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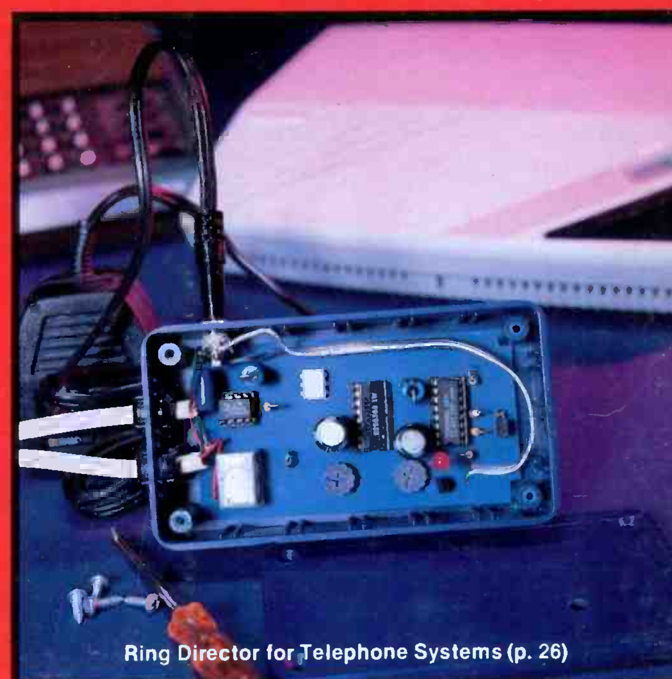
MODERN ELECTRONICS™

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

A Project-Building Festival
Full Construction Plans:

- Prototyping "Lab"
- Digital Compass
- Biofeedback Monitor & Lie Detector
- Incoming Phone Line Sharer For Phone, Fax & Modem
- Portable Exposure Meter ... to Darkrooms
- ...boards Electronic AB Switch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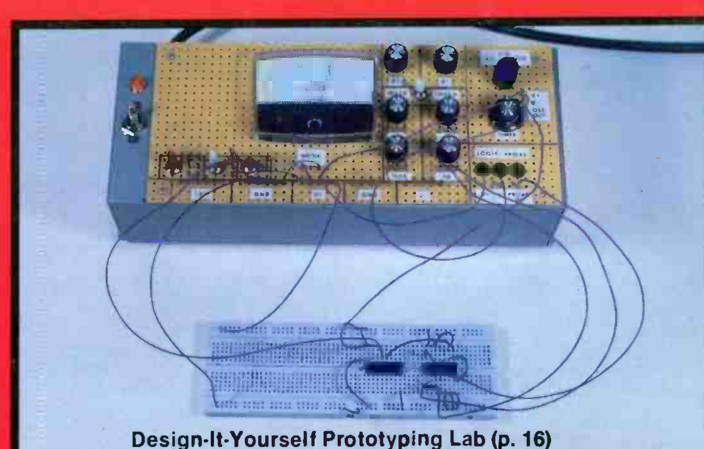
...back Monitor & Lie Detector (p. 34)


Design-It-Yourself Prototyping Lab (p. 16)

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CIRCLE 13 ON READER SERVICE CARD

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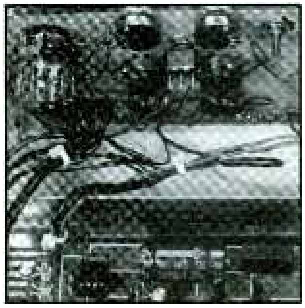
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

AUGUST 1990 VOLUME 7, NUMBER 8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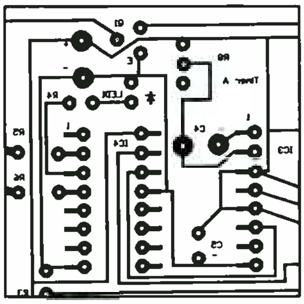
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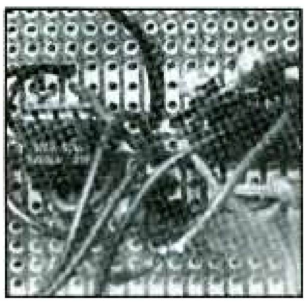
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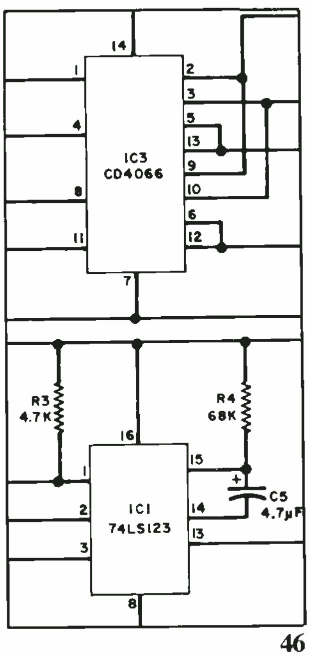

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DEPARTMENTS

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EDITORIAL

Embedding It

"You know," Dick Ross, our company president, remarked to me the other day, "there seems to be more microprocessors being used today in equipment other than computers." I agreed, observing that the devices appear in more and more of our non-computer electronic project articles, not to mention digital components supporting the CPU.

Was this just an intuition we shared or are there some hard, cold data to back it up? Doing a little research verified this perception. There are, indeed, more CPUs ending up in circuits of various electronic products that are not PCs or other types of computers. They're buried as embedded control devices in a wide variety of products: automobiles, security equipment, microwave ovens, washing machines, video games, VCRs, and more. Embedded control CPUs, in fact, accounted for about $3-billion in revenue in 1988, and they're rising fast with projected growth over the next five years to nearly $7-billion!

With all the ballyhoo about 16-bit and 32-bit CPUs, which are the darlings of the computer world, the revenue winner among embedded CPUs is actually the 8-bit microprocessor. This is the type that was used in computers at the start of the personal computer revolution and is still used for entry-level computers today. Though sneered upon now as a weak CPU sister, this type accounts for around 60% of the embedded control market.

Interestingly, within the embedded control category, even the lowly *4-bit* microprocessor beats out the more powerful 16-bit and 32-bit CPUs with a fat 30% share of this market. You don't have to be a math wizard to realize that the vaunted CPU powerhouses share only 10% of this market, though they have such a high profile.

Projections into the future, five years from now, suggest that things will change favorably for more powerful microcontroller CPUs. Even so, 8-bitters are still expected to hold a wide lead with a 40% share, with 32-bit ones, in second place, nearing 30%. The 4-bit CPUs are projected to slide to third place with about 20%, while the 16-bit will display little growth at about 10%.

About 30% of embedded control CPUs are in the consumer marketplace, leading all other categories. It's expected that the consumer share of the market, however, will decrease due to an anticipated upsurge in embedded controls incorporated into office machines of one sort and another.

The chips designed for computers and the ones designed for controllers are different, of course. Whereas the former are most often general-purpose types, the latter are dedicated to certain operations. Consequently, some people refer to the ICs used in computers as microprocessors, while the ones used for embedded controls are sometimes called microcontrollers. High-end types for both, however, are really micro*systems* since so many other functions are now packed into their silicon bodies. Nevertheless, there's still a distinction, with CPUs employed in computers requiring peripheral chips, while embedded controller CPUs are more self-contained systems. This is true for even low-end controller types.

You can expect to see more and more electronics projects in our pages that contain low-cost microprocessors and microcontrollers. The reason is simple: They can do an awful lot at low cost while taking up little space on a printed-circuit board or other real estate.

The deeper meaning of this is that general electronics, which has become increasingly digital in the past decade, is more akin to computers than ever. The technological rules are the same. Consequently, it doesn't take much to understand about one if you understand the workings of the other. At least, this is true for its circuit underpinnings.

We'll be exploring the similarities and differences of both as we continue to delve into the applied side of electronics and computers.

LETTERS

Confused View

• The conductor and component sides of a printed-circuit board seem to be confused with each other in "Quick and Easy PC Boards" (April 1990). This article states that a conductor-side pc layout (the kind usually found in magazines) can be copied onto blank Mylar and transferred onto a pc blank. In reality, it is the conductor-side copy (not the component-side copy, as stated in the article) that must be reversed using the intermediate step. Therefore, for a typical etching-and-drilling guide published in a magazine, the reversing process is a necessity.

Emmet E. Bonner III
Tuckahoe, NY

No Longer Available

• Please advise readers of *Modern Electronics* that, due to discontinuance of the TDA4060 IC by its manufacturer, the "Extended Play Remote-Control System" kit that was featured in the April and May 1990 issues is no longer available.

Crady Von Pawlak

Label Dilemma

• Your fine publication could stand one more innovation! More than a small irritant to me is the mailing label posted over pertinent information printed on the front cover of *Modern Electronics*. How about using easily removable labels?

J.D. Knight
Waterloo, IA

It's now being done.—Ed.

Mystery Solved

• I just received the latest issue of *Modern Electronics* and noted that a number of pages were missing. Did I get a defective magazine, or what?

Name Withheld

Your issue isn't defective. Post Office regulations require that any inserts—business reply and reader service cards and their stubs, for example—must be counted as pages, even though they don't have actual page numbers printed on them. If you check your issue, you'll find that the "missing" pages coincide with either cards or stubs.—Ed.

Will It or Won't It?

• The "Infrared Detector Event Counter" featured in the June 1990 issue of *Modern Electronics* will not function as described. If one connects an oscilloscope to any instrument that can record rapid voltage changes to the output of the GP1U52X receiver and points a visible-light source of low to modest intensity toward the module, he can stand back and watch the fireworks.

The author refers readers back to the February 1989 "Electronics Notebook" in which Forrest Mims devotes several paragraphs to explain why the GP1U52X module will invariably false trigger. The author does not even show an absorbtive filter or collimator tube in front of the module (as suggested by Mims in his column) to at least reduce the number of spurious events.

A properly functioning IR receiver must contain some type of decoding and/or filtering circuitry that will reject the wild gyrations common to a wide array of light-sensitive devices. Lack of design complexity should *never* be the primary goal if the result will be disappointing.

Finally, a transmitter using a TLC555 in conjunction with a crystal or ceramic resonator will provide a dead-on center frequency. Even when fairly close-tolerance RC combinations are used, the results cannot be compared to the simplicity and freedom from adjustment when using a resonator circuit to lock in whatever frequency is desired.

Daniel Katznelson
DesignElectrics, Inc.
Willingboro, NJ

You're correct that infrared receivers require decoding and filtering to prevent false triggering on ambient light. In the Event Counter, false counts are prevented by the debouncing circuitry contained in counting module MOD2. *The debouncing circuitry causes the counting module to ignore brief pulses, such as*

(Continued on page 82)

ELECTRONIC DEVICES. For PC users who have not yet filled their machine's math coprocessor socket, there's another device maker's product to consider besides Intel and Weitek's. The Cyrix Corp., founded in 1988, has its FasMath 83D87 high-speed math coprocessor family. The company claims 100% software and hardware compatibility with Intel's 80387, claiming for it up to 10X the performance of standard math processors. Cyrix offers a set of literature relating to the device, including reports on accuracy, compatibility and benchmark, as well as a user's and an installation manuals that describe installing the device in a 386-based computer. For more information, call Tom Silages at 214-234-8300.

Device freebies await you if you qualify. That is, if you have a pertinent application for a device(s), you can often get free samples as well as design assistance. For example, Zyrel, Inc., Milpitas, CA (408-433-0488) has introduced a new EMI-reduction component from Japan that's been used now for two years by such major companies as Sony, NEC and Epson, among others, to obtain Class-B FCC approval for their products. Its sales level has reached 1-million pieces per month.

This simple (and patented) device looks like a small, coated Mylar capacitor with either 3 or 4 leads. Due to the difficulty in calculating which noise cut-off frequency is best for a specific application, Japanese engineers just try various sizes and select the one that works optimally. Engineers can get a free trial kit of three pieces each among seven types (21 pieces). Prices vary from 32 to 61 cents in thousand-piece quantities.

Motorola, too, has an offer for free engineering samples of its new 12-ns 16K x 4 fast static RAM (FSRAM). Each sample pack contains eight MCM6290J12 devices in an SOJ package, making up a full 64K bytes. You can get the samples by sending Motorola your business card and a brief application description to Motorola Semiconductor, Literature Distribution Center, P.O. Box 20924, Phoenix, AZ 85036-0924. Request 12NSPAK/D.

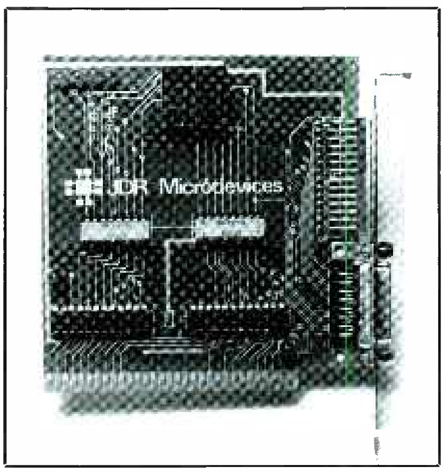
ELECTRONIC GAMES. Since its 1985 introduction, Nintendo Entertainment Systems (NES) have been sold in the U.S. to the tune of 21-million units. This is only for the machines! The enormously popular razor blades, Nintendo game packs, obviously dwarf this number. The company's new compact video game system Game Boy, contributed greatly to sales growth. Worldwide sales for GB alone for calendar 1990 is expected to be 9-million units.

In keeping with a fairly recent move by Japanese companies operating in the U.S. to make charitable contributions, Nintendo Co. Ltd., the parent company of Nintendo of America Inc., will establish a fund at the Massachusetts Instititute of Technology's Media Laboratory to support research into how children learn while they play. It will be a $3-million endowment to support the work of Dr. Seymour Papert, known for his development of the computer language, LOGO. The scholar is director of learning research at the Media Lab.

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.

Diagnostic Display Card

The POST Code display card from JDR Microdevices provides system designers, integrators, engineers and computer enthusiasts with a tool that locates the source of a system failure and displays a code that helps in diagnosing the problem. Easy to use, the display card simply plugs into any available bus slot and utilizes LEDs



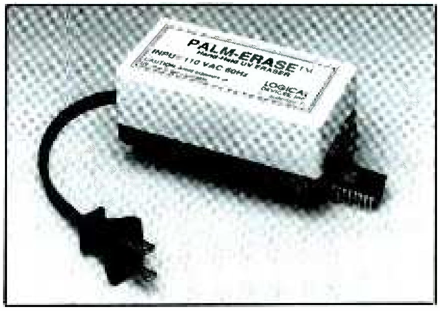
to display the code that corresponds to the problem it has located. The meaning of the code can be found in the BIOS listing in the manual that accompanies the card.

Features of the POST Card include: compatibility with 80286- and 80386-based computer systems; switchless and jumperless installation; display LEDs that can be placed on-board or on a back panel bracket for easy view with a closed system unit case; ultra-low-current and low-noise operation; LED indicators for all power-supply voltages. $49.95.

CIRCLE NO. 77 ON FREE INFORMATION CARD

UV EPROM Eraser

Palm-Erase from Logical Devices, Inc. (Ft. Lauderdale, FL) is claimed to be the world's smallest UV



EPROM eraser. Extremely fast, Palm-Erase is claimed to erase an EPROM in less than 3 minutes. It is designed to be used by field-service personnel and in engineering applications where space is at a premium.

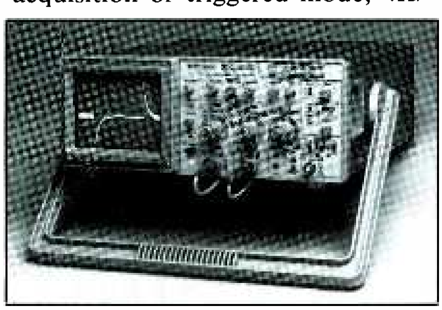
A small built-in tray accommodates a single 24- to 40-pin EPROM for erasure. Power for Palm-Erase is provided by the 117-volt ac line. Intensity from the UV lamp inside the device is rated at 1.7 $\mu W/cm^2$, and average life of the lamp is rated at 3,000 hours. The 4″L × 2″W × 2″H eraser weighs just 7 ozs. $49.95.

CIRCLE NO. 78 ON FREE INFORMATION CARD

Analog/Digital Scope

An analog/digital storage oscilloscope that combines waveform storage capabilities and high bandwidth at moderate cost has been introduced by Tektronix. The new Model 2210 scope features a 50-MHz analog bandwidth, 20 MS/s per channel sampling and 8-bit vertical resolution.

It allows the user to view a waveform in the usual analog scope mode or to digitize the waveform and store it for easier viewing and comparison. Other features include roll/triggered-roll mode for viewing low-speed signals in either a continuous-acquisition or triggered mode; 4K/

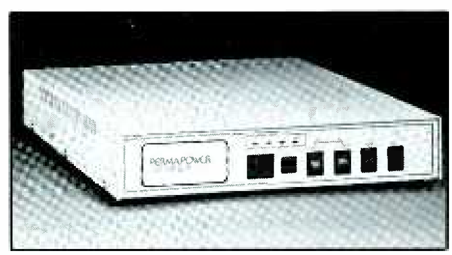


channel horizontal record mode for increased timing resolution and detailed signal displays; external clocking over a frequency range from dc to 10 MHz to allow samples to be taken at user-selectable rates; pre/post triggering that makes either 25 or 75 percent of the acquisition window available prior to the trigger event (identified by a bright on-screen dot); post-acquisition positioning that allows stored waveforms to be moved up and down on the screen for comparison with another reference waveform; 50× magnification for detailed waveform analysis. $2,195.

CIRCLE NO. 79 ON FREE INFORMATION CARD

Single-User UPS

An uninterruptible desktop computer power system/control center that is placed under a video monitor is offered by Perma Power Electronics, Inc. Rated at 250 VA, the Model SPS-250 provides 8 minutes of 250-VA backup power at full load capaci-



ty or 15 to 20 minutes at half load. The system also provides computer power regulation, switching to battery backup when power dips below 102 volts or rises above 132 volts. It switches back to the power line when there is a return to between 105 and 128 volts. Sense/transfer time is rated at 4 milliseconds typical.

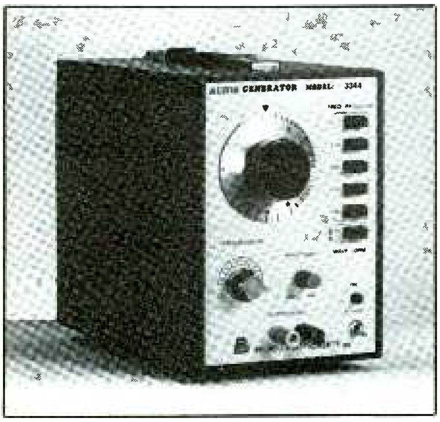
The SPS-252 provides four ac power outlets and serves as a control center for computer and peripherals. Two of the outlets are backed up and all four outlets are surge protected to prevent voltage spikes and rfi/emi from causing loss of data and damage to the equipment.

CIRCLE NO. 80 ON FREE INFORMATION CARD

NEW PRODUCTS . . .

Audio Generator

Brunelle Instruments' (Newport, VT) new Model BTL 3344 audio generator offers a frequency range from 10 Hz to 1 MHz in five selectable ranges. Featuring a high output design, the generator delivers more than 7 volts rms at no load and more than 3.5 volts rms into 600 ohms, sine-wave output. Output level is fully adjustable with a six-range attenuator with 10-dB steps and a level-adjustment control. Output impedance of the generator is 600 ohms, and an attenuator provides a rated accuracy of ±1.0 dB at 600 ohms. Sine and square waves are available.



The compact generator features a vertical panel for easy operation of the instrument. It also features solid-state circuitry designed for minimum warm-up time, high operating stability. and low power consumption.

CIRCLE NO. 81 ON FREE INFORMATION CARD

Palm-Size Camcorder

Panasonic's new Model PV-40 "Palmcorder" packs full-size features—including digital Electronic Image Stabilization (EIS), digital auto-focus, digital auto-iris, 8:1 power zoom and a flying erase head—in a camcorder that is about the same size as a 35-mm SLR camera and uses compact VHS-C tapes. Included adapters permit playback directly through a TV receiver or through a VHS videocassette recorder.

Digital EIS helps correct jitter in the played-back picture. It constantly scans the subject and surroundings being recorded and compares images and continuously adjusts to keep the CCD image stable.

Panasonic's 23% smaller Compact 1 Mechanism transport with miniaturized pinch roller, DD cylinder and capstan are primarily credited for the small size of the camcorder. Contributing factors include a four-layer pc board that puts the circuits in layers to reduce space requirements and scaled-down lens and CCD pickup. The $\frac{1}{3}$" lens is smaller than its $\frac{1}{2}$" predecessor and aspherical in design to be more effective in reducing distortion and lens aberration. With 250,000 effective (270,000 total) pixels, the high-resolution $\frac{1}{3}$" CCD offers better resolution than many $\frac{1}{2}$" imaging devices.

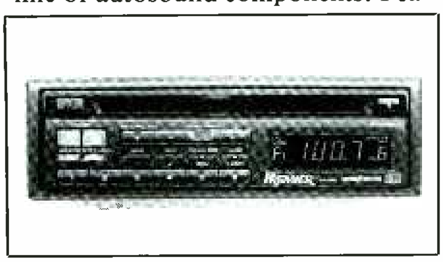
With a high-speed shutter, the PV-40 can capture action in about $\frac{1}{4000}$ second. The flying erase head helps ensure clean edits by eliminating distortion and "rainbow" noise. Pushing a still/strobe button once freezes on an image, while a second push causes the PV-40 to begin shooting the image every 0.2 second. A one-shot recording function can record a still picture that lasts for 5 seconds before return to the record/pause mode to produce a series of video stills. Digital Title Memory permits the Palmcorder to memorize a page of titles or graphics that can be superimposed over the picture in a choice of eight colors. Other features include: automatic digital back-light compensation, full automatic white balance, automatic date/time stamp and an electronic viewfinder that displays tape speed, tape count, tape-end warning, shutter speed and battery level.

The $10\frac{11}{16}$" × $6\frac{5}{16}$" × $4\frac{7}{8}$" camcorder weighs just 1.7 lbs. less battery.

CIRCLE NO. 82 ON FREE INFORMATION CARD

Faceplate Security CD Player

Pioneer's Model DEH-80 in-dash AM/FM/CD player is the latest addition to the company's Premier™ line of autosound components. Featuring a detachable faceplate for security, it allows you to remove the control panel of the head unit (but not the unit itself), leaving a blank plate in the dashboard. A warning beep reminds you to remove the faceplate upon exiting your vehicle.



The CD player section accommodates both 3" and 6" compact discs. It features a one-piece three-beam laser pickup and double floating suspension system and offers a 4× oversampling digital filter, random play, track scan and search, last-position memory and music repeat.

A high-power unit provides 25 watts of power in two channels. Gold-plated phono-type main-in jacks permit use of a passive equalizer for adjusting inboard and external power for use in a large system design. An electronic crossover unit can ➧

Electronic Organizers

Sharp Electronics' ZQ-Series of pocket-size electronic organizers feature many of the Wizard's powerful built-in functions but are designed for basic storage of important business and personal information. This series does not use the IC cards used in the original Wizard. It was designed for people who do not have extensive software needs.

Two lines of ZQ organizers are available: the Models ZQ-2000/2200 and ZQ-5000/5500. The Models ZQ-2000/2200 weigh about 5 ozs. and come with 16K/32K of RAM. Key features include: QWERTY typewriter-style keyboard; 12-character by 4-line LCD display; 200-year calendar with monthly, weekly and daily formats; schedule mode for entry and recall of dates, times and descriptions of appointments; telephone mode for storage and retrieval of phone entries by name, company, phone/fax number, address, etc.; anniversary mode for entry and recall of birthdays, anniversaries and other important dates; memo mode that stores up to eight pages of information; 12/24-hour clock time system; calculator mode; secure mode that protects personal information with a password; ability to exchange information with all ZQ models and other Wizards over a Dubbing Cable.

The Models ZQ-5000/5500 weigh about 6.5 ozs. and come with 32K/64K of RAM. Key features include all of the above, plus: 16-character by 8-line LCD display; To-Do List function with priority assignable to any entry; Expense Report function that manages and organizes time, activities and expenses (expense reports can be exchanged with a PC through optional links); storage for up to 700 names/addresses or 440 schedules (1,500 names addresses or 970 schedules for ZQ-5500); world clock that displays time in 212 cities; ability to upload and download data via optional Organizer Links for exchange of information with IBM- and Apple Macintosh-compatible computers. $109.99/$119.99, ZQ-2000/2200; $209.99/$239.99, ZQ-5000/5500.

CIRCLE NO. 83 ON FREE INFORMATION CARD

be used when designing a component speaker system to direct certain frequencies to the inboard power unit.

Pioneer's Supertuner® III™ with crystal-controlled PLL electronic tuner and 24 feather-touch button presets are featured in the AM/FM radio section. Best stations memory selects and locks onto the six strongest stations when traveling beyond the range of the preset stations. $540.

CIRCLE NO. 84 ON FREE INFORMATION CARD

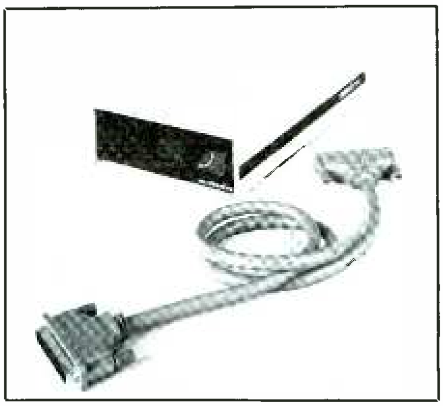
Screen Glare Eliminator

A new optical coating from Opto-Technics Co. (Northbrook, IL), the Glare Eliminator™, is said to eliminate glare from the screen of a video display monitor. The anti-glare, anti-reflective coating comes in aerosol-spray form and provides a one-time coating that is claimed to last for the life of the monitor. It can be used on computer monitors, teleconferencing displays, TV receivers and any other monitor type. The 3-ounce aerosol can provides enough coating to treat about four computer-monitor screens or two large TV receiver/monitor screens. $14.95.

CIRCLE NO. 85 ON FREE INFORMATION CARD

External Floppy Drives

The Overdrive from Micro Solutions Computer Products (DeKalb, IL) is a a series of two AT-style 5.25-inch external floppy-disk drive packages for IBM PS/2, PC/XT and compatible



computers. The package consists of the external drive unit, cable, interface card and software. Overdrive-1200 offers 1.2MB storage, while Overdrive-360 offers 360KB storage capacities.

Overdrive can be used to create 1.2MB compatibility on PCs and XTs and 5.25-inch capability on PS/2s. Micro Solutions' proprietary Background Format software allows diskettes to be formatted as a background operation while the user is working in other applications.

Overdrive works with DOS versions 2.0 and higher. A second Overdrive can be daisy-chained to the first, providing a maximum capacity of two drives. $349, Overdrive-1200; $319, Overdrive-360.

CIRCLE NO. 86 ON FREE INFORMATION CARD

Electromagnetic Radiation Monitor

A monitor for measuring potentially hazardous low-level electromagnetic field radiation and obtaining accurate readings on a digital display is available from Walker Scientific Inc. (Worcester, MA). The hand-held Model ELF-50D Field Monitor is designed to accurately measure the extra-low-frequency (ELF) electromagnetic radiation generated by power lines, TV receivers, video displays, home appliances and other

equipment. To operate it, the user simply switches the monitor on and holds it where radiation is suspected while viewing the 3½-decade LCD display to obtain a reading.

Calibrated to measure the electromagnetic radiation generated from any 50-to-60-Hz device within ±1% accuracy, the monitor has two switch-selectable ranges. Its low range measures from 1 milligauss to 2 gauss, while the high range measures up to 20.0 gauss. The pocket-size instrument is powered by a 9-volt alkaline battery for complete portability. $225.

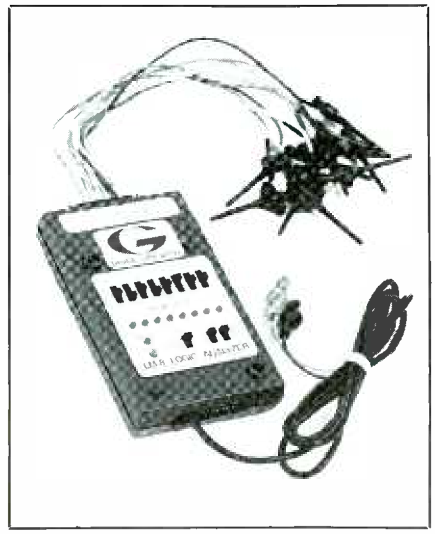
CIRCLE NO. 87 ON FREE INFORMATION CARD

Hand-Held Logic Analyzer

The Model LM-8 low-cost hand-held TTL logic analyzer from Global Specialties can replace multiple logic probes. It is suitable for troubleshooting 8-, 16- and 32-bit microprocessor circuits. The analyzer features trigger word recognition that permits it to be substituted for complex logic analyzers.

Eight input channels, an external-clock input and an oscilloscope trigger output are standard with the analyzer. Captured data cab displayed via built-in LEDs or on the CRT screen of an oscilloscope. The number of channels can be expanded to up to 32 by linking together four pods and triggering from a 32-bit trigger word, if desired.

The trigger of each channel can be set to 1, 0 or don't care. The logic status of each channel is continuously displayed via the LEDs. Pulse stretching enables short-duration and high-frequency pulses to be viewed. Maximum clock frequency is 25 MHz; so pulses as narrow as 10 ns wide can be captured and viewed.



Two operating modes are possible. In "run" mode, data is continuously updated every time the trigger word is recognized. In "trigger" mode, data is captured and displayed until the trigger word is recognized, at which time, the analyzer is halted and the last data held.

This analyzer is powered by the circuit under test. It is supplied with grabber leads for each data channel. $249.95.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Automatic Video Light

Sunpak (Hackensack, NJ) has a video light that automatically regulates light output for close distances. The Model CV-20SA light adjusts at ranges of 10 feet and closer for better color and clearer recorded images. In addition, its sensor monitors room lighting to provide balance between the ambient light and output from

the video light to improve detail and color at distances up to 25 feet.

Designed to fit all 8-mm and VHS camcorders, the CV-20SA uses Sunpak RB-55, RB-57 and RB-77S and Sony-style NP-55 and NP-77 battery packs. Estimated operating life for the three Sunpak batteries is 35, 45 and 66 minutes, respectively. The RB series batteries feature a thermal circuit breaker that automatically stops the charging cycle when a critical level has been reached to prevent overcharging.

Features include: a 15° tilt-down for close-up lighting; a built-in diffusion filter that spreads out illumination for wide-angle coverage; 7 to 20 watts of color-balanced halogen light. $149.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

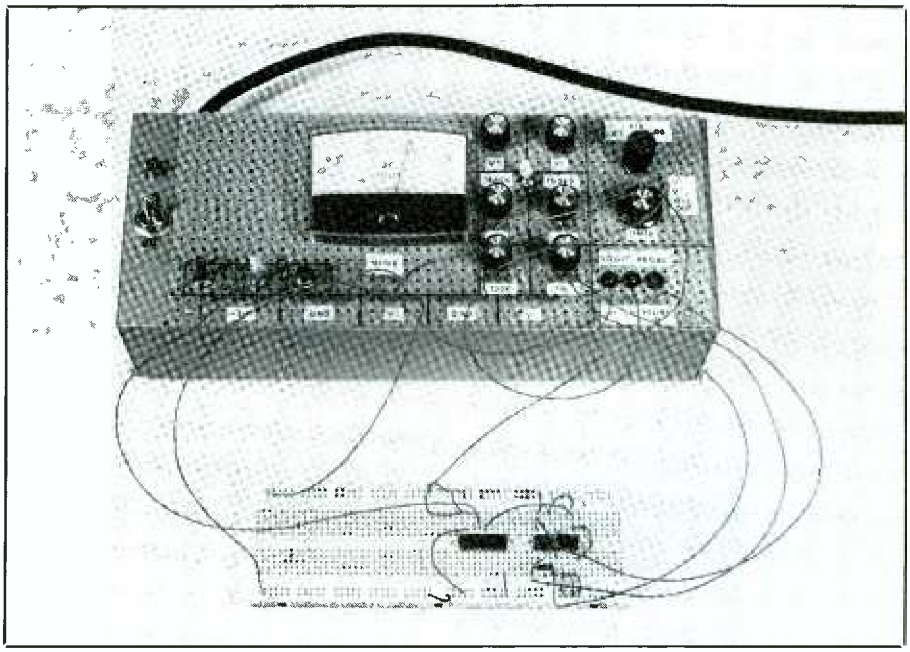
(Continued on page 81)

Prototyping Kit for Electronics Experimenting

This design "lab" can be built with power supplies, signal sources and other items tailored to your specific needs

By Jan Axelson

When experimenting with circuits, it's convenient to have everything you need in one place. One way to accomplish this is to use a prototyping kit that contains the power supplies and other elements—like a function generator, logic probe, switches and potentiometers—that can easily be connected to your circuits via jumper wires as needed. Most prototyping kits also include solderless breadboarding sockets on which to assemble circuit designs to permit easy changing of circuitry without having to desolder and solder each time a component or circuit section must be changed.



In this article, we describe a prototyping kit you can build to suit your normal requirements, including whatever features you need most. The kit includes a fixed +5-volt at 1 ampere power supply and individually adjustable dual supplies with a range of ±1.2 to 12 volts at 300 milliamperes. The adjustable negative supply can also be used as a tracking supply whose output automatically follows (tracks) the positive supply.

Also included in the kit are a 0.2-to-120,000-Hz square-wave generator, a logic probe with level and pulse detectors, switches and potentiometers that can be easily connected to your circuits. Connections to the built-in circuits are made via tubular jumper terminals that press-fit into perforated board and have spring-formed tapered sockets that grip wires 0.01 to 0.05 inch in diameter, including most popular breadboard-jumper sizes.

For maximum flexibility, you can build the system exactly as described, or you can add or change features according to your needs. For a complete prototyping setup, the kit and several solderless breadboard strips can be mounted on a piece of plywood or other wooden board cut to size. Alternatively, use the kit on its own with free-standing breadboarding strips.

About the Circuit

Separate modules make up the Prototyping Kit. These include the power supplies, signal source, logic probe, switches and potentiometers. We will discuss operation of each of these modules separately.

• *Power Supplies.* Shown in Fig. 1 is the circuitry for the power supply. This and the other schematic diagrams in this article use a special "circle-within-a-circle" symbol to indicate where a jumper terminal is wired on the project. In Fig. 1, these are located at +5V(out), V+(out), V−(out), GND and meter M1.

Transformer *T1* steps down the incoming 117 volts from the ac line to 25.2 volts rms. Bridge rectifier *RECT1* converts this stepped-down ac voltage into pulsating dc, and filter capacitors *C1*, *C2*, *C5* and *C6* smooth the pulsating dc outputs to about +18 and −18 volts dc with no load applied.

Neon-lamp assembly *I1* indicates power status (it is on when power is on) and contains its own current-limiting resistor. The + output of *RECT1* is the input to voltage regulators *IC1* and *IC2*. Fixed 5-volt regulator *IC1* provides the +5-volt output. Capacitors *C3* and *C4* provide decoupling for the +5-volt supply.

Adjustable voltage regulator *IC2* is an LM317 that provides the variable positive supply (V+). This regulator impresses 1.25 volts across *R1* to cause a constant 12.5 milliamperes to flow through *R1* and *R2*. Adjusting *R2* varies V+(out) from +1.25 to over +12 volts. Decoupling for this supply is provided by *C7* and *C8*.

Variable negative supply V− is controlled by 741 operational amplifier *IC3* and drives Darlington transistor *Q2*. Zener diodes *D1* and *D2* provide +15- and −15-volt supplies for *IC3*. These zener diodes receive power from the unregulated outputs of *RECT1*. Current through *D1*, *D2*, *R7* and *R8* causes pins 4 and 7 of *IC3* to regulate at −15 and +15 volts, respectively.

Op amp *IC3* is configured as an inverting amplifier. Its inverting (−) input at pin 2 is selected by *S2*. Its noninverting (+) input at pin 3 is tied to ground, which causes this input to be at ground potential at all times.

When *S2* is set to TRACKING, a current in proportion to V+ flows through *R3* and *R4*. Since *R3* has the same value as *R4*, *IC3* has a gain of −1, and V− is the negative of V+. Thus, if V+ is +10 volts, V− will be −10 volts.

Tracking mode is a convenient way of providing equal but opposite sup-

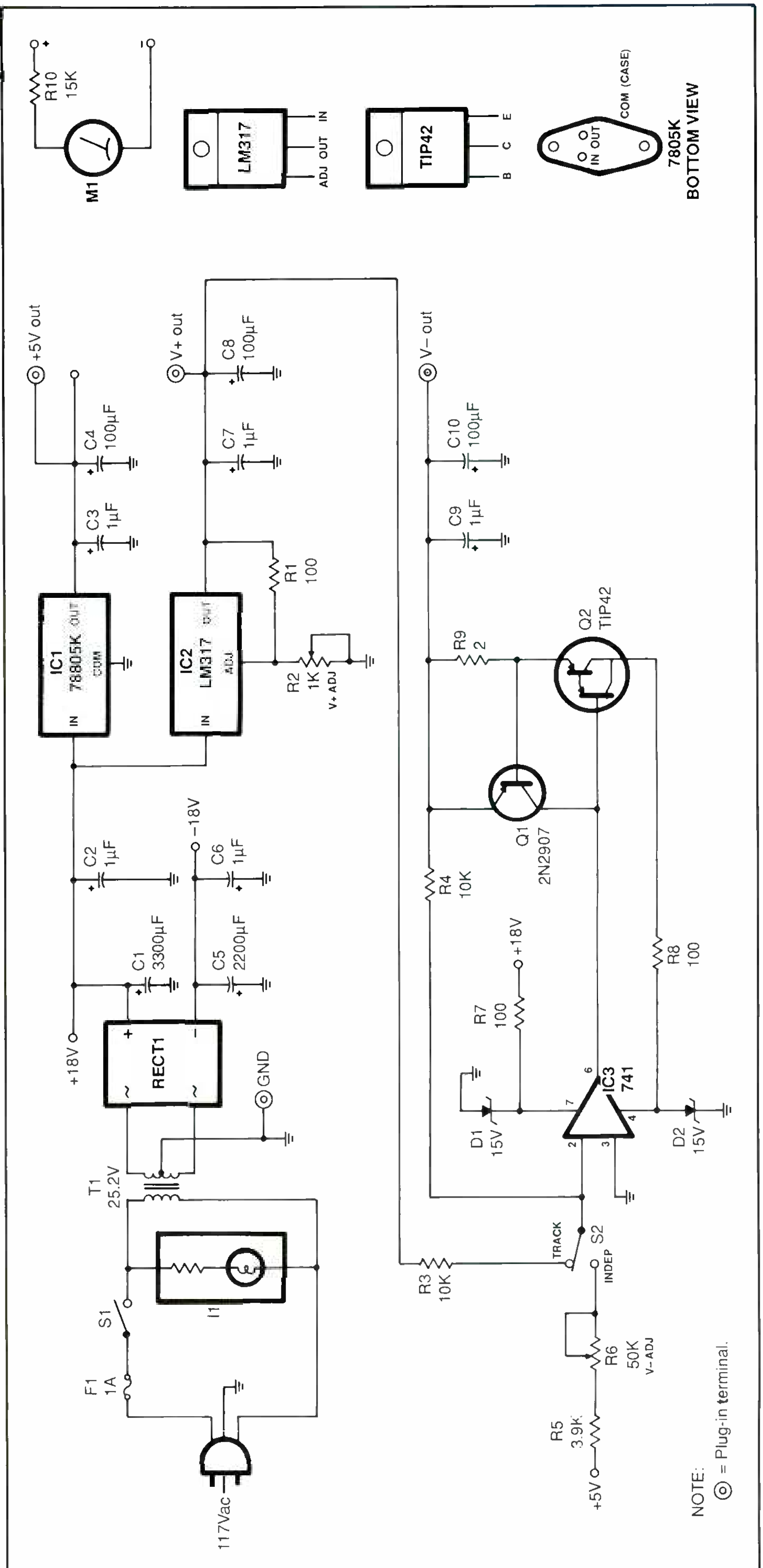


Fig. 1. Schematic diagram of Prototyping Kit's +5-volt and variable positive and negative power supplies.

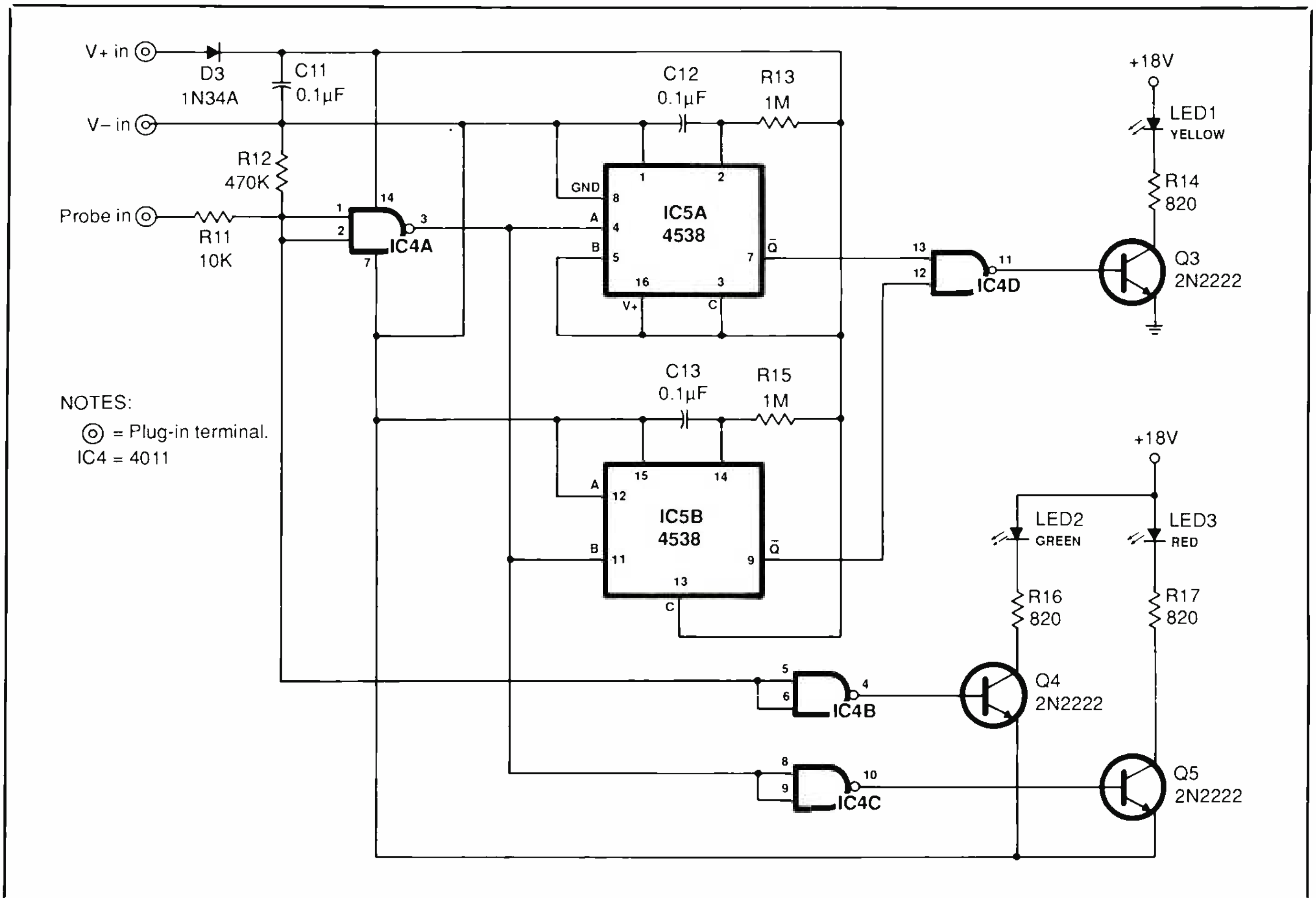


Fig. 2. Schematic diagram of logic probe with level and pulse detectors.

plies for op amps and other devices that require such supplies. Precision resistors with 1-percent tolerance are used for *R3* and *R4* to give close, accurate tracking of V+ by V−.

Darlington transistor *Q2* boosts the V− current-sinking capability beyond what *IC3* can provide. Transistor *Q1* and resistor *R9* protect *Q2* by limiting its collector current. As the collector current of *Q2* increases to 350 milliamperes, the potential across *R9* increases to 0.7 volt. This biases *Q1* on and prevents the potential across *R9* from rising beyond 0.7 volt. This limits the collector current of *Q2* to 350 milliamperes. Capacitors *C9* and *C10* provide decoupling for the V− supply.

With *S2* set to INDEPENDENT, circuit operation is similar, except that V− is now controlled independently of V+. That is, it depends on the ratio of *R5* and *R6* to *R4*. With the +5-volt supply as a reference, potentiometer *R6* varies V− from about −0.9 to −12.8 volts.

Meter *M1* provides a flexible means for monitoring a power supply or other voltage. The + and − terminals of *M1* can be jumpered to any of the supply outputs or across another dc potential of up to 15 volts. Resistor *R10* limits current to *M1*, an analog panel meter that indicates full-scale (15 volts) with a current of 100 microamperes through the its internal coil.

• *Logic Probe.* The circuitry for the logic probe is shown in Fig. 2. A logic probe is a convenient way to test and monitor digital circuits, especially when an oscilloscope is not available. The probe in this Kit indicates logic high, logic low and change of state with red, green and yellow LEDs, respectively.

In use, the V+(IN) and V−(IN) terminals of the logic probe connect across the power supply of the circuit under test. The V+(IN) terminal may connect to V+(OUT) in Fig. 1 (if set to 3 volts or greater), or to +5V(OUT), with V−(IN) connecting to GND. Or V+(IN) and V−(IN) can connect across another supply from 3 to 15 volts. The input under test connects to PROBE(in).

Resistor *R11* and diode *D3* protect the circuitry of the logic probe. If PROBE(IN) is accidentally connected to a voltage greater than V+(IN) or less than GND, *IC4* can be damaged as its input-protection diodes are forced to conduct current. Resistor *R11* protects *IC4* by limiting the input current in these situations.

Diode *D3* protects the probe by preventing current from flowing in case the probe's V+(IN) and GND connections are accidentally reversed. A germanium diode is used because of its low forward voltage drop (0.3 volt). Resistor *R12* holds the inputs of *IC4* low when the logic probe is not in use. Capacitor *C11* provides decoupling for the probe.

NAND gates *IC4B* and *IC4C* control *LED2* and *LED3*. When PROBE(IN) is low, pin 4 of *IC5B* is high, *Q4* switches on and collector current through *Q4* turns on green *LED2* to indicate that PROBE(IN) is a logic low. When PROBE(IN) is high, pin 10 of *IC4C* is high and *Q5* switches on, turning on red *LED3*.

Since *IC4* follows the CMOS standard for logic levels, the green LED is on when PROBE(IN) is less than 0.3 V+(IN), the red LED is on when PROBE(IN) is greater than 0.7 V+(IN), and the response is unpredictable when PROBE(in) is between these limits. For more precise voltage measurements, a voltmeter will do the job.

The pulse detector in the logic probe flashes the yellow LED when there is a change of logic state at PROBE(IN). Monostable multivibrators *IC5A* and *IC5B* stretch transitions at V_{in} into 100-millisecond pulses. Pulse length is set by *R13* and *C12* for *IC5A*, while *R15* and *C13* set pulse length for *IC5B*.

Low-going transitions at PROBE(IN) are responded to by *IC5A*. When PROBE(IN) goes low, pin 4 of *IC5* goes high, causing pin 7 of *IC5* to emit a "low" 100-millisecond pulse. In a similar way, *IC5B* emits a low pulse at pin 9 when PROBE(IN) goes high.

When pin 7 or pin 9 of *IC5* is low, pin 11 of *IC4D* is high and *LED1* is on. So each time PROBE(IN) changes state, *LED1* flashes on briefly. Stretching each transition into a 100-millisecond pulse ensures that even a brief pulse at PROBE(IN) will cause a visible flash of *LED1*. If PROBE(IN) oscillates faster than about 5 Hz, *LED1* will be on constantly.

Power for *LED1*, *LED2* and *LED3* is provided by the + output of *RECT1* in Fig. 1. This gives the LEDs a relatively constant brightness no matter what supply voltage is at V+(IN) on the probe. Resistors *R14*, *R16* and *R17* are current-limiting resistors for the LEDs.

• *Signal Source.* The signal source for the project is a square-wave generator based on a 555 timer, shown schematically in Fig. 3. This oscillator can be used as a test input for digital counters and other circuits.

Output frequency at pin 3 of *IC6* is adjustable in three ranges. Frequency is set by *R18*, *R19*, *R20* and *C15*, *C16* or *C17*, whichever is selected. Frequency can be estimated using the formula: $0.722(R18 + R19 + R20)C_x$.

In the Fig. 3 circuit, C_x is selected

PARTS LIST

Semiconductors
D1,D2—15-volt zener diode
D3,D4—1N34 or similar general-purpose germanium diode
IC1—7805K fixed +5-volt regulator in TO-3 case
IC2—LM317 adjustable positive voltage regulator in TO-220 case
IC3—741 operational amplifier
IC4—4011B CMOS quad NAND gate
IC5—4538B dual CMOS monostable multivibrator
IC6—555 timer
Q1—2N2907 or similar general-purpose pnp transistor
Q2—TIP42 pnp Darlington transistor in TO-220 case
Q3,Q4,Q5—2N2222 or similar general-purpose npn transistor
RECT1—2-ampere bridge rectifier, 50-PIV bridge-rectifier assembly

Capacitors (25 WV dc)
C1—3,300-µF electrolytic
C2,C3,C6,C7,C9—1.0-µF tantalum electrolytic
C4,C8,C10—100-µF aluminum electrolytic
C5—2,200-µF aluminum electrolytic
C11,C14—0.1-µF ceramic disc
C12,C13—0.1-µF polyester or other precision timing capacitor
C15—3.3-µF tantalum electrolytic
C16—0.047-µF polyester or other precision timing capacitor
C17—560-pF ceramic disc
C18—0.01-µF ceramic disc

Resistors (¼-watt, 5% tolerance))
R1,R7,R8—100 ohms
R5—3,900 ohms
R10—15,000 ohms
R11,R19—10,000 ohms
R12—470,000 ohms
R13,R15—1,000,000 ohms
R18—1,000 ohms
R3,R4—10,000 ohms (1% tolerance)
R9—2 ohms (½ watt)
R14,R16,R17—820 ohm (½ watt)
R2—1,000-ohm potentiometer
R6—50,000-ohm potentiometer
R20—1-megohm potentiometer

Miscellaneous
F1—2-ampere slow-blow fuse
I1—Panel-mount neon-lamp assembly with current-limiting resistor
M1—1-mA full-scale analog meter movement
S1—Spst toggle or slide switch
S2—Spdt toggle or slide switch
S3—Sp3t rotary or toggle switch
T1—25.2-volt, 2-ampere center-tapped power transformer
Perforated board with holes on 0.1-inch centers and suitable Wire Wrap and soldering hardware; miniature jumper terminals (see Note below), sockets for all DIP ICs; heat sinks for TO-3 and TO-220 cases; heat-transfer compound, in-line fuse holder; suitable enclosure; ac line cord with plug; ring or spade lugs; pointer-type control knobs; panel clips for LEDs; three-pin locking "quick" connector (optional—see text); rubber grommet; machine hardware; hookup wire; solder; etc.

Note: Miniature jumper terminals, Part No. 1236, are available from DC Electronics, P.O. Box 3203, Scottsdale, AZ 85271-3203; tel.: 1-800-423-0070.

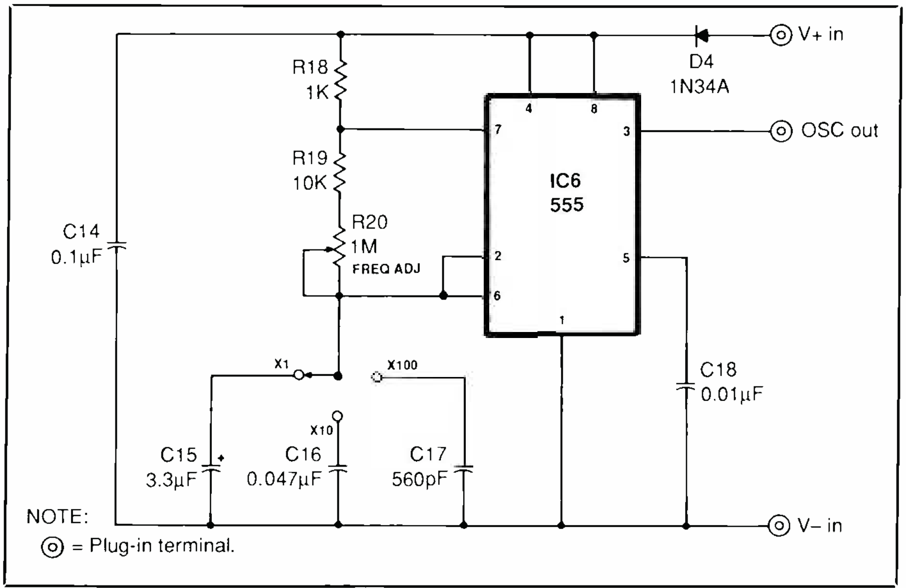


Fig. 3. Schematic diagram of kit's variable square-wave generator.

by *S3*. With *C15* selected (×1 position), *R20* varies the output between about 0.2 and 20 Hz. With *C16* (×10 position) selected, the output varies between 15 and 1,500 Hz, and with *C17* (×100 position), the output varies between between 1.2 and 120 kHz. The ranges have some overlap to ensure that all frequencies are available.

As with the logic probe, the power supply for *IC6* is connected via jumper terminals to V+(IN) and V−(IN). The V+(IN) terminal may connect to V+(IN) (if set to 4.5 volts or higher) or to +5V(OUT), with V−(IN) connecting to GND. Or another supply from 4.5 to 15 volts can be used. With a 5-volt supply, pin 3 of *IC6* sinks 5 milliamperes at 0.25 volt, and sources 100 milliamperes at 3.3 volts.

Capacitor *C18* is recommended for noise immunity at the otherwise unused input at pin 5 of *IC6*. Diode *D4* protects *IC6* in case the V+(IN) and GND inputs are accidentally reversed, and *C14* is a decoupler.

• *Other Components.* Also built into the project are "independent" potentiometers and switches for use in circuits you prototype. If you often require these components when experimenting, building them in means that you do not have to hunt for them every time you need them, and you do not have to solder wires or use a maze of alligator clips every time you want to connect them into a circuit.

In this project, each terminal on all potentiometers and switches is wired to a jumper terminal on the front panel. To use the components, you need only plug jumper wires from the terminals to your circuits.

The project has four potentiometers (1K, 10K, 100K and 1M ohms) and three switches: (spdt toggle, dpdt toggle and spst momentary-action pushbutton). You can use these or substitute whatever values and types you normally use most.

There are plenty of other items you might include in your Prototyping Kit. Possibilities include "debounced" logic switches that change state or emit a single clean pulse when toggled; sine- and triangle-wave generators, an audio amplifier and speaker, etc. For monitoring several points at the same time, you might want to include a series of logic probes like the one described above. Even a frequency counter or digital meter can be built-in.

What you include depends on what you need on a regular basis. For other circuits to include, back issues of *Modern Electronics* contain ideas for test-equipment projects that you can adapt for use in the Prototyping Kit you build.

Planning the Project

The circuitry of your Prototyping Kit can be housed in any suitable plastic or metal enclosure. Just make sure the enclosure you select is large and deep enough to fit the transformer, circuit-board assembly and front-panel components that extend down inside the enclosure.

Figure 4 shows the inside of a completed Prototyping Kit that was assembled using point-to-point wiring and Wire Wrap techniques. A 4 × 5-inch perforated board is large enough to accommodate all components. A board with plated solder pads around the holes is recommended for ease in soldering. Of course, you can design and fabricate a printed-circuit board for the project if you wish.

Jumper terminals and other front-panel controls and displays mount on a piece of perforated board with 0.062-inch diameter holes. Cut a large rectangular opening in the top of the enclosure and mount the perforated board over it.

The Parts List gives one source for the jumper terminals, but they may be available from other suppliers as well. Alternatively, you can use another type of connector, such as binding posts or banana jacks, for connecting wires to the circuits in the Prototyping Kit.

When wiring together the circuitry, sockets are recommended for all DIP ICs, and heat sinks are required for *IC1*, *IC2* and *Q2*.

Before you begin building the project, plan your front-panel layout, patterning it after the arrangement shown in Fig. 5 or using your own design. A sketch of your planned layout will save you time and trouble later. Include several jumper terminals for each of these: +5V(OUT), V+(OUT), V-(OUT) and GND. Also, plan placement of *T1* and the circuit-board assembly in the enclosure, and double check to be sure everything fits when the enclosure cover is fastened down.

When you have done all of the above, drill holes through the floor of the enclosure for mounting *T1* and circuit-board assembly. Drill a hole through the rear panel of the enclosure for the grommet-lined entry hole for the ac line cord.

On the face of the enclosure, lightly outline with a soft lead pencil the area that will be covered by the perforated board. Draw a second rectangle ¼ inch inside this outline to mark the area to be cut away. Blunt the corners of this rectangle diagonally to leave space for mounting screws. Lay the perforated board over its planned opening and at each corner select a hole for a mounting screw. Circle these holes on the perforated board, and mark through them to locate where to drill the holes through the panel.

Make the large opening in the enclosure by cutting along the marked inner lines. You can make this opening by drilling a ⅜-inch starter hole and then using a nibbling tool to cut cut away unwanted material. Also, drill holes through the front panel for mounting *S1*, *I1* and the perforated board. After drilling and cutting, deburr all holes made through metal to remove sharp edges.

Prepare the perforated board for the front panel by cutting the board to size and enlarging the four mounting holes as needed. Using your sketch as a guide and the pencil, lightly mark the locations of all jumper terminals, *M1*, *S2*, *S3*, *R2*, *R6*, *R20*, *LED1*, *LED2*, *LED3* and any other switches or/and potentiometers you plan to include.

The large hole required for the body of the meter can be cut with a nibbling tool.

Before wiring to the circuit board, plan the layout and orientations of the large components—*IC1* through *IC6*, *C1*, *C4*, *C5*, *C8*, *C10* and the heat sinks for *IC1*, *IC2* and *Q2*. Enlarge the mounting holes for *IC1*, *IC2* and *Q2*. Slightly enlarge the holes for the two leads of *RECT1* and any other large-diameter component leads. Drill mounting holes on the circuit board if necessary.

Because Wire Wrap makes use of small-diameter (No. 30) wires, it is not suitable for wiring the power-supply circuitry in which high currents exist. Therefore, for this section, use ar least 22-gauge wire here and in all circuitry from the ac power plug to the terminals for +5V(OUT) and V+(OUT) and all wiring to *Q2*, *R9* and V-(OUT).

Wire the power-supply circuits first. If your enclosure is metal, use a power cord with a three-prong plug and solder or crimp a spade or circular lug to the green (safety ground) conductor. Press a rubber grommet into the hole for the ac cord and route the cord through the grommet. As you mount *T1*, fasten the prepared ground lug on the ac line cord to one mounting screw of *T1* so that the safety ground makes a sound electrical connection to the chassis.

Install the power-supply components on the circuit board and wire the rest of its circuitry, using Fig. 1 and the following as a guide:

For safety, use heat-shrinkable tubing to cover all exposed connections at *F1*, *S1*, *I1* and *T1*. When soldering together two wires, first slide a ¾-inch length of this tubing onto one of the wires. Form a sound mechanical connection by stripping ¼ inch of insulation from each wire, bending the bare ends into hooks and hooking and crimping the two ends together. Solder the connection and slide and shrink the tubing over the bare wires.

Mount the neon-lamp assembly in its prepared hole. Using Fig. 1 as a guide, wire *S1*, *F1* and *I1* to the 117-volt line cord and the 117-volt primary windings of *T1*.

To permit easy removal of the circuit board from the enclosure, use a three-pin locking-type "quick" connector to wire the 25-volt secondary winding of *T1* to the circuit-board as-

(Continued on page 72)

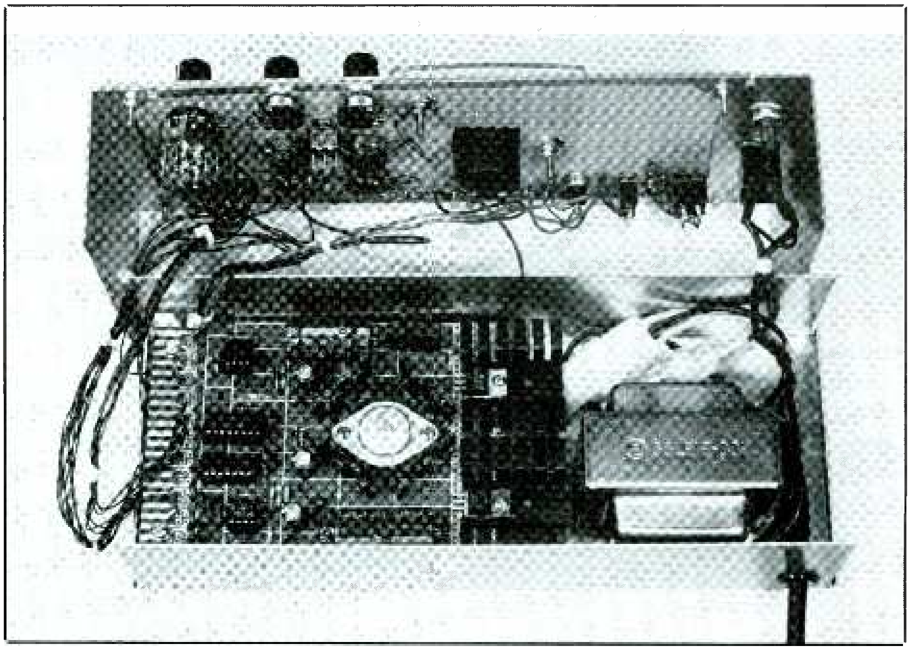


Fig. 4. Most of Prototyping Kit circuitry wires on perforated board.

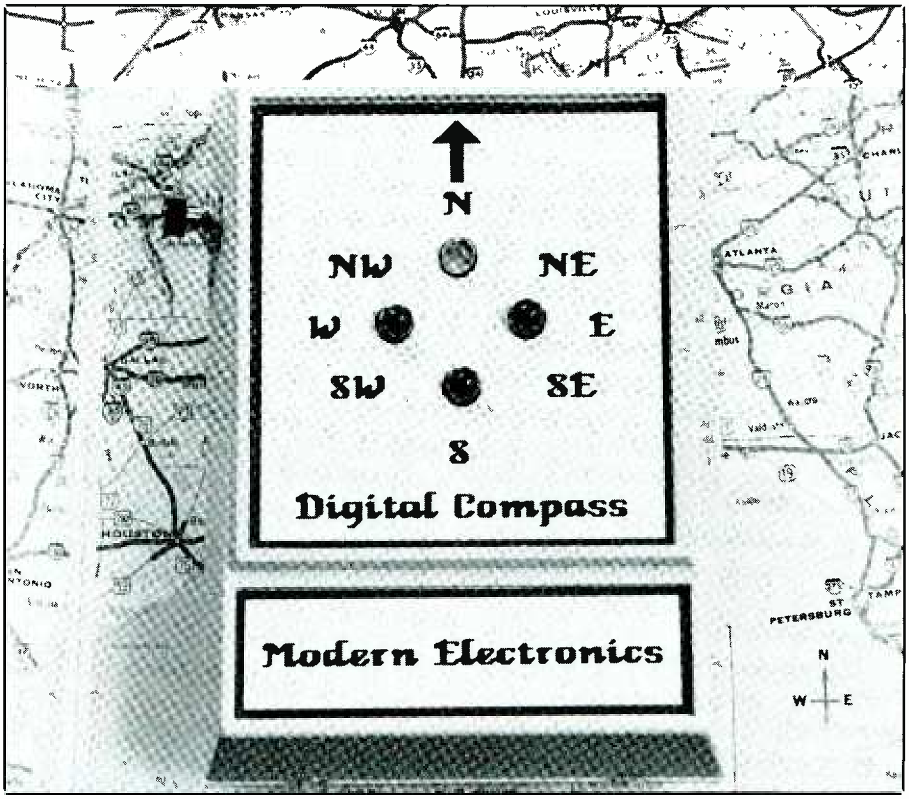
A Digital Compass

An all-electronic version of a centuries-old navigation instrument uses LEDs to indicate compass directions

By Steve Sokolowski

Modern electronics technology has made it possible to update traditionally mechanical devices, some of them hundreds of years old, into something from the Twenty-First Century. A good example is the Digital Compass described here.

Our Digital Compass is built around an inexpensive patented Dinsmore Digital Sensor. When interfaced with support components, an easy task, this sensor makes a fairly accurate compass that indicates the four cardinal points (North, South, East and West). By making use of overlapping sectors, intermediate directions (Northeast, Southeast, Northwest and Southwest) are indicated. The sensor is designed to be operated from just about any 6- to 18-volt dc source. It is powered here by a 9-volt battery to provide portability in a small hand-held package.



About the Circuit

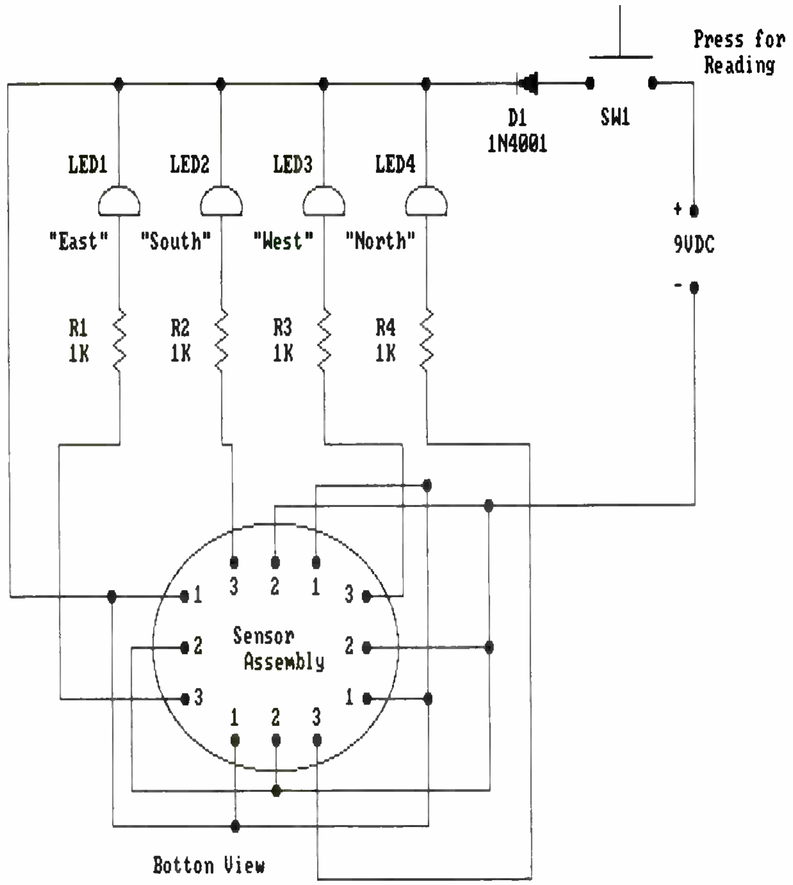
Show in Fig. 1 is the complete schematic diagram of the circuitry used in the Digital Compass. The interfacing circuitry from the Sensor Assembly to light-emitting diodes *LED1* through *LED4* consists simply of current-limiting resistors *R1* through *R4* to the 9-volt dc power source through momentary-contact switch *S1*. Diode *D1* is in the circuit to protect against reverse-polarity hookup of the 9-volt battery.

The Dinsmore Sensor used in this project magnetically indicates the four cardinal directions. By providing a means for overlapping indications, this sensor also provides indication of the four intermediate directions, as detailed above. The sensor itself is a combination of a subminiature rotor and solid-state integrated-circuit elements. This configuration is shown in Fig. 2.

Inside the sensor are special switches, called Hall-Effect devices, that surround a jewel-suspended critical magnet, which itself is able to rotate about its central axis. The sensor was specifically designed to measure the direction of the flux pattern at the magnet's horizontal position. This is exactly the definition of the traditional directional compass.

Slight internal damping is provided inside the sensor to produce a delay that simulates the response of a liquid-filled compass. The sensor requires approximately 3.5 seconds to indicate a 90-degree "pointer" displacement. Use of damping obviates any output fluttering for a stable display indication.

In digital terms, the output from the Dinsmore Sensor can be combined with a binary code. The Table shown elsewhere in this article lists the binary-like coded output from the sensor as it pertains to the standard four compass directions, as well as the four intermediate directions.



PARTS LIST

Semiconductors

D1—1N4001 or similar silicon rectifier diode

LED1 thru LED4—Jumbo red light-emitting diode

Resistors (¼-watt, 10% tolerance)

R1 thru R4—1,000 ohms

Miscellaneous

SW1—Normally-open spst pushbutton switch

Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); Dinsmore magnetic sensor (see text and Note below); 9-volt battery and snap connector; suitable enclosure (see text); top-panel artwork (see text); rubber cement; hookup wire; solder; etc.

Note: The Dinsmore magnetic sensor can be obtained for $15 (postage included for U.S.; add $1.50 for Canadian orders) from Del-Phone Industries, P.O. Box 5835, Spring Hill, FL 34606. Florida residents, please add state sales tax.

Fig. 1. Complete schematic diagram of circuitry used in Digital Compass.

Though this project can be built as described and used as-is to serve as a completely self-contained compass, there are other things you can do with the basic circuitry. For example, you can easily interface the output from the sensor to a computer chip to display direction headings. Or you can interface the Digital Compass to a voice synthesizer to have the circuit vocalize the directional indication. Another possibility is to connect the sensor to a liquid-crystal display module to show direction and corresponding heading. Other possibilities are likely to come to mind as you build and use the Digital Compass.

Construction

Building the Digital Compass is a relatively easy task to accomplish. The only thing that "critical" with regard to construction is layout of the four light-emitting diodes to obtain a traditional circular dial face.

Though you could design and fabricate a printed-circuit board on which to mount the Sensor Assembly and resistors, there is no real need to do so. The easiest approach is to mount these four items on a small perforated board that has holes on 0.1-inch centers and interconnect them and the LEDs, diode, switch and battery using suitable Wire Wrap or soldering hardware using the point-to-point wiring technique.

Your circuit-board layout should have the Dinsmore Sensor located in the center and the four LEDs in a diamond arrangement surrounding it. Before mounting the Dinsmore Sensor into the circuit, carefully examine it. As noted in Fig. 3, the sensor has 12 leads that are arranged in four bundles, each containing three leads and assigned as shown in Fig. 2. Identify and label which LED each set of leads on the Sensor is to control. Then install the Sensor on the board, orienting the "north" side of the Sensor so that it parallels the top edge of the board.

Keep in mind that the Dinsmore Sensor is very sensitive to polarity reversal. It is so sensitive that a mistake in wiring it into the circuit can destroy the delicate internal electronics. Therefore, exercise extreme care when connecting and soldering the positive and negative power leads to its pins.

Sensor Binary Output Listing

Direction	LED1	LED2	LED3	LED4
East	on	off	off	off
Southeast	on	on	off	off
South	off	on	off	off
Southwest	off	on	on	off
West	off	off	on	off
Northwest	off	off	on	on
North	off	off	off	on
Northeast	on	off	off	on

Note: "on" = 0; "off" = 1

Next, install the four current-limiting resistors, one each near its respective control lead (pin 3 in each bundle on the sensor). Crimp and solder one resistor lead to its respective pin 3 Sensor pin. Install the rectifier diode. Connect and solder a short length of insulated hookup wire to the anode-lead connection of the rectifier diode and terminate the other end at one lug of the pushbutton switch.

Returning Fig. 1, note that each three-lead bundle requires both positive and negative power-supply connections. Use hookup wire to tie together all four pins labeled 1 via wiring on the circuit-board assembly and connect this arrangement to the cathode of the rectifier diode.

Similarly, tie together all four pins labeled 2 and attach to this arrangement to the negative (black-insulated) lead from the battery snap connector. Crimp and solder the positive (red-insulated) lead from the connector to the other lug of the switch.

You can house the project inside any small enclosure that will accommodate the circuit-board assembly and 9-volt battery that powers it. A suitable all-plastic enclosure is illustrated in the lead photo.

Machine the enclosure as needed by drilling mounting holes for the switch and four LEDs. If your enclosure is small enough, you can use the actual-size panel artwork shown in Fig. 4 to locate the holes for the N, E, S and W LEDS. Use a drill that is just large enough to provide a snug fit for the LEDs. Also, use the artwork to determine where on the circuit-board assembly to mount the four LEDs.

When mounting the LEDs on the circuit-board assembly, make certain that each is properly polarized before making any connections to their leads. Adjust the height each LED sits above the top surface of the board so that when the LEDs are plugged into the holes in the top panel of the enclosure the sensor does not touch the inside surface of the top panel. If the LEDs are properly mounted and the enclosure is correctly machined, the circuit-board assembly should mount into place via just the LEDs.

Once the circuitry has been wired together and before it is installed inside its enclosure, snap a fresh 9-volt battery into the connector. Holding the project flat and parallel with the ground, press and hold the button on the switch while observing the LED display. If all is well, at least one LED will light, indicating the direction of the magnetic north pole.

Slowly turn in a complete circle while observing the display. Successive LEDs should light in a one-two-one-two, etc. sequence and previous ones extinguish as you rotate the project through the complete 360-degree circle. This indicates the changing position of the north pole with respect to the orientation of the project.

If no LEDs light or any one or more LEDs fail to light or the LEDs light out of proper sequence, release the button on the switch. Correct the problem before proceeding to install

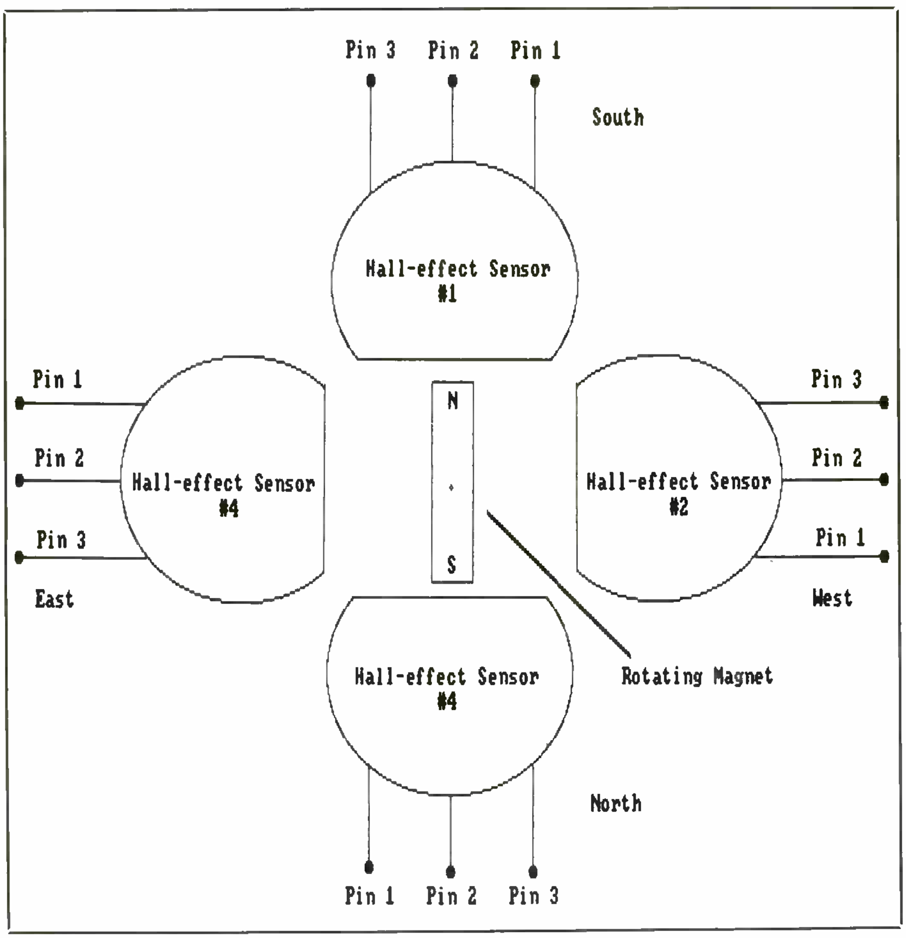


Fig. 2. Internal details of Dinsmore magnetic sensor around which Digital Compass is built.

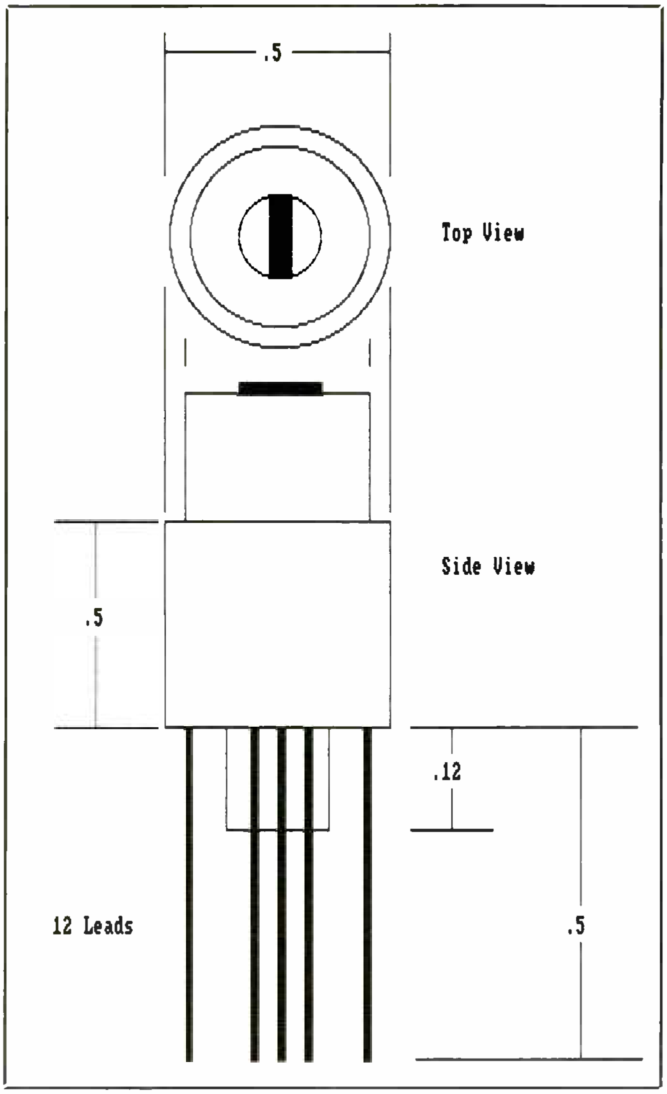
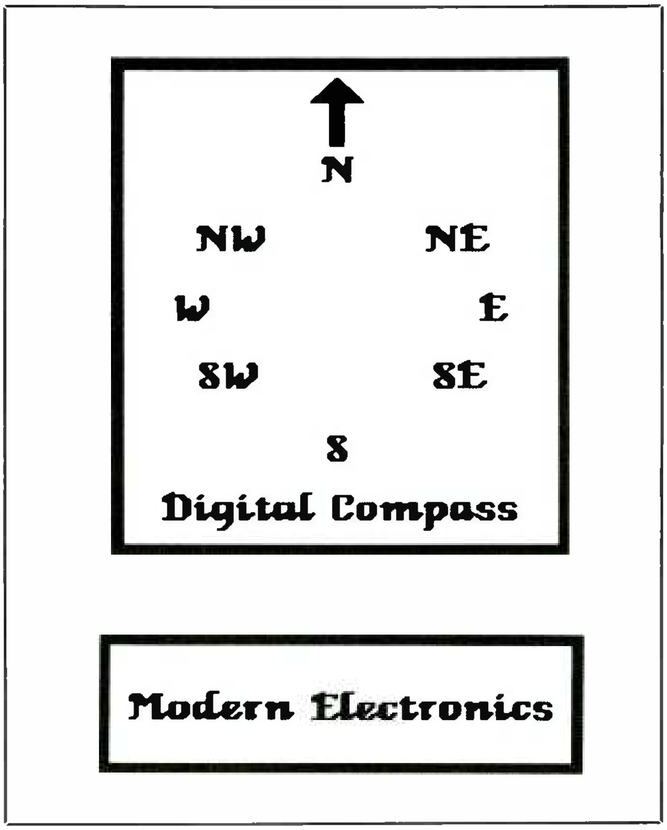


Fig. 3. Mechanical details of Dinsmore magnetic sensor.

Fig. 4. Actual-size top-panel artwork for Digital Compass.



the circuit-board assembly.

When you are certain that the circuit has been properly wired, install the circuit-board assembly inside the enclosure by fitting the domed cases of the LEDs into the holes you drilled in the panel. If the LEDs do not secure the circuit-board assembly in place, apply a very small daub of clear fast-setting epoxy cement to the junction between the domes of any two LEDs on opposite sides of the board and the edge of the panel holes in which they fit. Allow the cement to completely set.

Meanwhile, make a good same-size photocopy of the front-panel artwork shown in Fig. 4. Trim the copy to just the outer edge of the heavy black border. Then punch holes at the N, E, S and W positions to accommodate the domed tops of the LEDs. Make these holes the same size as those you drilled through the panel for the LEDs themselves.

Use rubber cement or other suitable adhesive to carefully secure the artwork to the top panel of the enclosure, with the domes of the LEDs projecting through the appropriate holes. This done, mount the switch in the hole you drilled for it, and secure the battery in place with a strip of double-sided foam tape.

Using the Compass

You use this Digital Compass in much the same manner as you would a traditional mechanical compass. Always hold it parallel to the Earth as you press the switch to take a reading. The LED or LEDs that light when you do this indicate the direction of the magnetic north pole. If two LEDs light, such as the N and E LEDs, magnetic north is in the direction somewhere between north and east of the relative orientation of the compass. To zero in on north, simply rotate the Digital Compass until only the N LED is lit. **ME**

Ring Director

This accessory permits two or three telephone answering devices—including a fax machine and a computer modem—to share the same incoming line while providing full outgoing call capability

By Mark V. Lucas

A few commercial devices permit use of facsimile (fax) machines with phone answering devices on the same telephone line. In fact, some newer fax machines have this facility built-in. Although most of these devices work, they are not capable of handling many conditions and combinations of answering devices, especially those that do not directly involve a fax machine. The Ring Director described here, however, works with virtually any answering device to permit two and, in some cases, three answering devices to share the same line while still providing full outgoing call capability.

The Ring Director monitors the telephone line for a ring signal. Calling, ringing once or twice, hanging up and calling back signals the Ring Director to disconnect (or connect) the device under its control. If you have a computer modem and a fax machine on the same line, you would connect the fax machine's telephone line to the Ring Director's controlled phone line output jack and the Ring Director to the telephone jack. Normal calls would be answered by the fax machine.

To access the modem, you dial your number, let your telephone ring once, hang up and call back. The Ring Director disconnects the phone line from the fax machine on the second call to prevent it from answering while you ring the line until the modem picks up. This "ringback" method of signaling, used a few years ago on computer bulletin boards, may not be the ideal way to go, but it is inexpensive and works.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Ring Director's circuitry. Ring detection is provided by TCM-1520 integrated circuit *IC1*. Similar to the 1512-type tone ringers, this chip provides built-in lightning and transient protection and anti-dial tapping. However, rather than driving a sounder, it gives a 5-volt regulated output during a ring. This output drives MCT-2 optical isolator *IC2*, which provides full isolation of the telephone line. The COM pins of *IC1* and the LED side of *IC2* are isolated from grounds on the logic side of the circuit to maintain full telephone line isolation.

The logic end of the circuit uses 4528 dual one-shot multivibrator *IC3* for Timers A and B and a 4017 decade counter for *IC4*. Timer A is set for a 6-second delay to time-out when the line stops ringing. Timer B is set for a 60-second reset.

When no ring signal is on the line, Timer B holds the 4017 in a high reset condition, and Timer A, which is wired to the CLOCK input of *IC4*, is low. Light-emitting diode *LED1* turns on to indicate that *IC4* is in the reset condition.

When a ring signal is detected, both timers are triggered into operation. Now, Timer B releases the reset on *IC4* and, while the output of Timer A goes high, increments *IC4*'s counter from zero to 1. Every subsequent ring pulse retriggers both timers until ringing stops, at which point, Timer A resets.

If another call is received within the 60-second period of Timer B, Timer A triggers again and increments *IC4* to a count of 2. Timer B retriggers, resetting the timer to 60 seconds. If a call is not received within the period set for Timer B, this timer counts out and resets the 4017, clearing the count back to zero and turning on *LED1*.

Two of the ten outputs available on *IC3* are used for control of the relay. Jumper block *JB1*, shown at the lower-right in Fig. 1, selects the output that energizes the relay.

In MODE A, the controlled answering device is allowed to answer on the first call but is disconnected after a ringback condition. When MODE B is selected, the device is disconnected on the first ring of the first call, which prevents it from answering. When a ringback condition occurs, this device is reconnected and allowed to answer on the second call.

Construction

There is nothing critical about construction. You can home-fabricate your own printed-circuit board for the project using the actual-size etching-and-drilling guide shown in Fig. 2 or purchase a ready-to-wire board from the source given in the Note at the end of the Parts List. Alternatively, you can mount the components on perforated board that has holes on 0.1-inch centers and wire them together with the aid of suitable Wire

PARTS LIST

Semiconductors

D1—1N4001 or similar silicon rectifier diode

IC1—TCM-1520 ring detector (Texas Instruments)

IC2—MCT-2 or similar optical isolator

IC3—4528 dual one-shot multivibrator

IC4—4017 decade counter

LED1—Green light-emitting diode

Q1—2N3904 or similar general-purpose silicon npn transistor

Capacitors

C1—0.1-μF, 350-volt Mylar

C2,C5—10-μF, 35-volt electrolytic

C3,C4—220-μF, 16-volt electrolytic

Resistors (¼-watt, 5% tolerance)

R1,R3,R5,R6—2,200 ohms

R2,R4—1,000 ohms

R7,R8—1-megohm pc-mount trimmer potentiometer

Miscellaneous

K1—5-volt dc relay with spdt contacts rated at 1 ampere (Fujitsu No. FBR-211NED005-M20, available from All Electronics, Cat. No. DRLY-211-5)

JB1—Three-circuit jumper block and shorting header (see text)

Printed-circuit board or perforated board with holes on 0.1" centers and suitable Wire Wrap or soldering hardware (see text); sockets for ICs; suitable enclosure (see text); materials for on-board power supply or 9-volt plug-in power supply (All Electronics Cat. No. DCTX-620 and matching panel-mount 2.5-mm jack, Cat. No. SMJW or similar—see text); telephone extension cord or double male cord with double female end-to-end coupler (see text); machine hardware or double-sided foam tape (see text); hookup wire; solder; etc.

Note: The following items are available from M. Lukas, P.O. box 777, Glenham, NY 12527: complete kit of parts, including pc board, all components, plug-in power supply with matching jack, telephone cords but not enclosure, $25; ready-to-wire pc board, $8; Ring Counting Microcontroller version kit is also available, $30.00. Add $2.50 P&H. New York residents, please add state sales tax.

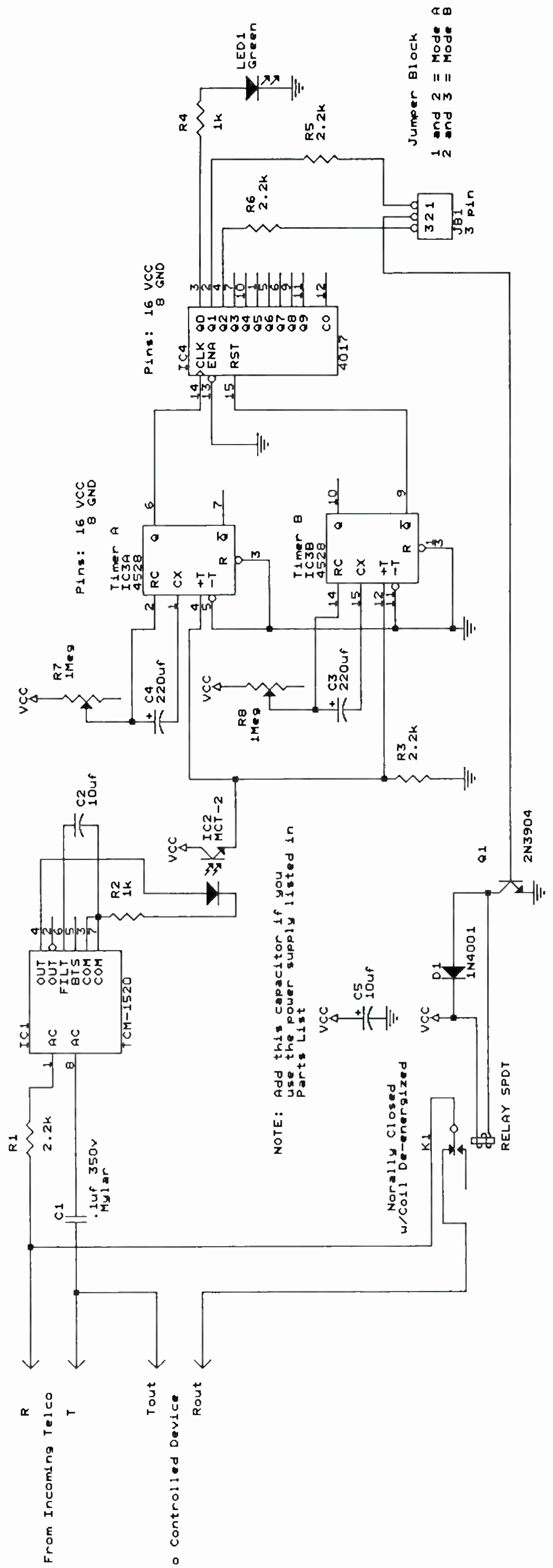


Fig. 1. Complete schematic diagram, minus its dc power supply, of the Ring Director circuitry.

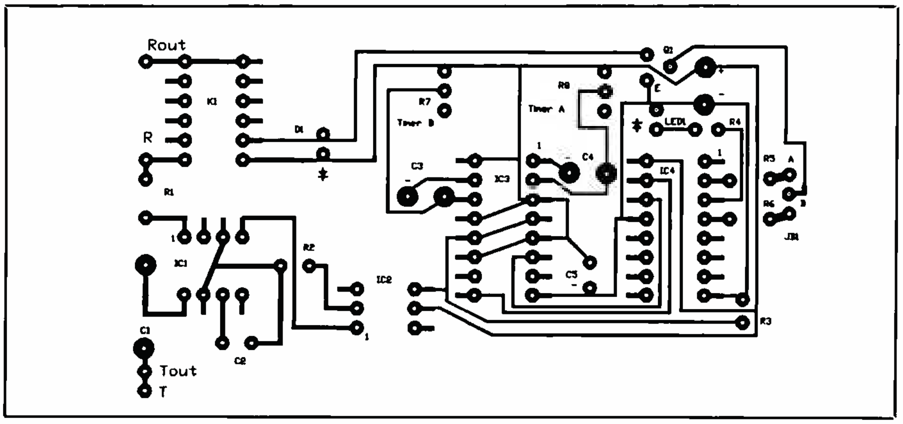


Fig. 2. Actual-size etching-and-drilling guide for project's pc board.

Wrap or soldering hardware. Whichever way you go, use sockets for the DIP ICs.

If you decide to wire the circuit on perforated board, lay out the components to keep *IC1*, *IC2* and *K1* on one side to maintain physical isolation between the logic circuit and the telephone line circuit. If you wish, follow the layout shown in the wiring diagram for the pc board in Fig. 3.

When *K1* is not energized, the circuit draws very little current but draws a bit more than 80 milliamperes when the relay is activated. If you wish, you can build a suitable power supply on the circuit-board assembly. Alternatively, you can use a plug-in 6- to 9-volt power supply rated to deliver at least 100 mA.

Although the relay specified for this project is has a coil rating of 5 volts dc, its maximum allowable coil potential is 11.25 volts. Do not neglect the diode across the coil of *K1*. Failure to include this diode will result in erratic operation and can damage the circuit.

You do not need a jumper block for selecting the desired operating mode. If you with, you can install a permanent jumper wire to effect your selection. Alternatively, you can wire the pads for *JB1* on the board to a selector switch you then mount on the enclosure you choose for the project.

Assuming you are using a pc board, wire it exactly as detailed in Fig. 3. Install first the IC sockets in their respective locations, but do *not* plug the ICs into the sockets until you have finished wiring the circuit and have conducted voltage checks and are sure everything is okay. Once the sockets are in place, install and solder the capacitors and resistors into their respective locations on the board. Make certain all electrolytic capacitors are properly polarized before soldering their leads into place.

Next, install and solder into place the relay, followed by the diode and transistor. Again, make sure the diode is properly polarized and the transistor is properly based before soldering any leads into place.

Strip ¼ inch of insulation from both ends of one red- and one black-insulated hookup wires cut to a length of about 4 inches. If you are using stranded hookup wire, tightly twist together the fine conductors at both ends of the wires and sparingly tin with solder. Identify the cathode lead of the light-emitting diode and clip it to a length of ½ inch. Form a small hook in the remaining lead stub and crimp and solder to it one end of the black-insulated wire. Do the same for the anode lead and red-insulated wire.

Slide a 1-inch length of small-diameter heat-shrinkable or other plastic tubing over the free ends of the two wires. Slide the tubing all the way to the bottom of the LED case, completely insulating the connections from each other, and shrink into place. Plug the black-insulated cathode wire into the hole identified with a K for *LED1* on the board and solder into place. Do the same with the red-insulated anode lead and the other *LED1* hole.

If you are planning on using a mode-selection switch instead of the jumper block, prepare three 4-inch-long insulated hookup wires as described above for the LED. Plug one end of the wires into the JB1 holes in the board and solder into place. On the other hand, if you are planning on using the jumper block, install

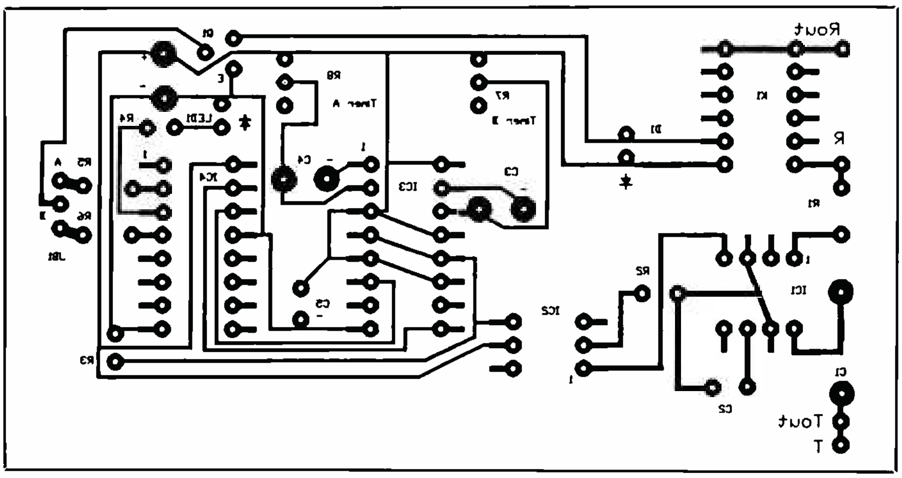


Fig. 3. Wiring diagram for pc board.

and solder into place a three-pin jumper assembly in the *JB1* location and place the jumper header on any two pins for now. Finally, if you plan on using the project permanently in a single mode, install and solder into place a short bare solid jumper wire from the center hole to either outer hole, depending on the mode desired.

When you are finished wiring the circuit-board assembly, carefully inspect it to make sure you installed all components in their correct locations and orientations. Turn over the circuit-board assembly and inspect your soldering. Solder any connections you missed and reflow the solder on any connection that appears suspicious. Check for solder bridges, especially between the closely spaced pads for the IC sockets and relay pins. If you locate any, clear them with a vacuum-type desoldering tool or desoldering braid.

If you have decided to use an on-board power supply for the project, wire it together now. Use a design that provides an output of at least 100 milliamperes at a regulated 12 volts dc. A simpler approach is to use a commonly available outboard plug-in 9- to 12-volt dc, 100-milliampere or more supply.

Select an enclosure in which to mount the circuit-board assembly. It can be an all-metal utility box, an all-plastic box or a plastic project box that has a metal panel. Machine the enclosure by drilling holes through which the telephone line and ac line cord or the cord from an external plug-in power supply can enter and the control line can exit, for mounting the LED and, if used, for mounting the mode-selection switch. If you are using an on-board power supply, also drill mounting holes for its power transformer and circuit-board assembly. Deburr all holes drilled through metal to remove sharp edges and line the entry and exit holes with small rubber grommets.

The incoming telephone line goes to points labeled R and T, the device to be controlled to R OUT and T OUT. An easy way to make the phone line connection is to use a 7-foot-long modular telephone extension cable with male and female modular connectors at opposite ends. Cut this cable about 1 foot from the end near the female connector. If you cannot find a short male-to-female extension, use a short male-to-male cord and cut it 1 foot from one end and attach a double female coupler to it.

Carefully remove 1½ inch of outer plastic jacket from the cut ends of both pieces of cable. Cut away and discard all but the red- and green-insulated conductors. Strip ¼ inch of insulation from these two conductors. Gently twist together the fine wires and sparingly tin with solder.

Route the unfinished ends of the cables into the enclosure through the holes you drilled for them. Tie a strain-relieving knot in each about 4 inches from the unfinished end inside the enclosure. Route the ac line cord or the cord from the plug-in power supply into the enclosure through its hole. Tie a strain-relieving knot in it as well. Tightly twist together the fine wires of either cord or cable and sparingly tin with solder. Then mount the mode-selector switch.

Plug the red-insulated conductor of the longer cable into the hole labeled R, the green-insulated conductor into the hole labeled T, and solder both into place. Install and solder into place the 1-foot cable with the female connector with the red-insulated conductor going to the R OUT and the green-insulated conductor going to the T OUT holes in the board.

With this arrangement, you have a male plug that fits a standard RJ-11 jack to provide the Ring Director with the incoming phone line, and a female jack into which to plug the controlled device to allow the project to control the phone line to the device.

Wire whatever power supply you are using to the circuit-board assembly. If you are using an on-board power supply, use heat-shrinkable or other plastic tubing to insulate the line-cord to power transformer primary leads.

Mount the circuit-board assembly in place inside the enclosure. Use ½-inch spacers and suitable machine hardware if the assembly is to mount inside a metal enclosure. If the enclosure is plastic, secure the assembly in place with a couple of strips of double-sided foam tape.

If you are using the mode-selector switch option, crimp and solder the free ends of the wires for it to the lugs on the switch. The wire coming from hole 2 for *JB1* goes to the toggle lug of the switch, the other two wires to the two pole lugs. Label the panel near the switch accordingly.

Plug the dome of the light-emitting diode into its hole. If the LED does not remain in place by friction, apply a small daub of clear fast-setting epoxy cement or silicone adhesive to it to secure it.

Checkout & Use

Use a dc voltmeter or a multimeter set to the dc-volts function to make preliminary measurements on the circuit before installing any ICs in their sockets. Clip the meter's common lead to a convenient point in the project that is at circuit ground. Plug the project into an ac outlet, but do not connect it to either the telephone line or device to be controlled.

Touch the "hot" lead of the meter to pin 6 of the *IC2* socket, pin 16 of the *IC3* and *IC4* sockets and the cathode of the diode. In all cases, you should obtain a reading of between +9 and +12 volts, depending on the output of the power supply used.

If you fail to obtain the proper reading at any point in the circuit, unplug the project from the ac line. Carefully check over your work to determine where the problem exists. Do not proceed with installation of the ICs and setting up the project until you have corrected any problems.

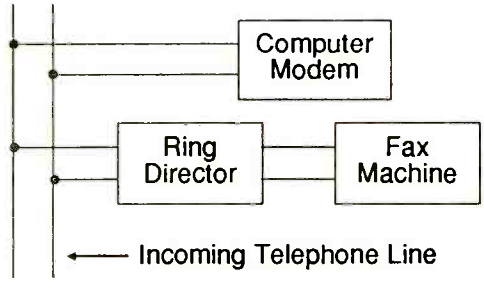
When you are satisfied that every-

Suggested Configurations

There are many different types of telephone equipment in use, each with its own special capabilities. Some devices answer at a fixed number of rings, others have a limited selection and still others allow you to set any number of rings. You should be familiar enough with your equipment to configure the connections and settings to work with the Ring Director. Presented here are some sample arrangements in which the Ring Director can be used and how to set up your equipment to take advantage of this project. Table 1 should give you some idea of what you can do with the Ring Detector:

Table 1
Use With a Fax Machine & Computer Modem

Primary Device	Fax Machine
Answers on Ring	Selectable
Set to answer on Ring	2 or 3
Secondary Device	Computer Modem
Answers on Ring	Selectable
Set to answer on Ring	4 or greater
Ring Director Selection	Mode A

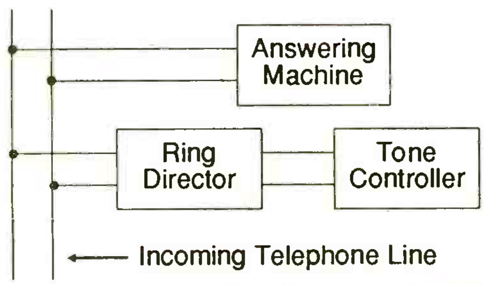


With the Table 1 arrangement, the fax machine should be connected to the Ring Director's controlled phone line output. Normal calls will be answered by the fax machine. After a ringback, the fax disconnects and the modem answers after four or more rings on the second call.

If you want the answering machine to answer (the Controller will normally answer first), connect the Controller to the controlled line output of the Ring Detector and select the Mode B, as in Table 2. In this mode, the first ring of the first call disconnects the controller to permit the answering machine to answer. On a ringback condition, the controller will be reconnected to the line and allowed to pickup before the answering machine does.

Table 2
Use With an Answering Machine & Touch Tone Controller

Primary Device	Answering Machine
Answers on Ring	Selectable
Set to answer on Ring	2 or 3
Secondary Device	Touch Tone Controller
Answers on Ring	1
Set to answer on Ring	Cannot Change
Ring Director Selection	Mode B

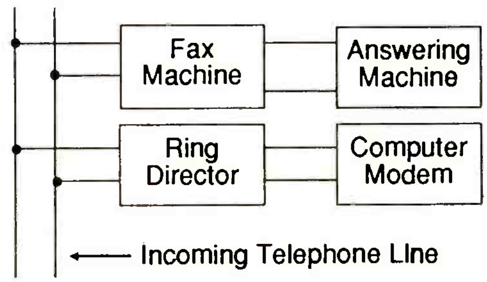


If your fax machine has the ability to automatically switch between an answering device and fax reception, you could add a third answering device, such as a modem as in Table 3.

You can also permit modem access on the same line by connecting your modem to the controlled line output of the Ring Director. Connect the answering machine to the controlled line output (this type fax machine has a controlled line output for controlling the answering machine) of the fax machine and the fax machine directly to the phone line. Set the Ring Director to Mode B.

Table 3
Use With an Answering Machine & Computer Modem

Primary Device	Answering & Fax Machines
Answers on Ring	Selectable
Set to answer on Ring	2 or 3
Secondary Device	Computer Modem
Answers on Ring	Selectable
Set to answer on Ring	1
Ring Director Selection	Mode B



With this arrangement, normal calls are answered by the answering machine. If the fax machine detects remote fax tones, it will automatically disconnect the phone line from the answering machine to receive the transmission. On a ringback condition, the Ring Director switches the modem back on-line to allow it to pickup before the answering machine does.

This arrangement leaves the fax machine listening on the line while the modem is on-line. If the Auto Fax interprets the modem call as a fax transmission, picks up and interferes, switch to Mode A, connect the fax machine to the Ring Director (and, subsequently, the answering machine through the controlled line fax output) and set the modem to answer on one ring beyond the setting of the answering machine. This makes the Ring Director remove the fax (and answering) machine from the line after a ringback condition and gives the modem exclusive use of the line, thus preventing the interference.

Using Mode B, the Ring Director can also "hide" an auto-answering device from normal dial-up so that only those people who know how to do so can access it. This can eliminate unsolicted fax calls, keep a sequential dialer wielded by a hacker from finding your computer modem or increase the security of your remotely accessible burglar alarm or Touch Tone home controller.

Ring Director . . . *(from page 31)*

thing is okay, plug the ICs into their respective sockets. Make sure that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

Plug the project back into the ac outlet and note that the LED lights, indicating that *IC4* is reset to a count of 0. If the LED fails to light, wait a minute or two. If it still fails to light, make sure power is being delivered to the circuit and recheck your work.

The *IC3* timers must be adjusted before the circuit can be used. Use *R7* to adjust Timer A. To do this, connect the "hot" probe of your meter to pin 6 of *IC3* and the common probe to pin 8 or wherever else is at circuit ground. Momentarily short together pins 4 and 5 of *IC2* to simulate a ring condition. When the short-circuit is removed, start timing while watching the meter display. When a simulated ring is generated, pin 6 should go high for a time, then low again. Now short together the same pins of *IC2* again and adjust *R8* until you obtain a 6-second period for the high pulse on pin 6.

Wait a minute or so for Timer B to reset. Then touch the "hot" probe of the meter to pin 9 of *IC3*. Momentarily short together pins 4 and 5 of *IC2* and adjust *R8* in the same manner until pin 9 of *IC3* remains high for about 60 seconds. These adjustments do not have to be precise. Timer A can be set for a period of 5 to 12 seconds, Timer B for a period of 20 to 120 seconds.

When the timers are adjusted, make the connection to the telephone line by plugging the cord with the male connector on it into a working RJ-11 jack and set the Ring Director to Mode B.

To finish testing, you must have your telephone ring. In some areas, you can make your phone ring by dialing 660 then the last four digits of your phone number. If you do this and hear a dialtone, hang up, pick up and hang up again. Your telephone should ring. If you do not hear the dialtone after you dial the numbers, you probably cannot use this method. If so, have a friend call your number from an outside line.

The first ring should energize *K1* and extinguish *LED1*. Pick up the receiver to stop the ring. The relay should remain energized for the length of time you set Timer B for. When the counter times out, the relay should deenergize and *LED1* should light once again.

Now switch to Mode A. Ring the phone again, but this time ring once or twice, hang up and ring again. On the first ring of the first call, *LED1* should extinguish, but the relay should not energize. On the first ring of the second call, the relay should energize. If all is okay up to this point, decide how to configure your equipment.

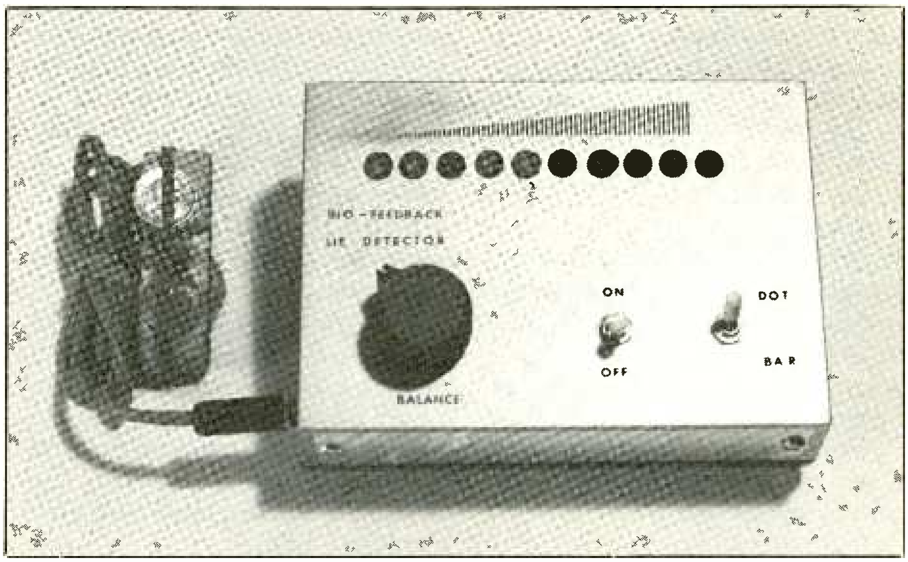
Once you have determined that the project is operating as it should, you can put it into service. Several suggested configurations for use of the Ring Director with common types of telephone-related equipment are detailed in the box titled Suggested Configurations.

Before closing, it is only fair to point out that this circuit has limitations. For example, it does not count the number of rings during a call, just the number of calls made within the Timer B countdown period. (If you wish to have this capability, see the Note at the end of the Parts List for a Ring Counting Microcontroller kit.) If a call is received just after another within the 60-second countdown period, the Ring Director considers the second call to be a ringback condition and switches the controlled device.

To limit such occurrences, you can reduce the countdown period of Timer B to 30 seconds. This still makes it possible to place a second call within 30 seconds to generate an intentional ringback condition, while it reduces the the possibility of such a condition from occurring inadvertently.

Biofeedback Monitor & Lie Detector

Device helps train you in controlling autonomic responses and doubles as a basic lie detector



By John Iovine

Biofeedback devices help train one to control such autonomic responses as brainwave activity, heart rate, blood pressure, body temperature and tension level. Proper training for accomplishing this requires use of an electronic device that monitors one or more body functions and reports physiology changes in real time. With such a "feedback" device to monitor reactions, one can strive to consciously control an autonomic function by changing the response of the device.

Numerous types of biofeedback devices are on the market. Each has its own advantages and disadvantages. Most common, however, is the biofeedback unit that monitors galvanic skin resistance (GSR). This is the type of device used in the Biofeedback Monitor/Lie Detector described here. Since galvanic skin resistance is a good indicator of stress level in the subject, the project is also useful as a lie detector.

Simple to build and use, our Biofeedback Monitor/Lie Detector employs a simple arrangement of color-coded light-emitting diodes to report biological responses to the user. The LED display can be operated in either bargraph or single-dot mode.

About the Circuit

The circuitry for the Biofeedback Monitor, shown schematically in Fig. 1, consists of two sections. The front-end biofeedback section is made up of operational amplifier *IC1* and the resistance bridge composed of fixed resistor *R1*, potentiometer *R2* and the resistance across the electrodes plugged into jack *J1*. The back end of the circuit consists of *IC2* and a series of 10 color-coded light-emitting diodes, shown as *LED1* through *LED10*.

The LED array that serves as the display for the project can be operated in either bargraph or moving-dot mode. Mode selection is via *S2*. Bargraph mode lights all LEDs successively and keeps them on to display an easy-to-interpret bar of light that lengthens and shortens with the magnitude of the input applied to *IC2*. Dot mode, on the other hand, lights only one LED, depending on the magnitude of the signal input to *IC2* at any given time. It is the position and color of the lighted LED in the display that tells you the magnitude of the input signal to *IC2*.

An important advantage of this galvanic-resistance device is that op amp *IC1* requires only a single-ended 9-volt power supply. This simplifies power requirements, though an additional 1.5-V AA cell, shown as *B1* is required to supply power to the resistance bridge separately from the main power provided by *B1*.

Circuit operation is straightforward. The electrodes plug into *J1* and you place the palm of one hand across the electrodes. The galvanic resistance across your palm becomes part of the bridge. Balancing of the bridge is accomplished with potentiometer *R2*. This is done at the start of a

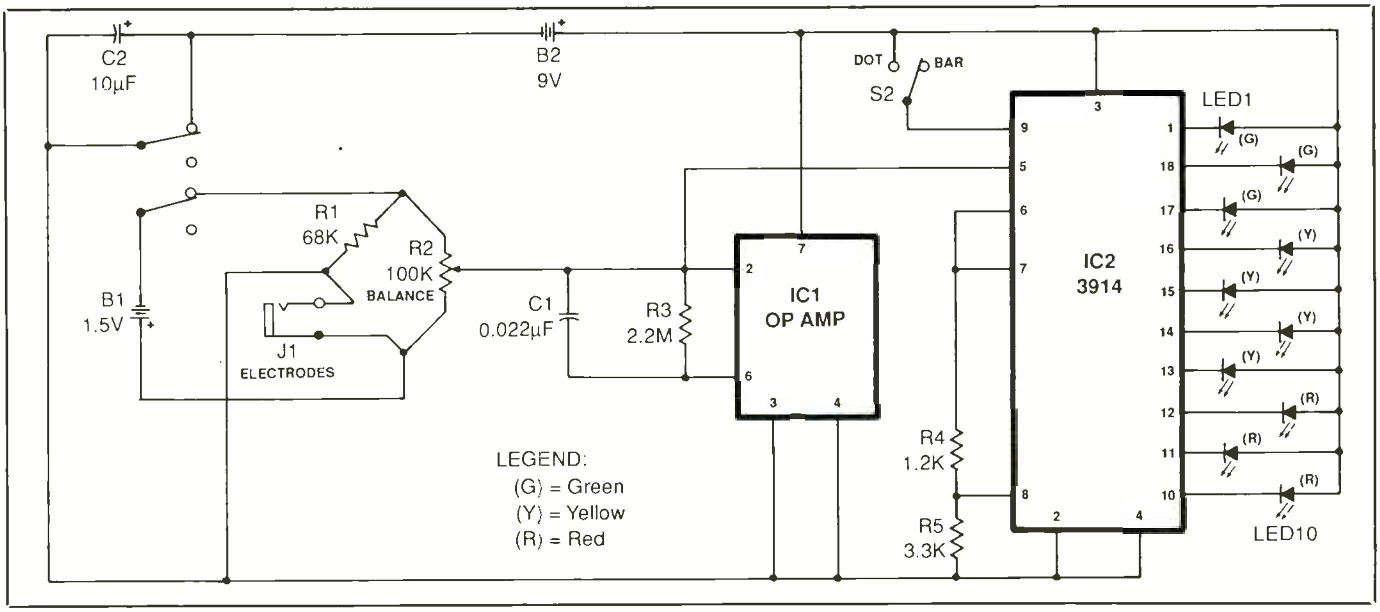


Fig. 1. Complete schematic diagram of circuitry used in Biofeedback Monitor/ Lie Detector.

session. Any leds that light or turn off thereafter are an indication that galvanic resistance is changing in response to a stimulus.

The output of the bridge goes to INPUT pin 1 of *IC1*. This op amp is set up as a differencing amplifier. Therefore, once the bridge is balanced, it amplifies any minor change in the subject's resistance.

The output of *IC1* drives *IC2*. This 3914 chip "reads" the voltage from the op amp and converts it into a digital signal or signals that light the appropriate LEDs.

Construction

As you can see in Fig. 1, the circuit is fairly simple. There is also nothing critical about component layout and lead/conductor routing. Therefore you can use any method of assembly that suits you. For example, you can design and fabricate a printed-circuit board on which to assemble the circuit. Alternatively, you can use a piece of perforated board that has holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever way you go, however, it is a good idea to use sockets for the ICs.

PARTS LIST

Semiconductors
IC1—CMOS operational amplifier (see Note below)
IC2—3914 bar/dot display driver
LED1,LED2,LED3—Green jumbo light-emitting diode
LED4 thru LED7—Yellow jumbo light-emitting diode
LED8,LED9,LED10—Red jumbo light-emitting diode

Capacitors
C1—0.022-µF ceramic disc or polyester
C2—10-µF, 16-volt electrolytic

Resistors (¼-watt, 5% tolerance)
R1—68,000 ohms
R3—2.2 megohms
R4—1,200 ohms
R5—3300 ohms
R2—100,000-ohm linear-taper panel-mount potentiometer

Miscellaneous
B1—1.2-volt alkaline AA cell
B2—9-volt alkaline battery
J1—Panel-mount phone jack
P1—Phone plug to match J1
S1—Dpdt slide or toggle switch
S2—spst slide or toggle switch
Printed circuit board or perforated board with holes on 0.1" centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosure (see text); wood block; holders for B1 and B2; snap connector for B2; two dimes; shielded cable; Velcro strap or large rubber band (see text); heat-shrinkable or plastic tubing; lettering kit; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Images Co., P.O. Box 313, Jamaica, NY 11419: 3914, $4.00 and CMOS op amp, $3.50. Add $2.50 P&H. New York residents, please add state sales tax.

Wire the circuit board in the usual manner. That is, start by installing the IC sockets and then proceed to mounting the resistors and capacitors. If you are using a pc board, make sure to properly polarize *C2* before soldering its leads to the copper pads on the bottom of the board.

Assuming you are assembling your project on perforated board, mount each component (again, except for the ICs themselves) in appropriate locations. Then refer to Fig. 1 for wiring details.

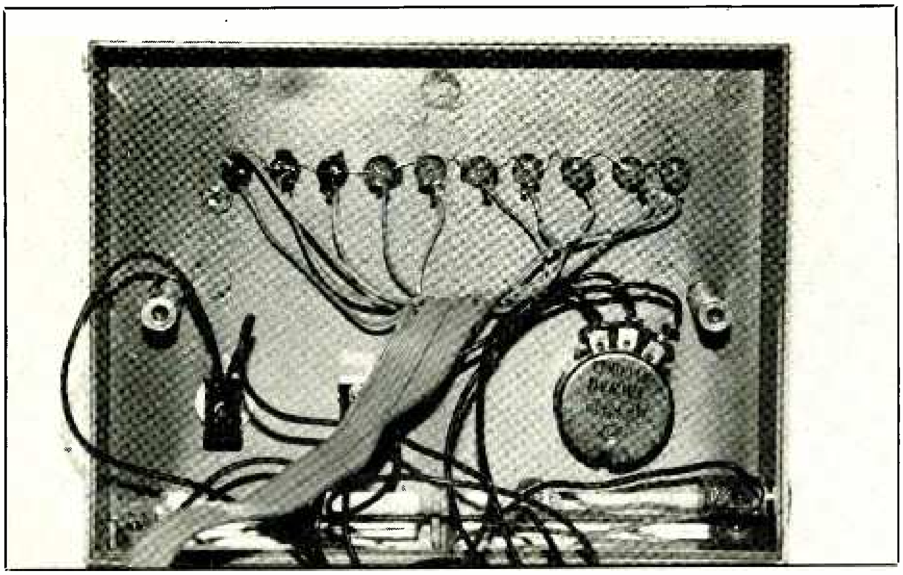


Fig. 2. LEDs, switches and potentiometer control mount on top panel of enclosure.

Off-the-board components include the 9-volt battery, AA cell, switches, jack, potentiometer and LEDs. Therefore, solder into place suitable lengths of hookup wire for these components (except the 9-volt battery, for which you will install a standard snap connector). If you use stranded wire, tightly twist together the fine conductors at both ends and sparingly tin with solder before installing the wires. If you wish, you can use a length of ribbon cable for interconnecting the LEDs and circuit-board assembly.

You can use any type of enclosure that will comfortably accommodate the circuit-board assembly and holders for *B1* and *B2* and has adequate panel space on which to mount the LEDs, switches and potentiometer. Machine the enclosure as needed (see lead photo for suggested panel layout). Drill mounting holes for the circuit-board assembly and battery holders through the floor of the enclosure.

When you are finished machining the enclosure, deburr all holes drilled through metal to remove sharp edges. Then label the panels with appropriate legends. If you use a dry-transfer lettering kit for this, protect the labels with two or more light coats of clear acrylic spray. Allow each coat to dry before spraying on the next.

Mount the switches and potentiometer on the top panel and ELECTRODE jack on an end panel. Place a pointer-type control knob on the shaft of the potentiometer.

Identify the cathode lead of all LEDs and clip these to ½ inch long. Slip a 1-inch length of heat-shrinkable or other insulating tubing tubing over the free ends of the 10 LED wires coming from the circuit-board assembly. Then solder the wires to the cathode leads of the individual LEDs. Take care to use the right color LED in each case. Slide the tubing over the connections until it is flush with the bottoms of the LED cases and shrink solidly into place.

Mount the LEDs in their respective holes in the top panel of the enclosure. If possible, use panel-mount clips for the LEDs. Otherwise, secure the LEDs in place with small rubber grommets. Make sure to mount each LED in its appropriate hole.

Next, clip the anode leads of all LEDs to a length of ½ inch and form a small hook in each remaining lead stub. Crimp the individual anode-lead stubs to a length of bare bus wire and solder each crimped connection. Referring to both Fig. 1 and Fig. 2, terminate the free end of the wire coming from the V+ bus on the circuit-board assembly at the end of the bus wire. Then gently bend the entire assembly away from the LEDs so that it does not interfere with or touch any portion of the circuit—especially the enclosure if it is metal.

Refer back to Fig. 1 and wire together the rest of the circuitry. Then

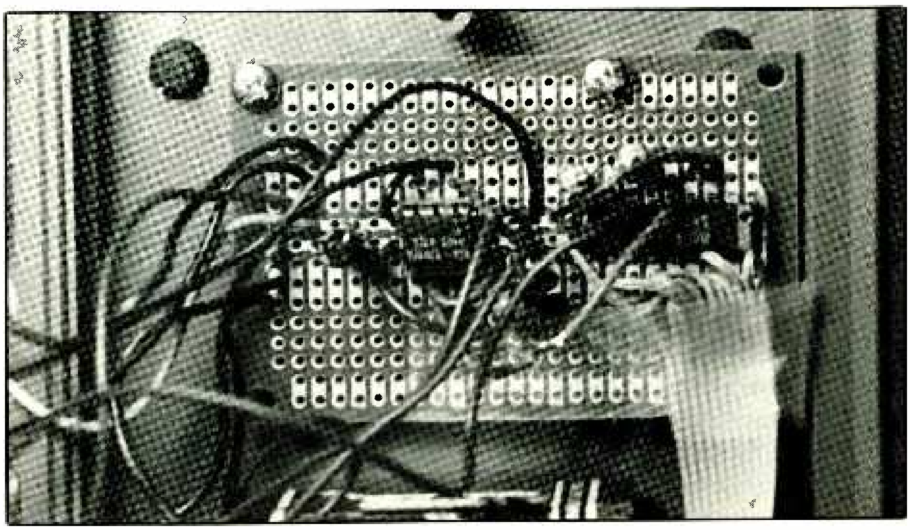


Fig. 3. Author's prototype was wired on perforated board, using ribbon cable to interconnect to LEDs on top panel of enclosure.

use ½-inch spacers and suitable machine hardware to mount the circuit-board assembly to the floor of the enclosure (see Fig. 3). Also, mount the battery holders to the floor of the enclosure with machine hardware. Place a fresh AA cell in the *B1* holder and snap a fresh 9-volt battery into the snap connector and place the battery in the *B2* holder. When you are done, your finished project should look much like that shown in Fig. 4.

Checkout & Final Assembly

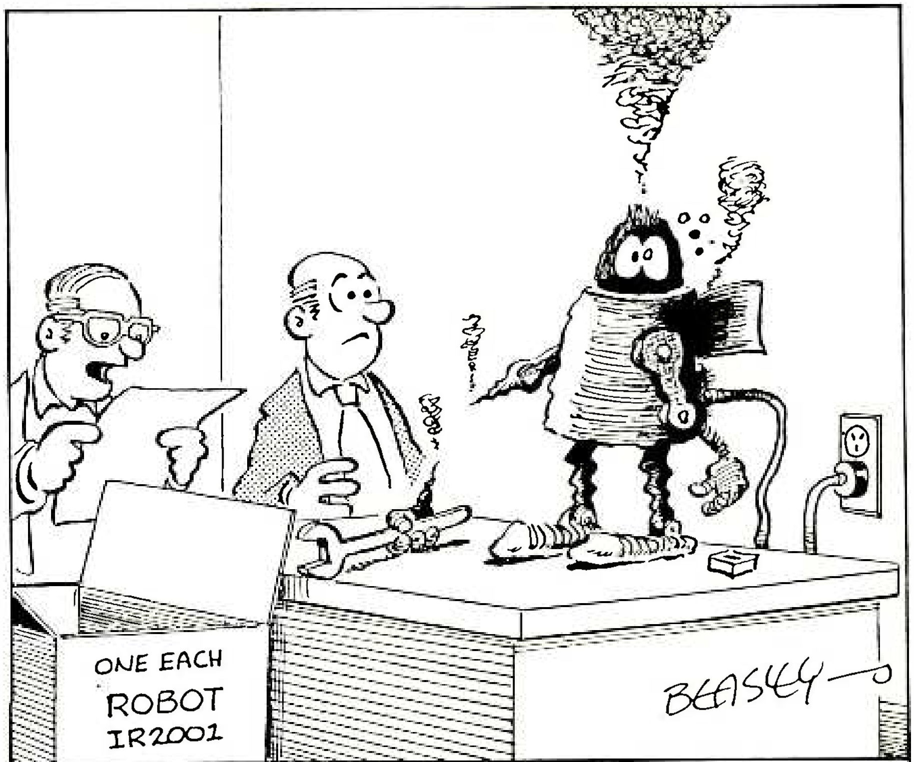
With no ICs in the sockets on the circuit-board assembly, connect the common lead of a dc voltmeter or multimeter set to the dc-volts function to any point in the circuit that represents the negative bus for the 9-volt power source.

Set *S1* to ON. Touch the "hot" probe of the meter to pin 7 of the *IC1* socket and pin 3 of the *IC2* socket and then to the common anode-lead junction for the LEDs. In all cases, you should obtain a meter reading of approximately +9 volts. If you do not obtain this reading at any indicated point, set *S1* to OFF and troubleshoot the circuit to correct the problem. Do not proceed until you have done so.

When you are certain that everything is okay, power down and plug the ICs into their sockets. Make sure each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets.

To test the circuit for proper operation, you must have some resistance connected across the electrodes. Otherwise, the LEDs will not light. So, begin your operational test by temporarily attaching a 50,000- to 100,000-ohm fixed resistor between the electrode connection points on the circuit-board assembly. The most convenient way to do this is with a pair of jumper/test cables.

Turn on the project and set *S2* to BARGRAPH. Adjust the setting of



THIS SAYS "GREETINGS, I AM A 120/240V INDUSTRIAL ROBOT--- BE SURE TO REMOVE SHORTING BUSS 'A' IF 240V OPERATION IS PLANNED"

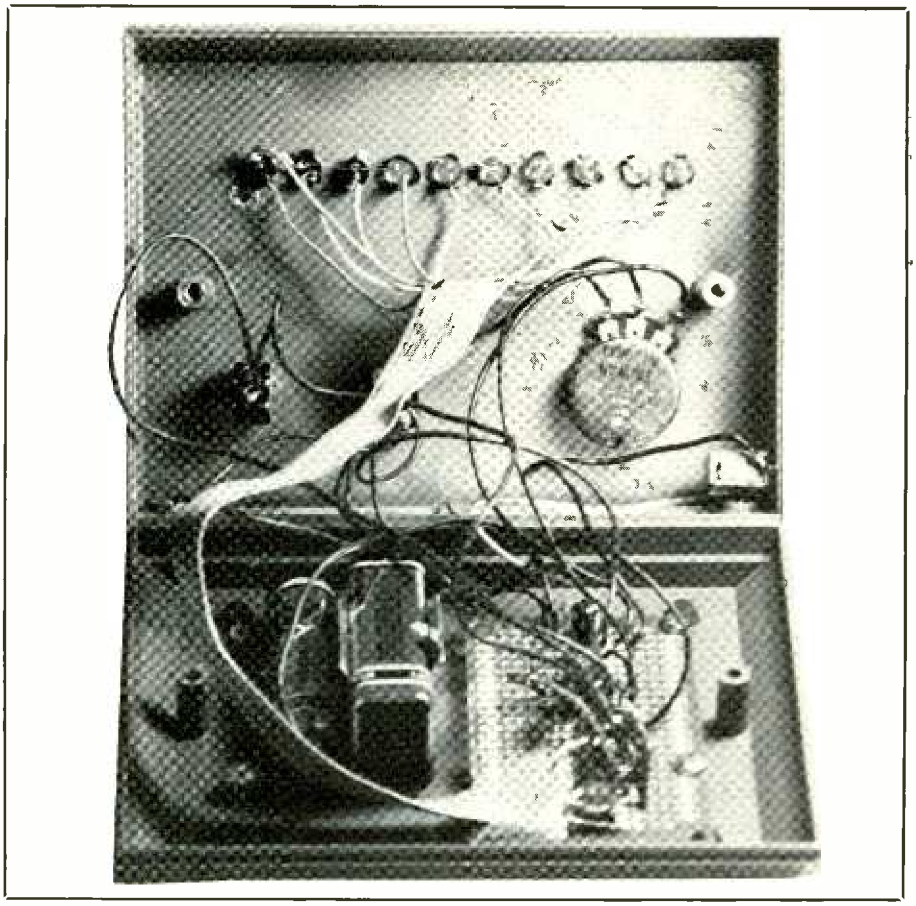


Fig. 4. Interior view of completed prototype.

BALANCE control *R2* to give a mid-range reading on the bargraph display (*LED1* through *LED5* or *LED6* lit). Now pinch both sides of the fixed resistor with the thumb and forefinger of each hand. This should cause higher-number LEDs to turn on as the resistor heats up and its resistance decreases. If fewer LEDs light instead, the polarity of the 1.5-volt cell in the bridge section is reversed. Remove it and replace it in the opposite direction.

Once you have the proper indication from the operational test, power down and remove the test resistor from the circuit.

Now fabricate the electrode assembly. The electrode contacts consist of a pair of dimes. To these must be soldered a cable whose other end terminates in a phone plug that mates with *J1* on the side of the project enclosure.

The cable used for the electrode assembly should be about 36 inches long and and contain two conductors and a shield. Carefully remove 1 inch of outer plastic jacket from one end and 2 inches from the other end. Then strip 3/8 inch of insulation from the inner conductors at both ends. Tightly twist together the fine wires of each inner conductor and shield at both ends and tin with solder.

Terminate one end of this cable in phone plug *P1* as follows. Crimp and solder one conductor and the shield to the "tip" lug and just the other conductor to the ring lug of the plug. Screw onto the plug the plastic barrel and temporarily set aside the cable.

Referring to Fig. 5, prepare a "platform" on which to mount the dime electrodes. Dimensions of this platform should be between 2½ and 3 inches across the top, about 4½ inches across the bottom, 1½ inches high and perhaps ¾ to 1 inch deep. Fabricate the platform from clear pine lumber, shaping it approximately as shown. Drill the hole through which the cable is to be routed so that it is just large enough for the cable.

Sand all surfaces of the platform so that they are very smooth. Then apply one or two coats of polyurethane or paint to seal the wood all over—except the surface on which the dimes will mount. Allow the polyurethane or paint to completely dry, preferably overnight.

When you are ready to proceed, route the unfinished end of the electrode cable through the hole so that it exits in the channel between the two peaks on the top of the platform. Strip an additional ⅛ inch of insulation from the ends of both conductors and solder the conductors to the dimes.

Soldering the cable conductors to the dimes can be a bit tricky. To do it properly, place the dime on a heatproof surface and hold the tip of your soldering iron on the dime until the coin becomes hot enough to melt solder on it—not between tip and dime. This takes a minute or longer of continuous heating.

When the dime is hot enough, melt a small puddle of solder on the coin. Then place the bare end of the cable conductor connected at the other end to the ring lug of *P1* in the molten solder. Remove the soldering iron from the coin without moving the conductor. Keep the conductor in place until the solder completely solidifies. Repeat for the other dime, but solder both shield and conductor to this coin. This will be the ground electrode.

When the connections have cooled to the touch, gently pull the cable back through the hole in the platform until there is just enough length to permit securing the dimes to the top surfaces of the platform. Cement the dimes to the tops of the platform, using hot-melt glue, silicone adhesive or epoxy cement.

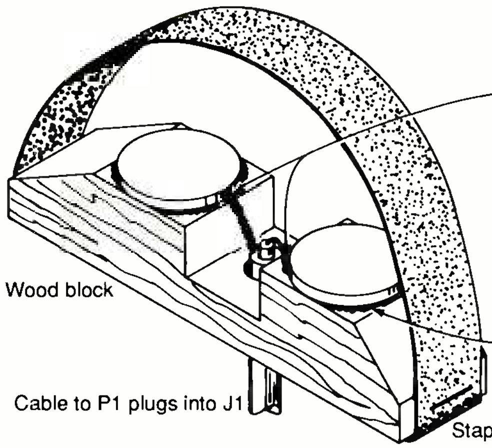


Fig. 5. Fabrication details for author's version of electrode assembly.

Finish up the electrode assembly by stapling or tacking a wide rubber band or Velcro® straps that can be adjusted as needed to the bottom of the platform. This will hold the electrodes firmly against the palm of the user's hand while the project is in use. The palm of the hand was the area of the body it was decided to monitor because it is very sensitive galvanic changes.

Using the Project

Attach the electrodes to your palm by slipping your hand between rubber band or Velcro loop and electrodes. Adjust the Velcro straps to provide a snug fit. Then turn on the project and adjust the setting of the BALANCE control so that the bargraph lights to approximately midway. You may notice that when making this adjustment that the LEDs jump very quickly when you reach balance; so use a light touch.

If you or a subject who is using the project is nervous, you may have to adjust for balance a few times until a relaxed state is achieved. When everything is stable, inhale quickly and exhale deeply (or have your subject do so). This should cause a momentary rise in the LED display that gradually returns to the previous level. If you get this result, the circuit is operating properly. If the opposite reaction occurs and the LED graph dips, the battery in the bridge section is reversed.

To use this device in a biofeedback mode for relaxation and reducing tension, set the BALANCE control to light the display as far as the upper one-third of its range. As you relax or reduce tension, your body's resistance increases. This will be seen as a gradual downward trend on the display as LEDs extinguish from the high to the low end of the range. When you reach the bottom of the range, adjust the BALANCE control to bring it back up and then try to bring it down again.

To use the project as a lie detector, set the BALANCE control so that the LEDs in only the lower third of the display are lit. Stress causes a decrease in body resistance, which results in more LEDs lighting in the display. Bear in mind that there is a delay of approximately 1.5 seconds between question and response. Also, keep in mind that this device is for entertainment purposes only. Even full-fledged lie detectors are fallible. So it could be the nature of the question regardless of the answer that can cause a stress reaction.

Darkroom Exposure Meter

Battery-powered device reduces waste in the photographic darkroom by improving the yield of usable prints

By Maurice P. Johnson

Anything that reduces waste in the photographic darkroom is welcome. The Darkroom Exposure Meter described here is just such an item. It saves on the cost of consumables by improving the yield of usable prints and enlargements. This handy little device is simple in design and to use. Powered by a common 9-volt battery, it is sure to be reached for whenever self-contained operation is desired.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry contained in the Darkroom Exposure Meter. The circuit is built around low-current operational amplifier *IC1* (the active element), cadmium-sulfide (CdS) photocell *PC1*, BALANCE control *R1* and light-emitting diodes *LED1* and *LED2*.

The sensor in this circuit is *PC1*, a photocell whose resistance is a function of the intensity of the light reaching its active element. The photocell, BALANCE control *R1* and fixed resistors *R2*, *R3* and *R7* make up a bridge circuit. Opposite sides of the bridge feed into input ports located at pins 4 and 5 of *IC1*.

The output of *IC1* at pin 10 drives parallel-connected *LED1* and *LED2*. These LEDs make up a convenient and accurate display for the Meter.

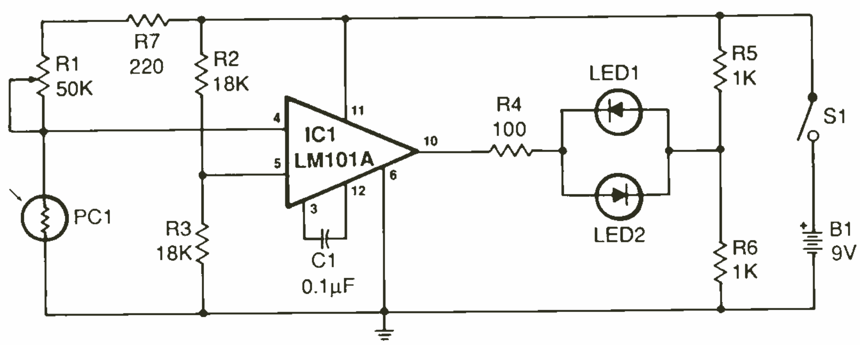
Battery *B1* is all that is needed to power the op amp, even though the latter requires a dual-polarity power source for proper operation. To obtain the positive and negative voltages required for *IC1*, a voltage divider network made up of equal-value resistors *R5* and *R6* is used. This arrangement provides equal-value positive and negative voltages with respect to circuit common at the junction formed by *R5* and *R6*.

Resistor *R4* provides current limiting for the LEDs when driven by *IC1*. The other ends of the LEDs connect to the junction of *R5* and *R6* to provide "flip-flop" display action.

Use of light-emitting diodes for the display of the Darkroom Exposure Meter is more convenient than an analog or digital-numeric because they require no additional illumination for monitoring. Additionally, LEDs are considerably less expensive than other traditional metering devices. In this application, the LEDs give a precise indication of bridge balance condition.

Construction

There is nothing critical about component layout or conductor routing. Therefore, you can use any traditional wiring scheme to build the Darkroom Exposure Meter. If you wish, you can fabricate a printed-circuit board on which to mount and wire together the components. Alternatively, you can use perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware. Whichever technique you use, though, it is a good idea to include a socket for *IC1*.



PARTS LIST

Semiconductors
IC1—LM101A or LM301 operational amplifier (see text)
LED1,LED2—Red light-emitting diode

Capacitors
C1—0.1-μF, 250-volt Mylar

Resistors (¼-watt, 10% tolerance)
R2,R3—18,000 ohms
R4—100 ohms
R5,R6—1,000 ohms
R1—50,000-ohm, panel-mount, linear-taper potentiometer

Miscellaneous
B1—9-volt alkaline battery
PC1—Cadmium-sulfide (CdS) photocell (see text)
S1—Normally-open spst pushbutton or spring-action toggle switch
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); suitable enclosure (see text); DIP socket for IC1; small-diameter heat-shrinkable or other insulating plastic tubing; fast-set epoxy cement; double-sided foam tape; battery clip (optional—see text); dry-transfer lettering kit; clear spray acrylic; machine hardware; hookup wire; solder; etc.

Fig. 1. Complete schematic of Darkroom Exposure Meter circuitry.

Fabricate the pc board using the actual-size artwork shown in Fig. 2. PC construction reduces the chances of wiring errors and permits the assembly to be mounted inside a 4.75 × 2.5 × 1.5-inch Radio Shack Cat. No. 270-222 project box that has a volume sufficient to house the circuit-board assembly on the underside of the top panel and the battery on the floor and adequate space on which to mount the switch, control, LEDs and photocell.

Wire the pc board exactly as shown in Fig. 3. If you elect perforated-board construction, use Fig. 3 as a component layout/spacing guide.

Begin wiring the board by installing and soldering into place the IC socket. (Note: The pc board is designed to accommodate either the 14-pin LM101A op amp or the eight-pin LM301. If you opt for the latter, use an eight-pin socket.) Do *not* plug the IC into the socket until after you perform voltage checks and are certain that the board has been properly wired. Then install and solder into place the fixed resistors and capacitor.

The CdS photocell selected for *PC1* should have a response peaked in the visible-light range (around 5,500 angstroms) with minimum infrared response. Its dark-to-light ratio should be about 100:1, and its viewing window should be about 0.25 inch. The resistance range of the selected photocell should be checked with the enlarger illumination it will encounter in actual use. Use an ohmmeter to check cell resistance with the brightest light level from the enlarger, perhaps for making 4 × 5-inch prints. Then measure cell resistance in a dense negative corner at maximum projected image size.

The Vactec VT200 series of photocells is suitable for this application. Vactec photocells are available from Newark and Allied Electronics, among others. They will most likely be well within the required light and dark resistance values. For example, a cell rated for a dark resistance of 500,000 ohms may range from only 30,000 to 500 ohms under the light levels put out by the enlarger.

Once this useful range has been determined, you can install and solder into place the photocell in the PC1 location on the circuit-board assembly. Leave the leads of the cell full length. If you wish, you can slide lengths of insulating plastic tubing over each lead before installation.

Strip ¼ inch of insulation from both ends of four 4-inch lengths of hookup wire. If you are using stranded wire, tightly twist together the fine conductors at all ends and sparingly tin with solder. Plug one end of these wires into the holes for *R1* and *S1* and solder into place.

Plug the leads of the LEDs into their respective holes, with the cathode leads in the holes identified with a K near them in the Fig. 3 wiring guide. Note that the LEDs mount on the copper-trace side of the board. Adjust the heights of the LEDs from the board so that the lips around the bases of their cases is at the same height as the potentiometer used for *R1* plus $\frac{1}{16}$ inch to permit them to fit into the holes that will be drilled in the top panel of the enclosure.

Double check to make certain that the LEDs are mounted in their respective locations in the proper orientations. They should be wired in parallel in opposite polarity.

If the exposed wires of the battery snap connector are loose, tightly twist them together and sparingly tin with solder. Plug the free ends of the conductors into the B1 holes, red-insulated conductor into the B1+ hole and black-insulated conductor into the B1− hole. Solder both conductors into place.

Now machine the enclosure in which the project is to be housed. Drill a ⅜-inch-diameter hole near the center of the top panel for mounting BALANCE control *R1*. Then drill mounting holes ½ inch in from the short edges and along the center axis of the panel for POWER switch *S1* and photocell *PC1*. Size these holes for the components selected.

Details for machining the top panel of the specified Radio Shack enclosure are given in Fig. 4. Size all holes according to the demands of the components being used. If you use any enclosure other than the specified one, maintain the hole orientations and spacings shown in Fig. 4. If you use a metal enclosure or drilled holes through a metal panel, deburr the holes to remove sharp edges.

Mount the BALANCE control in its hole and secure it in place with the provided hex nut and lockwasher. If you are using a battery clip to secure *B1* to the floor of the enclosure, mount it into place at this time with machine hardware.

Mount the POWER switch in its hole. (This switch can be an ordinary miniature pushbutton type or a miniature spring-return toggle type.) Crimp and solder the free ends of the wires coming from the holes labeled S1 on the circuit-board assembly to the lugs of the POWER switch. Snap a fresh 9-volt battery into the connector.

Now, use a dc voltmeter or multimeter set to the dc-volts function to make preliminary voltage checks. Clip the meter's common lead to the negative (−) side of the battery. Touch the "hot" probe of the meter to the junction between *R5* and *R6*

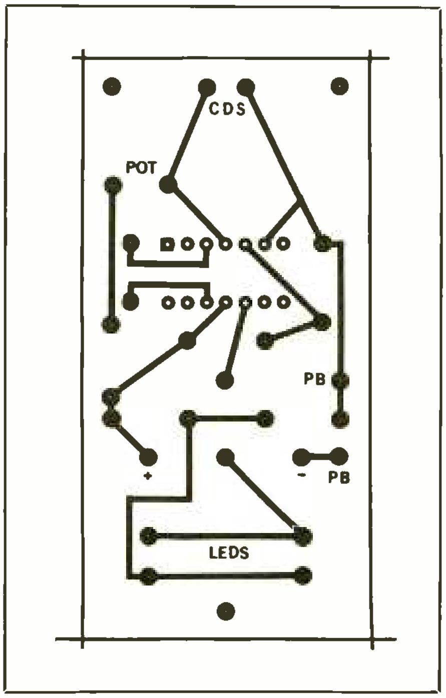


Fig. 2. Actual-size fabrication guide for project's pc board.

and note that the reading is approximately +4.5 volts. Then touch the "hot" probe to IC socket pin 11; this time, the meter reading should be approximately +9 volts.

If you fail to obtain the proper reading in either or both cases, first check to make sure the battery is fresh. If it is, power down the circuit and rectify the problem before proceeding.

Once you are certain that the project is properly wired, turn off power and install the LM101A or LM301 op amp in the *IC1* socket. Make sure the IC is properly oriented and that no pins overhang the socket or fold under between IC and socket.

Cut a 1-inch-square piece of double-sided foam tape and remove the protective strip from one side. Secure the exposed side to the rear of the BALANCE control. Place a pointer-type knob on the shaft of this control and rotate it through the full range of the control. If the center point in the travel arc does not point directly to the center of the hole for

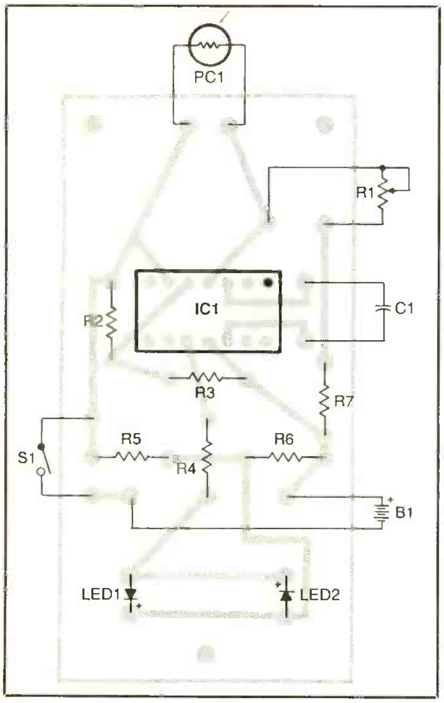


Fig. 3. The wiring guide for the printed circuit board.

the photocell, remove the knob and readjust the position of the control until it is.

Mark the locations to which the pointer on the knob points at minimum and maximum setting of the BALANCE control. Then divide the range into, say, 10 equal parts, making a mark at each of the remaining nine locations to which the pointer points. You now have the option of labeling the panel at each point with a numeral from 1 to 10 or 10 or 1 to 100 in increments of 10, as was done with the commercial calibration ring shown under the control knob in the lead photo.

Use a dry-transfer lettering kit to label the panel at the marked locations. Remove the knob from the shaft of the control and protect the control by wrapping it with masking tape. Spray two or more *light* coats of clear acrylic over the lettering to protect it. When the acrylic has completely dried, remove the masking tape and return the knob to the shaft of the control.

Crimp and solder the free ends of the wires coming from the R1 holes in the circuit-board assembly to the lugs of the BALANCE control. Plug the domes of the LEDs into the holes you drilled for them.

Remove the protective strip from the other side of the double-sided foam tape on the BALANCE control and carefully position the copper-trace side of the board against the exposed mastic, pushing it solidly into place. Then secure the photocell in its hole with a small bead of fast-setting epoxy [illegible]. Make sure not to get any cement on the front window of the photocell. Your project should look like the one shown in Fig. 5.

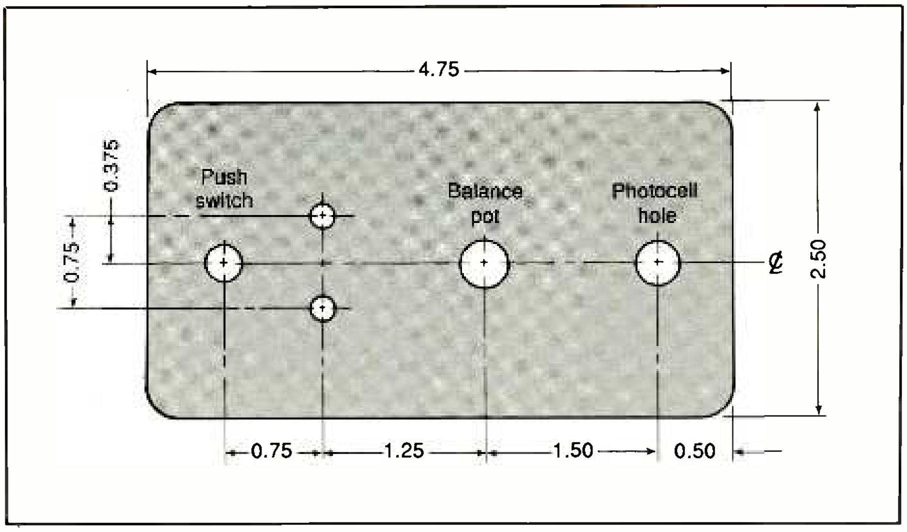


Fig. 4. Machining template for top panel of enclosure specified in text.

Calibration & Use

Your Darkroom Exposure Meter operates by measuring the intensity of the light coming from an enlarger as it appears at the easel when projecting a negative. The project is equally useful for contact printing if projected light from the enlarger is used as the exposure source.

Initial "calibration" is required for the Darkroom Exposure Meter, after which the project functions as a comparator device. As in color printing, the procedure is based upon establishing an exposure time that is always used, regardless of the density of the negative and changes in projected image size. This will typically be over a period of 10 to 20 seconds.

You can arrive at a satisfactory print by adjusting the lens F-stop on the enlarger, perhaps by using a trial-and-error method of making a series of 4 × 5-inch prints. Best results may be obtained with the lens set at, say, F-16. If necessary, change the time period until a satisfactory print is made with the lens well stopped down.

From now on, this exposure time will always be used when making a print at the test F stop. If a more dense negative is printed, the lens can be opened slightly to give a satisfactory print with the same exposure time. When making larger prints—5 × 7- or 8 × 10-inch, for example—open the lens until the standard exposure time again results in satisfactory prints.

Once you have produced a satisfactory print by trial and error, place the Darkroom Exposure Meter on the easel in a location where the light from the projected image falls on the photocell. Then adjust the BALANCE control until the conditions of the LEDs indicate a balanced condition. This is when both LEDs are extinguished or the flip-flop action occurs at a rate of several or more seconds.

Note and record the setting of the

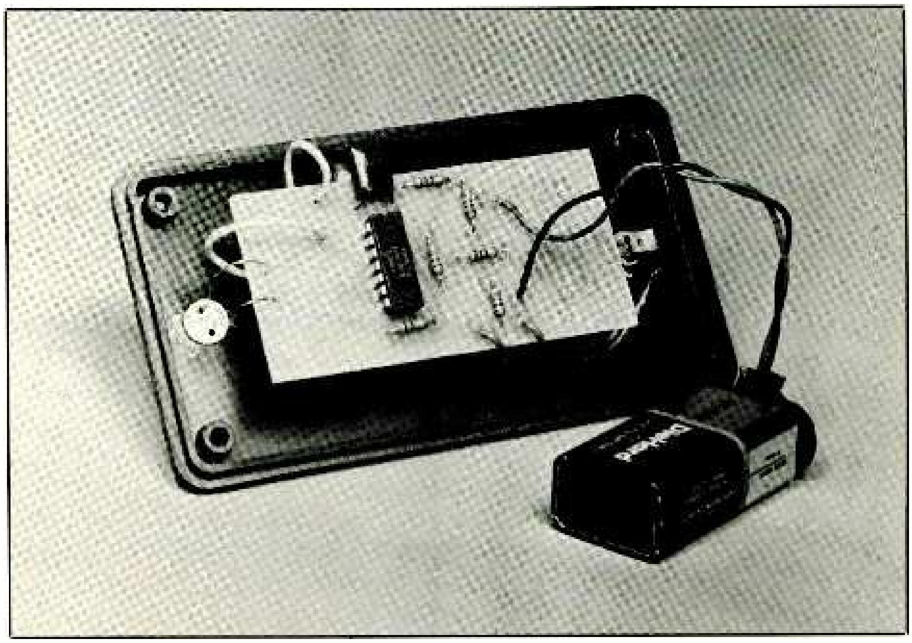


Fig. 5. Interior view of project wired on pc board. All components, except battery, mount to top panel of project-box enclosure.

BALANCE control. This will permit you to return to the same control setting whenever a print is to be made on a particular paper. This is all the "calibration" required for the project. Of course, if you use other print paper or even print paper from another batch or different enlargers, you may have to readjust the setting of the BALANCE control.

With the Darkroom Exposure Meter, two general measurement approaches are possible—spot and integrated (or "scrambled"). Both are useful under different circumstances.

Since the aperture of the photocell is considerably smaller than the projected image area, it is possible to position the photocell in the spot mode in a portion of the projected image that represents some specific density. For example, in an almost-clear region of the negative the resulting print will be blackest.

If similar areas are metered from one negative to another, prints that result will have similar densities in these areas. Alternatively, areas that represent an average gray can be used for spot reference.

Metering a similar region from one negative to another will always produce prints where these areas have the same density from print to print. Remember that only the lens opening of the enlarger is to be adjusted to keep the intensity of the image at the same level as "read" by the Darkroom Exposure Meter.

In integrated mode, you determine correct exposure by averaging the entire area, rather than selected small areas, of the projected image. Since the photocell "sees" a small portion of the projected image at any given location in which it is placed, some method of averaging the light before it strikes the photocell is required.

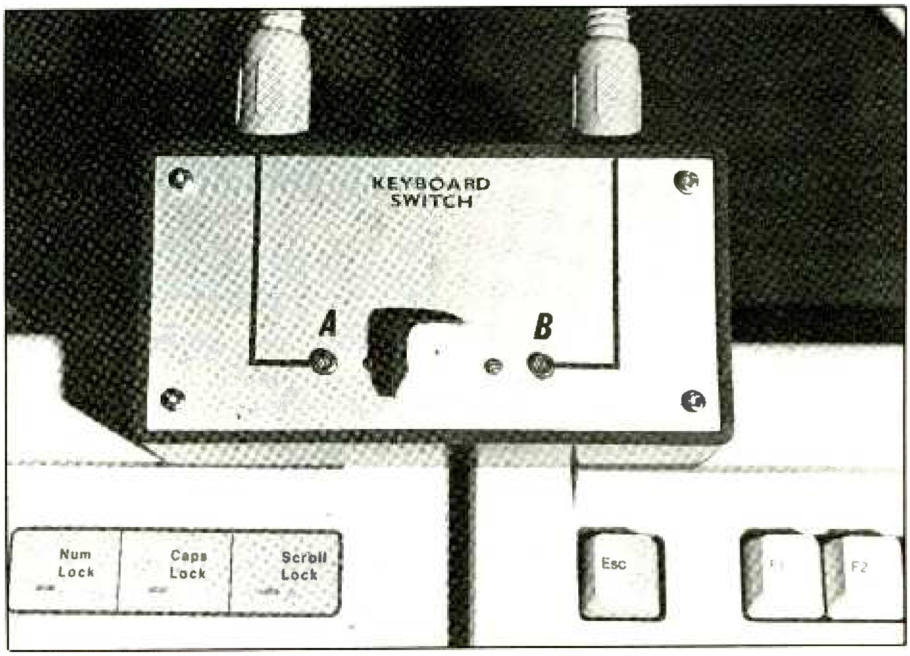
This is readily accomplished by inserting a translucent filter (used only during the measuring process) under the lens of the enlarger. The filter "scrambles" the image into a uniform gray average across the projected area with a no-longer-recognizable image. Doing this makes it possible for you to sample an averaged light level with the Darkroom Exposure Meter.

The filter introduces some insertion loss in the light path. However, this loss will always be taken into account by the measurement. Therefore, it is self-compensating when making measurements from one negative to another. This method of measuring has found wide application in exposure of color printing materials. It is equally useful for printing in black and white. ME

Electronic AB Switch For PC Keyboards

Electronically switches between two keyboards while keeping both keyboards powered at all times

By Adolph A. Mangieri



An AB data switch box allows a user to select between two printers or other peripherals by turning a knob. Commercial boxes include two-station (AB), three-station (ABC) and four-station (ABCD) units that provide selection with mechanical rotary switches that transfer all conductor lines of the connecting cables. With such an arrangement, peripherals that obtain power through the connecting cable, such as programmable PC keyboards, are undesirably powered down when not selected. This results in a loss of internally stored parameters. The solution to this problem is the Electronic AB Data Switch presented here.

Our Electronic AB Switch allows you to select one of two IBM PC or compatible keyboards going to a single computer. The project automatically boots up with main keyboard, designated "A," active. Transfer between keyboards is accomplished by pressing a keyswitch on the project's enclosure or with a remote keyswitch that permits transfer from either keyboard position. Because only keyboard data and clock signal lines are switched, both keyboards remain powered at all times, retaining individually programmed keyboard typematic rate and key repeat delay time of the programmable AT keyboard.

Ideally suited for frequent transfer between keyboards, the Electronic AB Switch was originally developed for playing board games like computer chess so that each player could be comfortably seated at his own keyboard. For cursor-intensive applications, such as paint and draw programs, you can program your main AT keyboard for rapid cursor action and an auxiliary keyboard for slow cursor action and reap the benefits of both actions. Of course, you will need another keyboard, in addition to the one you now have, to use the project. This should cost you about $50.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the circuitry employed by the Electronic AB Switch. Plug *P1* plugs into the jack on your computer that accommodates the keyboard. The +5-volt line at pin 5 of plug *P1* passes through fuse *F1* and powers the circuit and two keyboards plugged into sockets *S01* and *S02*. The DATA and CLOCK lines of the programmable AT-class keyboard are bidirectional.

When you turn on your computer, DOS checks and initializes the programmable keyboard by sending information to the keyboard. Pressing a key on the keyboard sends information to the computer, requesting an interrupt for keyboard service. The

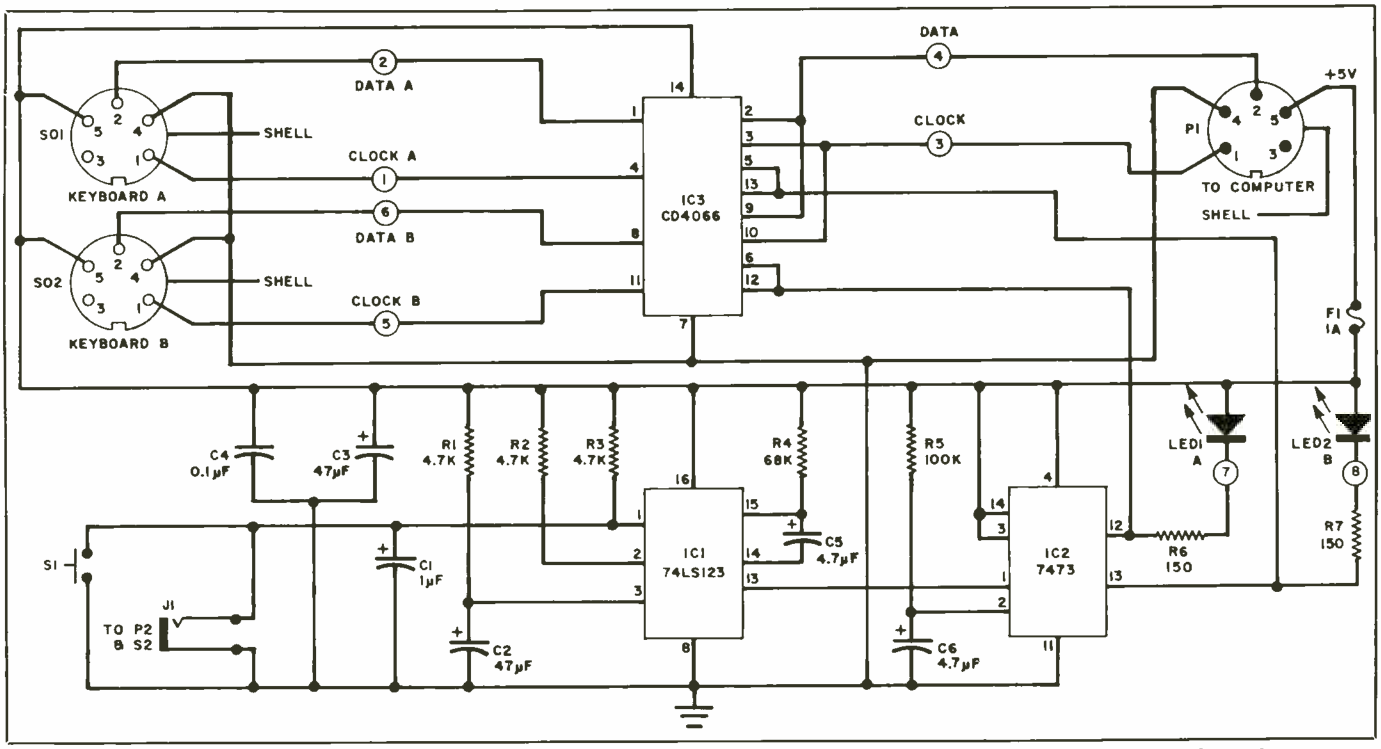


Fig. 1. Complete schematic diagram of the circuitry used in the Electronic AB Switch for two keyboards.

computer acknowledges the interrupt and inputs data from the keyboard to identify the key closure and take further action.

Quad bilateral switch *IC3* is a CMOS device that contains four electronic analog on-off switches. These switches transmit data in either direction. Inside this IC, field-effect transistors (FETs) are used as transmission gates. For the uppermost switch, pins 1 and 2 are the switch input/output terminals that correspond with the source and drain terminals of the FET, while pin 13 is the control gate terminal. The FET switches on when pin 13 is pulled up to +5 volts and switches off when this pin is pulled to near ground potential.

The on resistance of the switch is 80 to 250 ohms, reflecting the resistance of the channel of the FET. This is sufficiently low to preclude degradation of the low-current signals. The off resistance of the switch is in excess of 50 megohms, or essentially open-circuit. The upper paired switches in *IC3* are controlled by input at pins 5 and 13 forming a double-pole single-throw switch. Similarly, the lower paired switches are controlled by input at pins 6 and 12. The control signals driving the switches are in opposition, causing the IC to function as a double-pole double-throw solid-state switching arrangement.

JK flip-flop *IC2* has Q and not-Q (inverted Q) outputs that control the switch pairs of *IC3*. The flip-flop is toggled by applying a clock pulse at input pin 1. On power up, capacitor *C6* briefly holds CLR (clear) input pin 2 low, which forces the Q output low and not-Q output high. As a result, the upper *IC3* switch pair closes and selects keyboard "A," which is connected to socket *SO1*. With the Q output low, the lower *IC3* switch pair is open and, thus, disconnects keyboard "B." Under these conditions, Keyboard A *LED1* lights to indicate that that keyboard A is active.

Integrated circuit *IC1* debounces keyswitch *S1* and supplies a clean one-shot pulse that toggles JK flip-flop *IC2*. On power up, capacitor *C2* briefly holds CLR input pin 13 low. When *S1* is pressed, the high-to-low voltage transition at pin 1 initiates a positive-going one-shot pulse as the pin 13 Q output. The output pulse goes high for a period of time that depends on timing resistor *R4* and timing capacitor *C5*. The one-shot pulse simultaneously debounces *S1* and toggles *IC2*. Jack *J1* accepts a cable terminated at one end in plug *P2* and at the other end in keyswitch *S2*.

Construction

As shown in Fig. 2, the Electronic AB Switch can be wired on perforated board with holes on 0.1-inch centers using suitable Wire Wrap or soldering hardware. It can be housed inside a standard plastic project case that measures 5 × 2⅝ × 1¾ inches. Figure 3 shows the back of the device. No observable television interference (TVI) resulted from use of the plastic enclosure, but you can use a metal enclosure to minimize any radio-fre-

PARTS LIST

Semiconductors
IC1—74LS123 monostable multivibrator
IC2—7473 JK flip-flop
IC3—CD4066 quad bilateral CMOS switch
LED1,LED2—15-mA light-emitting diode

Capacitors (25-WV)
C1—1-μF tantalum electrolytic
C2,C3—47-μF electrolytic
C4—0.1-μF ceramic
C5—4.7-μF tantalum electrolytic
C6—4.7-μF electrolytic

Resistors (¼-watt, 5% tolerance)
R1,R2,R3—4,700 ohms
R4—68,000 ohms
R5—100,000 ohms
R6,R7—150 ohms

Miscellaneous
F1—1-ampere 3AG fast-blow pigtail fuse
J1—Miniature phone jack
P1—5-pin DIN male connector
P2—Miniature phone jack
S1,S2—Spst normally-open, low-bounce keyswitch
SO1,SO2—Chassis-mount 5-pin DIN-type female connector
Printed-circuit board or perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware (see text); sockets for all ICs; push-in board terminals; bus strips; microphone or other shielded cable (see text); suitable enclosures (see text); 6- to 8-lug terminal strip; 4-conductor shielded cable or keyboard extension cable (see text); dry-transfer lettering kit; clear spray acrylic; machine hardware; hookup wire; solder; etc.

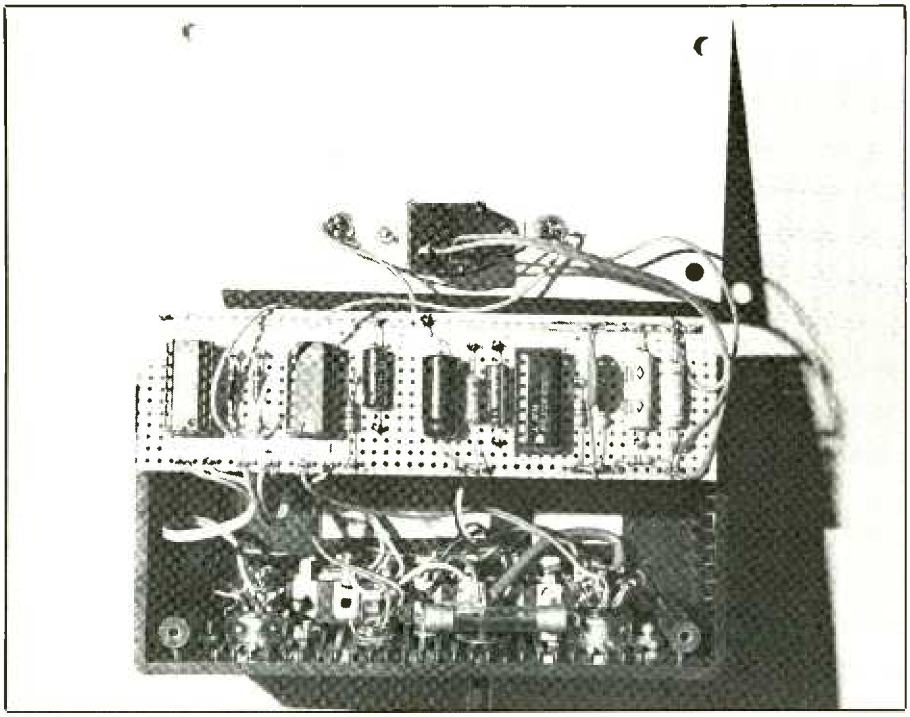


Fig. 2. Interior view of assembled project shows circuit-board assembly held in place by molded retainers in enclosure.

quency interference. The project was Wire Wrapped for speedy assembly, but you can use point-to-point soldered wiring or lay out and fabricate a printed-circuit board.

As you can see in the interior-view photo of the prototype in Fig. 2, the circuit-board assembly slides into guides molded into the enclosure. If you select a different type of enclosure from that shown, you might have to use spacers and machine hardware with which to mount the assembly.

Wire the circuit-board assembly exactly as shown in Fig. 1. Use sockets for the ICs to facilitate easy mounting and make it possible to easily replace chips should any fail during the project's lifetime. Also, do *not* install the ICs in their sockets until after you have conducted preliminary voltage checks and are certain that the circuit is properly wired.

Install and label board take-off terminals (1 through 6 in a row on one edge of the board. Install +5-volt and ground bus strips. Carefully observe the polarity of electrolytic capacitors as each is wired into place. Bear in mind that capacitor *C5* must rated at 20 volts dc or greater. When machining the enclosure, make allowances for clearances of the LEDs and keyswitch *S1*. Drill two holes in the back of the case for DIN sockets *S01* and *S02*. Drill a hole through the rear panel to accommodate jack *J1*. Then drill a large hole through the front panel through which to pass the cable that terminates in plug *P1* for connection to the cable that goes to the computer. If you are using an enclosure that does not have molded-in circuit-board retainer rails, drill mounting holes for the circuit-board assembly.

Install and label a six- to eight-lug terminal strip below the sockets for fuse *F1* and the keyboard cable connections. You can use a dedicated keyboard extension cable for plug *P1* and cable by cutting the female connector off and passing the cable into the enclosure. Feed the cut-off end of the cable through the hole in the front panel. A 2½ foot length of computer cable with male plug *P1* on the end that accepts the female connector of a keyboard extension cable is a convenient length to use.

Tie a strain-relieving knot in the keyboard cable about 6 inches from the free end inside the enclosure. Then carefully remove 3 inches of the outer plastic jacket from the end of the cable, and separate the braided shield wires. Tightly twist togeher the shield wires and sparingly tin the terminal end with solder for a distance of 1 inch or so. Slide a short length of plastic tubing over the shield to serve as insulation. Then strip ¼ inch of insulation from the ends of all conductors inside the cable. Tightly twist together the exposed fine wires in each case and sparingly tin with solder.

Connect and solder the cable shield conductor to the shells of sockets *SO1* and *SO2*. Crimp and solder the cable ground conductor coming from pin 4 of *P1* to the assigned ground lug on the terminal strip. Crimp the leads of pigtail fuse *F1* to the appropriate lugs of the terminal strip and solder into place.

Connect +5-volt line coming from pin 5 of *P1* to the input end of fuse. Then connect and solder +5-volt pins 5 of sockets *SO1* and *SO2* to the output end of the fuse. Strip ¼ inch of insulation from both ends of two 5-inch lengths of red- and black-insulated No. 28 hookup wires. Tightly twist together the exposed conductors and sparingly tin with solder. Connect the black-insulated wire from the ground lug of the terminal strip to circuit board ground. Then connect the red wire from the output end of *F1* to the +5-volt bus on the circuit-board assembly.

Connect the CLOCK conductor terminated at pin 1 of *P1* to the assigned CLOCK lug on the terminal strip and the DATA conductor terminated at pin 2 of *P1* to the assigned DATA lug of the lug strip.

Peel five 5-inch-long pairs of wires from a color-coded ribbon cable. Separate the wire pairs at each end a distance of 1 inch. Carefully strip ¼ inch of insulation from both ends of each wire pair. Tightly twist together the bared strands and sparingly tin with solder. Connect one wire of a pair to CLK A pin 1 of *SO1* and the other end of the same wire to CLK A terminal 1 on the circuit-board assembly. Connect the other wire of the pair to DATA A pin 2 of *SO1* and to DATA A terminal 2 on the circuit-board assembly. Similarly, connect pins 1 and 2 of *SO2* to terminals 5 and 6, respectively, on the board.

Connect and solder the CLOCK and DATA terminal strip terminations of the keyboard cable to board terminals 3 and 4, respectively. Connect and solder a wire pair *J1* with tip routed to the positive (+) end of *C1* and ground routed to the circuit-board assembly ground bus.

Drill the top panel of the enclosure to accommodate keyswitch *S1* and light-emitting diodes *LED1* and *LED2*. (Do *not* use ordinary pushbutton switches for either *S1* or *S2*. These may result in erratic operation of the project. Keyswitches removed from a surplus keyboard work well.) Two small aluminum L brackets secured to the sides of the switch with epoxy cement facilitate installation.

Label the top panel of the enclosure as shown in the lead photo. This done, spray on several light coats of clear acrylic spray before mounting the switch or LEDs into place. Allow each coat to dry before spraying on the next.

Install the LEDs on the panel, using epoxy cement to secure them into place. Then install the keyswitch on the panel. Connect and solder together the anode leads of the LEDs. Then connect a red wire from either anode lead to the +5-volt bus on the circuit-board assembly. Connect and solder the cathode lead of LED1 to board terminal 7 at *R6* and the cathode lead of *LED2* to terminal 8 on the circuit-board assembly. Connect and solder a wire pair to *S1* and *C1* lugs on the terminal strip.

The remote keyswitch assembly (not shown in Fig. 1) consists of a small enclosure that houses *S2* and a connecting cable terminated in plug *P2* that mates with *J1* on the rear panel of the project's enclosure. Drill the panel of the enclosure used for the remote switch and install *S2* in it. Also, drill a hole for the connecting a 6- to 8-foot length of shielded (microphone or similar) cable.

Solder miniature phone plug *P1* to one end of the cable, with the shield connected to the barrel or so-called "ring" lug. Pass the free end of the cable through the hole drilled for it and connect and solder it to the lugs of *S1*. Secure the cable to the case with a thick bead of silicone adhesive applied inside.

One circuit variation you may want to consider is replacement of plug *P1* and its cable with a five-pin DIN female chassis-mount socket installed on the front panel of the main enclosure. This requires use of a 6-foot-long connecting cable terminated in a five-pin DIN male connector at each end.

If your computer lacks a keyboard lockout switch, or if you want to lock out a keyboard in an office setup, you can add lockout switches alongside sockets *SO1* and *SO2*. To do this, remove the wire connecting pin 2 of *SO1* to terminal 2 on the circuit-board assembly. Then connect a single-pole single-throw (spst) switch from pin 2 of *SO1* to the vacated terminal 2 on the circuit-board assembly. Similarly, install another switch connecting pin 2 of *SO2* to terminal 6 on the circuit-board assembly.

When the switch is open, simulating a keyboard failure, that keyboard is rendered inoperable. Opening both switches locks out both keyboards.

For another keyboard lockout option, installation of an spst switch from pin 2 of *P1* to terminal 4 permits you to lock out and defeat both keyboards simultaneously. Choose the arrangement that best suits your particular situation.

Initial Checkout

Check the circuit as follows to preclude possible damage to your computer or keyboards. Start by checking all wiring for errors and omissions. With the project not connected

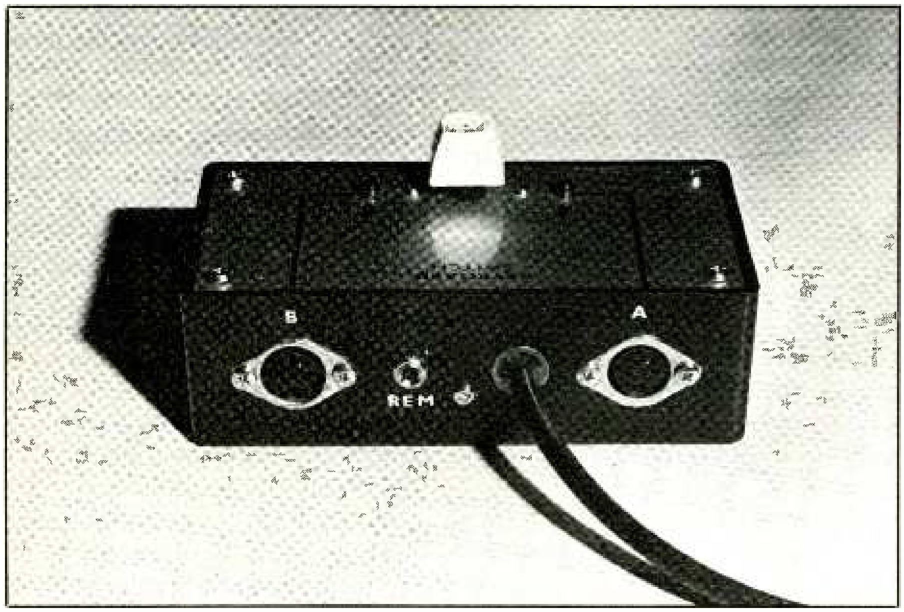


Fig. 3. Rear view of project shows placement of DIN-type keyboard connectors and miniature jack for a remote switch for selecting between keyboards.

to the computer and no ICs installed in the sockets, use short lengths of No. 28 solid-wire jumpers to connect together pins 1 and 2, 4 and 3, 8 and 9, and 11 to 10 of the *IC3* socket to simulate closed switches.

Use an ohmmeter to verify continuity from pin 2 of *P1* to pin 2 of *SO1* and *SO2*. Verify continuity from pin 1 of *P1* to pin 1 of *SO1* and *SO2*. Next, verify that an open-circuit exists between the ground and +5-volt buses to terminals 1 through 6 on the circuit-board assembly. Then verify continuity from circuit board ground to pin 4 of *SO1*, *SO2* and *P1*; that an open-circuit condition exists between terminals 1 and 2 on the circuit-board assembly; and that no short-circuit exists from the +5-volt bus to the ground bus. When all checks indicate everything is okay, remove the jumper wires from the socket of *IC3*.

Connect a 5-volt dc power supply to the +5-volt and ground buses on the circuit board, with an ammeter in the +5-volt line and turn on the power supply. If everything is okay, the ammeter should read zero. Using a dc voltmeter with a 10,00-ohm/volt or greater sensitivity, check to see if a nominal +5 volts appears at pins 1, 2, 3, 15 and 16 of the *IC1*; at pins 2, 3, 4 and 14 of the *IC2*; and at pin 14 of the *IC3* sockets.

If all is okay up to this point, turn off power to the project and plug a 74LS123 chip into the *IC1* socket and a 7473 chip into the *IC2* socket. Make certain that each is properly oriented and that no pins overhang the sockets or fold under between ICs and sockets as you push the ICs home.

Power up the circuit once again. The ammeter should now indicate a current draw of about 30 to 50 milliamperes. Also, *LED1* should light and *LED2* should be off. Pressing *S1* slowly several times should cause the LEDs to turn on and off alternately.

The project should consistently power up with *LED1* initially on, indicating that Keyboard "A" is active. If not, increase the value of *C2* and/or *C6*. The project should switch consistently between the two keyboards when *S1* is pressed. If it does not, increase the value of *C1* to 2, 5 or 10 microfarads to tame a noisy keyswitch. Additional debouncing can be obtained by increasing the value of *C5*, but higher leakage current in this capacitor can stop the one-shot from firing.

You can check operation of *IC1* by connecting an oscilloscope to pin 13 of this chip. Now, when you press *S1*, you should observe a positive-going one-shot pulse at pin 13.

Once you are satisfied that the circuit is properly wired and operating correctly, power down the project and install the remaining CD4066 chip in the *IC3* socket. Handle this chip with the same precautions you would use when handling any other MOS-type device.

The measured current drain of two keyboards and the AB Switch was about 250 milliamperes, which is well below the maximum allowable 500-milliampere current rating of the computer keyboard port. If your keyboard has non-standard additions that draw appreciable current from the keyboard port, the voltage drop across *F1* may be excessive and can result in a malfunctioning circuit. In this case, increase the rating of *F1* to 2 amperes, or replace the fuse with a direct connection. Check your computer manual for the maximum allowable current drain from the keyboard port before making any connections to it. If the stated maximum current is less than the amount of current that will be drawn by the keyboards, you must use an external 5-volt dc supply to power the project. If you do use an external supply, omit the connection to pin 5 of *P1* (+5V) to prevent damage to the computer. Make the correction from the top of *F1* and circuit ground.

Using the Project And Applications

With your computer powered down, plug main Keyboard "A" to the project into *SO1* and auxiliary Keyboard "B" into *SO2* (see Fig. 3). Then plug *P1* into the keyboard port of the computer.

The Electronic AB Switch was tested using two 101-key enhanced keyboards on an AT-class computer. Although tests were not performed with PC or XT keyboards, nor with pairing of a 101-key with an 84-key keyboard, the project should operate the same in either case. Be sure the XT/AT switch on the underside of each keyboard is set correctly.

When you power up the computer to which the project is connected, Keyboard "A" *LED1* on the AB Switch will light and all LEDs of both keyboards will briefly flash. DOS checks and initializes active keyboard "A" with the NUM Lock LED turned on. Inactive Keyboard "B" is not checked by DOS and, thus, all its LEDs are off.

The status of the NUM Lock, SCROLL Lock and CAPS Lock keys are held in computer memory. When you switch over to Keyboard "B," the status of NUM Lock, SCROLL Lock and CAPS Lock keys is identical with that of keyboard "A" at time of transfer but the NUM Lock LED does not light because the computer has not as yet accessed the LEDs of Keyboard "B."

To correct Keyboard "B" LED indications, press any one of the NUM Lock, SCROLL Lock and CAPS Lock keys on Keyboard "B." Doing this causes DOS to look at the status of the NUM Lock, SCROLL Lock and CAPS Lock keys stored in memory and lights or turns off the LEDs accordingly. Press the same key you selected once again to restore its previous status.

To avoid the need to update LED indications when you switch back and forth, you can use a utility that displays the status of these keys on the screen and ignore the keyboard LED indications entirely.

You can power up with Keyboard "B" active by holding down the keyswitch on the project's enclosure (*S1*) for a few seconds when you power up the computer. When DOS detects a keyboard failure, an error message "keyboard failure" appears onscreen and the computer continues with and completes booting up. You can verify this by booting up with Keyboard "A" disconnected. If you then press keyswitch *S1*, Keyboard "B" is selected and active.

The AT keyboard can be programmed internally to set key repeat delay time and typematic rate. The key repeat delay time determines how long you must hold down a key before it begins to repeat. For the AT keyboard, delay time can be programmed rom 0.25 to 1.25 seconds. Typematic rate determines the key repeat frequency that can be programmed from 2 to 30 characters per second. Default values are 0.5 second repeat delay time and 10 characters per second repeat rate.

You can move the cursor three times more rapidly by programming the typematic rate to 30 characters per second or otherwise slow it down to a crawl at 2 characters per second. These parameters are stored inside the keyboard itself and do not carry over to the next selected keyboard. This permits you set up each keyboard to your liking. On the other hand, when you reassign keys, the assignments are held in computer memory and automatically apply to both keyboards.

The typematic rate of PC and XT keyboards can be speeded up using utilities. However, the altered parameter is held in computer memory and applies to both keyboards.

With some application programs, you have probably wished that you could alter the speed of the cursor or select between several cursor speeds within the program. This can be done by using two keyboards and utilities often included on public-domain and shareware disks. The AT keyboard utility in use is a terminate-and-stay-resident (TSR) program executed either manually from the DOS prompt or from a batch file.

A paint and draw program in use moves the cursor far too slowly in the horizontal direction and a bit too fast in the vertical direction, reflecting a compromise of sorts. From the DOS prompt, Keyboard "A" might be programmed for normal repeat delay time and maximum typematic rate, while Keyboard "B" is programmed for maximum repeat delay time and minimum typematic rate. The paint and draw program is then loaded from either keyboard. Keyboard "A" speeds up drawing of long lines and large objects, and Keyboard "B" is instantly available for drawing small objects and for painstaking correction of errors.

When playing board games with

(Continued on page 76)

Multiple Monitors & Keyboards on a Single Personal Computer

A new product from ZAKI Corp. called "Co-Pilot" enables users of PCs to access their computers from different locations in their offices or homes by plugging into it multiple monitors and keyboards. It is for people who want to run the same program from different locations; display the same information on multiple screens; share a single computer in a classroom; and have a need to access computer data from different locations.

Co-Pilot requires no hardware or software installation. There is also no need for networking software or complex operating systems. The product is compatible with DOS, OS/2, XENIX and all other PC software, operating systems and networks. It is also compatible with XT, AT, 80386 and 80486 systems.

No external power source is needed to operate Co-Pilot, which supports MGA, CGA and EGA monitors. Each satellite station can be located up to 200 feet from the host computer. A security switch allows the user to selectively disable a screen from viewing displayed data or a keyboard from entering or accessing data.

A complete Co-Pilot package includes a Host Interface box with support for four Satellite Stations, 50 feet of cable and one Satellite Station interface box. $199.

Nonvolatile Event Timers and Totalizers

By Forrest M. Mims, III

There are many ways to electronically time the duration of an event or total duration of a sequence of events. One is to program a computer as a timer that monitors the event being timed. But this method is fairly expensive. If the numbers are stored in RAM, they may be lost if a power failure or voltage spike occurs. A way around this is to save the information on magnetic media or in a PROM or EPROM. Again, these methods add to the cost of saving information.

In this column, we will look at two very simple ways of keeping track of elapsed time and totalizing the number of occurrences of an event. The timer we'll examine is a miniature mercury elapsed-time indicator, or coulometer, and the totalizer is a mechanical counter. While neither offers the flexibility and sophistication of computer-based timers and totalizers, both are nonvolatile, relatively inexpensive and simple to use.

Timer and Totalizer Applications

For purposes of this discussion, a timer provides an indication of the duration of a single event or a sequence of events. A totalizer counts the number of events.

If you manufacture expensive products that are guaranteed to function properly for some specified number of hours, it is in your best interest to keep track of how long the product has been used should a customer request service under warranty. For this reason, some cars include timing devices that record how long the engine has been operated. A totalizer could be included to reveal how many times the engine is switched on.

A simpler application for a timer is keeping track of how long a storage battery is charged and discharged. A totalizer can be added to keep track of the number of times the circuit powered by the battery is operated.

Many applications exist in science and engineering for timers and totalizers. For example, a timer can be used to accumulate the numbers of minutes the sun shines on a given day. A totalizer can be used to record the number of times a cloud passes in front of the sun. A timer can be used to accumulate the number of minutes a bird spends on its perch. A totalizer can be used to record the number of times the bird leaves and returns to the perch.

Fig. 1. A mercury elapsed time indicator. (Courtesy Curtis Instruments, Inc.)

These and other applications for timers and totalizers require some means for initiating the timing or counting function. Often, a simple switch closure will do. For example, a bird's perch can be attached to a switch that is closed by the weight of the bird. When the bird lands on its perch, the resultant switch closure advances the totalizer count by one and starts the timer. When the bird leaves the perch, the totalizer is unaffected, but the timer switches off.

Frequently, a simple mechanical switch closure is not adequate. To record the total number of minutes of sunlight, for example, requires a sensor that determines when the sun is shaded and when it is not. One way to accomplish this is to mount a photodiode or solar cell in such a manner that it is always shaded from the sun but exposed to the sky. A second photodiode or solar cell is then mounted so that it is always exposed to the direct rays of the sun. Both detectors are then connected to a comparator.

When the second photodiode is exposed to full sunlight, its output will be more than twice that of the shaded detector. Therefore, the comparator will switch on and permit timing to take place. When a cloud passes in front of the sun, the output of the second detector will fall to about the level of the first detector, and the comparator will switch off. The timer is then switched off.

The basic principles outlined above can be applied to virtually any situation that produces a signal that can be measured. If you live under the approach to an airport, you can build a sound-activated relay that triggers both a timer and a totalizer. You will then know how many aircraft fly over your area and the length of time their sound exceeds the threshold of your monitoring system.

If you have a wind-powered generator, you can borrow a tiny bit of its output to actuate a timer that will record how long the generator is driven by the wind. A simple threshold sensor can be used to detect when the generator output falls below a specified level. This circuit can be connected to a totalizer that accumulates the number of times the generator starts and stops during the day.

A Mercury Coulometer

Shown in Fig. 1 is a Curtis Instruments, Inc. mercury coulometer. This miniature timer provides a continuous indication of elapsed time on an analog scale. Since the timer is designed to operate for periods of thousands of hours, its resolution is low. But it provides a very compact means for monitoring the length of time of an event or series of events.

Inside a mercury coulometer is a tiny glass capillary tube with an electrode at each end. The capillary is filled with a column of mercury broken by a narrow gap filled with a clear liquid electrolyte. When a direct current, either continuous or pulsed, is applied to the device's electrodes, mercury on the anode (+) side moves across the electrolyte gap and is deposited on the cathode (−) side. This causes the gap to move from the cathode terminal to the anode terminal as mercury is transported across the gap.

Figure 2 is a pictorial view of the capillary of a mercury coulometer, along with a magnified view of the gap. Note the presence of a tiny glass spacer within the gap. The spacer increases the resistance of the device to mechanical shock that might otherwise cause separation of the mercury and loss of the gap.

Figure 3 is a macrophotograph of the gap in an actual mercury capillary. When the lighting is good, the contrast between the gap and the opposing mercury columns is more vivid than shown in the photo. The gap appears like a thin black space in a silver tube.

The gap in a coulometer moves at a rate directly proportional to the current flow through the mercury and the electrolyte. In most applications, a regulated current is applied to the terminals so that the device functions as a duration timer. A precision series resistor may be used to limit the current flow to a specified value.

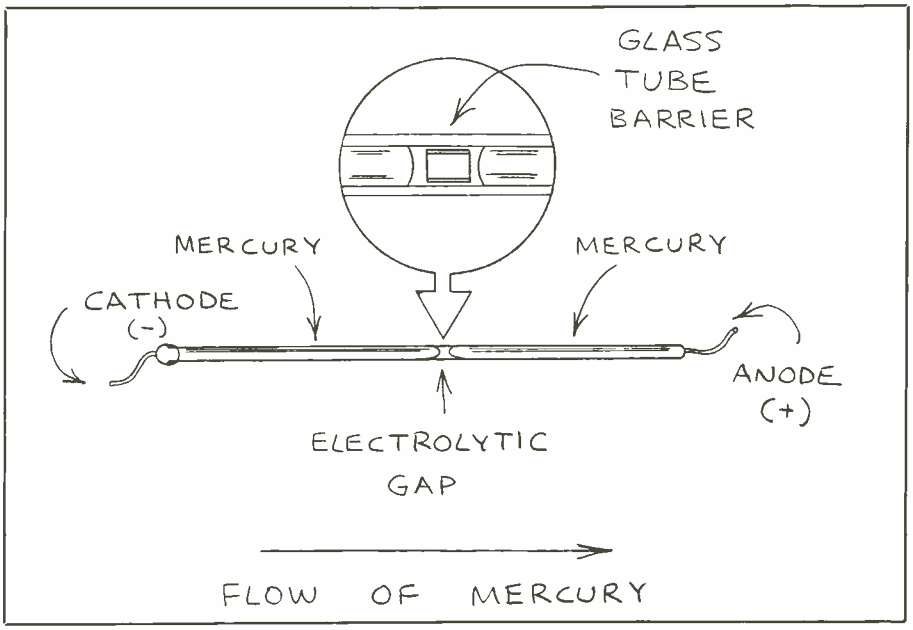


Fig. 2. Exploded view of gap in Curtis mercury elapsed-time indicator.

Mercury coulometers are made by Curtis. They are known as Curtis Indachrons or Elapsed Time Indicators/Integrators (ETIs). Price for Curtis ETIs in 100-unit quantities ranges from around $6 to $9. For smaller-quantity pricing and additional information about Curtis mercury ETIs, write to Curtis Instruments, Inc., 200 Kisco Ave., Mt. Kisco, NY 10549.

Curtis ETIs are very small, weigh but a tiny fraction of an ounce, and can withstand a 150-g shock. They can be operated over a temperature range of from 0 to 50 degrees Celsius, and their scale can be read to an accuracy within 1 percent.

The main drawback of an ETI, its nonresettability, can also be an asset since it prevents tampering. Some Curtis ETIs are equipped with a removable window and adjustable scale. This permits the scale to be moved with respect to the gap to reset the timer. Another way to reset the timer is to reverse the direction of current flow. This also permits an ETI to be recycled when its gap has moved from one end of the capillary to the other.

Recently, while visiting a surplus electronics store, I found a box full of Curtis ETIs on sale for around $1.50 each. As evidenced by stains and water marks on their display scales, these devices were rather old and some no longer had a gap. I purchased a half dozen or so with good gaps and found that they still worked.

Some of the devices were Model 420-LC units with short wire leads designed to be inserted into a circuit board. These devices are designed to indicate up to 10,000 hours elapsed time when biased by 5 volts. The remainder were CP3 devices with flexible, insulated wire leads. These have removable covers and 5,000-hour scales to permit quick resetting. Both ETIs are shown in Fig. 4.

Several weeks before writing these words, I inserted the leads of one of the 420-LC devices under the spring terminals of a 6-volt lantern battery and left it near my desk for 15.5 days. The gap moved exactly one scale division, or 5 percent of the distance from 0 to 10,000 hours. This coincides with 500 hours or 20.83 days. The reason the gap moved this distance in only 15.5 days is the higher voltage, hence higher current.

It would be nice if gap movement could be speeded up so that it would move com-

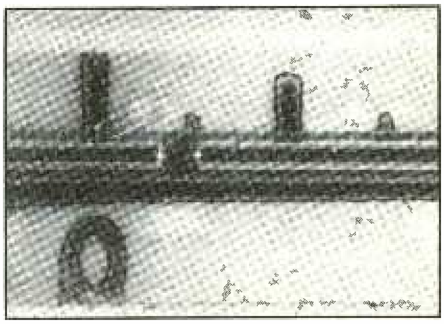


Fig. 3. Macrophotograph of gap in a mercury elapsed-time indicator.

pletely across the scale in only a day or so. Unfortunately, this isn't possible with the ETIs with which I have worked since maximum current must be kept below 50 microamperes.

The 10,000-hour Model 420-LC ETI that I connected to a 6-volt battery consumed around 1 microampere. If the movement of the gap is linear with respect to current, increasing the current flow of this unit to the maximum of 50 microamperes would move the gap across the scale in 1/50 of 10,000 hours, or 200 hours. This is 8.33 days.

Fig. 4. Two surplus mercury elapsed-time indicators purchased by author.

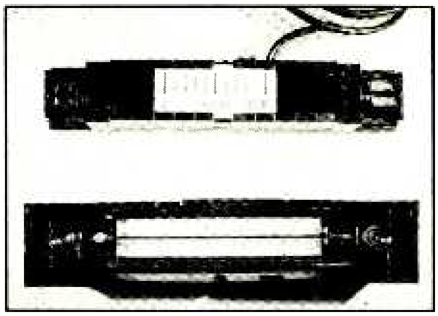


Fig. 5. Disassembled Curtis Model CP3 ETI shows scale attached to base and capillary tube that is, in turn, attached to removable window.

All the surplus Curtis ETIs I bought had built-in current-limiting resistors. The 420-LC devices are sealed, but the CP3 ones can be easily taken apart to reset the scale, as shown in Fig. 5. When this is done, the mercury capillary tube remains in the removable window assembly. When the window assembly is replaced, contact pins connected to the capillary tube are inserted into sockets in the device's main body.

The series resistor for the CP3 device is inside the main body, along with the two sockets for the capillary tube. Therefore, it's possible to bypass the series resistor and apply a current directly to the mercury capillary by removing the window assembly.

Graphed in Fig. 6 is the current through the capillary as a function of the voltage across the its terminals. To make this graph, I simply connected a 50-microampere meter in series with the capillary tube and a variable power supply. If you repeat this procedure, be especially careful to avoid applying too much voltage (hence, too high a current) to the tube. If your power supply control is jumpy, insert a series resistor between the supply and the capillary to avoid possible damage.

The measurements used to make Fig. 6 provide the basic information that allows you to transform a standard 5,000- or 10,000-hour ETI into one that gives a full-scale gap movement of as little as 200 hours. All that's necessary is to select a suitable series resistor and supply voltage. For example, when the current was at the maximum allowable 50 microamperes, the voltage across the exposed capillary tube of my CP3 device was 0.103 volt. Inserting these values into Ohm's law (R = E/I) gives a capillary resistance of 2,060 ohms.

Why not measure the resistance of the capillary tube with a multimeter? Depending on the meter and its setting, connecting it across an ETI without its series resistor in place might apply a damaging level of current to the device.

Suppose you want to operate the timer at 6 volts and 50 microamperes. What series resistance should you use? Solving for R (Ohm's law, again) gives a total resistance of 120,000 ohms. Subtracting the resistance of the capillary tube (2,060 ohms) gives a series resistance of 117,940 ohms. This is not a standard resistance value. Therefore, you must create this value by arranging several standard values in series, one of which might be a small trimmer for fine adjustment.

Alternatively, you can use a nearby standard resistance value and alter the voltage accordingly. For example, I connected a 100,000-ohm resistor in series with a disassembled CP3 and a variable power supply and then slowly increased the voltage. The current through the mercury-filled capillary reached 50 microamperes just as the voltage reached 5 volts. Since 5-volt regulators are so readily available, it makes as much sense to use this combination as to make up a 117,940-ohm resistor as trying to make one up from a number of resistors with different values.

As you can see, selection of the series resistor is quite critical. First, if the value is too low, the current through the capillary will exceed the 50-microampere upper limit. Secondly, the accuracy of the series resistor determines the accuracy of the timer itself.

In any case, you must be very cautious about bypassing the series resistor in a mercury ETI and especially about using the device without a series resistor. Exceeding the maximum allowable current for even a brief period of time might destroy the device.

How to Read A Mercury Coulometer

For most applications, the small gap in a mercury ETI can be read without magnification. In a brochure published by Curtis Instruments, an actual-size illustration of an ETI is given with this caption: "Looking at the left of the gap, if you read anywhere from 927-945 hours, you are within ± 1 percent—as accurate as an ETI." I read 940 hours.

More accurate readouts can be made with the help of calipers or an optical comparator with a reticle. Various other methods have also been developed. In one, the ETI is transformed into a variable capacitor. The capillary tube is covered with a conductive material and an ac signal is superimposed over the dc signal used to drive the ETI. The ac signal induces a small voltage on the conductor that covers the capillary. The magnitude of this voltage is related to the position of the gap inside the tube.

I don't know if it has been done, but an optical fiber could be used to indicate very tiny movements of the gap. A LED could be placed on one side of the gap and the fiber on the other. Since the mercury is highly reflective and the gap is not, both the fiber and the light source could be placed on the same side of the gap. In either case, the end of the fiber should be positioned as close as possible to the capillary. Ideally, it would be cemented to some kind of sliding gadget that permits it to be easily moved anywhere along the length of the capillary.

Pyranometers & Totalizers

A pyranometer is a device that measures the integrated amount of sunlight received over a set period of time. A paper on how to build an ultra-simple pyranometer was written more than 25 years ago by C.A. Federer and C.B. Tanner ("A Simple Integrating Pyranometer for Measuring Daily Solar Radiation," *Journal of Geophysical Research*, Vol. 70, No. 10, May 15, 1965).

Federer and Tanner built their pyranometer, which they called a pyrigrator, simply by connecting an ordinary silicon solar cell directly across a mercury ETI in series with a second solar cell and a series resistor. Why they used the second solar cell requires more space than is available here; so if you want more information you should find their paper in a library.

The electromechanical totalizer is an electrically-actuated mechanical counter. The typical totalizer resembles an automobile's odometer. The major exception is that the lowest-order digit moves a full digit each time an incoming pulse is received, instead of advancing gradually like the hands of an analog clock.

The major advantages of electromechanical counters are non-volatile memory and low cost. Its major drawback is the relatively high current required to advance the count. Radio Shack's Cat. No. 277-222 counter, for example, incorporates a small solenoid that has an internal dc resistance of 123.7 ohms. Therefore, this unit requires 65 milliamperes at 8 volts and 97 milliamperes at 12 volts.

While the current required for a single count is high, it need only be applied for a small fraction of a second. Therefore, if the count rate is low, average current consumption can also be low.

Input to a typical electromechanical totalizer is provided by a pair of wires connected directly to the device's solenoid. This means it is important to apply as brief a pulse as possible to the device. Otherwise, the solenoid will continue to draw current long after the count has been advanced.

Figure 7 shows a simple capacitive discharge method for applying a brief current spike to solenoid-type totalizer. In operation, *C1* charges to the supply voltage through *R1*. Switch *S1* can be any normally-open switch such as a manually operated pushbutton switch, relay, magnetically-actuated reed switch or even a power MOSFET. When *S1* is closed, *C1* discharges through the totalizer's solenoid and advances the count. If *S1* remains closed, current through the totalizer is limited by *R1*. Assume, for example, that the supply provides 10 volts, *R1* is 1,000 ohms and the resistance of the totalizer's solenoid is 123.7 ohms. According to Ohm's law, total current is 10/(1,000 + 123.7) or 8.9 milliamperes. This is only around 10 percent of the current that would be consumed if the totalizer were connected directly across the supply.

The major drawback to the Fig. 7 circuit is that the time required to charge *C1* restricts the count rate to one count every few seconds or so. If power consumption is no problem or if the switch closures that activate the totalizer are very brief, there is no problem in connecting the to-

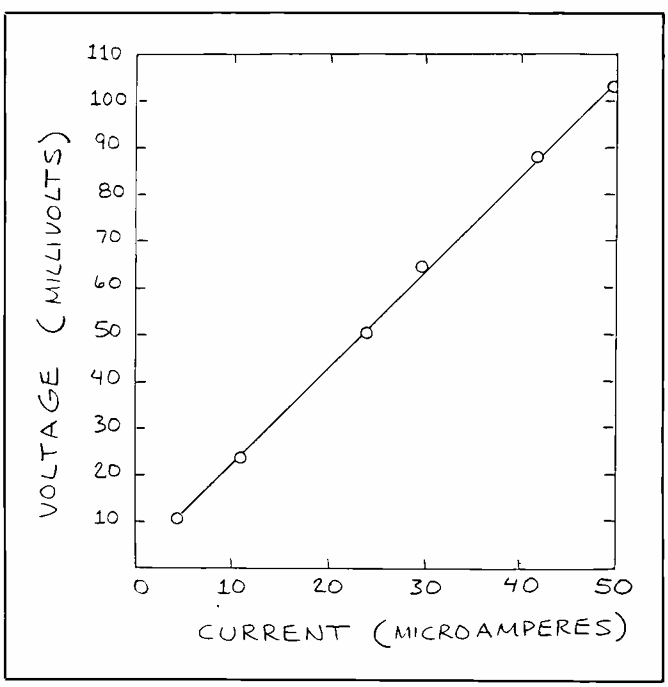
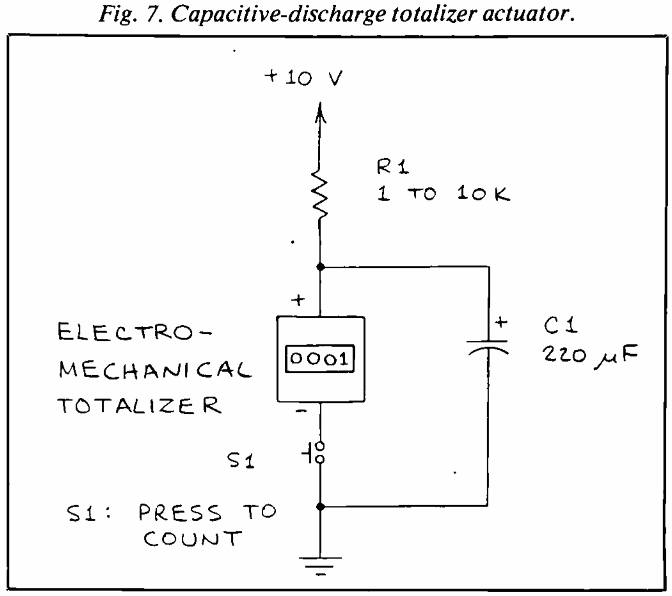


Fig. 6. Current flow through a Curtis mercury elapsed time indicator.

Fig. 7. Capacitive-discharge totalizer actuator.



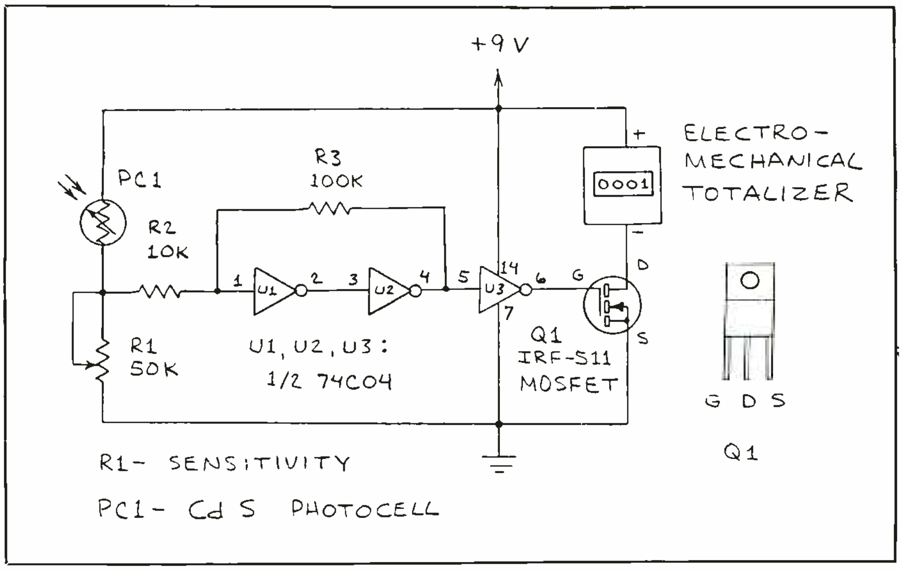


Fig. 8. A light-activated totalizer.

talizer and the series switch directly across a power supply.

Figure 8 shows one way to use a totalizer to count passing people or objects. In operation, cadmium-sulfide photocell *PC1* is arranged so that its active surface is illuminated by either artificial light or the sun. This lowers the resistance of *PC1* and makes pin 1 of the 74C04 high with respect to ground. Since the signal eventually applied to the gate of *Q1* is low, this transistor is switched off. When the light source is interrupted, the signal levels are reversed, and *Q1* is switched on. This permits the totalizer to receive current to advance the count by one. When *PC1* is again illuminated, the circuit is again ready to register another count.

Potentiometer *R1* permits the sensitivity of the circuit to be adjusted. Sensitivity can also be controlled by placement and intensity of the light source.

Operation of the circuit can be reversed by reversing the positions of *R1* and *PC1*. This done, the circuit increments the counter each time *PC1* is illuminated.

The circuit shown in Fig. 8 can be easily modified for other applications. Any CMOS circuit that provides either a positive or negative output in response to a stimulus can be connected to the gate of *Q1*, either directly or through an inverter.

The version of the circuit I built operated from a fresh 9-volt alkaline battery. However, if you use such a battery to power the circuit, it will quickly lose its capacity if *Q1* remains on for more than a fraction of a second per count.

If you can live with a maximum count rate of once every few seconds, the simplest solution to this problem is the capacitive-discharge circuit shown in Fig. 7. All that's necessary is to insert a 1,000-ohm resistor between the positive supply and the totalizer and connect a 220-microfarad capacitor directly across the totalizer.

Going Further

Emphasis in this column has been on non-volatile event timers and totalizers. CMOS totalizer circuits with liquid-crystal displays require continuous drive current, but the level is so low that they can almost be considered non-volatile. A major advantage of these counters over electromechanical totalizers is that little or no current is required to advance the count.

One way to make a CMOS totalizer non-volatile is to connect a 1-farad super capacitor across its battery terminals. When the battery fails, a new one can be installed without losing the current count. Another way is make a power supply from a pair of batteries connected in parallel. As one battery is being replaced, the other preserves the current count.

A CMOS totalizer is available from Radio Shack for $16.95 (Cat. No. 277-302). It counts up to 99,999 at a count rate of up to 7 Hz. A simple switch closure advances the count. This totalizer consumes only 4 microamperes when powered by a single AA cell.

Red Lion Controls makes many different miniature CMOS counters and totalizers. The CUB III general-purpose six-digit counters accept up to 100 counts per second. A lithium-cell-powered CUB III is available from Digi-Key (P.O. Box 677, Thief River Falls, MN 56701-0677) for $29.00. See Digi-Key's catalog for additional information about this and a variety of other Red Lion Controls counters and totalizers. ME

An Ultraviolet Sensor, Photoelectric Smoke Detector, Giant LEDs and Two Flash Converters

By Joseph Desposito

The last time I purchased a pair of prescription sunglasses, I was confronted with a dilemma. The gal behind the counter asked me if I wanted a special coating on the lenses to screen out ultraviolet rays. Since I had gone into the vision center armed with a "$39 special" coupon, I had to decide whether to spend the extra $20 for the coating. This fee was on top of the extra $10 for tinting the glasses. As I contemplated the lunacy of adding $30 to the price of a $39 pair of glasses, the clerk reminded me that I could ruin my eyes—fry my eyeballs I think she said—if I put dark glasses on and then when out into the sun (the dark glasses cause the iris to open wide, she explained). Naturally, I opted for the coating.

But I'm left wondering about a couple of things. Why is the coating an option if ultraviolet light is so dangerous? Do some people decline the coating?—"Twenty bucks? Forget it! I'll take my chances." And more to the point of this column, how would you test the glasses for their ability to screen out ultraviolet rays? Any circuit of this kind would need as one of its components a UV detector. A new product from Hamamatsu Corp. is just what the optometrist ordered.

An Ultraviolet Sensor

Hamamatsu Corp. (360 Foothill Road, P.O. Box 6910, Bridgewater, NJ 08807) has announced a semiconductor ultraviolet sensor (Model G3614) that consists of a GaAsP photodiode chip and an ultraviolet (UV) filter. This unique combination enables the sensor to gauge the sensitivity of visible light and infrared radiation from 260 to 400 nanometers. Within this sensitivity range, Hamamatsu's G3614 sensor is a good choice for commercial use in sunburn rate meters and other ultraviolet warning devices.

When used as a sunburn rate meter, the G3614 will give the user better control against excessive sunburn by helping determine how much protection is needed. In UV meters, the G3614 measures the level of UV radiation, thereby preventing overexposure from tanning devices such as used in tanning salons.

Available at discounted pricing for large orders, the G3614 with the built-in filter costs approximately $3.20 per unit in quantities of 10,000 or more.

A Photoelectric Smoke Detector

While we're on the topic of sensing devices, Motorola's MOS Digital-Analog Integrated Circuits Division (P.O. Box 6000, Austin, Texas 78762) has introduced the MC145010, an advanced smoke detector based on very-low-power analog and digital circuitry. The IC detects smoke when its external photoelectric chamber senses scattered light from minute smoke or aerosol particles floating in the air. This triggers a pulsating alarm sounded by on-chip drivers and an external piezoelectric transducer.

A local smoke condition activates a short-circuit-protected I/O driver. The I/O pin can, in turn, activate escape lights, enable auxiliary or remote alarms, and initiate auto telephone dialers. An I/O pin linked with the V_{SS} pin can be

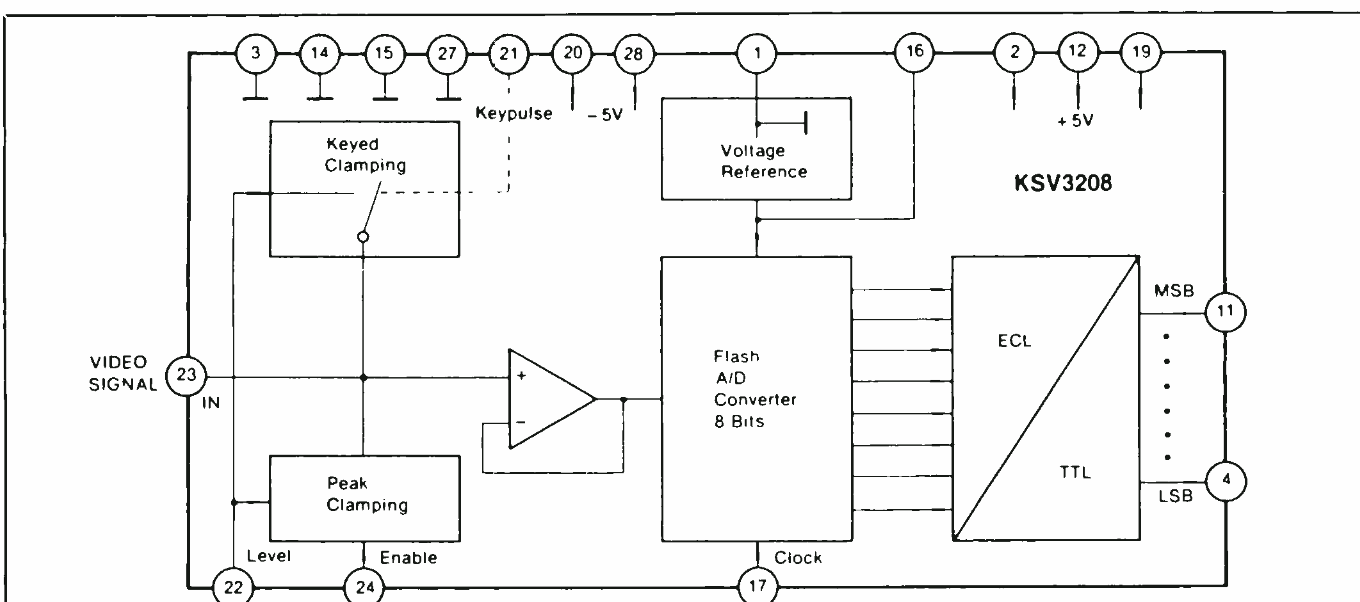


Fig. 1. Samsung's KSV3208 flash converter for image processing has a high-impedance signal input in spite of the high input capacitance of its internal A/D converter.

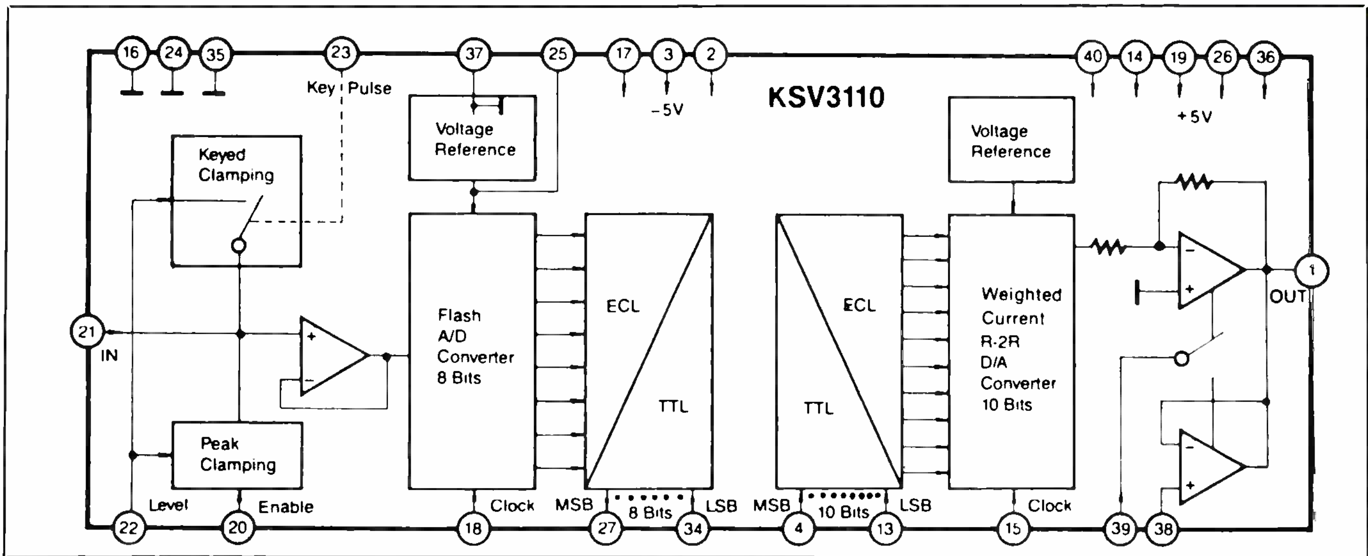


Fig. 2. Samsung's KSV3110 combines a high-speed flash eight-bit A/D converter on the same chip with a high-speed low-glitch ten-bit D/A converter.

used to interconnect up to 40 units for common remote signaling. The MC145010 Smoke Detector can be powered with a 9V battery or rectified line power.

The smoke detector is equipped with low-power-supply detection circuitry, which automatically conducts periodic checks of the power with a pulsed load current when the unit is in standby mode. Two external resistors set the low power trip point.

A simple system of audible and visible signals alerts the user to changes in status. LED flashes occurring with a pulsing audible alarm indicate a local smoke condition. A LED flash simultaneously occurring with an audible beep or chirp indicates a low power supply. The system can also indicate remote-smoke and degraded chamber sensitivity, as well as provide for pushbutton test capability.

The MC145010 is available in 16-pin DIP or SOIC packages. Both packages are priced at $2.29 (500 to 999 pieces).

"Glow Bulb" LED Has Edison-Screw Base

Though you might use typical LEDs in a sensing circuit, the new Glow Bulb LEDs from Ledtronics (4009 Pacific Coast Hwy., Torrance, CA 90505) are designed to fit into household-sized sockets, known as the "Edison-screw" base type, and put out a soft 25 millicandelas using only 10 milliamperes of current.

The 26-mm-diameter Glow Bulb uses the inexpensive and universally available screw-socket hardware to deliver a performance reliability 20 times that of the incandescent lamp technology it replaces. The large diameter, multi-chip, solid-dome Glow Bulb LEDs fit 1.02-inch-diameter bases and are a good choice for use as markers and indicators, as well as in large displays, moving signs, clock displays, pilot lamps, backlighting and many other uses where large size is required.

The Series S100 Glow Bulb can be expected to operate 100,000 hours, compared with approximately 4,000 hours for incandescents. And during this long lifetime, these solid-state LEDs can operate in the harshest conditions of moisture, shock and vibration, and bear up under high on/off cycling.

The comparatively high failure rates of incandescents make use of LED technology desirable from both maintenance costs and performance perspectives. The six-chip, big domed Glow Bulb LEDs have a minimum 160-degree-wide viewing angle and are available in lengths of 2 inches, 3.5 inches and 4.5 inches to suit a wide variety of vertical requirements. The standard product line includes 120V ac bulbs, as well as standard dc voltages of 12V/30mA, 14V/30mA, 24V/30mA, 28V/30mA, 36V/20mA and 48V/20mA. Colors are red, yellow and green. Lenses are translucent or translucent white.

Semi-custom voltages and currents are available, and internal circuits, such as bridges and rectifiers, can be provided to operate from a variety of sources up to 130V ac or dc. Orders can also include optional flashing or blinking operation. Center contacts can be positive, negative, ac or bipolar. In quantities of 100, S100 Glow Bulb LEDs cost $12 to $16.

Flash Converter For Image Processing

Now on to another type of device. A high-speed, single-chip, eight-bit flash analog-to-digital converter has been developed by Samsung Semiconductor (3725

North First St., San Jose, CA 95134) for use in a variety of imaging and industrial applications at almost any frequency from the video range down to zero.

The device, known as the KSV3208, uses Samsung's bipolar collector-implanted (CI) technology. The KSV3208 was designed initially as a high-speed converter for the video frequency range but can be used with equal benefits at lower frequencies, even down to zero.

The KSV3208 is intended for use in high-performance video/graphics image-processing, frame-storage, digital signal-processing and other applications requiring high-performance data conversion. It can also be used for decoding television signals in pay-TV converters or for MAC converters used in direct satellite TV broadcasting.

Integration of many functions on the chip offers a number of key advantages that result in high performance at lower cost. By including several auxiliary functions on the chip, Samsung has reduced the amount of external components needed to put the device to work. Included is an impedance-matching converter (see Fig. 1) that provides a high-impedance signal input in spite of the high input capacitance of the A/D converter.

The KSV3208 operates from ±5-volt power supplies, and all inputs and outputs are TTL-compatible. Separate inputs for clock signals, power supply and ground connections are provided, enabling the chip to be used for time-compression applications. The KSV3208 has an accuracy of eight bits and a differential nonlinearity of ±½ least-significant bit (LSB).

A reference voltage is generated internally, but it and the ground for the reference circuitry have been brought out to the pins so that they can be connected to an external filter capacitor.

Manufactured in a 28-pin dual-in-line plastic package (DIP), the KSV3208 has an operating temperature range of 0° to +70° C. When ordered in a quantity between 100 and 999, unit price is $18.40.

Samsung also announced a device, the KSV3110, that combines a high-speed flash eight-bit analog-to-digital converter on the same IC chip with a high-speed low-glitch ten-bit digital-to-analog converter. Auxiliary functions on the chip, including a clamping circuit, impedance matching preamp and output switch-over circuit (see Fig. 2), help reduce the amount of "glue" logic needed to put the device to work.

Manufactured in a 40-pin dual-in-line plastic package (DIP), the KSV3110 has an operating temperature range of 0° to +65° C. The A/D converter on this chip has an accuracy of eight bits, but the D/A converter is available with an accuracy of eight, nine or ten bits. Prices for the different models in quantities of 100-999 are $24 (8 bits), $32 (9 bits), and $48 (10 bits).

The data converter team at Samsung has written a number of application notes that describe how the two devices (KSV3208 and KSV3110) can be combined on a single small printed-circuit board to perform such functions as video frame grabbing (the claim is that it's the world's smallest), image enhancement, timebase error correction, and more. Anyone interested in these application notes should drop a line to the company.

Epson's Laptop Features Removable Hard-Disk Drives

By Ted Needleman

Looking over the past several years' columns, I noticed that I tend to write about laptops fairly often. It's not really all that surprising, though, because I frequently use laptops. I don't particularly like them, but I use them. Most of the time, it's just to write or edit an article at the kitchen table. I have a large, powerful 386 PC in my home office downstairs, but after spending all day away from home at the office, I sometimes just don't feel like being away from my family.

Unlike many laptop users, however, I often leave my laptop at home when I travel. Except for a Compaq LTE and a Toshiba 1000SE that I had on loan for a couple of months, my other laptops are just too heavy to drag through airports. A 15- or 16-pound system seems to weigh closer to 50 when hustling from gate 4 to gate 43 to make a connecting flight.

Reviewing these past laptop columns, I noticed a curious thing. While I've reviewed accessories like LapLink, and even the Compaq LTE, I've never done a review on the laptops I most often use (and in fact, am writing this review on). For the last few years my main laptop has been an Epson LT. Several months ago, I received Epson's replacement for the LT, the Equity LT-286e. Although Epson is much better known for its printers and, in fact, set the market standard for dot-matrix printers back when the personal computer revolution started, they have been making computers for quite some time.

Unfortunately, Epson's QX-10 CP/M system, QX-16 MS-DOS PC, and HX-10 laptop never really made much of a splash in the market, although the HX-10 was one of the first laptops you could buy. With the introduction of the Equity LT, the company has done much better, but still doesn't have anywhere near the share of this market that Toshiba, Compaq, NEC and Zenith have.

In most respects, the LT-286e is a terrific laptop, and a definite improvement over the older LT. A few "improvements," though, point out the wisdom of "if it's not broken, don't fix it."

At 12.9" wide and 11.7" deep (without the battery pack attached), the LT-286e is almost the same physical size as the earlier LT, though at 3.5" high, it's a bit taller (about ⅛"). Installing the 286e's Ni-Cd battery pack adds another two inches or so to the depth, though nothing to the width or height because it slides onto the back panel of the laptop.

The 286 weighs about 16.5 pounds with the battery installed, whereas the LT (which does not have a removable battery pack) is closer to 14 pounds. Both units have backlit LCD display panels and retractable full-width handles that pull out of the front of the case. They also both contain serial, parallel, and CRT ports. This is about it for the similarities.

The original Equity LT is a "turbo-XT" class machine. The actual CPU in the system is a NEC V30, a close clone of Intel's 80286. Running at 10 MHz, the V30 gave the LT performance about equal to the original 6 MHz AT. The Equity LT's performance wasn't boosted much by a 76-ms average seek time 20-MB hard disk. Using CHECK-IT Version 2.01 (reviewed in this column several months ago), I also measured the LT's hard disk track-to-track seek time at 23 ms, and the system's data transfer rate at 153.6 kilobits per second.

Using an Intel 80286 (actually, the low-power CMOS version, 80C286), running at 12 MHz (with an 8-MHz user-selectable clock speed), the LT-286e also has a performance-boosting hard drive that is unique in another respect—it's removable. It's also much faster than the LT's. The LT-286e's average seek time, 24.4 ms as measured by CHECK-IT, is about a third that of the older laptop, while the track-to-track seek time of 4.7 ms is a quarter of the LT's. Finally, the data transfer rate on the new system, 432 kilobits per second, is almost three times that of the drive in the older laptop.

In addition to the battery, the hard disk, RAM expansion and the built-in modem slot, there are other modules. Hard disks are available in 20- and 40-MB capacities, and just slide into the left side of the machine and lock into place. If you want to upgrade a 20-MB unit to 40-MB, just slide out the old drive and slide in the new one. This is also a good feature if you have several LT-286es in different locations. You can just take the drive with your programs and data, pop it into another 286e, and go right to work. The drives have embedded controllers.

The RAM expansion and built-in modem slots consist of a small panel on either side of the case. One houses the RAM expansion slot while the other is for Epson's optional modem. RAM memory can only be expanded from the base system's 1 MB to 2 MB—the RAM expansion card is only available as a 1-MB upgrade. Epson provides a software package called TurboEMS, an EMS driver utility that can also emulate EMS memory using disk space on the hard disk. It's considerably slower than RAM, but if you have an application that requires large amounts of EMS memory, it makes it possible to use it on the LT-286e.

Moreover, if you really need to expand RAM beyond 2MB, you can—the LT-286e also contains an ISA standard bus 16-bit expansion slot. Just install any ⅔-size memory card with up to 16 MB more memory into this slot. I've used a number of peripherals in this slot, including the HICO A4 hand scanner reviewed in the June column, and have not encountered any problems. Actually, this laptop is perfect for evaluating peripheral cards, as the slot is easily accessible without having to disassemble the whole machine to install or remove a board. In addition to the expansion slot, there is a socket for an 80C287 (low power) numeric coprocessor chip, a parallel printer port, serial port, a port for an external 1.44-MB 5.25-inch floppy disk drive, and a video output port for connecting an EGA monitor. There's even a port to connect a standard full-size keyboard to the system, something I consider doing every time I use the LT-286e.

It's not that the 84-key keyboard has a bad feel; it actually has a rather nice feel. It's just that in Epson's effort to include as many keys as possible, some of the keys are in very strange locations. There is a numeric keypad/arrow keypad tucked in the upper right hand corner of the keyboard with plus, minus, and backspace keys directly to the right. The functions are (thankfully) located in a horizontal row directly above the numbers row, but the control key is directly above the left-hand shift key.

Most of the keyboards that I work on have the caps lock in this position, and the control key directly underneath the left shift. On the LT-286e, the alt key is in this position. Considering that I don't touch type (though I'm probably the world's fastest two-finger typist), and even I slow down considerably on the LT-286e, I can't help but wonder what this layout does to a decent typist.

Epson's LCD display panel goes a long way to calming my annoyance at the keyboard. It is an NTN paper-white backlit LCD, with adjustable brightness and contrast, and features EGA resolution (640 by 480 pixels). In addition, at 8.5 by 7 inches, it's very large for a laptop display and is a very comfortable display to use for extended periods of time due to its crisp image and easy readability under various lighting conditions. I often use WordStar 4.0, which allows the user to set an EGA screen up for 43-line display, and it's quite readable in this mode on the LT-286e.

An unusual feature of the laptop is the small LCD status panel at the top left-hand corner of the keyboard. It replaces the common LEDs for indicating disk use, power on, etc. Instead, the panel displays a disk icon, with little arrows that indicate which disk (floppy or hard) is currently being accessed. If the arrow appears on the left of the disk icon, it indicates that you are using the hard disk, while an arrow on the right shows floppy-disk use. Next to the disk indicator is a message that shows whether the floppy disk is the internal 1.44-MB 3.5-inch unit, or an external floppy drive.

The message panel also indicates the speed you are operating at (12 or 8 MHz), if you are using the battery pack (and if so, whether the pack charge is low), and if an external CRT is being used. While some of these messages may be more information than you think you need, they can be helpful when you have to troubleshoot a problem.

Epson supplies MS-DOS 4.01 with the laptop. You must first install DOS on the hard disk before you can boot from it (though you can create bootable floppies). MS-DOS 4.01 contains an installation routine that automatically partitions the drive. All you have to do is answer a few questions about whether you want the default partitions and if you wish to install DOS' SHELL. SHELL is a graphical manager, very similar to the menu systems available from numerous third-party vendors.

Installing DOS is covered in ample documentation provided with the LT-286e and includes several DOS manuals: *Installation Guide*, *Guide to the DOS SHELL*, *DOS Reference*, and *GW-BASIC Reference*. There is also a thick *User's Guide*, which describes the hardware set up, the LT-286e's features and several of the more common DOS commands.

At $4,098 with a 20-MB hard disk, the LT-286e is not the least-expensive 286-class laptop around. But its unique removable hard disk and 16-bit expansion slot are features that need to be considered along with the price. I wrote almost 100,000 words last year, and will probably do about the same this year. About 40% of those words were written on an Epson laptop. If the LT-286e was $2,000 less expensive and 10 pounds lighter, I would advise you to drop everything and run out to buy one. Here in the real world, though, decisions are seldom that simple.

I really like the LT-286e, even with its quirky keyboard. Its very large LCD panel is a dream to look at, and even at 13 pounds, it's easy enough to drag it over to the kitchen table when I don't feel like a hermit. If you need 286 power, the ability to run on a battery and an excellent display, take a look at the Epson. **ME**

LT-286e
Epson America, Inc.,
2780 Lomita Blvd.
Torrance, CA 90505
213-539-9140
800-421-5426

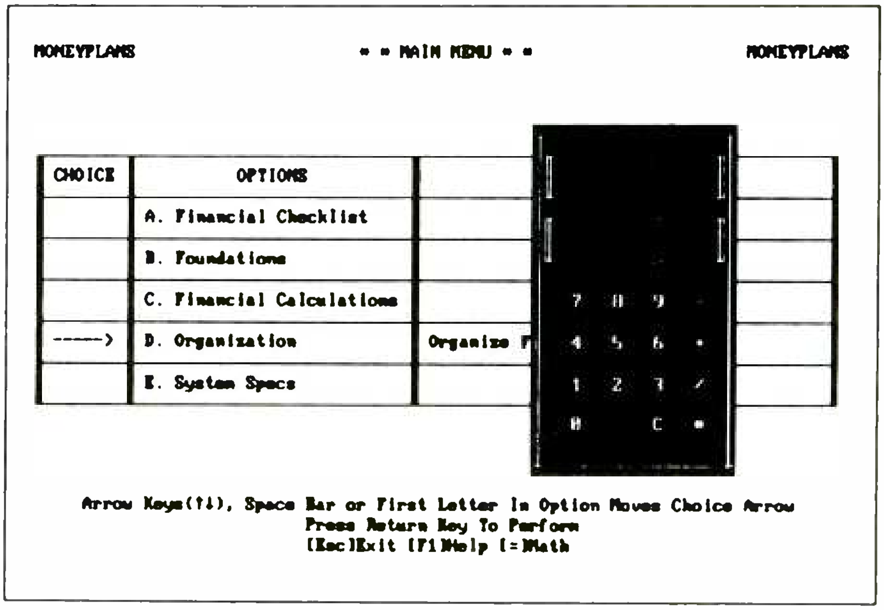
A Financial-Planning Tool: MoneyPlans

By Art Salsberg

Financial-planning software programs have been widely available for some years now. It's an increasingly popular application for home computers. A new one from Parsons Technology, a Cedar Rapids, IA software developer/publishing company that made its mark with its popular $35 MoneyCounts money management program, now in Version 6, is examined here. It's called MoneyPlans and retails for $49 plus $5 shipping/handling.

Unlike MoneyCounts or similar programs, which encompass accounting methods and reports that require regularly inputted financial information, MoneyPlans is an overall financial planner that one might modify once in a while to keep abreast of financial goals. These are primarily aimed at retirement or a survivor's financial status, and determining the best financial route to take when making a decision for a loan, lease, redeeming or buying a CD or bond, choosing a mortgage, etc. Thus, it's a self-appraisal type of program. Additionally, it has a section that helps you to organize your household inventory for estate-planning and insurance reasons.

You need an IBM PC, XT, AT or compatible computer with two floppy disk drives or one floppy and one hard disk drive, 384K of RAM minimum and DOS 2.0 or higher. You get a choice of two 5.25-inch or one 3.5-inch diskettes. Installation is simple as can be. Just type Install and you're quickly led by on-screen directions. The program can be linked with the company's best-seller MoneyCounts, and the install process gives you this choice and a file Path option for it. Printer control codes are preset for IBM, Okidata ML192, Epson FX85, NEC 2200, C. Itoh 8510 and HP Laserjet. If your printer emulates any of these, you needn't fill in codes for spacing, graphics print, etc. If not, you might have to make changes. A phone call to the company will help you out here.



The purpose of MoneyPlan's calculator function is to provide quick calculations of a few items—not to handle complicated functions.

The program is divided into four basic sections: a Financial Checklist, Foundations, Financial Calculations and Organization. Everything is menu and submenu driven, making it all exceedingly painless to move in, out and about. The Escape, Enter, Space Bar and Function Keys 10, 7 and 3 are all you really have to use to maneuver. A Help pop-up window is activated by pressing F1 at any time. Another pop-up, a simple math calculator, is displayed on screen when the equals (=) key is pressed. Results can be inserted into program text when the cursor is on a figure field.

Also, by keying F2, a user has access to Notepads in order to jot down some reminders, such as math calculations, and so on. The limit is two notepad pages. All screens have prompt lines at the bottom of the display.

Using the F10 key after feeding in information requested provides you with an Analysis screen, which summarizes what you've entered. Using F10 again causes a Commentary screen to appear, which outlines the results of the analysis. Most of the sections also give you the option of viewing a bargraph(s) relating to the data and, of course, an opportunity print it.

In-Use Comments

This is a very easy program to work with. The difficult part is gathering some of the information you need, such as life insurance policy data, date of purchase and value of furniture, etc. But this is all part of organizing yourself from a financial perspective. You needn't (and should not) try to do it all in one sitting.

The real strength of the program is in its automatic calculations and summaries that spell out in text, numbers and graphs all the final information. Its bargraph Retirement Analysis, in particular, is quite revealing, extending out to your anticipated life expectancy what your funds and the change of them from the previous year will be, all based on the information you previously entered.

There are a few shortcomings, though. For example, your survivor is expected to start drawing Social Security income at the age of 65. Consequently, the analysis will be skewed if your survivor chooses to take Social Security benefits at an earlier or later age.

Additionally, there is no data input section for an anticipated interim debt or income. For example, one might expect to draw money from a trust fund someone set up for you when you're five years into a retirement period. Alternatively, you would ordinarily have to figure in some large intermittent anticipated expenditures such as the purchase of a new automobile, giving a child a down payment for purchasing a home, paying for a daughter's elaborate wedding, etc.

Along with listing household inventory and insurance policies, it would be desirable to have a similar recording of one's stock/bond portfolio. Further, it would make things much more efficient later on when updating information to have a breakdown of assets. A CD's rate of return may not change, but the value of stocks certainly will. With a breakdown, it would be easier to readjust the total.

What's needed, therefore, is a "what-if" opportunity for the user to insert into the data mix some years past the present.

Missing, too, is the recording of a date when you last provided data in sections where a date, such as purchase date of a car, is not required. It would be helpful, though not absolutely necessary to know this when looking at the data some time later to bring it up to date.

If the above features were added, it would cause some operating complexities, naturally. At $49, this is without question a worthwhile piece of software to buy. It's sure to give you a rough overall fix on your present and future states. I'd like to see some of the fine-tuning nuances cited earlier. Others, however, will lean toward trading this off for the utter operating simplicity of the program.

According to the program's analysis of my modest retirement goal, I learned that I have to save about $152,000 more or get a steady 12-percent or more return on my investments to meet it. With the inexpensive MoneyPlans, you, too, can quickly have your computer tell you how attainable your goals are and what you need to reach them. Just call Parsons at 1-800-779-6000. **ME**

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Antenna Grounding Basics

By Joseph J. Carr

Shortwave listeners, CBers and ham radio operators need outdoor antennas that get the most out of their hobbies. Good grounding is a topic often overlooked in otherwise excellent articles about building an antenna. Two very good reasons exist for providing an outdoor antenna with a good ground. One is lightning protection for the radio equipment with which the antenna is used. The other is maximizing the operating effectiveness of the antenna.

Lightning & Effectiveness

Anyone who installs an outdoor antenna must take into consideration lightning protection. In most locations, the antenna doesn't add to the risk of a lightning strike (in fact, it may actually provide some modest protection during an electrical storm). In some locations, such as where lots of high pine trees are in the surrounding area, lightning is more apt to strike. In the event of a close strike, however, a tall vertical antenna will act something like a lightning rod and actually draw the strike to itself and safely dissipate the energy of the strike to ground—assuming, of course, that the grounding system is well-designed.

Local electrical codes and fire-insurance regulations determine whether or not you need a ground and what its minimum form must be. When you are planning a grounding system, therefore, always consult your local electrical inspector about minimum requirements. Also, keep in mind that an insurer can decline to pay off on your homeowner's insurance policy in the event of damage resulting from a lightning strike if minimum legal requirements are not met.

Antenna effectiveness is perhaps what motivates most users to bother with setting up a good grounding system. Poor grounds cause most antennas to operate at less than peak efficiency, robbing hams and CBers of r-f power that could otherwise be used to radiate a signal with lots of "punch." If the grounding system is really poorly designed, it's possible to

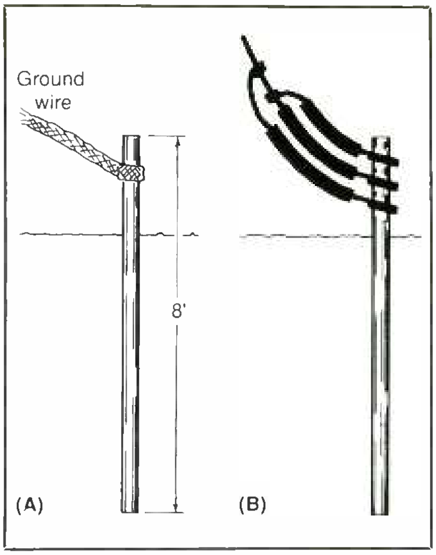

Fig. 1. Shown (A) a traditional grounding rod and (B) a method for making a low-resistance, low-inductance grounding wire by paralleling single conductors.

burn up between 50 and 90 percent of the power delivered by a transmitter heating the ground under the antenna. Any power lost to ground is less power propagated through the air and, as a result, reduced "signal" power is available.

Even SWLs must consider a good grounding system to obtain maximum possible reception range and sensitivity. The antenna principles that apply to efficient transmitting are the same for reception, regardless of whether the signal has microwatt or megawatt power behind it.

Ground resistances can vary from very low values of 5 ohms to more than 100 ohms (5 to 30 ohms is the frequently quoted range). R-f power is dissipated in the ground resistance in the form of heat. The factors that affect ground resistance include ground conductivity, composition of the ground and moisture content of the ground. The ideal depth of the ground is rarely on the surface. Depending on local water-table level, it may be a couple of meters or so below the surface.

It is common practice by many users to employ a building's 60-Hz ac electrical ground wiring for an r-f antenna ground. Instead of installing an outdoor ground to properly handle the job, they opt for a single connection to the grounded conductor in a nearby electrical outlet. Even if this weren't a dangerous practice (unless you know what you are doing), this type of connection provides a very poor *r-f* ground because it's too long for even the low hf bands and radiates large quantities of r-f around the house. Stations that use household electrical wiring as a radio ground tend to cause TVI, BCI and other electromagnetic interference locally and in nearby structures.

Traditional Grounds

Shown in Fig. 1(A) is a traditional ground rod used by most hams, CBers and SWLs. You would use either a solid copper or copper-clad steel rod measuring at least 8 feet long for this arrangement. Such rods are available from electrical supply houses and suppliers of amateur radio equipment. Do *not* use the steel rods that have no cladding and are sold by some electrical supply houses. These are usable by electricians when making service-entrance grounds in a home or workplace. R-f applications, however, require the low "skin" resistance of the copper-clad variety of rod. The rod need not be solid copper because the skin effect forces r-f current to flow on only the outer surface of the rod.

Always try to use an 8-foot rod if at all possible. It works better than shorter lengths—and may be legally required by your local electrical code. Don't bother with the short 4-foot grounding rods made for TV antenna installations; they are virtually useless for hf radio stations and may be illegal to use as well.

Drive the rod into the earth until only 6 inches or so remains above the surface. Then connect a good ground conductor from your station to the exposed end of the grounding rod. Make this conductor as short as possible, and use only low-inductance cable, such as heavy braid (or the outer conductor removed from a length of RG-8 or RG-11 coaxial cable) or sheet copper. You can buy rolls of sheet copper from metal distributors in widths ranging from 4 to about 18 inches.

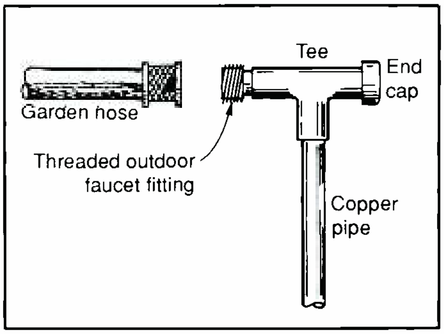

Fig. 2. Details for making a copper-pipe "water drill" for sinking a grounding rod made from copper pipe.

Sweat-solder the ground conductor to the rod. Though you may be able to initially get away with using mechanical connections the way electricians do, you'll eventually have to service the installation when corrosion takes its toll, as it inevitably will. The preferred way to go is to solder all connections and then cover the joints with petroleum jelly or a thick layer of spray acrylic lacquer.

If you can't obtain copper braid and find copper sheets too cumbersome to work with, try using parallel conductors, as illustrated in Fig. 1(B), to make the ground system low in both resistance and inductance. If you can find automotive copper—*not* aluminum—battery cable or primary wire, use it as the ground conductor. Otherwise, use a number of at least No. 6 or No. 8 stranded wires in parallel for this conductor.

Another alternative is to use copper plumbing pipe as the grounding rod. These pipes can be purchased in 8- through 16-foot lengths from plumbing supply douses and many do-it-yourself hardware stores. Select at least ¾-inch-diameter pipe for your grounding rod. The surface area of the hollow pipe is greater than that of a solid rod of the same diameter. Because of certain current-flow geometries in the system, however, the ground resistance is not half the resistance of a rod of the same diameter, though it is lower.

Driving a long pipe into compacted earth isn't an easy task. Unlike copper-clad steel rod, pipe has little compression strength and will deform when struck with a hammer or other driving tool. To overcome this, you can use a garden hose as a water drill, as illustrated in Fig. 2.

To make the water drill, sweat-solder a T joint on the top end of the pipe and an an outdoor faucet fitting that matches the coupling on your garden hose on one end of the T joint. Cap off the other port on the cross-bar of the T joint.

Use the T joint as a handle to drive the pipe into the ground with water at fairly high pressure running down the length of the pipe. When water pressure is applied, the pipe will sink into the ground as you apply firm and steady downward pressure on the T-joint "handle."

In some cases, the pipe will slip into the ground fairly easily, requiring only a few minutes to complete the operation. In other cases, where the soil is hard or has a heavy clay content, the job will take considerably longer and require greater effort to complete. When you're finished driving the pipe into the ground, turn off the water flow and disconnect the garden hose from the T joint. Some people also recommend that you desolder and remove the T joint.

Conductivity

The conductivity of the soil determines the effectiveness of the ground system to conduct electrical current. Moist soil over a brackish water dome conducts best, which accounts for why southern swamps make better radio-station locations. The sandy locations of the western deserts make the worst conductors.

Shown in Fig. 3 is a method for reducing the electrical resistance of the soil by treating the latter with either copper sulfate or common rock salt. The latter is one of several saline materials used for melting ice and snow. If you're unable to locate rock salt in a hardware or other store, look for a dealer who sells supplies for making ice cream; rock salt is a principal ingredient in making ice cream.

Figure 3 shows top (A) and side (B) views of a trench method for applying the chemical treatment. To make the trench, dig down 6 to 10 inches in a circle 12 to 24 inches around the grounding rod. Fill the

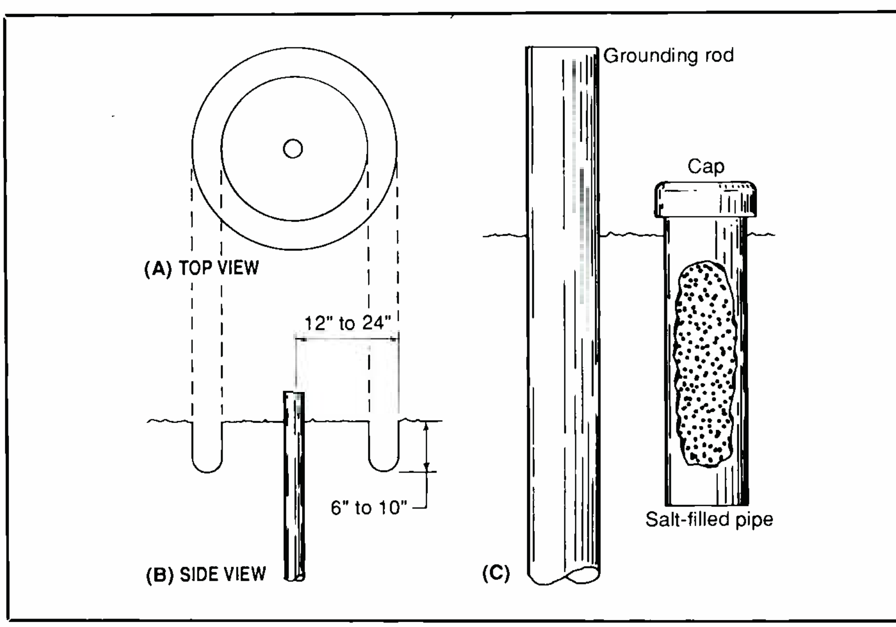

Fig. 3. Two methods of increasing the conductivity of soil: (A) top and (B) side views of a trench dug around the grounding rod and (C) a salt-pipe scheme.

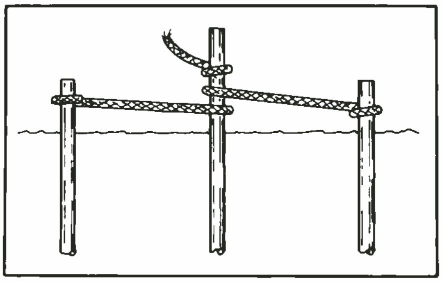

Fig. 4. A distributed ground makes use of more than one grounding rod.

trench with a 4- to 5-inch layer of rock salt or copper sulfate. Then cover the remaining depth of the trench with some of the soil you removed earlier. Water the trench well for about 15 minutes. Repeat the entire process every 12 to 36 months, depending upon local rainfall and soil composition.

Shown in Fig. 3(C) is an alternative to the trench method of changing the conductivity of the soil. Here, you use salt pipe made from either copper or PVC plumbing pipe measuring up to 4 inches in diameter. You'll find that 2- to 3-inch pipe is easier to work with.

Overall length of the salt pipe should be not less than 18 inches and preferably 24 inches. Longer pipe is also useful. Drill a large number of small holes, which should not be greater than ⅜ inch in diameter, through the portion of the pipe that will be buried. Do not drill any holes through the pipe portion that will be above ground level. When you are finished, fill the pipe with rock salt and cap off both ends.

Prepare several salt pipes, which you can arrange in a circle around the grounding rod. Each salt pipe should be the same distance away from the ones flanking and from the grounding rod.

Installation of the salt pipes is best accomplished with a post-hole digging tool. Dig the holes only to the depth required for burying the salt pipes. Drop a salt pipe into each hole and replace some of the soil removed during the digging operation to hold the pipes in place. Soak the ground directly around each salt pipe with water. Then remove the end caps from the pipes and hose down for about 15 minutes for each pipe. Periodically refill the pipes with salt to make up for salt that has been leached out of the pipes.

Multiple Grounding Rods

The key to a good low-resistance ground is the surface that comes in contact with the soil. One means for gaining maximized surface area and reducing ground resistance is to build a system of multiple grounding rods. Multiple 4-foot ground-

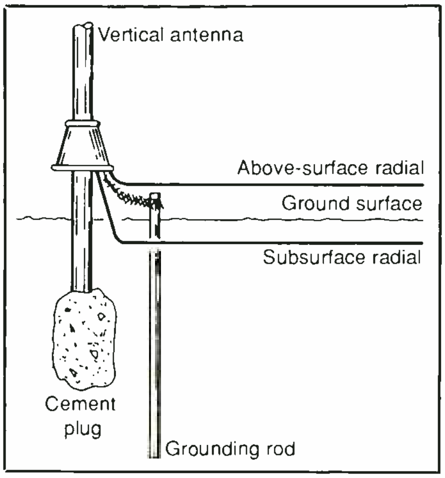

Fig. 5. Illustrated are methods for grounding a surface-mounted vertical antenna.

ing rods are better than a single 4-foot rod, but use of 6- or 8-foot rods is recommended even in cases where multiple grounding rods are used.

Figure 4 shows how to use three grounding rods in the same system. The 8-foot rods are placed 12 to 18 inches apart for low and medium power levels and perhaps 30 inches apart for higher amateur radio power levels. Make an electrical connection between the rods on the surface, using either copper stripping or copper braid. Sweat-solder the connections as described above, with the feed point at the center rod.

You can substantially enhance the effectiveness of your grounding system by using radials that can be located aboveground or buried under the surface of the soil. A vertical antenna with three different types of radials is shown in Fig. 5: above-ground, sub-surface and grounding rod. It isn't unreasonable to use both radials and a grounding rod in an antenna system. Vertical antennas are relatively ineffective unless they're provided with a good grounding system. For most installations, this requirement is best met with a system of ground radials.

An effective system of radials required a large number of radial elements. Although as few as two quarter-wavelength resonant radials can effect an improvement in the effectiveness of an antenna system, best performance is obtained with more radial elements.

Broadcasters in the commercial AM radio band are advised to use 120 half-wavelength radials. Of course, installing more than 120 radials is expensive, not to mention time-consuming. The added cost and time also don't provide any substantial improvement. For Amateur stations, use of a minimum of 16 quarter-wavelength radials is recommended for maximum communicating efficiency.

Above-ground radials should be made from insulated wire, though insulation is not a requirement. Below-ground radials should be made from wire that has no insulation on it. Although some people claim that any gauge wire from No. 26 to No. 10 can be used for the radials, it's best to use larger gauges in the range from No. 14 through No. 10. You can use solid or stranded wire for your radials.

Shown in Fig. 5 are the details for setting up a vertical antenna system. Here, the radials are arranged in a uniform spoke pattern centered around the antenna element. With this arrangement, you obtain both lowest resistance and best radiation pattern from the antenna. When putting together the system, solder together all radial elements at a common point, which might be the grounding or mounting rod used to support the vertical antenna element.

If you opt for above-ground radials, be sure to safeguard the area to prevent anyone from tripping over these elements.

Lightning Protection

If the worst occurs and lightning does strike your antenna, there's little you can really do to protect your equipment and home. However, there is a very useful thing you can do to avoid such a problem: install a lightning arrester in the transmission line outside your home, as in Fig. 6.

A lightning arrester contains a spark gap that's set to be neutral with the voltages represented by a properly operating antenna at Amateur power levels. If lightning-level potential appears on the transmission line, the air in the gap ionizes and provides a low-resistance path that shunts a large part of the current to ground. There are no guarantees with a lightning arrester, of course. With a direct strike, damage can occur, but it will at least be minimized. **ME**

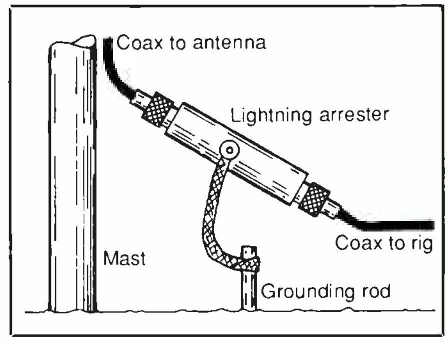

Fig. 6. Details for installing a lightning arrester in the transmission line that feeds the antenna.

BOOKS

Digital Video in the PC Environment. *By Arch C. Luther. (McGraw-Hill Book Co. 334 pages. $39.95 hard cover; $27.95 soft cover.)*

If you are looking for a definitive book on digital video interface (DVI) technology, look no further than this one. Through excellently written text and a multitude of tables, drawings and photos of screen shots (some of the last in full color), this book shows how DVI combines interactive full-motion video, stereo audio and powerful computer graphics. Written by an expert in the technology, this book is aimed at anyone who wants to learn about this new technology and the special skills required to apply it.

Beginning with an introduction of the need for such a system, the book goes on to introduce DVI, which becomes an illustrative system for all subsequent discussions. This gives the fundamentals for such systems, particularly the capabilities of DVI and how it can be applied, to permit the reader to evaluate competitive commercial offerings. Via 13 following chapters, the book discusses analog and digital video, digital audio, optical storage systems, the PC and digital audio/video together, DVI technology, hardware and software, still video imaging systems; video compression, digital motion-video systems, special video effects, and developing a DVI application. A final chapter looks into the future, examining industry trends, standards, markets and digital audio/video advances.

As the author points out, one book cannot possibly give comprehensive knowledge in all the disciplines involved in successfully applying DVI technology. However, he has done a creditable job in showing how they all come together in the creation of systems and applications. This is not a designer's book, though. Rather than detailing how things are done, the text teaches what things to do and what is needed to apply the features of audio/video/computer systems to specific applications. Even so, this is not a neophyte's book; rather, it presumes some technical background and familiarity with electronic systems and personal computers (including some programming), though not necessarily skill in these areas.

A knowledge of programming is a valuable asset in applying DVI technology, though it is not necessary for the reader to be a programmer to follow the discussions in this book. Deep software discussions are segregated into separate sections that non-programmers can simply skip over. Included at the end of each such section is a paragraph that brings the non-programmer back into the flow of the text.

Taken as a whole, this is, indeed, an authoritative one-stop source for information on DVI technology from a use, rather than design, point of view. It deserves a place in the library of anyone who is seriously interested in putting together or/and applying an interactive audio/video/computer system.

Land Mobile Radio Systems. *By Edward Singer. (Prentice-Hall, Inc. Hard cover. 257 pages. $29.80.)*

This book explains how computers, digital technology, spectrum-conservation systems, satellites and other technologies can be put to use to improve land radio communication. As such, it provides solutions to problems that can destroy the effectiveness of a radio system. An initial chapter gives an overview of land mobile radio. Then the book goes on to examine conventional FM mobile radio systems, covering simplex and duplex systems, transmitters, receivers, mobile relays, portables, antennas and towers, transmission lines, consoles and remote-control base stations.

Still later chapters deal with avoiding problems with squelch systems, combining receivers and transmitters on one antenna, controlling frequencies and improving and extending area coverage. A chapter on conserving spectrum space discusses use of trunking systems, cellular mobile radio systems, amplitude-compandored SSB, etc. A Ties that Bind chapter gets into telephone lines, replacing telephone lines with microwave links, use of fiber optics, cable TV in a two-way radio system and linking the system with r-f.

Combining computer technology and land mobile radio systems is followed with discussions of the digital revolution, using pager systems, maintaining system operation during power failures, minimizing lightning damage, solving radio interference problems. Improving radio shop management, understanding propagation, solving rfi problems, communication in enclosed areas, automatic location of vehicles, using satellites for land mobile communication systems and obtaining station licenses and frequency coordination are topics handled in later chapters in this book.

Two appendices are included. One gives a technical explanation of the decibel. The other is a list of companies that supply commercial computer programs germane to land mobile communications.

Considering its coverage, this book can indeed help one get on top of the latest technology in land mobile communications to help maximize system performance.

NEW LITERATURE

Test Equipment/Tools Catalog. A new catalog from Jensen Tools Inc. features tools, tool kits and test equipment specifically designed for use in workstation and network servicing. The colorful 32-page catalog contains complete technical specifications for each item listed. The products listed include strippers, crimpers, connectors and other LAN accessories, cable tools, datacom test equipment, diagnostic software, disk storage media, disk drive and circuit board repair products, shipping containers, static control equipment, etc. For a free copy, write to: Jensen Tools Inc., 7815 S 46 St., Phoenix, AZ 85044.

Full-Line Catalog. Sencore has a new full-line catalog for 1990 that lists and fully describes a wide variety of test instruments for video, audio and other applications. Other listed devices test cable systems and analyze components and waveforms. Included are IEEE/RS-232 instrument and a complete line of instrument accessories listings. Specifications are given for all products and are accompanied by application information. For a free copy, write to: Sencore Electronics, 3200 Sencore Dr., Dept. ME, Sioux Falls, SD 57107.

Antistatic Cleaner Sample. A free sample of and literature on an antistatic cleaner for conductive and insulative surfaces that does not generate a static charge and prevents static build-up between applications is available from Charleswater Products. The literature for the Reztore™ gives full technical details for the cleaner, including the fact that it is clean-room compatible per FED-STD-209C. For a free sample and copy of the literature, write to: Charleswater Prods., Inc., Alison Walsh, Mktg., 93 Border St., W. Newton, MA 02165.

Test Instruments Catalog. B&K-Precision's new 68-page full-line catalog lists and fully describes a wide variety of electronic test equipment. It includes listings for digital storage and analog oscilloscopes, IC testers, DMMs, signal and function generators, power supplies, component testers, video test instruments, probes and accessories. Complete performance and mechanical specifications are given for all products listed and are summarized in comparison charts. Also included is a glossary of technical terms for each major product category. For a copy of Catalog BK-90, write to: B&K-Precision, Maxtec Int'l. Corp., 6470 W. Cortland St., Dept. ME, Chicago, IL 60635.

SMT Brochure. A new brochure, "SMT for the Layman," for non-technical management who want to learn more about surface-mount technology is available from Bit 7 and Circuit Works. The eight-page brochure provides information that can help in making better decisions with regard to SMT. For a copy, write to: Bit 7, 505 E. Hawley St., Mundelein, IL 60060 or Circuit Works, 1840 Industrial Dr., Libertyville, IL 60048.

Test Instruments Catalog. The 1990 Distributor Products Catalog from John Fluke Mfg. Co., Inc. lists and fully describes more than two dozen bench-top and hand-held portable digital multimeters, counter/timers and digital thermometers. The 20-page catalog also lists a variety of accessories, including carrying cases and portable instrument holsters, test leads and probes, clamp-on ac and dc current probes, and immersion and non-immersion temperature probes. Among the items listed are highlighted the Fluke 80 series hand-held multimeters and the Fluke 45 dual-display multimeter that features a frequency counter, min/max recording, hi/lo/pass testing, dB measurements and RS-232 interface. A guide to selection of leads is also included. For a copy, write to: John Fluke Mfg. Co., Inc., P.O. Box 9090, Dept. ME, Everett, WA 98206.

Prototyping Kit For Electronics Experimenting *(from page 21)*

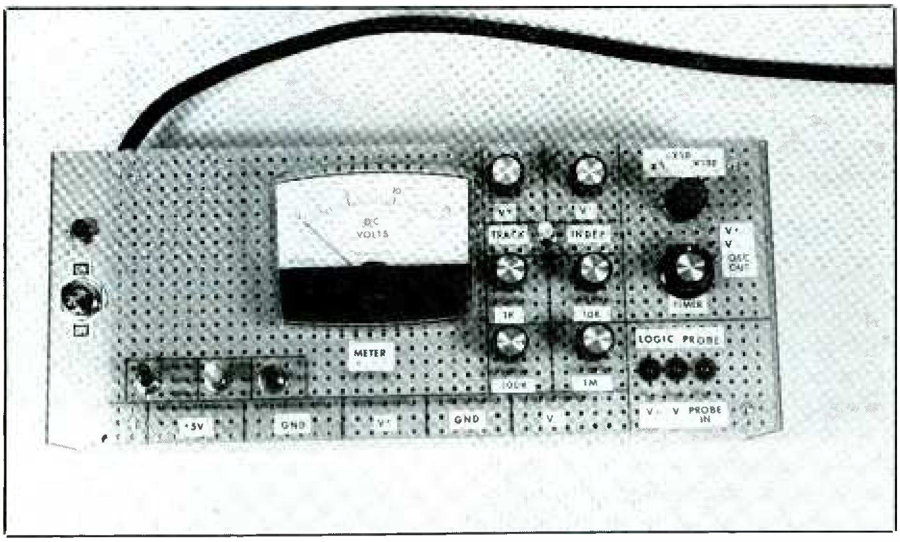

Fig. 5. Front panel of Prototyping Kit holds controls, displays and jumper terminals that give access to power supplies, logic probe, oscillator, meter, etc.

sembly. If you do not use this method, save the connections to the 25-volt secondary of *T1* for last.

Use small screws, nuts and lockwashers to mount *IC1*, *IC2* and *Q2* and their heat sinks on the circuit-board assembly. For efficient heat transfer between the heat sinks and these components, before mounting, lightly coat the components with heat-transfer compound where it will contact the heat sink.

The ground connection for *IC1* is its case. Make this connection by crimping or soldering a spade or circular lug to a short length of hookup wire and fastening the lug to one of the mounting screws of this device. Solder the other end of the wire to GND on the circuit board.

To keep track of your wiring, check off or outline each connection on the schematic or photocopy of it as you make it. Observe proper polarity for *C1* through *C10*, *D1* and *D2*. Install the socket for *IC3*, but do *not* install the IC in the socket yet.

Wire the connections to the components mounted on the front panel using lengths of hookup wire. Make these wires long enough so that when the project is completed, you can lift the cover off the enclosure.

Wire potentiometers *R2* and *R6* so that adjusting them clockwise causes V+ and V− to increase in voltage. That is, with the shafts of the pots facing you, wire *R2* so that the resistance across its two wires increases as you rotate the shaft clockwise, and wire *R6* so that its resistance decreases as you rotate the shaft in the same direction.

Use hookup wire to make connections from the circuit board to the jumper terminals, but wire only the circuit-board ends of these wires into place. Do not wire the ends to the jumper terminals just yet. Instead, wrap a short piece of masking tape around each end and label it with the terminal to which it is to connect.

The pointer of analog panel meter *M1* deflects according to the current through the coil winding. The meter movement used in the prototype gives a full-scale reading at 1 milliampere. With 15,000-ohm resistor *R10* wired in series with *M1*, 15 volts causes 1 milliampere to flow; lower voltages cause proportionately lower current flow and result in less pointer deflection.

Other meter movements may require different series resistors. Also, most movements can be disassembled to permit you to relabel a new scale if needed.

To find the value for *R10* that gives a full-scale reading at 15 volts for a given meter movement, use a 15-volt supply and a 1-megohm potentiometer. Connect one end of the pot to the + terminal of the meter movement, the other end to +15 volts, and the − terminal of the meter to ground on your supply.

Lower the resistance of the pot gradually until the meter pointer is at its full-scale position. The resistance measured (make this measurement out-of-circuit) from the wiper to the reference lug of the pot is the value you need for *R10*. Using this same resistance, replace the 15-volt source with lower, known voltages and note the needle's position at these voltages. From this information, you can prepare a template for a new meter scale if necessary.

After wiring the power-supply circuits, continue with the logic-probe and oscillator circuits in Fig. 2 and Fig. 3. Except for the front-panel connections, which should use No. 28 or larger hookup wire, these circuits can be entirely assembled using the Wire Wrap technique.

Install sockets for *IC4* through *IC6*, but do *not* plug the ICs into the sockets just yet. Observe proper orientations for *D3*, *D4* and *C15*. Use hookup wire to make connections to *LED1*, *LED2*, *LED3*, *S3* and *R20* Also, wire the circuit-board ends of wires to the V+(IN), V+(IN), PROBE(IN) and OSC(OUT).

Although the logic probe and the oscillator each have V+(IN) and V−(IN) terminals, each is wired independently—V+(IN) on the logic probe does not connect to V+(IN) in the oscillator.

You are now ready to install and wire the jumper terminals. The terminals press-fit into the perforated board holes, as shown in Fig. 6. A simple way to to install these is to lightly position a terminal in its hole, grip the underside of the perforated board and the top of the terminal between the jaws of pliers and squeeze to push in the terminal.

To wire a connection from a terminal to its circuit-board wire, wrap the free end of the wire around the terminal on the underside of the front panel. To keep the inside of the terminal from filling with solder, insert a small-diameter (No. 28) *insulated* wire into each terminal before soldering. Solder the wrapped wire to the terminal, applying only as much heat as needed to make a sound connection, and remove the insulated wire.

After soldering, insert a jumper wire of the type you plan to use with the terminals, and see if it fits and is gripped tightly by the terminal. If the wire does not fit or is loose, use a larger or smaller size to hold the terminal open as you solder.

When you are ready to wire the terminals on the front panel, press them into the perforated board and solder the prepared wires from your circuit board to each terminal. Mount holders for *LED1*, *LED2* and *LED3* and insert the LEDs.

To wire extra independent switches into the project, use 2-inch lengths of insulated hookup wire from which ¼ inch of insulation has been stripped from each end. Solder a wire to each switch terminal. Mount the switch on the front panel and wire each switch lug to a jumper terminal.

Use a consistent wiring scheme for all switches. For example, wire toggle switches so that when a switch is in the "up" position, it connects the top jumper terminal to the middle one. Measure with an ohmmeter or use an audible continuity tester across each pair of terminals in turn to determine which switch lugs connect in each position. Similarly, wire any extra potentiometers you are installing on the front panel.

Label the terminals, controls and displays on your project in any convenient way. The labels in the photos were made by transferring press-on lettering to small paper labels.

Install *R2*, *R6*, *R20*, *M1* and *S3* on the front panel. Place pointer-type knobs on *R2* and *R6* so that the pointers are directed to the left when the shafts are fully counterclockwise. Turn *S3* so that *C15* connects to *R20* and mount a knob pointing to the ×1 label. Also, place knobs on any other potentiometers installed.

Checkout & Use

When you are ready to check out the project, begin by visually inspecting all circuits for poor soldering, missed connections and solder bridges, the last especially between the closely spaced IC socket pads. Solder any connections missed and reflow the solder on any suspected connection. Clear any solder bridges with desoldering braid or a vacuum-type desoldering tool.

Place a fuse in its holder and rotate the shaft of *R2* fully counterclockwise. Set *S1* to "on" and verify that lamp *I1* lights. Clip the common lead of a dc voltmeter or multimeter set to the dc-volts function to any convenient point in the project that is at ground potential. Touching the "hot" probe to the +5V(OUT) terminal should yield a measurement of +5 volts. Touching this probe to the V+(OUT) terminal should give a reading of +1.2 volts at one end of travel and at least +12 volts at the other end of travel of *R2*.

The power supplies may adjust slightly beyond their 1.2- and 12-volt limits. For example, V+ may adjust as high as 14 volts, with the precise limits determined by the values of *R1* and *R2*.

At pins 4 and 7 of the *IC3* socket, the meter readings should be −15 and +15 volts, respectively.

If you see any problems now, or anywhere else during the checkout process, power down and rectify the problem before proceeding.

When you are satisfied that everything is okay, power down and install *IC3* in its socket. Set *S2* to INDEPEND-

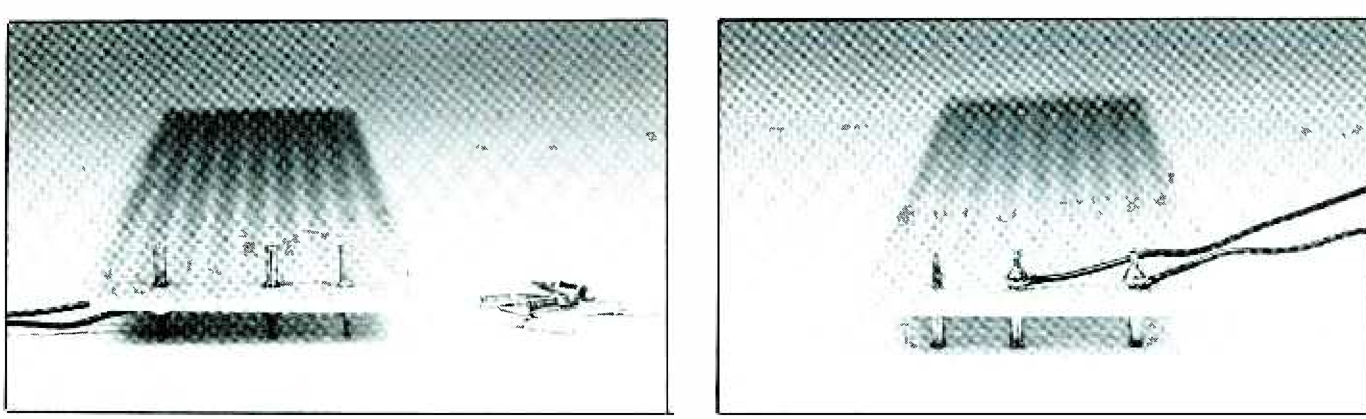

Fig. 6. Jumper terminals (A) press-fit into perforated board. Wires solder to terminals on the underside of the perforated board (B) and connect to components on main circuit board. Temporary connections are made by plugging jumper wires into terminal sockets on front panel.

ENT, set *R6* fully counterclockwise and power up. With the common lead of your meter still connected to circuit ground, touch the "hot" lead to V−(OUT) while adjusting *R6* from one end to the other. The meter should indicate from −1.2 volts or slightly more positive to at least −12 volts.

Set *S2* to TRACKING and measure from V+(OUT) to GND and from V−(OUT) to GND. The V− supply reading should be the same as the V+ reading, only with a negative polarity. That is, if V+ to ground measures +10 volts, V− to ground should measure −10 volts. As you adjust *R2*, both supplies should vary by the same amount with reference to ground.

Test *M1* by plugging a jumper wire from the *M1* + terminal to V+(OUT) and from its − terminal to ground. The reading on *M1* should match the V+ voltage. You can also measure negative voltages with *M1* as long as you plug the more-positive jumper to the + terminal on the movement.

You can test current-limiting circuitry for the V− supply with an ammeter or dc current function of a multimeter and a 10-ohm, 5-watt resistor. Make sure your meter is capable of measuring at least 1 ampere. Set V− to −10 volts, turn off the project, and connect the resistor from V−(OUT) to the common lead of the ammeter. Connect the "hot" ammeter lead to circuit ground.

Power up the project. Normally, you would expect the 10-volt supply to provide 1 ampere of current through the 10-ohm resistor. However, because of the current-limiting circuit, the measured current should be only around 350 milliamperes.

To check the logic probe, first power down. Then insert *IC4* and *IC5* in their sockets. Plug jumper wires between V+(IN) and +5V(OUT), V−(IN) and GND, and PROBE(IN) and +5V(OUT). When you power up again, the red LED should light, and the yellow and green LEDs should remain dark. Pulling the PROBE(IN) jumper from +5V and plugging it into GND should cause the green LED to light and the yellow LED to flash as the input changes from high to low.

You can use the logic probe to test an oscillator at low frequencies. Power down, insert *IC6* in its socket, set *S3* to ×1 and set *R20* fully counterclockwise. Plug jumper wires from V+(IN) to +5V(OUT), V−(IN) to GND and OSC(OUT) to PROBE(IN) on the logic probe. V+(IN) and GND on the logic probe remain plugged into +5V and GND as well.

Turn on the project. The red and green LEDs should alternately flash at about a 0.2-Hz rate, with the yellow LED flashing at each transition. Adjusting *R20* clockwise, the frequency should increase until all three LEDs appear to be on constantly.

To measure the exact output frequencies of the oscillator, you need a frequency counter or oscilloscope. If one of these is available, connect it to OSC(OUT) and GND. As you adjust *R20* clockwise in each range, the frequency should increase, and there should be no gaps between ranges (×1 should provide a 0.2-to-20-Hz range; ×10, a 15-to-1,500-Hz range; and ×100, a 1.2-to-120-kHz range). Due to variations in the values of *R18* through *R20* and *C15* through *C17*, the frequency ranges of your oscillator may vary slightly from these.

Finally, you can check your independent potentiometers and switches with an ohmmeter. Connect your leads across the jumper terminals for each pair of switch terminals in turn and check to see that the resistance changes between 0 ohms and infinite as you operate the switch. To check the potentiometers, measure from the wiper terminals to the other terminals, rotate the shafts and verify that the measured resistance is as expected for the values chosen.

Your Prototyping Kit will soon be the first thing you reach for whenever you sit down at your workbench to begin experimenting with circuits. It has all the basics needed for building circuit prototypes—power supplies, signal source, logic monitor and commonly used switches and potentiometers. In fact, if you routinely use other items, such as LEDs and other indicators, you will probably want to add these to the basic Kit as you go along. Feel free to expand upon the basic idea as you see fit. The objective is to make your prototyping easier and more productive. **ME**

Electronic AB Switch For PC Keyboards *(from page 51)*

two players of whom each has a separate keyboard, take command of the main keyboard and load the game program. Instruct your opponent how to enter moves, which usually involves use of the arrow and enter keys. If a weaker opponent wants the computer to suggest a chess move, be generous; take command to perform this function and restore program execution back to the two-player mode.

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

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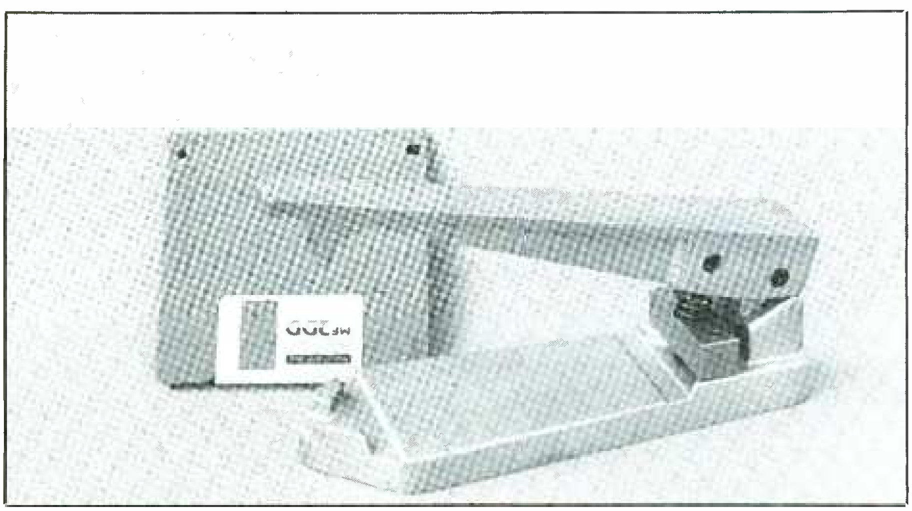

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LETTERS . . . *(from page 7)*

those generated by the "bounce" of a mechanical switch, or by false triggering at IR receiver MOD1 *in the Event Counter. (The data sheet for the counting module specifies a minimum pulse width of 100 µs and maximum frequency of 7 Hz.) In testing the project, I detected no false counts caused by incandescent, fluorescent or sun light.*

As you suggest, using a crystal or ceramic resonator to drive an oscillator is an effective way to design an IR transmitter at a specific frequency. Either this approach or use of the 555 circuit shown in the article will transmit close enough to the desired 40 kHz for reliable detection by MOD1.*—Jan Axelson.*

A Matter of Values

• Thanks for the "Electronic Controller for Slide Projectors" in the May 1990 issue. I would like to build the project, but before I do I need clarification on several component values that are not the same on the schematic and in the Parts List. The components specifically in question are *R15*, *R17* and *C6*.

John C. Taylor
Marion, IN

The correct values for the components are as follows: C6 *is a 22-µF, 10-volt tantalum capacitor,* R16 *is a 220,000-ohm trimmer potentiometer and* R17 *is a 1-megohm potentiometer.—Ed.*

Mystery Photo

• The photograph shown in the "Home Security Porch Light Controller" article (June 1990) on page 24 doesn't match that shown for the project on the cover. It's the same as that pictured at the beginning of the "Infrared-Detector Event Counter" in the same issue.

K. Furstman
Astoria, NY

The wrong photo was inadvertently used in the Porch Light Controller article. The correct photo for this article is, indeed, shown at the lower-right on the cover of the June issue.—Ed.

Author Feedback

• There are a few errors in my "Wide Coverage Water Sensor Detector" article (June 1990). In the Parts List, *U1* should be a CD40106BE, not a CD4010BE (the schematic and text are correct). The last full paragraph on page 36 should read: "You need a larger enclosure only if you use a lantern battery instead of the six D-side cells." Contrary to the text, Fig. 3 and Fig. 4 illustrate battery-powered versions of the water detector. Resistivity in the Table on page 35 should read 10^3 to 10^5 and 4×10^3 to 2.5×10^4 for ground water and soil, respectively. Finally, the Bayard sensor tape's aluminum wires cannot be tinned with solder as directed. The terminal board specified in the Parts List uses spring force to guarantee reliable connection of these wires.

Any reader who wishes instructions left out of the article for sensor preparation can send a self-addressed stamped envelope to me.

Brad Thompson
GMT Interface Products
Suite 233, 56-A Main St.
Maynard, MA 01754

Mystery Solved

• I just received the February 1990 issue of *Modern Electronics* and noted that a number of pages were missing (29 and 30, 49 and 50, 59 and 60, etc.). Did I get a defective magazine, or what?

Name Withheld

Your issue is not defective. Post Office regulations require that any inserts—business reply and reader service cards and their stubs, for example—must be counted as pages, even though they do not have actual page numbers printed on them. If you check your issue, you'll find that the "missing" pages coincide with either cards or stubs.—Ed.

Author Message

• The response to my "MC68701 Microcomputer Chip Programmer" in the May 1990 issue was so tremendous that I sold out my initial stock of pc boards in just a few weeks. I had more boards made, but they sold out, too. I am in the process of moving, so I won't be able to fill any more orders until the fall of this year. The new price of the minimal EP701 kit (includes pc board, EPROM, documentation on disk and shipping to the U.S. and Canada) is $37.50. Any readers who still wish to order the kit should write to me first so that I can have enough boards made to cover all orders. Do not sent payment at this time. I'll contact those who write as soon as I am established at my new address.

Brian Beard
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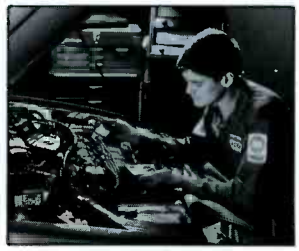
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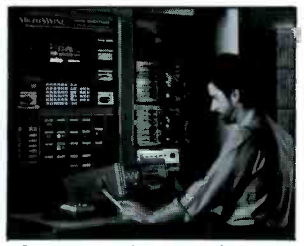
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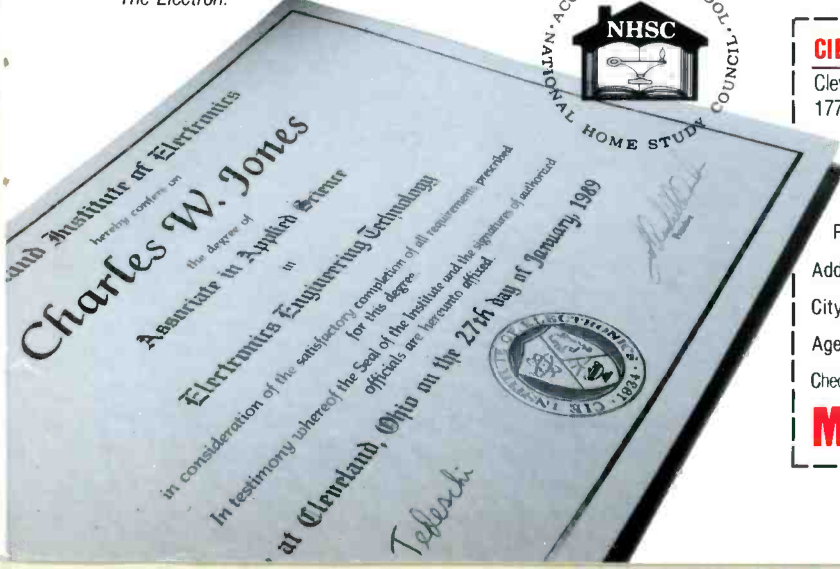

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Optional Accessories R-2000:
- **VC-10** VHF converter
- **DCK-1** DC cable kit for 12 volt DC use.

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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:
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