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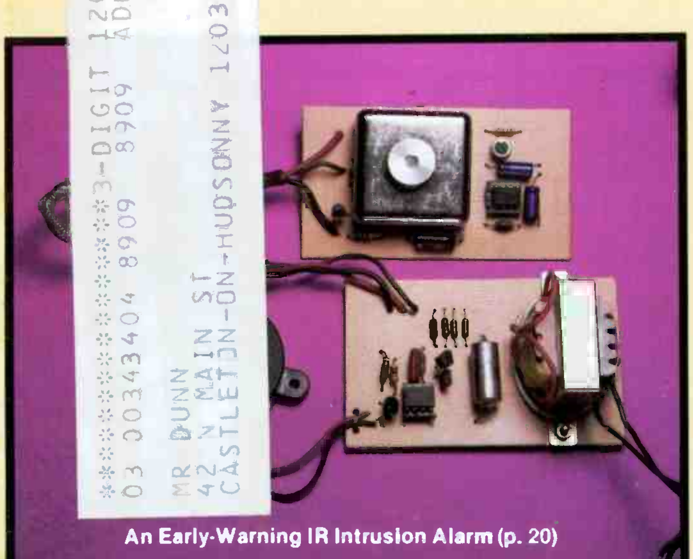

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CIRCLE 83 ON READER SERVICE CARD

BOB HANSON
MAY WELL HAVE HAD 200,000 FRIENDS.
NOW HE NEEDS THEM ALL . . .

The world of communications has lost a great friend and devoted public servant. On Wednesday, May 8, 1989 Bob Hanson, W9AIF, passed away on the operating table during a delicate and enormously costly liver transplant operation.

Bob will be mourned by literally hundreds of thousands of individuals whose lives he touched throughout the world as a noted columnist . . . public service association executive (SCAN, REACT, Community Watch) . . . communications industry advertising and marketing manager . . . and active radio amateur.

But mourning alone cannot pay adequate tribute to Bob's total dedication to serving others—including his wife of 23 years, Marilyn, and two teenage sons, Peter and Andrew.

Since liver transplants are regarded by some as "experimental surgery," not one dime of the expense—estimated in excess of $200,000—was covered by insurance. We simply cannot allow Bob's wonderful family to live with that impossible burden.

Your help is desperately needed. Immediately. Please, please send your contribution today. Make checks payable to: **Organ Transplant Fund Inc./Robert Hanson** a legally constituted non-profit organization. Any funds collected in excess of those required to pay actual medical expenses will be used to relieve similar transplant victims.

The Robert Hanson Fund.
A Living Memorial.

Organ Transplant Fund Inc./Robert Hanson
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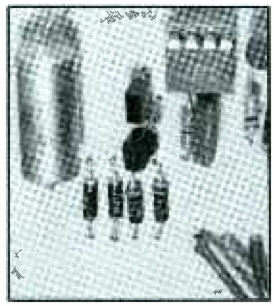
MODERN ELECTRONICS

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

SEPTEMBER 1989 **VOLUME 6, NUMBER 9**



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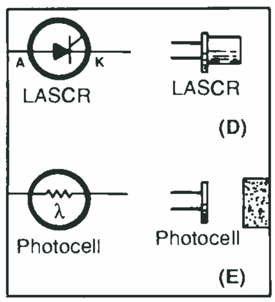

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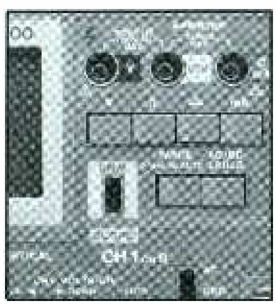

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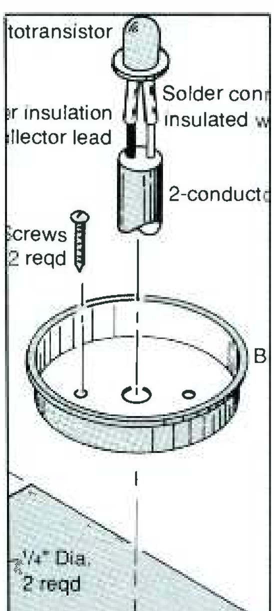

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EDITORIAL

Obsolescence

In electronics and computers, devices and even systems become obsolete in virtually no time at all. From vacuum tubes to transistors to integrated circuits, each transition period was shorter. Each new development spawned many new devices and systems. What's next in revolutionary terms?

Just look at hand-held electronic calculators, for example. It started in 1970 with a joint venture between Texas Instruments and Canon. This "four banger," with addition, subtraction, multiplication and division capabilities cost nearly $400 when it was introduced. Two years later, Hewlett-Packard debuted its first handheld, the HP-35, for $395. It added trig, logs and exponential functions. More than 300,000 were sold in just three years. It was called the "electronic slide rule," a popular device that has long been obsoleted by hand calculators. Simple four-bangers are so cheap that they're now throw-away products.

Automobile radios today are among other products that are a far cry from what they were some 35 years ago. Then they were strictly AM, bulky, and stations were selected mechanically. Its most vulnerable devices were a mechanical "vibrator" to convert dc to ac and, after being fed to a step-up transformer, rectified by an OZ4 vacuum tube. They were certainly easier to repair, though, as is the case with most earlier electronic products.

The world of professional electronic repairing has changed considerably, too, in keeping with design advances. An old-time service tech would be lost today if he had left the field a few decades ago and came back. He'd quickly discover that he was as obsolete as much of the equipment he used to repair. Moreover, much test instruments and many troubleshooting techniques used years ago would no longer be useful.

His salvation, though, would be learning anew through home study courses and seminars relating to electronic and computer service work. Added to this, naturally, would be test gear and accessories to meet modern needs. Unlike equipment, humans need not remain obsolete, thankfully.

Being out of fashion, or obsolete, needn't be a forever thing, of course. For proof of this, just look at video games. From a $3.25-billion industry in 1983, it crashed to under $100-million two years later. Warner subsidiary, Atari, which kicked off the industry in the first place, lost so much money that 4,500 employees were let go and the subsidiary sold for a song.

The end of a product-type line? Not at all. Only a few years later, a single Japanese company, Nintendo, was racking up video game sales of $1.7-billion. There's probably about another $500-million shared by other companies, including Atari Games and Sega. Now NEC is entering the video game fray with a more-powerful computerized system that uses a 16-bit microprocessor, as compared to Nintendo Entertainment Systems' (NES) 8-bit one. The latter has an enormous game cartridge library, though, as well as sales momentum.

We'll be watching this born-again product category with much interest to see if it once again fades away into obsolescence.

Art Salsberg

More, More

• I was fascinated by Forrest Mims' April 1989 "Electronics Notebook" column that explained the use of computers as Virtual Test Instruments. The prospect of converting my 80286-based IBM AT-compatible computer into a digital storage oscilloscope and other sophisticated test instruments left me giddy and thirsting for more.

David E. Hewitt
Las Vegas, NV

Keeping It On Hold

• Your "Put Your Telephone On Hold" project in the May 1989 issue is an exciting idea. I have a problem in that my project won't "hold" for longer than 20 seconds or so. Were there any corrections to the circuit as published, or is there something I can do to get this circuit to work properly?

Doyle Millwee
Enid, OK

I suspect that the voltage on the incoming telephone line may be sagging too low to maintain enough holding current to the SCR. If this is the case, you might try dropping the value of R1 to 1,300 or 1,200 ohms to bring up the current drive. I wouldn't go lower than 1,200 ohms for R1, however.—Andrew E. Van Loenen

Project Corrections

• While reading through the "Solid-State Digital Barometer" presented in the January 1989 issue, I found a few errors. In Fig. 1, +5V to pin 2 of the sensor should be +15V. In Fig. 5, the metal tabs on IC4 and IC5 should be on the other sides of both outlines, and the "f" and "g" legends at the top of the drawing should be transposed. In Fig. 6, the designations on the solder side should be "K4" through "K1" left to right, and the "DP" legend should go to the pad in the real K2 outline (second from right).

Ken Hotelling
Ramona, CA

In Rebuttal

• I was shocked to read your Editorial on "The Radar Detector Battle" in the June 1989 issue. I think if you research your statistics correlating radar detector ownership with safe driving you'll find that the reason most radar detector owners wear seatbelts is that they are protecting themselves against their high-speed driving habits! If we have a problem with law-enforcement not using radar "guns" properly, let's correct that situation. To state that radar detectors make driving safer is an irresponsible, childish attitude. If there are offenses relating to the misuse of radio-frequency devices, let's get the FCC involved.

Do you realize how many drunk drivers escape early detection because they were warned by their radar detectors, only to be caught at the scene of the accidents they caused? So, let's stay with technical Editorials that benefit the electronics community and not ones that benefit a few bad drivers and radar detector companies.

Frank Muratore
Garden City, NY

COMPUTER HAPPENINGS. Micropro International Corp. changed its company name to WordStar International. It's a long overdue move that'll take advantage of the name recognition of its word-processing software that's so well known.

The first rechargeable backup battery for the IBM AT and compatible computers is offered by Rupp Corp. (New York, NY and Los Angeles, CA). Called "bATPac," it continuously charges when the computer is on, and backs up clock and setups when power is off for up to 12 months. In contrast, standard lithium batteries are candidates for replacement after one year's use. Expected lifetime is said to be ten years. $39.95.

An extra-high-density 3-1/2-inch floppy drive with a 4-MB data storage capacity using ED or XD media has been introduced by Practical Computer Technologies (Fairfax, VA). Data transfer rate is said to be 1 MB/sec, which is four times faster than with standard micro disks. It's also reported to be downward compatible with standard 1- and 1-MB disks, and automatically adjusts for disk type and and format. The key ingredient appears to be the use of perpendicular recording techniques.

AppleLink's Technical Info library and many major bulletin boards are providing Free a non-Apple-labeled virus detection program, "Virus Rx, to assist Apple and Macintosh users in detecting the SCORES virus. In addition, this revision, Version 1.4, also supports strains of nVIR, INIT 29 and Hpat viruses.

A SERVICING SHARPIE. Sanford Corp., Bellwood, IL, has a new Sharpie[R] permanent marker designed for electronic repair technicians. It has an ultra-fine 0.3mm-diameter tip for precise marking in very tight areas. In use, techs employ the marker to "mark out" areas around faulty components, and mark on plastic and metal parts. The Sharpie Ultra Fine comes in four colors (black, blue, green and red), is highly water resistant, dries quickly, with retail price at only 99 cents at local stationers.

SURFACE-MOUNT TECHNOLOGY EDUCATION. Heath/Zenith claims to have the first home-study course for surface-mount technology. Developed by Modern Electronics columnist Forrest Mims, it's designed to give students an understanding of the technology and gain hands-on practice with it through building some projects.

NEW DIGITAL AUDIO COMPRESSION SYSTEM. A digital compression system that reportedly makes it possible to store or transmit four times the audio data now possible without a subjective loss in sound quality was developed at Queen's University, Belfast, Northern Ireland. Called "apt-X100," the hardware codes and compresses binary digits that encode audio signals from 16 to four. Accordingly, up to five hours of music could be compressed onto a compact disc with this system, which was commercialized by Audio Processing Technology, a subsidiary of Solid State Logic, Oxford, England.

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

386SX Computer

Tandy Corp.'s new Tandy 4000 SX personal computer is built around the Intel 386SX microprocessor running at 16 MHz. Included are VGA support and SmartDrive™ intelligent device electronics (IDE) storage technology. The standard configuration includes a 1.44MB 3.5" floppy-disk drive with three additional storage-device slots available, VGA graphics, 1MB of user RAM, 80387SX math coprocessor socket, 200-watt power supply, 101-key enhanced keyboard with tactile feedback, key lock, serial port and bidirectional parallel port.

A 40-pin IDE SmartDrive connector permits hard drives with integrated AT-type controllers to plug directly into the system to alleviate the need to use an expansion slot for a controller. Additionally, embedded controllers provide increased performance and assure compatibility between drive and controller.

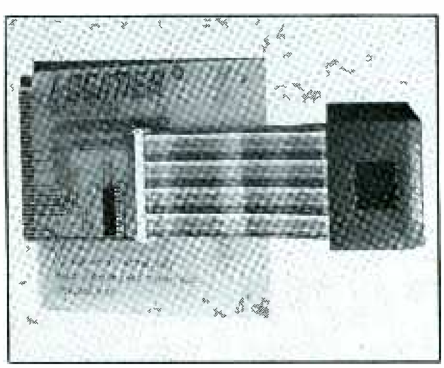
SIMMs (single in-line memory modules) give the Tandy 4000 SX a memory-expansion capacity of 16MB. Two high-speed Tandy-designed memory slots support the expansion modules. These slots are said to perform data transfers at rates faster than possible with conventional 16-bit expansion slots.

Expansion capabilities through one 3.5-" and two 5.25" front-accessible half-height disk-drive slots permit the user to tailor his mass-storage choices to his needs. Floppy-disk options include 1.44MB or 740KB 3.5" and 1.2MB or 360KB 5.25" drives. SCSI hard disks in capacities ranging from 40MB to 344MB and a 150MB tape backup system are also available as options. Addition of an SCSI adapter provides data transfers at speeds up to 10MB/second.

Four 16-bit AT-style and one 8-bit XT-style expansion slots are available on the bus. Video display monitors are available in monochrome and a range of color versions. The small-footprint system unit measures 17"D × 15.75"W × 6.25"H. $2,599 for base system; $3,248/$3,498 for system with 40MB/80MB hard disk; $199 for monochrome monitor; $499 to $629 for color monitors.

CIRCLE 52 ON FREE INFORMATION CARD

Computer Troubleshooter



"Logimer" from Barjus International (Willowdale, Ontario, Canada) is a plug-in device that is claimed to perform 1,000 tests and checks on IBM and compatible PCs, XTs and ATs built using the 80286 and 80386 microprocessors. The tests are said to check out every part of the motherboard circuit, including video, keyboard, disk controller and ports, to localize faults down to IC pin level in just one minute. The hardware tester consists of a circuit board that plugs into any open slot on the computer's motherboard and a display device that connects to the board via a ribbon cable. $649.

CIRCLE 53 ON FREE INFORMATION CARD

Wireless Microphone

Incorporated into Ambico's (Norwood, NJ) Model V-0625 wireless lapel microphone for camcorders is circuitry that allows the user to select from among three distinct frequencies to isolate the clearest, highest-quality audio transmission. Both transmitter and receiver feature a three-position switch with which the best sound path can be selected.

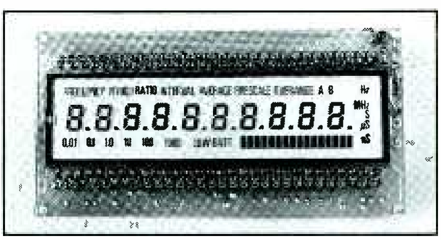
The compact, FCC-approved transmitter can easily be carried in a pocket. No antenna is visible because it is built into the cable that connects

the microphone to the transmitter. The unobtrusive microphone can be clipped onto a tie or lapel without drawing attention to itself. The receiver attaches to the lighting hot shoe on a camcorder and features a telescoping whip antenna and an earphone output jack. $89.95.

CIRCLE 54 ON FREE INFORMATION CARD

Universal Timer Counter Module

A new universal timer counter from Optoelectronics Inc. employs custom ASIC, custom LCD and surface-mount technology to increase performance capabilities and reduce size. The model UTC150 has a frequency range of 0.1 Hz to over 150 MHz, with up to nine digits of reso-



lution per second from 1 Hz to 150 MHz and 10-digit display in 10 seconds from 0.1 Hz to 150 MHz. Dimensions are only 1.8"H × 3.55"L × 0.6"D (0.85" at connector).

The 10-digit LCD display has ¼"-high characters. Also featured are annunciators for Function, Gate Time, Range, Measurement Units, Input A/B, Low Battery, Prescale, and 16 Analog Bar-Graph Segments. Also, the module has automatic decimal placement and automatic units display.

Gate times are 0.01, 0.1, 1.0 and 10 seconds. The UTC has four CMOS logic-level inputs for momentary switch control; sensitivity (sinewave) is 400 mV. On board is a 10-MHz time base with calibration adjust trimmer, an LCD contrast-control potentiometer, gate light LED and an 8-bit A/D. Power required is 5 Vdc, 50 mA; "Low Batt" is displayed when supply drops below 4.5 V. Connector is a 14-pin gold-plated dual header. $225 ea., $149 in 100-plus quantities.

CIRCLE 55 ON FREE INFORMATION CARD

High-Performance Compact Audio System

Yamaha has an audio system that is designed to deliver high performance in a small-footprint package. The Model AST-C10, dubbed the "Unity" system, includes an amplifier, AM/FM stereo tuner, dual cassette deck, CD player, four-band graphic equalizer and two speaker systems. It features PLL synthesized tuning with direct entry and 10 presets. A low-loss AM loop antenna is included for best possible performance. The timer can be set to wake up the user to the sound of any preprogrammed AM or FM station.

The dual cassette deck can provide endless playback with its automatic playback for both sides feature. It also features automatic-reverse re-

has a control section with a built-in timer function that can be set to wake up the user, turn off the unit at bedtime and just operate the system when no one is in the room. For maximum convenience, Yamaha has added an IR remote controller.

Yamaha's Active Servo Technology employs various types of matching and feedback circuitry to create in the AST-C10 a speaker/amplifier combination that is claimed to produce extremely low and accurate bass response from speakers that measure only 5⅞"W × 9½"D.

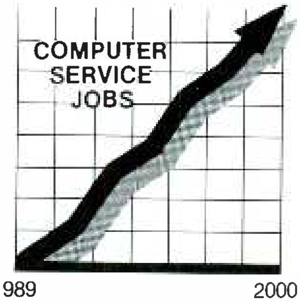
The AM/FM stereo tuner section cord for one cassette well; Dolby B noise reduction for both wells; and programmable timer record/play for unattended operation.

At the top of the stack is the CD player that features direct, random and programmed access and a 20-track calendar. Intro scan and intro program playback permit auditing of the first 10 seconds of a track and then moving on. CD replay synchronizes the CD player and cassette recorder for professional-like recording. The timer can be set to wake up the user to a favorite selection on a compact disk. $999.

CIRCLE 56 ON FREE INFORMATION CARD

5 sure steps to a fast start as a high-paid computer service technician

1. Choose training that's right for today's good jobs



Jobs for computer service technicians will almost double in the next 10 years, according to the latest Department of Labor projections. For you, that means unlimited opportunities for advancement, a new career, or even a computer service business of your own.

But to succeed in computer service today, you need training—complete, practical training that gives you the confidence to service any brand of computer. You need NRI training.

Only NRI—the leader in career-building, at-home electronics training for 75 years—gives you practical knowledge, hands-on skill, and real-world experience with a powerful XT-compatible computer you keep. Only NRI starts you with the basics, then builds your knowledge step by step until you have everything you need for a fast start as a high-paid computer service technician.

2. Go beyond "book learning" to get true hands-on experience

NRI knows you learn better by doing. So NRI training works overtime to give you that invaluable practical experience. You first read about the subject, studying diagrams, schematics, and photos that make the subject even clearer. Then you do. You build, examine, remove, test, repair, replace. You discover for yourself the feel of the real thing, the confidence gained only with experience.

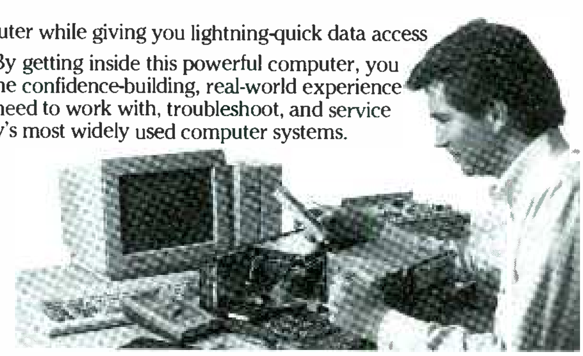
3. Get inside a powerful computer system

If you really want to get ahead in computer service, you have to get inside a state-of-the-art computer system. That's why NRI includes the powerful new Packard Bell VX88 computer as the centerpiece of your hands-on training.

As you build this fully IBM PC XT-compatible micro from the keyboard up, performing key tests and demonstrations at each stage of assembly, you actually see for yourself how every section of your computer works.

You assemble and test your computer's "intelligent" keyboard, install the power supply and 5¼" floppy disk drive, then interface the high-resolution monitor. But that's not all.

You go on to install a powerful 20 megabyte hard disk drive—today's most-wanted computer peripheral—included in your training to dramatically increase the data storage capacity of your computer while giving you lightning-quick data access.



By getting inside this powerful computer, you get the confidence-building, real-world experience you need to work with, troubleshoot, and service today's most widely used computer systems.

4. Make sure you've always got someone to turn to for help

Throughout your NRI training, you've got the full support of your personal NRI instructor and the entire NRI technical staff. Always ready to answer your questions and help you if you should hit a snag, your instructors will make you feel as if you're in a classroom of one, giving you as much time and personal attention as you need.

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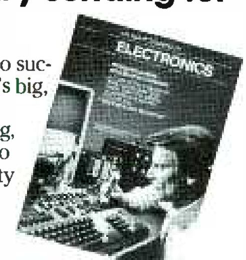

Discover for yourself how easy NRI makes it to succeed in computer service. Send today for NRI's big, 100-page, full-color catalog describing every aspect of NRI's one-of-a-kind computer training, as well as training in robotics, TV/video/audio servicing, electronic music technology, security electronics, and other growing high-tech career fields.

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New Video-Game Entries

Nintendo has an enormous market share of the resurgent video game market, but a handful of major companies continually try to chip away at its lead. A pair of new game entries from Atari Corp. and NEC continue this effort, as follows.

Atari Corp. debuted the first color portable, hand-held video game system, the Atari Portable Color Entertainment System. It's a $150 ("list price") package that has a 3.5" built-in color LCD monitor with a resolution of 160 × 102 pixels. It displays graphics in up to 16 colors from among a palette of 4,096 colors. Other features include four-channel sound and a headset jack to avoid disturbing others.

Atari Portable Entertainment System—world's first hand-held play-anywhere color portable video game system.

Large-game operating features have been incorporated into the new system, including an 8-way joypad, two "fire" buttons and five function buttons. Sound volume and video contrast can also be adjusted. The system is slightly larger than the size of a videocassette and weighs only one pound. It comes with 64K of RAM, operates with its system clock at a fast 16 MHz (claimed to be four times faster than the competition). Powered by six "AA" batteries or an ac adapter or car cigarette-lighter adapter, the Atari color video game system can be used while on the move—in a car, boat, park, etc.

The system uses game cards that are the size of a plastic credit card. It can use cards with up to 16 megabytes of action-oriented power. One game card ("California Games") is included with every system. Five other games, developed by Epyx, Inc. are already available at $35 each.

With a connecting cable, players can link up to eight Atari portable systems with use of a single game card for multi-player competition. The system provides each player competing a first-person view of game action from his perspective. For example, if one is playing a racing game, and a competitor passes, the screen shows the second car ahead of him.

CIRCLE 57 ON FREE INFORMATION CARD

NEC Corporation, the giant global communications and computer company, has moved into the home video game arena here recently with the announcement of its $199 TurboGrafx-16 system. This is an expandable color video game system that also uses game cards the size of a credit card for easy loading and storage. It comes with one TurboPad controller and one TurboChip game card, an adventure game.

The NEC TurboGrafx-16 system with TurboChip game card (shown in recess in top of console) and TurboPad controller.

It uses a 16-bit graphics processor. Peripherals include the TurboGrafx-CD player and the TurboBooster audio-video enhancer, as well as a bevy of upgraded controllers and a multi-play adapter. The special CD player attaches to the NEC video game unit to run advanced games accompanied by outstanding audio. A compact disc's large storage capacity is equivalent to that of 2,000 game cards. The CD player, at $399, can also play standard compact discs as well as the new CDs with graphics.

CIRCLE 58 ON FREE INFORMATION CARD

Bench-Top DMM

The Heath Company's new Model SM-2360 bench-top digital multimeter features true rms capability, a decibels scale, an audible continuity test function, data-hold capability and automatic polarity indication. The meter also measures the usual ac and dc volts and currents and resistance. It has a basic specified accuracy of 0.03%.

Among the instrument's features are a 4½-decade display, full pushbutton function/range selection, and recessed test-cable inputs. $269.95.

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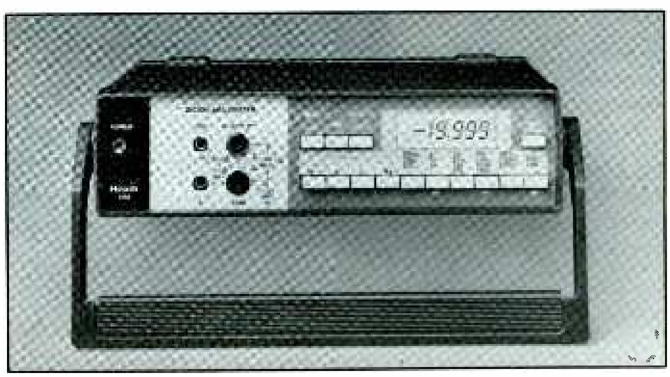


Graphics Database System

DataSketch from Tarbell Electronics (Long Beach, CA) includes drawing and picture graphics as a field type in addition to numeric, character, date, multi-line and sound fields. Though it is not promoted as a presentation/chart/business graphics package, its built-in art capability permits circles, lines, rectangles, dots, text and arcs to be drawn. Figures can be painted solid or with hatching. Sections can be rotated, duplicated, moved and zoomed with simple commands. They can be saved to disk and recalled at a future time. Picture files can be read from disk, combined with and modified by drawings, and can then be written into a database file.

The database system includes an English-like programming language that contains extensions for graphics fields and variables that permit the usual database commands to be used in unusual ways. For example, all records with circles in them can be listed, or the lengths of all lines in a file can be added up. The multi-key

balanced-tree indexing system can index several fields with different types without requiring fields to be converted to the same type.

DataSketch requires PC/MS-DOS 3.00 or later running on an IBM PC, XT, AT or compatible computer that has 512K of RAM and CGA, Hercules or EGA display. Any of several popular graphics printers can be used with the software. A hard disk is recommended, and a Microsoft- or Logitec-compatible mouse can be used (but is not required) for drawing. $99.

CIRCLE 60 ON FREE INFORMATION CARD

Soldering-Iron Accessory

Iron Sleeve™ from Electron Processing (Medford, NY) is a handy new device that eliminates time wasted by field technicians who use their soldering irons on a service call. It allows the technician to place his hot iron back into his toolkit without having to wait for it to cool. Time saving averages from 5 to 10 minutes per service call. The device consists of an 11"L × 1.5"Dia. tube that contains a proprietary heat-absorbing

(Continued on page 77)

The Many Faces of Fax

Business's versatile communications tool is becoming today's hottest new adult toy.

By TJ Byers

Originally designed for office use, the fax machine is emerging as this year's hot, new adult toy. In addition to sending documents, drawings, and photographs over standard phone lines, people are using their fax machines to play games like "fax" chess (similar to mail chess), or win prizes by entering radio- and TV-sponsored "fax" contests.

You can buy a desktop fax machine for as little as $600 or add fax to your personal computer for under $300, about what you'd expect to pay for a VCR.

Business likes fax for its speed and low operating cost. "When it positively has to get there overnight" just isn't good enough, you can rest assured that fax will zip your ten-page document to its destination in a matter of minutes—and do it for just the cost of the phone call.

Although there are four versions of fax (see Historical Fax), only the internationally supported CCITT Group 3 standard is in widespread use. The aged Group 1 and Group 2 faxes are all but obsolete, and Group 4 requires a special ISDN phone line that won't be available any time soon. Group 3 fax, on the other hand, is fast, simple, and *cheap.*

The inexpensive multi-featured OMNIFAX G36 features unattended fax transmission and reception, representative of the new breed of desktop fax machines.

How It Works

Basically, a fax (short for facsimile) machine scans your picture or document and converts it into an electronic signal (exactly like a TV camera converts a studio image into a video signal). Then it sends it over a standard telephone line at regular phone rates to a receiving fax machine, which in turn converts the electrical impulses back into a picture or document. In effect, fax is the purist form of electronic mail, going from paper to electricity and back to paper again. Seven steps are required to transfer a fax.

First, a scanner looks at the document and converts what it sees into electrical impulses using raster scanning. The most common scanning method has the document slide across a slot that is cut into a flat plate, as illustrated in Fig. 1. More expensive fax machines use what's called flatbed scanning, which has the slot move under a page that is held stationary on a glass plate. In both methods, the portion of the document over the slot is evenly illuminated by a light source that extends across the width of the slot. A curved mirror reflects a shortened image of the illuminated slot onto the face of a CCD (charge coupled device) through a focusing lens.

By electronically scanning the surface of the CCD, a binary-coded serial output voltage of the image is produced. After the scan is complete, the page or scan mechanism is advanced, and another sweep of the slot is made. Normally, the page is scanned at 200 dots per inch (dpi) horizontally and 100 dpi vertically, which means

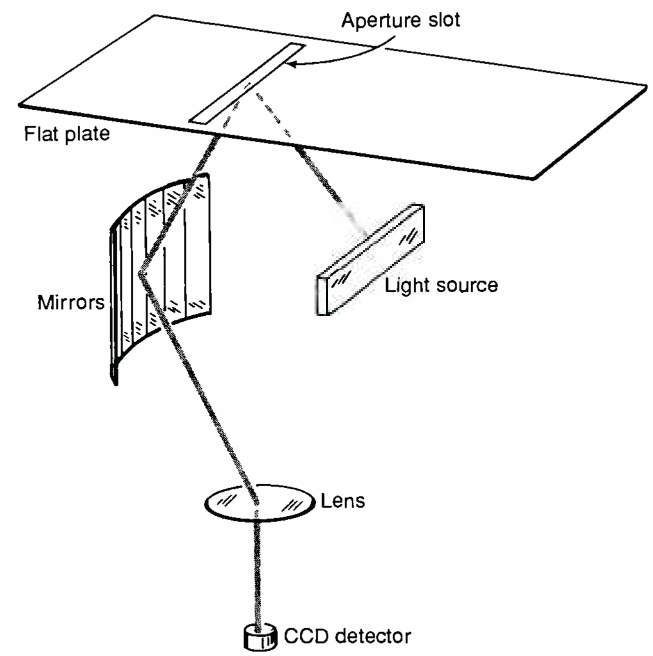


Fig. 1. A popular scanning technique uses a tractor device to move the document past a slot through which a light source evenly illuminates the page beyond. Optics then focus the image on the face of a scanning CCD sensor.

Reasons To Own A Fax

If you still can't justify buying a fax machine even after reading this article, we may suggest five more compelling reasons to do so:

1. Service technicians and field engineers will find it an ideal way to exchange blueprints, schematics, and parts lists.
2. Design engineers can use it to access up-to-the-minute price and product information from manufacturers.
3. It is the most reliable way of ordering merchandise over the phone.
4. Students can use it to exchange class notes and other sundry items.
5. Fax tag is cheaper to play and more rewarding than telephone tag.

there are 3.7-million dots on a standard 8½-by-11-inch page.

However, that is too much data to send over a telephone line in a reasonable amount of time. Fortunately, there is a lot of signal redundancy in most documents (especially printed pages, which are about 85 percent white), which makes it possible to reduce the size of the fax file using data compression. Group 3 fax uses two data compression techniques.

The first is boundary recognition. In boundary recognition, the only time a signal is generated is when the dots change from white to black or from black to white. The intervening dots are not recorded, but they are counted. The receiving fax reconstructs the page by putting in the number of counted white or black dots between boundary changes.

The second data compression technique exploits the fact that successive rows of dots (scan lines) are often similar. The method, which is called two-dimensional coding, compares each line of the raster to a reference line. By detailing only how each row differs from the last, further compression is achieved.

Typically, fax can describe a typed page using just 32K of data. Photos and other complex images require more data to describe them, of course, which means they take longer to send than a printed page.

The compressed sequence of dots is then input to a PSK (phase shift keyed) modulator for encoding. PSK encoding differs from the more familiar FSK (frequency shift keyed) encoding in that the data rate can be greater than the carrier frequency, which makes it possible to send fax data over a 2,700-Hz phone line at 9,600 bits per second (bps).

In the fax PSK modulator, the carrier frequency is held constant at 2,400 Hz and the phase of the carrier frequency is changed to indicate a binary zero or binary one code (see Fig. 2), a method that is popularly known as Quadrature Amplitude Modulation (QAM). Essentially, the signal is derived from two oscillators running at 90 degrees apart. The modulator creates the phase changes by switching between the oscillators according to the binary bit change. For example, if the carrier advances by 90 degrees, it may indicate a bit change from zero to one. Because you can have four phase shifts per cycle, the data speeds over the phone line at 9,600 bps.

During data exchange, the receiving fax constantly checks for transmission errors caused by poor conditions commonly found in telephone lines. If it senses too many errors in the data stream, it sends an electrical request to the originating fax to cut the transmission speed to 7,200 bps. This is called "fall back." If there are too many errors at 7,200 bps, the answering fax will request another fall back to 4,800 bps, and if there are still too many errors the machine falls back to 2,400 bps.

When in the fall-back mode, the sending fax will try from time to time to get back to 9,600 bps by kicking up the speed a notch. If there is no complaint from the answer fax, another

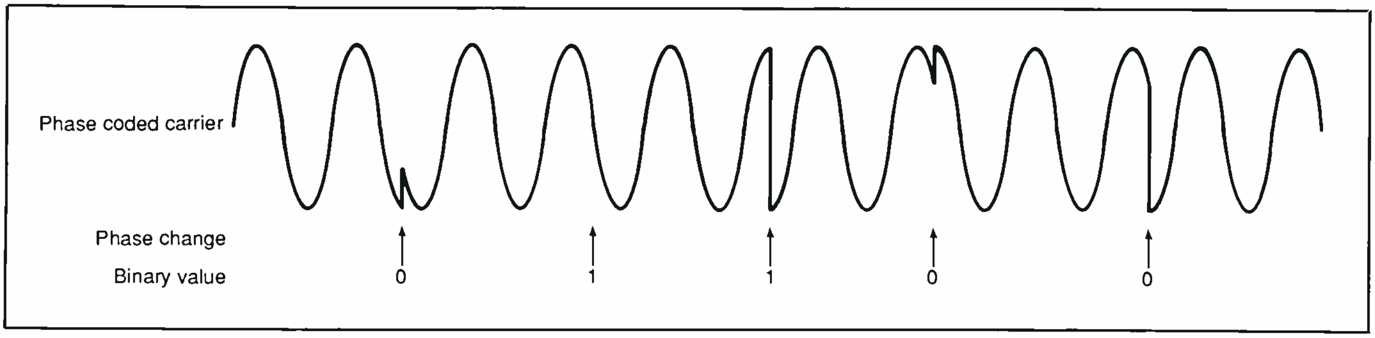


Fig. 2. Group 3 fax uses PSK modulation. The 0 or 1 value of the data bit is deter mined by the value of the previous data bit and the phase change, not the abso lute value of the phase shift itself.

gear is engaged until a 9,600 bps link is again established. If the condition of the phone lines make it impossible to send at 9,600 bps, the transmission proceeds at the highest acceptable rate, with a proportional increase in the time required to send the fax.

At the receiver, the fax signal is demodulated using a phase-locked loop (PLL) detector and passed through a digital signal processor that sorts out the data compression codes. A data expander then restores the document or image to its former self by inserting the line dots that were stripped out by the originating data compressor. Finally, the dots are printed on a sheet of paper to complete the copy process.

Fax Features

If the foregoing was all fax did, it would be accomplishment enough. But many fax machines can do much more, including multiple broadcasts and scheduled fax transmissions. This ups the machine's selling price, too, naturally.

Broadcasting, which also goes by the name of group distribution, is a very popular fax feature that allows the fax machine to automatically send a document to more than one fax receiver. Inside the fax machine is an area of nonvolatile memory that is used to store phone numbers and fax documents.

Before a broadcast session is initiated, the destination phone numbers are put into this memory along with the document you wish to send. You can also program a transmission time into this memory so that the fax machine can take advantage of reduced off-hour phone rates. At the scheduled time, the fax successively calls each of the numbers listed and sends the document.

Most high-performance fax machines also support polling, which allows the fax to act as a remote transmitter. In the polling mode, your fax answers a call from another fax machine as usual. But instead of receiving a document, it transmits a stored document to the calling party. This feature is very handy for establishing unattended contact between vastly different time zones (New York to Hong Kong, for example).

Polled documents are requested by the calling fax. To prevent just anyone from polling your fax and receiv-

Pioneer GammaFax remains the PC fax by which all others are compared. It is one of the easiest PC faxs to use and supports advanced file conversion and optical character recognition (OCR).

Historical Fax

The idea of sending facsimile images and documents over wire is neither new nor modern. Way back in 1842 Alexander Bain demonstrated and patented a telegraph-wire-operated rotating drum facsimile device that evolved into the facsimile wire machine that became the main source of international news photos through most of this century. However, these machines were both temperamental and expensive to operate.

In 1924, in an effort to promote fax over telephone lines, AT&T devised the paper-scanning fax technique by which all fax machines operate today. Although the idea was slow to catch on, it nonetheless gained in popularity. By the end of the 1950s, AT&T's Bell Telephone division had more than 40,000 fax machines in operation. Then came the FCC Carterphone suit that ultimately led to the divestiture of AT&T and the loss of Bell Telephone. Many manufacturers saw this as an opportunity to forge their own fax standard, an attitude that soon plunged fax into a world of babble.

It took the efforts of no less than the Cooperative Committee for International Telephone and Telegraph (CCITT) to put fax back on track. By the mid-1960s, their Group 1 proposal was adopted as the global fax standard, and harmony was again restored. However, Group 1 fax machines communicated at only 300 bps using analog frequency shifted modulation (FSK), and it took six minutes to send a single page from one fax machine to another. Costly communications indeed. In 1976, CCITT halved the transmission time to three minutes per page by adding a limited form of data compression. The new standard was called Group 2. But still, enthusiasm was less than overwhelming.

In 1980, CCITT proposed a Group 3 standard that sparked the fax explosion. Group 3 uses advanced digital data compression methods and a 9,600-bps modem that allows the fax machine to send a full page in as little as 15 seconds. Group 3 also supports two levels of resolution: a regular mode with 200 by 100 dots per inch (up from the 100 by 100 dots per inch resolution of Groups 1 and 2) and a fine-resolution mode with 203 by 193 dots per inch. It's no wonder the world now endorses Group 3.

Recently, the CCITT approved a Group 4 standard that can send a page in 5 seconds with resolutions of up to 400 dots per inch! Unfortunately, Group 4 requires an all-digital ISDN telephone network that won't be widely available for at least two decades—well into the next century. So chances are good that your Group 3 machine will wear out long before it becomes obsolete.

ing sensitive documents, password protection is provided. Password protection, which is based on the address of the polling fax, allows polling machines to request only the documents that they are authorized to receive.

Normally, a separate phone line is required for the fax machine, or the machine is manually switched off when not sending a fax (otherwise, someone calling you will get an earful of *very loud* carrier tone). However, some high-end fax machines have voice/fax recognition which allows the fax and a telephone to share a common line.

When the fax machine answers a call, it suppresses the carrier tone while it listens for a handshaking signal from the originating fax. If it senses the handshake, the fax turns on its carrier and proceeds to make the connection. If a handshake signal is not detected, the machine switches the line over to voice operation. Also, there are separate units available that the fax machine and phone are plugged into to achieve signal recognition and automatic switching.

Computer Fax

Because the Group 3 fax standard is digital from beginning to end, it was inevitable that someone would combine fax with the computer. That event occurred in 1984 with GammaLink's introduction of the GammaFax fax adapter card for the IBM PC. Today, you can find fax cards for the IBM PC and compatibles from a number of sources. There's a $699 AppleFax modem for Macintosh computers that allows for transmit and receive as well as computer data file exchange.

A PC fax card is basically a high-speed modem that supports the internationally recognized Group 3 fax standard through the use of fax-specific software. PC fax boards are completely compatible with stand-alone fax machines and other PC fax boards. So if you already have a PC, you're halfway to owning a fax machine. Furthermore, PC fax offers features not available in low-cost office fax machines.

Essentially, the features are provided by the software. While features vary from model to model, you can generally count on the most popular, such as scheduled unattended fax sessions, broadcasting capability, and polling with password protection. Most PC fax software will also maintain an on-line phone book and a cumulative log of fax activity. And because the features are software based, you don't have to buy a new fax board when the manufacturer adds new features. You only have to upgrade the software.

However, a PC fax's greatest feature is the ability to import and export files between the fax board and the PC. This allows you to create letters and images on the PC, then send them to another fax machine via the fax board. You can even import letterheads and signatures that can be used to paste together documents that look like they came from a real piece of paper.

(Continued on page 76)

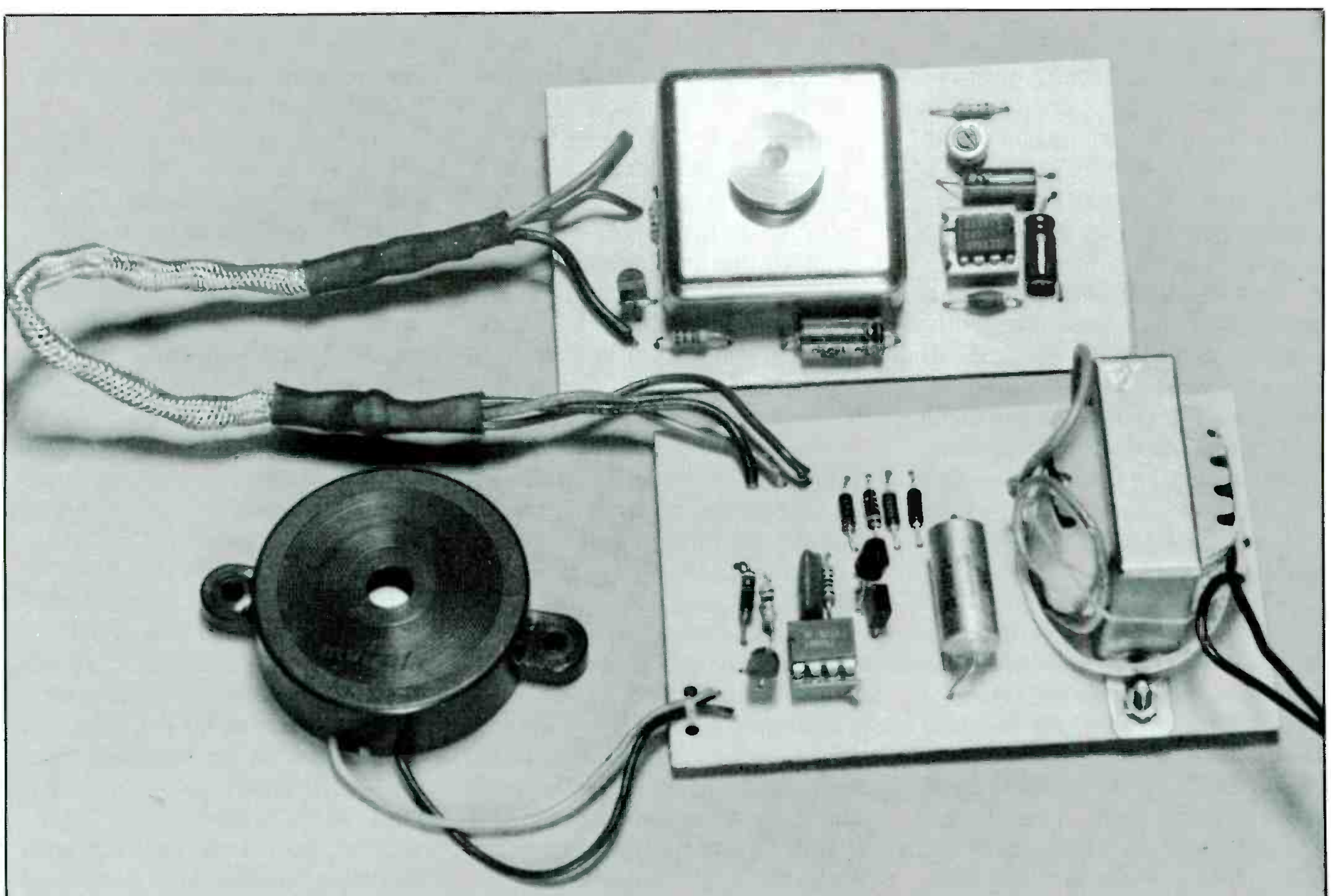
An Early-Warning Intrusion Alarm

Motion-detection system sounds an audible alert before an intruder or vehicle enters your property

By Anthony J. Caristi

Most alarm systems that announce the presence of an intruder do so either at the point he is about to gain entry or has already entered the protected premises. A much more realistic intruder-detection system would be one that senses the approach of a person on foot or in a vehicle at a far enough distance away to let you take appropriate action before he arrives. Just such a system, described here, can easily be implemented using a recently developed infrared detection module from Infrared, Inc. (Parlin, NJ).

Our Early-Warning Intrusion Detector is relatively low in cost and an easy to build infrared motion-detecting system. It is built in two separate sections to permit the ac-operated power supply with audible alerter and the sensor to be installed in physically separated locations. Locating the sensor at a distance from the remainder of the electronics gives the



project its ability to provide early warning of an approaching visitor at the entrance of your driveway or footpath.

If desired, you can add a simple lighting control circuit to the project to provide automatic illumination of virtually any time duration when a person enters or leaves the protected zone. This option is a convenience for invited guests and serves as a deterrent to uninvited individuals.

The sensor used in this project has enough sensitivity to detect the heat radiated by a human body at a distance of 10 to 15 feet. This distance can be increased substantially with a simple single lens optical system. Vehicles, also emitters of large amounts of infrared energy (heat) are also easily detected with or without an optical system. The detector is sensitive enough to respond to the IR energy radiated by a small animal, such as a dog or cat.

About the Circuit

The amount of infrared energy any given object radiates depends on the surface area of that object, its emissivity (how efficient a heat radiator it is) and its temperature. A perfect emitter of IR energy has an emissivity of 1. Most objects will emit less IR energy, while human skin has an emissivity rating of 0.95.

With the foregoing in mind, refer to the schematic diagram of the circuitry used in the project shown in Fig. 1. As you can see, the project consists of the power-supply/sound-generating circuit assembly shown at the left and the remote sensing assembly shown at the right. At the

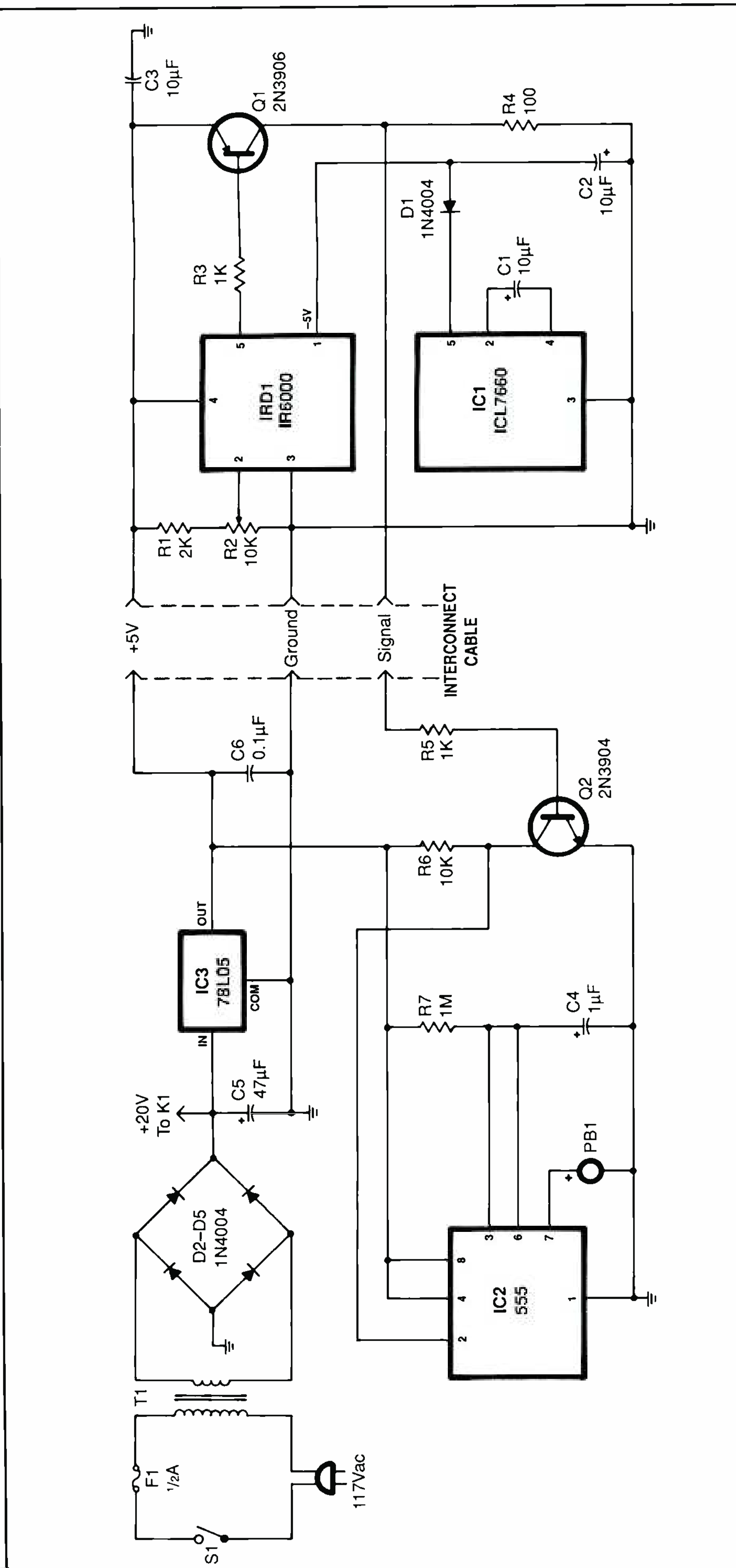


Fig. 1. Complete schematic diagram of the circuitry used in the basic project. The portion shown at the left is the power-supply/sound-generation section, while the portion at the right is the IR detection section.

PARTS LIST

Semiconductors
D1 thru D6—1N4004 or similar silicon rectifier diode
IC1—ICL7660 voltage inverter (Intersil)
IC2,IC4—LM555CN timer
IC3—78L05 fixed +5-volt regulator
IRD1—IRD1000 infrared detecting module (Infrared, Inc.)
Q1—2N3906 or similar pnp silicon transistor
Q2,Q3,Q4—2N3904 or similar npn silicon transistor

Capacitors
C1,C2,C3—10-μF, 16-volt electrolytic
C4—1-μF, 16-volt electrolytic or ceramic disc
C5—47-μF, 25-volt electrolytic
C6—0.1-μF, 25-volt ceramic disk
C7—220-μF, 16-volt low-leakage electrolytic

Resistors (¼-watt, 5% tolerance)
R1—2,000 ohms
R3,R5,R8—1,000 ohms
R4—100 ohms
R6,R9—10,000 ohms
R7—1 megohm
R11—270 ohms
R2—10,000-ohm pc-mount Cermet trimmer potentiometer
R10—2-megohm pc-mount trimmer potentiometer

Miscellaneous
F1—½-ampere slow-blow fuse
K1—12-volt dc relay with 10-ampere or greater contact rating (Radio Shack Cat. No. 275-218 or similar—see text)
PB1—Piezoelectric sound element (Radio Shack Cat. No. 273-065 or similar)
S1—Spst slide or toggle switch (optional—see text)
T1—12.6-volt, 300-mA power transformer (Radio Shack Cat. No. 273-1385 or similar)
Printed-circuit boards or perforate board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosures (see text); sockets for all DIP ICs; fuse holder for F1; ac line cord with plug; three-conductor cable or two-conductor shielded cable (see text); optical system (optional—see text); small rubber grommets; ½-inch spacers; machine hardware; hookup wire; solder; etc.

Note: The following items are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: Ready-to-wire pc boards for power-supply/sound-generation and detector sections, $17.95; ICL7660, $5; LM555CN, $1.75; 78L05, $2; IRD1000, $39.50. Add $2.50 P&H per order. New Jersey residents, please add 6% sales tax.

heart of the circuitry is infrared-sensing module *IRD1*. This electronic assembly is designed to respond to *changes* in the amount of IR energy that strikes its detecting element.

Contained inside the the *IRD1* module is an infrared detector and signal conditioning circuitry that produces both analog and digital output signals in response to any change in IR energy in the field of view of the detector element. A steady level of IR energy produces no output from the module. Thus, the module can be effectively used in full sunlight where there is an abundance of IR energy.

Radiation produced by moving sources of energy located near the module changes the ambient level being sensed by the detector element. These signals are amplified and passed through an analog-to-digital (A/D) converter inside the module. The output of the A/D converter, a digital signal, is buffered and made available at the digital output terminal of the module for further processing by the circuit.

The logic level at the output of the module remains high as long as there is no variation in the ambient IR energy near the detector element. Should the ambient level be disturbed by the presence of a moving body or vehicle, the logic level momentarily falls to zero.

Since there is always some level of ambient IR radiation changes, such as warm air drafts, a dc reference input to the module is provided by potentiometer *R2* for adjustment of sensor sensitivity. This allows you to set the response characteristic of the detector to the desired sensitivity to obviate any false alarms from sounding.

Since the detector section of the project may be located at some distance from the power supply and sound-generating circuitry, the digital output from the sensing module is passed through *Q1*, which provides low-impedance drive for the connecting cable between the two sections of the project.

The logic level present at the collector of *Q1* is low at all times except when a change of IR energy strikes the detector element. When this occurs, the collector of this transistor generates an output pulse of approximately +5 volts in amplitude. The duration of the pulse is relatively short but is sufficient to trigger the alarm circuit in the power-supply module. When the infrared disturbance in the vicinity of the detector element persists, multiple output pulses are generated.

A bipolar dc power source is required by *IRD1* for proper operation of the infrared sensor. Voltage-inverting chip *IC1* is used to generate a negative voltage source from the +5 volts developed by the power-supply circuitry. A +5-volt input to this IC produces −5 volts at output pin 5, which is essentially equal in magnitude to (but in opposite polarity) the potential fed into *IC1* at pin 8.

In the power-supply/sound-generating section, power transformer *T1* steps down the incoming 117 volts ac to 12.6 volts ac across its secondary. This reduced ac voltage is applied to the bridge rectifier consisting of diodes *D2* through *D5*, which converts the ac into pulsating dc. Capacitor *C5* then smoothes the pulsating dc to pure ac, which is then fed to fixed voltage regulator *IC3*. Regulated +5

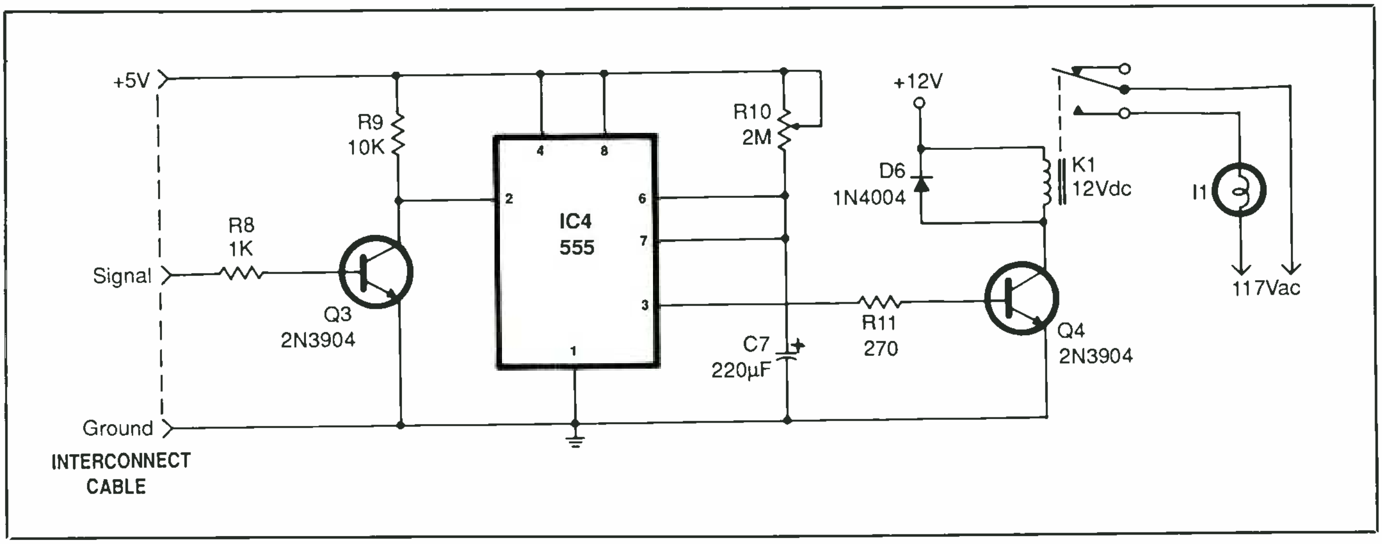


Fig. 2. Circuit details for an optional automatic lighting controller that can be activated by the basic project. You can use this circuit in place of or in addition to the sound-generation portion of the project.

volts at the output of *IC3* is then distributed throughout the circuitry.

The positive logic level produced by *Q1* in the remote section of the project when an intrusion is detected is applied to the base of *Q2*. The negative pulse generated by this action at the collector of *Q2* is applied to trigger input pin 2 of timer chip *IC2*. Note that the 555 timer chip in this application is operated as a monostable, or one-shot, multivibrator.

During standby, output pin 3 of *IC2* is held at zero volt. When a signal is detected by *Q2*, the timer chip is triggered. This causes pin 3 of *IC2* to rise to about +4 volts. At the same time, capacitor *C4* is permitted to charge through resistor *R7*. When the charge on the capacitor reaches about 66 percent of the supply voltage, *C4* suddenly discharges through *IC2*, causing pin 3 to return to zero volt.

Time duration of the output pulse at pin 3 of *IC2* is determined by the RC time constant produced by the values of *R7* and *C4*. With the values specified for these components, the time constant is approximately 1 second. During this 1-second time interval, piezoelectric buzzer *PB1* is energized and provides a 1-second duration that is independent of the pulse width generated by the detector module. Virtually any duration for the sound can be selected simply by choosing values for *R7* and *C4* that will yield the proper time constant.

If you wish to provide automatic area illumination when a visitor or intruder is detected, you can incorporate into the project the circuit shown schematically in Fig. 2. This circuit, which can be used in place of or in addition to the audible alerter, is also built around a 555 timer chip, identified here as *IC4*, operated as a one-shot multivibrator. The timer chip is triggered by the logic high output of the detector section, just as the audible alerter is. The timer circuit has an adjustable time constant that can be set for an on period of up to several minutes, as determined by the setting of potentiometer *R10*.

To obtain long time delays, such as 5 minutes or more, a low-leakage timing capacitor should be used for *C7*. The time constant of the circuit, in seconds, is approximately equal to the product of the *C7* value in microfarads multiplied by the value of the timing resistance represented by the setting of *R10* in megohms. If desired, a fixed value of resistance can be used for *R10*.

Once *IC4* is triggered, its output at pin 8 sends *Q4* into saturation. When *Q4* conducts, it energizes relay *K1*, causing its contacts to close. The contact rating of the relay must be sufficient to safely handle the load represented by the lamp being controlled. (The relay specified in the Parts List has a contact rating of 10 amperes, which will safely handle up to 500 watts of incandescent lighting.) This completes the circuit from the ac line through the lamp used for illuminating the protected area. Note that power for the *Q4/K1* circuit is obtained from the +12-volt line that comes directly from the output of the rectifier bridge before regulation in the power-supply section in Fig. 1.

Construction

As was pointed out in the beginning of this article, this project is built in two separate parts. Each section can be built on its own single-sided printed-circuit board or perforated board that has holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware.

If you wish to fabricate your own pc boards, use the actual-size etching-and-drilling guides shown in Fig.

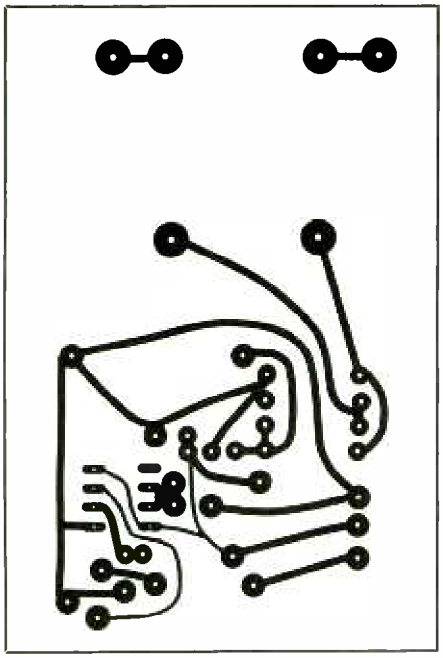


Fig. 3. Actual-size etching-and-drilling guide for printed-circuit board for power-supply/sound-generation circuitry.

3 for the power-supply/sound-generation section and Fig. 4 for the detector section. Alternatively, you can purchase ready-to-wire pc boards from the source given in the Note at the end of the Parts List. Whichever method of construction you decide upon, use sockets for the DIP integrated circuits.

From here on, we will assume you are wiring the circuitry on printed-circuit boards. Place the power-supply/sound-generation board on your work surface, oriented as shown in Fig. 5. Begin wiring this board by installing and soldering into place the eight-pin socket for *IC2*. Do *not* install the any ICs in their sockets during assembly until after you have conducted preliminary voltage checks and are certain your wiring is correct.

Continue wiring the power-supply/sound-generation board by installing and soldering into place the resistors, capacitors and rectifier diodes. Follow up with installation of the trimmer potentiometer, transistor and voltage regulator. Make certain that the diodes and electrolytic capacitors are properly oriented and that the transistor and voltage regulator are properly based before soldering any of their leads or pins into place. Mount the power transformer on the board, plug its primary and secondary leads into the appropriate holes and solder them into place. Then install and solder into place staking pins in the holes for the cable.

Set aside this circuit-board assembly and place on your work surface the detector printed-circuit board, oriented as shown in Fig. 6. Install and solder into place the socket for *IC1*. Then do the same for the resistors, capacitors, diode and transistor. Once again, make sure the diode and electrolytic capacitors are properly oriented and that the transistor is properly based before soldering any of their leads into place.

As you examine Fig. 6, you will note that pin 3 of the *IRD1* detector module is offset by 0.1 inch from the square layout of the pattern. This pin serves as an index for proper positioning of the module on the circuit board. Make certain that you install the sensor exactly as shown before soldering any pins into place. Install and solder into place staking pins in the holes for the cable.

When wiring the project on perforated board, follow the same general component layouts shown in Fig. 5 and Fig. 6. Then refer back to Fig. 1 for wiring details.

If you have decided to incorporate into your project the optional automatic illumination circuitry, wire the components for it on a separate printed-circuit board or perforated board that has holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware.

Make sure the transistors are properly based and that the capacitor and diode are properly oriented before soldering their leads into place. The relay mounts off the board, and the lamp mounts external to the enclosure in which the circuitry will be housed. Again, install and solder into place staking pins in the holes for the cable.

House the two sections of the project (three sections if you are planning to incorporate the optional automatic lighting feature into the project) in their own separate enclosures. The enclosures that house the detector section and optional automatic lighting circuitry must be weatherproof, as must be the portions of cable that are exposed to the elements. The enclosure for the detector must also have a window through which infrared energy can enter it. You can use any type of enclosure for the power-supply/audible-alerter section.

Machine the power-supply/sound-generation section enclosure for mounting the piezoelectric buzzer, circuit-board assembly, fuse holder and switch (the last is an option you can forego to save on the cost of the project) and to provide entry for the ac line cord, three-conductor cable

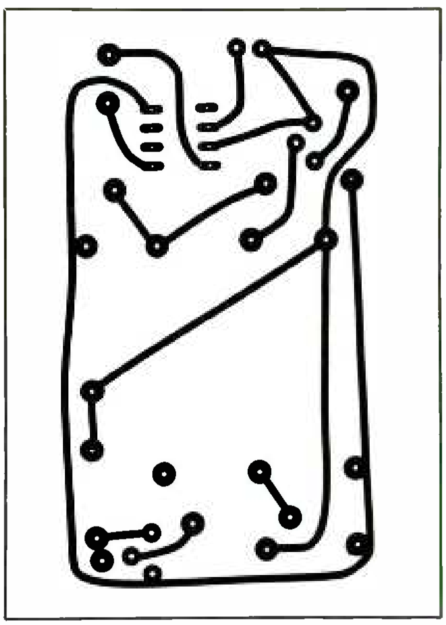


Fig. 4. Actual-size etching-and-drilling guide for printed-circuit board for IR detection circuitry.

and leads of the buzzer. If you drill any holes through metal, deburr them to remove sharp edges and line the holes for the line cord, cable and buzzer leads with small rubber grommets.

Route the free end of the line cord through its hole into the enclosure and tie a strain-relieving knot in it about 5 inches from the end inside the enclosure. Tightly twist together the fine wires in each conductor and sparingly tin with solder.

Mount the power transformer, fuse holder, buzzer and, if you are using it, the switch in their respective holes. Route the leads of the buzzer through their hole. Then crimp and solder the end of one conductor to one lug of the switch. Strip ¼ inch of insulation from both ends of two 3-inch-long hookup wires. If you are using stranded wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. (Do this for all stranded wires you use in the project.) Crimp and solder the opposite ends of one wire to the unoccupied lug of the switch and one lug of the fuse holder.

Plug one end of the remaining wire into one hole labeled 117 VAC and solder it into place. Plug the free end of the remaining line-cord conductor into the other hole labeled 117 VAC, solder it into place and trim away the excess protruding from the bottom of the board. Then plug the free ends of the piezobuzzer leads into the PB1 holes, observing polarity, and solder them into place. Mount the circuit-board assembly into place with ½-inch spacers and 4-40 × ¾" machine screws, nuts and lockwashers.

Next, machine the enclosure for the sensor circuitry by drilling holes for mounting the circuit-board assembly and entry of the three-conductor cable. Also, drill a window hole directly in line with where the sensing element will be when the board is mounted inside the enclosure. Make this hole at least ½ inch in diameter. You can easily accomplish this by drilling a ¼-inch-diameter hole and then enlarge it as needed with a tapered reamer. Deburr all drilled holes to remove sharp edges and line the entry hole for the cable with a small rubber grommet.

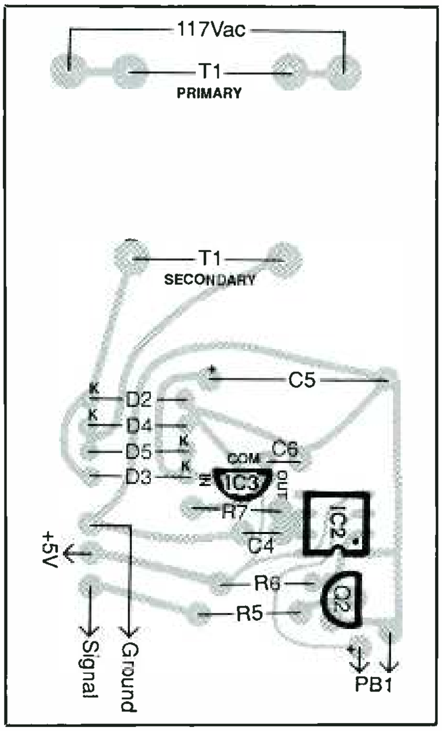


Fig. 5. Wiring diagram for power-supply/sound-generation pc board.

With no assistance, the project will have a range of about 10 to 15 feet for detection of a person. For a vehicle, which normally has a larger infrared "signature" because of the greater amount of heat it gives off, detection range will be slightly greater. If your intended location of the sensor with respect to the target is greater than this, you can enhance the sensitivity of the detector with a simple one-lens optical system, such as the one illustrated in Fig. 7. This will give you a range of up to 10 meters.

A good optional optical system can be had with a plastic Fresnel lens specifically designed for infrared applications, which you can purchase from Edmund Scientific Corp. (Barrington, NJ).

When designing the optical system, you must decide on the focal length of the lens, which can be as little as ½ inch. The lens must be positioned at a distance equal to its focal length from the detector element in the project, as illustrated in Fig. 8. For maximum light-gathering ability, use as large a lens as can be practically installed in the enclosure chosen for your project.

When using a lens, keep in mind that the field of view of the detector element will be reduced to a relatively narrow angle as compared to operation with no optical enhancement. The diameter of the beam is dependent upon the focal length of the lens and the distance between the lens and target. Reducing the field of view of the detector by means of an optical system has the advantage that extraneous IR signals from sources other than the target are less likely to produce false alarms.

When constructing the optical system, secure the lens in front of the detector element at the focal-length distance. If desired, a small metal or cardboard tube the same diameter as the lens can be placed in front of the detector element to restrict the field of view to retain system sensitivity when detecting IR disturbances in the target area while preventing false triggering from extraneous sources.

Whether or not you use optical assistance, it is mandatory that you cover the viewing window you make in the enclosure with glass or clear plastic cemented to the inside surface of the enclosure to maintain a weatherproof condition.

Mount the circuit-board assembly inside the enclosure with ½-inch spacers and suitable machine hardware.

Now machine the enclosure for the optional automatic illumination control circuit by drilling mounting holes for the circuit-board assembly and entry holes for the three-conductor cable and ac cable for the lamp load. Deburr all holes to remove sharp edges and line the cable holes with small rubber grommets. Mount the

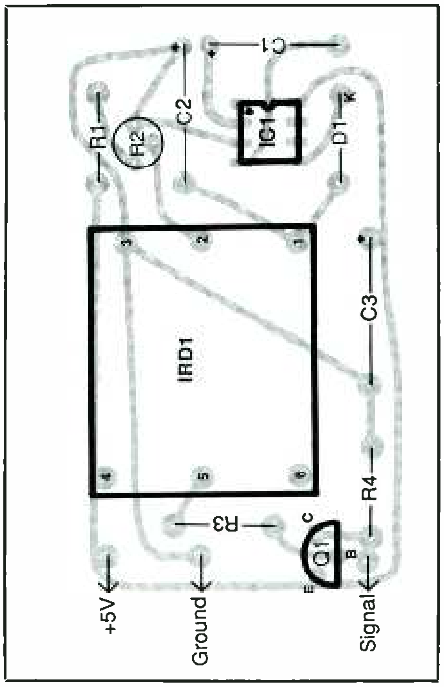


Fig. 6. Wiring guide for IR detection pc board.

circuit-board assembly in place with ½-inch spacers and suitable machine hardware.

Determine where you will be locating the two or three sections that make up your Early-Warning Intrusion Detector system and cut to length the required interconnecting cable(s). You can use either ordinary three-conductor cable for this or two-conductor cable with separate shield. In the latter case, use the shield as the ground conductor between the various sections that make up the project.

After cutting the cable(s) to length, route one end into the detector and lighting-control enclosures and tie a strain-relieving knot in them about 6 inches from the end inside the enclosures. Similarly, route the other end(s) into the power-supply/audible-alert enclosure and tie a strain-relieving knot in it (or them) as before.

Remove 3 inches of outer plastic jacket from both ends of the cable(s). If you are using shielded cable, undo the mesh of the wire shield back to the remaining plastic jacket and tightly twist together the fine wires. Do *not* connect the cable ends to the staking pins on the circuit-board assemblies until directed to do so.

Initial Tests

Begin your checkout procedure with the power-supply section. For this, you need a dc voltmeter or a multimeter set to the dc-volts function. Clip the common and "hot" leads of the meter to the negative (−) and positive (+) leads of of *C5*, and set the meter to a range of 25 or 50 volts full-scale. For any tests conducted in the power-supply circuit, keep foremost in mind that potentially lethal 117 volts ac is present. Exercise extreme caution when working in this circuit.

Turn on the meter. Then plug the line cord from the project into a convenient ac outlet. Set the power switch on the project to "on" (if you are using this switch) and observe the meter's display. If everything is okay, you should obtain a reading of about +20 volts. If so, touch the "hot" probe of the meter to pins 4 and 8 of the *IC2* socket, this time obtaining a reading between +4.5 and +5.5 volts.

If you do not obtain the proper readings, power down the project and disconnect the line cord from the ac line. Rectify the problem before proceeding. Check the orientations of the rectifier diodes as well as the voltage regulator and electrolytic filter capacitor. Measure the potential across the secondary leads of the transformer to ascertain that about 13 volts *ac* is available. Also, disconnect the project from the ac line and measure the dc resistance between the +5-volt and ground rails to determine if a short-circuit exists.

Once you are certain that the project has been correctly wired, power it down and install the 555 timer in the *IC2* socket. Make sure it is properly oriented and that no pins overhang the socket or fold under between IC and socket.

Again, power up the project. Strip ⅛ inch or so of insulation from both ends of a 3-inch length of solid hookup wire. Use this to momentarily jumper from the +5-volt bus to the unconnected end of *R5* to activate the sound generator. Make certain that you do not connect the wire to the junction between *R5* and base of *Q2*; if you do, you will destroy the transistor. If everything is okay, the piezobuzzer will sound for about 1 second and then shut off. Repeat this test a few more times to ascertain that the circuit is operating properly.

If the power supply is working satisfactorily but the audio generator does not work, check *IC2* for proper orientation and pins that are not plugged into the socket. Also check the basing of *Q2* and the polarity of the connections from *PB1*. Ascertain that *IC2* is operating by measuring the voltage at pin 3 while you trigger *R5* with the jumper wire. The potential should rise from 0 to about +4 volts for about 1 second and then drop back to 0 volt each time you trigger the timer.

When you are satisfied that the power-supply/sound-generating system is working properly, disconnect the project from the ac line. Then crimp and solder the conductors of the cable to the staking pins. Make note of which conductor connects to what pin so that you can repeat the sequence at the other end(s) of the cable(s). If you are using shielded cable, use the shield(s) as the common system ground connection.

Plug *IC1* into its socket on the detector circuit-board assembly. Make sure it is properly oriented and that no pins overhang the socket or fold under between IC and socket. If you built the lighting-control circuit, do the same for *IC4* in its socket.

Crimp and solder the free ends of the three-conductor or shielded cable(s) to the appropriate staking pins on the remaining circuit-board assemblies. Make absolutely certain that you follow the same sequence

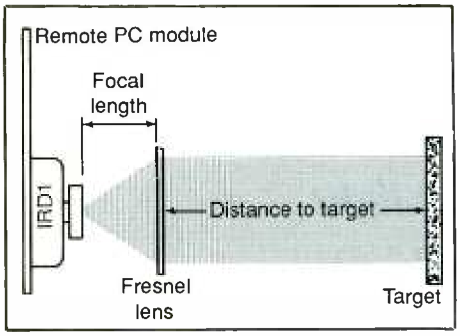


Fig. 7. Mechanical details for single-lens optical system for enhancing sensitivity of basic IR sensor element in project.

used in the power-supply/sound-generating portion of the project. Then apply a thick layer of silicone adhesive to the interior of the enclosure around the entry hole, rubber grommet and three-conductor cable in the sensor subsection. You want this adhesive to serve both as weatherproofing and mechanical anchor for the cable entry. Allow the adhesive to set completely overnight.

When you are satisfied that the cables are properly wired into the various sections of the project, set *R2* in the detector section to mid-rotation. Plug the line cord in the power-supply section into a convenient ac outlet and, if you are using it, set the optional power switch to "on." You may hear a 1-second burst of sound from the piezobuzzer when power is first applied to the circuit as a result of the transient turn-on from the power supply triggering *IC2* into operation.

Set the detector assembly so that the aperture of the sensing element is oriented in the horizontal plane. Now move about 5 feet away from the project and walk past the front of the detector to simulate an intruder. The 1-second burst of sound from the buzzer should be heard.

The project may generate two bursts of sound, since it detects the rise in IR radiation as you walk away. Each change in detected IR energy will thereafter produce a warning sound. Note that you must walk across the field of the detector to produce an abrupt change in IR energy at the sensor, owing to the fact that this is a motion-sensing device.

Experiment with the setting of *R2*. At one end of this control's rotation, the sound from the buzzer will be generated easier than at the other end. This is the result of maximizing the sensitivity of the detector. At the other extreme of rotation, fewer audible warnings are generated. The ideal setting for this control is the least-sensitive position that yields satisfactory results.

If you are not able to obtain the described results, troubleshoot the detector assembly by connecting the common lead of your dc voltmeter to circuit ground and measuring the potential at pin 8 and then pin 5 of *IC1*. If the circuit is working as it should, you should obtain readings of +5 and −5 volts, respectively, at these two pins. If not, check the interconnecting cable for correct connections to the power-supply section and check the orientations of components *IC1*, *D1*, *C1* and *C2*.

If +5 and −5 volts are present at the appropriate pins of *IC1* but you still do not obtain a response from the detector, check the orientation of the infrared module and *Q1*. Measure the potential at pin 2 of the module as you vary the setting of *R2*, which should yield readings that range from 0 to +4 volts. Set *R2* for a reading of +2 volts at pin 2 of the module and then measure the potential at pin 2 of the module. You should obtain a reading of about +5 volts at pin 2. Also, as you wave your hand across the front of the detector aperture, the reading should momentarily drop to 0 volt. Use an oscilloscope to observe the fast response of the detector.

To determine if your intrusion detector will operate as desired, place the sensor assembly in the best location for detection of a person or vehicle approaching your home or business. Remember to point the detector element so that the IR energy radiated by the intruder causes an abrupt change in level as the person or vehicle passes by.

Simulate an intruder by walking or driving past the detector at the desired distance and note if the response of the project is satisfactory. Also note if the detector keeps the buzzer silent when there is no approach of a guest or intruder. Bear in mind, though, that a gust of warm air will vary the level of IR energy received by the sensor and can cause the project to generate a false audible alert signal. You can correct for this by adjusting the sensitivity of the detector with *R2* as necessary.

Mount the various sections that make up the project in suitable locations. The power-supply/sound-generation and optional lighting-control sections should be located indoors near a supply of ac power. The IR detection section should be located out of doors where it will reliably pick up the IR signatures of approaching persons and vehicles. Choose a location that is fairly well isolated from the elements, and do not forget to weatherproof the installation with silicone adhesive around all enclosure joints and mounting hardware and the entry hole for the three-conductor cable.

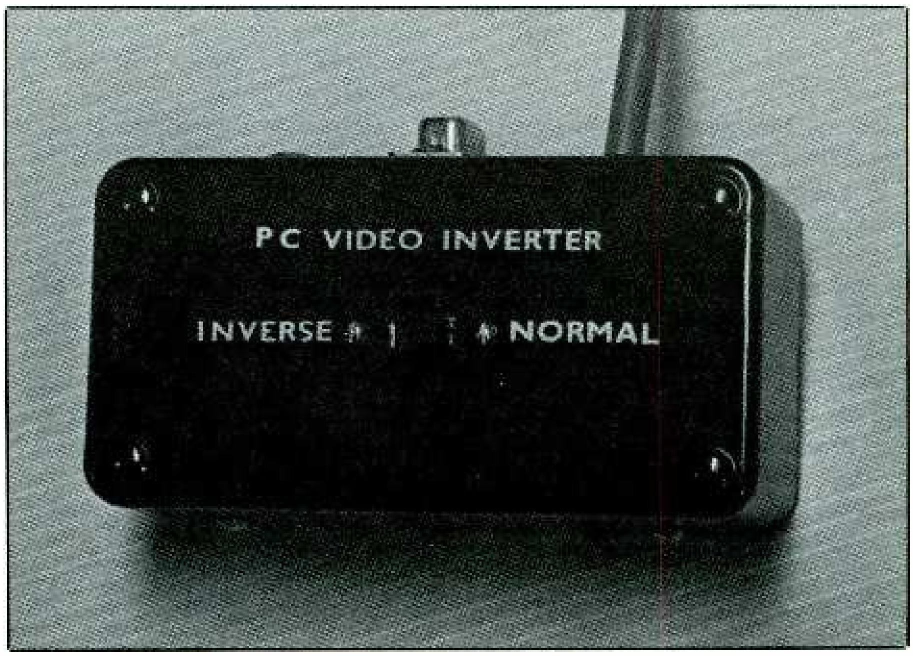
The best way to integrate the optional lighting-control section is to wire it to an existing lighting fixture. If none is available, or you prefer to have a separate controlled lighting fixture, have an electrician install one in a location that will illuminate the protected area and wire it to the contacts of the relay and ac line.

If after installation you discover that your detector is far too sensitive to assure minimal false alarms, you can restrict the amount of IR energy that strikes the detector by placing a card that has a small aperture in front of the sensing module. This will restrict the field of view and minimize responses to extraneous IR signals.

A Full-Screen Video Inverter

Converts an IBM PC's or compatible's normal light characters on a dark background to easier-on-the-eyes dark characters on a light background

By Adolph A. Mangieri



Normal video display of text and graphics for IBM PCs and compatible computers place bright characters on a dark background. This can be difficult on your eyes, especially if you spend a considerable amount of time in front of your computer each day. To alleviate this, you have the option of inverting the video display so that dark characters appear on a light background, as is common in everyday printed matter on paper. In this article, we present a hardware project that can do this better than the software driver included in MS/PC-DOS for this purpose.

Our video inverter adapter installs between your computer's video monitor and system box and requires no modification to the system. Thus, it does not void any warranty of your system. The project has a switch on it that lets you select either normal or inverse video. This inexpensive project ensures full and correct inversion of the display regardless of program control of screen attributes. As a bonus, switching between normal and inverse video on a regular basis helps to minimize screen "burn" by aging the screen phosphors more uniformly.

Hardware vs. Software

Either of two approaches can be used to produce an inverse video image. One is software, using the ANSI.SYS driver in MS/PC-DOS. The other is using hardware, as is done with this video-inverter project.

Using ANSI.SYS to invert the video, a displayed page of text does place dark characters on a light background. However, as you can see in Fig. 1(A), this software approach includes dark margins on both sides of the text. Also, you will note that unequal length lines leave a ragged right margin, which can be disconcerting. Note in Fig. 1(A), the first column of text may be displayed adjacent to the black left margin. Too, graphic displays may not invert correctly, depending on how they are created.

A major drawback of using ANSI.SYS to invert the video arises when using programs that control screen attributes from within the program itself. These cannot be inverted using ANSI.SYS.

With the hardware approach used in our project, *everything* is just the reverse of the "normal" screen situation. You start with a clean white (or other color, depending on the phosphor used in your video display's CRT) page similar to that used in so-called "paper-white" displays used in desktop publishing and other applications. This is illustrated in Fig. 1(B), which is the same screen image of the identical data illustrated in the image in Fig. 1(A). Note that in Fig. 1(B) there are no "margins" on the

(A)

(B)

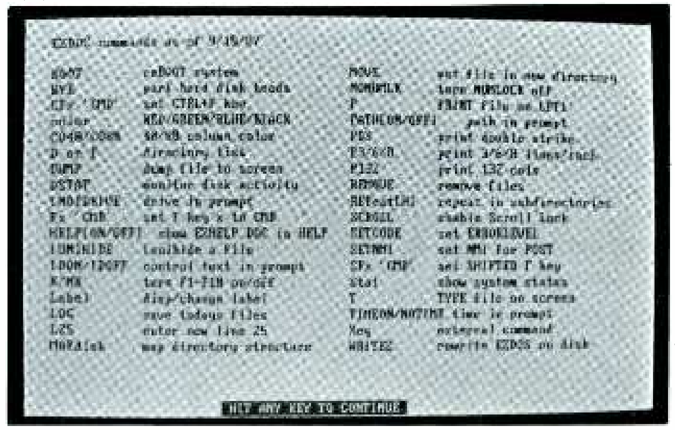


Fig. 1. Typical help screen of software-invoked inverse video (A) using INVERSE.BAT and ANSI.SYS and the inverter adapter. It exhibits margins at left and right of text block, with ragged right margin on unequal text lines and non-inverted blank lines. Hardware-invoked inverse video (B), obtained with project, starts with a completely bright screen, with no left and right margins, similar to "paper-white" displays used in desktop-publishing monitors.

screen, especially a ragged one on the right side, to mar the appearance of the display.

Though the hardware approach to video inversion has a more pleasant overall aesthetic appeal, screen inversion utilizing ANSI.SYS should be a part of your tool kit, regardless of its shortcomings. To this end, batch files INVERSE.BAT and NORMAL.BAT are provided here to permit you to switch between the hardware and software approaches at the DOS prompt.

Using ANSI.SYS

MS/PC-DOS device driver ANSI.SYS permits use of American National Standards Institute (ANSI) escape sequences to control video screen attributes of monochrome and color monitors. An escape sequence begins with escape character ESC (decimal code 27) followed by one or more character codes. You have probably used special ESC sequences to send control codes to your printer. A peripheral device or device driver decodes the sequence and effects the function.

As explained in the DOS manual, ANSI.SYS inverts the screen upon receiving the sequence ESC[7m. Unfortunately, you cannot type the sequence directly into a batch file or use the ESC key to encode the sequence. With most computers, the ESC key merely aborts the current command. However, machine-language and BASIC programs afford means of sending ESC sequences to hardware devices.

Additionally, the PROMPT command encodes ESC as meta-string $e. Provided ANSI.SYS is installed in the CONFIG.SYS file, you can invert the screen by typing PROMPT $e[7m at the DOS prompt. Install ANSI.SYS in the CONFIG.SYS file by adding the following line to the latter file:

```
device = ansi.sys
```

The file must be located in the root directory of the drive that boots the system. If no CONFIG.SYS file exists, create it using EDLIN, a word processor or the COPY command as follows at the DOS prompt:

```
.-
C    copy con config.sys
device = ansi.sys
  ^ Z (type end-of-file control-Z)
.+
```

Create batch file INVERSE.BAT and place it, too, in the root directory:

```
.-
C    copy con inverse.bat
prompt $e[7m
prompt
cls
  ^ Z (type EOF control-Z)
.+
```

The first prompt statement sends the inverting escape sequence to ANSI.SYS and the video screen. The second prompt statement restores the default prompt. The last statement clears the screen.

Boot up your computer and type "INVERSE" (follow this and all other keyed-in entries with a "Return" or "Enter") at the DOS prompt. You should now see a bright background (of whatever monochrome color your video monitor has) with the DOS prompt at the top left corner. Type "DIR/W" and observe the screen. Run assorted utilities in the inverse mode. Keep in mind that programs that utilize high intensity for bold text or graphics usually set screen attributes to normal and cannot be inverted. With some utilities, observe that some lines or portions of lines are not reversed, resulting in a ragged display.

To return to normal screen attributes (all attributes off), create batch file NORMAL.BAT rather than rebooting your computer. Do this by placing the following file in the root directory:

```
.-
C   copy con normal.bat
prompt $e[0m
prompt
cls
  ∧ Z (type EOF control-Z)
. +
```

Observe that all you have changed is the numeral preceding the final "m" of the escape sequence in the first line. Type "NORMAL" at the DOS prompt to return to normal display. You can run either batch file at any time from the DOS prompt.

Execute other ESC sequences listed under ANSI.SYS, either directly from the DOS prompt or create similar batch files. The command "PROMPT $e[5m" causes the screen to blink. The command "PROMPT $e[1m" selects high intensity or bold visible only in the normal screen mode. The command "PROMPT $e[4m" turns on underscore. The command "PROMPT $e[8" causes non-display except for the cursor. After typing the command at the DOS prompt, type "PROMPT" to restore the default prompt to the screen.

Each character displayed on-screen consists of an eight-bit ASCII byte for display and an accompanying eight-bit screen-attribute byte, both of which are held in a 16-bit word. ANSI.SYS alters the screen by modifying the fields of the attribute byte. As such, several attributes can be set simultaneously, such as invert with blink, making ANSI.SYS a valuable computing tool.

Certain combinations of the use of ANSI.SYS and direct writes to the attribute bytes held in memory can produce unexpected or undesirable results when using INVERSE.BAT. On the other hand, the video inverter adapter always inverts the screen correctly, regardless of program control of screen attributes.

About the Circuit

The monochrome video monitor receives four TTL signals from the computer video board. These include the horizontal and vertical synchronization (sync) pulses, the video signal and the intensity signal illustrated in Fig. 2. Figure 3 shows the schematic diagram of the video inverter. The display viewed on the screen is "painted" by an electron beam scanning from left to right, beginning at the top of the screen and proceeding line-by-line to the bottom of the screen.

Each horizontal line is triggered by a horizontal pulse. Following additional horizontal scan lines that are not displayed on-screen, a vertical pulse triggers movement of the electron beam to the top of the screen to "paint" the next video display raster. The video signal supplies the information that forms text and graphics on the screen.

Within each displayed horizontal scan interval, the video signal delivers a train of pulses, each of which forms one bright dot associated with a line of text. Successive scan lines eventually fill the screen with text. All pulses are in precise time relationship with each other.

In Fig. 2, (A) is a drawing of the vertical sync pulses that go negative from a logic 1 of about 5 volts to logic 0 level of near zero volt. (B) illustrates the horizontal pulses that go positive from logic 0 to logic 1. (C) is a video signal that forms four bright dots during its associated horizontal scan line. In the normal video mode, logic 0 corresponds with a dark background, logic 1 a bright foreground or alphanumeric text.

Shown in Fig. 2(D) is the intensity signal that rests at logic 0 when high intensity is off. When a character, word or text line is intensified, each associated video pulse is accompanied by a high-intensity pulse that brightens the dot. This signal typically operates through the contrast control circuit of the video monitor. When a character is inverted to dark, the action of the intensity pulse can no longer be observed on the screen.

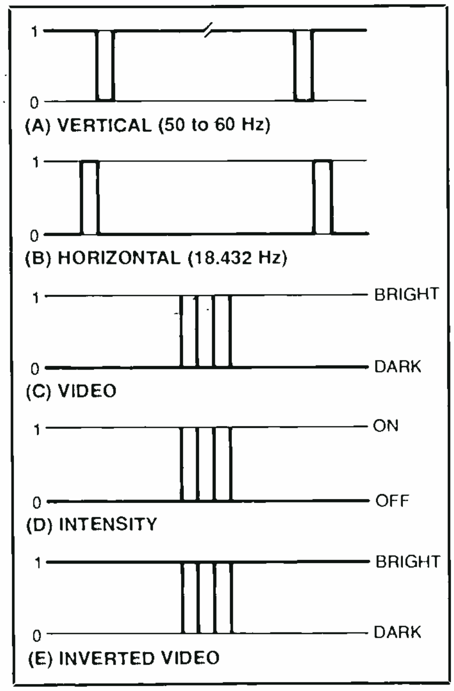


Fig. 2. Waveforms (A) through (D) show TTL-level inputs to the video monitor. Waveform (E) is inverted-video signal.

The video inverter reverses the video display by turning the Fig. 2(C) video waveform up-side down as shown in Fig. 2(E). However, during the vertical retrace interval, a few horizontal scan lines appear diagonally on the screen, which mars the display. This is corrected by the vertical pulses, which blank the screen during vertical retrace.

As shown in the schematic diagram shown in Fig. 3, the adapter connects to the computer video board via a cable and male DB-9 plug *PL1*. All signals, except for the video signal, pass directly to female DB-9 socket *SO1*. The video signal passes to NOR gate *IC1A* and to switch *S1*.

With *S1* set to NORMAL, the video signal passes through unaltered. Gate *IC1A* functions as a gated inverter. When pin 3 is held low, the video input applied to pin 2 is inverted at output pin 1.

When pin 3 is held high, output pin 1 is forced low, producing a dark screen. Gate *IC1B* is connected as an inverter. When the vertical signal at input pin 5 goes low, the output at pin 4 goes high. In turn, this forces the output of *IC1A* low, thereby blanking the screen during the vertical retrace interval.

The circuit is powered by a 9- to 15-volt dc plug-in wall transformer that plugs into jack *J1*. Integrated circuit *IC2* regulates the potential delivered by the transformer to 5 volts dc. Rectifier diode *D1* protects the circuit from inadvertent application of reversed supply voltage.

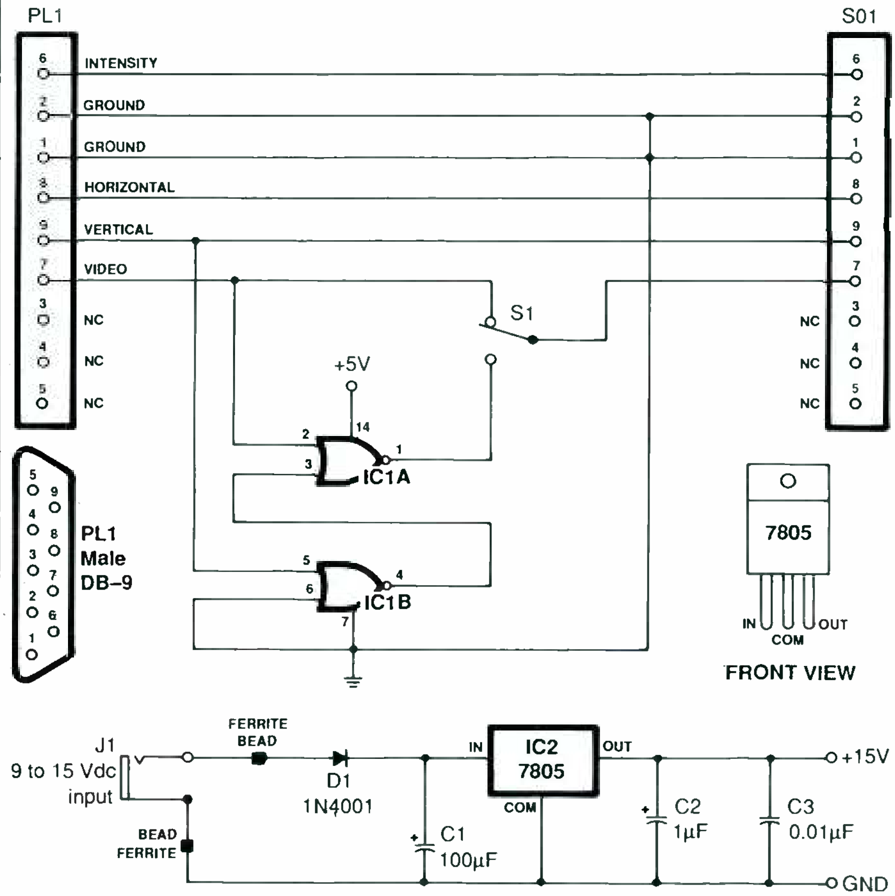
Construction

Assemble the video inverter in a small project box as shown in Fig. 4. A plastic box was used for the prototype and caused no television interference (TVI). You can use a tight-fitting metal case and shielded computer cable and plug to minimize rfi (radio-frequency interference).

The project is easily assembled on perforated circuit board that has holes on 0.1-inch centers, as shown in the photo of the prototype. Use Wire Wrap or soldering hardware and point-to-point wiring to assemble the circuitry on the board. Alternatively, you can design and fabricate a small printed circuit board if you wish.

Component layout on the board and wiring are not critical, but do make sure to keep signal wires as short as possible. The video and intensity signals have frequency components ranging up to 20 MHz.

Begin construction by machining mounting holes for socket *SO1*, power jack *J1* and switch *S1*. Drill a hole for entry of the video cable.



PARTS LIST

Semiconductors
D1—1N4001 rectifier diode
IC1—74LS02 quad 2-input NAND gate
IC2—7805 fixed +5-volt regulator
Capacitors
C1—100-μF, 30-volt electrolytic
C2—1-μF, 10-volt tantalum electrolytic
C3—0.01-μF, 25-volt ceramic disc
Miscellaneous
PL1—DB-9M male connector
J1—Jack to match plug on 9- to 15-volt dc power supply
S1—Spst slide or toggle switch
SO1—DB-9F female connector
Small plastic workbox; 9- to 15-volt dc plug-in power supply; 3 feet of six-wire bundled computer cable; perforated board with holes on 0.1-inch centers; suitable Wire Wrap or soldering hardware; solder wrap posts; ferrite beads (see text); machine hardware; hookup wire; solder; etc.

Fig. 3. Complete schematic diagram of video-inverter module's circuitry.

You can use a surplus computer cable having a male DB-9 plug on one end for the video cable. This cable must contain at least six color-coded conductors. Cut the cable to 30 inches in length. Remove the cover from the plug and rewire if necessary, making connections to the pin numbers shown in Fig. 3.

You may find it easier to unsolder all wires from the plug. Remove solder from the plug using desoldering braid or a vacuum-type desoldering tool. Strip about ⅛ inch of insulation from the ends of all conductors. Then tightly twist together the fine wires in each conductor and sparingly tin with solder.

Push each wire end into the solder cup of its appropriate pin on the connector and solder into place. Clip off any unused conductors to prevent short circuits from occurring.

Prepare a list of the pin numbers and insulation colors used before replacing the cover on the plug. Remove about 3 inches of outer plastic jacket from the other end of the cable, taking care to avoid cutting into the conductors.

Using excess cable as a source of color-coded wire, prepare 3-inch lengths of wire and solder to corresponding pins of female socket *SO1*. Figure 3 shows the wire insulation color codes used in my prototype, but yours may differ. This is okay, as long as you match the color-coding on the pin connections to *PL1* with those to the pins of *SO1*.

Install socket *SO1* on the enclosure. Pass the end of the cable into the enclosure and anchor in place with a strain relief or epoxy cement. If you selected an all-metal enclosure, first line the entry hole for the cable with a rubber grommet. Solder three 3-inch lengths of color-coded wire to *S1* and install the switch in its location on the enclosure.

Crimp and solder 3-inch lengths of wire (red insulation for positive, black insulation for negative) to the lugs of *J1* and install the jack in its hole. Slide an rfi-reducing ferrite bead onto the two wires and secure them near the jack. You can salvage ferrite beads from some TV circuit boards, purchase them new from many electronics parts suppliers or omit them if you cannot locate a source form them.

Cut a piece of perforated board to size and attach two small L-brackets for support on the side of the enclosure. Assemble and wire the circuit board outside of the enclosure. Install a row of flea clips or solder-wrap posts along the edge of the board for connections to the video cable, *SO1*, *PL1* and *S1*. Install several pins for ground connections.

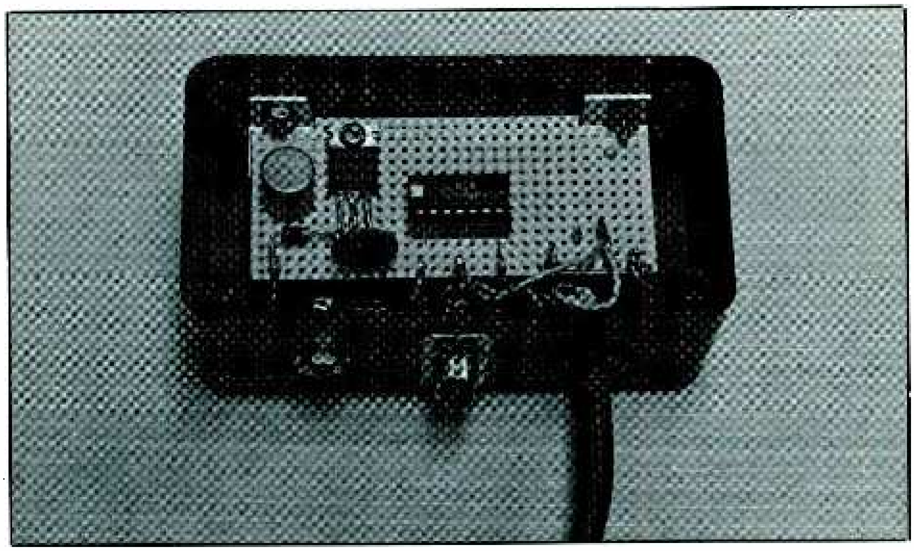


Fig. 4. Interior view of author's prototype with circuitry assembled on perforated board and housed inside a common plastic project box.

Install the DIP socket with pin one facing the DB-9 socket. Secure voltage regulator *IC2* to the board with a 4-40 × ¼-inch machine screw and nut. As you wire the board, prepare a sketch that identifies all board take-off terminals. Install the circuit board and make connections to its take-off terminals, carefully observing wire insulation color coding. Connect extra unused wires of the video cable to circuit board ground. Then apply labels to the enclosure that identify the functions of the positions of *S1*. When you are finished, carefully check all wiring.

Perform the following test with *IC1* not installed in its socket on the board and with *PL1* disconnected from the computer. The circuit draws a few milliamperes of current, which allows you to use any wall transformer delivering 9 to 15 volts dc.

Using a dc voltmeter or a multimeter set to the dc-volts function, check the polarity of the power supply output jack to make certain that the tip is positive before you power the circuit. The potential measured across capacitor *C1* should measure 9 to 15 volts dc. The potential from pin 14 of the *IC1* socket to circuit ground should measure 5 volts dc.

With the common probe of the meter connected to circuit board ground, verify the absence of supply voltages at all pins of *PL1* and *SO2*. This done, remove power from the circuit and install *IC1* in its socket, taking care to properly orient it and making sure no pins overhang the socket or fold under between socket and IC.

Using the Project

Use the NORMAL display mode with bright foreground for maximum legibility of the video display, especially under high ambient room lighting conditions. Much less harsh to view, the INVERSE display mode tends to mask the dot-matrix appearance of text characters. The text appears to be slightly bolder and more like solidly formed printed characters. You may prefer the light background because text appears more conventional, as on video monitors with paper-white screens commonly used in desktop publishing.

With power to the project turned

off, connect Inverter plug *PL1* to your computer and connect the monitor video cable plug to the to Inverter. Plug the power supply cable into jack *J1*, and set switch *S1* to NORMAL. Turn on the computer to verify a normal screen display.

Now type "DIR/W" and fill the screen with text. Set *S1* to INVERSE and verify that the screen's background and foreground do indeed transpose. On a Samsung monitor with amber screen, text appears near-black or very dark-brown. The visual effect you obtain depends on the particular video monitor and range of contrast adjustment you use. Best settings of contrast and brightness controls may vary with brand of video monitor being used.

Load any program that displays both normal and high-intensity (bold) text, such as WordStar. Set *S1* to INVERSE, and contrast to maximum and adjust brightness for desired background intensity.

Set *S1* to NORMAL and check for proper display of bold and normal-intensity text. If needed, trim the two controls, which tend to interact somewhat. It should be possible to set the controls so that you can select either mode with little or no further adjustment.

Set *S1* to NORMAL and type "INVERSE" at the DOS prompt. Load any application program that makes use of high-intensity or bold text. Most likely, the program will cancel the effect of INVERSE.BAT and set screen attributes back to normal.

Now set *S1* to INVERSE to force the display to reverse its background and foreground effects. Although high-intensity text will now be lost, other features like an inverted command title in the normal mode are not lost but appear reversed once again.

A word processor in use that resets screen attributes to normal is preferably operated with *S1* set to INVERSE video and switched back to NORMAL only when bold text is used to mark and move text. The inverted display in the edit mode proved much easier to scan and read quickly. The saved ASCII text files do not control screen attributes and can be inverted by either INVERSE.BAT or the inverter adapter.

Double inversion is possible, provided the application program does not set screen attributes to normal. To obtain double inversion capability, type "INVERSE" at the DOS prompt and set *S1* to INVERSE. As you adjust brightness and contrast, you can set the video display to a somewhat luminous brown background. Try this mode for a more interesting display of games and pictorial graphics.

The inverted and cleared screen may show a form of screen "burn" that appears as slightly darker horizontal bands each corresponding with a row of text. This is the result of normal fall-off of emissivity of phosphors that carry all of the load in the NORMAL display mode. By operating the screen in the INVERSE mode, the balance of the phosphors on the screen are made to carry a fair share of the load. Ultimately, the darker bands begin to blend in, tending to produce a more uniform display.

A final note: When you switch to INVERSE, the display tends to expand or bloom slightly. This is normal and occurs because the 15,000-volt CRT electron beam accelerating voltage is pulled down slightly when the beam excites a much larger percentage of the screen. Any excessive blooming or any loss of focus (picture sharpness) indicates a high-voltage circuit problem or a weakening CRT. **ME**

A Multiple-Application Strobe Light

This ac-operated strobe light can be adapted to a variety of practical and fun applications with simple changes in circuitry

By Charles D. Shoemaker, Ph.D.

Strobe lights can be used to good advantage in a wide variety of applications. Among these are as photoflash strobe lights in photography, taking multiple-position photographs of a person or object in motion, providing stimulating lighting effects in a discotheque, measuring the revolutions per minute of a rotating object, alerting one to danger, a deterrent to burglars and signaling an intrusion, to name just a few. The primary difference in usage of the basic strobe-light unit is in the manner in which it is triggered.

In this article, we will describe a basic strobe light unit that you can build for low cost. Our strobe light is ac-line operated to eliminate dependency on expensive batteries and simplify circuit design. We will describe a number of triggering options to permit you to adapt the project to specific applications as well.

Only low-cost and readily available components, including the xenon flashtube, are used in the project. You have the option of wiring the project on a home-fabricated printed-circuit board or mounting the components on perforated board and wiring them together using the point-to-point technique.

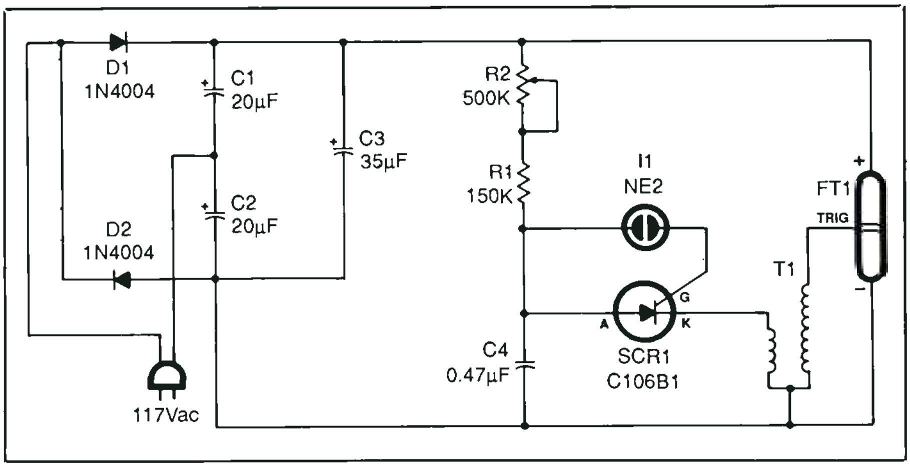


Fig. 1. Complete schematic diagram of the Multiple-Application Strobe Light circuitry.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry used in the basic strobe unit. The power circuit is a voltage doubler consisting of rectifier diodes *D1* and *D2* and capacitors *C1*, *C2* and *C3*. This doubler circuit produces a potential of approximately 320 volts dc.

On one half of the excursion of the ac line voltage applied to the power input to the project, current flows to *C1* and through *D1* to the other side of the ac line. The peak potential of 170 volts ac charges *C1* to a level of 165.44 volts. This level is based on the formula $E_{PEAK} = E_{rms} \times 1.414$. Plugging the figures into the equation, we obtain 117 volts rms $\times$ 1.414 = 165.44 volts peak.

During the second half of the ac line voltage excursion, current flows through *D2*, up from *C2* and back to the other side of the ac line. Capacitor *C2* now charges up to approximately 170 volts.

The charges on *C1* and *C2* arithmetically add to each other to yield an effective total of 340 volts. Capacitor *C3* smoothes the ripple to some degree, which results in an actual output voltage from the power source of approximately 320 volts dc.

Now the 320 volts dc is applied to the cathode and anode terminals of flashtube *FT1*. However, the flashtube does not instantly flash. To get it to do so, a trigger potential of about 4,000 volts must be applied to the trigger terminal of *FT1*.

The trigger potential is applied between the cathode and trigger terminal of the flashtube. When it is applied, the trigger voltage causes the xenon gas inside the flashtube to ion-

PARTS LIST

Semiconductors

D1,D2—1N4004 or similar silicon rectifier diode

SCR1—C106B1 (TO220 case) or Radio Shack Cat. No. 276-1662 or similar (TO92) silicon-controlled rectifier

Capacitors

C1,C2—16- to 20-μF, 200-volt electrolytic

C3—22- to 25-μF, 400-volt electrolytic

C4—0.47-μF, 200-volt Mylar or ceramic disc

Resistors

R1—150,000 ohms, ¼-watt, 10% tolerance (see text)

R2—500,000-ohm linear-taper panel-mount potentiometer

Miscellaneous

FT1—50-watt-second straight xenon flashtube/reflector/lens assembly

I1—NE-2 neon lamp

T1—Trigger transformer

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; suitable enclosure (see text); spst slide or toggle switch, fuse holder and 1-ampere slow-blow fuse (optional—see text); pointer-type control knob for R2; ac line cord with plug; fast-setting epoxy cement or silicone adhesive (see text); ½-inch spacers (4); machine hardware; hookup wire; solder; etc.

Note: Flashtube assemblies and trigger transformers are available from: DC Electronics, P.O. Box 3203, Scottsdale, AZ 85271-3203.

ize and create a low-impedance path through which the charges on the capacitors can be instantly dumped to ground. In doing so, the ionized gas inside the flashtube produces a brilliant flash of light.

Resistor *R1*, potentiometer *R2* and capacitor *C4* make up an RC time-constant circuit that is controlled by *R2*. The potentiometer is connected here in the rheostat configuration. Increasing the resistance in the circuit by adjusting *R2* in the appropriate direction slows down the flash repetition rate, while decreasing the resistance speeds up the flash rate.

When *C4* begins to charge, it soon reaches the ignition potential for neon lamp *I1*. Then, when the neon gas inside *I1* ionizes, it creates a low-impedance path for the charge on *C4* to the gate of silicon-controlled rectifier *SCR1*. Thus, the charge on the capacitor discharges to ground through the SCR and primary of trigger transformer *T1*.

The brief discharge pulse through the primary of *T1* is inductively coupled into the secondary winding, where it is stepped up to about 4,000 volts and used to trigger the flashtube. When discharge of *C4* occurs, the capacitor begins to charge for the next triggering cycle. This action will repeat for as long as ac line power is applied to the project.

When operation of the circuit is as described above, the project serves as a free-running strobe flash with a flash rate governed by the setting of potentiometer *R2*. In this configuration, the circuit can be used as a device to signal for help or to warn of a possible hazard in the vicinity of the flashing light.

Figure 1 does not show a switch or fuse in series with the ac line cord. These are options you might wish to incorporate into your project. If you do decide to use them, the switch comes first and is followed by the fuse (use a 1-ampere slow-blow fuse here) between the upper conductor of the line cord and the point where it is shown connected to the junction between *D1* and *D2*.

Now that we have covered basic operation of the Multiple-Application Strobe light, let us briefly discuss some of the possible applications for the project:

- *Discotheque Lighting.* By adding a footswitch in series with *I1* in the basic circuit, as shown in Fig. 2(A), you can manually control the on/off flash for discotheque lighting. You can also use a foot-controlled rheostat in place of potentiometer *R2* to control the repetition rate of the flash as the circuit operates as a free-running strobe.
- *Position-Action Photography.* Another possible use for the basic strobe circuit is as a device for controlling position photography, like the dropping of a white ball in a dark room with the camera shutter open. For this application, set the strobe rate with *R2* to catch the ball in a series of positions as it falls and bounces.

With a little ingenuity, you can make a setup with a normally-open pushbutton switch, as shown in Fig. 2(B), to start the strobe automatically upon action impact. Fig. 2(C) illustrates switch closure upon impact.

- *Photoflash Strobe Slave.* A photoflash strobe slave for backlighting or highlighting in photography is yet another possible application for the basic strobe light. In this application, you use the flash from the camera to trigger the strobe light in the project. To set up the basic circuit for this application, you can modify the project by adding a light-activated silicon-controlled rectifier (LASCR) to trigger the strobe action.

To implement the LASCR modification illustrated in Fig. 2(D), replace the existing NE-2 lamp in the project with the LASCR. Be sure to place a shroud around the LASCR. A good choice for a shroud is a common plastic insulator "boot" from a small alligator clip. Trim the front end of the boot to permit the LASCR to force-fit into this end and use the narrow end through which a wire normally enters as the viewing orifice for the LASCR. Of course, you must point the LASCR toward the flash on the camera for proper circuit action to take place.

A photoresistive cell, shown in Fig. 2(E), also works well for this application, though it is a bit slower to respond. As with the LASCR, the photocell replaces the NE-2 lamp. It must similarly be shielded with a shroud as well.

- *Rpm Indicator.* The basic strobe

circuit operated in its free-running state can also be used as an indicator of revolutions per minute made by a rotating member. Strike a white chalk line on the rotating member. Start the member rotating and point the strobe at the member. Slowly adjust the setting of *R2* until you "freeze" the white chalk line (make it appear to be stationary). Then read the revolutions per minute pointed to by the knob on the potentiometer. Of course, this function is predicated upon an accurately calibrated series of markings on the panel behind the control knob.

In this application, the fastest repetition rate is determined by the value of *R1*. If you wish a higher flash rate than is possible with the basic project, reduce the value of *R1* to 100,000 ohms. With the 150,000 value specified for this resistor, you can measure the shaft rotation of 1,750 rpm of an ac-operated motor. Bear in mind, though, that the speed of an electric motor can vary by as much as ± 50 rpm. Hence, if the strobe is set for an rpm of exactly 1,750, the white mark will tend to drift slightly.

• *Intrusion Detector or Deterrent.* For this application, place a normally-closed spst switch in series with the NE-2 lamp in the basic circuit. Open the switch to place the free-running strobe light in its standby state. When an intrusion is detected by the closure of the switch, the strobe light will begin flashing. If it flashes inside the protected premises, the light serves as a warning to you that an intrusion is taking place. If it flashes outside the protected premises, the light will signal a potential intruder to the fact that his presence has been detected. Hopefully, he will then hightail it for safer pickings.

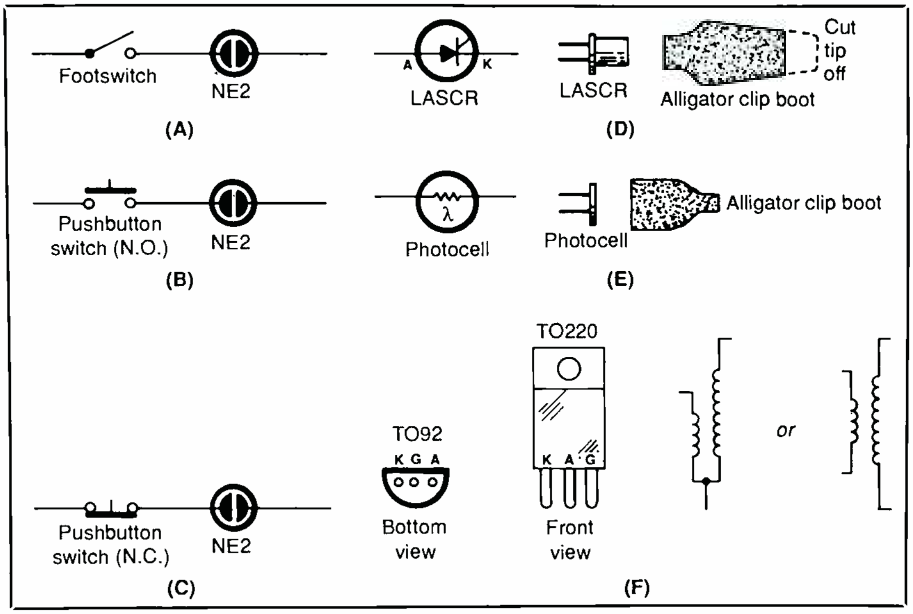


Fig. 2. Some simple changes that can be made to the basic strobe-light circuit to adapt it to specific applications: (A) a footswitch controller for discotheque applications; (B) switching arrangement for position action photography and (C) closed activated switch arrangement for same; and (D) and (E) photoflash strobe slave using a light-activated silicon-controlled rectifier (LASCR) and photoresistive cell. (F) shows the pinouts for the SCR in plastic TO92 and tab-mount TO220 packages and the two possible configurations for the trigger transformer.

Construction

The easiest way to build this project is to wire its circuitry on a printed-circuit board you fabricate yourself, using the actual-size etching-and-drilling guide shown in Fig. 3. Alternatively, you can replace the pc board with a perforated board and use suitable Wire Wrap or soldering hardware to permit interconnecting the components.

If you decide to use a pc board, it is a good idea to locate the capacitors before actually fabricating the board. Slight adjustments might have to be made in the spacing of the copper pads for each capacitor, depending on the physical sizes of the actual capacitors you will be using. Also, you may have to rearrange the pads for the SCR, depending on the type of package in which the one you use is housed. Additionally, after etching and drilling the pc board, drill a hole near each corner away from any copper traces to facilitate mounting the wired board inside an enclosure.

As you can see in Fig. 1, this is a very simple circuit. Wiring of the printed-circuit board is very easy. The only thing you must keep firmly in mind is that the diodes and electrolytic capacitors must be properly oriented and the SCR must be properly based before soldering their leads or pins to the copper pads on the bottom of the board. Note in Fig. 2(F) that you can use an SCR that comes in either a miniature TO92 plastic package or a metal-tab-mount TO220 package. Depending upon which you use, you must follow the appropriate pinout, which is different for the two package styles.

Begin wiring the board by installing and soldering into place the rectifier diodes in the orientations shown in Fig. 4. Then install and solder into place fixed resistor *R1*, followed by the capacitors (observe orientation for *C1*, *C2* and *C3*. Then install and solder into place the SCR (observe basing) and neon lamp.

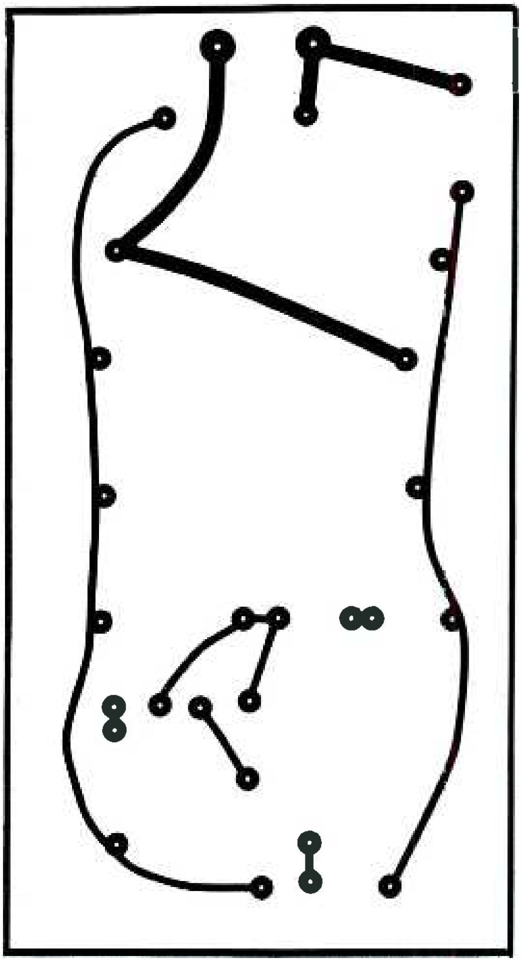


Fig. 3. Actual-size etching guide for pc board.

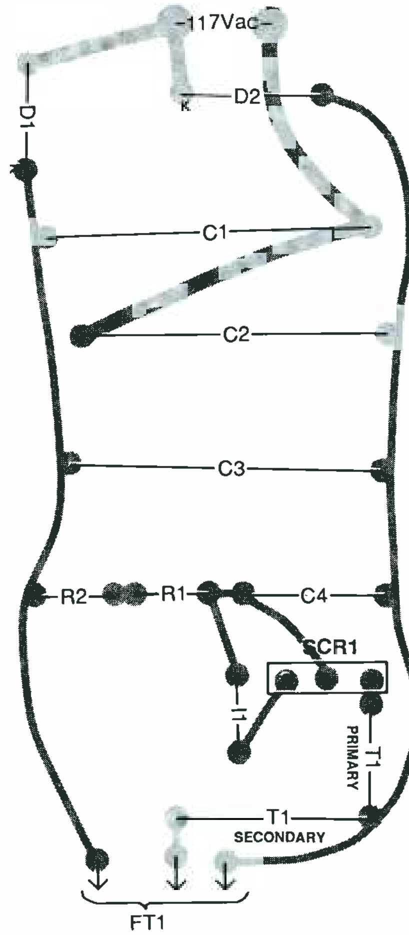


Fig. 4. Wiring diagram for printed-circuit board.

Now install and solder into place the trigger transformer. This transformer can have primary and secondary windings that are electrically isolated from each other or that share a common line at one end, as illustrated at the right in Fig. 2(F). Neither is preferable from an operating point of view, though the common-line configuration makes installation of this component a bit easier. This version simply plugs into the T1 holes in the board (make sure the installation is correct) and solders into place.

If your transformer has four separate leads, twist together the lower primary and secondary winding leads and treat the two as one. If necessary, slightly enlarge the appropriate pad hole to accommodate both leads.

As you can readily see in Fig. 4, the flashtube in its reflector/lens assembly mounts off the board. Before you attempt to wire the flashtube into the circuit, make sure you clearly identify its anode, cathode and trigger leads. Place a piece of tape on each lead and label it accordingly. Do not wire the flashtube into the circuit-board assembly until after the former is mounted in the selected enclosure.

You can house the project in any enclosure that will accommodate the circuit-board assembly, flashtube assembly and potentiometer control without crowding and the fuse holder and switch if you decide to use these. The chosen enclosure can be plastic, metal or a mixture of the two. Machine it as needed. That is, drill mounting holes for the circuit-board assembly, the potentiometer, switch and fuse holder and an entry hole for the ac line cord. Also, make the cutout in which the flashtube assembly will mount.

If you use a metal enclosure or machine any metal portion of your selected enclosure, deburr all holes and the flashtube cutout to remove sharp edges and line the entry hole for the line cord with a small rubber grommet.

Mount the flashtube assembly in

its cutout, using either a fast-setting clear epoxy cement or silicone adhesive. Allow the cement or adhesive to fully cure before attempting further work on the flashtube assembly.

Meanwhile, feed the free end of the ac line cord into the enclosure through its hole and tie a strain-relieving knot in it about 5 inches from the end inside the enclosure. Tightly twist together the fine wires in both conductors and sparingly tin with solder.

If you are using the optional switch and fuse, mount the switch and fuse holder via their respective holes. Strip ¼ inch of insulation from both ends of two 3-inch long hookup wires and prepare the exposed ends as detailed above if you are using stranded hookup wire. Crimp and solder one line cord conductor to either lug of the switch. Then crimp and solder opposite ends of one wire to the other lug of the switch and one lug of the fuse holder. Plug one end of the remaining wire into the hole in the circuit-board assembly that connects to the trace that goes to the anode of *D1* and cathode of *D2* and solder it into place.

If you are not using the optional switch and fuse holder, simply plug the free ends of the ac line cord into the holes labeled 117 VAC on the board in Fig. 4 and solder into place.

Mount the potentiometer in the hole you drilled for it and place on its shaft a pointer-type control knob. Then loosely mount the circuit-board assembly into place inside the enclosure using ½-inch spacers and 4-40 × ¾-inch machine screws, nuts and lockwashers. Crimp and solder the free end of the wire from which ¼ inch of insulation was removed to either outer lug of the potentiometer. Thread the free end of the other wire through the other outer lug and crimp it to the center lug of the potentiometer. Solder the connections at both lugs.

Strip ¼ inch of insulation from both ends of two 4-inch-long hookup wires. Then strip an additional ⅜ inch of insulation from one end of one of these wires. If you are using stranded hookup wire, tightly twist together the fine conductors at all wire ends and sparingly tin with solder. Plug one end of these wires into the holes labeled R2 and solder into place. Use ends from which only ¼ inch of insulation was removed, and locate the wire from which the additional amount of insulation was removed in the hole nearer the edge of the board.

You will now perform a voltage check on the circuit prior to connecting the leads from the flashtube assembly to the circuit-board assembly. Before you do, however, it is imperative that you understand that you will be dealing with potentially lethal ac line voltage and high dc voltages. Exercise extreme caution when working on the powered circuit.

With the foregoing admonition firmly in mind, connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to a convenient circuit ground point, such as the negative (−) lead of *C3*. Connect the "hot" lead of the meter to the positive (+) lead of *C3*, and set the meter to a range that permits safe measurement of at least 250 volts dc and turn on the meter.

Place a 1-ampere slow-blow fuse in the fuse holder if you are using the fuse and plug the line cord from the project into an ac receptacle. Flip the switch to "on" and observe the display of the meter. If you wired the circuit properly, you should obtain a reading of approximately +230 volts.

If you do not obtain the appropriate meter reading, power down the circuit and rectify the problem before proceeding. Make sure all connections have been soldered on the bottom of the board. Check to make sure that the rectifier diodes and electrolytic capacitors are properly polarized.

When you are certain that the project has been properly wired, disconnect line power from it and allow the charges to bleed off the electrolytic capacitors. Then dismount the circuit-board assembly from the enclosure. Plug the free ends of the wires coming from the flashtube assembly into the appropriate holes in the board and solder them into place. Remount the circuit-board assembly, and assemble the enclosure.

Plug the line cord into an ac outlet and observe project operation. Do *not* look directly into the flashtube as the project is operating. Rather, face the flashtube away from your line of sight. Slowly adjust the setting of the potentiometer from one extreme to the other and observe that the flash rate changes with different settings. If it does, the project is complete and you can put it into service.

If you built the project to permit you to make measurements of rpm, you will have to calibrate the pointer range for the knob on the potentiometer control. To do this, you will need a tachometer of known accuracy and a motor whose speed can be varied over the entire range of the project.

Start the motor running at a low speed and use the reference tachometer to take an rpm reading. Adjust the speed of the motor and the strobe rate of the tachometer for a reference rpm of, say, 100. Then, without changing the speed of the motor, freeze the white reference mark on its shaft with bursts of lights from the project. Make a pencil mark on the panel at the position the index on the potentiometer's knob points and write in the rpm figure obtained with the reference tachometer. Do this for a sufficient number of motor speeds in multiples of 100 yield a useful range of indexes on the panel behind the project's control knob for the entire range of the potentiometer.

If you plan to use the project in an application other than as a variable-flash-rate free-running strobe, as described above, make whatever changes are required at this time. **ME**

A Smart Weather Monitor

(Part IV)

Construction details for A/D Memory Expansion and Keyboard modules, sensor/cable fabrication and chassis work

By Tom Fox

Last month, we explained how the A/D Memory Expansion modules work in concert with the CPU and Display modules covered in Parts I and II. In this latest installment, our focus is on wiring of the A/D and Keyboard printed-circuit boards, chassis work, and putting together the sensor/cable arrangements required for taking temperature, light and humidity readings with WISARD. In the final installment, which will be presented next month, we will discuss placement of the sensors to obtain the most accurate and reliable readings, getting WISARD up and running and some hardware and software modifications you can make to expand upon WISARD's basic configuration.

Construction

Use of printed-circuit boards for these two modules is highly recommended because the A/D Memory Expansion module circuitry is quite complex and the Keyboard module will be subjected to mechanical stresses under normal keying pressure. Of course, if you prefer, you can assemble the circuitry on perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or/and soldering hardware instead of pc boards if you wish, but be extra careful with wire runs, especially on the A/D board. Also, whichever board medium you choose, use sockets for all DIP ICs.

From this point on, we will assume printed-circuit construction. If you are using perforated board, make whatever adjustments are needed in the construction details for them.

Fabricate the double-sided A/D Memory Expansion board using the actual-size etching-and-drilling guides in Fig. 12. If you prefer not to home fabricate this fairly complex board, a ready-to-wire board with plated-through holes is available commercially from the source given in the Note at the end of the A/D Module Parts List.

Place the blank pc board on your work surface in the orientation shown in Fig. 13. Begin populating it by installing and soldering into place the DIP IC sockets. If your board does not have plated-through holes, substitute Molex Soldercon socket strips instead to give you soldering access on both sides of the board. In this case, solder *all* connections—not just the socket pins—to the pads on *both* sides of the board. Do *not* install the ICs in the sockets until after initial voltage checks have been performed and you are satisfied that your wiring is correct.

Next, install and solder the three male headers (*P406*, *P407* and *P408*) into place in the indicated locations. Make certain you mount these on the *solder* (bottom) side of the board before soldering them into place. These connectors must plug into mating sockets already installed on the CPU module, where they provide electrical connections and mechanical support for the assembly.

Power supply connector *P1001AD* can be of any convenient type. In fact, if you wish to save a few dollars on the cost of the project, you can eliminate the connector altogether and replace it with a wire cable that directly interconnects the A/D and CPU modules. (The A/D module requires connection to the Enable line of the MCU; so, at least one wire must be connected to the CPU module.)

In the author's prototype, a connector similar to Digi-Key's Part No. WM4406 was used. If this particular connector is used on the CPU and A/D modules, a short six-conductor cable (or six separate wires) with a suitable plug—such as the Digi-Key Part No. WM2106—at each end can be used to bridge the two.

No particular connectors are specified in the Parts List for the temperature sensor cables. The cables can be connected directly from *TS1* and *TS2*. Ten-pin male headers *P408A* and *P406A* are optional. Their purpose is to make further expansion of WISARD a bit easier to accomplish. If you use them, mount these connectors on the *component* side of the circuit-board assembly.

Now mount and solder into place the small components, beginning with the resistors and diodes and working your way up through the capacitors. Make sure that the diodes and electrolytic capacitors are properly oriented before soldering their leads into place.

When the A/D Memory Expansion module is completed, visually inspect both sides of the assembly. Solder any connections you missed, and reflow the solder on any suspicious connections. Check for solder bridges, particularly between the closely spaced IC pads. Use desoldering braid or a vacuum-type desoldering tool to remove any you find.

Set aside the A/D Memory Expansion module and proceed to Keyboard module assembly. Because of the relative simplicity of this module, a printed-circuit board is not needed, though one is recommended just the same. You can fabricate this board using the actual-size etching-and-drilling guide shown in Fig. 14.

When the board is ready, place it on your work surface oriented as shown in Fig. 15. Begin assembly by installing and soldering into place the 20 keyswitches in the indicated locations on the *solder* side of the board. The conductor pattern accepts momentary-contact pushbutton switches made by Panasonic and sold by Digi-Key as Part No. P9952. (If you wish to keep down the cost of building this project, use only the 13 switches that have functions assigned to them, as detailed in Fig. 11. Also, if you have no plans to modifying the project, eliminate *IC303*, *R301* through *R308*, *P301* and *C306*.) Then install and solder into place the sockets for the ICs, but do *not* plug the ICs into the sockets yet.

Install and solder into place the resistors and capacitors. Make sure electrolytic capacitors *C304* and *C305* are properly oriented before soldering their leads into place.

It is highly recommended that you remove pin 19 from *P301* and install a polarization key in socket pin 19 of the cable from the CPU board.

The enclosure in which you house WISARD can be any type that is

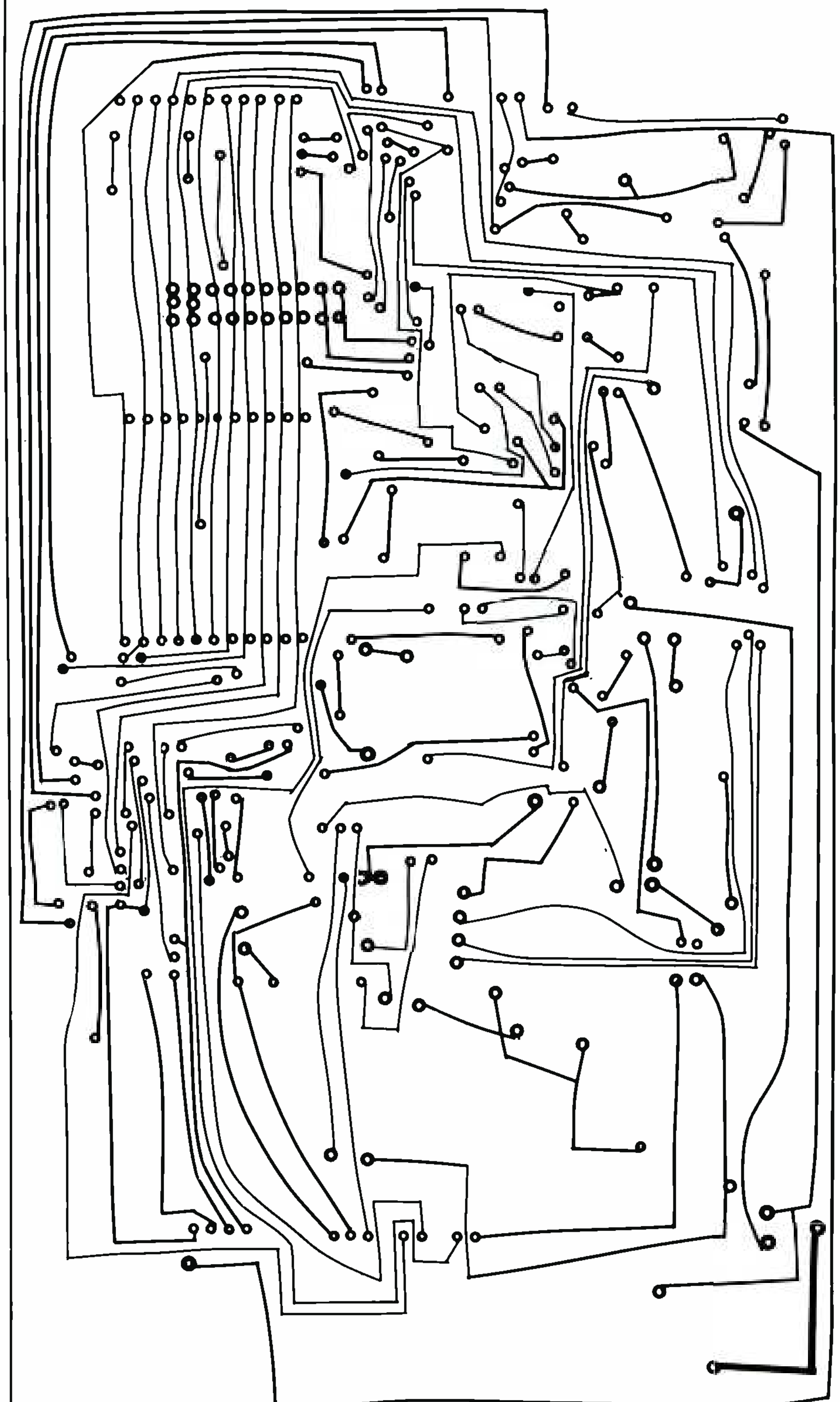


Fig. 12. Actual-size etching-and-drilling guide for A/D Memory Expansion module printed-circuit board.

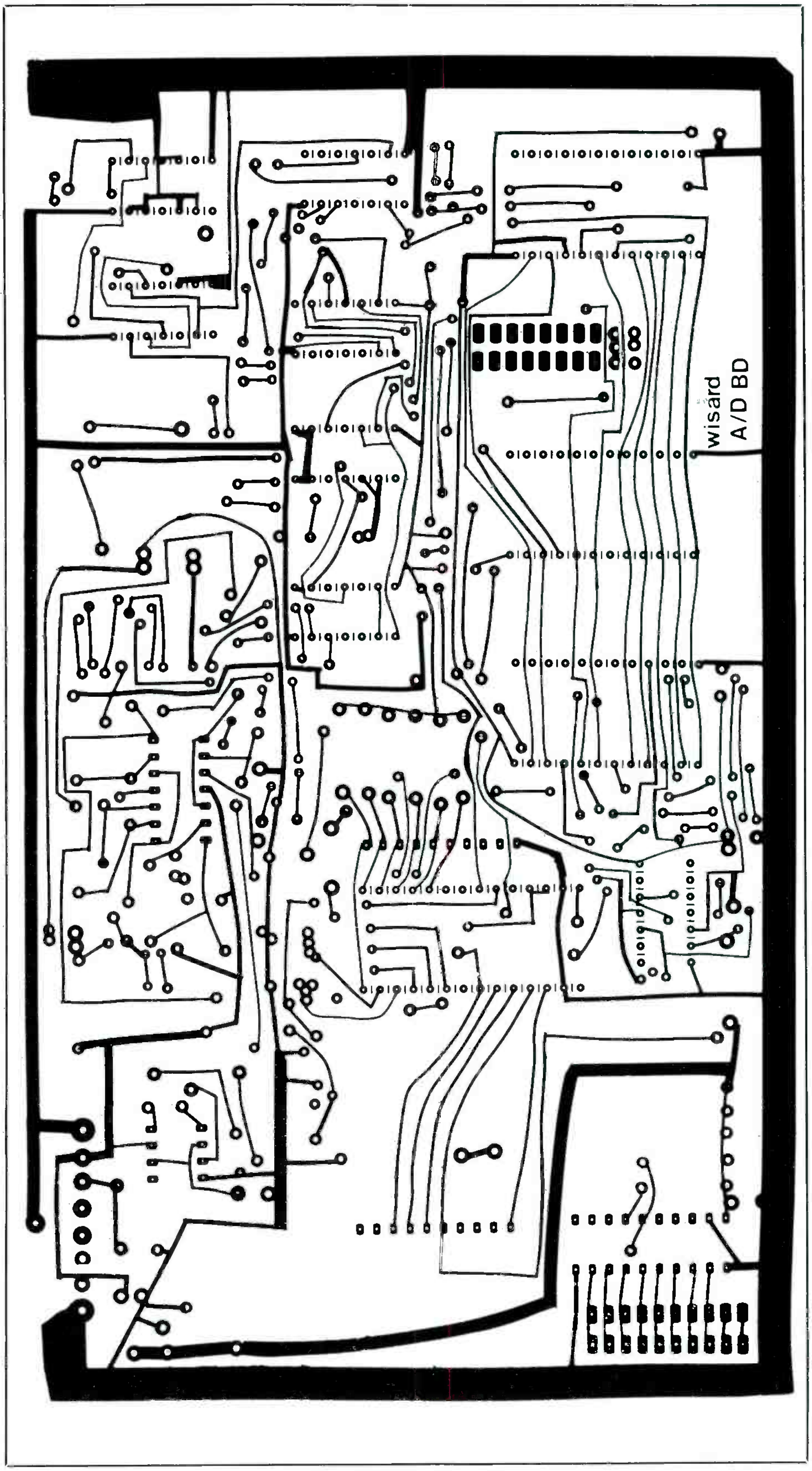


Fig. 12 (Continued).

large enough to accommodate all the assemblies that make up the project. For the prototype, shown in the lead photo, the author used a Digi-Key Part No. L131-ND aluminum console. This enclosure is very roomy and well-made, but it is rather expensive at about $35.

If you want to cut costs, your choice of an enclosure is an excellent place to start. For example, you can fabricate a suitable enclosure. Alternatively, you can look around for a used console. Whatever cabinet you decide upon, it should ideally be made from a conducting material to minimize rfi.

When machining the enclosure, drill mounting holes for the circuit-board assemblies and commercial power-supply module (see Part II for details on ratings). Then drill an entry hole for the ac line cord and separate entry holes for each of the cables for the five sensors described so far. Also cut the rectangular slot for the display window and the square slot for the keyswitch cluster on the bottom of the keyboard module.

The slots are easiest cut using a nibbling tool, after first drilling pilot holes. Alternatively, you can drill small holes in each of the four corners of the slot areas and use a thin abrasive wheel chucked in a rotary tool (such as a Moto-Tool), but be sure to wear safety goggles if you go this route. If you do not have a nibbling tool or Moto-Tool, drill a series of small interconnected holes around the entire perimeter of the cutouts to remove unwanted material and then follow up with a file to square up and smooth the edges.

Whichever method you choose, deburr all sharp cut and drilled slot and hole edges and line the entry holes for the ac line cord and sensor cables with small rubber grommets.

When the enclosure is ready, paint it, if desired. When the paint has completely dried, use a dry-transfer lettering kit to label the panel just below the keypad, as shown in the lead photo and Fig. 11. Protect the lettering with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next.

Glue a red plastic filter over the display slot from the inside of the enclosure. When the glue sets, mount the display module to the panel, using ½-inch spacers with a lockwasher at each end and 4-40 × ¾-inch machine screws and nuts. Then mount the keyboard module in place with 4-40 × ½-inch machine screws and nuts. To make sure that the keyboard module is electrically insulated from the metal panel, place two or three washers or a machine nut between the panel and circuit-board assembly at each of the four screw locations.

Route the ac line cord for the power supply through its grommet-lined hole and tie a strain-relieving knot in it 6 inches from the unconnected end inside the enclosure. Tightly twist together the fine wires in each conductor and sparingly tin them with solder. Connect and solder the conductors to the selected power supply module. Then mount the power supply in its selected location with suitable machine hardware.

Mount the CPU module to the floor of the enclosure with ½-inch spacers, 4-40 × ¾-inch machine screws and nuts and lockwashers. With no ac power applied to and no back-up batteries installed in the project, plug the A/D module into the CPU module by carefully inserting *P406, P407* and *P408* on the A/D module into *S406, S407* and *S408*, respectively, on the CPU module. Note that the ICs should still *not* be installed in their sockets at this time.

Connect the keyboard module to the CPU module in the same manner you used to connect the display module in Part II. However, make certain you use connector P15K-CPU on the CPU module this time to make the connection. Also, be certain you connect the power and ENABLE lines to P10001AD in proper polarity.

Shown in Fig. 17 is an interior view

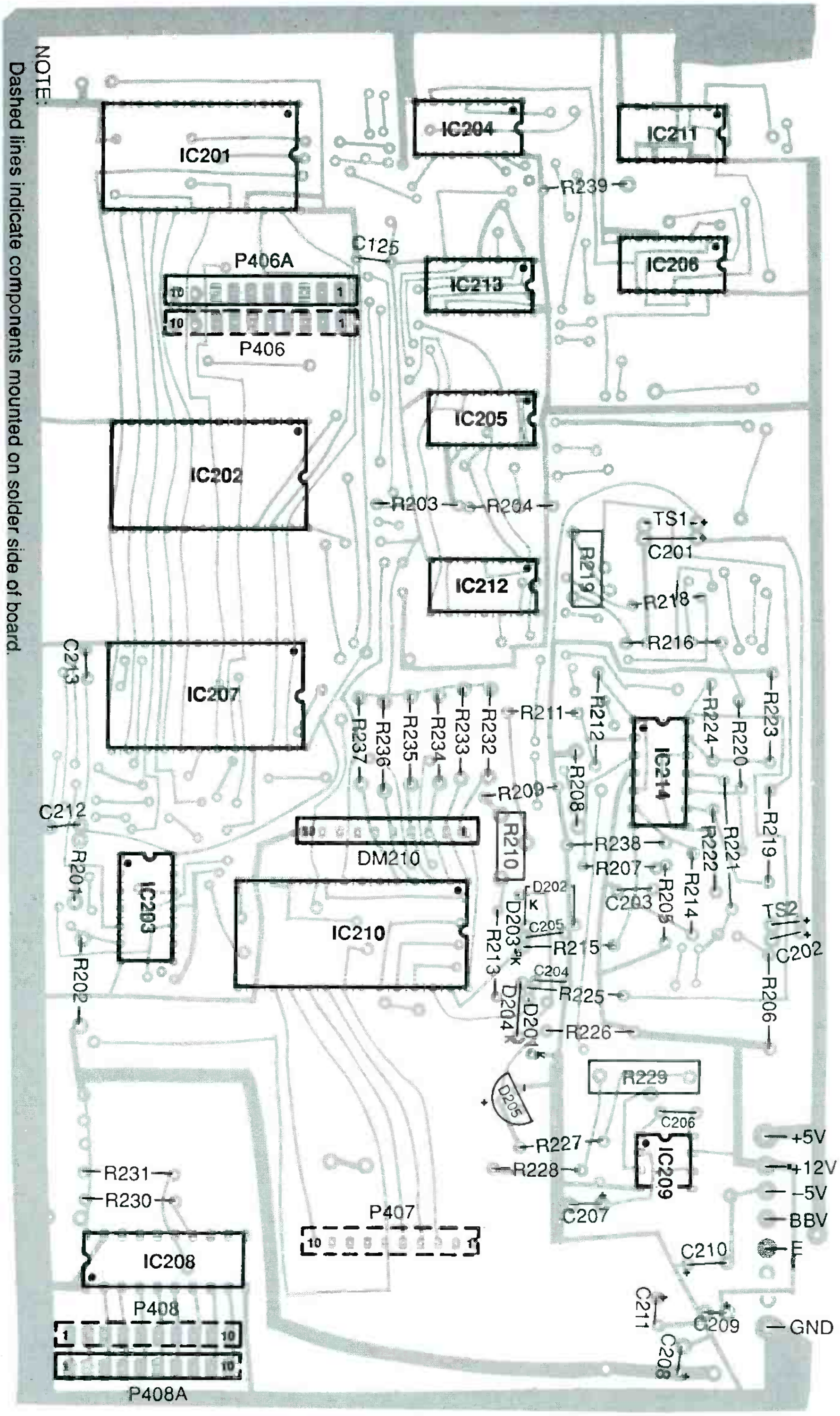
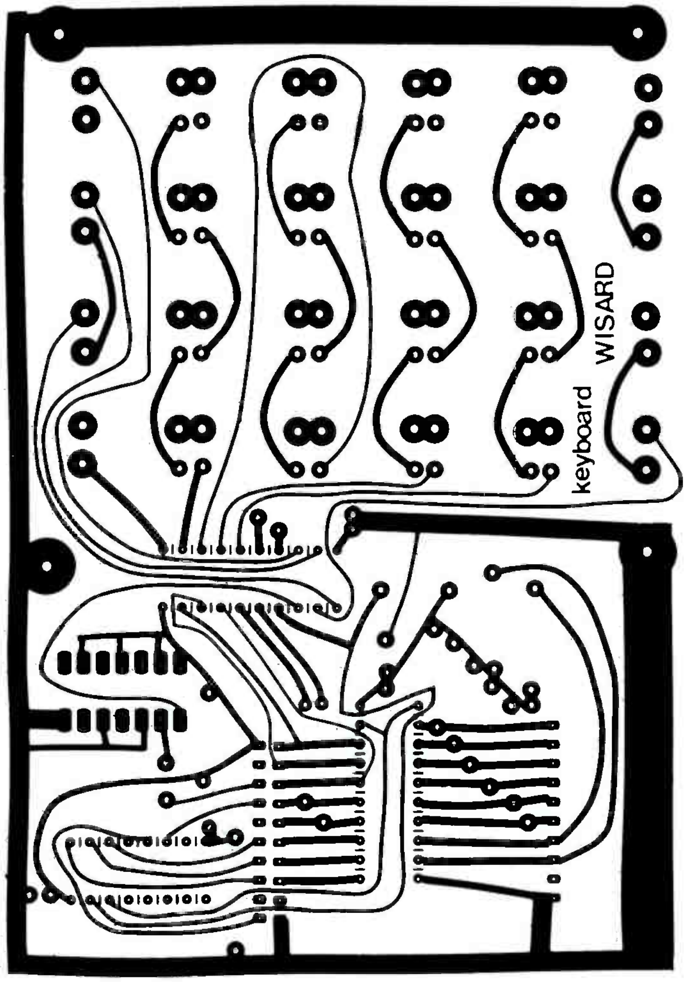


Fig. 13. Wiring guide for A/D module.



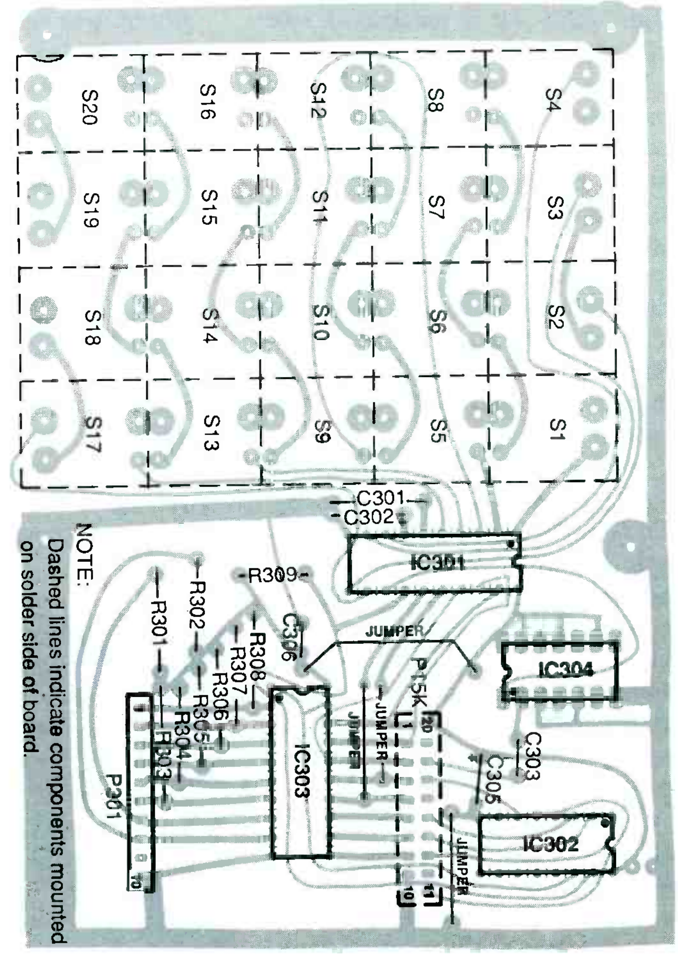


Fig. 15. Wiring guide for Keyboard module.

Fig. 14. Actual-size etching-and-drilling guide for Keyboard module printed-circuit board.

of the author's prototype with the top of the console swung up. As you can see, the commercial power-supply module is shown mounted to the left of the CPU and A/D modules on the floor of the enclosure. The keyboard and display modules are shown mounted in their respective locations on the sloping control panel of the enclosure. The black-tape-wrapped item shown in front of the power-supply module is an optional panel-mounted bayonet fuse holder that can be wired into the primary side of the transformer in the power-supply module.

Preliminary Checkout

With all cables connected, apply power to WISARD. Use a dc voltmeter or a multimeter set to the dc-volts function to perform preliminary voltage checks. Since all measurements are to be made referenced to circuit ground, clip the common lead of the meter to a suitable ground point on the A/D module.

Now, touching the "hot" probe of the meter to pin 24 of the *IC207* socket should yield a meter reading between +4.8 and +5.25 volts. Pin 12 of this socket should be at 0.0 volt. You should obtain a reading between +4.8 and +5.25 volts at pin 20 of the *IC301* socket on the keyboard circuit-board assembly, and pin 10 of this socket should be at 0.0 volt.

Now measure the voltage at all +5-volt power supply pins of all IC sockets, referring back to Fig. 1 and Fig. 2. Your readings should be close to +5 volts, though you might obtain a shade different readings from the rest at the *IC202* and *IC205* sockets. The measurement at pin 4 of the *IC214* socket should be close to +12 volts and at pin 11 should be close to −5 volts. This completes the voltage checks. Whether you obtained the proper readings or not, turn off power to the poject.

If everything appears to be normal up to this point, install *IC209* in its socket, making sure that it is properly oriented and that no pins overhang the socket or fold under between IC and socket. Turn on the power and adjust *R229* for a reading of 5.00 volts at pin 6 of *IC209*.

Turn off power to the project and install the remaining ICs in their respective sockets. Again, make sure each IC is properly oriented, that no pins overhang the sockets and that no pins fold under between ICs and sockets. Then install the fully charged back-up battery. If optional RAM *IC202* is not used by custom firmware, do not install *IC202* or *IC205*. These ICs will only be an unwanted drain on the back-up battery.

Once the project has passed these tests, fabricate the sensor/cable assemblies. There are four such sensor/cable assemblies that are normally located remotely from the project itself. The fifth, *TS1*, samples the temperature inside the project and mounts directly on the A/D circuit-board assembly. When installing *TS1*, be sure to properly orient it before soldering its leads into place.

Cables for the sensors are all simple two-conductor lines and can be either light-duty zip cord or plastic-jacketed two-conductor cable. Use cable that has easily identified conductors, either ribbing of the insulation on one conductor of zip cord or two different colors of insulation on plastic-jacketed cable. Before you cut any of these to length, decide on where you will locate the WISARD console and the individual sensors. Obviously, the shortest distances between sensors and console are preferred to keep down line attenuation.

Begin fabrication by cutting to length the four cables needed. Add about 6 feet to the measured length for the cable to permit moving the console if needed. If you are using zip cord, separate the conductors at both ends of all cables a distance of 1½ inches. If you are using plastic-jacketed cable, remove 1½ inches of outer plastic jacket. Then strip ¼ inch of insulation from both ends of all conductors, tightly twist together the exposed fine wires and sparingly tin them with solder.

Route one end of each cable through its own rubber-grommet-lined hole into the enclosure. Tie a strain-relieving knot in each cable 10 inches from the free end inside the enclosure. Separate the conductors of three cables an additional 2 inches (or remove an additional 2 inches of outer plastic jacket) at the ends inside the enclosure. Plug the conductors of one cable into the MOISTURE SENSOR and any available nearby ground holes and solder into place. Plug the conductors of a second cable into the Q1 EMITTER and any nearby +5-volt holes and solder into place. Similarly, plug the conductors of the third cable into the Q2 EMITTER and any nearby +5-volt holes and solder into place. The free ends of the remaining cable solder into the TS2 holes in the A/D circuit-board assembly.

Refer now to Fig. 17 for fabrication details at the other ends of the Q1, Q2 and TS2 sensor cables. All three of these sensors mount on blocks of lumber that have been drilled as shown to permit mounting of the assemblies in the selected outdoor locations. A screw-type baby juice jar is ideal to protect the sensors from rain, sleet and snow.

After drilling the holes specified sand the lumber smooth and paint all

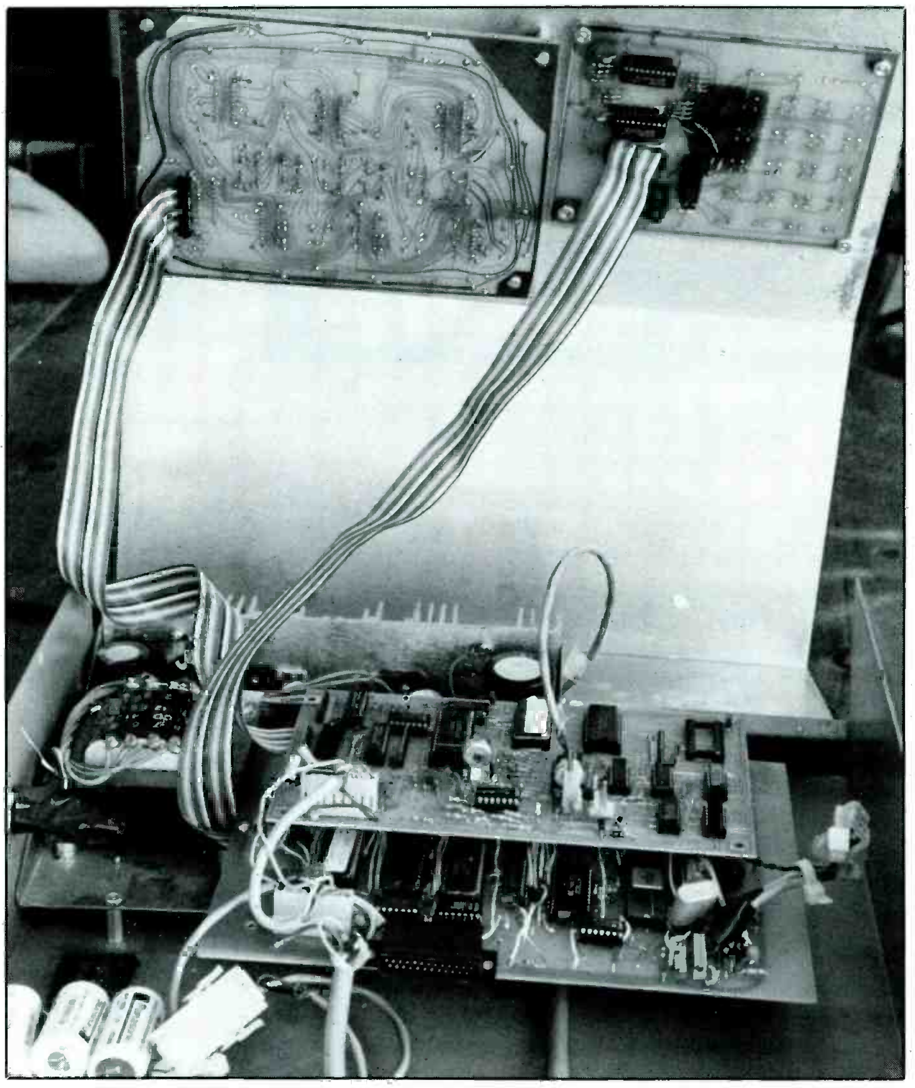


Fig. 16. Interior view of author's prototype built into custom console enclosure.

surfaces with outdoor-rated enamel. Give the lumber two coats of paint, waiting for the first coat to completely dry before painting on the next. When the paint has completely dried, route the free ends of the cables through the drilled holes as illustrated, leaving about 2 inches of free cable visible from the tops of the boards.

Now drill a ¼-inch-diameter hole in the center of the fruit-juice jar lids and ⅛-inch-diameter holes to either side of this one as shown. Set the lids into place on the painted lumber, routing the free ends of the cables through the holes. Secure each lid in place with a small woodscrew.

Trace each cable back to its source and place and label each according to the sensor with which it is to be terminated. Also identify the polarity of each temperature- and light-sensor cable conductors. Then cut to length six 1-inch lengths of small-diameter heat-shrinkable tubing.

Slide a piece of tubing onto each of the conductors of all but the MOISTURE SENSOR cable. Clip the emitter lead of one TIL78 phototransistor to ½ inch in length and form a small hook in the remaining lead stub. Crimp the conductor of the cable that originates at the *C6/R14/R15/R18* junction on the CPU module to this emitter lead and solder the connection. Then repeat the procedure for the collector lead and the conductor that originates at the +5-volt bus. Slide the tubing up over the soldered connections until it is flush with the phototransistor's case and shrink into place.

Repeat the above operation for the other phototransistor, connecting its emitter lead to the Q2 cable conductor that originates at the *C7/R22/R16/R21* junction on the CPU module and the collector lead to the remaining conductor of this cable.

Clip the + lead of the LM335 to ½ inch in length and form a small hook in its stub. Crimp this lead to the TS2 cable conductor that originates at the *R206/R221* junction on the A/D module and solder the connection. Then repeat for the − lead and remaining conductor of the cable. Once again, slide the tubing up over the connection until it is flush with the bottom of the case of the LM335 and shrink into place.

Screw the fruit-juice jars onto the caps to see if they touch the tops of the sensors. If any do, gently but firmly pull on the cables to reduce the amount sticking up through the holes in the lids until no sensor touches the glass jar.

Remove the jars from the lids. Seal the cable entry and exit holes and the screw heads with silicone sealer. Allow the sealer to fully cure for at least 24 hours before screwing the glass jars onto the lids.

Meanwhile, plug the conductors at the free end of the remaining cable into the holes in the home-made moisture sensor (see Part II) from the *copper-trace* side of the board and solder into place. Turn over the board and clip the protruding leads flush with the surface of the board.

Drill a ¼-inch hole in each of the four corners of a 5 × 5 × ¼-inch piece of Lucite or similar plastic. Use two strips of double-sided foam tape to secure the sensor to the plastic plate, centering it all around.

Place over the cable a small U-shaped plastic or metal cable clamp, positioning the clamp about ½ inch away from the sensor. Mark the locations for the two holes for the cable clamp on the plastic plate. Drill the two holes, making them just large enough to accommodate small sheet-metal screws.

Secure the cable to the plastic plate using the cable clamp and ¼-inch-long sheet-metal screws.

Operational Tests

Set *S1* and *S2* to ON and *S3* and *S4* to OFF (these switches are located in the DIP switch assembly on the CPU module). Plug the project into the ac line and turn on power. The display should flash on and off the message "6803UP." If not, power down the project and remove the A/D module.

If when you restore power to the project the "6830UP" message now flashes, there is likely a short circuit in the address or data bus for the A/D module. If the display appears "dead" or "resting," power down the project and remove the cable from the Keyboard module. Now if the test message appears when you restore power, there is a short circuit in the data bus or address line of the keyboard. If the message still fails to appear in the display, refer to Part II for hints on troubleshooting the CPU module.

Once you get the "6830UP" message to appear in the display, turn off the power and set *S2* to OFF. When power is restored, the display should alternately flash "1.00 A" (the preprogrammed start time) and then a temperature reading in Fahrenheit and Celsius. The trailing "i" you see in the display at this point indicates the display is of the inside temperature. A different temperature with a trailing "o" should appear in this display, this for the "outside" temperature reading.

If WISARD fails to perform as described, power down the project and use an ohmmeter or audible continuity tester to check for continuity between the A/D and CPU modules. Also, check all connections, especially those to the *IC210* and *IC207* sockets. As a last resort, try replacing *IC210*, *IC203*, *IC204*, *IC213*, *IC206*, *IC208* and *IC207*.

Set the clock and calendar by first pressing the TIME SET switch, which causes an "S" to periodically appear in the display, indicating that the clock can be set. Hours, minutes, month, days and years are set by pressing the appropriate switch the necessary number of times. Then to start the clock you again press the TIME SET switch at the exact second. (Note: If a time or date switch is pressed *before* pressing the TIME SET or DISPLAY switches, the message "ErrOr" will appear in the display.)

A quick and easy way to calibrate the temperature circuit is to use a digital dc voltmeter or multimeter set to the dc-volts function. Connect the common lead of the meter to circuit ground. Power up the project and adjust *R210* and *R217* for a 2.33-volt reading at each of their center (wiper) lugs. This method of calibration results in a typical error of 1° C(2° F), but it could be as much as 10° F!

For guaranteed accuracy, it is best to use the "ice point" of water for calibration purposes. Half-fill a small plastic bucket with small ice cubes or crushed ice and add water until the bucket is about 75 percent full. Assuming you have waterproofed the sensors, place both temperature sensors in the ice-water mixture. Stir the mixture for a few minutes. Then set *R210* and *R217* for a 32° F (0° C) display for both temperature readings (trailing "i" and trailing "o"). Because of the nature of the sensors and use of precision resistors, only a single-point calibration is required.

Now wet the moisture sensor. The display should now flash "rAIn," after the indoor and outdoor temperatures are displayed. Place SUN sensor *Q1* in sunlight and adjust *R20* so that the display flashes "SunnY." Place this sensor in a room with average lighting. The display should no longer show "SunnY." If it does, readjust *R20* until this message disappears. Then go back to bright sunlight conditions and check to make sure the "SunnY" message returns. If necessary, repeat the adjustments under both conditions until you obtain the correct responses.

To adjust the "daylight" sensing circuit, use a meter to monitor the voltage of pin 7 of *IC8*. Place LIGHT sensor *Q2* in a dimly-lit—but not dark—area. Adjust *R25* until the measured potential on pin 7 of *IC8* just drops to between 0.0 and 0.3 volt. When you place *Q2* in total darkness, the potential on pin 7 should rise to nearly +5 volts.

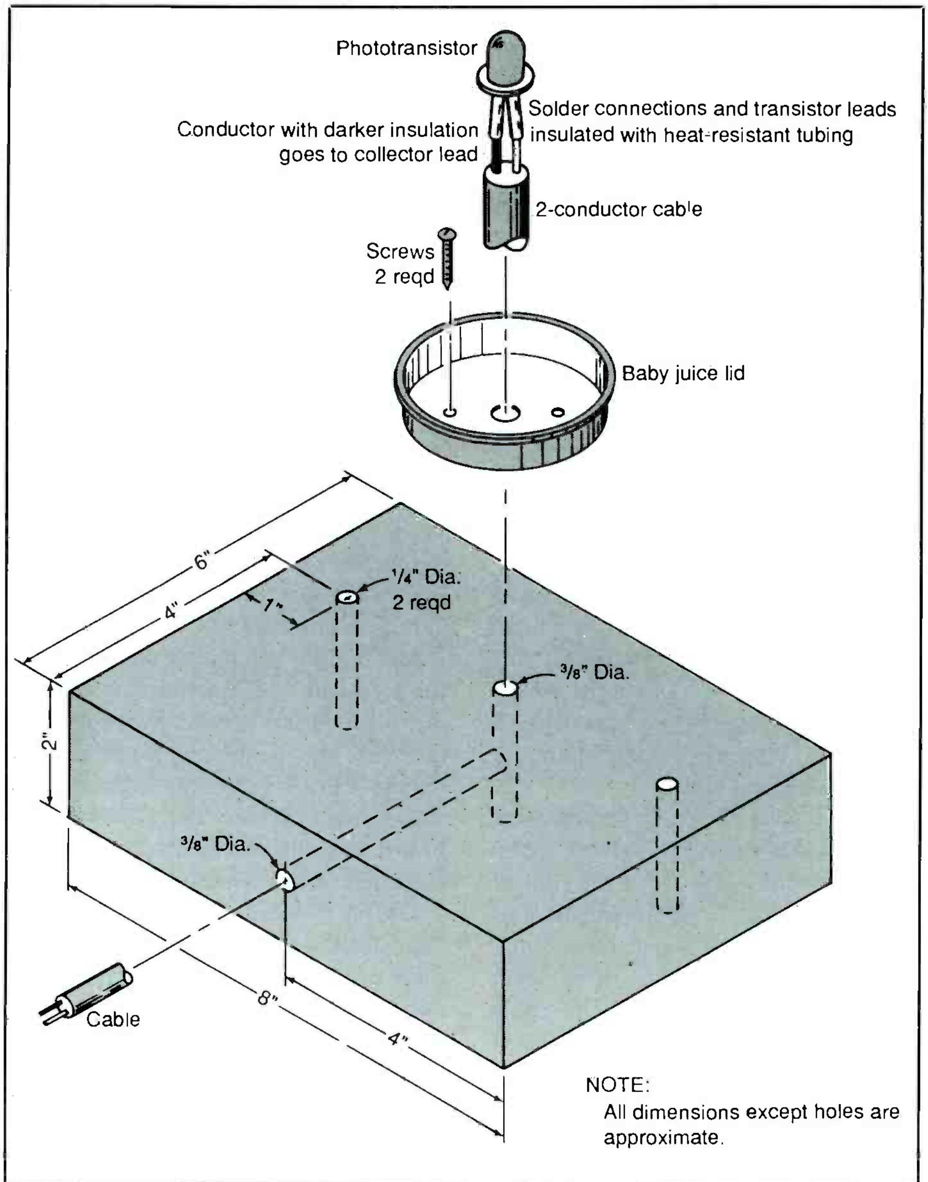


Fig. 17. Details for finishing off input cables with sensors. Infant juice jars with screw-on lids make ideal see-through weather sealers for sensors.

To use the serial interface, you need a printer, terminal or computer that has terminal-emulation software and a serial interface that can be set to 4,800 or 600 baud. The following assumes that a printer is being used. Many printers with a serial interface require only three conductors at their RS-232 connectors. Those that require more can be made to work by appropriate placement of jumpers and other educated "fixes."

WISARD sends data on pin 3, and its Request To Send (RTS) input is on pin 4 of its RS-232 connector. Pin 7 is ground. All pin numbers correspond to standard RS-232 connections. For 4,800-baud operation, set *S4* to ON and for 600-baud, set it to OFF. The baud rates of WISARD and the printer *must* be identical.

Before connecting the printer to WISARD, turn off the power to both units. WISARD "reads" *S4* only on power-up. Connect the printer to the project and turn on the printer and then WISARD. After a few seconds, the printer should print a message that starts: "WISARD (ME1)—FIRMWARE(WISCPUBD) ver 1.XME (F1)." The "power-on" time and date and present outside temperature are also displayed.

Now press the PRINT key. Most, if not all, temperatures on the printout have question-mark entries. This means WISARD had its power off at the times listed. If there are no missing characters, everything is probably working properly. If characters are missing, or the printer appears to be dead, the most likely cause is a handshaking difficulty. If this is the case, disconnect pin 4 from WISARD's RS-232 interface from pin 4 of the printer's interface and try connecting it to pin 5 on the printer.

If the printer still does not respond properly, try connecting WISARD's RTS input to pin 6 or even pin 20 of the printer's interface connector. If the problem still persists, read the manual supplied with the printer. With information from the printer manual and a working knowledge of WISARD, you should be able to achieve compatibility.

Coming Next Month

Next month, we will discuss sensor placement and details on using WISARD, including specifics on controlling alarms, heaters and other heavy-duty electrical equipment. We will also include hints on modifying the firmware to suit specific needs and the equipment needed to modify the firmware. **ME**

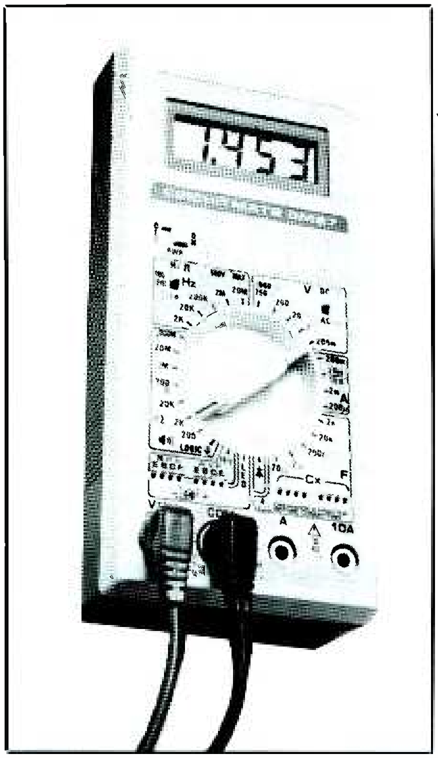
New Multi-Function Digital Multimeter

Beckman Industrial Corp.'s Instrumentation Products Division just introduced a DMM, the Circuitmate DM27, that packs a breathtakingly wide number of functions into a small, portable package for a modest price. The 3½-digit multimeter expands standard expected multimeter functions with a built-in 20-MHz TTL logic probe, frequency counter for both sine and square waves, bipolar transistor gain measurements, and capacitance measurements. All for $129.95 (suggested manufacturer's price).

Add LED and diode testing, and audible continuity beeper to the foregoing and the new meter is surely one for all seasons. A single rotary switch in the middle of its face is used to select function and range. These include five dc voltage ranges from 200 mV to 1,000 V, five ac voltage ranges from 200 mV to 750V, seven resistance ranges from 200 ohms to 2,000 megohms, five capacitance ranges from 2,000 pF to 20 μF, five frequency count ranges from 2 kHz to 20 MHz, and up to 10 amperes for ac and dc current. Accuracy is specified to be 0.8 percent.

The DM27's LCD digits are ½ inch high ones. Negative polarity is indicated and zero adjustment is automatic. Powered by a standard 9-V battery, LO BAT is displayed when battery voltage falls below the operating level. Typical battery life is given as 60 hours for carbon-zinc and 100 hours for alkaline.

Dimensions are 6.3"H × 3"W × 1.4"D, and weight is 11 ounces. The multimeter is protected electrically by a 0.8A 250V fuse, and features recessed input sockets matched by the pair of test probes included with the meter, and ¾" jack spacing.



In-Use Comments

The DM-27 is easy to use, enhanced by its single rotary switch selector that's cream colored with a contrasting red pointer line at one end. The LCD digits are large and pronounced, with dark and broad outlines. Functions and ranges are clearly indicated on the case's face, though they're necessarily a bit congested in layout owing to so many functions and small size. A separate on/off switch is located atop the function/range switch. There's also a small dc-ac manual selector switch at the right side of the front face area. A tilt bail at the unit's rear allows the meter to stand upright.

When using the 2,000-megohm resistance range, shorting the leads displays a 10 count, which is a residual reading offset. This has to be subtracted from any measurement made in this range. Other resistance ranges perform normally, registering zero when a short circuit is faced. In the continuity position, 200, the beeper sounds when resistance is less than about 60 ohms. The beeper has a high-pitched sound that's more on the weak than robust side.

At the bottom of the range/selector label section are NPN and PNP holes for plugging in the leads of a transistor to be tested. Openings are marked E B C E, for emitter, base, collector leads, ostensibly with an extra emitter connection for convenience. An h_{FE} or gain measurement can be displayed when switching to this function.

To the transistor plug-in area's right are two more sets of four holes. These are for plugging in capacitors. One lead is inserted into any hole in one group, while the other lead is inserted into a hole in the second group of openings. Four holes are provided for each lead, making it possible for the meter to accommodate a wide range of lead spacings. With the selector switch set to an appropriate range (marked in nanofarads and microfarads), the capacitance reading is shown directly on the liquid-crystal display.

For frequency measurements, the user can switch to either a high or low trigger level. TRIG LOW is for any wave type, with a 100 mV rms sensitivity from 2 kHz to 2 MHz and 200 mV rms to 3.5 V rms for 2 MHz to 20 MHz. TRIG HI is designed for measuring TTL or CMOS square waves only, with peak voltage of 1.6 V to 10 V for 2 kHz to 2 MHz, 1.6 V to 5 V for 2 MHz to 15 MHz. Users are cautioned that 500 Vac or dc should not be exceeded since overload protection doesn't extend beyond this.

Finally, the DM27's 20-MHz TTL logic test position will display a high indication for logic 1 and a low indication, along with a beep sound, if its logic 0. The probe detects 25 nanosecond pulses, with 2.4V for Hi and 0.7V for Lo. Other functions are a diode selector position and an LED function switch position.

Conclusions

This is a lot of meter for the money. It's not a heavy-duty type instrument, of course, so don't look for it to be drop-proof, water-proof, etc. Don't look for it to have industrial-strength overload protection either, handling 6-kilovolt transients and the like. It's not for use on high electric power lines.

But for ordinary test and measurement work, it's a very appealing instrument to have on the bench or for on-the-go work. Its wide-ranging capabilities can arm the user with a bevy of test instruments in a single small package that would have defied one's imagination not that many years ago. And its modest under-$130 price is not hard to take.

Add to the foregoing a newly extended warranty policy of one year and a bevy of optional accessories that can make the DM27 multimeter even more versatile. The latter include a high-voltage probe for up to 50 kV dc, an r-f probe for measurement in the 2-kHz to 200-MHz range, an ac current transformer for measuring from 10 to 150 amperes, and a vinyl carrying case. —*Art Salsberg*

CIRCLE 87 ON FREE INFORMATION CARD

ELECTRONICS NOTEBOOK

Chart Recorders & Storage Oscilloscopes

By Forrest M. Mims III

Most of us who experiment or work with electronics spend a good deal of time making measurements with instruments like multimeters and oscilloscopes. Usually, I measure things like ohms, volts, frequency and the shapes of pulses, but I've lately spent a good deal of time measuring various kinds of natural phenomena.

For example, every day that the sun shines, I measure its peak ultraviolet (UV) radiation at a wavelength of 300 nanometers. This wavelength is near the peak susceptibility of human skin to sunburn. I've been making these measurements almost every day since July 1988 and have learned a good deal about daily and seasonal variations of the ultraviolet.

In addition to my UV project, I've been preparing for the arrival of Africanized bees, the so-called "killer bees," by measuring the wing beat frequency of European honey bees. I've been studying the various electrical and acoustical signals produced by lightning and thunder, and I've been experimenting with several different kinds of do-it-yourself seismometers and humidity sensors. For these measurements, the Cole-Parmer Instrument Co. (7425 N. Oak Park Ave., Chicago, IL 60648) Catalog No. 8376-60 two-channel chart analog recorder shown in Fig. 1 has proved invaluable.

In view of the availability of digital oscilloscopes and sophisticated data-logging software for personal computers, you might be wondering why I spent some $1,400 for an "old-fashioned" chart recorder. Even though I've had experience with all these recording methods, this isn't an easy question to answer. Perhaps the best way to answer it is to make some side-by-side comparisons of a chart recorder with a digital storage oscilloscope (DSO).

Now where do *you* come in? If you aren't yet using any of these recording instruments, chances are you soon will. Many new kinds of recording instruments are being manufactured, and their prices have fallen considerably. Hopefully, some of my experiences with these instruments will help you make batter decisions about which to use for a particular measuring situation.

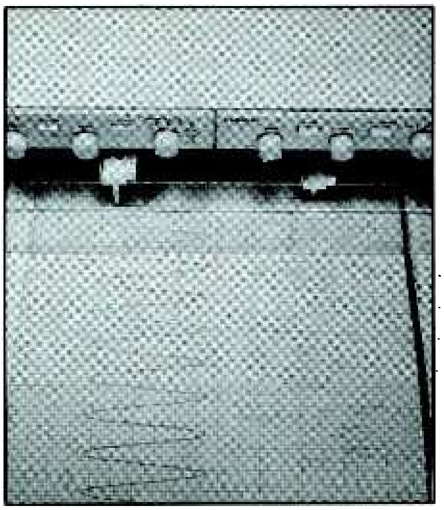


Fig. 1. Author's two-channel analog chart recorder in operation.

Analog Versus Digital

Let's begins this discussion with a brief review of analog and digital displays. For many years, I've taught Sunday School classes. While it's not all that important that the class begins at the set time, it is important that it ends on time. Therefore, as the class winds down, I look at my watch more and more often.

I've worn both digital and analog watches while teaching, and I could never pinpoint which style of display seems easier to read with a quick glance. Then I started wearing a watch with both an analog *and* a digital display. During most of the class, a quick glance at the minute hand on the analog display provided a good time check. Then, during the last few minutes of the class, I began looking at the digital display.

In other words, the analog display provided a fast, general idea of the remaining time, while the digital display provided an exact time reading. The drawback of the digital display is that it requires more brain processing time to understand what is being displayed. The analog display is a picture of the time, the digital display a set of symbols.

Now, let's compare a conventional multimeter equipped with an analog meter movement and a digital multimeter. The latter is perfect for precise measurements of fixed voltages, currents and resistances. However, an "old-fashioned" analog meter is often a better choice in measuring applications in which the signal level fluctuates. For example, a DMM can function as a digital display device for my homemade UV radiometer. It provides precise measurements that can be logged into my notebook. But the DMM is of no use in understanding the wave-like variations in the ultraviolet radiation from the sun. The slowly oscillating pointer of an analog meter movement clearly shows these fluctuations.

Analog meters are also ideal for observing the increase and decrease of the charge on a capacitor. And such meters are well suited for monitoring slowly changing signal levels from various kinds of sensors and transducers.

What all this means is that there is an important place for both analog and digital displays schemes. This explains the existence of wristwatches that have dual displays. It also explains why a radio or tuner with a digital frequency display has an analog level indicator.

The moving-coil level meter is being rapidly replaced by various kinds of digitally controlled analog bargraph displays. Many tuners and equalizers feature one or more rows of bargraphs, each representing a particular audio frequency band. The result, in the case of the equalizer, is an audio spectrum analyzer. The picture provided by such a display is easily grasped. Replacing each analog bargraph with a digital display would provide a confusing and meaningless array of fluctuating numbers.

The Chart Recorder

The chart recorder or oscillograph can be considered a low-frequency oscilloscope with hard-copy output. In most chart recorders, variations in an input signal

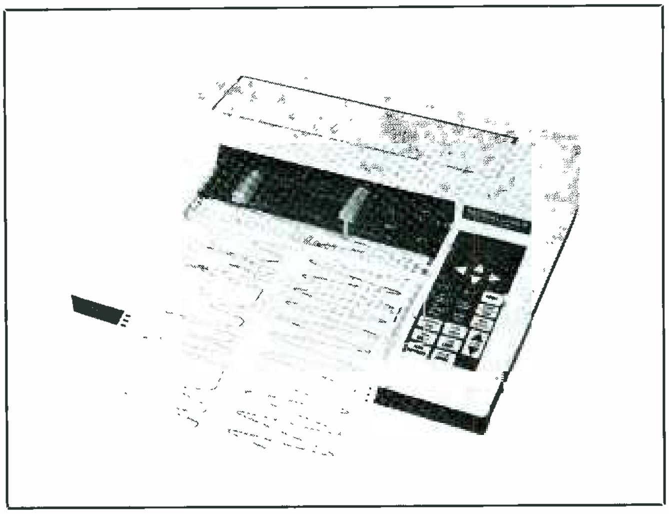


Fig. 2. Series 4500 Microscribe™ microprocessor-controlled chart recorder. (Photo courtesy of The Recorder Co.)

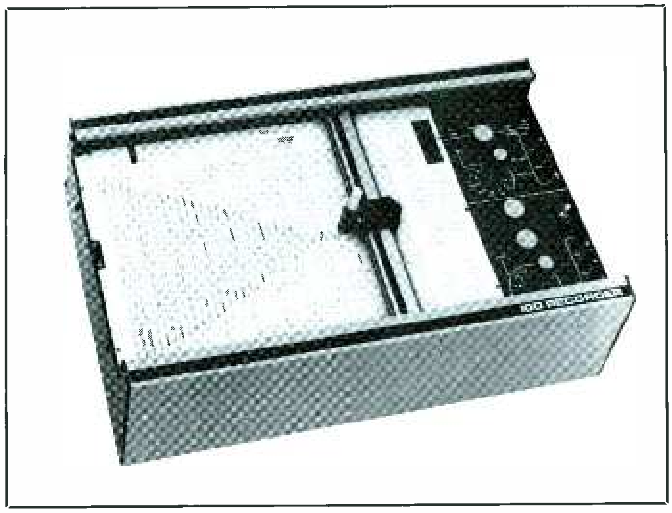


Fig. 3. Series 100 X-Y recorder incorporates capacitance position transducer. (Photo courtesy of The Recorder Co.))

cause proportional changes in the position of a moving pen or stylus. The pen is moved by either a galvanometer mechanism or a servo system. The paper is moved by a regulated motor-driven mechanism.

Many different methods are used to write the signal received by the recorder onto a moving strip of paper. If a pen is used, a line of ink records variations in the signal on the moving paper. Some recorders achieve the same result with a heated stylus and thermal paper, while others use a pointed stylus and pressure-sensitive paper.

The frequency response of all such recorders is limited by the mechanics involved. One way to obtain a faster response is to replace the moving pen with a tiny mirror mounted on the moving axis of a galvanometer. The mirror reflects a narrow beam of light toward a moving sheet of photographic film. Since a galvanometer/mirror assembly has very little mass, it achieves much faster response times than simple galvanometer-driven pens and servos.

The frequency response of a chart recorder can be greatly increased by replacing the moving stylus or pen with a thermal printhead. This printhead consists of a row of closely spaced elements that print small dots on thermal paper. The printhead of some thermal recorders will annotate the paper with such information as the date and time of a measurement and the sensitivity of the recorder and timebase settings.

Figure 2 shows the Series 4500 Microscribe™, one of a line of chart recorders manufactured by The Recorder Co. (P.O. Box 8, San Marcos, TX 78667). This recorder, which was originally developed by Houston Instruments, has 34 chart speeds and 18 sensitivity ranges. A dedicated microprocessor controls the recorder and drives its LCD status display. A single-pen 4500 costs approximately $1,090, while a dual-pen version costs about $1,650.

Chart recorders record information on long rolls of paper. The X-Y recorder is variation of the chart recorder in which the pen is mounted on a slider that can move up and down along a bar that can be swept back and forth across a single sheet of paper.

While the chart recorder can record information over a long period of time, the X-Y recorder is usually—but not always—used to record information relatively quickly. For example, X-Y recorders are used by optical filter makers to record the transmission of their filters as a function of wavelength.

Figure 3 shows a Series 100 X-Y recorder manufactured by The Recorder Co., the same company that makes the recorder shown in Fig. 2. The movable sliders of the Series 100 family use no sliding contacts. Instead, a capacitance position transducer provides nearly frictionless operation with no electrical noise. The Series 100 X-Y recorder sells for approximately $2,600.

The recorders shown in Fig. 2 and Fig. 3 are merely representative of what's available. On my desk as this is being typed is a file I've labeled "Chart Recorders" that's slightly more than 2 inches thick! Therefore, if you're in the market for a chart recorder, be sure to check one of the electronics trade directories under this heading.

Another good source for information on chart recorders is the catalogs put out by companies that sell various recorders. Among the best of these are those from Omega Engineering (Box 4047, Stamford, CT 06907), Transcat (Box D-1, Rochester, NY 14606) and Cole-Parmer Instrument Co.

Digital Storage Oscilloscopes

When I was assigned to a military laser laboratory many years ago, I used dozens

Fig. 4. Model 100 battery-powered, dual-trace portable digital storage oscilloscope. *(Photo courtesy of Leader Instruments, Inc.)*

of packages of Polaroid film to record oscilloscope traces that displayed the power produced by various kinds of lasers. Scope cameras are still an important laboratory tool, but a new kind of oscilloscope can transfer the image on its screen directly to a computer for printout by a printer. No camera is needed to accomplish this feat. This new kind of scope is known as the "digital storage oscilloscope," or DSO for short.

DSOs incorporate a fast analog-to-digital (A/D) converter that digitizes the incoming signal. The most important advantage of the digitized signal is that it can be temporarily stored in a memory in the DSO that saves one or more screens. Alternatively, it can be transferred to a desktop computer and saved on the computer's disk drive. Some DSOs include built-in floppy-disk drives for saving screen displays.

Another important advantage of the digitized signal has already been mentioned. Since the signal is in digital form, everything displayed on the screen of the DSO can be printed on paper. Yet another advantage is that some DSOs can be used in a roll mode that simulates a chart recorder. A single screen can represent minutes or even hours of data.

Though DSOs are still more expensive than analog scopes, their prices have fallen considerably in recent years. On the low end, Hameg, Inc. (8890 Harbor Rd., Port Washington, NY 11050; Tel. 800-247-1241) sells its Model HM 205-2 for less than $1,000. Optional accessories available for this 20-MHz scope include an IEEE-488 bus, X-Y plotter output, and a graphics printer. Also available is a software package that permits the scope to be used with an IBM PC-AT or compatible computer. This combination provides such capabilities as data logging, wave analysis, automatic measurements, calibration and various kinds of mathematical processing. Waves displayed on the CRT screen of the scope can be saved in disk files and printed.

If you need a portable DSO, Leader Instruments Corp. (380 Oser Ave., Hauppauge, NY 11788; Tel. 800-645-5104) manufactures the single-trace Model 100P and dual-trace Model 200 battery-powered DSOs. Both miniature scopes double as digital multimeters, and both can be used with a miniature thermal printer that provides a printout of everything displayed on the screen.

Both Leader scopes store up to three screens in an internal nonvolatile memory for later review and, if desired, printout. The Model LCD-100 sells for $895; the Model 100P and a companion thermal printer together sell for $1,612; and the Model 200, shown in Fig. 4, sells for $1,645. The Model 710 printer costs an additional $480.

If your budget permits, you can consider an advanced DSO like Hewlett-Packard's Model HP 54501A. This 100-MHz, four-channel DSO sells for around $3,500, which includes a built-in

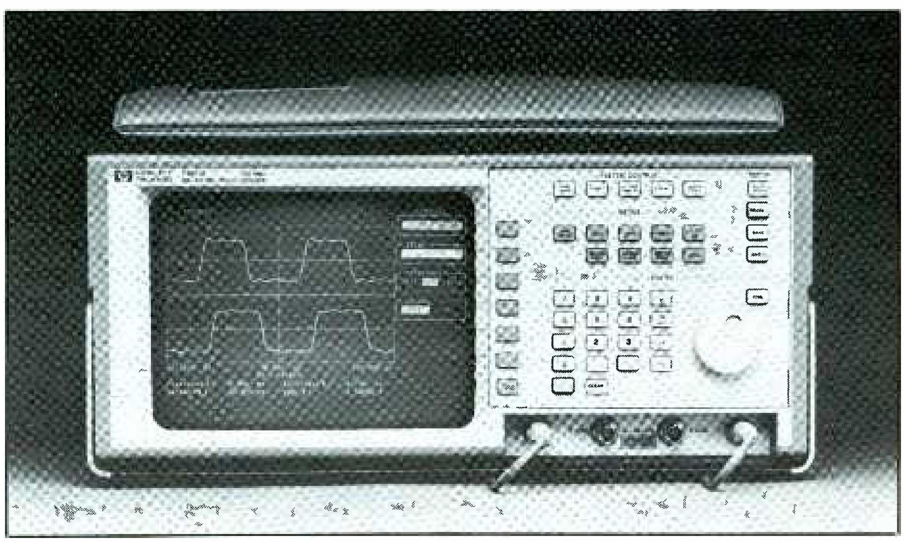


Fig. 5. HP 54501A digitizing oscilloscope has four input channels and 100-MHz bandwidth. *(Photo courtesy of Hewlett-Packard Co.)*

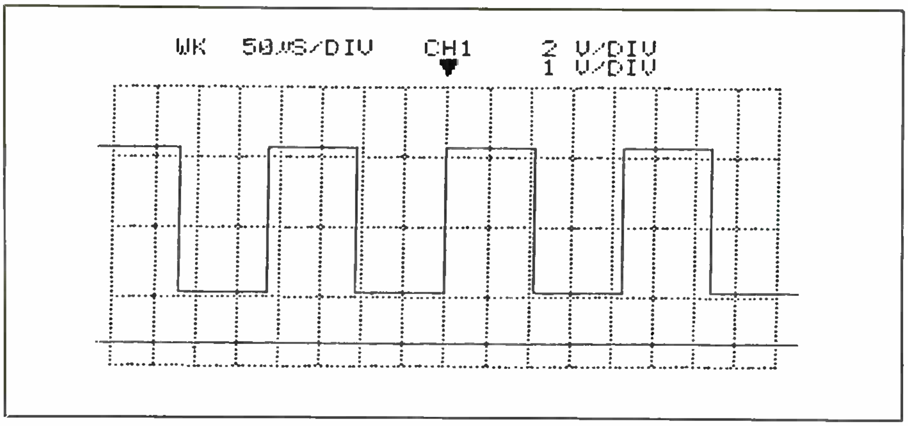


Fig. 6. Square wave displayed and printed out by Leader Instruments Model 200 digital storage oscilloscope.

IEEE-488 interface and hardcopy output to a graphics printer. As Fig. 5 reveals, the front panel of the HP 54501A has only one analog control. Otherwise, all control over this instrument is by means of pushbuttons.

Besides Hameg (West Germany) and Leader Instruments (Japan), major domestic manufacturers of DSOs include Tektronix, Inc. (P.O. Box 500, Beaverton, OR 97077; Tel.800-426-2200) and Hewlett-Packard Co. (19310 Pruneridge Ave., Cupertino, CA 95014; Tel. 800-752-0900).

Bill Siuru, jr., reviewed DSO basics in the March 1989 issue of *Modern Electronics*. That same issue included a DSO Buyer's Guide. If you're in the market for a DSO, be sure to see this article.

Data-Acquisition Computer Software

The same computer into which these words are being typed can perform many of the functions of both chart recorders and digital storage oscilloscopes. The October 1988 installment of this column described how my son transformed a Tandy 1000 personal computer into a chart recorder. The April 1989 column described how I transformed a PC into a slow-scan storage oscilloscope with the help of reasonably priced 8-bit A/D conversion board made by Alpha Products (242-M West Ave., Darien, CT 06820).

If you don't need a full eight bits of resolution, you can use the analog game ports of some computers as built-in A/D converters. This means these computers can be used as DSOs with only the addition of software and without the need for any external hardware. It's especially easy to transform Radio Shack's Color Computer and IBM's PC*jr* and similar machines into basic DSOs. For full details on how to accomplish this, including program listings and sample screens, see *Forrest Mims's Computer Projects* (Osborne McGraw-Hill, 1985).

Comparing Chart Recorders & Digital Storage Scopes

As I mentioned early on, I recently purchased a two-channel chart recorder. About the same time, Leader Instruments Corp. lent me a Model 200 portable digital storage oscilloscope and printer to evaluate for *Modern Electronics*. I've also had the opportunity to work with various data-acquisition systems, including do-it-yourself versions and an IBM AT-compatible computer connected to a 110-MHz Tektronix Model 2230 DSO and various kinds of data-acquisition and interface hardware. What follows is based upon my experience with these and similar instruments.

Shown in Fig. 6 is a printout of a square wave provided by the Leader Model 200 DSO and its companion thermal printer.

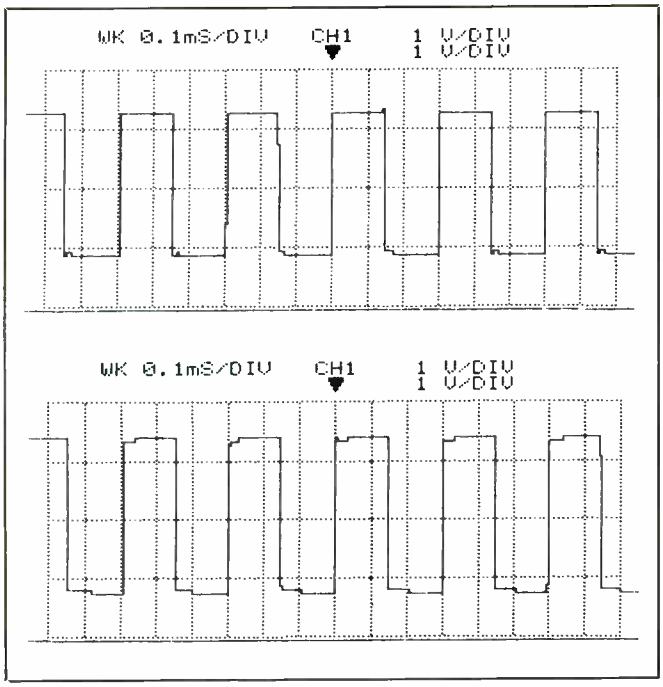


Fig. 7. Resolution-limited square wave displayed and printed out by Leader Instruments Model 200 DSO.

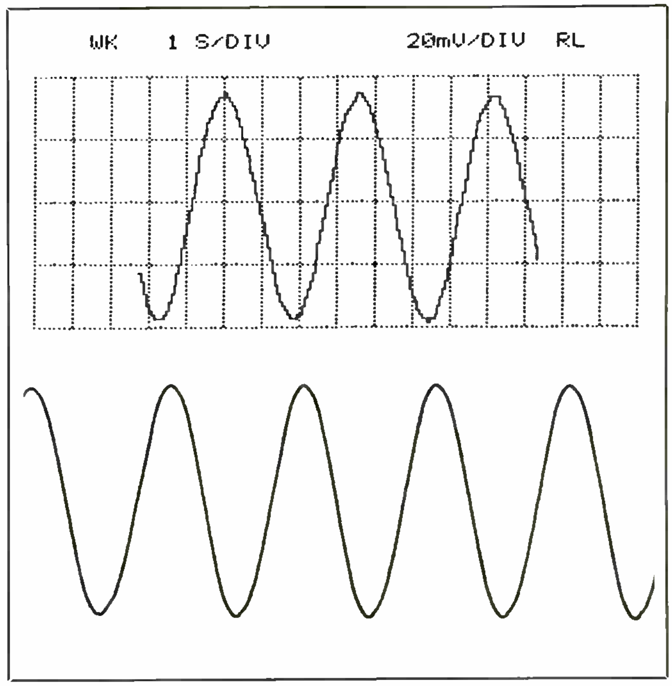


Fig. 8. Identical sine waves printed out by Model 200 DSO (upper) and drawn by analog chart recorder (lower).

The trace is displayed on channel 1 and no signal is applied to channel 2. Note that the printout is annotated with the settings for each channel.

The resolution of the most expensive DSO is less than that of the least expensive analog scope or chart recorder. This resolution limit is clearly revealed in Fig. 7, a pair of printouts of a square wave displayed on a Model 200 DSO. The actual square wave has no overshoot and almost perfectly flat tops and bottoms. However, the amplitude of the wave falls between two of the DSO's resolution points; hence the choppy tops and bottoms shown in Fig. 7.

The two sine waves shown in Fig. 8 illustrate another aspect of the resolution limit of DSOs. Here, the same sine wave has been applied to the Model 200 DSO (upper) and my Cole-Parmer chart recorder (lower). The limited resolution of the DSO transforms the smooth sine wave into a stepped function.

The waveform shown in Fig. 8 is clearly recognizable as a sinusoid. At slow sweep speeds, however, the display of a DSO can become very confusing because of a phenomenon known as "aliasing." For example, Fig. 9 shows a collection of printouts of the sine wave shown in Fig. 8 displayed at a range of sweep speeds by the Model 200. Fortunately, storage scopes like the Model 200 have an auto-ranging feature that automatically seeks out a sweep speed that presents a clear, easy-to-read display.

Incidentally, the lower two printouts in Fig. 9 were made by placing the Model 200 DSO in its roll mode. This causes the display to resemble a chart recorder. When the Model 200 is in its roll mode, the printer prints only the on-screen portion of the display. All other Model 200 screen printouts in Fig. 9 show the scope's entire memory contents.

While old-fashioned chart recorders have superb resolution, their response time is slower by far than the slowest DSO. This can easily lead to missed events. In Fig. 10, for example, is shown a particularly interesting comparison of the printout from the Leader Model 200 and the chart from the Linear Instruments recorder. The two images are simultaneous recordings of the 300-nm ultraviolet radiation from the sun at my office in south-central Texas at 1120 hours CST on March 29, 1989. The DSO sweep speed was 5 seconds per division, and the chart speed was 5 centimeters per minute. The UV flux was 0.016 watt per square meter. According to Sunsor, Inc. (and both my exposed ears), that level will cause mild burning of unprotected Caucasian skin in about an hour.

Notice in Fig. 10 the two square-shaped negative pulses. These were recorded when I placed a UV blocking filter in front of the ultraviolet detector for approximately 5 seconds. The reason for this was to keep tabs on the small amount of sensitivity of the UV detector to red light. The trace on either side of and between the two negative pulses is the total signal from the UV detector.

Also note that the DSO trace is perfectly flat, while the chart-recorder trace is an endless sequence of tiny squiggles. At first glance, these squiggles might appear to be electrical noise. Actually, though, they indicate the constantly changing nature of the atmosphere's transmission of UV energy. Ozone, water vapor, sulfur-dioxide and dust are some of the most important absorbers of UV energy in the air. In other words, the squiggles on the chart represent the noise level of the atmosphere's optical transmission at a wavelength of 300 nm.

The most interesting aspect of these two traces is the narrow negative spike inside the two circles. This occurred when a small branch about 25 feet above the detector was momentarily blown into the field of view of the detector. This spike is much more pronounced on the DSO trace because the scope had a much faster response time than the chart recorder. Indeed, had I not been monitoring the sun with with DSO at the same time, I would probably have not noticed the tiny negative spike n the chart recorder's trace.

During the measurement session, I adjusted the Model 200 DSO to show the subtle variations so easily indicated by the chart recorder. As Fig. 11 reveals, the DSO display is not nearly as interesting as that of the chart recorder. (The negative square wave in Fig. 11 was produced when I placed a UV blocking filter over the ultraviolet detector.)

Summing up, the DSO recording does not provide the fine detail of the chart recorder's squiggly trace. On the other hand, the DSO clearly displays fast, transient events that might be missed by the much slower chart recorder. Of course, even the DSO will miss spikes that occur *between* the scope's A/D time samples.

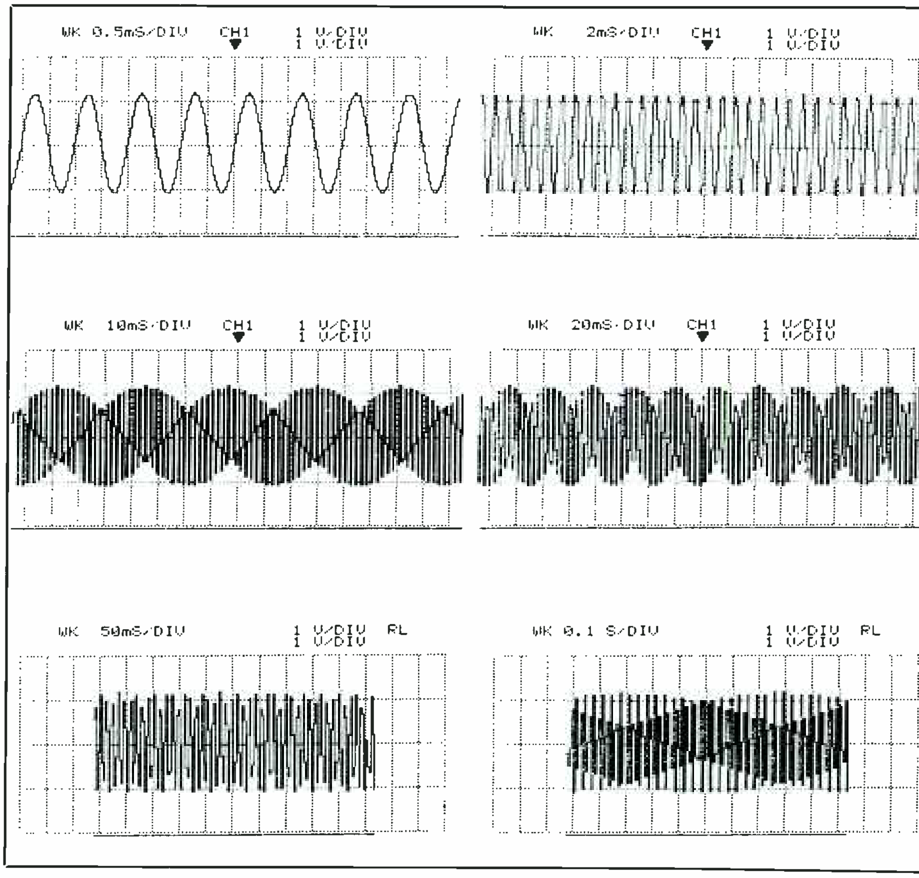


Fig. 9. Identical sine waves displayed at different sweep speeds on Model 200 DSO.

Why Use a Chart Recorder?

Readers of *Modern Electronics* have such diversified backgrounds in electronics that I'm sure many of you must have strong ideas about the relative merits of the various recording instruments discussed in this column. Leader Instruments' Model 200 DSO has a limited capability, but it is portable and battery powered. Full-featured digital storage oscilloscopes have much faster sampling rates than the Model 200, and their CRT displays provide significantly better resolution than the liquid-crystal display (LCD) of the Model 200.

Chart recorders are inherently slow and tend to swamp their users, especially this one, with endless rolls of charts. Since only the most expensive chart recorders have an automatic annotation feature, you have to remember to write down the recorder's settings.

One thing we can probably all agree upon is that each instrument has its role to play. That's why I bought a chart recorder to supplement my do-it-yourself computerized data logger. The various computer data loggers I've designed require several minutes or more to set up from scratch. I can begin recording data with my new chart recorder in less than a minute, and the recorder shows very subtle trends that are sometimes lost when data is digitized.

I've already made many lightning and thunder measurements with my chart recorder. Soon, I plan to build an automated tracking system to monitor the radiation from the sun at several wavelengths. My present plan is to feed the signals from the detectors into a multi-channel A/D converter. The digitized signals will be stored in a computer for later presentation and analysis.

The computer can easily be programmed to sound an alarm when something unusual occurs. For example, I'll probably program a set point that will sound an alarm when the UV energy exceeds a certain level. If the alarm sounds, I can then decide if what is happening is interesting enough to supplement the relatively low-resolution digitized data with a high-resolution chart recording. The chart recorder will show subtle signal variations and trends that the digital approach will miss entirely.

In a few years, we'll be able to store vast quantities of data on CD ROMs. Consider that a single compact disk can store up to 600 megabytes, or approximately 300,000 pages of data! Even then, I suspect, there will still be a role for analog chart recorders.

Going Further

Please keep in mind that this discussion touches on only some of the high points of the ins and outs of storing data with DSOs and chart recorders. For more information, be sure to contact some of the manufacturers whose names and addresses are given above. Various electronics trade directories will point you to additional makers of DSOs and chart recorders. ME

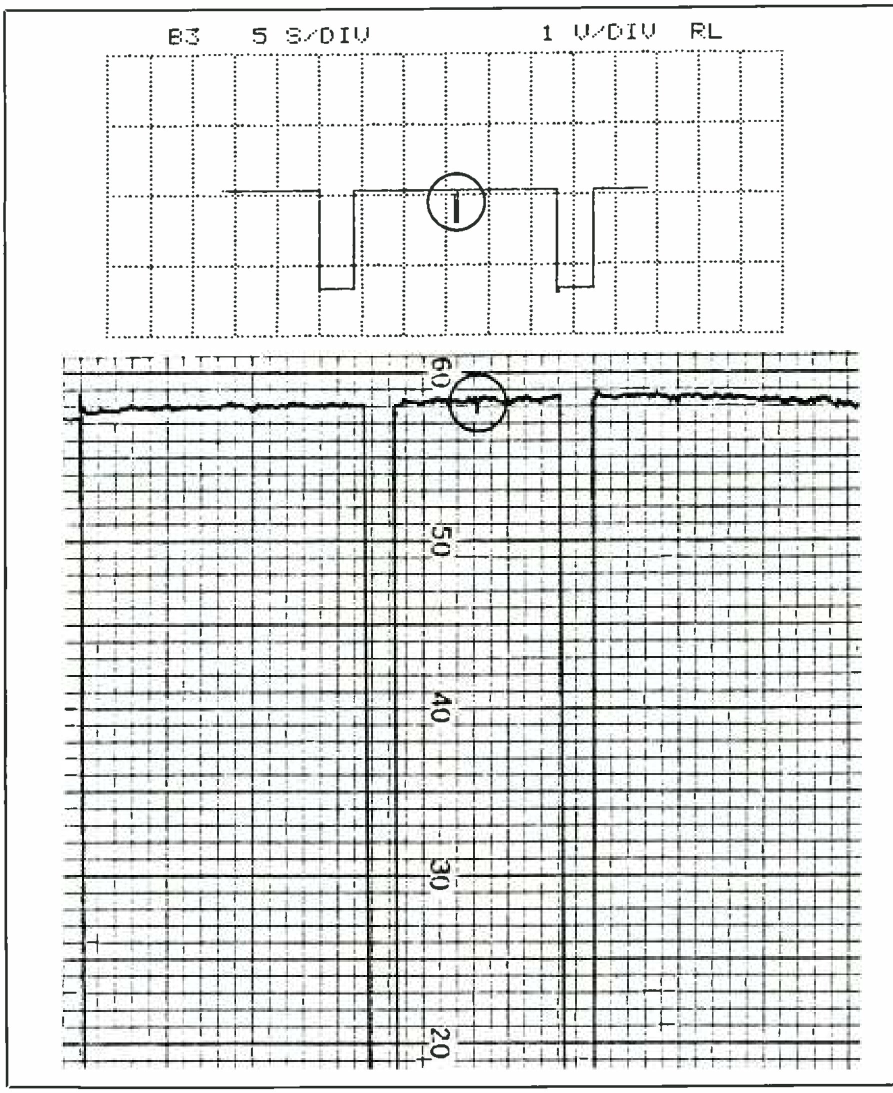


Fig. 10. How Model 200 DSO captured a glitch and displayed it better than it was drawn by chart recorder at same time.

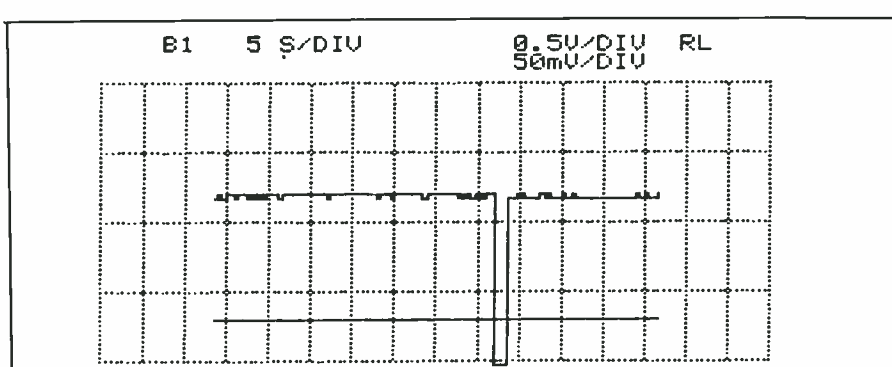


Fig. 11. How Model 200 DSO displays minor fluctuations in ultraviolet flux from the Sun.

The Complete PC's Page Scanner; Traveling Software's Lap-Link III; and MicroSolutions' megamate 3.5" disk drive

By Ted Needleman

In past columns, I've discussed some products from The Complete PC that I've used. For a company that's only been around since 1986, they've managed to churn out innovative peripherals at quite a clip. Their latest product, examined here, is an inexpensive, yet very capable page scanner.

Whereas hand-held scanners, which cost $250 to $400, are normally moved across a page where they scan a swath of between 2.5 and 5 inches per pass, sheet-fed and flatbed scanners scan an entire page in one pass. These page scanners provide a cleaner scan, too, since it's impossible to pull a hand-held scanner across a page at an absolutely constant rate. They're much costlier, though, with prices generally ranging from $1,300 on up. The Complete Page Scanner, however, provides just about all of the features of those expensive units for a list price of only $899, which is a price breakthrough of sorts.

Shown here is the result of a color photograph of the author's son that was scanned at 300 dots per inch with the Beyer Dithering Pattern.

Based on a Canon scanner engine, the Complete Page Scanner is a small (13 by 9.5 by 3-inch) lightweight unit, which is accompanied by a quarter-sized (4⅝ by 1¾-inch) interface card. The interface card fits in an eight-bit slot, so the unit can be used with PCs ranging from older 8088-based units up to the newest 386 systems.

The unit can accept 8.5-inch-wide paper up to legal size (14-inch length), and can scan at either 200- or 300-dot-per-inch resolution. The scanned images, incidentally, can be saved at a different resolution than what was used to scan. These saved resolutions vary from 75 to 400 dots per inch. This allows you to better match the image with the resolution of the output device, such as a printer or fax board.

The Complete Page Scanner also allows you to scan half-tones. Although it does not output gray-scale images, it provides three different dithering methods to simulate gray-scale when scanning photographs. As discussed in previous columns on imaging, photographs are not strictly pure black and white; they also contain different shades of gray.

Much more expensive scanners are able to capture these shades directly, though few printers, including most laser printers, are able to reproduce gray-scale images. Other printers (and many scanners) use a technique called "dithering" to approximate these gray tones. Dithering involves adding and subtracting dots of pure black and white on the page. When done effectively, the eye is fooled into seeing these areas as gray.

Installing the Complete Page Scanner was easy, and took less than 15 minutes. The interface card is placed in an empty expansion slot in the PC and, if necessary, the card's DIP switches are set to change the I/O address of the scanner port and its interrupts. With my installation, the default settings worked fine.

After the board is installed, plug in the scanner's cable and install the software. The scanner includes a diagnostic program on the first of three software disks that checks the installation, I/O address settings and the interrupts. If there is a potential conflict between the scanner and another peripheral, this program, called SCANCHK, will warn you.

Software installation is otherwise completely automatic. The install routine creates a subdirectory on your hard disk and moves the programs over to this new subdirectory, prompting you to insert additional diskettes as they are needed. You really need a hard-disk drive to use this or any other scanner. Even if a vendor allows their scanning software to be run off floppies, some image file formats can really eat disk space.

Using the Complete Page Scanner is as simple as installing it. The software's menus are easy to understand, and there is on-line help available at any time. The software permits you to scan a document, edit it at the pixel level (which is very handy for cleaning up the document before saving it), zoom in and out for different views of the scanned image, rotate the image, and crop it. The Complete Page Scanner's software supports a mouse, and having one on your system greatly simplifies working with the image once you've captured it.

When you're happy with the image, you can save it in a variety of formats including the Complete PC's own image format, PC Paintbrush format, Dr. Halo format, either of two Windows Paint formats, as a TIFF or GEM file, or one of two formats (Fine and Regular resolution) to be used with the Complete PC's Complete Fax board. (In fact, using the scanner with a PC equipped with the Complete Fax gives you the equivalent of a fully functional deluxe fax machine.) The software even allows you to save the image in one format, then recall it at a later time and convert and save it again in a different file format.

In sum, the Complete Page Scanner is easy to set up, easy to use, and works well. It's also very affordable. If you're doing much desktop publishing or presentation graphics, you're probably going to need a scanner. If you can get away without a gray-scale scanner, the Complete Page Scanner is a great buy.

Lap-Link Release III

Over a year ago, I reviewed Traveling Software's Lap-Link package, which lets you transfer files and programs between any two MS-DOS based PCs, whether they are desktops, laptops, or a combination of both types. Lap-Link is a useful package, and I use it often. The newest version of the software, Lap-Link Release III, is even better.

In its previously available format, it used the serial ports of the two PCs. The latest version, Release III, adds the capability of linking the two systems through the PC's parallel ports. This is accomplished with the special cable that is supplied with Lap-Link. It is actually three cables molded together. Two of the cables contain serial connectors, one has a set of the DB-25 connectors used in older PCs, the other has DB-9s, used in AT-class systems. The third cable has DB-25 connectors on both ends wired for the parallel printer port on a PC.

Using the parallel port, rather than one of the PC's serial COM ports, offers two benefits. The first is that your PC may already be using one or more of its COM ports for a serial printer, a modem, or a mouse. When this is the case, not only would you have to start connecting and disconnecting cables to use Lap-Link, but you might also need to start re-configuring your software if you've used the DOS MODE command to set up the COM port for a particular piece of equipment.

More importantly, though, is the increase in data transfer speed that can be realized by using the parallel port. Serial COM ports operate at a maximum speed of 115-kilobaud (115,000 bits per second). Parallel ports, in contrast, allow the transfer of data at rates of approximately 500KB, almost 5 times faster. If you have a large number of files to transfer over, or if your files are very large, this speed boost really makes a difference.

Lap-Link III also offers another unusual feature. With most transfer packages of this type, you need to run the accompanying software on both PCs. First you boot the software on the PC from which you will control the process, then it must be booted again on the other PC involved in the transfer process. This means that even if you have the software on your laptop's hard disk, you must always carry around the diskettes so that you can boot up the second system.

If you use the serial port transfer mode of Lap-Link III, it can sense whether or not Lap-Link is running on the second system. If it isn't, the "master" system transmits a copy of Lap-Link to the other system so that a transfer can take place. In a sense, this is a benign virus, carefully constructed so that it doesn't replicate itself except when you need it.

Also included with the Lap-Link III package is another utility, which Traveling Software calls a device driver program (which is different from the DOS device drivers that install into the operating system). This program provides your laptop with direct access to the disk drives, printer, and other peripherals of the system you've used Lap-Link III to connect with.

Setting up and using Lap-Link is a snap. Connect both systems together with the special cable via the serial or parallel ports. Then simply boot Lap-Link III on both systems and start transferring files. If you're already familiar with Lap-Link, the commands are the same. If you're not, the user interface, with its split screens (files on the PC you're working on are shown on the left, the remote system's files are on the right), is almost intuitive. I don't think I've looked in the manual more than a few times in the two years I've been using Lap-Link.

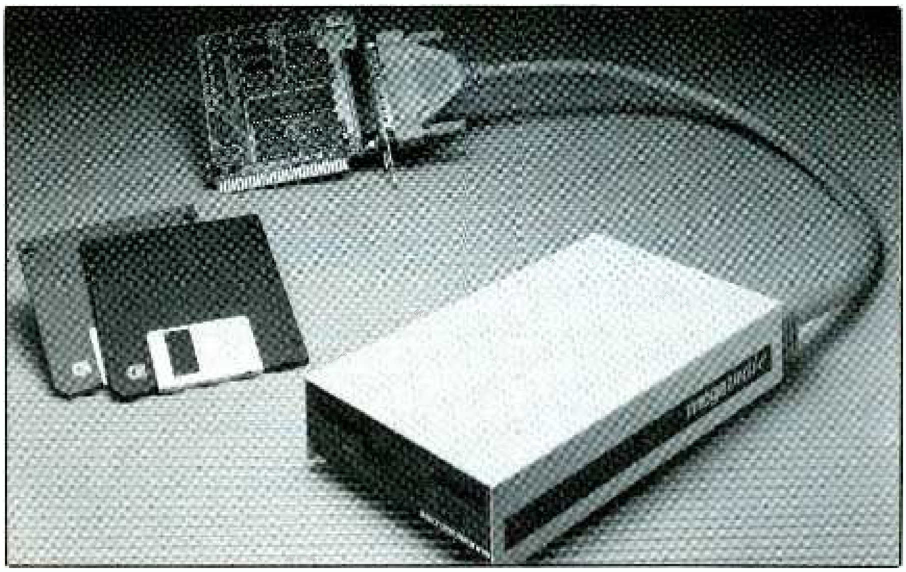
In last year's review, I recommended Lap-Link if you needed to transfer files between nearby PCs. The latest version of Lap-Link is even better. It's faster, and if you have it on a laptop's hard disk, its "cloning" capability eliminates the need to carry around a floppy disk to install it on the target machine.

Megamate

With the proliferation of floppy disks of different sizes and densities, it's becoming more important to gain the capability of transferring files between these different formats. The Lap-Link package discussed above is one way to do this. Another method, which is more expensive but offering several additional advantages, is to add a 3.5 inch disk drive to your desktop PC.

If you use a unit having a 1.44MB capacity, rather than the 720K storage that laptops provide, you will also garner the ability to transport files between your system, laptop PCs, and IBM PS/2s. While it is fairly easy to install a 3.5-inch drive internally, not every user has the empty space in their PC for another internally-mounted disk. If you're in this situation, or you simply want an easy way to add a 3.5-inch drive, megamate from MicroSolutions, Inc. provides an easy to implement answer.

The megamate unit is very compact. At 4 inches wide by 7.5 inches deep and only an inch-and-half high, megamate isn't much larger than the drive itself. It is accompanied by a customized version of MicroSolutions' CompatiCard floppy disk controller and a disk containing software drivers and utilities. The drive draws power from the controller card,



MicroSolutions' megamate external 3.5-inch floppy-disk drive.

eliminating the need for a separate power supply.

Installing the megamate took only a few minutes. Plug the adapter card into an empty expansion slot, and then attach the cable from the drive unit. The controller card has several jumpers which are used to specify the adapter's I/O address. These are set so that the adapter does not conflict with the floppy disk adapter the PC already contains. The default jumper settings worked fine in the Epson Equity 1e I installed the unit in.

Installing the driver software is just as simple. MicroSolutions provides an installation program, called MEGAPREP, on a 5.25-inch 360K diskette. When run, MEGAPREP asks where your boot disk is, and copies the required programs and software drivers to your boot disk. When you reboot your system, you will be greeted with a message stating that the megamate drive is available and what drive letter has been assigned to it.

MicroSolution's software package also includes a utility called BACKFMT, which allows you to initialize diskettes in the megamate drive while other programs are running on your PC. After BACKFMT is configured and installed, the CTRL/ALT/F key sequence will pop up a window asking what capacity you wish to format the disks to.

BACKFMT worked well, but it does have two limitations; it won't run while a graphic program is running (they both need to use the same area of RAM), and formatting is temporarily suspended when another floppy disk is accessed by your application program (only one floppy disk can normally perform an access at any time). Other than these limitations, the background formatting capability is an appreciated bonus.

It should also be mentioned that the megamate, as with most 1.44MB drives, can also read and write 720K diskettes. The MicroSolutions unit can automatically sense what capacity diskette is in the drive, and adjusts itself accordingly. When formatting a new diskette, you will use the MMFORMAT utility included on the software disk. This utility allows you to specify, with the use of a / 720 or / 1.4 switch, the way the diskette will be formatted.

The megamate drive is a bit more expensive than just purchasing a 3.5-inch drive and installing it inside the PC. For this extra cost you get a solution that is easy to install and use, and works well. MicroSolutions is another company that has been around for a while quietly producing excellent products that solve specific needs. If one of your needs is for 3.5-inch disk compatibility, megamate or one of MicroSolutions' other disk products is a worthwhile solution.

(You'll note this month that three extra names have been added to the Manufacturers Mentioned box. These were accidentally omitted from the July 1988 installment of this column.—Ed.)

Manufacturers Mentioned

The Complete Page Scanner
The Complete PC
521 Cottonwood Dr.
Milpitas, CA 95035
(408) 434-0145

Lap-Link Release III
Traveling Software, Inc.
18702 N. Creek Pkwy.
Bothell, WA 98011
(800) 343-8080; (206) 483-8088

megamate
MicroSolutions, Inc.
132 W. Lincoln Hwy.
Dekalb, IL 60115
(815) 756-3411

Digital Darkroom
Astral Development Corp.
Londonderry Center Rd.
Suite 112
Londonderry, NH 03053
(603)432-6800

Hijaak Ver. 1.1B
Inset Systems, Inc.
71 Commerce Dr.
Brookfield, CT 06804
(203)775-5866

Picture Publisher
Silicon Beach Software
9770 Carroll Center Rd.
Suite J
San Diego, CA 92126
(619)695-6956

Disk Technician Advanced: A Cure-All for Hard-Disk Crashes

By Joseph Desposito

Of all the phobias that afflict mankind, fear of crashing is the one most likely to affect the guy or gal working at a computer. When your hard disk crashes, you immediately think about your backup—or lack of it. Depending on how often you back up your hard disk, and at what moment the crash occurs, you might lose a minute, an hour, a day, a week, a month, or all of your work! Since hard-disk crashes are not a rare occurrence, fear of crashing is not an irrational fear.

Prime Solutions, Inc. (1940 Garnet Ave., San Diego, CA 92109) is like a good therapist when it comes to hard disks. Its Disk Technician Advanced software is designed to monitor potential hard-disk problems and deal with them before they can cause a fatal crash. Disk Technician Advanced can't prevent all types of crashes, but it can help you to avoid the terrible

ABORT, RETRY, IGNORE, FAIL?

error message that DOS uses to inform you that your hard disk (or floppy) has big problems.

Disk Technician Advanced is for single IBM PC, XT, AT, or compatibles that conform to the IBM standard of low-level formatting and 512 bytes per sector. The software also works on the IBM PS/2, except for models with translating controllers. (A translating controller reports to DOS a different number of cylinders, heads and/or sectors than are physically present on the hard drive.) Disk Technician Advanced can monitor two physical disk drives up to 136 megabytes, each with MFM-type controllers; or 248 megabytes, each with RLL/ARLL-type controllers.

The program works on physical C and D hard disk drives with a maximum of 31 sectors per track, 1,024 cylinders and 16 heads, provided they are partitioned as C through Z drives (up to 24 partitions) of up to 32 megabytes each. It also works on non-IBM standard controllers, such as hard disks and hard cards that do not permit low-level formatting.

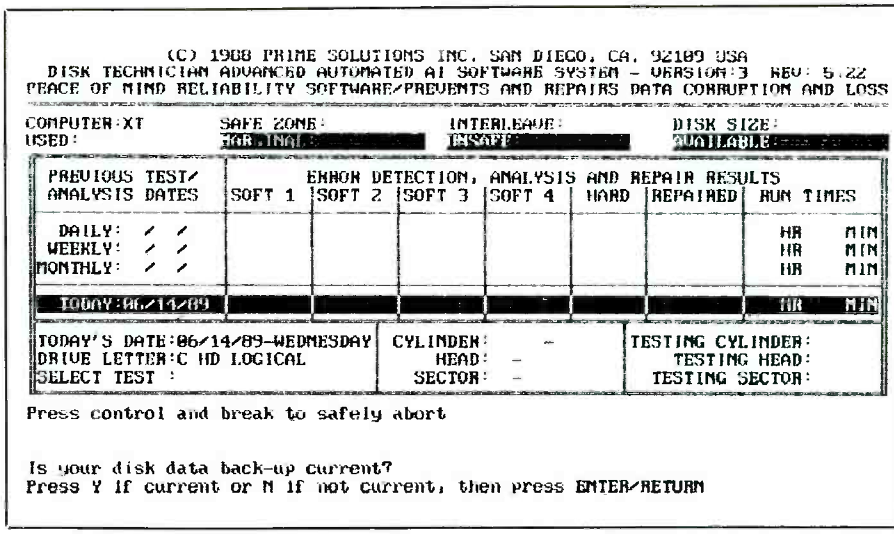


Fig. 1. This screen appears after installation is complete and computer is rebooted.

Disk Technician Advanced requires PC or MS-DOS version 2.1 to 3.32 and 512K RAM. The disk controller must be set in a non-translation, non-cache mode. The program, which is for both novice and advanced users, has a suggested retail price of $189.95.

What It Does

According to Prime Solutions, Disk Technician Advanced can predict and prevent hard disk file corruption, file loss and hardware failure before they happen. And the program will either repair the problem automatically or give precise instructions on how to correct it, in advance, without risking anything (or everything) stored on the hard disk.

According to the company, a particular location on a hard disk usually fails in a gradual way. It will generally begin to show soft errors at an ever-increasing rate until total failure causes loss of data. As the soft error rate climbs, it becomes increasingly harder for the disk controller to read the contents of the location. The controller must retry again and again to get data in a marginal location.

DOS is totally unaware of the impending failure because it is not notified of the retries. Programs that get below DOS and use the controller's own Error Correction Code (ECC) will not, Prime Solutions says, detect the impending failure either. The reason is that the controller will not yet be attempting ECC correction of the failing location since it is still able—even if just barely—to read the data by re-trying many times. As long as the controller can get the data after many retries, it will not attempt to perform ECC recovery.

The company says that disk sectors in this condition will vary quite a bit in their error rate. This means that sometimes the controller will be able to read with only one, two, or three retries, and then suddenly 30, 50 or more retries will be required. Since DOS will eventually give up re-trying the read, the marginal sector will inevitably be totally unreadable.

DOS responds to this type of failure with the error message:

ABORT, RETRY, IGNORE, FAIL?

Typing an R for RETRY sometimes gets the data right away, but sometimes it doesn't. Powering the system down and back on again sometimes helps and sometimes doesn't.

At this point, according to Prime Solutions, the controller will attempt to recov-

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DISK TECHNICIAN ADVANCED AUTOMATED AI SOFTWARE SYSTEM - VERSION:3  REV: 5.22
PEACE OF MIND RELIABILITY SOFTWARE/PREVENTS AND REPAIRS DATA CORRUPTION AND LOSS

COMPUTER:XT          SAFE ZONE:36,864     INTERLEAVE:4        DISK SIZE:21,282,816
USED:11,958,272      MARGINAL:0           UNSAFE:0            AVAILABLE:9,[illegible]

PREVIOUS TEST/      ERROR DETECTION, ANALYSIS AND REPAIR RESULTS
ANALYSIS DATES    SOFT 1 |SOFT 2 |SOFT 3 |SOFT 4 | HARD |REPAIRED| RUN TIMES

  DAILY:06/14/89     0       0       0       0      0       0        HR  4 MIN
 WEEKLY:06/14/89     1       0       0       0      0       1      1 HR 18 MIN
MONTHLY:06/14/89     1       0       0       0      0       1      3 HR 32 MIN

  TODAY:06/15/89                                                     HR    MIN

TODAY'S DATE:06/15/89-THURSDAY   CYLINDER:   1-  613   TESTING CYLINDER:
DRIVE LETTER:C HD LOGICAL            HEAD: 0- 3            TESTING HEAD:
SELECT TEST :DAILY AUTOMATIC       SECTOR: 1-17          TESTING SECTOR:

Use arrows ↑↓ to go to previous or next field. ESCAPE to clear/restore entry
Press ENTER/RETURN for automatic Disk Technician selection shown, or:
Press ESCAPE to clear selection for other tests. Enter DA for "Daily Automatic"
WA for "Weekly Automatic," MA for "Monthly Automatic," DM for "Daily Manual,"
WM for "Weekly Manual"  or MM for "Monthly Manual"
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Fig. 2. Screen of results produced by running mandatory daily, weekly and monthly tests.

er the data by using its ECC. It will only be successful a very small percentage of the time. At this advanced stage of failure, the error is usually too severe for the ECC to reconstruct the missing data. If the controller does manage to recover the endangered data using its ECC, it will inform DOS of this fact. However, this sometimes adds to the problem since most versions of DOS will proceed to use the marginal, barely recoverable data as if it were perfect and ignore the error as if nothing were wrong.

Disk Technician Advanced is designed to detect below both DOS and ECC error recovery, down to a single occurrence of a soft error. The hard disk controller detects these soft errors at their first occurrence in order to properly process data through the microprocessor.

However, the controller does not inform the user of these errors since it only retrieves the data, and does not keep track of the number of retries needed to do it. Disk Technician Advanced monitors the flow of data across the interface and senses the controller's reaction to these errors. Thus, the program can detect the soft errors found by the controller even though the controller gives no direct indication to the microprocessor that any soft errors occurred.

Disk Technician Advanced uses artificial intelligence techniques together with an error pattern database. This feature combines with the program's sensitivity to monitor, analyze, and characterize the soft error rate of any disk location over a period of time and predict data failure in its very earliest stages. This is when the data is still easily recoverable by retries and well before ECC is required.

Using the Software

To begin using Disk Technician Advanced, you simply format a disk with the /s option, and then copy all the files from the program disk (which comes in either 5.25- or 3.5-inch format) to the newly formatted disk. You then insert this disk into the A: drive and reboot the system.

The program installs automatically, asking questions such as "Do you want to run Disk Technician from a floppy or hard disk?" (the program suggests a floppy) and "Would you like Disk Technician Advanced to automatically select optimum operating options for your system?" Among the options that the program sets for you is the optimum hard disk interleave and a screen saver that operates while the program is running.

Part of the installation procedure is to install a program called SafePark on your hard disk, if you want it. This program, which is RAM-resident and uses less than 700 bytes, automatically parks your hard disk's head in a safe zone on the disk when there is no disk activity for about seven seconds (factory preset but user adjustable). This prevents loss of date from such occurrences as static electricity and power spikes, as well as power fluctuations and power loss.

After the installation procedure is complete, you reboot the system, whereupon a screen similar to the one in Fig. 1 appears. After you confirm the correct date, drive letter, and whether your backup is current, the program begins a comprehensive repair test.

Prime Solutions describes these tests as follows: Disk Technician Advanced first tests the system areas of the hard disk. It then tests the main File Allocation Table (FAT) and the backup FAT for soft errors. If there are soft errors in either of the FATs, the program repairs them. If any of the information stored in a damaged section is irrecoverable, it is automatically restored from the other table. The program also compares the two FATs with each other.

The next step is to test the root directory for soft errors. If soft errors are detected the program repairs the directory. If any information is irrecoverable, the entries that make up that sector are cleared and the user is prompted to recover the files by running CHKDSK/F.

Disk Technician Advanced next tests sector timing to be sure that the controller is reporting the correct number of sectors per track for the particular encoding method in use (MFM, RLL, or ARRL). The program also detects the current interleave. Finally, it determines the optimum interleave value for the fastest system input/output (I/O). The program does this by non-destructively formatting a single track at successively higher interleave values and measuring the I/O speed.

Disk Technician Advanced has three levels of testing: Daily, Weekly, and Monthly. The tests differ from one another in terms of intensity of testing. The Daily test only reads the hard drive and

Cumulative preventions/detections/repairs/recoveries from 06/14/89 TO 06/14/89

	SOFT 1	SOFT 2	SOFT 3	SOFT 4	HARD	REPAIRED
FAULTS:	1	0	0	0	0	1
BYTES:	512	0	0	0	0	512

	RELOCATED SECTORS	SYSTEM SECTORS	TOTAL ERRORS
FAULTS:	0	0	1
BYTES:	0	0	512

Total potential problem bytes continually
being specially monitored by each Disk Technician run: 8,704

Fig. 3. Printed report shows 8,704 potential problem bytes that Disk Technician Advanced plan to specially monitor.

does not normally perform any tests that require writing to the drive. Both the Weekly and Monthly tests perform tests that both read and write to the hard disk.

The Monthly test is more comprehensive than the weekly and was the initial test performed right after installation of the program. If the program's AI Expert System determines that, because of excessive or abnormal failure patterns, the Daily test is not sufficient, it will automatically switch to a more comprehensive test profile that will include both read and write tests.

Any time the controller is unable to read any single bit on the hard disk on its first try, that is a soft error. Disk Technician Advanced performs its tests in two passes. On its first pass, it detects soft errors but does not categorize them. On its second pass, it re-tests, categorizes and repairs all the errors it found during the first pass.

If there is data in a bad area, the program performs sophisticated processes to recover it, including seek profile reading and ECC recovery techniques. These refined algorithms allow the program to recover data that, according to the company, DOS and other recovery programs cannot. If the data is irrecoverable, Disk Technician Advanced informs the user which file(s) contain the corrupted data, giving the entire path and name so that they can be restored from the backup.

The program repairs bad areas by performing a single track, non-destructive, low-level format. It saves the data on the track in RAM and reformats only that single track at the existing interleave as determined by the program at setup. After reformatting the track on which an error occurred, Disk Technician Advanced re-tests the track and restores the data to it only if it is perfect. If the bad areas are not repairable, they are written as bad in the FAT and the data is automatically relocated to good areas.

Testing the Software

We used two computers to test Disk Technician Advanced, one a new Vendex Turbo-888-XT with a 20-MB Tandon hardcard, the other an eight-year-old IBM PC with an updated ROM BIOS and a 10-MB Qubie hard disk that was installed five years ago and has never had any problems.

Installation and use on the Vendex computer was extremely simple. We did the mandatory monthly test and also the daily and weekly tests; the results were as shown in Fig. 2. The test shows one soft error and the program expects to specially monitor 8,704 potential problem bytes as shown in the printed report in Fig. 3.

I half expected results like this since the hard disk is less than a year old and has not had severe use during that time. I was much more interested in what the program would report about the older drive, which worked fine.

Again, installation was as simple as could be (as described earlier in this review). However, problems began to occur once the mandatory monthly test started. This initial test of the hard disk, which took 3½ hours on the Vendex system, ended in less than five minutes on the old IBM PC. I received the following message on screen:

> Critical system sectors have been damaged and are not recoverable!!! Disk Technician will repair the damage but your valuable data has been lost!! Restore data to your disk from your backup after running Disk Technician.

I pressed Return and got the next message:

> Disk Technician has found an abnormal failure pattern and/or excessive disk errors. Call your computer hardware service repair technician. See your Disk Technician User's Manual.

Pressing Return one more time gave me this message:

> Disk Technician has found severe errors! File Report is not allowed. Disk Technician has completed its tests and repairs.

When I checked the on-screen report I found that the program had detected 170 soft errors after checking only three cylinders of the hard disk.

When I rechecked my hard disk, I found that everything was still working fine. I read the manual again and it said the following:

> If this message (the error message received during the test) was accompanied by high error rates or happens frequently, you should suspect bad hardware. Take your system to a qualified hardware technician for repairs.

I decided to follow the advice in the User's Manual on "How to Deal with Bad or Crashed Hard Disks." I let my system warm up for more than two hours and then did a destructive low-level format of the disk. After this, I partitioned the drive and did a DOS format and tried the monthly test again. Same results.

At this point, I called Prime Solutions Technical Support for advice. The technical support person suggested that I might be having heat problems in the computer, which could affect the controller. In fact, I knew I was having heat problems since the time I had installed the hard disk—I routinely ran the computer with the cover off. At this point I decided to install a more powerful power supply to replace the original under-powered one and eliminate the heat problem. This did eliminate the heat problem (I can run the computer with the cover on), but did nothing to alleviate the controller problem.

When I ran the tests again, I got exac the same results. I even tried removing the cover again and pointing a portable fan on the hardware to keep it cool, but nothing changed.

More Features

Before wrapping up this review, there are some other features of the program that should be noted. The program can do daily, weekly and monthly tests as described above, either automatically or under manual control.

The program can do non-destructive low-level formatting in order to reset the interleave on a hard drive without having to remove the data files or programs. This is suggested, however, only for AT-type systems.

Disk Technician Advanced can perform four types of seek tests: track to track, relative, expanding and random. The difference in each of these tests is how the disk head moves to different tracks.

The program lets you remove sectors or even entire tracks from use by DOS and your programs. It marks the areas you have chosen as bad in the FAT and relocates data files or programs stored in them to a new location.

The program also lets you create several types of reports. You can create a bad track report, or you can create reports from any of the tests you have performed.

Final Comments

Disk Technician Advanced appears to be a sophisticated program that can give you early warning about hard-disk problems. In the case of the Vendex computer, using Disk Technician Advanced will indicate how the disk performs over time, and how it degrades. In the case of the IBM PC, I have to assume that my disk controller is not working at its optimum capability and may soon fail. However, as mentioned earlier, I have never had a problem with the disk or the controller.

The program is easy to use and does most of its work without requiring any input by the user. This indicates that it is an appropriate tool for both novice and advanced users. The documentation is thorough and easy to follow. Novice users need only read the first three chapters (8 pages), which include straightforward instructions for installation and use.

Disk Technician Advanced is not for everyone, though. For example, the current version cannot be used with DOS 4.0, OS/2, and SCSI or ESDI drives, although the company expects to support these in the near future.

My overall feeling about the program is that it does the job it sets out to do, which is to monitor soft errors on your hard disk and repair them when possible. But I also think it comes up short when trying to guess at any hardware problems. For example, the advice I was given by the program: "Call your computer hardware service repair technician" is not something I would do. I think I would be more likely to follow the old adage: If it ain't broke, don't fix it.

Finally, there are some disk crashes that are caused by reasons other than the ones that Disk Technician Advanced addresses, so a potential buyer of this product should not view it as a panacea for all types of disk crashes.

I think Disk Technician Advanced is a good product and one that is very much needed, especially if you have an intense fear of losing date due to a crash. And the inclusion of the SafePark program is an added bonus. However, as with any such sophisticated technological product, you will not know for certain whether it will help you until after you've used it for a long period of time. ME

CIRCLE 74 ON FREE INFORMATION CARD

A 12-bit DAC, a floppy disk controller chip, two UARTs, two FIFOs, and a speech/sound chip

By Joe Desposito

Precision Monolithics, Inc. (1500 Space Park Dr., Santa Clara, CA 95051) has introduced a 12-bit DAC that is available in an 8-pin mini-DIP package. Its serial input data port accepts a digital word one bit at a time, thus saving pc board space by eliminating byte-wide bus traces.

The DAC-8043 operates from a single 5-V power supply and can be used for such applications as trip-point setting, auto calibration, industrial control loops, and instrumentation applications. Its low power consumption makes it a good choice for battery-operated applications, and its small size makes it a good choice for hand-held applications. Additionally, the device's ± ½ LSB (least significant bit) linearity and ±1 LSB gain error performance reduces parts count through the elimination of external trimming components.

The DAC-8043 allows full microprocessor or stand-alone control of data loading and analog output due to its separate strobe input and load-DAC control lines. A clock input signal loads data into the DAC, and a load pulse updates the analog data. The digital inputs, SRI, LD and CLK, are all TTL compatible.

As shown in the block diagram of Fig. 1, the circuit consists of a 12-bit serial-in, parallel-out shift register, a 12-bit DAC register, a 12-bit CMOS D/A converter, and control logic. Serial data is clocked into the input register on the rising edge of the CLOCK pulse. When the new data word has been clocked in, it is loaded into the DAC register with the LD input pin. Data in the DAC register is converted to an output current by the D/A converter.

In most applications, the DAC is connected to an external op amp with its noninverting input tied to ground, as shown in Fig. 2. The circuit may be used with an ac or dc reference voltage. Its output will range between 0 V (all zeros) and approximately $-V_{ref}(4095/4096)$ (all ones), depending on the digital input code.

The DAC-8043 is available in each of the three temperature ranges: military, extended industrial, and commercial. CERDIP and plastic packages are available in the extended industrial temperature range from −40 to +85 degrees centigrade. Pricing in 100-piece quantity starts at $8.95 for the low-grade commercial part; the military 883 is priced at $49.34.

The DP8473 Floppy Controller PLUS-2

The DP8473 Floppy Controller PLUS-2 from National Semiconductor Corp. (2900 Semiconductor Dr., Santa Clara, CA 95052) is a chip that will allow designers to implement the floppy disk controller function with just two chips. The DP8473 features a precision analog data separator and write pre-compensation circuitry. Data rates of up to 1 megabit per second permit the use of new high-density disk drives and tape backup systems. Since the chip is fully compatible with IBM PC/AT and PS/2 personal computers, it also operates at the standard PC data rates of 250, 300 and 500 kilobits/second.

A complete DP8473-based floppy disk controller system requires only the DP8473, an address decoding device, and a few passive components for filtering purposes. The low component count and low power consumption of the chip—it draws just 100 microamperes in either of its two power-down modes (manual and automatic)—make it a good choice for portable and laptop computers.

Some features of the chip are an on-chip 24-MHz crystal oscillator, an implied seek capability of up to 4,000 tracks per surface, and IBM and ISO disk formats. Implied seeking is the ability of the controller to perform a seek operation (moving the read/write head) upon issuance of a single read or write command. A conventional controller must first seek

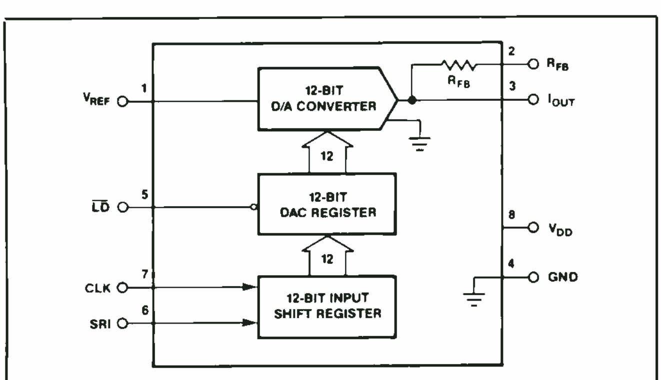

Fig. 1. Functional block diagram of Precision Monolithics' DAC-8043 12-bit serial-input multiplying CMOS D/A converter.

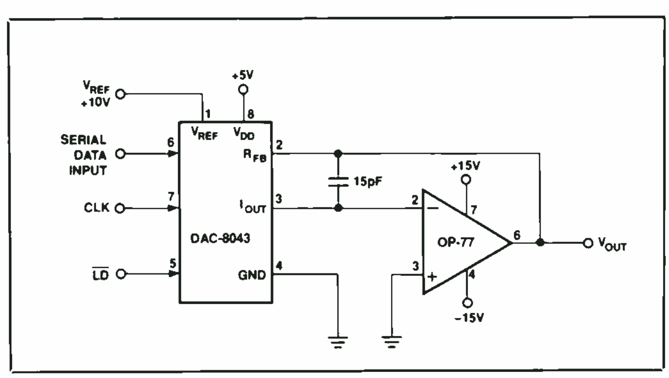

Fig. 2. In most applications, the DAC-8043 D/A converter is connected to an external operational amplifier whose noninverting input is tied to ground as shown here.

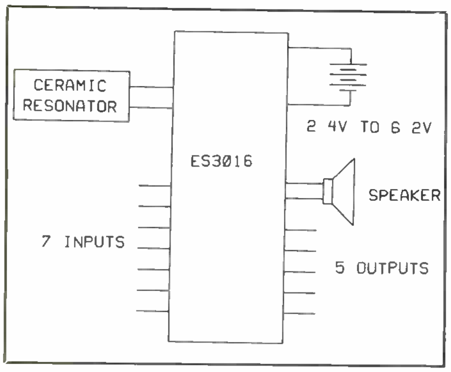

Fig. 3. To get Electronic Speech Systems' ES3016 speech/sound chip operational, all that are needed are a battery, ceramic resonator, two capacitors (not shown here) and a speaker.

the correct track on the disk, wait for an interrupt and then issue a read/write command.

The DP8473 chip contains analog as well as digital functions. Incorporated on the chip is a high-precision analog data separator. The data separator consists of a self-trimming analog phase-locked loop (PLL) with a phase comparator, VCO (voltage controlled oscillator), filter and associated circuitry. Up to three external filters can be switched automatically, depending on the data rate programmed into one of the chip's PC/AT compatible registers. The data separator also has a secondary PLL that connects to an internal quarter-period delay line circuit. The PLL automatically calibrates the delay line, as well as the VCO's center frequency.

According to National Semiconductor, the advanced circuitry in the DP8473's analog data separator provides the best possible window margin performance. Higher window margin performance means fewer disk errors and eases the task involved in mixing the DP8473 with a wide variety of disk drives and disk media.

Window margin is a measure of how much a data bit can be misaligned from its ideal position, yet still be recognized as valid information. Bit misalignment can result from imperfections in the disk media and speed variances in the motor turning the disk. Digital data separators cannot read data bits as well as analog separators due to inaccuracies associated with clock synchronization and a restricted number of discrete frequencies that limits the accuracy of the PLL.

The PD8473 contains drive-select latches, 40-mA interface buffers that allow direct hook up of up to four floppy disk drives, and 12-mA microprocessor bus interface buffers that eliminate the need to externally buffer the data bus.

A major function built into the DP8473 is the write pre-compensation circuit that consists of a 3-bit shift register and multiplexer. The pre-compensation value can be modified by setting the logic level on one of the device's pins.

The DP8473 Floppy Disk Controller PLUS-2 is available in both a 52-pin plastic leaded chip carrier (PLCC) and a 48-pin DIP. It is priced at $12 each in 5,000-lot quantities.

The NS16C551/52 UARTs

Two other new chips from National Semiconductor are the NS16C551 and NS16C552 UARTs (universal asynchronous receiver-transmitter). These chips are functionally equivalent to National's CMOS NS16550A UART used in IBM PS/2 personal computers.

The NS16C551 is a single IC that contains a CMOS version of the NS16550A, a parallel printer port, and an on-chip PC/AT address decoder. The parallel port is compatible with software written for the IBM PC, XT, AT, PS/2 and Centronics parallel ports.

The NS16C552 is a dual CMOS version of the NS16550A with two serial channels that are completely independent except for a common CPU interface. The chip can be used in modems, mouse devices, and serial I/O cards with limited board space. The chip is also a good choice for

SOLID-STATE DEVICES...

manufacturers who want to design a small motherboard, yet provide the UART functions.

Both UARTs feature 16-byte transmitter and receiver FIFOs to reduce the number of interrupts to the CPU in FIFO mode. All FIFO control logic is on the chip. An 8-bit Alternate Function Register lets the CPU select multifunction pin signals on both UARTs or enable concurrent writes on the NS16C552.

The UARTs also feature a programmable Baud Rate Generator (BRG) that is capable of taking any clock input (dc to 24 MHz) and dividing it by any divisor to produce a 16× clock for driving the UART's internal logic. The baud rate for transmitting or receiving serial data can be as high as 1.5 megabaud.

The UARTs have a programmable processor interrupt system that prioritizes the interrupts, minimizing the computing required to handle the communications link. Also on-board is a complete modem-control capability.

Other features include full double buffering; independently controlled transmit, receive, line status, and data-set interrupts; false-start bit detection; and line-break generation, detection and internal diagnostic capabilities.

The NS16C551 UART is available in a 68-pin PLCC package for $20 each in 100 plus quantities. The NS16C552 dual UART is available in a 44-pin PLCC for $25.90 each in 100-plus quantities.

The KM75C01A/02A FIFOs

The KM75C01A and KM75C02A from Samsung Semiconductor (3725 N. First St., San Jose, CA 95134) are dual-port memories that implement a special First-In, First-Out (FIFO) algorithm that loads and empties data on a first-in, first-out basis. Access times are less than 25 ns, which means that the devices are capable of operating at 40 MHz, the speed of RISC machines and other advanced processors. In fact, the chips are intended for use in high-speed high-end computers and communications systems.

The KM75C01A is 512 × 9 bits, while the KM75C02A is 1,024 × 9 bits. The 9-bit width is useful in applications that require a byte-wide data bus with parity. Some features of the chips include: logic that allows unlimited expansion capability in both word size and depth without sacrificing speed; full and empty flags to prevent data overflow; and ring counters to automatically generate the addresses required for every read and write.

When ordered in lots of 1,000 or more, the KM75C01A is priced at $14 each and the KM75C02A is priced at $18 each.

The ES3016 Speech/Sound Chip

The ES3016 from Electronic Speech Systems, Inc. (1900 Powell St. #205, Emeryville, CA 94608) is a speech/sound chip with on-board ROM, D/A converter, and amplifier. Features of the chip are automatic power down, direct speaker drive to 20 mW, and selectable I/O interface with seven input lines and five programmable output lines.

A programmable logic array (PLA) gives the chip the ability to address as many as 120 sound effects or speech segments without a microprocessor. Bit addressable output ports allow the chip to control external devices in coordination with sound data. The ES3016 requires only a battery, ceramic resonator, two capacitors and a speaker, as shown in Fig. 3.

BOOKS

Using the Triggered-Sweep Oscilloscope by Robert L. Goodman (Tab Books. Hard cover. 299 pages. $23.95.)

Learning how to use a triggered-sweep oscilloscope is very important, if not vital, to effective troubleshooting of modern electronic circuits and systems. Without a thorough grounding in the use of the triggered-sweep scope, professional and amateur alike work at a disadvantage. This new book describes in detail operation and rapid troubleshooting with the dual-trace triggered-sweep scope. Though the text is specific to the Sencore SC61 Waveform Analyzer, many of the applications described can be used with other brands of scopes.

Appropriately, the book begins with a brief chapter that discusses oscilloscope features and specifications. The material in this "general-purpose" chapter can be applied to just about any triggered-sweep scope. Chapter 2 is specifically oriented toward the SC61, discussing operational set-up and theory of operation. With the generalities out of the way, the book settles down to troubleshooting topics, beginning with ac and dc voltage checks. The next four chapters deal with TV power-supply system operation and checkout, sync and agc systems, video and chroma circuits, and vertical-interval reference and test signals.

Separate chapters deal with VCR circuit troubleshooting and alignment and troubleshooting stereo, and TV stereo systems. An extensive chapter focuses on troubleshooting microprocessor and digital circuits. Another deals with using the IEEE-488 General-Purpose Interface Bus for automated testing. The last chapter deals with SC61 Waveform Analyzer service and maintenance.

This is a well-written, easy-to-read book. It is profusely illustrated with photos, schematic diagrams and drawings that support specific points made in the text.

If you are serious about troubleshooting electronic circuits and systems, this book deserves a place in your library.

Tips & Techniques for Using Low-Cost & Public Domain Software by John Gliedman. (McGraw-Hill. Soft cover. 387 pages. $24.95.)

Anyone who uses an IBM PC or compatible personal computer will find this book to be a valuable resource to use in selecting public-domain and economy software. It is written for serious users who want to push their computers to the limits in terms of software and hardware. To this end, the author explores more than 130 program packages and utilities designed to speed up a hard disk, stop a cursor from blinking and simplify editing of text with a desktop publishing program, among other applications. Program packages investigated include word processors, communications programs and miniprogramming languages.

This book is by no means limited to software. It contains a great deal of information on hardware fixes and upgrades. Among these are installation of 80386 turbo cards and math coprocessors to speed operation of a slow computer and graphics displays. Other hardware "fixes" for aging and inadequate machines covered in this book include expanding memory, defenses against Trojan-Horse programs, a low-cost way of improving readability of Toshiba's laptop computer screens, rejuvenating an Epson or IBM printer and more.

Among the many topics covered in detail in this book are taking charge of your operating system, making a PC as fast as a turbo XT clone for $150, mice and menus, multitaskers and task switchers and the CP/M connection. The book is well written and reasonably well documented. It is excellently supported with printouts, screen displays and useful short routines that can be hand keyed into a computer. Instead of using the traditional index approach, this book has separate name and subject indexes for easy look-up.

The Complete Microwave Oven Service Handbook by J. Carlton Gallawa (Prentice Hall. Hard cover. 406 pages. $36.)

This book is dedicated to showing the reader how to restore an ailing microwave oven to service. Not just a simple shop manual of troubleshooting techniques, it offers a course in microwave theory, safety practices, test procedures and more. The book's 18 chapters are divided into five main sections, each of which deals with a different topic. For example, the first section, consisting of three chapters, gives an introduction to microwave energy. From here the reader is shown how to prepare to repair microwave ovens, with discussions that focus on safety considerations, the service shop and in-home service practices. Having given a general idea of the theory and practice behind the microwave oven's operation in the five chapters that make up Part 3, the author presents another five chapters that deal exhaustively with component tests, failures and corrective actions. Troubleshooting procedures is the topic of Part 5, which deals with common-sense troubleshooting procedures and locating the causes of particular problems in specific makes and models of ovens.

Five appendices appear at the end of the book. One contains touch-panel and reference matrix diagrams. A second deals with special techniques required for removing the outer cases of certain ovens. General information on microwave cooking techniques makes up the third appendix. The final appendices contain a glossary of technical terms and the addresses of microwave oven manufacturers mentioned in the book.

This is a well-rounded handbook on microwave-oven theory, servicing and safety practices. Its well-written text is amply illustrated with photos, schematics, line drawings and tables. In sum, this book is worth every cent of its moderate cost to the professional service technician.

NEW LITERATURE

VCR Service & Repair Training Info. Viejo Publications is offering a comprehensive package that contains a description of the VCR Cleaning, Maintenance & Repair course for people who want to service VCRs in their spare time or as a full-time pursuit. Included in the package are a four-page covering letter, some samples from the 400-page manual that accompanies the course, a description of a training videocassette included in the course, and a brochure that details what the course is all about, including a chapter-by-chapter description of the manual. Also provided are a sign-up card that details methods of payment and a prepaid return envelope. For a free package, write to: Viejo Publications, 3540 Wilshire Blvd., Suite 310, Dept. ME, Los Angeles, CA 90010-9625.

Test Instrument Catalog. B&K-Precision's new BK-89 Instrument Catalog covers the company's complete line of test equipment, which lists and describes in detail products suited for engineering, research and development, product line testing, industrial maintenance and repair, field service and education. Contained in the catalog are complete performance and mechanical specifications with key setting features highlighted and a photo of each product. Comparison charts that highlight performance features and performance characteristics are included, as is a glossary of key terms. In addition to instruments, the catalog lists and describes accessories. For a free copy of the Catalog BK-89, write to: B&K-Precision, Maxtec International Corp., 6470 W. Cortlandt St., Dept. ME, Chicago, IL 60635.

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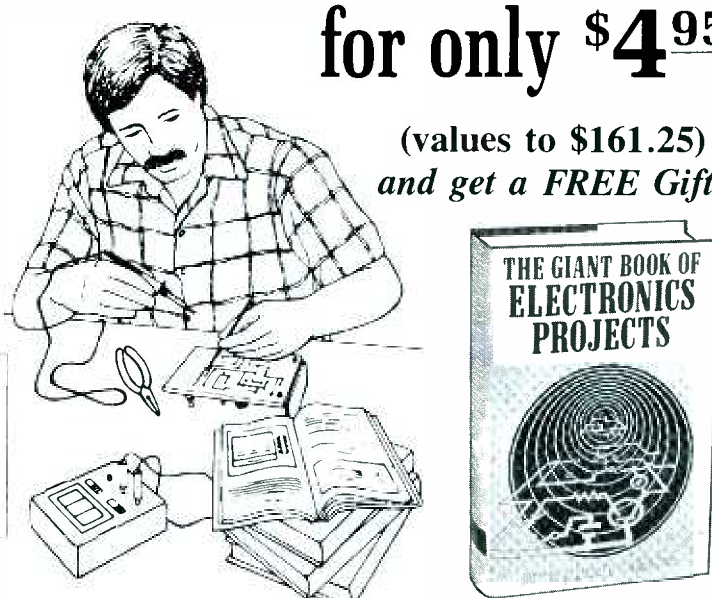

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Fax On The Go

JT Fax Portable "pocket fax" by Quadram.

Cobra's Model PP-110 Print Phone personal portable facsimile and copier.

Although portable computers make it possible to take your office with you, it's an exercise in futility to send a fax from your favorite laptop. First, you have to print out a copy of the file from the PC, which means also lugging around a not-so-portable printer. Then find a fax machine and hope you can afford the prices.

Fortunately, there's an easier way you might use a "pocket fax." Similar to a pocket modem, the pocket fax is a small communications device that attaches directly to the serial port of any computer. Plug the pocket fax into any phone line, load the software, and you're in instant fax communications for both send and receive.

There are portable office fax machines available, too. For example, Cobra offers a Model PP-110 that weighs only 7.25 lb. and has a case with an integrated carrying handle. Nissei Electric has a similar type machine, the Model FAX-305, that runs on a built-in Ni-Cd battery.

Generally, the PC fax board reads the file from a disk, then converts it into a serial fax signal (with data compression) that is sent over the phone line to the receiving fax. Fax files received by the PC fax board can either be displayed on the screen or sent to a printer. Because the files are electronically processed rather than optically scanned, as in separate desktops, PC fax images can be sharper than mechanical fax pages for both sent and received files.

Several PC fax boards can convert received fax files into graphics formats usable by such applications as *PC Paintbrush* and *Dr. Halo*. Optical character recognition (OCR) software that converts incoming fax files into ASCII text is also available on some PC fax boards. The nice thing about file conversion is that you can edit the received fax by using your PC's word processor or graphics program before you print it out.

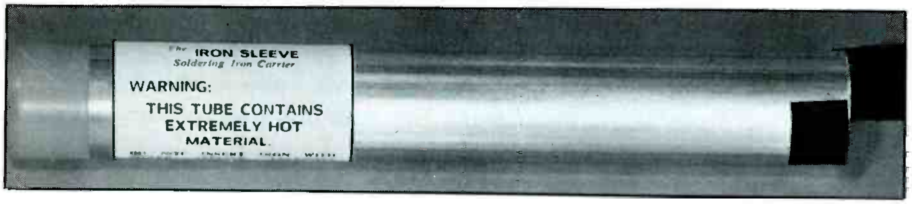
Usually, the PC fax software resides in memory, which means it can work in the background. Once installed, the PC fax software patiently waits for an incoming fax call without tying up any computer resources (other than RAM), thus freeing your PC for other tasks.

However, there are disadvantages. A stand-alone fax machine has both a scanner and a printer built into it. With PC fax you'll need an external printer to get hard copies of incoming faxes and a scanner if you want to read pages into the PC for transmission. Therefore, PC fax isn't a universal replacement for standard fax machines in all applications. But for the office typist or CAD/CAM engineer, it's ideal. For the recreational fax user, its potential for creativity is extremely wide.

Here To Stay

With 7.7-million fax machines worldwide and U.S. fax sales expected to exceed 2-million units this year alone, the value of owning a fax is growing simply because of the number of people who have access to it. Whether you use it for business or pleasure, alone or in combination with a PC, you'll find fax as fascinating to use as it is practical. ME

NEW PRODUCTS . . . *(from page 15)*



mass that drains the heat safely from the hot soldering iron. A label on the tube warns anyone who handles it that extremely hot material is inside. The tube can accommodate most popular soldering irons rated at 50 watts and less and holds the iron in place with a hook-and-loop strap. In addition to making a soldering iron safe to transport immediately, Iron Sleeve protects the tip of the iron from damage caused by other tools in a toolkit. $19.95.

CIRCLE 61 ON FREE INFORMATION CARD

CB Radio System

A recently announced radio system from K40 Electronics (Elgin, IL) brings together a new K40 Speech Processor CB radio, K40 CB microphone and K40 CB antenna. The patented Speech Processor circuitry in the radio electronically adjusts the loud and soft portions of a voice signal to provide more gain for clearer signals.

The compact 40-channel K40 Speech Processor CB Radio features a full-time anl (automatic noise limiter) and 7 watts of r-f output. The microphone offers a retractable coil cord and a unique magnetic disc for easy hang-up. The antenna was designed with a quarter-turn quick release loading coil, 30-degree angle adjustable mounting base and rust-free stainless-steel components.

CIRCLE 62 ON FREE INFORMATION CARD

Computer Controls VCRs

Hill and Hill Post Production's (Duluth, MN) Model EC-42 hardware and software package lets Commodore Amiga and IBM PC/XT/AT and compatible computers have edit control over two VCRs that have camera remote jacks. The hardware connects to the computer through a parallel port and to the source and record VCRs via a series of subminiature cables. This product is claimed to provide very accurate edit control on consumer and commercial VCRs. It can be used on VCRs that are not equipped with an edit control capa-

(Continued on page 81)

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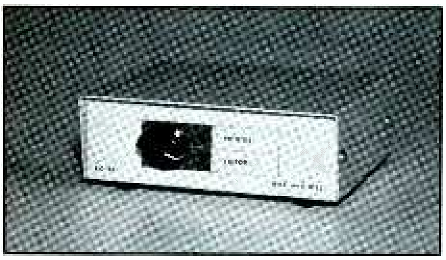
bility. A simple modification is needed on the VCR used as the source. (An A/B switch is used to select Editor or normal printer operation.)

Full keyboard control of play/pause, record/pause and forward/reverse are provided in both manual and automatic control modes. An



S.E.G. trigger control for fades, wipes and special effects is included, and control of two source VCRs is an option. Frame accuracy depends on the transport mechanism of the source VCR (+4 frames on some machines). For best results, the record VCR should have a flying erase head to eliminate any chroma artifacts and timing glitches.

Included in the package are the hardware interface unit, all interconnect cables, source VCR modification kit, a set-up program (for timing purposes), edit control software that works in both monochrome and CGA display mode, a VHS tape for set-up and tests and a manual. $149.

CIRCLE 63 ON FREE INFORMATION CARD

Home Automation via the Telephone

Household lights and appliances can be controlled from anywhere in the world over the telephone network using the Model TR2700 Telephone Responder/Controller from X-10 (USA) Inc. and suitable modules. The responder/controller lets you turn on and off up to eight lights and/or appliances, including a central air-conditioning or heating system, with a single telephone call. And when you are at home, the device can be used as a convenient local remote-control system.

Installation is a snap. You just plug the Telephone Responder/Controller into any ac receptacle and plug its phone cord into a standard telephone jack. No wiring or light/appliance modifications are needed. After this, the device sends coded signals over the ac house wiring that are responded to by the modules that interface the lights and appliances to the line. Each light and appliance has its

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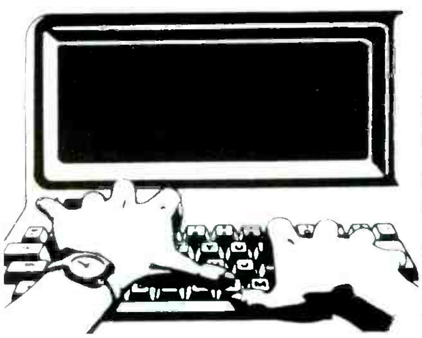

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NEW PRODUCTS ...

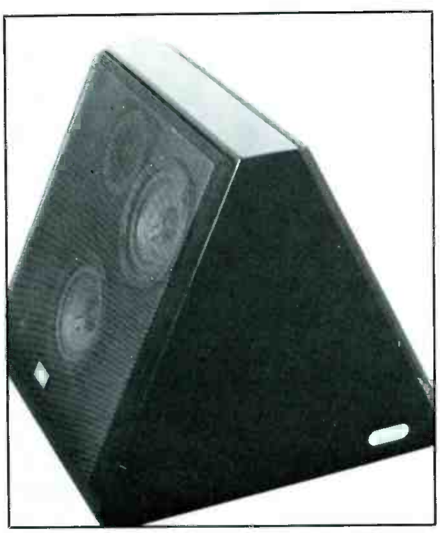
own interface module. These modules are available from X-10 (USA) Inc., and compatible ones are available from Sears, Radio Shack, Leviton and Heath/Zenith. Among the specialized modules with which the Responder/Controller works are the HD243/HD245 220-volt Heavy Duty Appliance Module for window air conditioners and room heaters and the TH2807 Thermostat Set-Back Controller. $39.99.

CIRCLE 64 ON FREE INFORMATION CARD

Single-Speaker Stereo

"Duetto" from Revox is said to give stereo sound from a speaker system contained inside a single enclosure. The ability to produce left- and right-channel sound, as well as a three-dimensional effect, is accomplished by two sets of three drivers in opposite sides of the system's triangular-shaped cabinet. The drivers are acoustically coupled to each other to build a stereo matrix.

Duetto can be set on a floor or suspended from a ceiling. It was designed to be used with a separate subwoofer, which handles reproduction of very low audio frequencies. The Duetto/subwoofer combination can be used as a primary or extension speaker system, for surround-sound applications, or enhancing the sound from stereo TV receivers and video equipment.



The speaker system is available in black or white vinyl ($795) or high-gloss lacquer ($1,095) finish.

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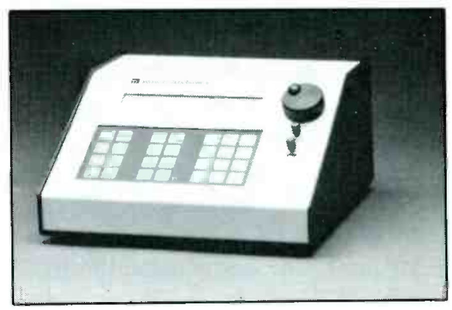
Stepping-Motor Control

The 300 Series of stepping-motor controllers from Maxwell Electronics (Research Triangle Park, NC) is designed with flexible control features to match a wide range of applications in instrument control. Front-panel controls include a membrane keyboard and rotary encoder knob that can be used for manually adjusting parameters. An alphanumeric display consisting of two lines of 40 characters each is available for displaying parameter values. Half-step or precision micro-step drivers provide coordinated motion for up to four motors per control unit.



An embedded microprocessor in each unit provides intelligent motion control, including conversions and calibration, acceleration and deceleration ramping, stored program control, relative and absolute positioning, and automatic backlash compensation. For OEM applications, the embedded software can be customized to perform preprogrammed functions, with the keyboard overlay and display format modified to match.

RS-232C serial port and a GPIB/IEEE-488 parallel buses permit simplified interfacing to computers. Options for the controller include a trackball input for manual control, encoder feedback for closed-loop operation, and nonvolatile memory to save programs during power loss.

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(The VHF converter options must be used in the R-5000 and R-2000.)

R-5000

The R-5000 is a high performance, top-of-the-line receiver, with 100 memory channels, and direct keyboard or main dial tuning—makes station selection super easy! Other useful features include programmable scanning, large, built-in speaker, 110 volt AC or 12 volt DC operation (with optional DCK-2 cable), VHF capability (108-174 MHz) with the VC-20 option, dual 24-hour clocks with timer, and even voice frequency readout with the VS-1 option.

R-2000

The R-2000 is an all band, all mode receiver with 10 memory channels and many deluxe features such as programmable scanning, dual 24-hour clocks with timer, all-mode squelch and noise blankers, a large, front-mounted speaker, 110 volt AC or 12 volt DC operation (with the DCK-1 cable kit), and 118-174 MHz VHF capability with VC-10 option.

RZ-1
Wide-band scanning receiver

The RZ-1 wide-band, scanning receiver covers 500 kHz-905 MHz, in AM, and narrow or wideband FM. The automatic mode selection function makes listening easier. One hundred memory channels with message and band marker, direct keyboard or VFO frequency entry, and versatile scanning functions, such as memory channel and band scan, with four types of scan stop. The RZ-1 is a 12 volt DC operated, compact unit, with built-in speaker, front-mounted phones jack, switchable AGC, squelch for narrow FM, illuminated keys, and a "beeper" to confirm keyboard operation.

Optional Accessory
• **PG-2N** Extra DC cable

Optional Accessories

R-2000:
• **VC-10** VHF converter • **DCK-1** DC cable kit for 12 volt DC use.

R-5000:
• **VC-20** VHF converter • **VS-1** Voice module • **DCK-2** for 12 volt DC operation • **YK-88A-1** AM filter • **YK-88SN** SSB filter • **YK-88C** CW filter • **MB-430** Mounting bracket.

Other Accessories:
• **SP-430** External speaker • **SP-41** Compact mobile speaker • **SP-50B** Mobile speaker • **HS-5** Deluxe head-phones • **HS-6** Lightweight headphones • **HS-7** Mini-headphones.

Specifications, features, and prices are subject to change without notice or obligation.

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