)

Peak Instrument Co.

"The Woofer Tester"

Peak Instrument Co. proudly introduces "The Woofer Tester". Just ask any loudspeaker engineer, and they will tell that the only way to design enclosures of the correct size and tuning is to measure the Thiele-Small parameters for the actual drivers to be used. The reason? Manufacturers published specs can be off by as much as 50%! But until now, measuring the parameters yourself required expensive test equipment and tedious calculations, or super expensive measurement systems ($1,200 to $20,000). The Woofer Tester changes all that.

Finally, a cost effective, yet extremely accurate way to derive Thiele-Small parameters, in only minutes! The Woofer Tester is a combination hardware and software system that will run on any IBM compatible computer that has EGA or better graphics capability and an RS232 serial port. The Woofer Tester will generate the following parameters. Raw driver data: Fs, Qms, Qes, Qts, Vas, BL, Re, Le, SPL @ 1W/1m, Mmd, Cm, and Rm. Sealed box data: Fsb and system Q. Vented box data: Fsb, ha, alpha, and Q loss. The Woofer Tester system includes hardware, test leads, serial cable, AC wall adaptor, detailed instructions, and software.

#EN-390-800 .... $249.00 EACH

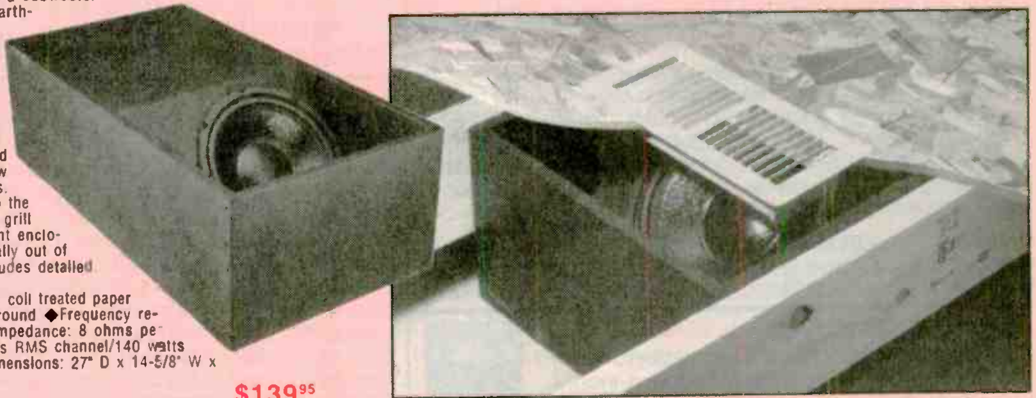
900 MHz Wireless Speaker System

- 900 MHz technology sends signal up to 180 ft., through walls, floors and ceilings.
- Ideal for use as rear surround speakers or for adding wireless sound to every room in the house!
- Full range, bass reflex design with built-in high power, low distortion amplifier.
- Weather resistant cabinet for outdoor use.
- Selectable battery (six C size for each speaker) or AC operation, adaptor included. Built-in recharging circuitry for ni-cad batteries.
- System includes: 900 MHz transmitter, wireless speaker pair, AC adaptors, and all cables necessary to hook up system.
- Limited availability. ◆ Net weight 9 lbs.
- Frequency response: 20-18KHz.

#EN-319-030 .... $169.95 EACH

Home Theatre In-Floor Subwoofer

Dayton Loudspeaker Co.®



To fully appreciate the potential of movie soundtracks, a dual voice coil subwoofer is a must! Many film special effects are extremely demanding in the low frequency range and require a subwoofer that can duplicate explosions, earthquakes, even the footsteps of Tyrannosaurus Rex! This subwoofer fits the bill by featuring a 10" dual voice coil woofer for true stereo operation and high pass filters for your main speakers. The most unique feature of this subwoofer is the fact that it is designed to be mounted in between the floor joists in new and existing home constructions. Simply mount the in-floor sub to the joists and mount a heat register grill above opening in subwoofer front enclosure. The subwoofer is now totally out of view and ready to rumble! Includes detailed installation manual.

Specifications: 10" dual voice coil treated paper cone woofer with poly foam surround ◆Frequency response: 30-100 Hz ◆Nominal impedance: 8 ohms per coil ◆Power handling: 100 watts RMS channel/140 watts max ◆SPL: 89 dB 1W/1m ◆Dimensions: 27" D x 14-5/8" W x 9" H ◆Net weight: 29 lbs.

#EN-300-445 .... $139.95 EACH

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◆30 day money back guarantee ◆$20.00 minimum order ◆We accept Mastercard, Visa, Discover, and company C.O.D. orders ◆24 hour shipping ◆Shipping charge = UPS chart rate + $1.90 ($5.00 minimum charge) ◆Hours 8:00 am - 8:00 pm ET, Monday - Friday ◆9:00 am - 5:00 pm Saturday. Mail order customers, please call for shipping estimate on orders exceeding 5 lbs. ◆Foreign destination customers please send $5.00 U.S. funds for catalog. ◆Quantity pricing available.

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Fantastic DMM Offer!!!

Don't let the price fool you. This meter is a digital multimeter designed for engineers and hobbyists. Equipped with 5 functions and 19 ranges. Each test position is quickly and easily selected with a simple turn of the FUNCTION/RANGE selector rotary switch.

Rubber Boot Included

Our Best Offer Ever on a High Quality Full Sized DMM

General

Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)
Low Battery Indication: BAT on Left of LCD Display
Dimensions: 188mm long x 87mm wide x 33mm thick
Net Weight: 400g

$19.00 any qty

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100µV	±(1%rdg+2dgts)
2000mV	1mV	
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200µA	100nA	±(1.2%rdg+2dgts)
2000µA	1µA	
20mA	10µA	
200mA	100µA	
10A	10mA	±(1.2%rdg+2dgts)

Overload Protection: mA Input. 2A/250V fuse.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	±(1.2%rdg+2dgts)
2000Ω	1Ω	
20KΩ	10Ω	
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Switchable Scope Probe Sets

(Selectable X1/Ref/X10) These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP 9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

CAT NO	DESCRIPTION	PRICE EACH 1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe SetDC~150MHz	24.95	21.95	18.62

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3	Makes 1 pint	$3.50	$2.75

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12" NEW!	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12" NEW!	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12" NEW!	22.09	18.35	14.68

Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

REDUCES ETCHING TIME!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

Removeable Hard Drive Racks

The ideal solution for protecting highly sensitive data. Or, buy one computer and allow individual users to keep their hard drive with their own applications and set-ups. Just turn the system off, lift the handle and the hard drive pops right out. Key lock included to avoid accidental or unauthorized removal. Includes hard drive activity LED's. Rack includes mounting hardware, keylock, front panel LED, convenient pull out handle. Made from high impact ABS plastic. Fits in 5.25" bay.

Features: *• Ideal for Hard Drive Portability • Solve Software Data Security Issues • Carry Your Hard Drive Between Home and Office • Each User Can Have His or Her Personal Hard Drive*

CAT NO	DESCRIPTION	PRICE
SpecialHDRACK-IDE	For IDE Hard Drive	$14.95

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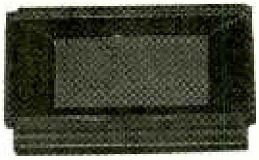
CIRCLE 315 ON FREE INFORMATION CARD

Digital Panel Meters (LCD & LED)



Don't let the prices fool you. These digital panel meters are not surplus, so even if you design them into an ongoing manufactured product, you can be assured of continued availability. These high quality digital panel meters are decimal point selectable with guaranteed zero reading at zero volts input.

Applications Include:
- Voltmeter
- Thermometer
- pH Meter
- dB Meter
- Watt Meter
- Current Meter
- Capacitance Meter
- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

PM-128: 3-1/2D LCD Digital Panel Meter
PM-129: 3-1/2D LED Digital Panel Meter

Features
- 200mV Full Scale Input Sensitivity
- PM-128 - Single 9VDC Operation
- PM-129 - Single 9VDC Operation
- Decimal Point Selectable
- PM-128 - 13mm Figure Height
- Automatic Polarity Indication
- Guaranteed Zero Reading for 0 Volt Input
- High Input Impedance (>100Mohm)

Specifications - PM-128/PM-129

Maximum Input	: 199.9mV DC
Maximum Display	: 1999 counts (3-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: PM-128 - LCD Display PM-129 - LED Display
Measuring Method	: Dual-Slope Integration A/D Converter System
Overrange Indication	: "1" Shown in the Display
Reading Rate Time	: 2-3 Readings per sec.
Input Impedance	: >100 Mohm
Accuracy	: +-0.5% (23+-5°C, <80% RH)
Power Dissipation	: PM-128 - 1mA DC PM-129 - 60mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: PM-128 - 9V DC PM-129 - 9V DC
Size	: 67mm x 44mm

3-1/2 Digit LCD 3-1/2 Digit LED 4-1/2 Digit LCD

PM-328: 4-1/2D LCD Digital Panel Meter

Features
- 200.00mV Full Scale Input Sensitivity
- Single 9V DC Operation
- Decimal Point Selectable
- 11mm LCD Figure Height
- Automatic Polarity Indication
- Low Battery Detection and Indication
- High Input Impedance (>100 Mohm)

Specifications - PM-328

Maximum Input	: 199.99mV DC
Maximum Display	: 19999 counts (4-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: LCD Display
Overrange Indication	: "1" Shown in the Display
Input Impedance	: >100 Mohm
Accuracy	: +-0.05% (23+-5°C, <80% RH)
Power Dissipation	: 1mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: 9V DC
Size	: 67mm x 44mm

AS LOW AS $5.25 ea.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25	100	250
PM-128	3-1/2 Digit LCD Panel Meter	$ 9.90	$ 7.09	$ 6.40	$ 5.86	$ 5.25
PM-129	3-1/2 Digit LED Panel Meter	11.49	9.54	8.67	7.95	6.95
PM-328	4-1/2 Digit LCD Panel Meter	19.88	16.40	14.90	13.66	11.93

Ball Bearing 12V DC Fans

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

INDUSTRY BEST PRICING!

CAT NO	PRICE EACH 1	10	25	100
CSD 4010-12	$ 9.88	$ 6.38	$5.48	$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

Specifications

CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H_2O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

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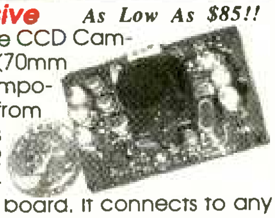
We stock high quality 60/40(Sn%/Pb%), .031" and 63/37, .031" diameter. This is prime JIS certified solder that we maintain as a regular stock item (It is not "Left-overs, Rejects or Surplus") and you can buy it from us at a fraction of the price that you are used to.

Tired of Paying Inflated Prices for Solder?

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
RH60-1	1-lb. Spool, .031", 60/40	$ 6.90	$ 5.96	$ 5.30
RH63-1	1-lb. Spool, .031", 63/37	6.95	6.10	5.41
RH60-4	4.4-lb. Spool, .031", 60/40	24.00	21.90	17.92
RH60-TUBE	6-oz. Tube, .031", 60/40	.99	.89	.79

CCD Camera - IR Responsive

As Low As $85!!



This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connecting three wires: red to 12V, black to ground (power & video) and brown to video signal output.

Power Supply Regulating Kit for CA-H34 This simple kit is designed to fit onto the back of the CA-H34 CCD camera. It resolves the problem of hooking up the camera to an UNREGULATED supply (which damages the camera) by providing safe regulated power from any 12V-14V DC supply. It also provides regulated 12V DC from a 12V AC source.

CAT NO	DESCRIPTION	PRICE EACH 1	5
CA-H34A	PCB Mounted IRCCD Camera	$99.00	$85.00
A34	Power Supply Regulating Kit	$6.95	-----

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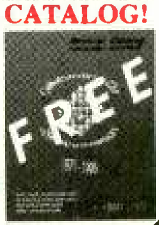

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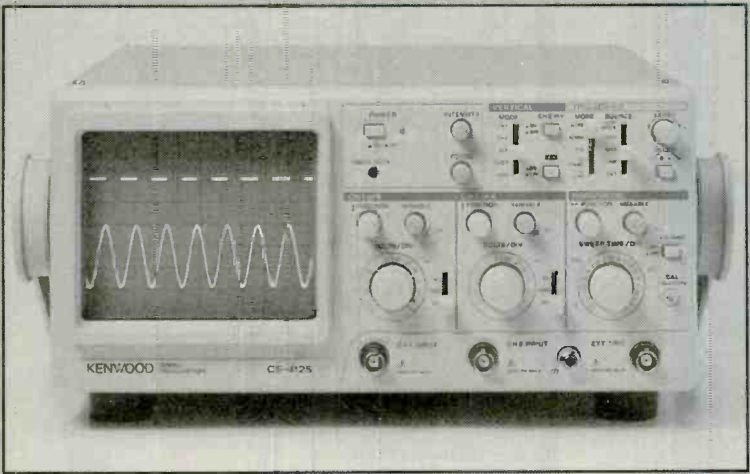
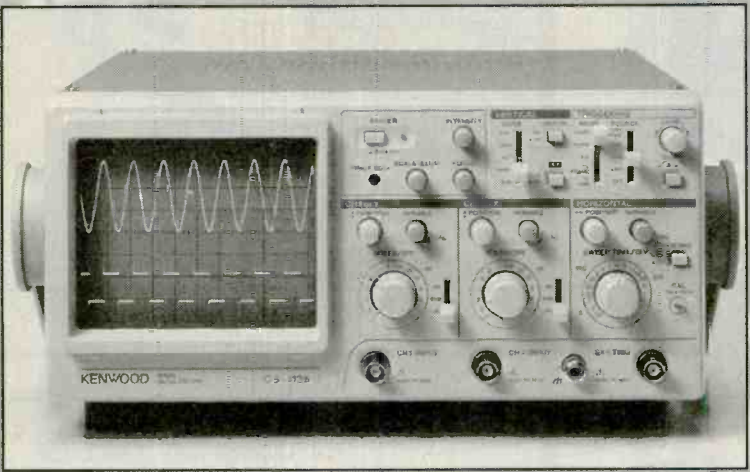


2-Channel, 20-MHz

CS-4125

Regular $595

Sale $389



2-Channel, 40-MHz Oscilloscope

CS-4135

Regular $855

Sale $685

Hybrid IC Technology is the Key to the High Quality and High Reliability at Low Cost!

- **FIX SYNCHRONIZATION** detects the trigger level automatically for the acquisition of stationary waveforms without complicated sync level adjustments.
- **VERT MODE TRIGGERING** enables the acquisition of stationary waveforms for both CH1 and CH2 even when the input signals to the two channels have different frequencies.
- **HIGH WITHSTAND INPUT** voltage of 400V (800Vp-p).
- **RELAY ATTENUATORS** are provided for reliable logic switchover.
- **SCALE ILLUMINATION** (CS-4135 only)
- **DIMENSIONS** (WxHxD): 300(343) x 140(150) x 415(430)mm ( ) including protrusion.
  WEIGHT: approx. 7.2kg (CS-4135) approx. 7kg (CS-4125)

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CIRCLE 264 ON FREE INFORMATION CARD

EDITORIAL

continued from page 4

certain test markets sometime this spring.

Will Divx fly? No one is certain. Proponents give it a resounding yes. However, many insiders in the home-video industry say that it is DOA, and might have a hard time even getting shelf space anywhere outside of Circuit City's stores (Circuit City owns a majority stake in Digital Video Express L.P., the developer of Divx). But one thing is certain: Throwing confusion into an emerging market is never a good thing. The timing here is such that holiday sales could fall well short of expectations, and thus stunt the growth and delay the acceptance of DVD, perhaps even enough to kill it.

Introducing Prototype

On a more pleasant note, we are proud to introduce a fascinating new feature that we are certain you will enjoy. Called Prototype, each month it will offer a peek inside company R&D departments and university laboratories world wide. Once there, we'll peer over the shoulders of researchers and technicians to learn about emerging technologies, new trends in electronics, and exciting products under development.

Sure, some are certain to be merely pipedreams, destined to never see the outside of a lab, but others could profoundly affect our personal and professional lives some day. Which is which? Ahh, there's the fun, as no one can be certain; you'll just have to read and judge for yourself.

Carl Laron
Editor

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TY-35
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Kit $ ~~12.50~~ 6.99

Clearance Sale

TA-001
It employs high stability power IC & has a build in temperature compensating system. It has large power output & output & good distortion characteristic. Accept various magnetic & capacitor micro-phone input & other line input. 6-16V DC.

Kit $ ~~7.85~~ 4.85

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		Kit
Melody Generator	▲	$ 13.85
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36W Class A Power Amp.	▲▲	32.50
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Stereo Pre-Amp with Mic Amp.	▲	10.78
Mini Stereo Multi-Input Amp.	▲	30.50
130-in-one Electronic Lab		29.99

SEE OUR CATALOG FOR MORE KITS !

Stereo Loudspeaker Protector

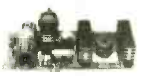
TY-25 ▲

Kit: $ 16.75

Super fast acting relay protects speakers against destructive DC voltages. Can connect directly to a power amplifier or can use a separate power supply. Has a 3 second turn-on delay to avoid turn-on thumps.

Regulated DC Power Supply

TR-503 ▲▲



Kit: $ 18.75

It is short circuit proof and has overload protection. Output voltage is variable over a range of 0-50 volts. Current limit trip is adjustable up to max of 3A. May use Mark V #002 transformer.

Fluorescent Light Driver

TY-2 ▲ (1 lb.)

Kit:$ 14.75

This unit drives 6-40 watts fluorescent light for portable and emergency use. Works from a 7.2 - 16 VDC battery. Includes a "Hi-Efficiency Switching Mode IC Driving Circuit" suitable for use with different lights.

120-250W Mosfet Power Mono Amplifier AF-2 (6 lbs.) ▲▲

Kit: $ ~~89.80~~ 82.80 Asmb.$ 114.80

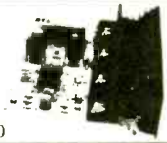
Power Output: 250W into 4 ohms RMS(42VX2 6A transformer is used). 120W into 4 ohms RMS(33VX2 4A transformer is used). Frequency Response: 3Hz-22,000Hz. THD: <0.03%. Signal to Noise Ratio: 91dB. Sensitivity: 1V RMS at 47k. Load Impedance: 4 or 8 ohms. Power Requirement: ±46VDC 4A or ±60VDC 6A. May use Mark V model 012 Transformer. Suggested Capacitor 8,200uf 100V Model 020. Suggested Metal Cabinet LG-1925.

30-in-one Electronic Lab Kit

KA-901 $ ~~15.99~~ 12.99

No soldering is required! This simple electronics kit safely teaches the fundamentals of electronics. Build a radio, alarm, timer and more. Earphone for private listening. Uses safe battery power. Requires 4 "AA" batteries!

300W High Power Mono Amplifier TA-3600 (5 lbs.) ▲▲▲



82.00
Kit ~~89.00~~
Asmb.$ 115.00

Power Output: 300W into 8 ohms RMS. 540W music power into 8 ohms. Frequency Response: 10Hz-20KHz. THD: < 0.05%. Sensitivity: 1V RMS at 47K. Power Requirement: 60 to 75 VDC at 8A. May use Mark V Model 007 or 009 Transformer. Suggested Capacitor: 8,200uf 100V Model 020 Capacitor. Suggested Metal Cabinet LG-1925.

150MHz 8 Digit Frequency Counter

SM-100 (2 lbs.)

Kit:$ ~~79.00~~ 68.00
Asmb.$ 99.00

It is used for adjustment, test & repair of any kind of high frequency circuit products. It can give up to 8 digit of resolution for a wide frequency range 10Hz - 150 MHz. The last input frequency can HOLD on the display for future reference & comparison. The circuit structure is compact & reliable for the most updated A/D LSI circuitry. The input impedance is 1M ohm.

120W + 120W Pre & Main Stereo Amplifier TA-800MK2 (4 lbs.) ▲▲

Kit: $ 67.92 Asmb.$ 86.95

Power Output: 120W into 4 ohms RMS. 72W into 8 ohms RMS. Frequency Response: 10 - 20 KHZ. THD: < 0.01%. Tone Control: Bass ±12dB, Mid ±8dB, Treble ±8dB. Sensitivity: Phono Input, 3mV into 47K. Line, 0.3V into 47K. Signal to Noise Ratio: 86dB. Power Requirement: 40V DC @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Metal Cabinet Model LG-1924.

80W + 80W Pure DC Stereo Main Power Amplifier TA-802 (4 lbs.) ▲▲

Kit: $ 49.94
Asmb.$ 69.94

Power Output: 80W per channel into 8 ohms. THD: < 0.05%. Frequency Response: DC to 200 KHZ, -0 dB, -3dB @ 1W. Power Requirement: 30V AC X 2 @ 6A. May use Mark V Model 001 or 008 Transformer. Suggested Capacitor 8,200uf 50V Model 017. Suggested Metal Cabinet LG-1924

60+60W Stereo Power Amp. ▲▲

SM-302 (11 lbs.)

Kit:$ 85.00

It provides 3 input jack pairs. One pair accept a high impedance micro-phone. The two remaining pairs are for high & low level input sources. Power Output: 60W per channel into 4 ohms RMS. 20Hz-20KHz. THD:<0.1%. Input Sensitivity :Mic /Guitar 10mV, Hi 380mV, Lo 640mV. Ready to plug in when assembled.

30W + 30W Pre & Main Stereo Amplifier TA-323A (1 lb.) ▲

Kit: $ 32.50 Asmb.$ 50.50

Power Output: 30W into 8 ohms RMS per channel. THD: < 0.1% from 100 HZ to 10 KHZ. Sensitivity: Phono 3mV @ 47K. Tuner, Tape 130mV @47K. Signal to Noise ratio: 80dB. Power Requirement: 22 to 36V AC, 3A. May use Mark V Model 002 Transformer. Suggested Cabinet LG-1684.

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Aluminum Front Panel

LG-1273	3x12x7"	(4 lbs.)	$ 26.50
LG-1684	4x16x8"	(7 lbs.)	32.50
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LG-1925	5x19x11½"	(10 lbs.)	42.00
LG-1983	2¼x19x8"	(7 lbs.)	35.25

Transformers (5-12 lbs.)
**Toroidal Transformers

# 001	28V/30V x2	6A	$ 30.00
# 002	36V x2	3A	25.00
# 003	40V x2	6A	32.00
# 008**	28V/30V x2	6A	42.00
# 009**	48/53V x2	8A	68.00
# 012**	33/40/42V x2	6A	52.00

3½ Multi-Function LED DPM ▲▲

SM-43 (1 lb.)

Kit: $ 35.50
Asmb$ 48.00

To use this instrument as a voltmeter, ammeter, ohmmeter, temperature meter.. AC/DC Voltage range:1mV-1000V.Thermometer range :0-100C.DC current range: 1 microamp - 2 amp. Capacitance range: 1pf-2 microfarads. Frequency Counter: 10HZ-20KHZ. Max indication ±1999. Power Supply: 5-6V DC, 200ma.

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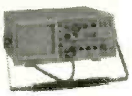

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- Dual time base
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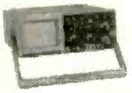
- Component tester



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- Single Sweep
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- 1mV/div sensitivity
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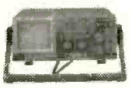
- Component tester
- Z-axis input
- Single sweep



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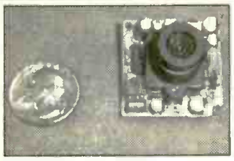
C-2000 Video Transmitter Cube..$89.95
C-3000 Video and Audio Transmitter Cube.................$149.95

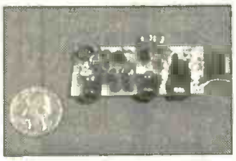
CCD Video Cameras



If you're looking for a good quality CCD board camera, stop right here! Our cameras use top quality Japanese Class 'A' CCD arrays, not the off-spec arrays that are found on many other cameras. You see, the Japanese suppliers grade the CCDs at manufacture and some manufacturers end up with the off-grade chips due to either cost constraints or lack of buying 'clout'. These cameras have nice clean fields and excellent light sensitivity, you'll really see the difference, and if you want to see in the dark, these are super IR (Infra-Red) sensitive! Available with Wide-angle (80°) or super slim Pin-hole style lens. Both run on 9 VDC and produce standard 1 volt p-p video. Add one of our transmitter units for wireless transmission to any TV set, or add our Interface board (below) for Audio sound pick-up and direct wire connection to any Video monitor or TV video/audio input jacks. Fully assembled.

CCDWA-2 CCD Camera, wide-angle lens.....................$99.95
CCDPH-2 CCD Camera, slim fit pin-hole lens.............$99.95

CCD Camera Interface Board



Here's a nifty little kit that eases hook-up of your CCD camera module to any video monitor, VCR or video input TV set. The board provides a voltage regulated and filtered source to power the camera (CCD Cameras require a stable source of power for best operation), sensitive electret condensor mike for great sound pick-up and RCA Phono jacks for both audio and video outputs. Runs on 11 - 20 VDC.

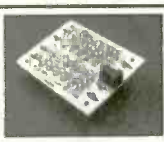
IB-1 Interface Board Kit...$14.95

Budget TV Transmitter

Transmit audio and video to any TV set with this fully assembled transmitter. Although not tiny, it still offers some neat features. Takes standard 1 volt p-p video and audio and transmits on any UHF TV channel of your choice from 17 - 42. Has rugged metal case, includes AC adapter, whip antenna and even RCA phono plug patch cords! Can also run on 12 VDC.

VS-2 Video and Audio Sender, Fully Assembled.........$29.95

IR Illuminator for CCD Cameras



See in total darkness with one of our CCD video cameras and this IR illuminator! IR light can't be seen, illuminate the scene with IR and a CCD camera 'sees' just fine. The array of 24 extra high intensity LEDs are invisible to anybody - except for aliens and Casper! Runs on 12 VDC. Illuminates similar to that of a bright flashlight.

IR-1 IR Illuminator Kit...$24.95

MicroEye CCD Camera & Transmitter Combo

We married together one of our quality CCD cameras, a sensitive electret microphone and a small TV transmitter to give you a super neat - and tiny - all in one, 'knows all, sees all, hears all' package! Small enough to fit into a cigarette pack and powerful enough to transmit up to 150' to any standard TV set. Tunable to operate on TV channels 4, 5, or 6 and runs on 9 to 20 VDC. The sensitive mike picks up normal voice within an average size room. Ideal for private detectives, investigators, hobbyists, babysitters, model rocketeers, RC airplanes and other uses limited only by your imagination. Camera module is fully wired and the transmitter unit is an easy to build kit that goes together in an evening. Includes all parts, handsome jet-black case and clear, concise instructions with ideas for use. And, don't forget, our CCD cameras are very sensitive to IR light - just add the IR-1 IR Illuminator kit for see-in-the-dark operation!

ME-2000 MicroEye TV Transmitter Combo $149.95

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The Wavecom Sr. has all of the features above plus adds the capability of transmitting your TV/DSS/VCR remote control signals from the receiver unit back to the transmitter unit. This is great for controlling your DSS satellite receiver or VCR from any room in the house. We also offer the small internal transmitter module assembly for those who wish to make their own concealed video transmitter system. Module is about the size of a couple of matchboxes and includes microwave patch antenna.

WC-1 Wavecom Jr. Wireless System..................$189.95
WC-5 Wavecom Sr. with Remote Capability........$239.95
WC-TX Transmitter Module Assembly................$105.00

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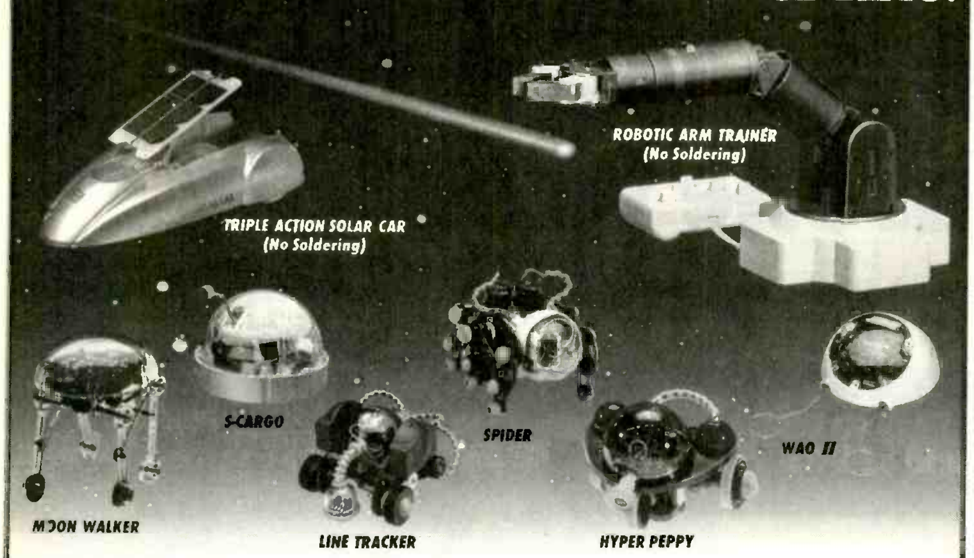

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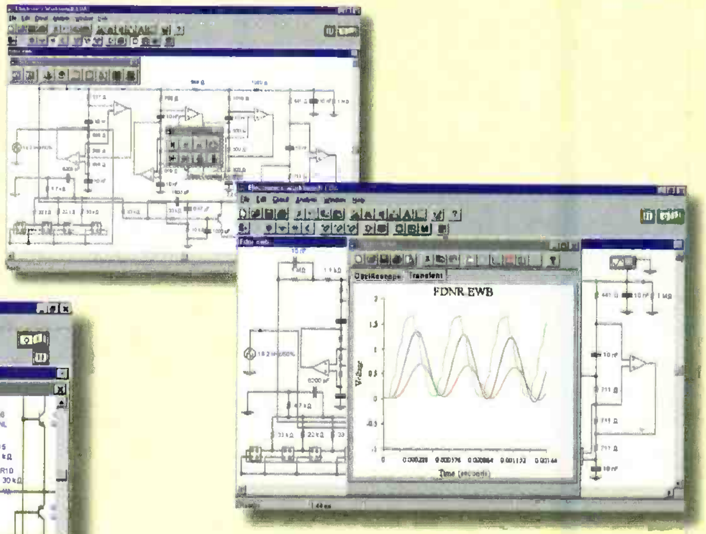

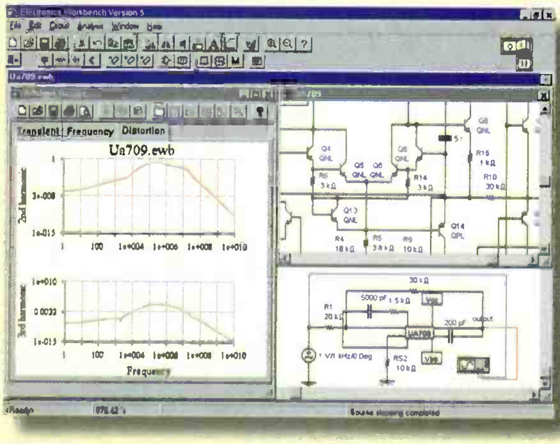

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