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- **An Emergency Electronic Ignition**
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- **Phone & Answer Machine Tester**
- **Automobile Headlights Monitor**
- **Musical Instrument
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Computer-Controlled Robotic Arm (p. 24)



Phone-Ring Visual Indicator (p. 32)



Plus: Understanding Negative Logic • Phone-Call Visual Indication • Forrest Mims' Computerized Chart Recorder • Radio Communication Propagation Data • Evaluating "Dac-Easy Light" Home/Small Business Accounting Software • Monolithic Accelerometers • Electronics & Computer News • Latest Books & Literature



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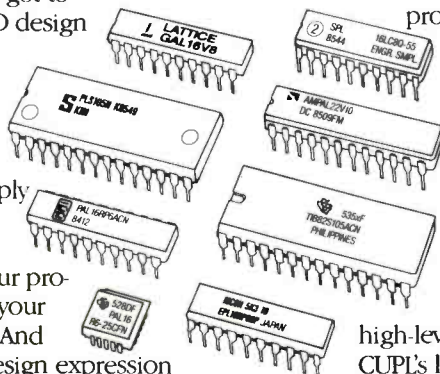
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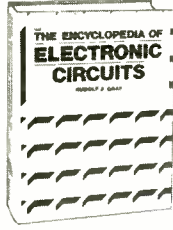
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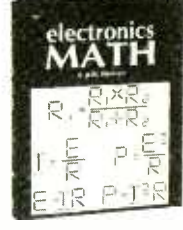
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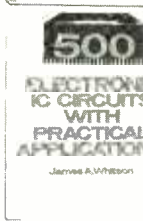
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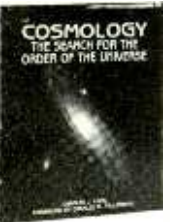
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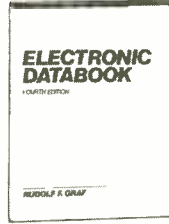
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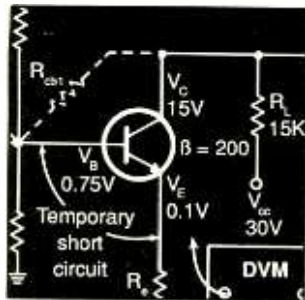
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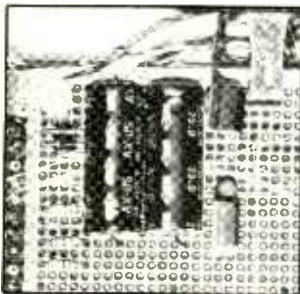
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- Modern Electronics**
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- Advertising Manager
Peter Conn
Sales Assistant
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76 North Broadway
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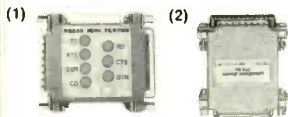
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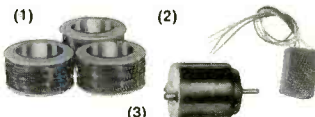
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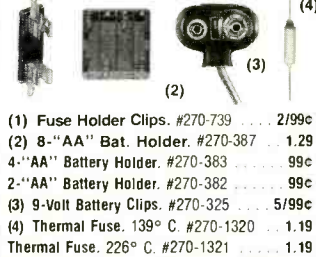
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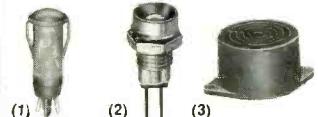
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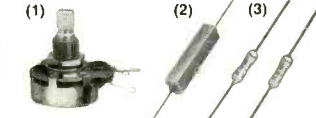
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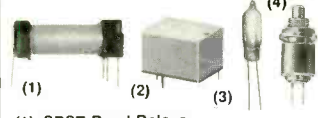
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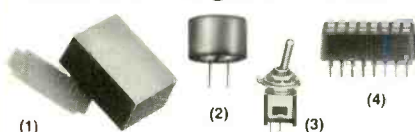


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EDITORIAL

The Fifth

Here we are putting to bed the first issue in our fifth year of publication. Although this longevity pales next to one of our sister magazine's (*CQ The Radio Amateur's Journal*) 43 years of continuous publishing, it's nevertheless impressive because the first few years in magazine publishing are especially fragile ones due to high startup costs, among other challenges.

Electronics and computer life has not changed too dramatically since *Modern Electronics* bowed in October 1984, though evolutionary changes have indeed taken place, and revolutionary changes to come can be seen.

On the latter, for example, how many of you have actually worked with surface-mount devices? Not many, I'll bet, but you know that you'll be facing them some time soon. Do you own an S- (for "super") VHS videocassette recorder and a TV set equipped to take full advantage of its higher resolution capabilities? Not many of you do, for sure. But this will change down the road. I'm confident, too, that few of you have upgraded your computers to IBM Personal System/2 models at this time, but the day will come.

So though the past four years have given us a glimpse of what's really new and heavily adopted, it's clear that most people just don't dump what they've invested in quickly unless the gain is too appealing to possibly resist.

Typically we ride with what we've got and try to do some jury rigging to make advancements—a plug-in

adapter, a speedup computer board, a wider-bandwidth scope, etc.—until it's clear that there's more to lose than gain by holding off new investments.

Adding a 3½" disk drive to a computer would be one change that will be made by many of you fairly soon as this format passes 5¼" ones in service. If you're into electronic repair or development work, you'll want to upgrade to more useful oscilloscopes as quickly as possible in order to capture elusive signal glitches. The list of possibilities is long, depending on your needs.

We'll continue to keep you apprised of upcoming changes in the broad fields of electronics and computers, as we have in the past. These changes affect all of us, of course. Here it has meant adding a slew of desktop computers and a laser printer, connectivity with our own recently upgraded professional typesetting equipment, adding a facsimile machine (our FAX number is 516-681-2926), expanding and integrating our publication offices for the three monthly magazines we produce (*Modern Electronics*, *CQ The Radio Amateur's Journal* and *Popular Communications*), a new annual for hams (*CQ Amateur Radio Buyer's Guide*) and a handful of books.

Our publications reach out to more than 200,000 readers every month now with special-interest information. All of them have been combined under one corporate banner, too—CQ Communications, Inc.—thanks to your support. Happy 5th!

Art Salsberg

LETTERS

Likes Balance

• I think *Modern Electronics* is the best and most well-balanced electronics magazine on the market in terms of computers and general electronics coverage. I most enjoy Forrest Mims' "Electronics Notebook" and the occasional articles about specific components (thyristors, the 555 timer, etc.) and their uses, as well as the informative construction articles. Keep up the good work and format!

Kevin Kendall
Eagle Lake, AK

Oldies Are Goodies

• In response to the closing question in "The Electronic Chariot" Editorial in the April 1988 issue, I'm not alone in thinking that we got *nothing* for something in automotive electronics. In the automotive environment, at least, high-tech simply means high prices—not high quality. Bring back the '55 Olds, '56 Ford, '63 Valiant. In medicine, business machines and communications, I agree with you—but not in cars.

Ed Jones, Jr., WB2DVL
Somerset, NJ

Don't Change

• You've got a great format. Whatever you do, please don't change it. Too many magazines start off great and then change their format so they can reach a larger readership. The result is usually god-awful. Once again, please keep doing what you do so well.

Gary Thielmann
Alberta, Canada

SMT Hints

• I enjoyed Forrest Mims' articles about SMT [surface-mount technology] and am offering hints gained from my experience. Multicore Solders sells a syringe of 60/40 solder cream that is handy for SMT except that it does not come in a convenient needle. I found that Testor's, the people who make glue for plastic models, sells a package of applicator tips for their glue tubes that perfectly fit the Multi-core Solder syringe. The orifice is about the size of a pin. It takes a bit of pressure to make the solder cream go through, but it is more convenient than a toothpick for applying solder cream to SMT pads. This

(Continued on page 89)

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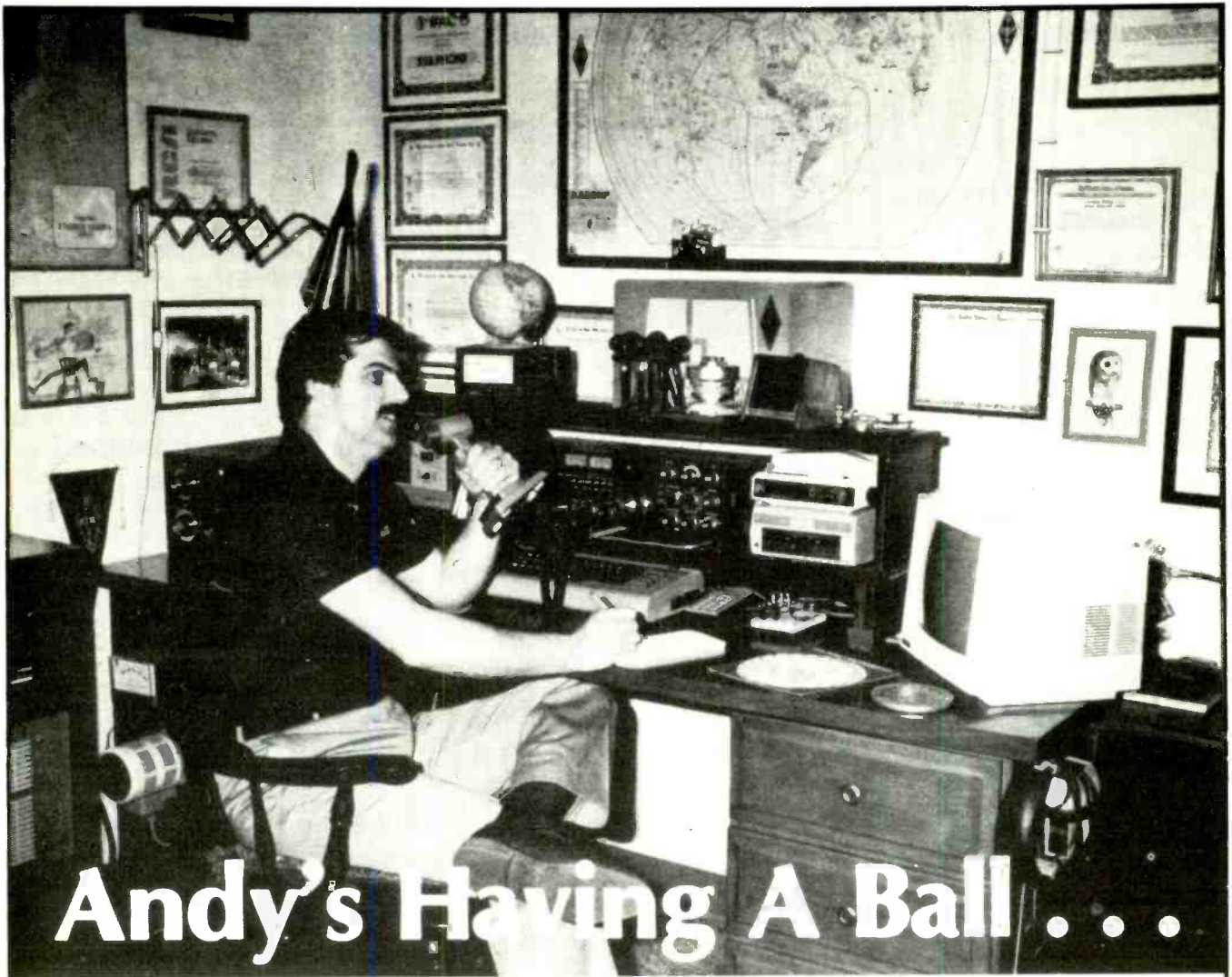
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Canine Life Saver. The U.S. heat wave is likely to be over by the time you read this, but an innovative product introduced mid-summer, called "K-9 Lifeguard," is worth thinking about for the next heat cycle. It's an electronic alarm system that's said to be used by many law-enforcement agencies in Florida to prevent dogs from suffering heat strokes when left unattended in cars. According to John Johnston, president of Radiotronics, Jupiter, FL (407-746-0935), which introduced the system, air temperature in a car can reach 140 degrees within five minutes if an air conditioner fails to continue operating for some reason. Under this condition, it takes only a few minutes for a dog to die. When heat is excessive, the alarm causes the horn to beep, sounds a siren and turns on emergency lights. Optional system features included signaling a remote beeper and rolling down power windows.

USED COMPUTERS. The used computer market continues to expand as new, advanced-performing machines displace them. IBM, interestingly, announced it is taking in customers' older machines, the ones that were dropped from its line some time ago, when new PS/2 systems are bought, refurbishing them, and reselling them at low prices.... An on-line database of 13,500 used and new computer items is offered by Thomas Business Systems (Boca Raton, FL), an 11-year-old computer brokerage company. Its computer system is open to any person or company wishing to buy or sell used computer hardware. The listings are said to cover everything from IBM clones to mainframes, from DEC Rainbow PCs to full-scale VAX systems. All that's needed to tap the database is an IBM-compatible computer, a modem, and a \$5 fee for a communication program and instructions on how to access the bulletin-board system, which is active 7 days a week, 24 hours a day. For more information, call 407-392-2005.

HOME AUTOMATION ADVANCES. Mitsubishi's subsidiary, Medama Inc., is finalizing its year-long field-testing program of Home Automation Systems installed in homes in ten states. The beta sites are actual home environments and end users are reported to be families representative of the marketplace potential seen for home automation. Using the CEBus adopted by the EIA as a proposed standard for all home automation products, system prices range from \$2,000 to \$10,000. To see a demonstration of the system at a test home, call Bruce Abraham at 714-220-4609 or Al Schuyler at 714-220-4745,...Panasonic has an exciting new VHS VCR, the Model PV-4826, that enables users to program a VCR's recording instructions by "calling" the unit over any Touch-Tone telephone.

ADD-ON D/A CD PLAYER DECODER. Britain's Cambridge Audio has introduced its DAC2 Digital-to-Analog Decoder to upgrade compact disc players that do not feature 16-bit x 16-times oversampling. The add-on unit is self-powered and plugs into the "Digital Out" connector of a CD or DAT player, allowing music lovers to experience its 22-million bits per second conversion rate.



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Video Telephone

A new video telephone from Panasonic, the Model KX-TV10, features a 4-inch-diagonal screen that lets a caller view sequential pictures of the called party (also with the same or similar video telephone). The video monitor/camera/telephone instrument features speakerphone, automatic speed dialing and last-number redial. It uses existing telephone lines.



Its built-in black-and-white solid-state CCD camera, equipped with a 2.8-mm lens, can send a still image at a maximum rate of one picture every 5.7 seconds and can be focused on other objects besides the caller. Two transmission speeds are available. The video display offers 96 horizontal and 100 vertical pixels on images sent at a 5.7-second rate, or 160 horizontal by 100 vertical pixels on images sent every 9.4 seconds. Pictures are displayed in 32 different tones from black to white for good image contrast. \$499.95.

CIRCLE 51 ON FREE INFORMATION CARD

Updated 80286 Computer

Tandy's new AT-compatible Model 3000 NL computer is built around the 80286 microprocessor running at 10 MHz and is both MS-DOS and OS/2 ready. Targeted for business applica-



tions, the computer can also function as a network workstation or workgroup communications server. It can accommodate a wide range of video graphics options, including VGA, EGA and CGA. The standard configuration includes a 3.5-inch microfloppy disk drive with 1.44 MB capacity; socket for an optional 80287 math coprocessor; seven AT-compatible (three 8-bit and four 16-bit) expansion slots also running at 10 MHz but configurable to run at 8 MHz for compatibility with slower peripherals and expansion cards; 512 KB of RAM, expandable to 640 KB on system board and expandable to a system maximum of 16 MB using the high-speed memory (30 percent faster) and standard expansion slots; 101-key enhanced keyboard with tactile feedback; serial port; parallel port; and keylock.

Storage options include 3.5-inch microfloppy disk drives with 1.44 MB and 720 KB capacity; 5.25-inch floppy disk drives with 1.2 MB and 360 KB capacity; hard drives rated at from 20 MB to 70 MB at from 65 ms to 28 ms access time; SCSI hard drives rated at from 40 MB to 344 MB capacity at 19 or 16 ms access time; and a 150-MB tape backup system. One 3.5-inch and two 5.25-inch open front-accessible half-height device slots are available in the system unit, each with a new rail system that allows the user to simply slide the disk drives into the slots and connect their ribbon cables. \$1,699.

CIRCLE 52 ON FREE INFORMATION CARD

SMD Removal Unit

O.K. Industries' Model SMT-W2 features a new "hot tweezer" for SMD (surface-mount device) removal and variable temperature control. Its handpieces has been ergonomically designed to fit comfortably in any operator's hand, regardless of size.

Two 80-watt ceramic heating elements are said to provide exceptional temperature stability and sufficient power to remove any SMD, from chip resistors to large quad packs. A

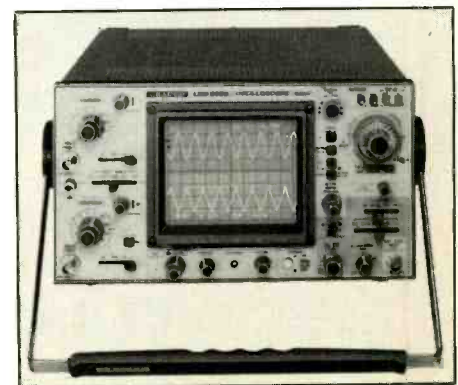


full range of tips are available, including 5-mm sizes for chip resistors and capacitors, mini-flat tips for SOICs and right-angle tips for PLCCs with up to 84 pins. \$425.

CIRCLE 53 ON FREE INFORMATION CARD

60-MHz Oscilloscope Has CRT Readout

Leader Instruments' new two-channel, dual-timebase Model LBO-2060 60-MHz oscilloscope features on-screen display of setting conditions and measured values as well as waveforms. On-screen cursors are said to eliminate troublesome procedures



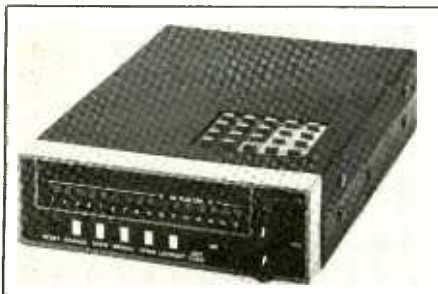
and errors often encountered with conventional oscilloscopes. It eliminates the need to align a signal waveform against the graticule, counting scale markers and multiplying to determine voltage, time and frequency. The cursors provide direct readout of voltage difference in volts and percentage, time difference in seconds and percentage, frequency in hertz and phase difference in degrees.

The scope comes with comprehensive triggering facilities, including alternate triggering for stable display of asynchronous signals. It features a carrying handle that doubles as a tilt bail on the testbench. \$1,490.

CIRCLE 54 ON FREE INFORMATION CARD

Mini Mobile Scanner

Ace Communications (Indianapolis, IN) is now marketing a miniature mobile radio scanner with a frequency synthesized keyboard. The Model AR160 scanner tunes the 29- through 52-MHz, 136- through 174-MHz and 436- through 512-MHz bands to give coverage of conventional police, fire and emergency services.



Twenty keys located on the top of the scanner provide access to an on-board microprocessor that controls the scanner. A unique system of LEDs provides channel information and serves to verify frequencies through a count-off system. An internal battery retains data programmed into memory in the event of a power failure. The scanner is claimed to have excellent sensitivity and specifications that exceed those of more costly mobile units.

Supplied with the Model AR160 scanner are a fused dc power cable,

telescoping whip antenna, mobile mounting bracket with hardware, and an ac adapter for indoor use. The scanner measures only 6.5"D × 4/62"W × 1.5"H and weighs just 20 ounces. \$189.

CIRCLE 55 ON FREE INFORMATION CARD

Computer Motion-Sensor Security Alarm

Alarmcard from AlarmCard (Bellevue, WA) is a half-size add-in board for IBM PC/XT/AT and compatible and PS/2 Models 25 and 30 computers that is said to discourage computer hardware and data theft. The system consists of a plug-in board, a separate alarm module that mounts inside the computer's case and software-control diskette. It can be set up to work in computers that are oriented horizontally or vertically. On-board motion sensors trigger a piercing battery-powered alert when unauthorized movement occurs and



computer power is turned off. A user-controlled password stored in battery-protected hardware guards against access and tampering.

Software provided with Alarmcard permits complete control of the device through menu options. Diagnostics, on-screen battery check and alarm test are provided. Under software control, the Alarm card system can be set up to protect data from unauthorized access while the computer is running, protect the hardware while the computer is turned off, and

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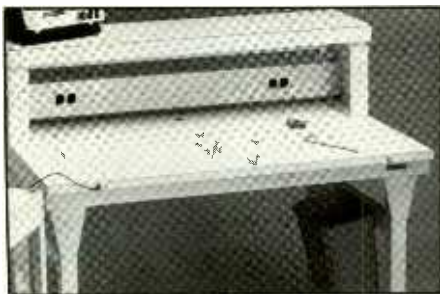
sound an alarm when power has been interrupted. The software can also be used to perform system checks. The password that unlocks the system can be changed as often as desired.

Alarmcard, which discourages PC theft without the use of locks, keys, cables, chains or adhesives, comes with a special hex-head screw and key that replaces one of the computer's cabinet screws to further deter theft. A 9-volt battery is also provided for the alarm module. \$119.95.

CIRCLE 56 ON FREE INFORMATION CARD

Conductive Work Surface

Workplace Systems, Inc.'s (London-derry, NH) new Conductive Top is designed for safe testing, assembly and repair work of electrostatic-discharge electronic components. Its Flush-Mount Grounding System

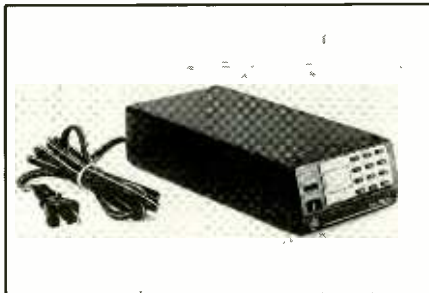


uses a 1"-diameter grounding bolt that is set flush into the worksurface and leaves the entire top free of obstruction. Connection to earth ground is made from beneath the top. Two banana plugs are set flush into the front edge of the top for convenient connection of antistatic wrist bands.

CIRCLE 57 ON FREE INFORMATION CARD

Camcorder Tuner Adapter

RCA/TCE's new Model 1CVA900 tuner adapter allows any camcorder to record programs off the air. It provides the camcorder with the tuner capability required to receive broadcast signals. It has 155-channel tuning capability, including 99 cable channels. The accessory offers digital keyboard/scan tuning, frequency synthesized tuning, audio/video out-



put jacks and an unswitched ac receptacle. It also supplies an auxiliary signal for picture-in-picture VCRs. The compact tuner adapter weighs just 1.9 pounds. \$129.99.

CIRCLE 58 ON FREE INFORMATION CARD

Digital & Analog Trainers

Heath's new Model ETW-3600 analog and Model ETW-3700 digital trainers can serve as versatile experimental and circuit-design tools. Both trainers accept a new Model ETW-3568 accessory backpack that makes it simpler and more reliable to bench test and experiment on circuit boards.

The analog trainer is equipped to help the user to build, analyze, test and modify analog circuits. It has variable regulated +15- and -15-volt power supplies, 15- and 30-volt ac sources and a 200-Hz to 20-kHz sine/square-wave frequency generator. Solderless breadboarding blocks are provided for circuit building as well as potentiometers that can be incorporated into circuit designs and a built-in connector for the accessory backpack. \$199.95 (\$119.95 ET-3600 kit).

The digital trainer can be used to build and test digital circuit prototypes, confirm circuit operation and test digital ICs. Built-in regulated



power supplies provide +12, -12 and +5 volts to accommodate both digital and analog circuits. Four logic data switches, two no-bounce logic switches, a three-frequency pulse clock generator and four LED logic-state indicators are provided. This trainer also has solderless breadboarding blocks and a connector for the accessory backpack. \$199.95 (\$119.95 ET-3600 kit).

When mounted to either trainer, the accessory backpack provides ± 1.2 - to ± 15 -volt dc power supplies to power analog, linear and CMOS circuits and a +5-volt dc power supply for TTL circuits. Included is a digital metering system that measures up to 500 volts ac/dc, 200 mA dc and 2 megohms. Its high-impedance input is designed for minimum loading, and is fused for protection. \$199.95 (\$119.95 ET-3568).

CIRCLE 59 ON FREE INFORMATION CARD

Solar-Electric Panels

Hal-Tronix (Southgate, MI) now has a series of no-frills solar panels that are ideal for backpackers, campers, RVs, boats, airplanes and other applications where conventional power isn't available. Four different versions are available. Sun Pal, a folding unit, delivers 6 or 12 volts at 6 or 12 watts and comes with a mini voltage regulator. The non-folding Sun Flex delivers 12 volts at 3 to 33 watts and is designed to float. Porta Volt, a multi-panel unit that folds to small size, can deliver high power for transmitters, camp power and fast charging of batteries. Power Plus and Series R units, lightweight ridged panels designed for portable or permanent installations, deliver 20 to 45 watts of power. These panels can be wired together as needed to provide higher voltages and/or wattage. All styles are weather-tight, flexible and very thin. Prices range from \$67.46 to \$419.72, depending on panel type, size and power delivery.

(Continued on page 88)

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CIRCLE 74 ON READER SERVICE CARD

Troubleshooting With dc Voltmeters

Helpful hints for getting the most out of your multimeter's dc voltmeter mode

By Robert G. Middleton

A dc voltmeter can be a very powerful tool in troubleshooting electronic circuits. To use it effectively, however, you must know how to interpret the readings you obtain during tests. Because this is a largely unexplored new world for many readers, here are a bevy of practical application hints on use of the dc voltmeter and the dc voltage function of multimeters. Armed with the information in this article, you will soon be optimizing your time at the testbench.

Types of Circuit Action

To effectively use any type of electronic test instrument, one must know something about how a circuit is supposed to work under proper conditions. Refer to the simple single-stage circuit shown in Fig. 1. This basic transistor circuit may operate under steady-state or transient conditions; in the linear or nonlinear mode; with voltage-divider bias, signal-developed bias, or a combination of both. When it is operating properly, this circuit outputs at its collector an amplified version of the signal applied to its base input. However, any of a number of things can go wrong in this circuit, resulting in a reduced-level output or no output at all. Locating the fault of a problem is the task of the dc voltmeter.

In Fig. 1, visible resistors are the voltage-divider biasing network

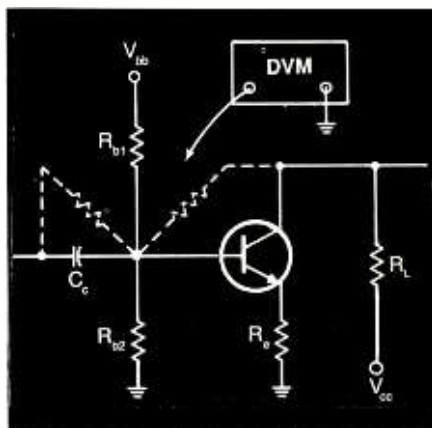


Fig. 1. A basic transistor circuit in which resistors shown phantom represent possible leakage paths.

made up of R_{b1} and R_{b2} , emitter resistor R_e and collector load resistor R_L . Invisible resistors are represented by the emitter-collector and collector-base junction resistances. Under fault conditions, invisible leakage resistance may shunt the collector-base junction resistance and may also shunt coupling capacitor C_c .

When a circuit malfunction occurs, the first thing you should do is measure dc supply voltages V_{cc} and V_{bb} . If you obtain the proper voltage readings in both cases, check the dc-voltage distribution in the circuit. In Fig. 1, for example, the collector, base and emitter voltages provide the pattern of dc-voltage distribution. Typical rated voltage and resistance values might be as follows:

$$R_{b1} = 10,000 \text{ ohms}$$

$$\begin{aligned} R_{b2} &= 1,000 \text{ ohms} \\ R_e &= 100 \text{ ohms} \\ R_L &= 15,000 \text{ ohms} \\ V_{cc} &= 30 \text{ volts} \\ V_{bb} &= 8.3 \text{ volts} \\ \text{dc beta } (\beta) &= 200 \\ V_C &= 15 \text{ volts} \\ V_B &= 0.75 \text{ volt} \\ V_E &= 0.1 \text{ volt} \end{aligned}$$

The potentials listed represent the dc-voltage distribution pattern for class-A operation of the circuit, wherein V_C is midway between V_{cc} and V_{dd} . Observe that the base-emitter bias voltage in this pattern is the difference between V_B and V_E , or 0.65 volt.

Fault Conditions

Under fault conditions, you should initially assume that only one defect exists. For example, the value of R_{b1} , R_{b2} , R_e or R_L might be too high or too low. Alternatively, the dc beta (β) value might be too low (don't worry if it's too high), collector junction leakage may be present or capacitor leakage may be present. Any one of these defects will cause a change in the dc-voltage distribution pattern. Among the tricks of the trade is recognition of the basic circuit action that is at work.

It is a general principle that defects in the collector circuit do not noticeably change the voltage in the base circuit. If R_L increases in value from 15,000 ohms to 20,000 ohms, for example, V_C falls from its normal value of 15 volts to 10 volts. However, V_B

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and V_E will still measure 0.75 and 0.1 volt, respectively.

In another example, if R_L decreases in value from 15,000 ohms to 10,000 ohms, V_C will rise from its normal value of 15 volts to 20 volts. However, V_B and V_E will still measure 0.75 and 0.1 volt. From a theoretical point of view, voltage changes in the collector circuit do have a slight interaction with voltages in the base circuit; however, this interaction is so small that it can be ignored for all practical purposes.

Though voltage changes in the collector circuit may not have much of an effect on the voltages in the base and emitter circuits, it is a different story altogether with changes that occur in the base circuit. Whatever changes occur in the base circuit greatly influence the voltage in the collector circuit. For example, if R_{b1} increases in value from 10,000 ohms to 11,000 ohms, V_B falls from its normal value of 0.75 volt to 0.69 volt. This causes V_C to rise from its normal value of 15 volts to 24 volts and V_E to fall from its normal value of 0.1 volt to 0.04 volt! This is a typical base fault condition dc-voltage distribution pattern. An easy way to visualize this effect is to view the base circuit as a valve and the collector circuit as a tank.

Now observe the dc-voltage distribution pattern that results from a weak (low-beta) transistor. If the dc-beta value of the transistor deteriorates from its normal rating of 200 to 10, V_B remains unchanged at 0.75 volt, but V_C rises from its normal value of 15 volts to 21.8 volts and V_E falls from its normal value of 0.1 volt to 0.05 volt. The pattern distinction between a high R_{b1} and a low beta is chiefly in the base voltage: if R_{b1} is high, V_B goes low and if beta is low, V_B remains unchanged.

It is helpful to observe why V_B remains unchanged when beta is low. Base current is normally quite small; so when a bias voltage divider such as 10,000/1,000 ohms is used, V_B is de-

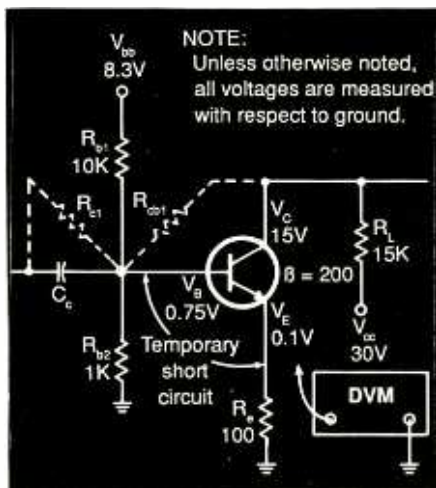


Fig. 2. Base-emitter short-circuit test shows whether off-value V_C is being caused by collector-junction leakage or by some other circuit fault.

termined solely by voltage-divider proportions (from a practical viewpoint, the very small base current does not load R_{b2}). Beta is the current-amplification factor that simply “opens the valve” for V_{cc} to permit a comparatively large collector current to flow.

Although a low dc-beta value results in a considerable change in the dc-voltage distribution pattern, a high dc-beta value causes comparatively little change in the pattern. If beta decreases from 200 to 10, a significant pattern change occurs, but if beta increases from 200 to 300, V_C edges down from its normal value of 15 volts to 14.8 volts—hardly a significant change. In practice, such a small change in the pattern is usually disregarded.

It is of technical interest at this point to note why low beta causes a large change in dc-voltage distribution, whereas high beta causes very little change in distribution. This distinction is evident in the dc-voltage equations for the configuration:

$$R_{TH} = R_{BT} \times R_{BT} / (R_{BO} + R_{BT})$$

$$V_{TH} = V_{bb} \times R_{BT} / (R_{BO} + R_{BT})$$

$$I_E = (V_{TH} - A(1)) / (R_E + R_{TH} / \beta)$$

$$V_E = I_E \times R_E$$

$$V_C = V_{cc} - (I_E \times R_C)$$

$$V_{BE} = V_{TH} - V_E$$

$$V_{CE} = V_C - V_E$$

These equations state that the base of the transistor “sees” a Thevenin resistance R_{TH} and Thevenin voltage V_{TH} and that the emitter sees a current I_E in accordance with Ohm’s law. Current I_E , in turn, produces a voltage drop I_E across the emitter resistor. Furthermore, the collector circuit is the servo circuit that sees I_E and produces the voltage drop V_C across the collector load resistor; the base-emitter voltage is the difference between the Thevenin and emitter voltages; and the collector-emitter voltage is the difference between the collector and emitter voltages. Dc-beta value β is the denominator in the second term of the denominator of the I_E equation. The mathematical significance of these formulas is that small values of β produce rapid changes in the second-term values, whereas large values of β produce slow changes in the second-term value.

Barrier Potential

Dc-voltage distribution patterns are responsive to the barrier-potential value, which is just another way of saying that a bipolar transistor does not conduct until the base-emitter voltage exceeds a threshold commonly referred to as the “barrier potential.”

For silicon transistors, the barrier potential is ordinarily assumed to be 0.65 volt. In other words, the term $A(1)$ in the foregoing I_E equation is routinely assigned the value 0.65, which “linearizes” the nonlinear system insofar as class-A operation is concerned.

Barrier potential is a function of temperature. At room temperature, a 0.65-volt value is assigned. However, at higher operating temperatures, an assignment of 0.6 volt is more realistic.

Barrier potential may range up to 0.7 volt at low temperatures. Therefore, it is helpful to observe the dc-

voltage distribution patterns for the Fig. 1 circuit configuration at barrier potentials of 0.6 and 0.7 volt. If the barrier potential decreases from its median value of 0.65 volt to 0.6 volt, V_B remains unchanged at 0.75 volt, but V_C falls from its normal value of 15 volts to 7.8 volts and V_E rises from its normal value of 0.1 volt to 0.15 volt.

If the barrier potential increases from its median value of 0.65 volt to 0.7 volt, on the other hand, V_B again remains unchanged, but V_C rises to 22.2 volts and V_E falls to 0.05 volt. If you have a temperature probe for your DVM, you can easily measure the operating temperature of the transistor to determine whether the measured dc-voltage distribution reflects a barrier potential in the vicinity of 0.65 volt or of 0.6 volt, for example. This is one more helpful trick of the trade.

Now let us examine circuit action and dc-voltage distribution patterns in the presence of collector junction and coupling-capacitor leakages.

Test-Circuit Action

As shown in Fig. 2, an informative test circuit can be provided by temporarily short-circuiting the base and emitter terminals of the transistor when the collector voltage measures below normal and collector-junction leakage is suspected. This is called a "turn-off" test. If collector-junction leakage is present, V_C will not jump to the V_{cc} value when the short circuit is applied. On the other hand, if there is no collector-junction leakage, V_C will jump up to the V_{cc} value when the short circuit is applied.

For the time being, we will disregard the possibility of leakage R_{C1} in the coupling capacitor and focus on off-value components and parameters, as tabulated in Fig. 3, which lists the dc-voltage distribution patterns that encompass five measurements. Two of these measurements are checks of V_{bb} and V_{cc} values to en-

Patterns of dc-Voltage Distribution Under Test Conditions										
	R_L		R_e		R_{b1}		R_{b2}		Beta	
	High	Low	High	Low	High	Low	High	Low	High	Low
V_C	Low	High	High	Low	High	Low	Low	High	—	High
V_B	—	—	—	—	Low	High	High	Low	—	—
V_E	—	—	—	—	Low	High	High	Low	—	Low

If R_L is high, V_C approaches its normal class-A value when R_L is shunted by a test resistor. If R_L is low, V_C departs more from its normal class-A value when R_L is shunted by a test resistor.

If R_e is high, V_C approaches its normal class-A value when R_e is shunted by a test resistor. If R_e is low, V_C departs more from its normal class-A value when R_e is shunted by a test resistor.

If R_{b1} is high, V_C approaches its normal class-A value when R_{b1} is shunted by a test resistor. If R_{b1} is low, V_C departs more from its normal class-A value when R_{b1} is shunted by a test resistor.

If R_{b2} is high, V_C approaches its normal class-A value when R_{b2} is shunted by a test resistor. If R_{b2} is low, V_C departs more from its normal class-A value when R_{b2} is shunted by a test resistor.

Fig. 3. Patterns of dc-voltage distribution under test conditions indicate the component or parameter that is off-value and whether it is too high or too low.

sure that a malfunction is not being caused by a fault in the power supply. After the V_{cc} and V_{bb} values have been verified (or corrected as required), you proceed to look at dc-voltage patterns that comprise three measurements: V_C , V_B and V_E .

Blank spaces in the Fig. 3 tabulation denote a dc-voltage change that is so small that it is ignored in tests. Note that there are various combinations of high and low dc-voltage measurements at the collector, base and emitter terminals. A measured value is "high" if it exceeds the normal value, and vice-versa. In this example, normal transistor terminal values are: $V_C = 15$ volts, $V_B = 0.75$ volt and $V_E = 0.1$ volt. (In any case, normal transistor terminal voltages will be specified in the service data.)

It is evident in Fig. 2 that there is more than one possible fault for each three-group pattern of voltages. For example, V_C high with V_B and V_E low can be caused by a high value of R_{b1} or a low value of R_{b2} . To resolve this ambiguity, temporarily shunt R_{b1} with a resistor. In turn, if R_{b1} is

high, V_C approaches its normal class-A value when R_{b1} is shunted by the test resistor. Otherwise, V_C will go even further from its normal class-A value when the test resistor is applied. (In this example, a 50,000-ohm shunt test resistor might be used. The resistor's value is not critical; just be sure to choose a "ballpark" value.)

In the event that all three transistor-terminal voltages are incorrect, the fault is in the base circuit. Thus, if beta is low, only two of the terminal voltages will be incorrect. If the fault is in the collector circuit, only one terminal voltage will be incorrect. Accordingly, the initial dc-voltage distribution patterns tell you which section of the circuit is malfunctioning so that you do not waste time making shunt tests in normally operating sections.

Because capacitor leakage resistance can cause confusion in base-circuit tests, it is important for you to know how to check for this possibility. To do so, apply a temporary short circuit between the left-hand terminal of C_c and ground in the Fig. 2 cir-

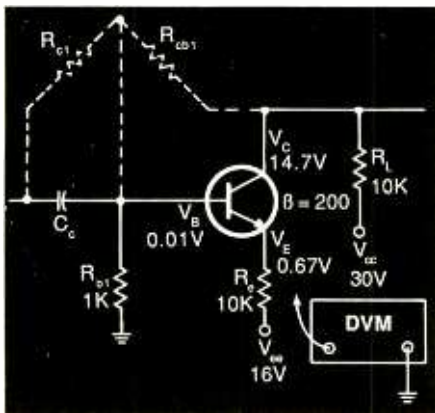


Fig. 4. Basic emitter-bias configuration is essentially the same as the basic base-bias configuration.

circuit and observe the change in base voltage (if any). If there is no change in V_B , there is negligible leakage in C_c . However, if there is noticeable change in V_B when this test is made, C_c is leaky and should be replaced.

Emitter-Bias Circuit

The basic emitter-bias circuit configuration shown in Fig. 4 is also in popular use. Closely related to the basic base-bias configuration, from a circuit-action viewpoint, it can be regarded as essentially the same. As noted, V_B is near ground potential at 0.01 volt, whereas V_E is 0.67 volt above ground. Thus, V_B and V_E are interchanged with respect to the base-bias circuit configuration. However, the base-emitter voltage (the difference between these two voltages) is the same in either circuit at 0.66 volt.

Conveniently, R_{b1} in Fig. 4 is regarded as the parallel combination of R_{b1} and R_{b2} in Fig. 2. Physically, the emitter-bias arrangement uses one less resistor. Functionally, the trade-off is slightly less bias stability in the emitter-bias arrangement. In other words, R_{b1} in Fig. 2 has a comparatively high value, which makes the bias source appear more like a current source than a voltage source.

Localization of circuit defects in the Fig. 4 circuit follows the same

principles discussed above for the Fig. 2 circuit. That is, the Fig. 2 tabulation applies to the emitter-bias circuitry, just as it does for the base-bias circuitry. A turn-off test is made in the same way, and ambiguous situations are resolved in the same way. The only difference is that there is only one base-bias resistor, so there is one less dc-voltage value in the distribution pattern. Capacitor leakage is checked as above, by monitoring V_B when a temporary short circuit to ground is applied to the left-hand end of capacitor C_c .

Differential Amplifier

Shown in Fig. 5 is a basic differential-amplifier circuit configuration. In this circuit, two transistors are operated in a balanced (push-pull or double-ended) mode. Emitter biasing is usually used in such an arrangement. The collectors of both transistors normally have the same dc voltage, and both bases normally have the same dc voltage on them.

The bases of the transistors are a bit above ground potential as a result of the base-emitter bias voltage developed chiefly in the emitter circuit. Note that both transistors are emitter-coupled. If emitter current in one

transistor increases, emitter current in the other transistor is forced to decrease.

You are concerned primarily with whether the circuit is operating in class-A (collector voltages approximately half-way between V_{cc} and V_e) and whether the dc-voltage distribution pattern is balanced. That is, the two collector voltages are normally the same, within a slight tolerance range. Similarly, the two base voltages are normally the same, again within a very small tolerance range. Observe that if the collector load resistor (R_L) for the left transistor becomes too high, V_C for that stage will be subnormal. An off-value R_L has no noticeable effect on V_B and V_E , however.

It follows that although a high value of R_L for the left transistor results in a subnormal V_C there, this change in the dc-voltage distribution pattern is not reflected into the right transistor branch circuit. In turn, the circuit becomes unbalanced with unequal collector voltages.

Insofar as dc-beta values are concerned, it is helpful to consider the limiting case in which the beta value of the left transistor, for example, becomes zero. In this case, the two-section amplifier becomes a one-section

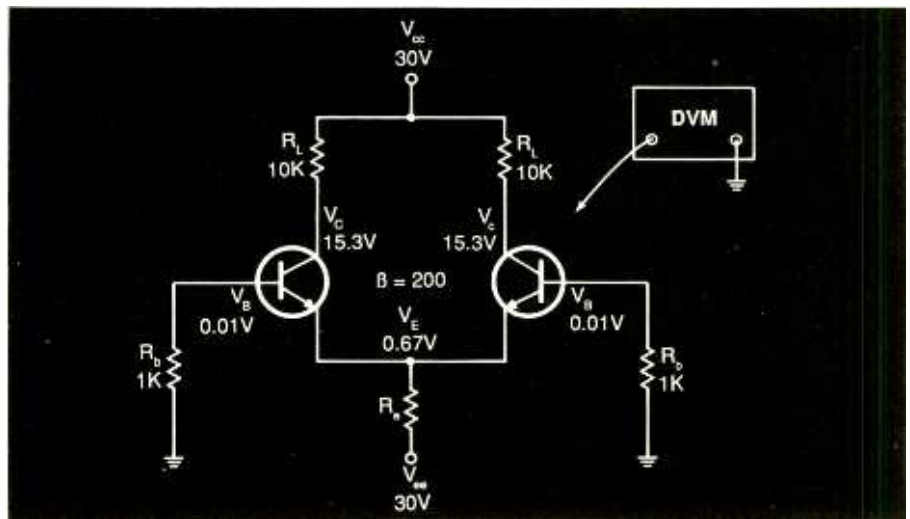


Fig. 5. Basic differential amplifier configuration is essentially a "twinning" of the emitter-bias configuration.

tion amplifier and its circuit action follows that discussed for the Fig. 4 circuit.

In this comparison, V_{ee} for the Fig. 4 circuit is now double its normal value, with the result that V_C falls to a very low value, saturating the transistor. Thus, if the beta value of one transistor in Fig. 5 becomes seriously subnormal, the other transistor will go into saturation. As would be anticipated, the value for R_b is not critical. If one base resistor in Fig. 5 goes considerably off-value, the circuit remains essentially in a balanced state. Of course, if one of the base resistors goes greatly off-value, the associated V_B will be significantly affected and the circuit will be in an unbalanced state.

It is helpful to note that R_E in the typical differential-amplifier arrangement ordinarily has a comparatively high value, resulting in significant feedback. In turn, bias stability

is good and the value of R_E can go considerably up or down without causing serious shifts in the collector voltages.

Although you are primarily concerned with dc-voltage distribution patterns, you should also take note of the basic signal-voltage considerations in the Fig. 5 arrangement. For example, the bases of the transistors may be driven in push-pull such that when one base is driven positive, the other base is driven negative and when one collector goes positive, the other collector goes negative.

Suppose both bases of the transistors were driven positive (common-mode drive). Under this condition, both collector voltages would decrease equally. Consequently, there would be no collector-collector output, resulting in a condition known as "common-mode rejection."

In addition to push-pull drive, the differential amplifier arrangement

shown in Fig. 5 is often driven by a single-ended source. Thus, the base of the left transistor may be driven positive while the base of the right transistor remains essentially at ground potential. Accordingly, V_C at the left transistor falls, due to increased emitter current. In turn, increased emitter current results in a higher V_E , with the result that the right transistor is driven toward cutoff and its V_C increases. Hence, the single-ended input has been changed into a double-ended output.

As the foregoing has demonstrated, a dc voltmeter can be an invaluable aid in troubleshooting circuits. However, it can be put to effective use only if you have a basic understanding of circuit-action conditions, both proper and otherwise. Once you understand and apply this, the first instrument you reach for to troubleshoot an ailing circuit is likely to be your dc voltmeter. ME



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Understanding Negative Logic

Taking the mystery out of a logic type that can greatly simplify circuit design and analysis

By Delton T. Horn

With the proliferation of digital circuits in most modern electronic and many electrical products, electronics hobbyists and technicians usually have at least some basic understanding of digital circuitry. Though you might be familiar with positive logic—the kind in popular use in modern digital circuits—you may not understand and even be intimidated by its counterpart, *negative* logic. This is unfortunate because negative logic can greatly simplify design and analysis of many digital circuits. Fortunately, negative logic is also really no more difficult to grasp than is positive logic.

Some Basics

In positive logic, a logic 1 is represented by a more-positive signal voltage than a negative logic signal. Negative logic reverses this relationship: the more-positive signal level represents a logic 0 and a near-ground signal level is a logic 1.

In terms of functionality, no difference exists between the two logic types. They are simply two different ways of viewing the same action performed by digital gates. For example, consider the truth table for a 2-input AND gate that uses positive logic:

Input		Output
A	B	
0	0	0
0	1	0
1	0	0
1	1	1

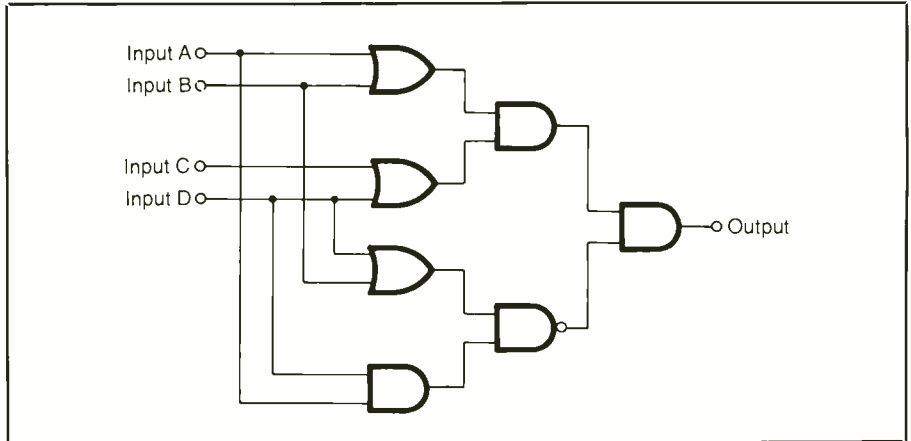


Fig. 1. An example of a multiple-gate positive-logic circuit.

Each 1 in the table indicates a high signal voltage, each 0 a low signal voltage. The truth table for the same device using negative logic is:

Inputs		Output
A	B	
1	1	1
1	0	1
0	1	1
0	0	0

This time, each 1 represents a low signal voltage, each 0 a high signal voltage. As you can see, each input and output signal level has reversed its normal (positive) state, even though the actual voltages in the circuit remain exactly the same. The only thing that has changed is the names used to identify each of the possible input and output conditions.

Taking a close look at the negative-logic truth table for the AND gate, you'll notice something very interesting. The output from the gate is a log-

ic 0 if and only if both inputs are a logic 0. Stated differently, if either input A or input B or both are a logic 1, the output will be a logic 1. A circuit element that behaves as an AND gate in positive logic functions as an OR gate in negative logic. It is important to keep in mind that no change has been made in the circuitry, which is operating in exactly the same manner in both cases. The only thing that has been altered is your way of interpreting the action of the circuit.

You can compare the positive- and negative-logic functions of each of the basic digital gates as follows:

Positive Logic	Negative Logic
AND	OR
NAND	NOR
OR	AND
NOR	NAND

Noticeably absent from the above are the inverter and buffer. The reason

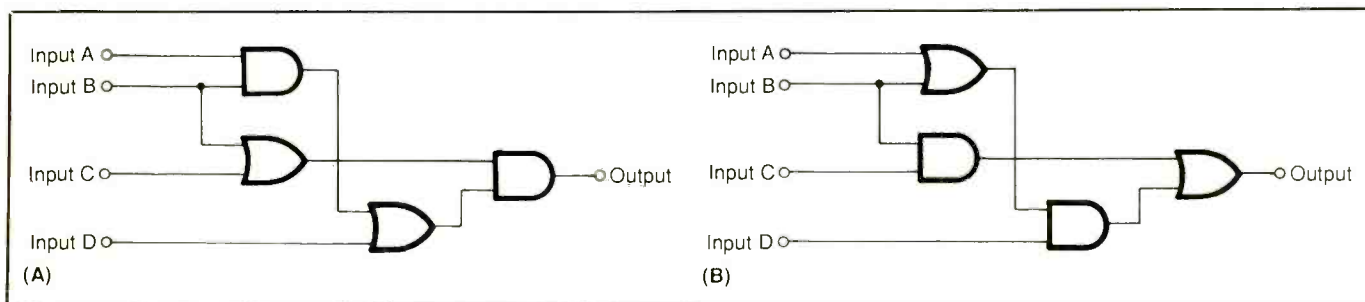


Fig. 2. Shown here are (A) a positive-logic circuit and (B) the equivalent negative-logic circuit.

for this is that both logic elements function in the same manner in both logic systems.

Why Negative Logic?

Often in the course of designing digital electronic circuits, you will encounter a truth table that appears to be quite complex and requires a large number of gates to implement. Consider for example the following truth table:

Inputs				Output
A	B	C	D	
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

This would appear to be a very easy truth table pattern to generate—at least not if you stick to positive logic. You might come up with the seven-gate circuit shown in Fig. 1. This circuit will work, but it's rather awkward to implement in hardware.

Now let's try converting the above truth table into negative logic. For easier readability, we'll reverse the

order of the table entries so that the inputs still run from 0000 to 1111, as follows:

Inputs				Output
A	B	C	D	
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	01
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

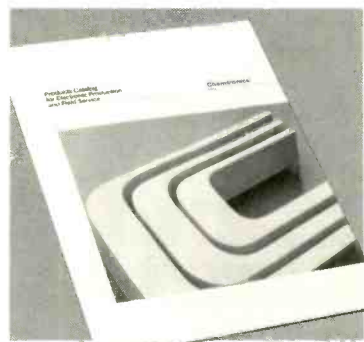
A simpler solution should now become more obvious. This negative-logic truth table can be generated with the four-gate circuit shown in Fig. 2. The circuits shown in these two schematics are functionally identical. They generate the same truth table in either positive or negative logic. However, you might not have thought of the Fig. 2(B) circuit, which is more efficient than the Fig. 2(A) circuit, if negative logic had not been used.

Obviously, it is possible to arrive at the Fig. 2(B) circuit, even using just the positive-logic truth table. Using the negative-logic truth table simply makes the solution easier to arrive at.

Some circuit designs will be easier

to implement with positive logic, others with negative logic. In many cases, it won't make a difference which type of logic is used. It is even okay to mix both positive and negative logic throughout a circuit design of a single system, as long as you manage to keep the two separate. Don't confuse the two types of logic or you won't obtain the results you want.

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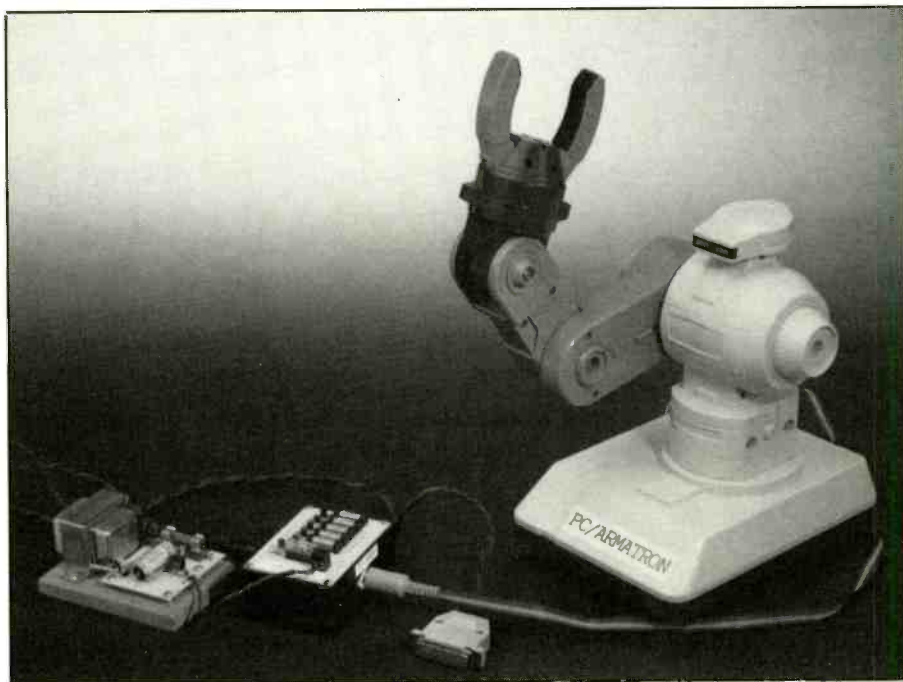
How to modify Radio Shack's Mobile Armatron robot for control with an MS/PC-DOS personal computer

By Jim Barbarello

Radio Shack's newest robot, the Remote Control Mobile Armatron Robot Arm, is a more powerful version of its earlier robot arm. The \$40 assembled model can lift objects weighing a pound or more, as compared to the few ounces of its predecessor, and adds a hand-wired pushbutton remote controller in place of joysticks to move the Arm in any direction, rotate its arm and hand, and pick up and release objects with its pincers. Standing 14-inches high at maximum arm extension, it's powered by four "D" cells.

It's a fascinating and fun device as it is. But converting it to be controlled by a computer, as we will describe, opens new functional and educational vistas reminiscent of the two-wheeled "Turtle" device used in combination with the Logo computer language that was so popular some years ago. The "smart" arm and powerful pincers of the RC Armatron, however, makes it many times more useful than the old Turtle ever was, of course. After all, the Turtle could only scurry around the floor, not pick up and put down chess pieces on a playing board, get a cup for its master, etc.

Adapting the RC Armatron Robot for use with an IBM PC or compatible is easily accomplished, unlike the mechanically intensive modifications of the earlier Armatron Arm that appeared some time ago in a few



articles. Furthermore, our simple modifications substitute a keyboard or disk for the latest Robot's hand-held remote and a small ac power supply for its "D" batteries. Now it's possible to create programs to put the Robot Arm into action *automatically* as well as saving the command sequences on a disk. All it takes is a minor internal modification and construction of a simple low-cost interface to transform the model into PC-Armatron. Then just add the small power supply, whether it's purchased, added from your stock of equipment or built.

The interface hooks directly to a PC's parallel printer port, powered by the stand-alone 5-volt dc supply that also powers the robot. In addition to providing you with full construction details, a short utility program is included that allows you to control PC-Armatron and illustrates how to create more sophisticated project applications. A full-featured Logo-like program is also available from the author.

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Shack, the Armatron device consists of an articulated arm/gripper assembly mounted on a motorized platform and is supplied with a control unit. The arm is motorized at only the shoulder and wrist, while the elbow joint can be moved only by manual means. In addition to up and down arm motion, the wrist can rotate. The pincer-type gripper, attached at the wrist, can close and open to grip and release an object. Two of the three wheels in the base are individually driven for two-dimensional control in all directions. The third, undriven wheel pivots.

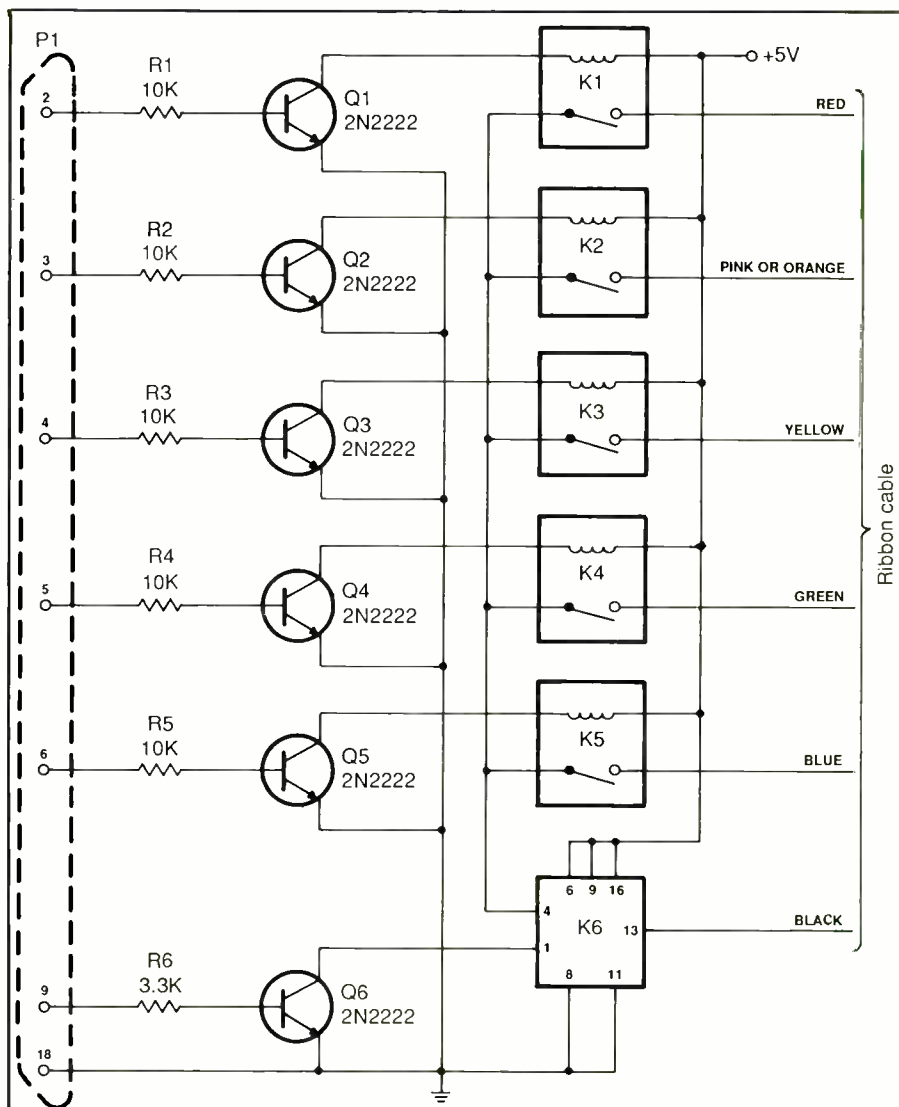
In normal operation, the Armatron device is powered by four D cells that provide +3 and -3 volts as needed to forward or reverse the direction of any of the controlling motors. The control unit connects to the Armatron via a multicolored seven-conductor ribbon cable.

For computer-control purposes, neither the control unit nor the D cells are needed. Instead, the interface that connects the robot to a computer will use a single 5-volt dc supply. Required forward/reverse voltage requirements for the motors are provided with relays that switch the polarity of the 5 volts dc as needed. To accomplish this, however, you must bring a ground lead out of the Armatron to the interface.

When an unmodified Mobile Armatron robot is operated, the black and brown-insulated conductors in the ribbon cable provide the +3 and -3 volts, respectively. Because in this application, these wires are no longer needed, either conductor can be used to bring the ground conductor out of the device.

Modification begins with removal of the six screws that secure the bottom panel. Once this is done, carefully lift up the bottom panel (there are wires attached to this panel; so exercise care to avoid pulling on them).

With the robot open, locate the two battery terminals closest to you. There are a white-insulated wire go-



PARTS LIST

Semiconductors

- D1—1N4001 rectifier diode (optional see text)
- IC1—7805 +5-volt, 1-ampere voltage regulator
- Q1 thru Q6—MPS2222A or 2N2222 npn silicon transistor

Capacitors (16-WV minimum)

- C1—1,000- μ F electrolytic
- C2, C3—1- μ F electrolytic

Resistors ($\frac{1}{4}$ -watt, 10% tolerance)

- R1 thru R5—10,000 ohms
- R6—3,300 ohms

Miscellaneous

- K1 thru K5—5-volt dc reed relay (Radio Shack Cat. No. 275-232)
- K6—5-volt dc dpdt DIP relay (Radio Shack Cat. No. 275-215 or 275-215A)

- P1—Male DB-25 connector
- T1—6.3- or 12.6-volt power transformer (Radio Shack Cat. No. 273-1385)

Printed-circuit board; suitable enclosure; machine hardware; solder; etc.

Note: A series of enhanced programs and sample procedures for operating the PC/Armatron are available on a 5 $\frac{1}{4}$ " 360K PC-formatted disk for \$8 (specify PCARM) from JJ Barbarello, RD #3, Box 241H, Tennent Rd., Manalapan, NJ 07726.

Fig. 1. Schematic diagram of circuit required to interface Mobile Armatron to computer.

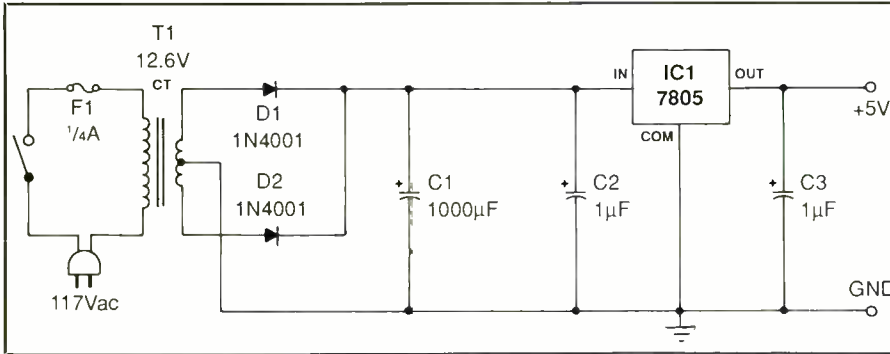


Fig. 2. Schematic diagram of optional power supply for interface and PC/Armatron.

ing to the left terminal and a jumper wire that goes from the left to the right terminals. Unsolder the jumper wire. Then remove the right terminal and discard it and the jumper wire. Unsolder the white wire.

To the right, you will see the seven-conductor multicolored ribbon cable that goes to the control module. Insulation on the two outermost conductors is coded blue and black. Use a hobby knife to separate the black-insulated conductor from the ribbon about half way into the Armatron. Now cut the separated black-insulated conductor about midway into the robot's base and strip about ¼

inch of insulation from the end that goes out of the Armatron. Connect the white-insulated wire you previously unsoldered to this black-insulated wire and solder the connection. This connects the ground in the Armatron robot to the black-insulated wire. Reassemble the robot.

Remove the six screws from the control unit and open it up. Remove the single screw that holds the printed-circuit board in the unit. Now unsolder the seven conductors (insulation coded black, brown, red, pink or orange, yellow, green and blue) from the pc board. Cut off the free end of the brown conductor; this conductor

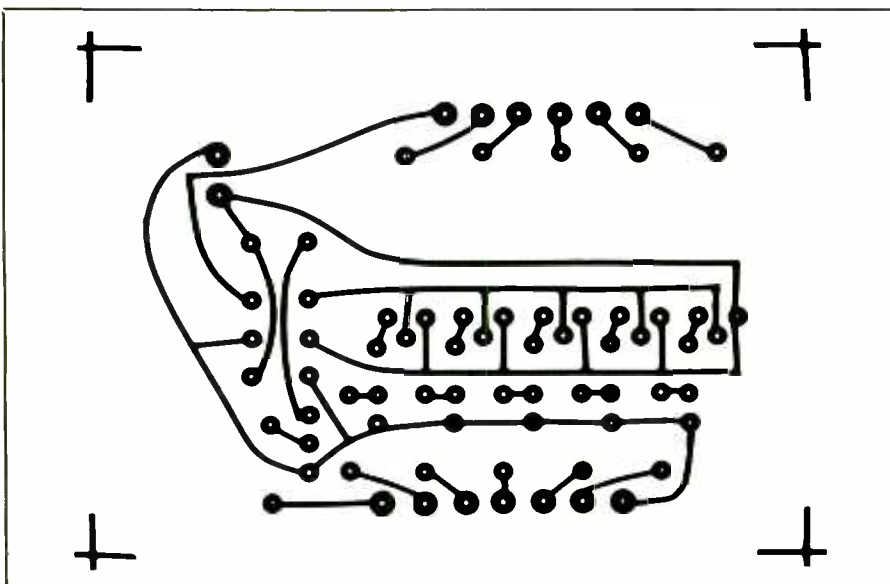


Fig. 3. Actual-size etching-and-drilling guide for interface printed-circuit board.

is not used. Discard the control unit and pc board. Modification of the robot is now complete.

The Interface

To understand how the interface works, you must first know something about your PC's printer port. LP1, as it is commonly known, is addressed at memory location 888 decimal. Among other signals, it provides an 8-bit binary representation of each character sent to the printer (or other device) and a ground reference. The eight bits, labeled D0 through D7, are on pins 2 through 9, respectively, of the DB-25 female connector on the rear of your computer.

To control these eight data lines, simply use the BASIC OUT command. For instance, to make all lines high, execute an OUT 888,255, which is the decimal equivalent of binary 11111111. Similarly, an OUT 888,16 (00010000) will cause D4 to go high and all other data lines to be low. Once set, these data lines remain in that state until changed by a subsequent OUT command. You can gain access to these signals by using a DB-25 male connector (PI in Fig. 1).

Referring to the interface schematic diagram in Fig. 1, a standard circuit is repeated five times for relays K1 through K5. In each, the transistor buffers the input from the computer's parallel port. When a logic 1 is input, the transistor conducts and energizes the coil of the relay. The five relays replace the mechanical switches in the control unit. Relay K6 is controlled in a similar manner. Its function is to reverse power polarity. When energized, ground is provided to the line common to relays K1 through K5, while +5 volts is delivered to the black-insulated (Armatron's ground) wire. In essence, this provides -5 volts between any of relays K1 through K5 and ground. In K6's unenergized state, +5 volts is delivered to the other relays.

The output of the interface con-

nects directly to the ribbon cable. The input is provided through a seven-conductor cable terminated in *PI*, which plugs directly into your computer's printer port.

Any standard 5-volt supply which can deliver about 1 ampere of current can be used to power the interface and modified Armatron robot. If you do not have such a supply on hand, you can build one from the Fig. 2 schematic diagram.

You can build the interface circuit on a printed-circuit board or on perforated board that has holes on 0.1-inch centers, using suitable Wire Wrap or soldering hardware. If you want pc-board construction, use the actual-size etching-and-drilling guide in Fig. 3 to fabricate the board. The power supply, on the other hand is simple enough to be wired together with the aid of terminal strips, though you can use perforated board or design and fabricate a pc board for it as well.

Wire the pc board exactly as shown in the Fig. 4 wiring diagram. (If you elect perforated-board construction, follow the same general component

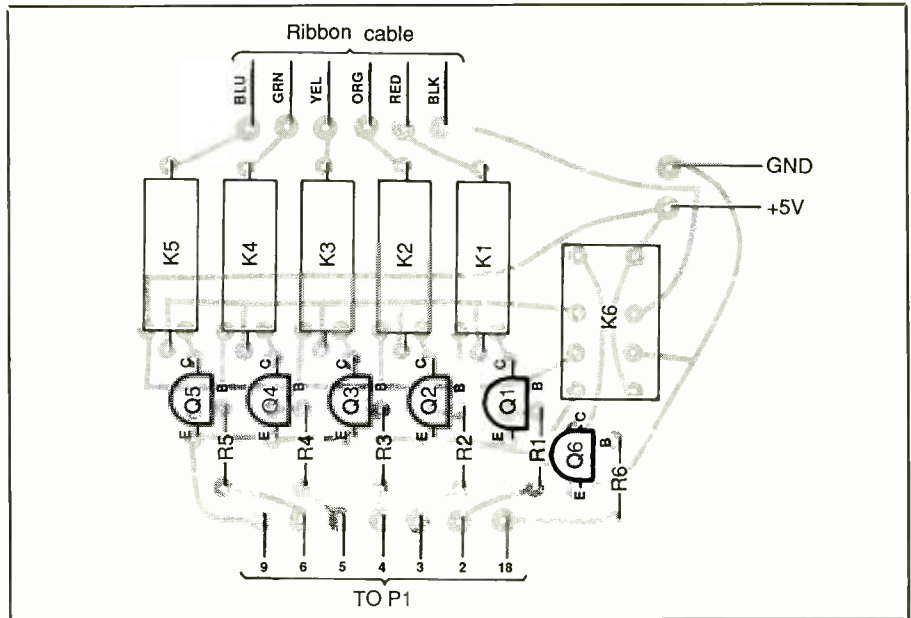


Fig. 4. Wiring diagram for interface pc board. Use this diagram as a general component layout if you use perforated-board construction.

layout shown in this drawing.) Make sure you properly base the transistors before soldering any leads to the copper pads on the bottom of the board. Also, make sure you follow the proper color-code sequence for the ribbon

cable and the cable or wires that go to *PI*.

When you are finished wiring the board, double check all component installations and check for poorly soldered connections and solder

Using PC/Armatron

Unless you're adept at programming, if you buy and modify an RC Mobile Armatron Robot Arm (Radio Shack Cat. No.60-2396), you'll want to buy the \$8 PCARM software program (called Arm-A-Talk) noted at the end of the Parts List. With it, you can really get into controlling the Arm.

You should be aware that the robot's arm should not be moved by hand, so don't try to force it in one direction or another in this manner. Use signal commands. A program file called ASETUP permits you to calibrate the program to match the Arm to your computer if the existing setup is not optimum. (Each Arm seems to be slightly different and the setup program determines how it should be energized to allow maximum travel.)

A number of commands, such as **FORWARD**, are listed, followed by a

space and then a number that represents the percentage of maximum travel. Each part of the robot can be moved at this time to set up the proper factors, whether it's Hand Up, Hand Down, etc. By entering a command, a space and an asterisk, the action will take place without recording it as a stored factor. When maximum travel has been reached, press any key to stop movement. (Actually, you should stop movement slightly before maximum is reached because the ARM continues to move a smidgen after power is removed.)

The factor that you stopped at appears on the video screen. When all factors are determined, simply type **END**, then press Enter, then the letter, **Y**, to save the factors in a data file that's automatically created as **FACTORS.DAT**. The setup can be run again at any time to change stored factors.

The program isn't case-sensitive, so you can type lower- or upper-case letters and it won't make a difference. Also, there's a **HELP** command at your fingertips for information on syntax and command explanations.

To initiate the language-environment program from a DOS prompt, one simply types **ARM**. you can then create movement commands and other procedures, building up to complex ones by starting with the command, **MAKE**. The program also includes **DO** (execute a previously created procedure), **LIST** (display commands in the named procedure), **EDIT**, **HELP** and **END**, the latter enabling you to save the file.

The system to control the PC/Armatron is certainly versatile. It's easy to use, too, once you get the hang of it, and gives the experimenter an exciting way to enter the world of robotics.

PC/Armatron Movement Values

Function	Number
Wrist Turn	2
Gripper In-Out	3
Hand Up	4
Hand Down	5
Turn Right Forward	8
Turn Left Backward	9
Turn Left Forward	16
Turn Right Backward	17
Arm Up	32
Arm Down	33
Forward	24
Backward	25

bridges between closely spaced pads and traces. Reflow the solder on any questionable connections and remove any solder bridges discovered with desoldering braid.

Controlling PC/Armatron

Data bits D1 through D5 are available on printer port pins 3 through 7, respectively. Similarly, data bit D0 is available on pin 2 of the printer port. To send movement information to PC/Armatron, simply calculate the appropriate number to represent the movement you want, and perform an OUT 888,n (where n is that number). To stop all movement, execute OUT 888,0 (zero). The time between these two commands will determine how far the selected arm component moves.

To energize K1 with +5 volts (K6 deenergized), for example, issue an OUT 888,2 to bring bit D1 high. To reverse the voltage, add 1 to that number, to bring bit D0 high. The following table lists all possible movements and the corresponding numbers.

These functions are incorporated into the BASIC code provided in the Program Listing. Lines 20 and 30 define the movement numbers to be sent to the printer port in array A. Lines 40 and 50 define the associated movement codes you can enter to execute the movements. Lines 60 through 80 define the movement functions associated with the movement codes and

BASIC Program Listing for Computer Control of PC/Armatron

```
1 REM** PC/ARMATRON DEMONSTRATION PROGRAM
2 REM** NAME: ARMDEMO
3 REM** V880525
4 COLOR 7,0:CLS:CLR:KEY OFF:OUT 888,0:DEFSTR C:DIM A(12),
  C(12),CN(12)
5 A(0)=2:A(1)=3:A(2)=4:A(3)=5:A(4)=8:A(5)=9:A(6)=16
6 A(7)=17:A(8)=32:A(9)=33:A(10)=24:A(11)=25:A(12)=0
7 C(0)="W":C(1)="G":C(2)="HU":C(3)="HD":C(4)="FR":C(5)="BL":
  C(6)="FL"
8 C(7)="BR":C(8)="AU":C(9)="AD":C(10)="F":C(11)="B":C(12)="S"
9 CN(0)="Wrist":CN(1)="Grip":CN(2)="HandUp":CN(3)="HandDown":
  CN(4)="FwdRight"
10 CN(5)="BackLeft":CN(6)="FwdLeft":CN(7)="BackRight":CN(8)=
  "ArmUp"
11 CN(9)="ArmDown":CN(10)="Fwd":CN(11)="Back":CN(12)="Stop":GOSUB
  200
12 REM** PROGRAM BEGINS
13 LOCATE 18,1:PRINT SPC(79):LOCATE 18,40:PRINT"LAST COMMAND: "
  ;C
14 LOCATE 18,1:LINE INPUT "COMMAND:?" ;C:GOSUB 350:IF C="" THEN
  110
15 IF C="END" THEN LOCATE 20,1:PRINT"SESSION ENDED":END
16 FOR I=0 TO 12:IF C(I)=LEFT$(C,S) THEN LOCATE 18,1:GOTO 150
17 NEXT C:"UNRECOGNIZED COMMAND":GOTO 100
18 PRINT"EXECUTING ";CN(I);"...":OUT 888,A(I):WHILE INKEY$="":
  WEND
19 OUT 888,0:BEEP:GOTO 100
20 REM**
21 REM** SCREEN FORMATTING
22 REM**
23 CLS:LOCATE 1,1:PRINT CHR$(201);STRING$(77,205);CHR$(187)
24 LOCATE 2,1:PRINT CHR$(186);" "STRING$(24,176);
25 PRINT" PC/ARMATRON DEMONSTRATION ";STRING$(24,176);" ";
  CHR$(186)
26 LOCATE 3,1:PRINT CHR$(200);STRING$(77,205);CHR$(188)
27 LOCATE 5,3
28 PRINT"This program demonstrates how to control PC/
  Armatron.;"
29 PRINT" Execute a movement by"
30 PRINT"typing the movement code listed below";
31 PRINT"(ex: HU or F), and then pressing Enter."
32 PRINT"To stop movement, press any key. To end session, enter
  END.;"
33 LOCATE 10,31:PRINT"MOVEMENT COMMANDS"
34 LOCATE 12,1:FOR I=0 TO 12:IF (I MOD 4)=0 THEN LOCATE
  CSRLIN,1
35 PRINT C(I);" = ";CN(I);:PRINT TAB((I MOD 4)*21+20);:NEXT
  I
36 RETURN
37 REM** U/L CASE SHIFT
38 IF C="" THEN RETURN
39 S=INSTR(C," "):IF S=0 THEN S=LEN(C) ELSE S=S-1
40 FOR J=1 TO S:M$=MID$(C,J,1)
41 IF M$>"Z" AND M$<"(" THEN MID$(C,J,1)=CHR$(ASC(MID$
  (C,J,1) AND 223)
42 NEXT J:RETURN
```

numbers. For instance, movement number 2—array element A(0)—produces function “Wrist”—array element CN(0)—that is entered as movement code “W”—array element C(0).

Line 110 gets your input and shifts it to upper-case, if necessary, via the subroutine at line 350. Line 120 checks for the word “END” and, if found, terminates the program. Line 130 compares your input to the 13

valid movement codes. If a match is not found, the error message “UNRECOGNIZED COMMAND” is displayed and execution loops back to line 110 for another input. When a valid code is found, execution jumps to line 150. Here, the associated movement number is sent to the printer port (OUT 888,A(I)). The WHILE/WEND loop continuously

(Continued on page 86)

Phone-Ring Visual Indicator

Lighting up a lamp when a phone call comes in is a helpful signal for hearing-impaired people and those who are awaiting a call but do not want to wake up sleeping persons

By Andrew Van Loenen

In the old days, when visual indication of a ringing telephone was needed, telephone company personnel used a neon lamp. Though it wasn't good at a distance, if several telephone instruments were close together, it could identify which instrument was ringing. The appeal of the neon lamp was that it was cheap and extremely easy to connect. All you had to do was connect the arrangement across the telephone line. No capacitors or resistors (other than the one in the lamp assembly) were needed because, when the phone isn't ringing, the -48-volt dc line potential isn't sufficient to ionize the neon gas; so, the lamp appears as an open circuit to the telephone line. When the ring signal of approximately 90 volts ac at 20 Hz is superimposed on the -48 volts appears on the line, however, the neon gas ionizes as the potential increases beyond about 65 volts. The lamp then flashes on and off at the ringing rate. The lamp draws so little current from the telephone line that there is no danger

of it "answering" the phone when it lights.

With modern technology, solid-state electronics makes it possible to build a much more sophisticated ring indicator that has all the benefits of the original lamp assembly, plus a few of its own. The Telephone Ring Indicator to be described is such a circuit. It can be adapted to a variety of applications, such as the controller for a flashing table lamp to signal the hearing impaired of an incoming call, a ring counter, and any number of other uses you can think up.

About the Circuit

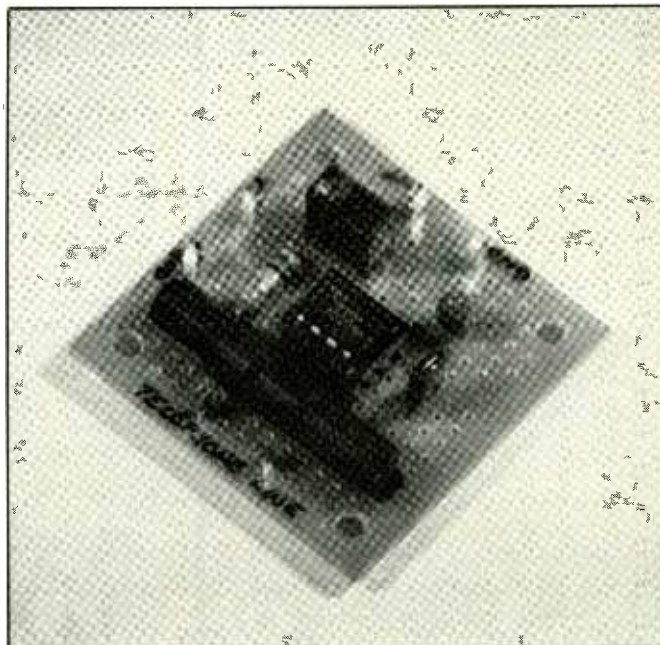
Shown in Fig. 1 is the complete schematic diagram of the Telephone Ring Indicator. In this circuit 555 timer *IC1* is configured as a monostable, or one-shot, multivibrator. When TRIGGER pin 2 is brought low, OUTPUT pin 3 goes high for a period of time determined by the relationship of the values of *R2* and *C1*, expressed mathematically by the formula $0.693 R2C1$. With the values shown for these components, the output will

ideally remain high for about 2.5 seconds.

Phototransistor *Q1* normally holds the TRIGGER input at pin 2 of *IC1* high (not triggered). However, when light from neon lamp *II* strikes the photosensitive surface of *Q1*, the phototransistor is biased into conduction and pin 2 of *IC1* goes to ground potential through its collector/emitter circuit. This triggers the timer into operation.

One of the features of a monostable multivibrator is that it will not respond to more than one trigger pulse during its timing cycle. The key to successful operation of this circuit lies in exploiting this feature because *II* flashes at the ringing rate and thereby provides multiple trigger pulses to *IC1*. Therefore, the time constant provided by *R2* and *C1* must be long enough to permit *II* to stop flashing before it allows the output of *IC1* to return to logic low.

A very common ring sequence, used by telephone companies throughout the country, is 2 seconds ringing followed by 4 seconds of silence, repeated for as long as an at-



tempt is made to reach a dialed number or for the recipient of a call to pick up the receiver of his instrument. This being the case, *I1* will flash for about 2 seconds. Therefore, it is necessary that the product of the *R2* and *C1* values provide a time constant that will exceed this. In practice, it is a good idea not to exceed it by very much to allow *IC1* to have an output timing that resembles as nearly as possible the phone company's ring timing.

If your local telephone company uses a different ringing sequence from that described above, use the above equation to determine the best resistor/capacitor value combination to use for your needs. In general, it's a good idea to stay away from extremely low values of capacitance teamed with extremely high values of resistance.

As has already been mentioned, the values of *R2* and *C1* will ideally permit the output of *IC1* to be high for about 2.5 seconds. However, this assumes a capacitor whose value is exactly 10 microfarads and a resistor whose value is exactly 360,000 ohms. In practice, this is almost never the case. Electrolytic capacitors usually have a wide tolerance and most tend to err to the high side of that tolerance. Beyond this, electrolytic capacitors are often too "leaky" for reliable use in a timing circuit. Tantalum capacitors, on the other hand, are smaller, less leaky and commonly have a tolerance of 20 percent or better. That is the reason why a tantalum capacitor is specified for *C1* in the Parts List. Nevertheless, you may have better luck using a 500,000-ohm, 10-turn trimmer potentiometer for *R2* so that you can "tune" the time constant as needed for the desired results.

Capacitor *C2* provides bypassing to ground for the MODULATING input at pin 5 of *IC1* to prevent pickup of unwanted signals that could interfere with the proper timing.

This circuit always draws current

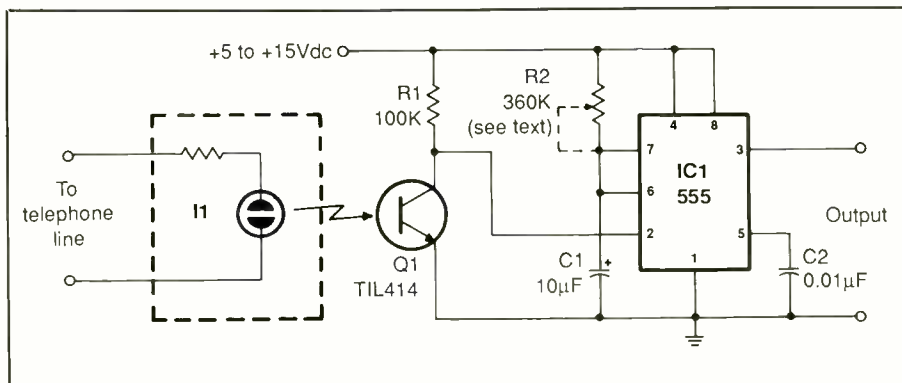


Fig. 1. Schematic diagram of the basic Telephone Ring Indicator circuit.

from the power source and, therefore, battery operation is not recommended. However, a small plug-in wall transformer with an output between 5 and 15 volts dc will work well with the circuit. Alternatively, you can build your own power supply inside the enclosure used for housing the project. Building your own supply would make sense in projects like the aid for the hearing-impaired (described below) because you must have available inside the enclosure 117 volts ac anyway.

Shown in Fig. 2 is the schematic diagram of an ac-line-operated 9-volt dc supply suitable for powering the project. Because the project is meant to be on at all times, there is no power switch in the supply's design. Also, if you wish, power transformer *T1* can be either a discrete device built into the project's enclosure or an external plug-in transformer.

You will note that no output device is specified for the Fig. 1 circuit. This is because the output from the circuit can be used to drive a variety of devices according to specific needs.

One of the features that make this Telephone Ring Indicator so versatile is that it will operate from any dc power supply that delivers between 5 and 15 volts and the logic transitions are from ground to very near the positive rail. This makes the project suitable for use with both TTL and CMOS logic families, as well as analog circuits. In fact, the number of

PARTS LIST

Semiconductors

D1,D2—1N4001 rectifier diode

IC1—555 timer

Q1—TIL-414 infrared phototransistor (Radio Shack Cat. No. 272-145 or equivalent)

Capacitors

C1—10- μ F, 16-volt tantalum

C2—0.01- μ F, 50-volt polyester or ceramic disc

C3—1,000- μ F, 50-volt electrolytic

Resistors

($\frac{1}{4}$ -watt, 5% tolerance)

R1—100,000 ohms

R2—360,000 ohms (or substitute 500,000-ohm, 10-turn trimmer potentiometer—see text)

Miscellaneous

I1—Amber neon-lamp assembly with current-limiting resistor (Radio Shack Cat. No. 272-707 or equivalent)

T1—12.6-volt center-tapped miniature power transformer

Printed-circuit or perforated board and suitable Wire Wrap or soldering hardware; socket for IC1; $\frac{1}{4}$ -inch-diameter heat-shrinkable tubing; suitable enclosure (see text); fast-set clear epoxy cement; hookup wire; solder; etc.

uses to which you could put the project are limited only by your imagination. Some examples of projects that you might want to undertake include: a ring counter, an automatic answering device, a distinctive ringer, a loud outdoor ringer, a delayed

ringer to cut down on nuisance calls, remote control of devices as home while you are away, and an aid for the hearing impaired.

Shown in Fig. 3 is a schematic diagram of a circuit that adapts the project for use as an aid to the hearing impaired. This circuit will flash a table lamp in step with the rings of the telephone. A solid-state relay can be used for *K1*. Generally, these relays require an input of from 3 to 36 volts dc, are capable of being directly driven from TTL and CMOS sources, and the output can switch several amperes of current at 117 or 240 volts ac, depending on device rating.

When the output of *IC1* goes high, *K1* energizes. At this time, 117 volts ac is conducted through fuse *F1* to relay *K1* and its contacts and on to the ac receptacle. Note that the neutral side of the ac line is connected directly to the ac receptacle. The table lamp, plugged into the ac receptacle, must be left in the turned-on state so that it can be controlled by the ringing telephone signal.

The rating of *F1* depends on the amount of current drawn by the table lamp and the current-carrying capability that connects the project to the ac line. If you use an 18-gauge line cord for the project, the rating of *F1* should not exceed 3 amperes, regardless of the current demand of the load plugged into the ac receptacle. Therefore, if you want to be able to control a load rated at more than 3 amperes, use a 16-gauge or larger line cord for the project.

Switch *S1* provides a means for turning on the lamp when the telephone is not ringing. It simply applies *V+* to the input of the solid-state relay, bypassing the *IC1* controller. Diode *D1* provides protection for *IC1* when *S1* is closed.

Construction

Building the Telephone Ring Indicator presents no particular difficulties. The simple circuit is very

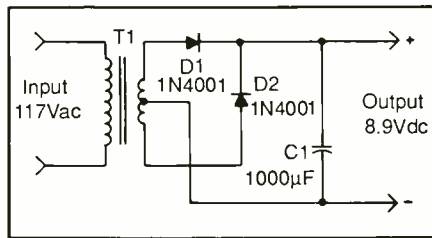


Fig. 2. Schematic diagram of an ac-line-operated 9-volt dc power supply suitable for use with the Telephone Ring Indicator.

straightforward and requires no attention to component layout. The only potential difficulty with regard to construction is in assembly of the *II/QI* assembly, though there is no real difficulty involved.

For this project, perforated-board construction (use a board that has holes on 0.1-inch centers) is perhaps the simplest way to go, though if you wish to design and fabricate your own printed-circuit board instead, feel free to do so. In either case, be sure to use a socket for *IC1*.

Start construction by assembling the *II/QI* assembly. These components must be in close physical contact with each other, and *Q1* must be shielded from extraneous light for it to properly respond to only the light from the neon lamp. Start with a 1 $\frac{1}{16}$ -inch length of $\frac{1}{8}$ -inch-diameter heat shrinkable tubing.

To make it possible for the neon

lamp's case to fit into one end of the tubing, slide the tubing over the closed jaws of longnose pliers and gently stretch the tubing by slowly opening the jaws of the pliers, as illustrated in Fig. 4(A). Test the fit of the lamp in the stretched end of the tubing, as in Fig. 4(B). If it is still a bit too tight, stretch the tubing some more. Push the neon lamp into the stretched end until the tubing is flush with the read edge of the lamp's housing.

Next, apply a small bead of fast-setting clear epoxy cement around the case flange of the phototransistor, as in Fig. 4(C). Then insert the transistor into the open end of the heat-shrinkable tubing until its case touches the case of the neon lamp, as in Fig. 4(D). Use a cigarette lighter or heat gun to solidly shrink the tubing over the neon lamp and phototransistor, as in Fig. 4(E), but be careful to avoid heat damaging the components. Shown in Fig. 4(F) is the completed neon-lamp/phototransistor assembly as it should appear after shrinking the tubing. Note the solid outlines of both components, indicating a solidly made assembly that will meet all criteria.

As you install and wire together the components on the circuit board, be sure not to have *IC1* in its socket. Install the 555 timer in its socket only after all connections to its socket pins

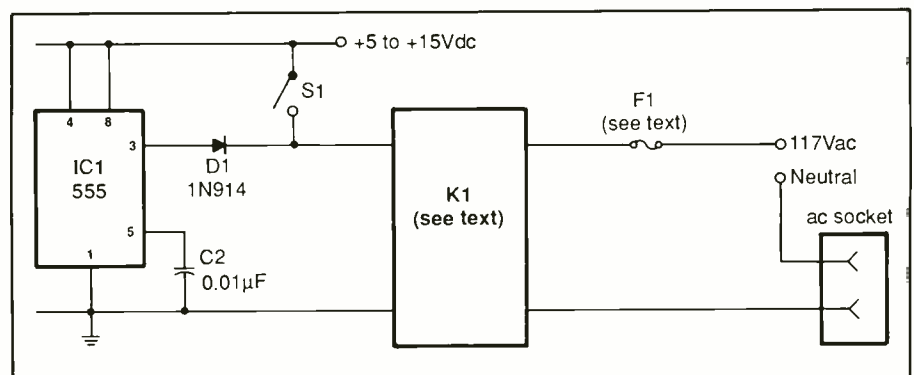
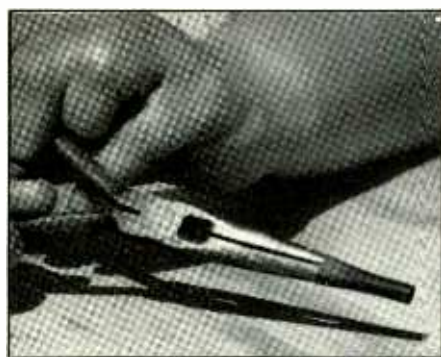
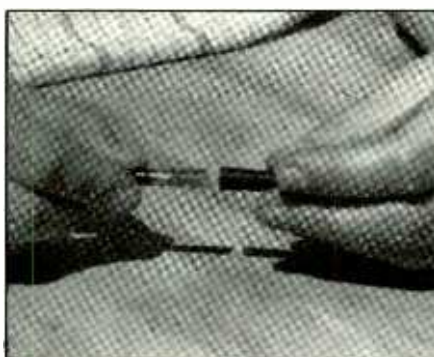


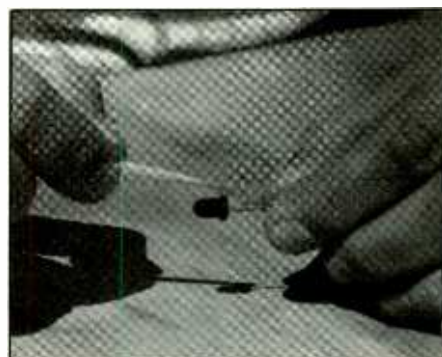
Fig. 3. How to adapt the basic Telephone Ring Indicator circuit to flash a table lamp in step with the ring signal on the telephone line to alert the hearing impaired to incoming calls.



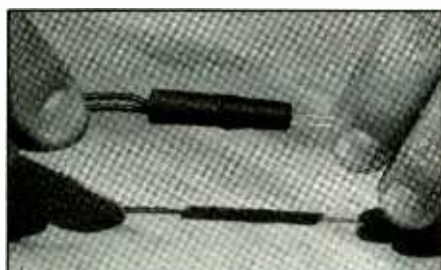
(A)



(B)



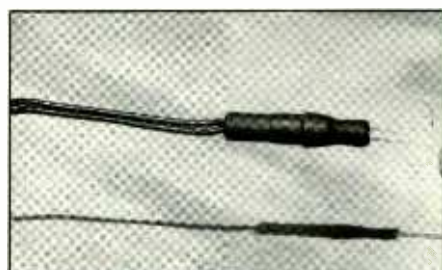
(C)



(D)



(E)



(F)

Fig. 4. Assembly of the neon-lamp/phototransistor assembly: (A) stretch heat-shrinkable tubing to accept the neon lamp; (B) test fit lamp into tubing; (C) apply epoxy cement to phototransistor prior to installation in tubing; (D) insert transistor into tubing; (E) heat shrink tubing to form a light-tight assembly; (F) neon-lamp/phototransistor ready for installation in circuit.

have been soldered. If you elected to use a trimmer potentiometer for $R2$ set its resistance for 360,000 ohms as indicated on a high-accuracy digital multimeter between pins 7 and 8 of the IC socket before installing the timer chip in the socket. This will give you a reasonably good starting point for calibration later on. When installing the timer in its socket, make certain that it is properly oriented and that no pins overhang the socket or fold under between socket and chip as the IC is pushed home.

You can house your Telephone Ring Indicator in any small enclosure that will comfortably accommodate it and its ac power supply and whatever controlled circuit you use with it. Machine the enclosure to permit entry of the Telephone Line and Output cables for the basic project and for jacks or other receptacles and cords you decide to use with the project. A simple way to mount the circuit-board assembly in place is with a

2-inch square or two 2×1 -inch pieces of thick double-sided foam tape.

Calibration

Once construction is completed and the project is checked for wiring and component installation errors, proceed with calibration. For purpose of adjustment, power up the circuit with a 9-volt battery and connect an oscilloscope, logic probe or LED and resistor across the output of $IC1$. Connect the Telephone Line cord to a convenient modular connector block (polarity is not important in this project) while leaving the telephone instrument connected to the line as well. If necessary, use a one-to-two adapter to obtain a second jack at the telephone's location.

Now either call the number yourself from a nearby telephone or have someone else call it if there is no nearby telephone. When the phone rings, the output of $IC1$ should go from low

to high and should remain high until very shortly after the phone stops ringing. At this point, the output of $IC1$ should return to its normally low condition. This sequence should repeat every time the telephone rings.

With the values of $R2$ and $C1$ taken out to the high end of their tolerances, the worst-case on time for $IC1$ is about 4.6 seconds. Keep in mind that the time constant should never be so long that it ends on subsequent rings. If it is too short, it can give the appearance of being too long because as the 555 times out, it is immediately retriggered. The result is that the output goes low and then immediately high again. This can best be seen with an oscilloscope or logic probe. A resistor/LED arrangement will also show it, but you must watch carefully. You can guard against these conditions by using a multi-turn trimmer control in instead of a fixed-value resistor for $R2$ and adjust its setting as required.

ME

Musical Instrument Phase Shifter

Selectively and controllably shifts the phase of signals fed to it from an electric guitar, electric bass, synthesizer and electronic drums to produce special sound effects

By C.R. Fischer

Over the years, only a few audio effects have been versatile and popular enough to be used in almost all styles of music. Compression and limiting, for example, are widely used to prevent excessive signal levels from overloading tapes or subsequent equipment, while reverberation and echo effects add ambience to instruments and vocals alike. Still another popular effect, known as phase shifting or simply phasing, has been in use for nearly 30 years.

During their heyday in the mid-to-late 1970's, the "churning" and "swooshing" of phasers filled hundreds of records. With the introduction of low-cost analog delay integrated circuits, phasing disappeared, only to make a comeback in recent years. While phasers were originally designed to be used with electric guitars, they can also be used with other electric instruments, including the electric bass, electronic synthesizers and electronic drums.

In this article, we'll describe operation, construction and use of a high-quality phaser that can be used with any of the instruments cited. The project contains only three ICs (other than the two voltage regulators in its power supply) and features low noise and distortion, voltage-control inputs and electronic in/out switching to make it useful to both the amateur



and professional musician. Because different readers will build this project for different purposes, two approaches to construction are offered, one that optimizes performance regardless of cost and the other that trades off a bit of performance in the interest of saving money on components. The objective is to provide a phaser that will suit any budget.

Phasing Defined

Phasing was originally developed to serve as a method of simulating the sound of rotating speakers like the Leslie that were extensively used in the 1960s. The Doppler effect produced by these speakers was and still is exciting, but the bulk and weight of these mechanical monstrosities made them less than popular among the great majority of listeners. In

an attempt to duplicate the Doppler effect in a smaller package, a number of companies sought an electronic solution.

Shown in Fig. 1 is a block diagram of the phaser. To create the phasing effect, the input signal is passed through a special circuit configuration known as an "all-pass" filter. As its name implies, the all-pass filter is not frequency-selective; thus, the entire signal passes through it without undergoing attenuation. However, each filter pole provides a frequency-selective phase shift that can vary from 0 degree at low frequencies to 180 degrees at higher frequencies. When this phase-shifted signal is mixed with the original input signal, the phase shifts produce several notches in the output signal, as illustrated in Fig. 2. By sweeping the all-pass filter's center frequency un-

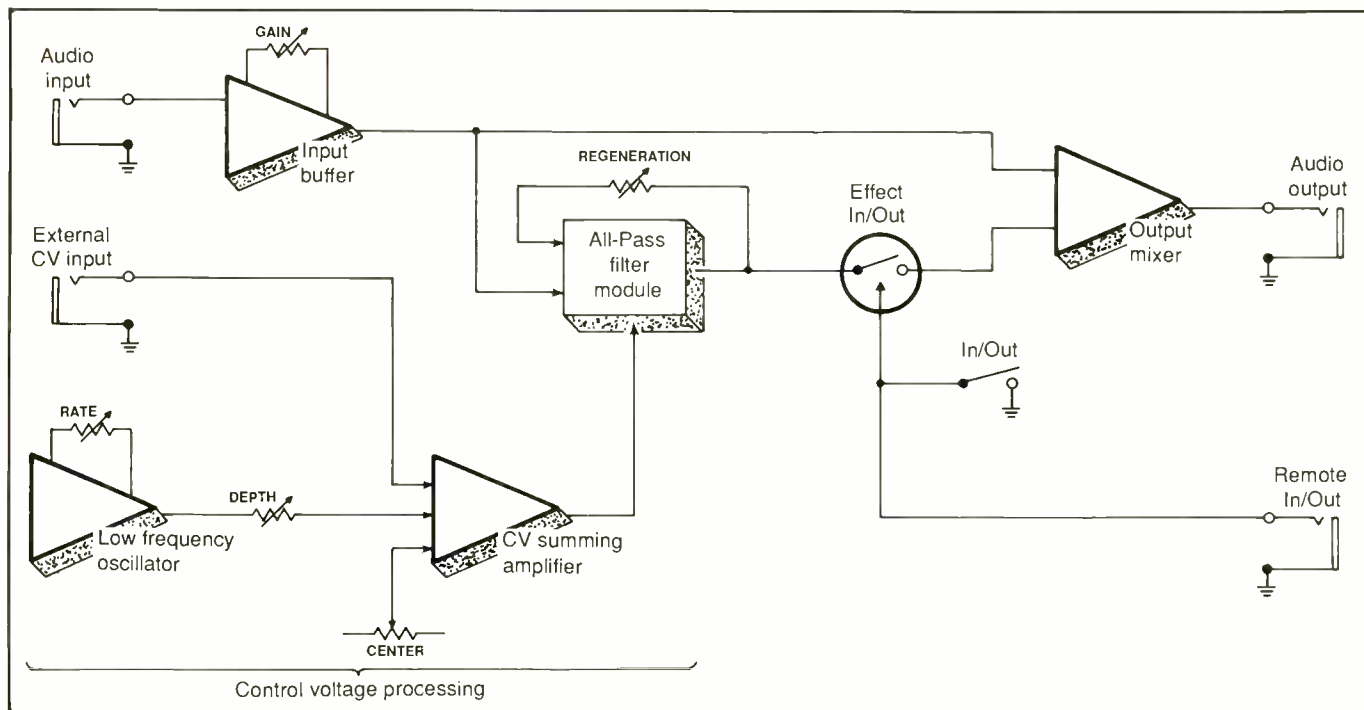


Fig. 1. Block diagram of typical phase shifter circuit.

der electronic control, an ethereal “churning” or “swooshing” effect is produced.

By changing the depth and rate of the modulating signal, a number of variations on the basic effect can be produced. Also, by regenerating the output of the filter back into the filter’s input, the depth of the notches can be increased to further exaggerate the effect.

As it turned out, phasing did not do a terrific job at recreating the Doppler effect produced by rotating speakers. Ironically, their lower cost and portability made phasers much more popular than the speakers whose effect they were supposed to duplicate by electronic means! While phasers were, in turn, supplanted by flangers and chorus boxes in the late 1970s, the unique effects produced by them has led to a recent comeback in their popularity.

About the Circuit

Examining Fig. 1, you will note that the phaser is comprised of five circuit

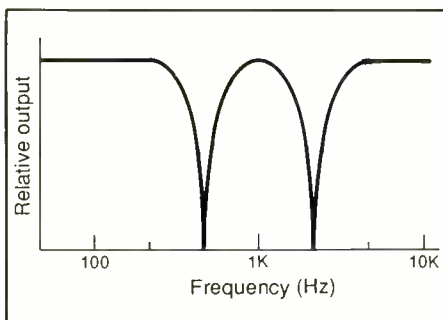


Fig. 2. Relative frequency response of the phaser with Depth and Regeneration controls set fully counterclockwise and Center control set at 1 kHz.

groups: an input buffer, an all-pass filter module, an output mixer, a control-voltage processor and a dual-polarity power supply. Thanks to advances in integrated-circuit technology, the entire processing circuit can be built with just three chips.

Half of dual low-noise operational amplifier IC1 is configured as an input buffer that minimizes loading of high-impedance source signals like

those from a guitar pickup. Without buffering, the input signal source could be loaded down, resulting in such unwanted effects as loss in volume or high-end response. The gain of buffer IC1A is adjustable from 0 to 4 via trimmer potentiometer R2. This allows the phaser to be used with a variety of instruments. After buffering, the input signal is sent to the output mixer and the all-pass filter module built around IC2.

The all-pass filter is the heart of the phaser. It is built around a CEM3320 low-noise voltage-controlled filter (vcf) integrated circuit. Originally designed to be used in music synthesizers, the CEM3320 chip contains four matched filter poles that can be swept over a 1,000:1 range by an external control voltage. In addition, it contains a resonance control cell that allows the filter’s output to be regenerated.

Two special features of the CEM3320 warrant mention here. One is the chip’s on-board –2-volt negative supply regulator available at pin 13. This output must be current

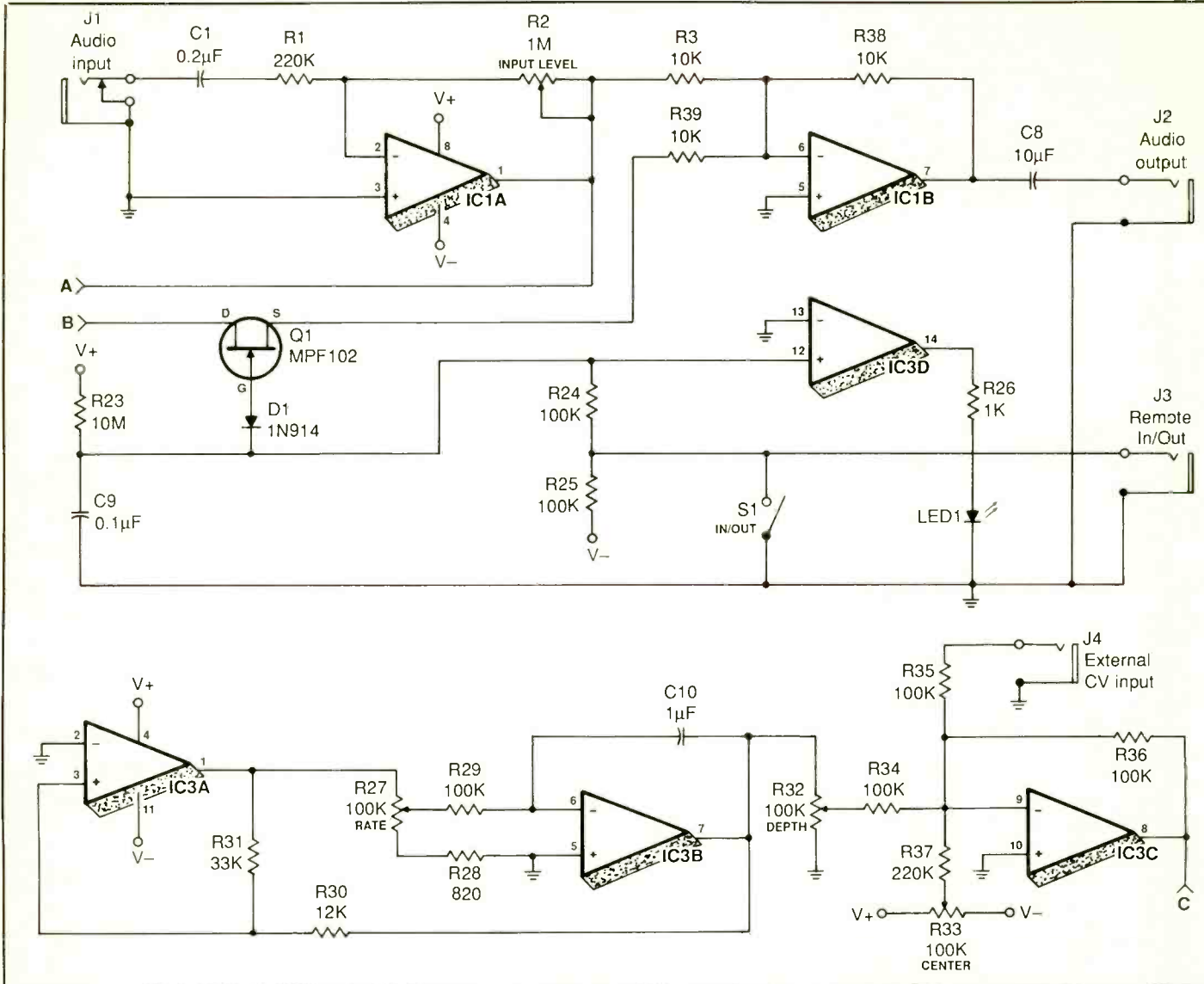


Fig. 3. Complete schematic diagram of project minus its ac-operated power supply.

PARTS LIST

Semiconductors

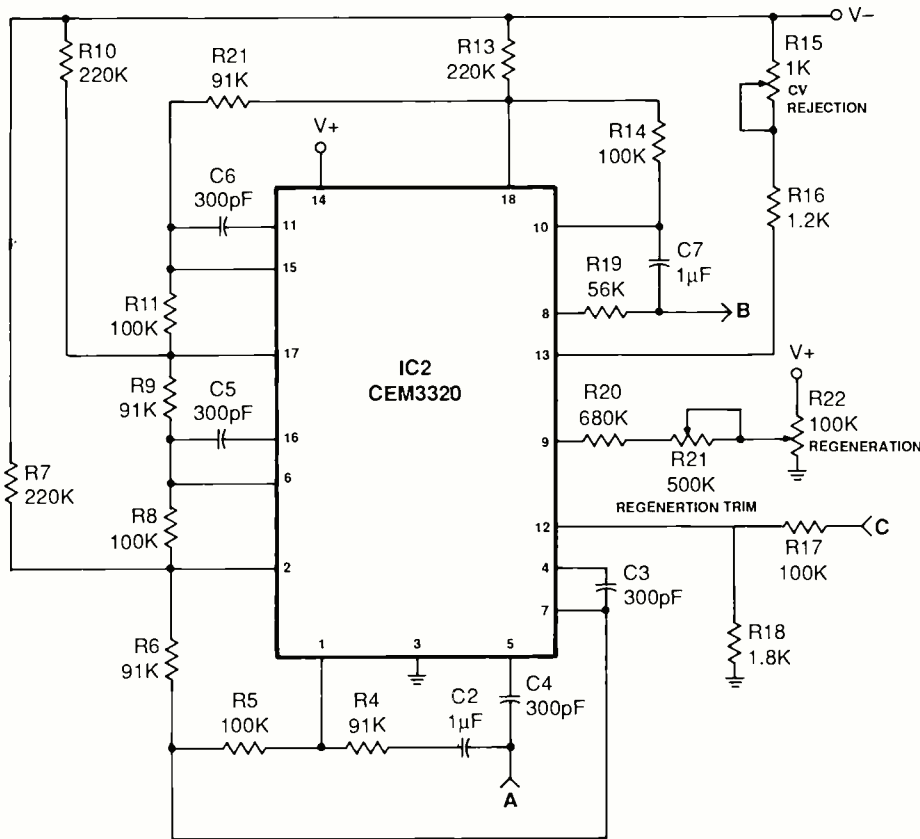
D1—1N914 switching diode
 D2,D3—1N4001 rectifier diode
 IC1—NE5523, TL072 or LM1458 dual operational amplifier (see text)
 IC2—CEM3320 voltage-controlled filter (see Note below)
 IC3—LM324 quad operational amplifier
 IC4—7815 +15-volt regulator
 IC5—7915 -15-volt regulator
 LED1—Red light-emitting diode
 Q1—MPF-102 general-purpose, n-channel field-effect transistor

Capacitors (25 WV or better)

C1—0.2- μ F polypropylene or ceramic disc
 C2,C7—1- μ F electrolytic or tantalum
 C3 thru C6—300-pF mica or ceramic disc
 C8—10- μ F nonpolarized electrolytic or tantalum
 C9,C15,C16—0.1- μ F polypropylene or ceramic disc
 C10—1- μ F nonpolarized film (preferred), electrolytic or tantalum
 C11,C12—1,000- μ F electrolytic
 C13,C14—10- μ F electrolytic or tantalum

Resistors

$\frac{1}{4}$ -watt, 1% metal-film—see text
 R1,R7,R10,R13—220,000 ohms
 R3,R38,R39—10,000 ohms
 R4,R6,R9,R12—91,000 ohms
 R5,R8,R11,R14—100,000 ohms
 R19—56,000 ohms
 $\frac{1}{4}$ -watt, 5% tolerance
 R16—1,200 ohms
 R17,R24,R25,R29,R34,R35,R36—100,000 ohms
 R18—1,800 ohms
 R20—680,000 ohms
 R23—10 megohms
 R26—1,000 ohms



- R28—820 ohms
- R30—12,000 ohms
- R31—33,000 ohms
- R37—220,000 ohms
- R2—1-megohm trimmer potentiometer
- R15—1,000-ohm trimmer potentiometer
- R21—500,000-ohm trimmer potentiometer
- R22, R27, R32, R33—100,000-ohm panel-mount linear-taper potentiometer

Miscellaneous

- J1—Closed-circuit phone jack
- J2, J3, J4—Open-circuit phone jack

- J5—To match plug on wall transformer
 - S1—Spst pushbutton or toggle switch
- Perforated board and Wire Wrap or soldering hardware or printed-circuit board (see text); suitable enclosure; 12-volt, 250-mA plug-in wall transformer; sockets for all DIP ICs; 4 pointer-type control knobs; panel clip for LED1; 1/2-inch spacers; machine hardware; hookup wire; solder; etc.
- Note:** The CEM3320 vcf chip is available for \$10 each plus \$2 S&H for up to 5 pieces from PAIA Electronics, Inc., P.O. Box 14359, Oklahoma City, OK 73113; tel. 405-340-6300.

limited to prevent the IC from being destroyed by excessive current. Current limiting is accomplished in this circuit with R15 and R16. This arrangement allows the supply current to be adjusted for minimal noise.

The other special feature of the CEM3320 is that the amount of resonance is controlled by a control voltage input, which increases flexibility. If the amount of resonance is increased past a certain point, the CEM3320 will break into oscillation. While the sine wave produced under these conditions can be used as a signal generator, the high-amplitude output signal level will blow out speakers if it is not used with care. To prevent this from occurring, R21 allows you to preset the phaser so that maximum regeneration short of oscillation can be obtained.

The output of the all-pass filter goes to IN/OUT switch S1 to permit the phasing effect to be switched in and out as needed. For maximum versatility, an analog switch built around Q1 is used in this circuit. With S1 open, Q1 is held in cutoff by the negative bias voltage across D1, R24 and R25. Grounding the junction between R24 and R25 reverse biases D1 and turns on Q1. This allows the output from the all-pass filter to reach output mixer IC1B. This action can be controlled remotely via REMOTE IN/OUT jack J3 to allow the musician or sound engineer to activate the effect with an spst foot switch. Comparator IC3D monitors the voltage level at the gate of Q1 and turns on LED1 to indicate when the phaser is switched in.

Mixing of the phased and original signals is accomplished in IC1B. When the phasing effect is turned on, both signals are mixed in equal proportions. With the effect switched off, only the original signal is sent to AUDIO OUTPUT jack J2. Because of the mixer's low output impedance, the phaser will work as a buffer whether or not the effect is switched in or out.

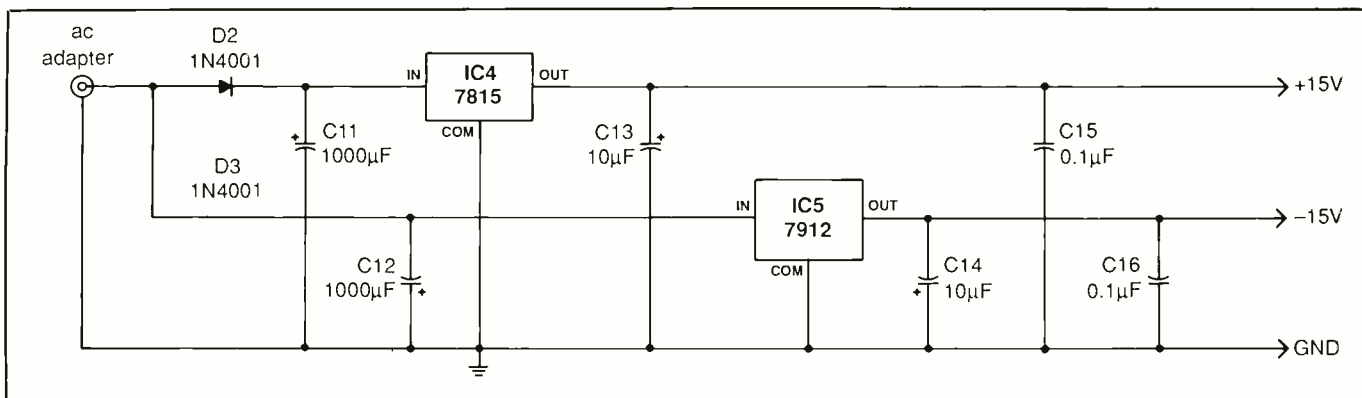


Fig. 4. Dual-polarity +15- and -15-volt regulated power supply.

Having obtained a phaser, you must now generate some form of control voltage to produce an effect. For this, you have a choice from among three sources: CENTER potentiometer *R33*, the low-frequency oscillator (lfo) and EXTERNAL CV INPUT jack *J4*. The CENTER control is simply a variable-voltage source that permits you to set the positions of the notches within the audio spectrum. This allows the phaser to be "tuned" for best effect with different types of instruments.

Many inexpensive phasers are designed to sound best with an electric guitar, while instruments that output signals that are outside the guitar's range sound weak or ineffective. Including the CENTER control in this circuit permits the notches to be placed for strongest effect with your particular signal source.

The low-frequency oscillator generates a sub-audio triangle wave that automatically sweeps the center frequency of the phaser over an extremely wide range. The amount of sweep is set by DEPTH control *R32*. The time for the lfo to complete its sweep is set by RATE control *R27*. Timing capacitor *C10* must be non-polarized and should ideally be a low-leakage film type for the widest possible range of sweep frequencies.

Optional EXTERNAL CV INPUT jack *J4* permits you to sweep the phaser with an external voltage source, such as a foot pedal or a synthesizer. The

three control voltage sources are summed by inverting amplifier *IC3C* and are then fed to the all-pass filter via a voltage divider made up of *R17* and *R18*.

A well-regulated source of +15 and -15 volts is required by the phaser. To avoid hum pickup generated by ac transformers, this supply should employ a plug-in wall transformer rated to deliver 12 volts ac at 250 milliamperes. Such a supply is shown schematically in Fig. 4. Rectifier diodes *D2* and *D3* and filter capacitors *C11* and *C12* form a raw supply of +20 and -20 volts, which are converted to +15 and -15 volts by regulators *IC4* and *IC5*. Bypass capacitors *C13* through *C16* stabilize the supplies by filtering out small variations and noise in the supply lines.

Construction

Electronics hobbyists seem to fall into either of two categories when it comes to building their gear. One group is simply out to save money, the other to have access to high-quality equipment that performs a function that off-the-shelf commercial gear does not address or if it does, it does so at prohibitive cost. Therefore, this project was designed to take into account both motivations.

If you wish to obtain the highest possible operational quality from the phaser, regardless of cost, use an

NE5532 low-noise dual operational amplifier for *IC2*; 1-percent-tolerance metal-film types for all resistors in the signal path; and 5-percent-tolerance silver mica capacitors for *C3* through *C6*. If you are building for lowest cost, substitute an ordinary LM1458 dual op amp for the NE5532; 5- or 10-percent tolerance carbon-film units for the metal-film resistors; and ceramic discs for the silver-mica capacitors.

Use of metal-film resistors may cause some confusion. You might well ask, why bother with more expensive and difficult-to-find metal-film resistors when cheap carbon resistors are readily available? Bear in mind, though, that carbon-composition resistors are 10 to 20 times noisier than their metal-film counterparts. Therefore, it is absurd to purchase a low-noise op amp for a circuit only to ignore other sources of noise.

You can build the phaser on either perforated board or on a printed-circuit board of your own design. If you go the former route, select a board that has holes on 0.1-inch center and suitable Wire Wrap or soldering hardware. Regardless of which method you use, it is a good idea to use sockets for *IC1* through *IC3*.

As you can see in Fig. 5, the original prototype of the project was assembled and wired on a plug-in perforated board sold by Radio Shack (Cat. No. 276-188). This board has a

ground plane that helps to shield the electronic circuitry from outside noise. It also plugs into a standard 44-contact connector so that the board can be conveniently removed for testing and repair.

Though component layout is not particularly critical, you must exercise some care in locating *IC3* relative to audio chips *IC1* and *IC2*. Because the lfo can induce a "click" whenever the triangle waveform changes direction, *IC3* should be kept as far as possible from the other two chips. In addition, the conductors going to *R27* should be kept away from this circuitry as well, especially from buffer *IC1A*. It is also a good idea to shield the input lead to minimize noise pickup between *J1* and the buffer circuit. When you are finished assembling the project, the only ICs that should be installed are voltage regulators *IC4* and *IC5*. Hold off installing *IC1*, *IC2* and *IC3* in their sockets until after initial checks have been made.

Testing & Calibration

Plug the ac adapter into the project and then into a convenient ac outlet. Use a dc voltmeter or a multimeter set to measure dc voltage to check for the presence of +15 volts at the OUT pin of *IC4* and -15 volts at the OUT pin of *IC5*. Your readings should be within 1 volt of the specified levels. If either or both are not within the ± 1 -volt tolerance, immediately power down the project and disconnect it from the ac outlet. Examine the wiring of whichever supply (or both supplies if both are out-of-specifications) for miswired or/and defective components. Do not proceed until you have remedied the problem.

Once the power supply outputs are within their proper ranges, turn off power to the phaser and install the ICs in their respective sockets. Make certain that you properly orient each chip and that no pins overhang the sockets or fold under between ICs

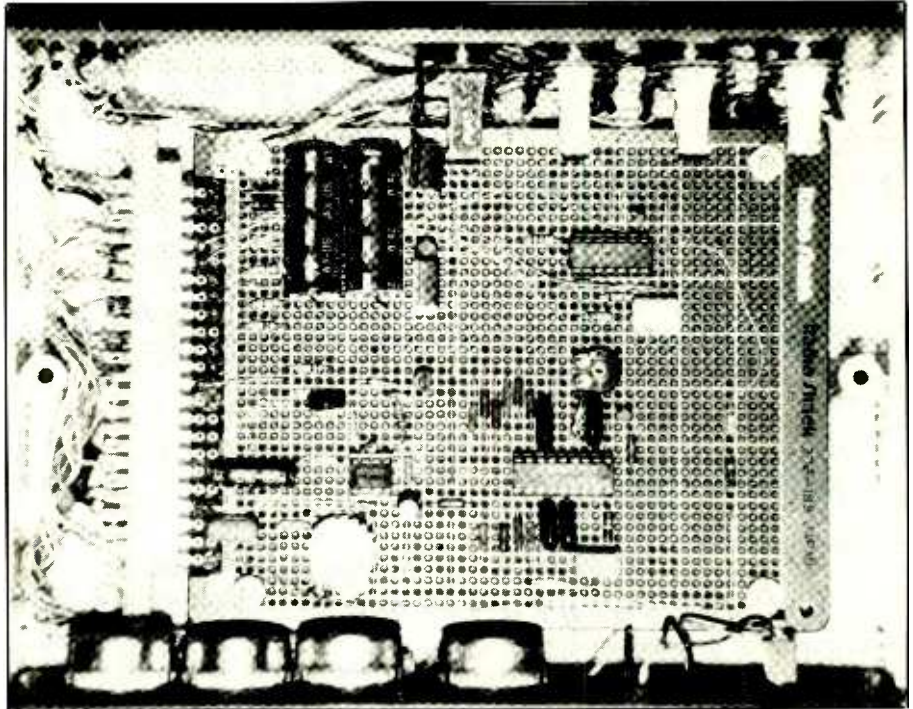


Fig. 5. Interior view of author's prototype. Circuit was assembled on perforated board, but pc board of your own design can be substituted, if desired.

and sockets as you push them home.

Set the CENTER, DEPTH and RATE controls to the center of their rotation; the REGENERATION control fully counterclockwise; and all three trimmer controls to mid-rotation. Connect the musical instrument or signal source to the project by plugging it into AUDIO INPUT jack *J1* and the phaser to an audio amplifier via a cord from AUDIO OUTPUT jack *J2* and the amplifier's input.

Before turning on either the amplifier or the phaser, make absolutely certain that the former's volume control is set to full off. If the phaser is miswired, it is possible that the project will oscillate, which can damage your speakers or even your ears!

Apply power to the phaser and turn on the amplifier. Slowly raise the volume of the amplifier until you hear the sound of the instrument plugged into the phaser. If you hear nothing, power down the phaser and amplifier and check the *IC1* circuit for miswired or/and defective com-

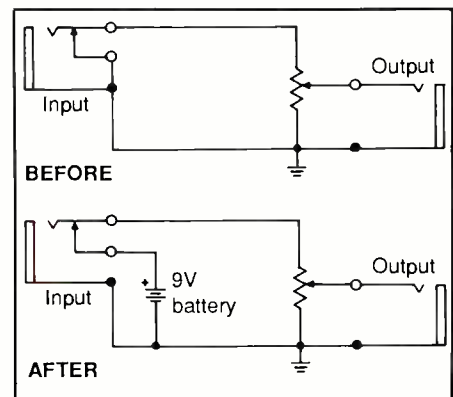


Fig. 6. Adding a 9-volt battery to an inexpensive pedal-type volume control allows the phaser to be swept by foot for more expression. Plugging into the pedal's Input jack returns normal operation.

ponents. Once again, do not proceed until you have remedied the problem.

Continue checkout by setting *S1* to

(Continued on page 87)

An Emergency Electronic Ignition

Gets your car running long enough to drive it to a service center

By Michael J. DiJulio

If your car won't start or run due to an ignition problem, the Emergency Electronic Ignition device described here can get it operating long enough to reach an auto service station. This inexpensive-to-build accessory can be kept handy in every car, along with other basic tools one should have.

The EEI works on most vehicles by bypassing the vast majority of ignition defects, from older electromechanical to later electronic ignition systems. It should not, of course, be used as a permanent substitute in an existing ignition system.

How It Works

The main purpose of an ignition system is to generate an electric spark to ignite the air/fuel mixture in an engine's cylinder. There are three basic types: (1) the classical electromechanical system, (2) the separate electronic ignition system and (3) the integrated electronic ignition system.

The elements that make up the old electromechanical Kettering ignition system are illustrated in Fig. 1. This system uses a set of mechanical contact "points" that rapidly open and close the circuit from the bottom of the ignition coil to ground to simulate an ac waveform that can be transformed by electromagnetic action from the low 12-volts dc of the vehicle's electrical system to a high-voltage pulse (20 kV to 40 kV) that is

ultimately applied to the engine's spark plugs.

In the Kettering system, the points are opened and closed by a cam driven by a distributor. Rapid chopping of the current flowing through the coil's primary winding electromagnetically induces a corresponding current in the coil's secondary winding. Since the coil's secondary has many more turns than does its primary, a voltage many times greater than the initial 12 volts applied to the primary from the vehicle's electrical system is generated. The high voltage from the coil's secondary winding is sent to the distributor and then to the appropriate spark plugs to fire each cylinder's air/fuel mixture at the right time.

Though the Kettering ignition system is simple and fairly reliable, it requires routine maintenance to adjust or replace the breaker points as they

mechanically wear, as well as replacing other worn mechanical parts, such as a rotor, cam, etc.

Electronic ignitions, on the other hand, have no points or other mechanical parts to wear out. The separate type of electronic ignition system has a timing sensor to trigger an electronic circuit that generates a properly timed pulse that's amplified. A switching amplifier's action replaces mechanical breaker points in the classical system.

Modern automobile models, in contrast, employ integrated systems; that is, it's part of a whole digital engine-control system that employs computer technology for spark control that takes a variety of operating factors into consideration. In addition to the improved reliability of distributor-less design, other benefits are better gas mileage and increased engine torque. On the other hand, re-

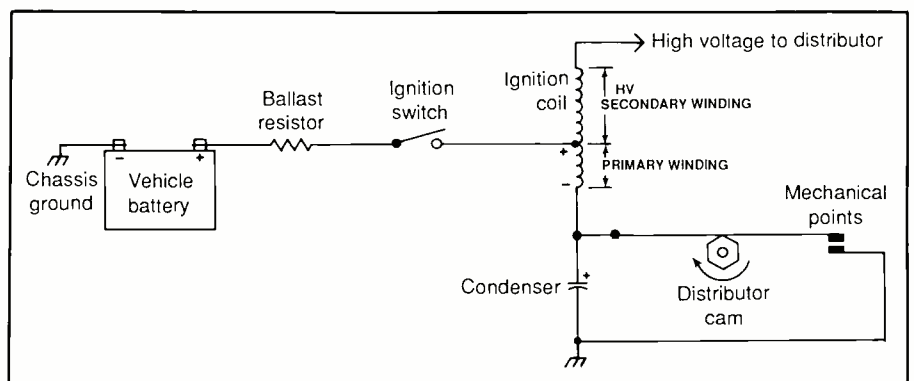
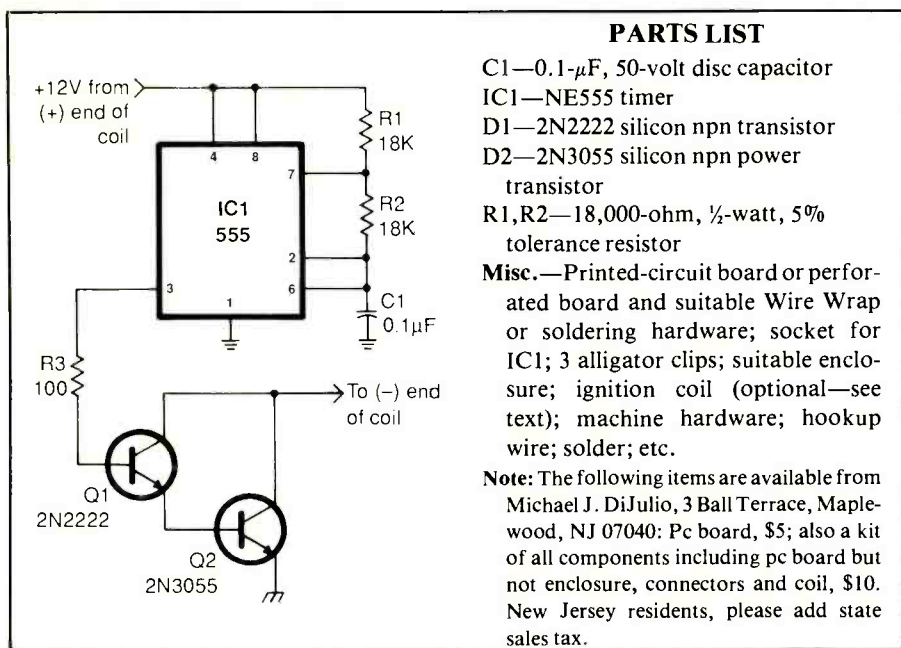


Fig. 1. Elements that make up the conventional electromechanical Kettering ignition system.



PARTS LIST

- C1—0.1- μ F, 50-volt disc capacitor
- IC1—NE555 timer
- D1—2N2222 silicon npn transistor
- D2—2N3055 silicon npn power transistor
- R1,R2—18,000-ohm, 1/2-watt, 5% tolerance resistor

Misc.—Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; socket for IC1; 3 alligator clips; suitable enclosure; ignition coil (optional—see text); machine hardware; hookup wire; solder; etc.

Note: The following items are available from Michael J. DiJulio, 3 Ball Terrace, Maplewood, NJ 07040: Pc board, \$5; also a kit of all components including pc board but not enclosure, connectors and coil, \$10. New Jersey residents, please add state sales tax.

Fig. 2. Complete schematic diagram of the Emergency Electronic Ignition's circuit.

pair costs are higher and some auto service people can't properly diagnose the cause of a problem.

An ignition-system failure can result from a multitude of causes. These might include a bad ignition switch, an open coil, an open ballast resistor, a broken wire, a fused or open set of points, a shorted condenser or a failed transistor or module, to name just the most common causes. An emergency ignition system must bypass as many of these components as possible, yet be simple in design so that it is not itself vulnerable to failure. These were the criteria used in designing the Emergency Electronic Ignition system shown schematically in Fig. 2.

Timer IC1 and its associated components in Fig. 2 make up a standard astable oscillator that operates at a frequency of approximately 250 Hz and a duty cycle of about 66 percent. This frequency and duty cycle have been experimentally determined to be optimum for most cars.

The output signal at pin 3 of IC1 drives the power Darlington circuit

made up of Q1 and Q2. This latter stage performs electronically the same switching action as mechanical points do, opening and closing the ignition coil's circuit to ground.

As you can see, this is a very simple circuit. Simple as it is, though, this module is a very effective emergency substitute for an existing ignition system, whether electromechanical Kettering type or all-electronic.

Construction

Component layout is not critical in this project. Therefore, you can use any traditional wiring technique to assemble the circuit. For example, you can fabricate a printed-circuit board on which to wire together the components, using the actual-size etching-and-drilling guide in Fig. 3. Alternatively, the circuit can be wired on a perforated board that has holes on 0.1-inch centers with the aid of suitable Wire Wrap or soldering hardware.

Whichever wiring technique you decide upon, it is a good idea to use a

socket for IC1. Wire the pc board exactly as shown in Fig. 4. Make sure you properly orient the transistors before soldering any leads to the copper pads on the bottom of the board. To conserve space and keep the project as compact as possible, the resistors mount on-end. If you elect perforated-board construction, follow the same basic component layout shown in Fig. 4, but refer back to Fig. 2 for wiring instructions.

Plug the 555 timer chip into the IC1 socket. Make sure this IC is properly oriented and that no pins overhang the socket or fold under between IC and socket during installation.

When all components have been installed, prepare the three 36-inch lengths of 16-gauge stranded wire that will connect it to the ignition system of the vehicle. To do this, first strip 1/4 inch of insulation from both ends of each. Tightly twist together the fine conductors at both ends of the wires and sparingly tin with solder. Plug one end of these wires into the holes labeled COIL +, COIL - and GROUND and solder into place.

An all-plastic project box that is just large enough to accommodate the circuit-board assembly makes an ideal enclosure. Machining of the enclosure is very easy. All you need do is drill the exit holes for the three wires and the four mounting holes for the board. You can even eliminate the board mounting holes by using thick double-sided foam tape to secure the assembly to the floor of the box instead of using machine hardware. Doing this gives you the additional benefit of shock mounting the circuit-board assembly while it is operating in the automotive environment.

Mount the board inside the box. Then tie a strain-relieving knot in each of the three wires about 3 inches from where they plug into the board. Route the free ends of the wires through the holes drilled for them so that the knots are inside the box. Ter-

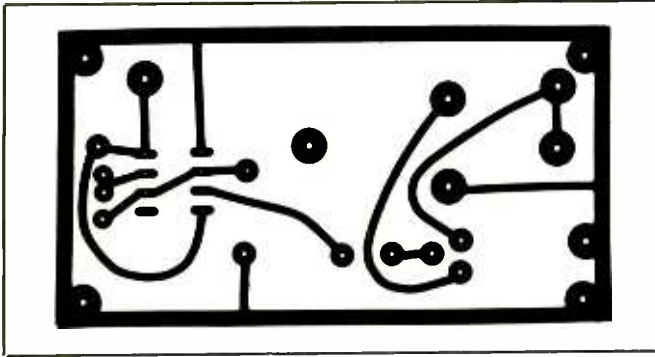


Fig. 3. Actual-size etching-and-drilling guide to use for fabricating a printed-circuit board.

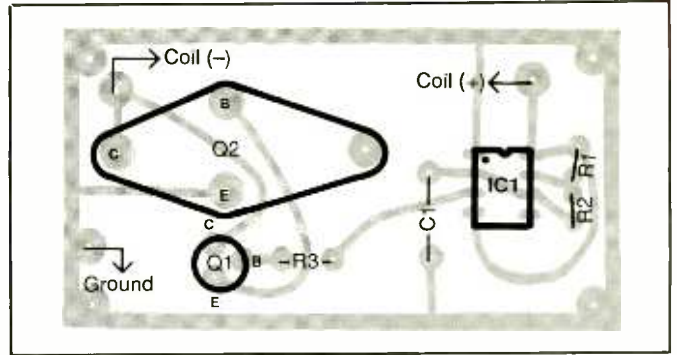


Fig. 4. Wiring guide for pc board.

minate the free ends of these wires in large alligator clips and label each according to destination.

Using the Project

You can use this Emergency Electronic Ignition in either of two ways. One is to use it in conjunction with the coil already in your car, the other is to use a separate coil, as illustrated in (A) and (B), respectively, in Fig. 5. Automobiles that use the General

Motors High Energy Ignition (HEI) System and ignition systems like it have their coils embedded in the distributor and, thus, restrict use of an external coil.

When using the existing coil, the Emergency Electronic Ignition module attaches to the vehicle via its three wires as follows: the GROUND wire goes to a good electrical ground in your vehicle, preferably the negative (-) terminal of the battery; the COIL - wire that originates at the collectors

of transistors Q1 and Q2 in the project goes to the negative (-) terminal on the coil; and the COIL + wire coming from pins 4 and 8 of IC1 goes to the positive (+) terminal of the coil.

Alternatively, the COIL + wire can go directly to the + terminal of the battery, which then eliminates the vehicle's ignition switch. However, exercise extreme caution when operating the Emergency Electronic Ignition module in this manner because as soon as the COIL + wire is con-

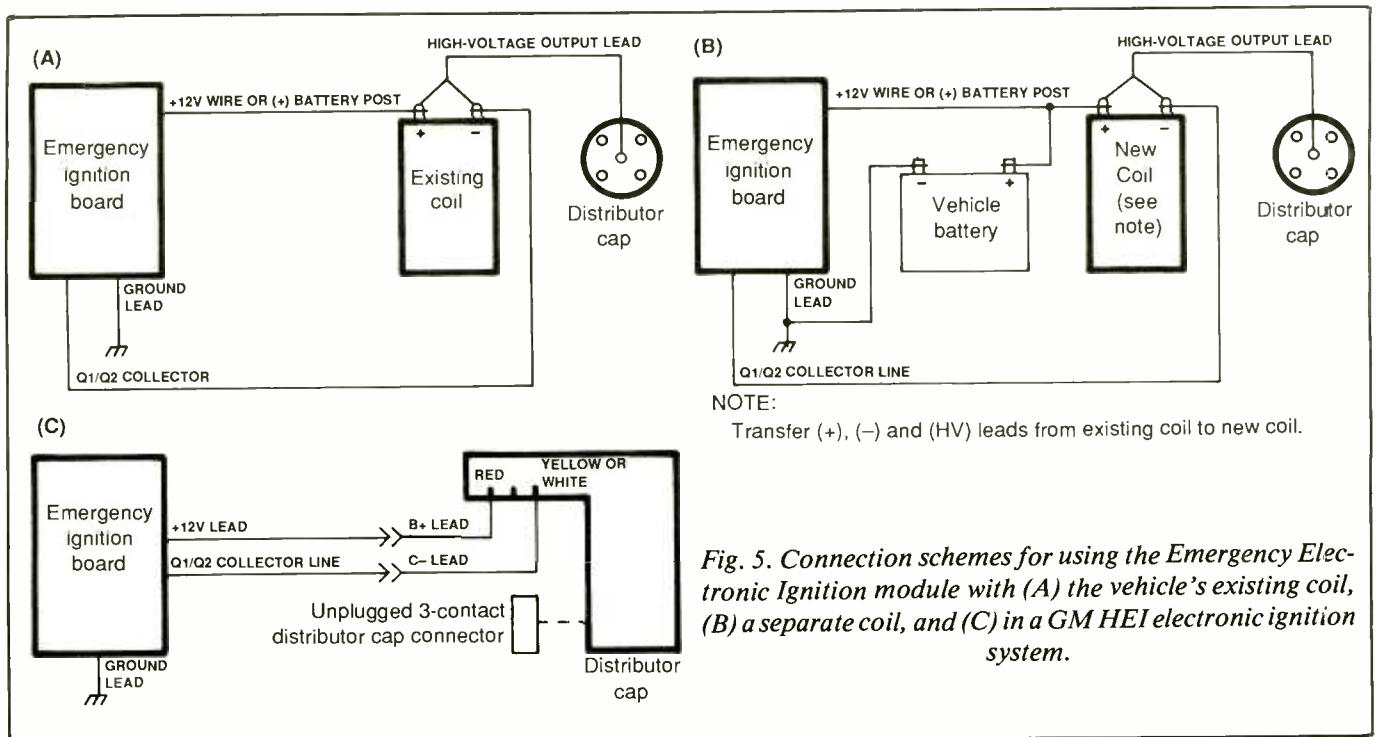


Fig. 5. Connection schemes for using the Emergency Electronic Ignition module with (A) the vehicle's existing coil, (B) a separate coil, and (C) in a GM HEI electronic ignition system.

nected to the battery, a dangerous high voltage is generated. Also, once the vehicle is started, its engine can be stopped only by disconnecting the COIL + wire from the battery.

If you use a separate coil with the Emergency Electronic Ignition, this coil connects to the project as shown in Fig. 5(B). Then the high-voltage lead that goes from the distributor to the coil must be disconnected from the existing coil and be attached to the new coil. This connection arrangement eliminates everything in the ignition system except the distributor.

When using a separate coil, it may be necessary to transfer some or all of the wires on the positive and negative terminals of the old coil to the new coil. Some of these wires may provide signals to other parts of your car, such as the fuel pump, that will be necessary for the car to start and run properly. It is for this reason that connection of the Emergency Electronic Ignition to the existing coil should be tried first.

For GM HEI systems, the connections are different, as illustrated in Fig. 5(C). To make the connections, you must first disconnect the plug that goes from the base of the distributor (the part that contains the electronic ignition module) to the distributor cap. This plug has three wires that are insulated red, black and white or yellow. The red-insulated wire is the B + conductor of the coil, the black-insulated wire is the conductor that goes to the ground or frame of the coil, and the white- or yellow-insulated wire is the C- or contact part of the coil.

As per Fig. 5(C), you connect the COIL + (+12V lead) from the Emergency Electronic Ignition module to the red-insulated B+ lead and the COIL - wire to the white- or yellow-insulated C - lead in the GM HEI system. The project's GROUND wire does not require connection, but you can connect it to any convenient electrical chassis ground in the vehicle if

you wish.

The best way to identify the color of the insulation on the HEI system's upper connector wires is to make note of them in the bottom connector before separating the two connectors. Another way is to remember that as you face the distributor cap

with the connector facing you, the left-to-right order is white or yellow, black and red. Keep in mind that the connections from the Emergency Electronic Ignition module are made to the end of the plug that resides in the distributor cap and that they are best made with spade lugs. **ME**



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Telephone Equipment Tester

Instrument tests telephones, answering machines and other telephone equipment

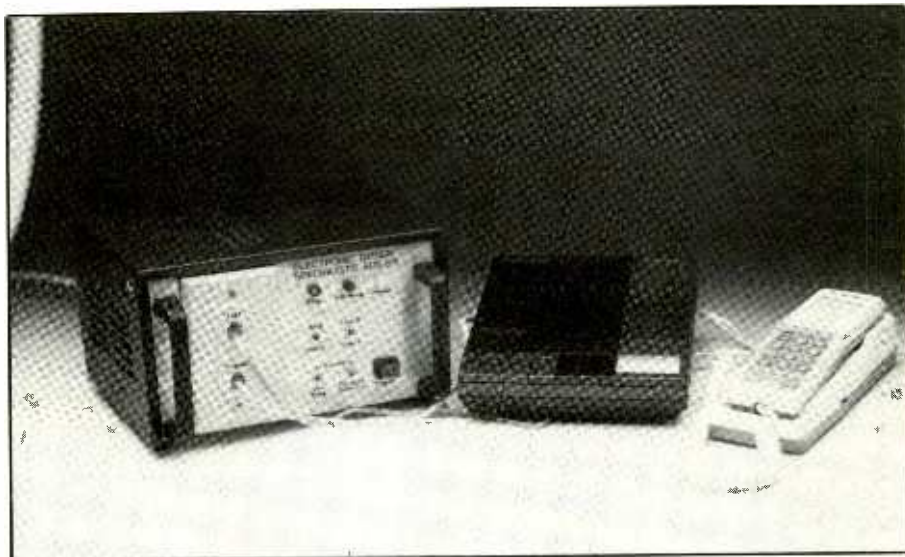
By David Miga, CET

If you test or repair such telephone equipment as answering machines and cordless telephone instruments, you already know that there are only two ways to operate these devices. Either you install two telephone lines at your test-bench, or you spend \$400 or more for a professional testing device. Fortunately, there is now a third alternative—the Telephone Equipment Tester to be described. Our Tester does just about everything the professional units do and actually has several features those units don't have. And you can build it for about \$70, including enclosure.

With this Telephone Equipment Tester and a low-cost telephone instrument (preferably with Touch Tone dialing), you have all the facilities you need to quickly and accurately test a wide variety of telephone equipment, including the newer answering machines equipped with all the "bells and whistles" and cordless telephone instruments.

Some Background

Ma Bell has put a lot of signals on just the two wires from the central office to your telephone instrument. Included are audio signals, signals that generate the ring alert, signals to indicate when a line has a party waiting, signals to show when a party has picked up or hung up the receiver, and so on. Many telephone answering machines utilize these signals, which can make them very difficult to troubleshoot and repair unless you



can simulate the telephone company's signals *exactly*.

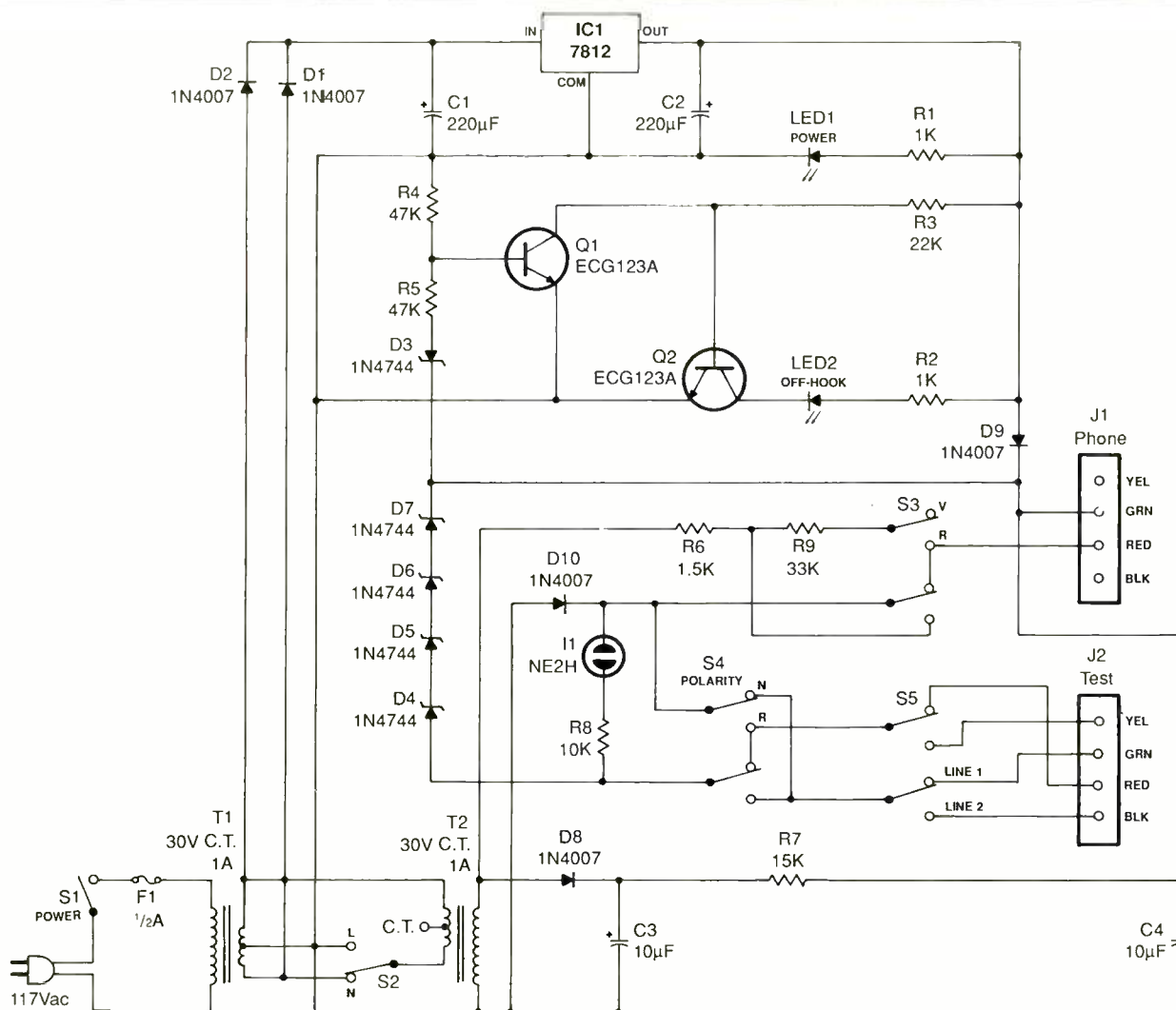
Let's review some of those signals and how they are represented:

- **On Line.** This is a standard "resting" signal of about +50 volts dc, measured from the green-insulated to the red-insulated conductor at the telephone jack. If your house has two lines, the black- and yellow-insulated conductors are used for the second line. When your telephone instrument is "on-hook," it presents a very high dc resistance but a low ac impedance to incoming ac signals, the result of the ringer circuit having a dc-blocking capacitor in series with it. (For more detailed information on how telephones work, see "Telephone Technology" in the August and September 1988 issues of *Modern Electronics*—Editor.)

- **Off-Hook.** When a telephone receiver is lifted from its cradle, the +50-volt signal drops to about +7 volts and signals the phone company to provide dialtone or, if you are being called, to stop the ring signal. Your telephone instrument measures 600 ohms or lower dc resistance while off-hook.

- **Ring.** When someone calls you, a pulsating dc signal with an amplitude between 90 and 150 volts and a frequency between 20 and 60 Hz appears on a low-impedance line. Like all the other signals generated by the telephone company, the ring signal is positive when measured from the green- to the red-insulated conductor.

- **Party Waiting.** When someone calls you, between ring signals the +50 volts is raised higher, to about +70 volts.



PARTS LIST

Semiconductors

LED1—Jumbo red light-emitting diode
 LED2—Jumbo green light-emitting diode
 D1, D2, D8, D9, D10—1N4007 or similar 1,000-volt, 1-ampere rectifier diode
 D3 thru D7—1N4744 or similar 15-volt, 1-watt zener diode
 IC1—7812 + 12-volt regulator
 Q1, Q2—ECG123A or 2SC945 npn transistor

Capacitors

C1, C2—220-µF, 25-volt electrolytic
 C3, C4—10-µF, 250-volt electrolytic

Resistors (¼-watt, 10% tolerance)

R1, R2—1,000 ohms
 R3—22,000 ohms

R4, R5—47,000 ohms
 R8—10,000 ohms
 R9—33,000 ohms
 R6—1,500 ohms, 10-watt wire-wound
 R7—15,000 ohms, ½-watt

Switches

S1—Spst toggle (Vanco No. PB-4 or similar)
 S2—Spdt toggle (Vanco No. SMM-33 or similar)
 S3, S4, S5—Dpdt toggle (Vanco No. SMM-63 or similar)

Miscellaneous

F1—½-ampere pigtail fuse
 I1—NE-2H neon lamp
 J1, J2—Dual modular telephone jack on wall plate (Radio Shack Cat. No. 279-350 or similar)

T1, T2—30-volt center-tapped, 1-ampere power transformer (EDS No. 256861 or equivalent)
 Suitable enclosure (see text); multiple-lug terminal strips, perforated board and hardware or printed-circuit board (see text); ac line cord with plug; machine hardware; hookup wire; solder; etc.

Note: The following items are available from Electronic Design Specialists, Inc., 951 SW 82 Ave., N. Lauderdale, FL 33068: Kit of all parts but *not* including enclosure and dual telephone jack wall plate, \$59; 30-volt C.T., 1-A power transformer, \$12 each. Add \$5 P&H per order. Florida residents, please add 6% sales tax.

Fig. 1. Complete schematic diagram of the Telephone Device Tester.

• *Hang-Up.* When your caller hangs up, your off-hook line voltage quickly drops to 0 volt for a fraction of a second before being restored.

Most answering machines and some electronic and cordless telephone instruments won't acknowledge a ring signal unless they receive the special pulsating dc, low-impedance signal with the +50 to +70-volt signal riding between rings. Most newer answering machines will stop recording when they intercept the hang-up signal, instead of recording silence or dialtone. This is known as the CPC (Calling Party Control) signal.

Our Telephone Machine Tester can simulate all these signals. Therefore, it can check all functions of any single- or dual-line telephones and answering machines.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the project. As you can see, the circuitry is basically very simple. Two identical transformers serve two purposes. They isolate all signals from Earth ground so that you can use an oscilloscope to trace ring signals without the need for an isolation transformer. They also provide all of the special voltages and signals that are required by the device you are testing.

Transformer *T1* supplies low-voltage ac to diodes *D1* and *D2* and integrated circuit *IC1*, which supplies regulated +12 volts dc. This supply powers the OFF-HOOK *LED2* circuitry and provides the correct voltage and current for the off-hook signal used in testing. The +12 volts from the OUT terminal of *IC1* is passed through PHONE jack *J1*, which normally has a regular low-cost telephone instrument plugged into it, and to TEST jack *J2*, which would have plugged into it an answering machine or other telephone equipment. The drop is 6 volts per device, since both are in series with each oth-

er. This is close enough to simulate the off-hook signal standard. Regulator *IC1* was used in this circuit to obtain a stable +12 volts so that a minimum of hum is transmitted along with the audio signal.

Transformer *T2* is connected into the circuit in "backward" fashion so that its output is 117 volts ac. Note that switch *S2* can toggle *T2*'s output to 60 volts ac to simulate a weak ring voltage, thus simulating an installation in which seven or eight older telephones with *real* bells are connected to the telephone line. If a customer complains that his answering machine does not answer calls, but the machine works fine on your test-bench, you can simulate a heavy wiring load condition by setting *S2* to the L (low-ring) position.

The high-voltage ac output from *T2* is routed to two locations in the circuit. First, it is rectified, filtered and regulated to +60 volts by the circuit made up of *D8*, *C3*, *C4*, and *D4* through *D7*. A +60-volt potential was chosen because it is between the +50- and +70-volt signals of *on-line* and *party-waiting* standards and will fool the device under test into operating normally.

The second routing of the high-voltage ac supply's output is through current-limiting resistor *R6*, switch *S3* and on to the low-cost telephone plugged into *J1* and the device under test plugged into *J2*. All items in the string are in series with each other. Note that this signal is not passed through a diode, even though the ring signal must be a pulsating dc voltage. The reason for this is that there would be no low-impedance return to discharge the dc blocking capacitor in the ring circuit of the device under test. Therefore, the ac signal is sent through the limiting resistor but diode *D10* is installed across the output to discharge the blocking capacitor in the device under test.

Diode *D10* also shorts out *T2* during the negative half of the ac alterna-

tions. Hence *R6* limits current to about 80 milliamperes to prevent damage. The 33,000-ohm resistance of *R9* provides a small portion of the ring signal to the telephone instrument plugged into *J1* to simulate a ring signal in the earpiece. RING neon lamp *I1* lights only when a "normal" ring signal is present; it will *not* light with low ring voltages.

Turn your attention now to diode *D9*. Normally, the voltage at the green conductor of the phone jack module would be at +60 volts, derived from the high-voltage regulated power supply. When the telephone instrument plugged into *J1* and device under test plugged into *J2* are both off-hook, the high-voltage supply is essentially shorted out because the maximum current it can supply is 5 milliamperes through *R7*. The +12-volt supply is switched in by *D9* to supply the 20 milliamperes for the signal loop. The high-voltage supply could have been used here, but it would have required a large-value resistor to drop the voltage so far down while having to supply a larger current than zener diodes *D4* through *D7* can safely handle. Also, because there would have been a considerable amount of hum in the audio, the low-voltage regulator was chosen as the better solution.

When the drop is to +12 volts, the off-hook circuit made up of *D3*, *Q1* and *Q2* detects the change in voltage and turns on OFF HOOK indicator *LED2*. This handy indicator tells you if a dialing-type telephone instrument is working. The circuit will flash the OFF HOOK LED the same number of times as the number selected on the dialing keypad. Answering machines with line seizure problems (dirty contacts and the like) will cause the indicator to flash intermittently.

Switch *S4* provides a means for reversing the polarity of the signal applied to the telephone equipment plugged into the jacks. Most tele-

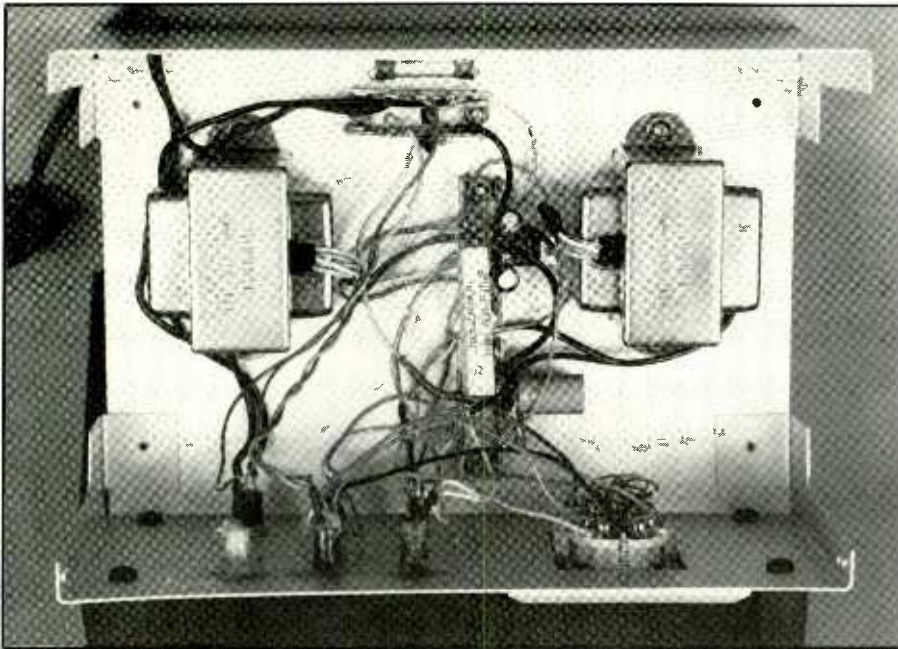


Fig. 2. Interior view of author's prototype. Circuit was built using a "modular" construction technique, using multiple-lug terminal strips.

phone equipment is designed to operate with either polarity. This switch will allow you to identify the ones that do not.

Finally, LINE 1/LINE 2 switch *S5* enables you to check the large number of telephones and answering machines that have been appearing lately with two-line capability.

Construction

For the prototype, a Radio Shack Cat. No. 270-270 enclosure was used, as shown in the lead photo. You may find this enclosure difficult to locate because Radio Shack has discontinued it. You can use any other brand or type of enclosure that will accommodate all components on the inside and has enough panel space on which to mount the telephone jacks, switches and indicators.

Circuit layout is in no way critical. The circuit itself is fairly straightforward in design and, therefore, can be wired together by any traditional means. As you can see in Fig. 2, the

entire circuit was mounted and wired together with the aid of a number of multiple-lug terminal strips. If you wish, however, you can use perforated board with suitable Wire Wrap or soldering hardware or even design and fabricate a printed-circuit board for the project.

The simplest way to build this circuit is with terminal strips, using "modular" construction techniques. Make one terminal strip the high-voltage regulator circuit, another strip the off-hook indicator circuit, and so on. It took a minimum of six three-lug terminal strips for the prototype, which would have been neater laid out if seven or eight terminal strips had been used. Of course, you can use fewer strips if you choose ones that have more lugs per strip.

As you install and wire together the various components, be sure to double-check polarities of diodes and capacitors and the basing of *IC1*. After assembling the project, plug it into an ac outlet, turn it on and quickly measure the outputs of the

+60- and +12-volt power supplies. If you obtain the proper readings in both cases and POWER *LED1* is lit, chances are pretty good that you wired the project correctly. If not, power down the circuit and carefully check all your wiring and component installations. Do not proceed until you have rectified the problem.

As you operate the project, nothing should heat up noticeably, including 10-watt power resistor *R6* and non-heat-sinked voltage regulator *IC1*. The regulator will normally get only warm to the touch when a telephone instrument and a device under test plugged into the jacks are both off-hook at the same time. Resistor *R6* will become warm only during extended ringing.

Using the Tester

Plug a telephone instrument into PHONE jack *J1*. For test purposes, use an "el Cheapo" instrument that you can dedicate for testing purposes. It will be used only for monitoring the device under test plugged into TEST jack *J2*. If you use a DTMF (Touch Tone) instrument in *J1*, you will have the advantage of being able to test answering machines that have remote-control functions that are controlled by the DTMF tone signals.

To check an answering machine, plug it into the TEST jack and set it to "answer." Lift the telephone instrument plugged into the PHONE jack off-hook and flip RING switch *S3* to "ring" (R) for about 2 seconds then "voice" (V) for about 4 seconds. You will hear a ring signal in the instrument's earpiece. Continue ringing until the answering machine answers. Then leave the switch in the "voice" (V) position. OFF-HOOK indicator *LED2* will light and you will hear the OGM (out-going message) in the telephone's earpiece.

When the answering machine answers, leave your message, and if you

(Continued on page 89)

A Visual Regulator Monitor

Separate circuits with LEDs alert you to loss of regulation, overcurrent and thermal problems caused by regulator ICs in power supplies

By Fernando Garcia Viesca

You've finished breadboarding or assembling your latest creative electronic circuit and, while checking it out, discover that it's behaving erratically. Checking your wiring, substituting components and rechecking your circuit design, you can find no reason for the problem. Just as you're ready to scrap everything and start fresh, you check voltages again and discover that the problem lies in the regulator part of the power supply.

The foregoing experience isn't an uncommon one when using voltage-regulator ICs. The three-terminal voltage regulator has long been subjected to considerable use—and abuse—by experimenters. Because they're so simple and easy to use, many people don't take the time to learn how to use them correctly. Indeed, many experimenters aggravate the situation by not giving sufficient thought to the designs of their power supplies.

In this article, we'll discuss how you can avoid regulated power supply problems with a simple circuit that provides early warning that something is amiss. Our focus is on three-terminal regulators—specifically those in the 78XX series. However, the technique to be discussed can be applied to any IC or discrete regulator, regardless of circuit design, since it will have a raw dc input, regulated dc output and a common reference.

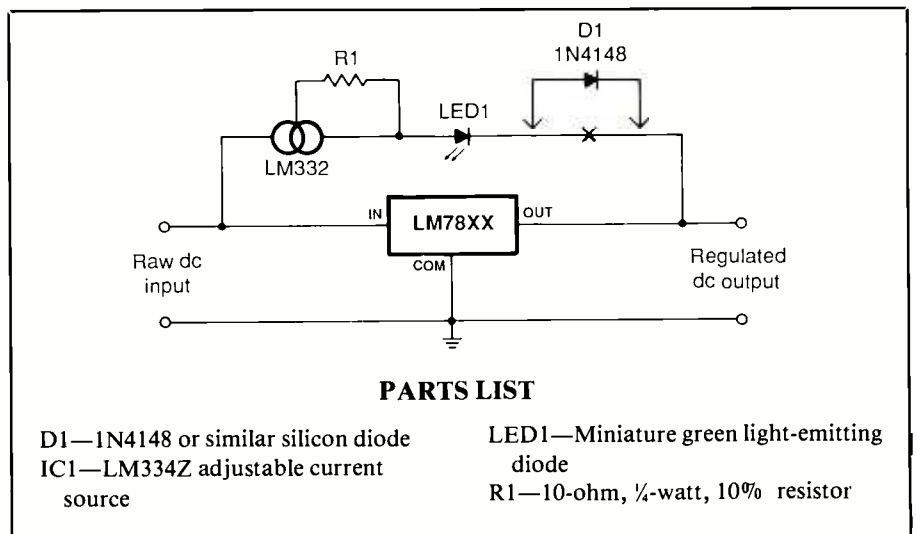


Fig. 1. Circuit monitors input-to-output voltage differential of power supply's voltage regulator; if loss of regulation occurs, LED1 lights.

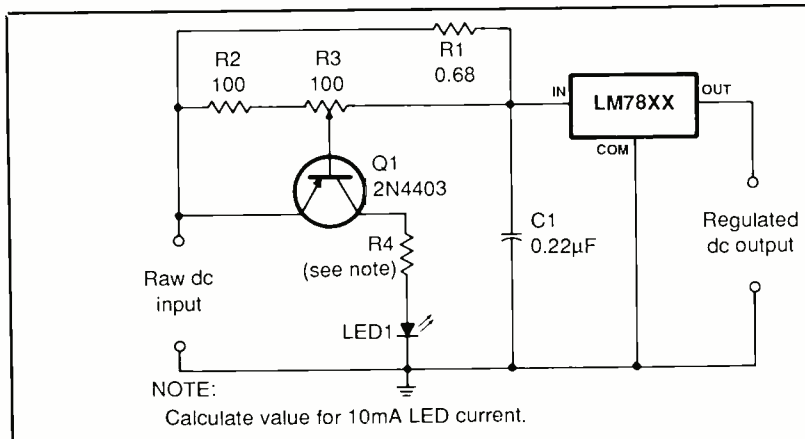
Input-to-Output Voltage Differential

Perhaps the most frequent cause of regulation problems in a power supply results from an improper input-to-output voltage differential. All regulators must have a minimum input voltage for them to output their specified voltage. The input voltage is invariably greater than the output voltage; otherwise, the output voltage will simply follow the input voltage. This situation is only aggravated by an inserted series impedance.

In the case of the common three-terminal integrated-circuit voltage regulator, there must be about 1.6 volts minimum input-to-output po-

tential difference, at least theoretically. That is, if you are using a 5-volt regulator, not less than 6.2 volts must be applied to its input terminal for it to output its specified 5 volts. However, you must also take into consideration the effects of ripple in the dc input voltage. Therefore, you would be safer to increase this differential to 2.6 volts or more to provide a safety margin.

Shown in Fig. 1 is an extremely simple circuit that monitors this condition. It provides early warning of a loss of regulation due to insufficient input-to-output voltage differential. This circuit basically uses the forward voltage drop of a constant-current source LM332 to light visual in-



PARTS LIST

- C1—0.22- μ F, 50-volt ceramic disc capacitor
- LED1—Miniature red light-emitting diode
- Q1—2N4403 or similar general-purpose silicon pnp transistor
- R1—0.58-ohm, 2-watt resistor
- R2—100-ohm, $\frac{1}{4}$ -watt, 10% tolerance resistor
- R3—100-ohm, linear-taper trimmer potentiometer
- R4—Calculate value for 10-mA LED current

Fig. 2. Circuit for keeping tabs on current; LED1 lights whenever an overcurrent condition exists.

indicator LED1. At least 1 volt in the LM332 and 1.6 volts in LED1 are needed to light up the light-emitting diode. Any decrease in the potential below 2.6 volts decreases the LED's brightness. The greater the decrease, the less bright the LED, until it reaches a point where LED1 becomes completely extinguished. At potentials above 2.6 volts, the LED glows at a uniform brightness, owing to the fact that the current delivered by the LM332 is constant.

Note in Fig. 1 that no current-limiting resistor is used between the

LM332 constant-current source and LED1. Such a resistor isn't required in this circuit arrangement, thanks to the constant current from the LM332. If you wish to increase the safety margin, you can install DI, a 1N4148 or similar silicon diode, in series with LED1 as shown. This inserts an additional 0.6-volt drop.

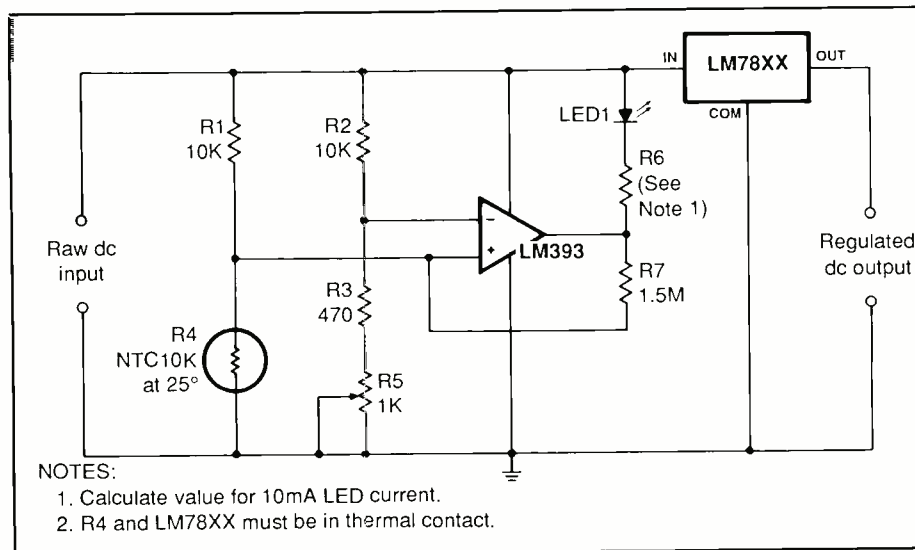
There is a slight catch to using the Fig. 1 circuit—the LED current is bypassing the LM78XX voltage regulator. Therefore, the minimum output load current is increased by the amount of current passing through

LED1, which is about 6.7 milliamperes in this case. If you cannot guarantee this minimum load current, a bleeder resistor must be used.

The circuit shown in Fig. 1 is for use with a positive voltage regulator. It can also be used with a negative regulator simply by reversing all polarities.

Current Limiting

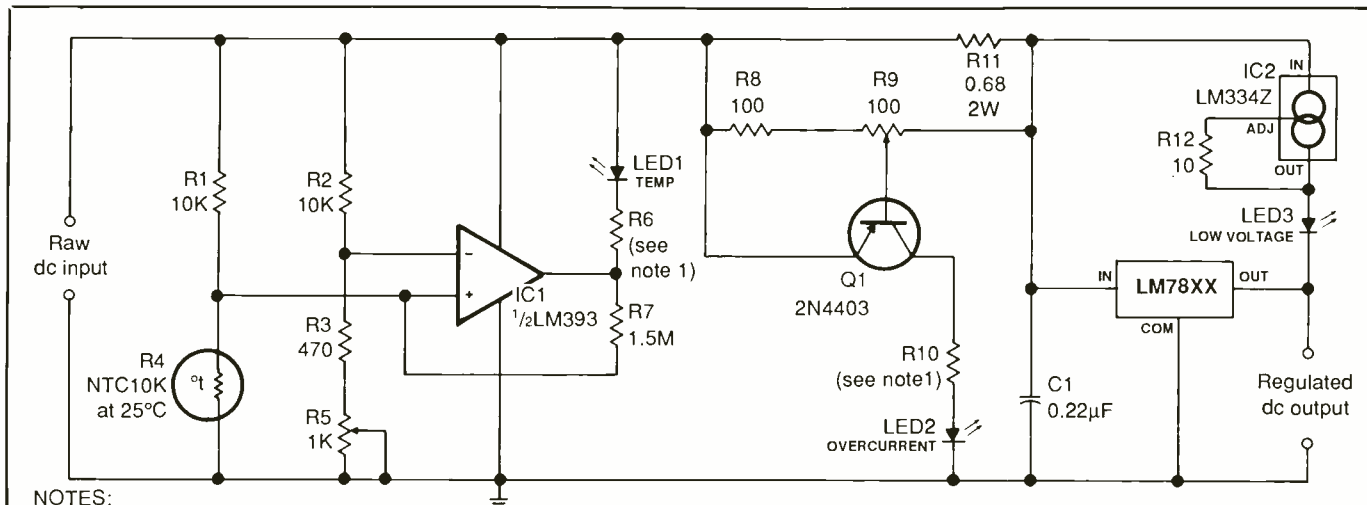
Since three-terminal voltage regulators are so deceptively easy to use and are basically foolproof in operation,



PARTS LIST

- IC1—LM393 dual voltage comparator
- LED1—Miniature red light-emitting diode
- All resistors $\frac{1}{4}$ -watt, 10% tolerance
- R1, R2—10,000 ohms
- R3—470 ohms
- R6—Calculate value for 10-mA LED current
- R7—1.5 megohms
- R4—10,000-ohm NTC at 25°C thermistor (Digi-Key Corp. Cat. No. KC018N-ND or equivalent)
- R5—1,000-ohm, linear-taper trimmer potentiometer

Fig. 3. Thermistor R4 in Wheatstone bridge monitors the power supply voltage regulator's thermal condition and lights LED1 when the regulator becomes too hot and goes into thermal shutdown.



NOTES:

1. Calculate value for 10mA LED current.
2. R4 and IC1 must be in close thermal contact.

PARTS LIST

Semiconductors

- D1—1N4148 or similar silicon diode (optional—see text and Fig. 1)
- LED1 thru LED3—Miniature light-emitting diodes (mix colors for easy identification)
- IC1—LM393 dual voltage comparator
- IC2—LM334Z adjustable current source
- Q1—2N4403 or other general-purpose pnp transistor

Capacitors

- C1—0.22-µF, 50-volt ceramic disc

Resistors (¼-watt, 5% tolerance)

- R1, R2—10,000 ohms
- R3—1,000 ohms
- R4—10,000-ohm NTC at 25° C thermistor (Digi-Key Cat. No. KC018N-ND or equivalent)
- R6, R10—Calculate value for 10-mA LED current
- R7—1.5 megohms
- R8—100 ohms
- R11—0.68 ohms, 2 watts
- R5—1,000-ohm, linear-taper trimmer potentiometer

- R9—100-ohm, linear-taper trimmer potentiometer

Miscellaneous

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware (see text); DIP socket for IC1; panel clips for LEDs; epoxy cement; machine hardware; hookup wire; solder; etc.

Note: The LM78XX voltage regulator shown in the schematic is part of the power supply in which the circuit is installed.

Fig. 4. All-in-one monitoring circuit includes all previous circuits.

it is easy to pay less than adequate attention to overcurrent conditions. An overcurrent condition, at the very least, can result in loss of voltage regulation and, at worst, can damage the power supply's voltage regulator.

A simple circuit that monitors a power supply for an overcurrent condition is shown schematically in Fig. 2. The current is monitored via resistor R1, which feeds the potential at the input of the LM78XX regulator to potentiometer R3 and on to the base of transistor Q1. Whenever the voltage developed across R3's wiper is greater than the base-emitter voltage threshold, LED1 lights.

To determine the amount of cur-

rent for which the circuit must be adjusted, refer to the peak output current graph in the data sheet for the current regulator you are using in the power supply. You will see that the rated output current of the regulator is a function of both the input-to-output voltage differential and junction temperature. For the LM78XX series of regulators, maximum current I_{max} is 2.5 amperes at a junction temperature of 0 degree Celsius and a differential of not more than 10 volts. At a junction temperature of 125 degrees Celsius and a differential of more than 27 volts, I_{max} can drop not less than 0.5 ampere! Therefore it is recommended that you calculate

maximum raw input voltage with a high line and full load.

Assume that the junction temperature will be about 125 degrees Celsius, which is valid because maximum voltage differential and output current will cause the regulator to run hot. Now read the output current from the graph. Because this is typical regulator behavior, you should examine the appropriate data sheet for the specific voltage regulator you are using. Adjust R3 in the Fig. 2 circuit so that LED1 lights at this particular current.

As with the Fig. 1 circuit, the one shown in Fig. 2 can be used with a negative voltage regulator. In this

case use an npn transistor for *Q1* as well as reversing all polarities.

Overtemperature

Let's assume you've just powered up your project after having repaired a short circuit but that it still doesn't work. It's possible that something has burnt up as a result of the short circuit. It's equally likely that the voltage regulator in the power supply, after suffering a short circuit and the excessive current it had to pass to the circuit as a result, hasn't had time to recover from thermal shutdown.

With the help of a thermistor, an IC comparator and a few passive components, you can build a temperature sensor that turns on a LED when a voltage regulator overheats and goes into thermal shutdown. Such a circuit is shown schematically in Fig. 3. This arrangement requires that the thermistor be placed in close physical (thermal) contact with the case of the regulator, epoxied to the regulator's case.

In Fig. 3, thermistor *R4* and resistors *R1*, *R2* and *R3* make up a Wheatstone bridge that is unbalanced by the change in resistance of the thermistor. Use of a Wheatstone bridge arrangement permits the circuit to be fed from an unregulated supply with no loss in accuracy, since it is the unbalance condition—rather than an absolute voltage level—that is used for sensing.

Whenever the voltage at the LM393 comparator's noninverting (+) input swings to a level that is lower than at the inverting (-) input, the output of the comparator swings low and sinks current. When this occurs, *LED1* lights. The resistor values specified in Fig. 3 are for the particular thermistor specified.

The thermistor specified changes resistance value by about 10 percent between 25 and 100 degrees Celsius. If you use a different thermistor, experiment with different resistance values to obtain the required results from the Wheatstone bridge.

If you refer to a data book, you will notice that the LM393 is one of two comparators in a single DIP IC package. If you are using this circuit to monitor temperatures in a power supply that has positive and negative regulators, use the other comparator for the negative regulator, repeating all other parts of the Fig. 3 circuit for the second monitor circuit.

All-in-One Monitor

All circuits thus far described can be combined into a single all-purpose circuit, as shown in Fig. 4. As you can see, this is simply a repeat of the Figs. 1 through 3 circuits. A complete Parts List accompanies Fig. 4, so that

you can build this composite circuit.

These circuits require very little additional room in a power supply, whether you are designing it from scratch or adding them to an existing power supply in a project. Build them on perforated board that has holes on 0.1-inch centers, using suitable Wire Wrap or soldering hardware. Alternatively, you can design and fabricate a printed-circuit board. In either case, use a socket for *IC1*.

Mount the light-emitting diodes in any convenient locations, such as on the project's front panel or inside the project's enclosure, where they will be ready for instant view when the cover is removed. **ME**

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Automobile Headlights Monitor

Latches off auto-on headlights until the vehicle's engine catches for easier cold-weather starts

By Harold Wright

More and more cars on our highways are being operated with their headlights on during daylight hours. This makes vehicles more conspicuous, sharply reducing the risk of collisions. In other countries, having headlights on during daylight hours has become a mandatory requirement. In Finland, for example, the collision rate dropped by 27 percent as a result of having headlights on in the daytime. Canada currently has legislation in preparation to require all imported vehicles to be wired so that headlights come on as soon as the ignition is turned on, and the U.S. has the subject under study (Federal Register, Vol. 52, #6, March 27, 1987) with possible legislation in the future.

For all its advantages, having headlights come on automatically upon start-up is not without its problems. Where temperatures drop to well below the freezing point, a very heavy drain is placed on the vehicle's battery, as much as 300 to 400 amperes. The additional drain on the battery during cranking makes an already "hard" start even harder. Under very-low-temperature starting with these conditions, the engine should be cranked for brief periods with the minimum possible load, followed by a brief rest for both the battery and starter motor. For maximum cranking efficiency, the *only*

load that should be placed on the battery is the starter motor.

Our retrofit Automobile Headlights Monitor is the solution to this problem. It disables the headlights when the ignition key is set to "crank" until the engine starts and is running on alternator power, at which point it automatically turns on the headlights. The lights remain off during any unsuccessful cranking attempts. This project may not solve all cold-weather hard starts, but it does not exacerbate the problem, either.

About the Circuit

Shown in Fig. 1 is the complete schematic diagram of the Automobile Headlights Monitor. This circuit uses a pair of comparators (two of the four contained inside *IC1*) to sense voltage variations during cold-weather starting and to latch the headlights off until the engine has caught and is running on its own. As soon as the engine's alternator takes over from the battery to supply electrical power to the vehicle, 13.5 volts will appear in the electrical system.

When the ignition is turned on, relay *K1* closes. Relay *K2*, on the other hand, is normally passive, with its contacts closed. The heavy-duty contacts of *K1* and *K2* are in series with the battery supply voltage to the floor switch for the headlights.

Quad comparator *IC1* serves as the sensor circuit. A stable voltage for which the comparators inside

IC1 is supplied by 2.5-volt reference chip *IC2*. Because only two comparators inside *IC1* are used in this circuit, all unused *IC1* pins must be connected to circuit ground as shown to obviate unstable operation.

When cranking begins in the vehicle in which the project is installed, *IC1B* senses the sharp drop in battery voltage and its output at pin 2 goes high. This turns on *Q2* and, in turn, energizes *K2*. When this occurs, the circuit from the vehicle's battery to its headlights is interrupted and the latter is thus held in the off condition. The extra pair of contacts on *K2* latch this relay in the "off" position by means of the diode-OR circuit made up of *D4* and *D5*.

To make *IC1B* sense a dropping voltage, the 2.5-volt reference from *IC2* is tied directly to the noninverting (+) input at pin 5 of *IC1B*, while the voltage to be sensed goes to the inverting (-) input at pin 4 of *IC1B*. This latched condition now remains static until the vehicle's engine starts.

When the engine does start, the voltage at the battery rises to between 13 and 15 volts (13.5 volts average). Now *IC1A* senses the higher voltage and output pin 1 goes high. This turns on *Q1* and, in turn, causes the normally-closed contacts of reed relay *K3* to spring open. When this occurs, *K2* deenergizes and restores the electrical path from the electrical system to the headlights. The system will now remain in this state until the vehicle's engine is switched off.

PARTS LIST

Semiconductors

D1, D2, D3—1N4004 rectifier diode

D4, D5—1N4001 rectifier diode

IC1—LM339 quad comparator

IC2—LM336Z 2.6-volt reference

Q1, Q4—2N2222 general-purpose

npn transistor

Capacitors (200 WV)

C1, C2—0.33- μ F

Resistors ($\frac{1}{4}$ -watt, 10% tolerance)

R2, R4—10,000 ohms

R5—5,600 ohms

R6, R8—3,300 ohms

R7, R9, R11—6,800 ohms

R1, R3—50,000-ohm pc-type multi-turn trimmer potentiometer (Bourns No. 3006P-1-503 or equivalent)

R10—10,000-ohm pc-type trimmer potentiometer (Bourns No. 3299W-1-103 or similar)

Miscellaneous

F1—1.0-ampere fuse

F2—10-ampere fuse

K1, K2—Power relay (see text)

K3—Miniature reed relay (Radio Shack Cat. No. 275-241)

S1—Spst toggle switch

VR1—GE-MOV-33MA1A varistor (General Electric)

Printed-circuit board or perforated board and suitable Wire Wrap or soldering hardware; best-quality 14-pin DIP socket for IC1; suitable enclosure (Radio Shack Cat. No. 220-274 or similar); bayonet-type fuse holder for F1; fuse block for F2; four-position barrier block with through-wall solder lugs; small clip-on heat sinks for transistors; ring and spade lugs (see text); $\frac{1}{2}$ " spacers; heavy-duty stranded wire; machine hardware; solder; etc.

Switch *S1* provides a means for disabling the circuit by removing power from the sensing circuit. It is included here just in case a malfunction should occur in the circuit that would cause the circuit to the headlights through *K2*'s contacts to remain continuously open. Opening *S1* in no way will affect the on/off function of *K1*. The system will then op-

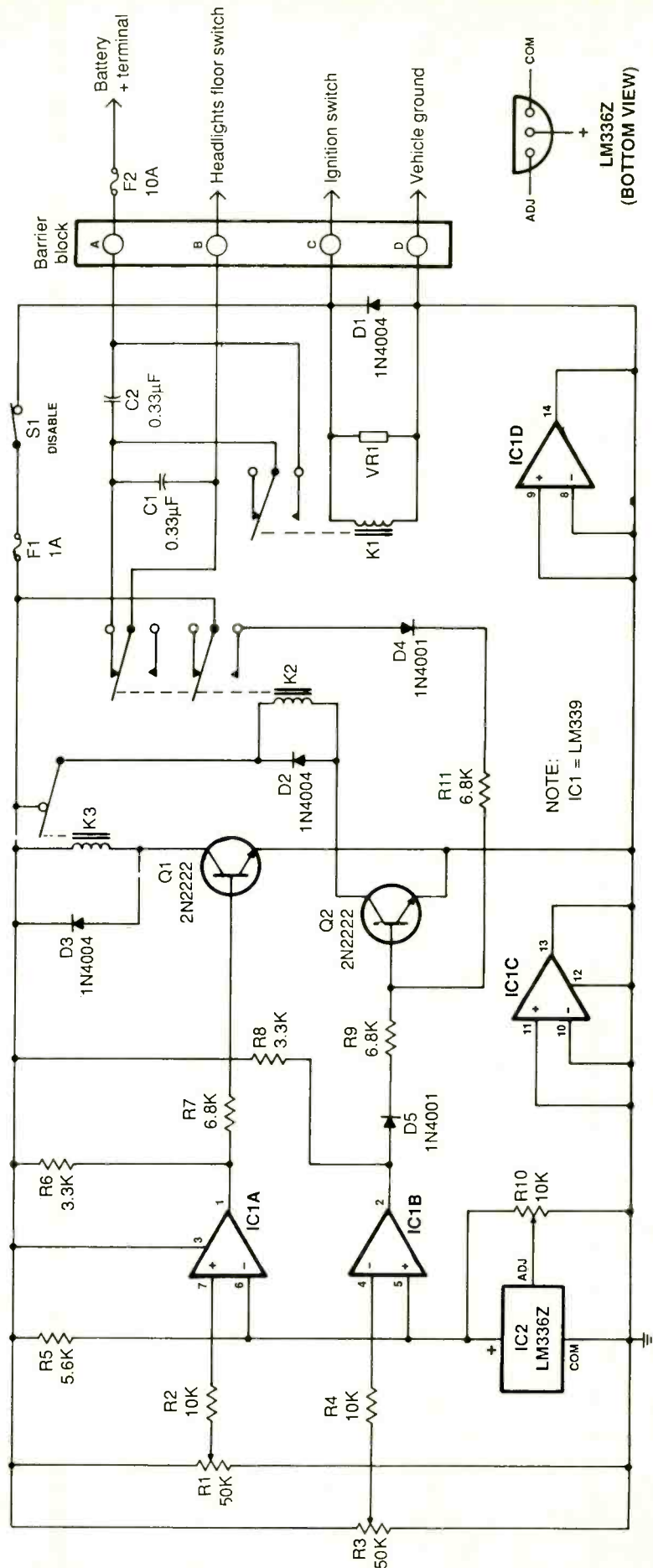


Fig. 1. Schematic diagram of Automobile Headlights Monitor circuit.

erate as required by safety practices and government regulations.

Motor vehicles are notorious producers of voltage transients that can reach 140 volts and more in either polarity. Therefore, the Automobile Headlights Monitor circuit is protected against damage due to transients by varistor *VR1* that is wired directly across the V+ and ground buses of the circuit.

Construction

Since this is a dc-only circuit, there is nothing critical about component layout. Therefore, construction of the project presents no difficulties. You can use perforated board with holes on 0.1-inch centers and suitable Wire Wrap or soldering hardware to mount and wire together the components that make up this project or home-fabricate a printed circuit board. If you elect the latter, use the actual-size etching-and-drilling guide shown in Fig. 2.

When the board is ready to be populated, use the wiring guide shown in Fig. 3 to install and solder into place the components exactly as shown. (Note: If you use perforated board, use Fig. 3, which is based on 0.1-inch increments, as a layout guide for the circuitry.) Start with a socket for *IC1*. This socket is optional but is recommended to simplify replacement of the IC should this ever become necessary. Do not install the IC in its socket until after the circuit-board assembly is fully wired.

Now install and solder into place the resistors, varistor *VR1* and diodes, observing polarity for the last before soldering any of their leads to the copper pads on the bottom of the board. Next, install and solder into place multi-turn trimmer resistors *R1* and *R3*, trimmer controls *R10* and *IC2*. Again, observe orientation of *IC2* (see Fig. 1 for pinouts) before soldering any of its leads to the copper pads on the bottom of the board. Then install reed relay *K3* in the specified location.

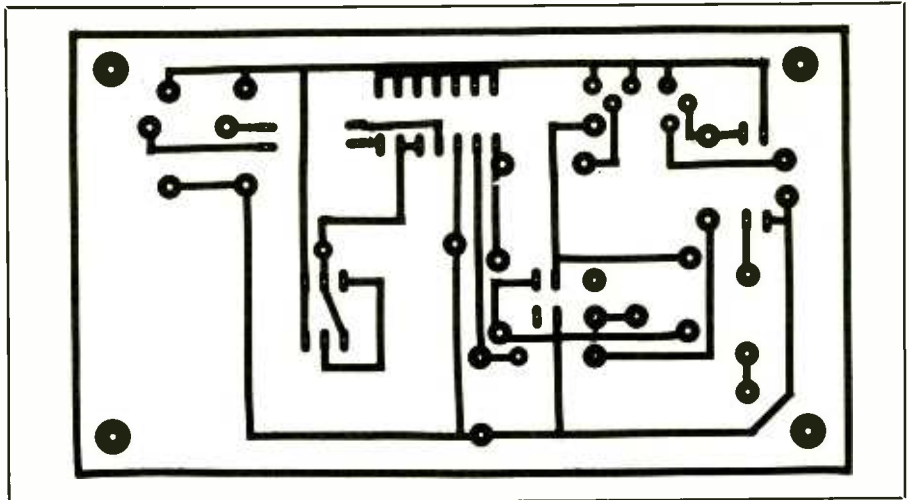


Fig. 2. Use this actual-size etching-and-drilling guide for fabricating a printed-circuit board for the project.

Plug heavy-duty staking pins into the holes labeled SP1 through SP5 and solder them into place. To these pins will be crimped and soldered the heavy wires that interconnect the circuit-board assembly and off-the-board relays and connection to the vehicle's electrical system.

The relays selected for *K1* and *K2* must have contacts rated at not less than 10 amperes for ordinary incan-

descent headlights, greater current if your vehicle has halogen lights that draw even more current. If possible, measure the current drain with the headlights on and make your selection of these relays accordingly. To be on the safe side, add 20 percent or so to the measured current.

The size of the enclosure used for the project will be dictated by the size of the printed-circuit-board assembly,

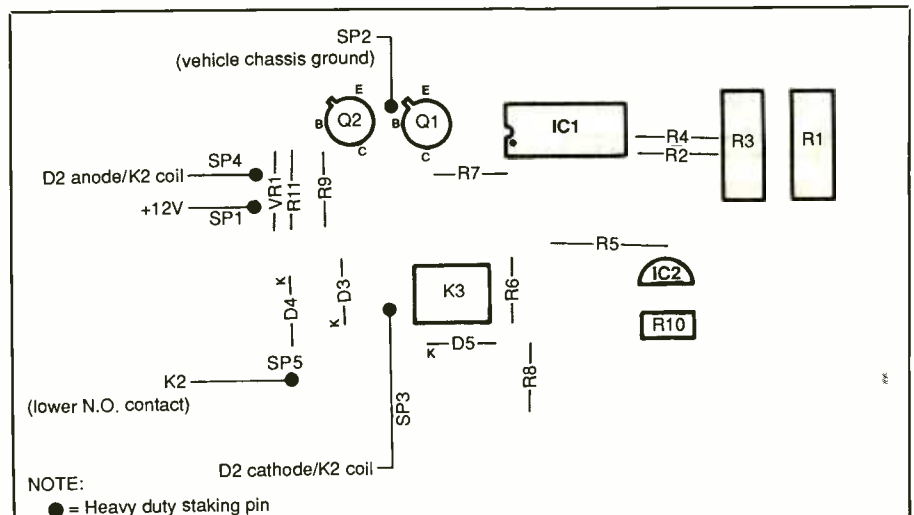


Fig. 3. Wiring diagram for pc board. Use this diagram as a guide to component placement if you use perforated-board construction.

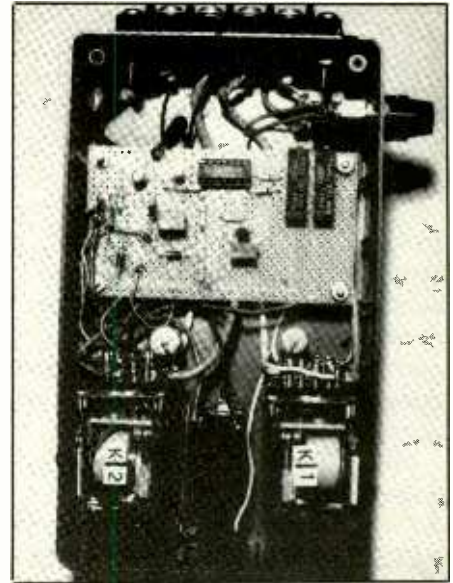
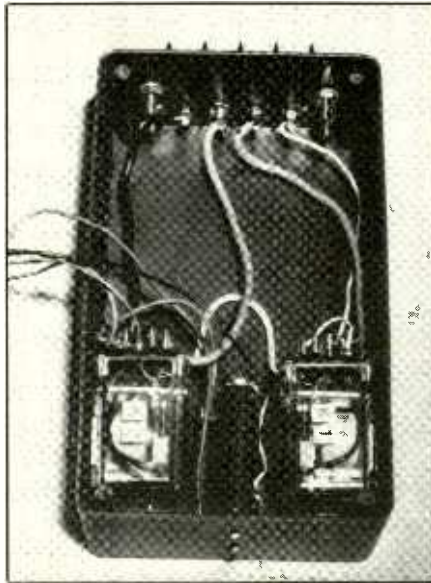
relays used for *K1* and *K2*, switch, barrier block and fuse holder mounting. The Radio Shack project box specified in the Parts List is ideal for this application when using the relays shown in Fig. 4.

Depending on the physical dimensions of the relays chosen for *K1* and *K2*, it is a good idea to test-fit them, the bayonet-type fuse holder for *F1* and the circuit-board assembly in the enclosure to make sure everything fits okay and that no component interferes with any of the others. While you are at it, mark the hole locations for the mounting hardware for the circuit-board assembly on the floor of the enclosure.

Remove all components from the enclosure and set them aside. Drill the mounting holes for the circuit-board assembly. Then temporarily mount the assembly in place using ½-inch spacers and suitable machine hardware. Now determine where to mount the DISABLE switch and fuse holder for *F1* and mark the centers of both locations. (A good location for the fuse holder is between *K1* and *K2*, as shown in the photos.)

Remove the circuit-board assembly and set it aside. Then drill the mounting holes for the switch and fuse holder. Now mark and drill the mounting and lug feed-through holes for the barrier block through the wall of the enclosure opposite that on which the fuse holder is to be mounted. The four feed-through holes should be about ¼ inch above the inside surface of the floor of the box. Also, drill three ¼-inch holes through the floor of the enclosure in locations that will be accessible by screwdriver when all components are in place. Mount the barrier block in place.

Use only heavy-duty *stranded* hookup wire, no smaller than 12 gauge and preferably 10 gauge, in this project, especially for the wiring to the off-the-board relays and barrier block. Whenever you prepare a wire for installation, strip from both ends



*Fig. 4. Interior views of project with only *K1*, *K2*, fuse holder for *F1* and the barrier block mounted in place (left) and just prior to final assembly (right). Note in right photo that *S1* mounts on one side wall of the enclosure.*

of it ¼ inch of insulation, tightly twist together the fine conductors at both ends and sparingly tin with solder.

You will note in Fig. 3 that there are no locations on the pc board for installing diodes *D1* and *D2* and capacitors *C1* and *C2*. This is because these components mount directly to the coil and contact lugs of *K1* and *K2*, as shown in Fig. 1. After wiring these components to the appropriate lugs on the relays, crimp and solder suitable lengths of heavy-duty wire to the fixed lower (normally open) contact lug of *K1* to which one lead of *K2* is connected, the upper movable contact of *K2* to which one lead of *K1* is connected, and separately to the coil lugs of *K1* and *K2*. Note that there should be two wires connected to the lugs to which the cathode and anode of *D1* are connected.

Label the two relays according to how you wired them and label the wires coming from the coils to which the anodes of the diodes are connected with a “+” sign. Then identify and label the wires connected to *K1* as follows: coil lug to which the

cathode of *D1* is connected with the legends C and S1; coil lug to which the anode of *D1* is connected with the legends D and SP2; lower fixed contact lug with the legend A. Similarly, identify and label the wires connected to *K2* as follows: coil lug to which the cathode of *D2* is connected with the legend SP3; coil lug to which the anode of *D2* is connected with the legend SP4; and upper movable-contact lug with the legend B. Then solder wires to *K2*'s upper movable-contact and lower normally-open contact lugs and identify them with labels with the legends SP1/*F1* and SP5/*D4* ANODE, respectively.

Mount *F1*'s fuse holder in its hole. Then use thin double-sided foam tape on two case surfaces in each case to mount *K1* and *K2* to either side of the fuse holder. Label the positions of the barrier block with the legends A through D. Then route the wires labeled A through D from the relays along the floor of the enclosure and crimp and solder them to the same labeled position lugs on the barrier block.

Crimp the free end of the wire coming from *K2* labeled D4 ANODE onto staking pin SP5 on the circuit-board assembly and solder the connection. Remount the circuit-board assembly with the same spacers and hardware you used before. Be sure to use lockwashers here and anywhere else machine hardware is used to prevent the hardware from coming loose as a result of vibrations in your vehicle.

With the board mounted in place, crimp and solder the free ends of the *K1* wires to the staking posts on the board with the same legends on the wires. Mount the switch in its hole. Route the wire from *K1* labeled S1 and crimp and solder it to one lug on the switch. Connect and solder a heavy duty wire from staking pin SP1 to one lug on the fuse holder. Then do the same from staking pin SP2 to the lug for position D on the barrier block. Route the *K1* wire labeled SP2 to staking pin SP2 on the circuit board, crimp it into place and solder the connection. Then connect and solder a wire between the remaining lugs on the switch and fuse holder.

Place a 1-ampere fuse in the bayonet fuse holder. If you have not already done so, plug *IC1* into its socket. Make sure that the IC is properly oriented and that no pins overhang the socket or fold under between IC and socket as you push it home. Then clip small heat sinks onto the cases of the transistors.

Calibration

Temporarily dismount the circuit-board assembly. Then make a small test rig from a set of red- and black-insulated test-clip leads. Connect these to a series-connected light-emitting diode and 1,000-ohm resistor.

Connect a variable dc voltage power supply capable of delivering 15 volts or so to staking pins SP1 and SP2 on the circuit-board assembly (observe polarity!). Adjust the supply for an output of 11.5 volts. Then

connect a DMM, set to indicate at least 15 volts dc, between SP2 and the center lead of *IC2* or the *R5* lead connected to it. Adjust the setting of trimmer *R10* until the meter indicates exactly 2.50 volts.

Next, connect the meter between SP2 and the junction between *R4* and wiper of *R3* and adjust the setting of trimmer *R1* for a reading of exactly 2.45 volts.

Connect the previously prepared LED tester between SP1 (anode end of tester) and SP4. The LED should light. If it does not, try reversing the tester connections.

Readjust the setting of the bench supply for an output of 13.5 volts. Connect the meter from the junction of *R2* and wiper of *R1* to SP2 and adjust the setting of *R3* until you obtain a reading of 2.55 volts.

Connect the LED tester between SP2 and SP3. The LED should be off and should remain off even if you reverse the tester's connections. Readjust the power supply back to a 11.5-volt output. The LED should light, indicating that the *IC1A/Q1* circuit is working. If the LED does not light, try reversing the connections of the LED tester.

If you fail to obtain any of the above results, power down the project and perform a point-by-point check of all component installations, wiring and soldering. Start by looking for poorly soldered connections, pins and lugs that have not been soldered, incorrect orientation of ICs, transistors and diodes. If you find a suspicious connection, reflow the solder to correct it. Similarly, remove any components that are installed in the wrong locations or orientations and replace them properly.

You can use the LED tester to simulate headlights to make a relay-operation check. Set the bench supply for an output of 12.6 volts and then connect its common (ground) line to contact D and leave the other positive end lying loose. Connect the power

supply's positive lead to barrier block position A. Then connect the LED tester's anode lead to position B and its cathode lead to position D.

Touching the loose positive lead of the power supply to position C on the barrier block should cause *K1* to energize with an audible click and the LED should light. Breaking this last connection should cause the LED to extinguish. Now solidly reconnect this positive power-supply line to position C and note that the LED lights once again.

Simulate a cranking condition by lowering the power supply's output to 11.0 volts. Relay *K2* should now energize, again with an audible click, and the tester's LED should extinguish. When you simulate the cranking rest period by raising the supply's output to 12.6 volts, the LED should remain off.

Now simulate an engine-start condition by raising the supply's output to 14.00 volts. At this point, *K3* should energize and break the latch to allow *K2* to deenergize and the LED should turn on once again.

When everything appears to be operating as it should, wrap masking tape over the staking posts and connections to them. Then use an appropriate solvent to clean away all solder flux on the bottom side of the circuit-board assembly. Then spray the entire assembly, top and bottom, with urethane to protect it from the harsh vehicular environment.

Remount the circuit-board assembly in the enclosure. Then prepare a table that identifies the points in your vehicle to which the various contacts of the barrier block are to connect. Cement this table to the top of the enclosure and spray it with two or more coats of clear acrylic.

Installation

Keep in mind that there is usually a lot of vibration in an automotive environment. Therefore, it is advisable to shock-mount the project on a fen-

der wall, where it will be as close as possible to the firewall. Mounting of the project is via the three holes you drilled in the floor of its enclosure. Use long self-tapping sheet-metal screws for the mounting operation.

For shock mounts, you also need two rubber grommets and a large flat washer for each mounting screw. To begin installation, place the open project in the mounting location and use a pencil to draw the outlines of the mounting holes on the fender wall. Remove and set aside the project and then drill small pilot holes in each marked location.

Place a large flat washer on each sheet metal screw and follow up in all three cases with a small rubber grommet. Plug the ends of the screws into the holes in the enclosure's floor and follow up with a rubber grommet on each. These last grommets should be selected for a tight but not excessively so fit on the screw ends. Tighten the screws in the washers to slightly compress both grommets in all three cases. Then set the project in place on the fender wall with the screw ends engaging the pilot holes. Drive all three screws into the fender wall, making them tight enough to only slightly compress the grommets.

Once the project is mounted in place, attach its cover plate with the screws provided with the project box. Now make the connections from the barrier block to the various points in your vehicle's electrical system, using 10-gauge insulated stranded wire for all connections.

Run a black-insulated wire from barrier block position D along the fender wall to the bolt where the negative cable from the battery is attached to the engine block. Crimp and solder a large ring-type terminal to the end of this wire and attach it to the bolt on the battery cable connector. Make sure everything at the bolt is clean. (Note: Terminate all wires at the project end in medium-size spade lugs. After crimping them to the wire

ends, solder the connections.)

Most headlights high/low floor switches are removable to permit easy access to their terminals. Once you remove the switch, use a dc voltmeter to identify the "hot" terminal on the switch and disconnect the wire attached to it. Tape the end well to thoroughly insulate it. Attach a new wire with the same type of terminal on it as is on the wire just removed to the vacated lug. Route this to the project and connect it to position B on the barrier block.

Terminate another length of wire in a large ring-type terminal and bolt this to the battery's positive cable connector. Many late-model cars have an arrangement where several smaller heavy wires are permanently molded into the cable clamp connector. If this is the case in your vehicle, carefully slice about $\frac{3}{8}$ inch of insulation from one of the larger of these wires down to bare copper. Make sure you do not cut into any of the exposed conductors as you do this. Now strip 1 inch of insulation from one end of the wire you are installing and firmly wrap its conductors around the exposed cable wire. Solder the connection and thoroughly insulate it.

Drill a hole for and use a self-tapping screw to mount a fuse block on the fender wall near where the project is installed. Route the wire you just attached to the battery's positive connector to the fuse block and connect and solder the free end to one lug, leaving about 4 inches of slack. Cut to length another wire to bridge between the other lug on the fuse block and position A on the barrier block. Terminate one end in a medium-size spade lug and connect and solder the other end to the other lug on the fuse block. Plug a 10-ampere (or greater, depending on the normal current drain of your headlights) fuse in the block.

If you do not know or are not sure of which points in your vehicle's

electrical system to use, consult your auto mechanic. Bear in mind that the project must not affect anything but your vehicle's headlights.

Vehicle electrical systems vary widely among various makes and models, as do battery conditions and capacities, alternators and regulators. Before you calibrate your Automobile Headlights Monitor, it is best that you make some measurements on the vehicle in which you plan to install it. An analog meter is the best choice for these measurements.

Measure a cold battery that has not been used for eight or more hours. It should measure between 12.6 and 12.9 volts. Once you have this measurement, start your vehicle's engine and observe the meter reading during the first couple or so seconds of cranking. The reading can drop as low as 8 or 9 volts on a freezing morning. Remember that the starter motor may be drawing as much as 400 amperes of current at this time on a cold day. Note the sharp rise in measured voltage when the engine starts and is operating on the alternator. The measured potential can climb as high as 15 volts or more.

If there are wide variations from normal, this could be an indication that something is wrong with your vehicle. In this case, it might be a good idea to consult your mechanic to correct an incipient problem. If variations are not very wide but are different from the norm and there is nothing wrong with your vehicle, you may have to make minor adjustments in the settings of trimmer controls *R1* and *R3*.

When you are finished with installation, dress all wire runs neatly against the walls in your vehicle's engine compartment. Use whatever cable ties or hold-downs already exist to keep them in place.

Now you're all set to further reduce the risk of automotive collisions while enhancing the ability to start your engine during cold weather.

ME

Monolithic Accelerometers & the Domestic DRAM Situation

By Harry L. Helms

Sensors are devices that measure or monitor an environment and produce an electrical output or signal of some sort in response to the environment and changes in it. Most sensors have previously been electromechanical devices that combine a mechanical or "quasi-mechanical" element (such as a piezoelectric crystal) with an electronic circuit to "process" and amplify action of the mechanical element caused by environmental factors. For years, the only commonly used solid-state sensors have been solar cells and photoresistors, which produce an electric voltage or change in resistance in response to light falling upon the device. However, today there are an increasing number of sensors that are monolithic semiconductor devices. Three good examples are SenSym's recently introduced SXL series of accelerometers.

The term "accelerometer" sounds like the name of a device to measure speed; indeed, that is one possible application for such devices. However, they actually work by measuring vibrations in their immediate environment, regardless of what caused such vibrations. This means devices such as the SXL series can be used in a variety of applications other than speed measurement. Two applications that come to mind are vibration detectors for security systems and seismometers.

The performance of an accelerometer is measured in *g-force* units, commonly known as a *g*. The *g* is a unit referred to the force of the Earth's gravity. The force we normally feel is equal to 1 *g*. When something moves against the force of gravity, an increasing number of *g*'s is felt as gravity attempts to restrain the move against it. A familiar example to most of us is being pressed back into our seats during an airplane takeoff or on a downward run on a roller coaster. Astronauts at lift-off are also subject to several *g*'s as their rocket climbs against the pull of gravity.

The SXL series consists of three accelerometers, each measuring a different *g*

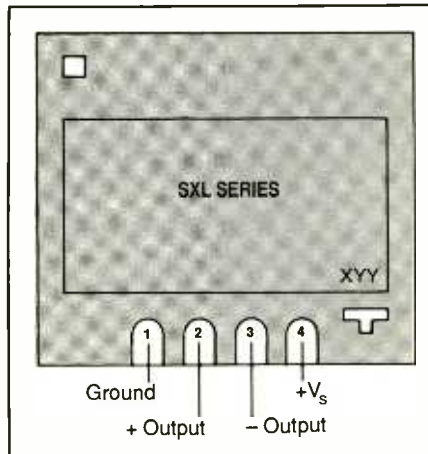


Fig. 1. Package configuration and pin-outs for all three of SenSym's SXL series accelerometers.

range. The SXL020G can measure up to ± 20 g, the SXL050G measures ± 50 g, and the SXL200G can measure ± 200 g. Of course, there's no such thing (at least as far as we know now!) as "negative gravity"; the "-" portion of the specification refers to a decrease in *g* forces being measured.

Figure 1 shows the pin connections for all three SXL accelerometers. The basic configuration is a 4-pin ceramic single in-line package (SIP) designed for pc-board mounting. The internal circuitry of all three devices uses a Wheatstone bridge circuit similar to the one shown in Fig. 2.

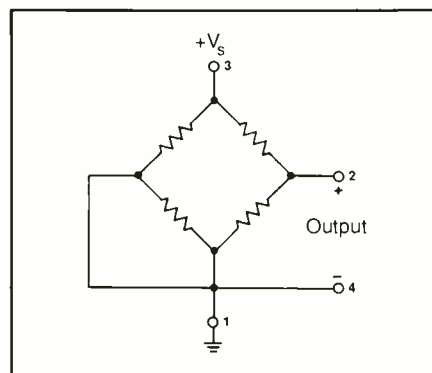


Fig. 2. Internal circuitry for all three SXL series accelerometers.

Instead of actual resistors, though, piezoresistive elements are used. These elements change their resistance in accordance to stress in vibration placed upon them. Changes in the resistance of the elements produce changes in the voltage present at the two outputs. Output is typically 20 mV/V, and the supply potential for all three devices can range from 3 to 15 volts dc, although the accompanying specifications were measured at 5 volts.

Figure 3 shows a cross-section of an SXL series device. The key to each device is the active wafer that contains the piezoresistive elements. The Wheatstone bridge circuit is fabricated on the active wafer using conventional bipolar techniques. At the center of the active wafer is a large mass, known as the seismic mass, between two cavities. This mass acts as something of a "pendulum" when the sensor is subjected to movement or vibration. Movement of the seismic mass causes stresses in the active wafer that, in turn, affect the piezoelectric elements in the circuit's output.

The active wafer rests upon a constraint wafer that supports the active wafer and "dampens" effects of the vibrations for accurate indications. Some special versions of the SXL series have a cover wafer that provides extra ruggedness.

Currently, the SXL series is not cheap, with a single-unit price of \$57. However, this price should drop as production "ramps up" and competing units are introduced. A data sheet and technical report can be obtained by writing on your business letterhead to SenSym, 1255 Reamwood Ave., Sunnyvale, CA 94089.

Giving a DRAM

The U.S. electronics industry has been hobbled for most of 1988 by crucial shortages of dynamic RAM chips, particularly 256K types. The brutal price wars of 1985 drove all domestic manufacturers but Texas Instruments and Micron Technologies from the DRAM marketplace. By late 1987, the demand for DRAMs began to exceed the supply, particularly

SXL020G/050G/200G Specs.

Sensitivity (typical)	50 $\mu\text{V/V/g}$
Resonant Frequency (nominal)	5 kHz
Linearity (typical)	0.1%
Input/Output Impedance	4.5K ohms
Supply Voltage Range	+ 3 to + 15 Vdc

since U.S.-Japan agreements to limit semiconductor imports resulted in fewer DRAMs being shipped to the U.S. than would have otherwise been shipped. The output of 256K DRAMs was also curtailed as Japanese producers began to change over to 1M devices. The result was that DRAM prices tripled and even quadrupled in only a few months and some production lines had to be shut down because of DRAM shortages. (One computer board manufacturer continued production but stockpiled a warehouse full of boards *minus* all memory chips!)

Not surprisingly, several domestic semiconductor houses have begun efforts to re-enter the DRAM business. One that is making a big effort is Motorola, which is now making DRAMs at its facility in Mesa, AZ. Motorola will not be resuming production of 256K chips, however, but plans to begin production volumes of 1M

chips by the end of this year. Another company that may "leapfrog" to 1M DRAMs is SGS Thomson, which is currently giving serious consideration to manufacturing DRAMs at its Phoenix facility, according to president Dan Queyssac.

National Semiconductor is also exploring re-entry at the 1M level but is having second thoughts than some other semiconductor manufacturers. National took substantial losses in the DRAM marketplace back in 1985 and still remembers those days well.

Discussing whether or not to get back into the market, National president Charles Sporck observes, "It is difficult to make that decision because having lost hundreds of millions of dollars once in the business, I'd hate like hell to get back into a dumping situation again sometime and decide for a second time to get out. I'd have trouble explaining that to my stockholders."

Short Takes

LSI Computer Systems announced its LS7310-7313 series of ac power controller ICs. These are designed for use with ac universal and shaded-pole motors (such as those used in blenders, mixers, etc.) and have ten discrete power-level inputs/outputs. The LS7310 and LS7311 versions are designed for use with external

mechanical switches, while the LS7312 and LS7313 are designed for external "touch" controls. More details about all four are available from LSI Computer Systems Inc., 1235 Walt Whitman Rd., Melville, NY 11747. . . Gennum Corp. is a Canadian manufacturer of semiconductors. One of its more interesting offerings is the LD405, a pulse-width-modulation (PWM) power-supply controller IC that is capable of operation at frequencies in excess of 1 MHz. Its application note, "Using the LD405 as a 125 W Resonant Mode Power Supply," tells how to use the LD405 to build a power supply capable of providing 5 volts dc at 25 amperes from either a 110- or 220-volt ac line. Request it from Gennum Corp., P.O. Box 489, Station A, Burlington, Ontario, Canada, L7R 3Y3. **ME**

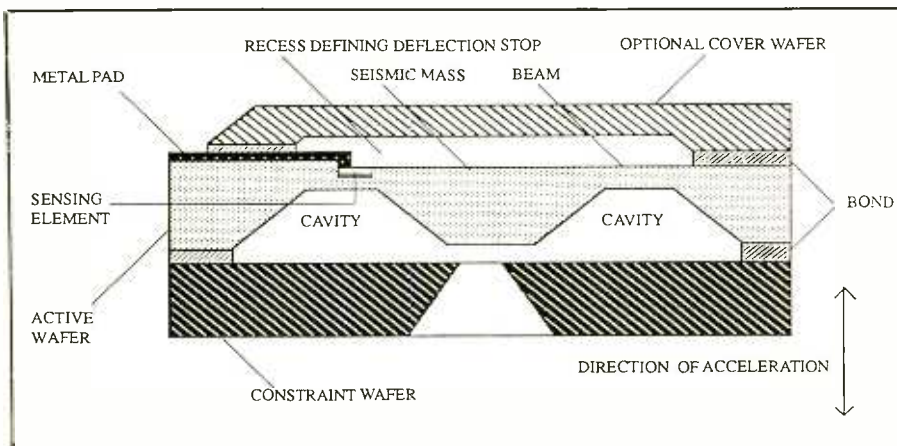


Fig. 3. Cross-sectional drawing of all three SXL series accelerometers.

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A Computerized Chart Recorder

By Forrest M. Mims III

The old adage that a picture is worth a thousand words should be the motto of everyone who is charged with collection and display of data. Just ask anyone who has tried to make sense out of endless columns of computer-tabulated numbers.

Consider for a moment the data depicted in Fig. 1. This figure shows a table of measurements of the optical output power of a semiconductor laser for a range of drive currents. It also shows a graph of the same measurements. While the numbers in the table require time to analyze, a quick glance at the graph provides a good understanding of the significance of the data, namely that the laser diode exhibits a sharp threshold point at the onset of laser oscillations.

Figure 1 was taken from one of my laboratory notebooks. The data was measured point by point and then plotted by hand. While data measurements can be plotted automatically with a strip chart or XY recorder, these devices are relatively expensive. A suitable alternative to owners and users of personal computers is a program that transforms a computer into a sophisticated chart recorder.

In 1987 my son, Eric Ryan Mims, needed a strip chart recorder to record the measurements from an ultra-sensitive seismometer he had constructed for a high school science-fair project. Since he couldn't afford a chart recorder, he wrote a program that transforms a Radio Shack Color Computer and an XY plotter into a basic chart recorder.

Recently, Eric developed an improved version of his strip chart recorder program for IBM-compatible PCs that are equipped with joystick ports. The program transforms one or two analog signals applied to a joystick port into a moving graph on the screen of a computer monitor. The graph that appears on the monitor's screen can be printed out on a dot-matrix printer.

This chart recorder has many practical applications beyond seismometry. For example, it can be used to record both the

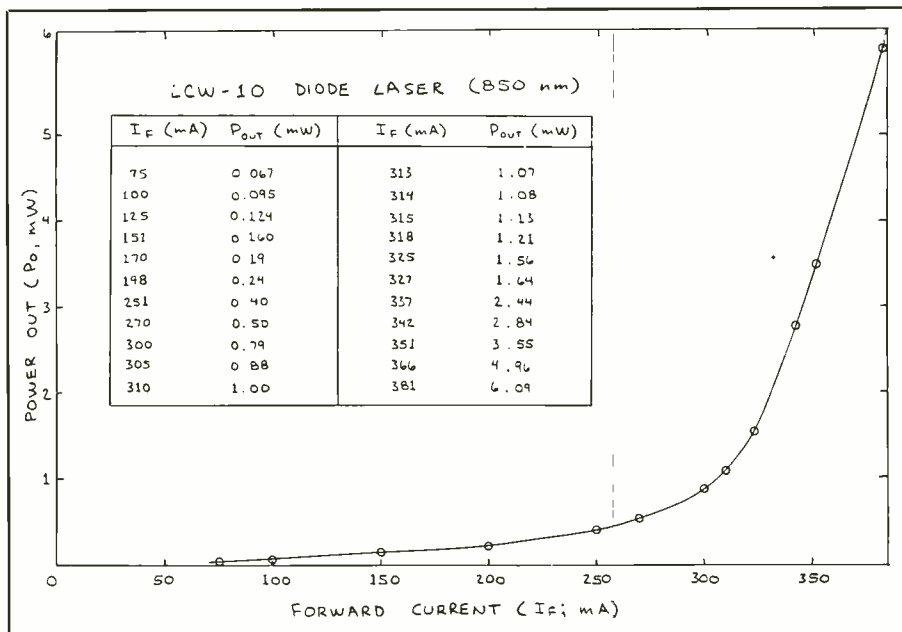


Fig. 1. A comparison of tabulated and graphical data.

temperature and light intensity inside a greenhouse. It can also keep track of the performance of solar heating systems and laboratory test equipment measurements and perform many other functions.

Using Joystick Ports as Analog Input Ports

Before looking at Eric's chart-recorder program, let's first examine the manner in which a computer's joystick port can be used as an analog input port. The BASIC listings that follow were developed on a Tandy 1000 series computer, an IBM PC-compatible machine. The programs should work on most joystick-port-equipped IBM and compatible machine. Other computers may require slight program modifications.

Some computers are equipped with non-analog joysticks, in which switches are closed when the joystick handle is moved. The listings that follow and Eric's chart recorder program will function with only those computers that are equipped with *analog* joysticks in which movement of the handle rotates the

shafts of a pair of interlinked potentiometers.

The BASIC command STICK(n) returns the coordinates of the joysticks in the Tandy 1000 computer. The (n) function designates which joystick and which coordinate are returned as follows:

STICK(0) returns the horizontal (x) coordinate for joystick A;

STICK(1) returns the vertical (y) coordinate for joystick B;

STICK(2) returns the horizontal (x) coordinate for joystick A;

STICK(3) returns the vertical (y) coordinate for joystick B.

Joystick A is usually, but not always, designated as the left joystick, while joystick B is usually designated the right joystick.

It is important that you understand that STICK(0) retrieves the values for all four values of n. Therefore, it is necessary to include a STICK(0) command in any program in which other joystick values are called. STICK(1), STICK(2) and STICK(3) retrieve the values already called by STICK(0); they do not themselves sample the joystick values.

The range of coordinate values returned by the Tandy Deluxe Joysticks used in conjunction with a Tandy 1000-type computer ranges from around 2 or 3 to around 130 or 131. The range depends on the joysticks, and some joysticks give higher ranges. The following simple BASIC routine will quickly show you the coordinate range for your system:

```

10 'STICKOUT
20 CLS
30 X = STICK(0)
40 Y = STICK(1)
50 LOCATE 15,15
60 PRINT "X="X;"Y="Y
70 GOTO 30

```

It is often desirable to modify a joystick's coordinate range. This can be easily done by simply inserting a correction factor into the above routine. For example, the following BASIC program converts the 2-to-131 range of a joystick to a more convenient 1-to-100 range and displays the result on the computer's video screen:

```

10 'MAX STICK (0-100)
20 CLS
30 X = STICK(0)
40 X = (X/131)*100
50 LOCATE 15.15

```

```

60 PRINT "STICK(0):"INT(X)
70 GOTO 30

```

Line 40 includes a correction factor that converts the retrieved value of STICK(0) from 2 to 131 to 1 to 100.

Connecting Sensors to Joystick Ports

Shown in Fig. 2(A) is the internal circuit diagram of the joysticks used with the Tandy 1000 computer. Note that these joysticks are simply two mechanically linked potentiometers. Each potentiometer is connected across a 5-volt dc supply provided by the computer. The center tap of each potentiometer then provides a potential that varies from nearly 0 to almost 5 volts as the potentiometer's shaft is rotated. In other words, each potentiometer in the joystick functions as a basic voltage divider.

Since the joysticks are resistive devices, it is a relatively simple matter to connect resistive-type sensors, such as thermistors and photoresistors, directly to the joystick inputs of a Tandy 1000 or similar computer. Before going further with this subject, however, it is important to insert the following warning:

Caution: Computer manufacturers

might not honor the warranties on equipment that has been modified or operated in a manner that is inconsistent with the equipment's instruction manual. Some manufacturers may interpret as a violation of a machine's warranty connection of non-standardized external devices.

With this caveat in mind, we can now go on to connect a resistive-type sensor directly to the input of the computer. Figure 2(B) shows the pin connections for the joystick sockets of the Tandy 1000. To connect an external sensor to the computer, it is necessary to make an appropriate cable and plug assembly. Radio Shack's Tandy 1000 series computers require a 6-pin DIN-type plug for each joystick port. This plug is available from Radio Shack as Cat. No. 274-020.

Caution: Use care when making and using a cable designed to be used with a joystick port. As shown in Fig. 2(B), the joystick port incorporates a 5-volt supply. Inadvertently shorting these power-supply leads may reset the computer or possibly even damage its internal circuitry.

After making the cable, you can connect a resistive-type sensor to the computer. Figure 3 shows how a cadmium-sulfide photoresistor, a typical resistive-type sensor, can be connected to the comput-

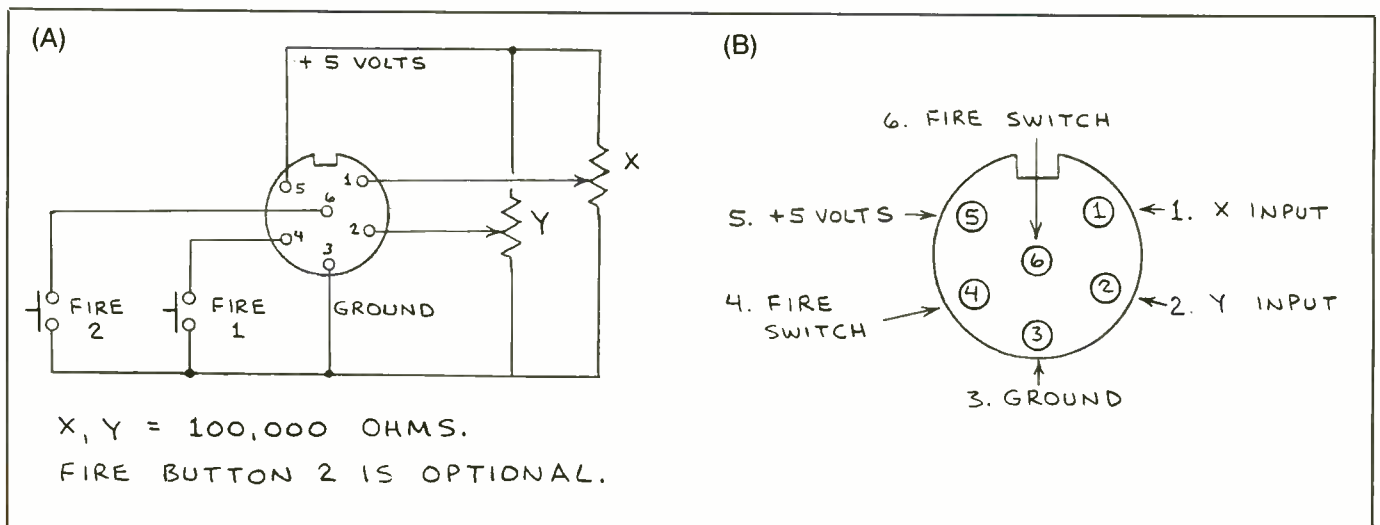


Fig. 2. Tandy 1000 joystick circuit (A) and socket connections viewed straight-on (B).

er. The combination of a photoresistor and $R1$, which can be either a fixed resistor or a potentiometer (the latter for calibration or zeroing purposes), provides the voltage divider required by the joystick port. The end result is a simplified computerized light meter.

Sometimes it is necessary to invert the signal (not the polarity) applied to the joystick port. This may be necessary when the voltage from a resistive sensor plus resistor increases when the stimulus decreases. The signal can be inverted simply by exchanging the positions of the resistive sensor and $R1$ in Fig. 3. Alternatively, the signal can be inverted in software. For example, this line can be added to the previous program to effect this result:

`45 X = 100-X`

Many kinds of non-resistive, self-generating sensors can also be connected to a computer's joystick ports. For example, a silicon solar cell can be connected directly between the ground and x inputs.

Finally, sensors that have low-level outputs can be connected to a computer through an appropriate amplifier. This is the approach my son used to implement his seismometer. For best results, use an operational amplifier. It is essential that the amplifier's output be limited to a 0-to-5-volt swing. *Never* power the amplifier from line current; instead, always use a battery power supply for it.

Chart-Recorder Program

The accompanying listing is a condensed version of the various chart-recorder programs Eric has written in GW-BASIC for Tandy 1000 and compatible computers. This program implements a two-channel chart recorder that includes a menu-selectable sample frequency, sample selection intervals, tick-mark spacing and user-selectable start time. A single trace or two traces appearing on the screen can be converted to hard copy with a dot-matrix printer.

A conventional analog chart recorder

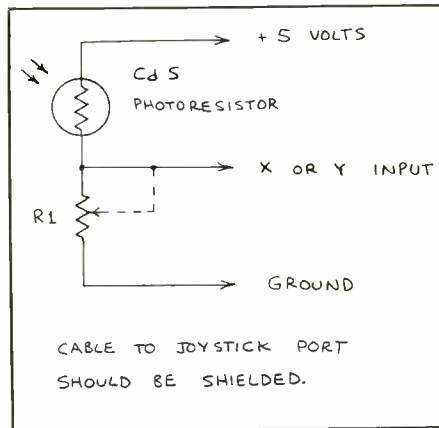


Fig. 3. Connecting a resistive sensor to a joystick port.

has controls for amplitude and chart speed. The program presented here does not include an amplitude control since Eric and I have found it much easier to control amplitude by means of the external sensor circuitry.

As for chart speed, this program operates somewhat differently than conventional chart recorders. The chart speed of

a conventional chart recorder is usually selected in terms of centimeters per second or minute. Paper passing through such a recorder is usually preprinted with a uniform grid that permits the readout to be measured.

Departing from tradition, this program doesn't display a complete grid to avoid excessive on-screen clutter. Instead, it displays two horizontal rows of parallel tick marks that are separated along the left side of the screen by a fixed vertical axis that represents amplitude.

Though this program is rather slow, this is not a major drawback because it was designed to monitor slowly changing signals. Since the program is so slow, it is better to vary the distance between the tick marks displayed on-screen than it is to vary the speed of the trace. In other words, this program provides a chart recorder with a grid that can be dimensionally varied along its x (horizontal) axis.

The paper—and, hence, the grid—of a conventional chart recorder moves as the trace is applied. In this program, the tick marks remain fixed as the trace moves from the left to the right side of the monitor's screen. In this respect, the program

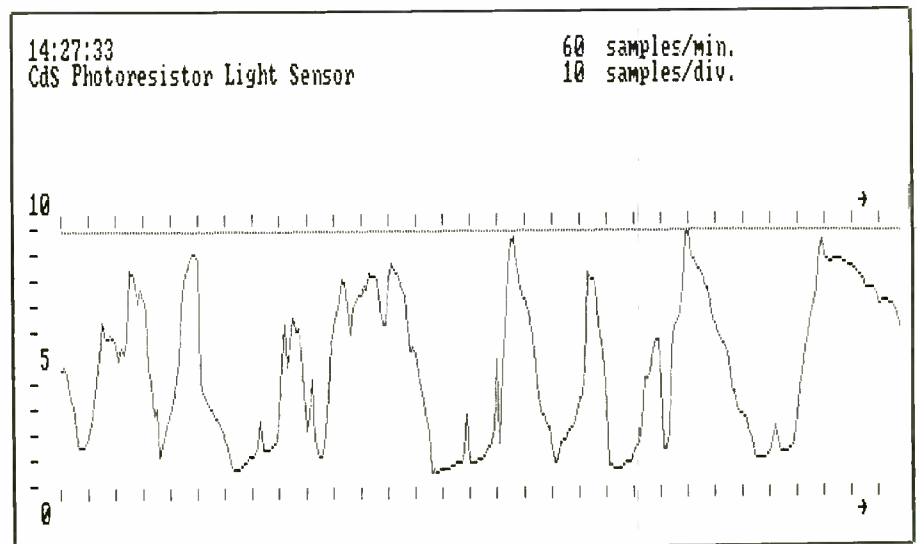


Fig. 4. Single-channel recording of light level at surface of a cadmium-sulfide photoresistor; unused channel is indicated by straight line across top of graph.

emulates a low-speed oscilloscope more than it does a chart recorder.

The number of samples per minute or hour can be selected with this program. In this mode, the tick marks displayed on the monitor's screen remain unchanged, and ten samples are plotted between each pair of tick marks no matter which sample frequency is selected.

Running the Program

After the program is entered and RUN, an on-screen prompt requests a name for the chart to be recorded. This name will later be displayed on the upper-left portion of the monitor's screen, below the time.

Next, another on-screen prompt asks that you specify the sample interval. If you select the maximum interval, the program will sample the incoming signal as fast as it can cycle through its sampling loop. A prompt will then request the number of seconds between the on-screen tick marks. The distance between tick marks will be automatically adjusted to match the selected time.

If the specific time option is selected, the program will ask if you wish to monitor samples per minute or per hour. After you make a selection, the program will ask how many samples per minute or hour you wish to monitor.

After selecting the sample interval, the program asks if you want the chart recorder to begin operation at a specific time. This is a particularly nice feature if you want the system to begin recording data during the night or while you are away. If you don't select this option, the chart recorder will begin to operate as soon as you press any key on the computer's keyboard. You can stop the recorder at any time by pressing the down-arrow key.

Everything displayed on the monitor's screen can be printed out by a dot-matrix printer by means of a suitable MS-DOS graphics screen-print command. Since the syntax of this command is determined by the type of printer connected to your computer, consult the MS-DOS manual

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BASIC Chart-Recorder Program Listing

```

10 SCREEN 0,1: CLS: KEY OFF
20 PRINT "DUAL CHANNEL CHART RECORDER"
30 PRINT "Copyright 1988 by Eric R. Mims"
40 'This program developed on Tandy 1000 SX.
50 'Minor revisions may be necessary for other computers.
60 KEY(14) ON
70 ON KEY(14) GOSUB 960
80 PRINT "Press any key to continue"
90 IF INKEY$="" THEN 90
100 CLS: LOCATE 1,33: PRINT"CHART RECORDER"
110 ' *****
120 ' *** Graph Type Option ***
130 ' *****
140 DIM AA(3122)
150 SPACE = 0
160 LOCATE 5,3: LINE INPUT"Name of chart: ";NS
170 ' *****
180 ' *** Sample Frequency ***
190 ' *****
200 LOCATE 5,3: PRINT"Sample Interval: ",
210 LOCATE 6,3: PRINT"Maximum (M) or Specific (S) time"
220 LOCATE 7,3: INPUT"(M or S)";CS
230 IF CS="M" OR CS="m" THEN 280 ELSE IF CS<>"S" AND CS<>"s"
THEN 210
240 GOTO 360
250 ' *****
260 ' *** Tick Mark Spacing Option ***
270 ' *****
280 CLS: LOCATE 1,33: PRINT"CHART RECORDER"
290 LOCATE 5,3: PRINT"How many seconds between tick marks?",
300 LOCATE 6,3: INPUT"(2, 5, 10, 15, 30)";SEC
310 IF SEC=2 THEN INCR=7 ELSE IF SEC=5 THEN INCR=16 ELSE IF
SEC=10 THEN INCR=34 ELSE IF SEC=15 THEN INCR=51 ELSE IF
SEC=30 THEN INCR=102 ELSE 290
320 GOTO 470
330 ' *****
340 ' *** Sample Interval Selection ***
350 ' *****
360 CLS: LOCATE 1,33: PRINT"CHART RECORDER"
370 LOCATE 5,3: INPUT"Do you want to monitor samples per
minute(M) or samples per hour(H)";AS
380 IF AS<>"M" AND AS<>"m" AND AS<>"H" AND AS<>"h" THEN 370
390 IF AS="M" OR AS="m" THEN MSS = "minute" ELSE MSS =
"hour": LOCATE 6,1: PRINT,,,
400 LOCATE 7,3: PRINT"How many samples per ";MSS;
410 INPUT" (60 maximum)";NUM
420 SPACE = CINT(60/NUM): INCR = 20
430 IF AS="H" THEN SPACE = SPACE * 60
440 ' *****
450 ' *** Specific Start Time ***
460 ' *****
470 CLS: LOCATE 2,3: PRINT"Current time = ";TIMES
480 LOCATE 4,3: PRINT "Do you want the chart to start at a
specific time?"
490 LOCATE 5,3: INPUT "(Y or N)";BS
500 IF BS="Y" OR BS="y" THEN GOSUB 930 ELSE IF BS="N" OR
BS="n" THEN 510 ELSE 490
510 CLS: LOCATE 2,3: PRINT"Press any key to begin sampling."
520 LOCATE 3,3: PRINT"Press HOLD to freeze display for screen
dump to printer."
530 LOCATE 4,3: PRINT"Press the DOWN ARROW key to stop
sampling." 540 IF INKEY$="" THEN 540
550 IF GRAPH$="M" OR GRAPH$="m" THEN 590
560 ' *****
570 ' *** Graph ***
580 ' *****
590 SCREEN 2: CLS: ' Prepare screen
600 LOCATE 2,1: PRINT NS;
610 FOR T = 24 TO 639 STEP INCR
620 LINE(T,58)-(T,55)
630 LINE(T,140)-(T,143)
640 NEXT
650 LOCATE 7,1: PRINT "10": LOCATE 8,1: PRINT "- "
660 LOCATE 9,1: PRINT "-": LOCATE 10,1: PRINT "- "
670 LOCATE 11,1: PRINT "-": LOCATE 12,1: PRINT "- "
680 LOCATE 13,1: PRINT " 5": LOCATE 14,1: PRINT "- "
690 LOCATE 15,1: PRINT "-": LOCATE 16,1: PRINT "- "
700 LOCATE 17,1: PRINT "-": LOCATE 18,1: PRINT "- "
710 LOCATE 19,1: PRINT " 0"
720 LOCATE 7,77: PRINT CHR$(26);
730 LOCATE 19,77: PRINT CHR$(26);
740 LOCATE 1,49
750 IF SEC = 0 THEN 780
760 PRINT SEC;" sec/div."
770 GOTO 810
780 PRINT NUM;" samples/";
790 IF AS = "H" OR AS = "h" THEN PRINT "hr." ELSE PRINT
"min."
800 LOCATE 2,50: PRINT"10 samples/div."
810 Y=99: B=99
820 A=INT(TIMES)
830 IF A+SPACE > INT(TIMES) THEN 830
840 C=STICK(0): D=STICK(1)
850 YY=CINT(C*.74)+59: BB=CINT(D*.74)+59: ' Correction
factor
860 LOCATE 1,1: PRINT TIMES
870 LINE(26,Y)-(24,YY): LINE(26,B)-(24,BB),,H5555
880 GET(24,59)-(637,139),AA
890 LINE(26,Y)-(24,YY),0: LINE(26,B)-(24,BB),0
900 Y=YY: B=BB
910 PUT(26,59),AA,PSET
920 IF AS="C" OR AS="c" THEN 840 ELSE 820
930 LOCATE 4,3: INPUT"Enter starting time. (HH:MM:SS)";START$
940 IF START$ <> TIMES THEN 940
950 RETURN
960 SCREEN 0,1:CLS
970 END

```

applicable to your computer and printer to implement a screen print.

Shown in Fig. 4 is a typical chart recording as printed out by a dot-matrix printer. In this case, only one of the two channels was connected to an input signal. Note that the printout shows the user-assigned name of the trace, time the trace was completed, number of samples per minute (or hour) and number of samples per division (tick-mark spacing).

Figure 5 shows a typical dual-trace chart recording. Here, the maximum sample interval option was selected, and the distance between tick marks is quite small.

Finally, Fig. 6 shows a typical dual-trace chart recording in which the maxi-

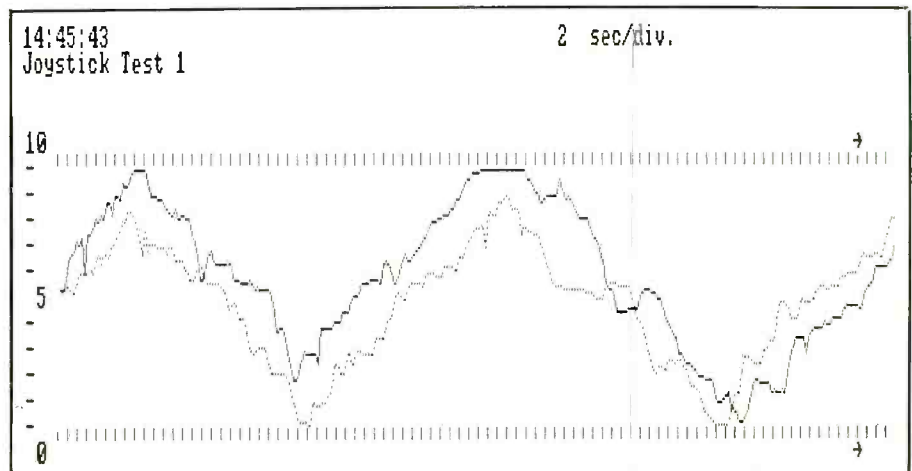


Fig. 5. Sample dual-trace chart recording in which maximum sample selection interval option has been selected.

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430-060	Pana VXPO521	4.50	3.90
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30 sec/div.

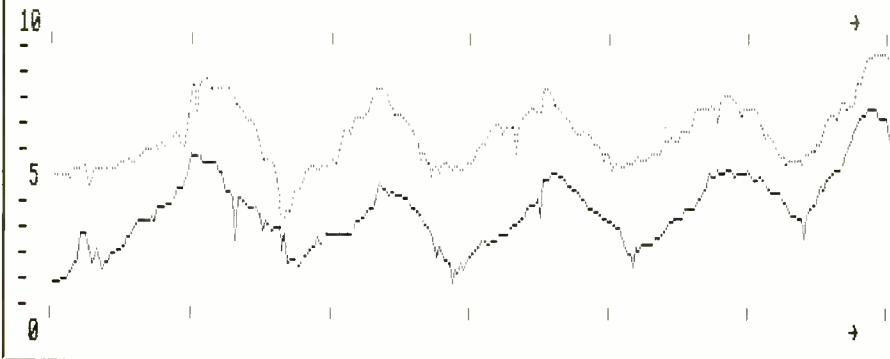


Fig. 6. Sample dual-trace chart recording in which maximum spacing between "tick" marks has been selected.

imum interval option was also selected. However, here the distance between tick marks is quite large since the maximum interval (30 seconds per division in this case) was selected.

Going Further

Eric's program nicely demonstrates the amazing versatility of the personal computer, a machine many of us take for granted. In the case of the two-channel chart-recorder program, a PC simulates a laboratory instrument that costs \$1,000 or more.

The program presented here can be easily expanded to include various other options. For example, Eric has expanded the program to include a separate trace option in which the two traces are plotted parallel to each other rather than being superimposed. Another feature of the expanded program is its capability to store incoming data on disk for later display on the computer's video monitor screen. Although we haven't yet required a variable-amplitude feature, one can easily be added.

Only one of the joystick ports is accessed by Eric's program. By accessing

the second port, a four-channel chart recorder can be simulated.

Simply by changing the control program, the PC can perform many other instrument features. Perhaps there's a laboratory instrument you would like to have but can't afford. If you own a personal computer, it might be possible to develop a program for it that will permit the computer to perform at least some of the functions of the machine you can't afford. I've discussed several such applications, including a storage oscilloscope, in a book titled *Forrest Mims's Computer Projects*, (Osborne/McGraw-Hill, 1985). You might want to look into these. **ME**

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The Secret of Radio Success

By Curt Phillips

Based on the number of books on the market today dedicated to antennas, radio enthusiasts obviously realize the vital part a good antenna system can have on communications, whether SWL, ham or other.

But a crucial variable that is still given little more than cursory attention is propagation. Almost all books on shortwave radio mention that signals bounce off the ionosphere and thereby travel around the world. Most also mention the tremendous effect of the (approximately) 11-year sunspot cycle on radio transmission. However, the effect of daily and monthly changes on radio propagation is generally ignored, though special-interest ham radio publications like *Modern Electronics's* sister publication, *CQ*, covers this subject regularly. But predicting propagation, combined with lead-time of publications is far different than getting propagation information that is up-to-date, which is the subject here.

I chose the title of this column somewhat deceptively, because if I had called it "Radio Propagation," some of you might have skipped over it. Yet in many ways, a knowledge of the vagaries of propagation is the secret of radio operating success.

Information on sunspot and geomagnetic activity is broadcast on WWV every hour. At 18 minutes after each hour, WWV (but not WWVH) broadcasts information on solar and geomagnetic activity for the previous day and a solar-activity index for the previous three hours. This information is useful, but to be most effective this data needs to be regularly monitored and plotted.

The Propagation BBS

For evaluating and plotting a large quantity of data, a personal computer is invaluable. A direct transfer of data into the computer is the easiest way to enter the data.

To this end, the Space Environment

Propagation Report

File lono downloaded at 06:30:39Z 07/07/88

PRIMARY HF RADIO PROPAGATION REPORT ISSUED AT 070600Z JUL 88.
PART I. SUMMARY 070000Z TO 070600Z JUL 88/
FORECAST 070600Z TO 071200Z JUL 88.

		QUADRANT			
		I	II	III	IV
		0 TO 90W	90W TO 180	180 TO 90E	90E TO 0
REGION	POLAR	N5/P40	N5/P30	N5/P30	N5/P40
	AURORAL	N4/P40	N4/P30	N5/P30	N5/P40
	MIDDLE	N6/P30	N6/P30	N7	N7
	LOW	N8/P40	N8/P30	N8	N8
	EQUATORIAL	N7	N8	N8	N8

PART II. GENERAL DESCRIPTION OF HF RADIO PROPAGATION CONDITIONS OBSERVED DURING THE 24 HOUR PERIOD ENDING 06/2400Z, AND FORECAST CONDITIONS FOR THE NEXT 24 HOURS. WITH THE EXCEPTION OF A LITTLE NOISE IN THE AURORAL LATITUDES, CONDITIONS WERE NORMAL IN ALL LATITUDES.

FORECAST: HF PROPAGATION IS EXPECTED TO CONTINUE AT NORMAL CONDITIONS AT ALL LATITUDES.

PART III. SUMMARY OF SOLAR FLARE INDUCED IONOSPHERIC DISTURBANCES WHICH MAY HAVE CAUSED SHORT WAVE FADES IN THE SUNLIT HEMISPHERE DURING THE 24 HOUR PERIOD ENDING 06/2400Z JUL 88 . . . NONE
PROBABILITY FOR THE NEXT 24 HOURS . . . MODERATE

PART IV. OBSERVED/FORECAST 10.7 CM FLUX AND K/AP.
THE OBSERVED 10.7 CM FLUX FOR 06 JUL 88 WAS 152.
THE FORECAST 10.7 CM FLUX FOR 07, 08, AND 09 JUL 88 ARE 145, 139, AND 136.
THE OBSERVED K/AP VALUE FOR 06 JUL 88 WAS 04/23.
THE FORECAST K/AP VALUES FOR 07, 08, AND 09 JUL 88 ARE 03/15, 03/18, AND 03/15.

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SECONDARY HF RADIO PROPAGATION REPORT ISSUED AT 080000Z JUL 88.
PART I. SUMMARY 071800Z TO 072400Z JUL 88/
FORECAST 080000Z TO 080600Z JUL 88.

		QUADRANT			
		I	II	III	IV
		0 TO 90W	90W TO 180	180 TO 90E	90E TO 0
REGION	POLAR	N5	N5	N5	N5
	AURORAL	N4/P20	N5	N5	N4/P20
	MIDDLE	N7	N7	N7	N6
	LOW	N7	N8	N8	N7/P20
	EQUATORIAL	N8	N8	N8	N7

A typical HF Propagation Report printout.

Services Center (SESC) under the U.S. Department of Commerce and the other federal agencies in the alphabet soup (see below) established an experimental computer bulletin-board system (BBS) in Boulder, Colorado. The SESC, for reasons described, continuously gathers information from all over the world and from the Geostationary Operational En-

vironmental Satellites (GEOS). This data is analyzed and compiled in a major on-site computer system. Part of this data is transferred into the PC clone that runs the BBS.

After accidentally finding this BBS while exploring computer bulletin boards in the Denver area, I talked with the System Operator (SysOp), Howard Sargent

W0MPG, to get more information of this system's purpose and history.

Alphabet Soup

The Space Environment Laboratory (SEL) of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), provides both real-time monitoring and reporting services and research activities. The SEL, through the Space Environment Service Center, is a national center for providing around-the-clock forecasts and warnings of solar and space disturbances. The rest of its efforts are devoted to studying and analyzing solar and terrestrial disturbances and to developing systems to improve monitoring, understanding, forecasting and analysis of disturbances.

U.S. Government interest in ionospheric effects on communications dates back to World War II, when solar and geomagnetic disturbances could disrupt hf military communications. By the middle 1960s, the scope of concern had expanded well beyond ionospheric communications to include such problems as radiation hazards, increased drag on navigation satellites during magnetic disturbances, upsets of geostationary satellite electronics and other systems, as well as induced currents in long lines.

Currently, the SEL's Space Environment Services Center disseminates information through several means, including the WWV broadcasts, commercial satellite broadcasts and a telephone recording (303-497-3235). The forecasts, warnings, real-time data, and summary information provided by SEL's Space Environment Services Center are generic products designed to serve the entire set of users concerned with these problems.

The computer bulletin board is an experiment to determine if this method of distribution can make the products available conveniently to a wider audience. Also, the BBS provides a forum for disseminating historical data and information too lengthy to be transmitted via WWV or by voice over the telephone line.

Table I. The SESC BBS Main Menu

P)ropagation Report	O)ther SESC Products
S)olar Report	C)omments to Sysop
R)egion Report	U)ser Records
A)ctivity Summary	*H)elp Menu
Q)uick Look Data	N)ews
*D)ata Listings	I)nformation on SESC
M)UF Predictions	B)ye (Leave System)
* = sub-menus exist	

On-line since January 1987, the SESC BBS has received approximately 13,000 phone calls and has had about 1,500 people register as users.

Since the data is paid for by taxpayers, the SESC is interesting in it being distributed to all interested parties. The SysOp told me that they would not mind the data from this BBS being transmitted on the ham radio packet networks. The SysOp is also soliciting suggestions on what other information would be useful to users.

Using the SESC BBS

The main menu is listed in Table I. Of immediate interest is choice "P," the Propagation Report. A sample of this report is reprinted here.

Part I of the HF Propagation Report provides observed and forecast hf propagation conditions in 20 areas of the Northern Hemisphere. That hemisphere is divided into four longitude sectors and five latitude zones, as listed in Table II.

Observed conditions (over the previous six hours) are specified on a relative

scale. One of three letters (N = normal, U = fair, W = poor) identifies overall propagation conditions in comparison to normal conditions for that latitude, local time, season and phase of the sunspot cycle. Consequently, an N at auroral latitudes in the sunrise sector does not have the same absolute meaning as an N in the afternoon sector at low latitudes. Conditions are *N(ormally)* much better in the latter block than the former, but N(ormal) may apply to both blocks.

Numbers 1 through 9 represent forecast conditions for the next six hours:

1. Useless
2. Very Poor
3. Poor
4. Poor to Fair
5. Fair
6. Fair to Good
7. Good
8. Very Good
9. Excellent

Forecast conditions are described on an absolute scale that ranges from 1 to 9. A given number has the same absolute meaning *regardless* of the block in which

Table II. Zone and Sector Allocations

	Sectors		Zones
I	0 to 90 degrees west	Polar	More than 70 degrees
II	90 to 180 degrees west	Auroral	55 to 70 degrees
III	180 to 90 degrees east	Middle	30 to 55 degrees
IV	90 to 0 degrees east	Low	10 to 30 degrees
		Equatorial	0 to 10 degrees

Table III. Remainder-of-Day Solar Flare Probabilities

Probability	Descriptive Word
Less than or equal to 1 percent	Nil
Equal to or greater than 2 percent but less than 20 percent	Slight
Equal to or greater than 20 percent but less than 50 percent	Moderate
Equal to or greater than 50 percent	Strong

it is placed. Referring to the previous example, it would be extremely unusual for all blocks to have the same number forecast. The number forecast refers to overall propagation conditions.

Also included in this part is a six-hour prediction of maximum usable frequency (MUF) deviations of 20 percent or more from seasonal means. These figures, used in conjunction with monthly mean predictions, can help you to decide which frequencies are most appropriate for use during the forecast period.

Part II of the HF Report contains a plain-language discussion of geomagnetic and ionospheric conditions and their effects on propagation. It covers conditions observed on the previous day and a forecast for the remainder of the current day. For purposes of these reports, each "day" is considered to be-

gin and end in Universal Coordinated Time (UTC).

Next, Part III is a summary of possible and confirmed solar-flare-induced ionospheric disturbances, specifically short-wave fades (SWFs), during the previous UTC day. This part also includes a plain-language forecast of the probability of a solar-flare-induced SWF during the remainder of the current day.

Part IV contains information that can be used to plan operations during the three-day forecast period. It includes the previous day's observed F10, Ap and corresponding geomagnetic K value. It also includes a three-day forecast for F10, Ap and K.

The F10 is the 10.7-cm solar radio flux reported daily at 1700 UTC, also known as the Ottawa 2,800-MHz reading. The 10.7-cm radio flux correlates well with

the general level of solar activity. Variations of 10 units or more above the 90-day mean indicate a reasonable change of solar-related disruptions occurring. Conversely, values significantly below the 90-day mean can be interpreted as an expectation of low solar activity. Generally, a flux value between 100 and 200 indicate the intermediate years of the solar cycle (as in this example), with 66 meaning "quiet sun" and readings over 200 occurring during the more active years of the sunspot cycle.

The Ap value is a daily figure for the level of activity of the geomagnetic field. A reading of under 10 is best for hf propagation. The K reading is a short-term indicator of geomagnetic activity, with readings under 4 and/or a descending trend best for hf propagation.

The HF Propagation Report is issued at 0600Z (UTC) daily. Secondary reports (six-hourly updates) are issued at 1200Z, 1800Z and 2400Z.

Connection Information

The SESC BBS phone number is 303-497-5000. It operates at 8 bits, 1 stop bit and no polarity (8N1) at either 300 or 1,200 bits per second. Registered users are allowed 15 minutes access per call. Callers who refuse to register can still use the system but are limited to 5 minutes per call. No file downloads are available at present, but they are planned for implementation soon. The BBS is accessible via Telenet's PC Pursuit on the Denver node.

For any serious ham operator or short-wave listener with a computer and modem, this BBS is definitely worth a long-distance call. Knowledge of propagation conditions can make the difference between productive and enjoyable time at the radio and twiddling the dials on a dead band. **ME**

Your comments and suggestions are welcome. You can contact me at P.O. Box 678, Garner, NC 27529, or by computer on Delphi (CURTPHIL), CompuServe (73167,2050) or The Source (BDK887).

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Experiments With EPROMS by Dave Prochnow. (Tab Books. Soft cover. 230 pages. \$16.95.)

If you have ever wanted to program your own EPROMs but did not know where to turn for information on how to do so, this book is for you. It is a comprehensive, practical guide to EPROM technology, programming and programming equipment. The operative word here is "practical" because the book contains a number of projects you can build and experiments you can perform to help you master programming of your own EPROMs.

The book does not assume that the reader is familiar with EPROM programming or even what an EPROM is in all its guises. It begins with a chapter titled EPROM Technology that discusses digital memory, binary codes, binary math, binary logic and concluding with two hands-on projects the reader is expected to assemble. This lays the foundation for later material, especially chapter two, which deals with programmable memory structures. The following three chapters are devoted exclusively to descriptions of some popular PROMs, EEPROMs and EPROMs and include pinouts and internal details for 19 devices.

Getting down to programming cases, chapters 6 and 7 detail construction and testing of two versions of two EPROM programmers. Then chapter 8 details the actual programming process. Another chapter deals with erasing a programmed EPROM to ready it for reprogramming. For those readers who do not wish to hunt around for parts, yet another chapter discusses commercially available EPROM programmers, including construction details of a commercial programmer kit.

Throughout, the book contains a total of 15 projects the reader can build and use. These include a "Boole's Box" logic tester and keyboard encoder, an EPROM program tester, ROM drive, speech and music synthesizers, a message center and two EPROM erasers, as well as the four versions of programmers. All in all, this is a well-rounded book. It is well-written and its text is nicely supported by informative illustrations.

Mastering DOS by Judd Robbins. (Published by Sybex Inc. Soft cover. 650 pages. \$19.95.)

This book is the first to target the

workings of DOS 3.3. It also serves admirably for earlier versions, of course, noting when a 3.3 feature is not available on previous disk operating systems. It's divided into five major parts, opening with fundamentals of hardware, software and DOS diskettes. Parts 2 through 4 are self-teaching parts that start with common commands and gradually advance to in-depth discussions for power users. The final section lists alphabetically what all commands do and the format used, serving as a complete reference guide for even obscure software switches.

In 18 chapters and three appendixes, *Mastering DOS* can indeed show the reader all the ins and outs of using MS/PCDOS. It's as thorough a coverage as I've read anywhere. More than this, though, the author writes with exceptional clarity that will be appreciated by all readers, novice or advanced user. Practical examples on using various DOS functions are strewn throughout the book, amply supported by screen shots and printouts.

Additionally, the book's typography, layout, and two-color printing adds to its utility since it both invites the reader to read and simplifies coverage of so many functions. Furthermore, visual icons, three different ones, are used in margins: Note, Tip and Warning. The Note adds information that's in the text; the Tip gives practical hints; the Warning calls attention to a possible problem or how to avoid it.

The book represents a masterful, up-to-date presentation of DOS that offers readers both a wonderful learning experience and a reference text they'll treasure. Given what such books cost today, it's one of the best bargains among computer books you'll likely find.

NEW LITERATURE

Old-Time Radio Parts Catalog. Old-time radio parts, construction plans and kits are listed and described in an eight-page catalog from Yeary Communications. Items listed include hard-to-find components like crystal headphones, multi-plate air variable tuning capacitors, coil forms and enameled wire, galena crystals, "cat's whiskers," vernier dial

(Continued on page 94)

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CIRCLE 4 ON FREE INFORMATION CARD

Accounting for Non-Accountants

By Art Salsberg

Accounting programs are among the major computer software sellers in the industry, along with word processors, spreadsheets and database management applications. They range in scope and power for giant corporations to small businesses. As you might guess, you have to be well-versed in accounting to make use of most of them, which are usually divided into a group of complicated modules that include Accounts Receivable, Accounts Payable, General Ledger, Billing, Inventory, and so on.

Dallas, TX-based Dac Software (1-800-992-7779) established itself a few years back in this field with its Dac-Easy Accounting Series for microcomputers, which was acclaimed for its low price, tutorials, and reasonable power. Nonetheless, it's still a bit too much to handle for non-accounting-oriented people. The company's "Dac-Easy Light" is intended to fill this lower-end need for efficiently maintaining accounting records, whether for a sole proprietor or for personal finances.

It's a simplified multi-level, double-entry system that automatically adjusts figures throughout when you enter a transaction. Moreover, you can have many sets of books—say for two businesses and one for home finances. When setting up

Light for a file, you can choose a Business or Home accounting system to work with. Priced at only \$69.95 (plus \$7.50 shipping), Dac-Easy Light requires an IBM PC/XT/AT/PS2 or true compatible computer, 256K memory, MS or PC-DOS 2.0 or later, and one or two floppy disk drives or a floppy disk drive and a hard disk drive. For printout, an 80-column printer that can print 132 columns in compressed mode is required.

In Use

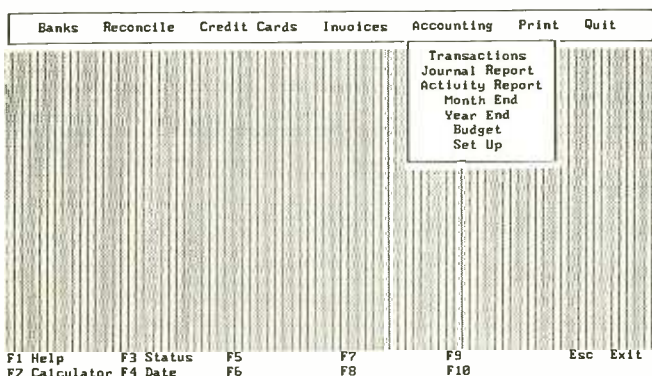
The package consists of a single 5¼" or 3½" disk and 102-page user's manual. Installing the program is a snap since most of it is done automatically, including installing or modifying a CONFIG.SYS file and setting up a sub-directory. Light will automatically reduce the number of records that can be handled on some files if you don't have more than 256K of memory or a hard disk drive or high capacity floppy diskette drive. For example, general ledger transactions would be reduced from 2,200 records to 800 records; invoices reduced to 300 instead of 500.

Monochrome or color displays can be used, with the latter providing the user with a wide variety of colors for the menu or windows. A small choice of dot-matrix printer drivers are given that encompass most popular types. You can insert your

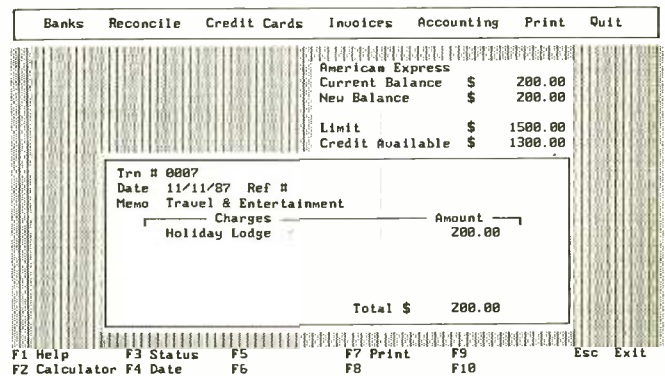
own printer codes to choose a printer not listed. Options can be user-changed at any time.

Function keys are fully employed to simplify actions and are lined up at the bottom of the screen. They include a Help key and a Calculator key, the latter producing a "calculator" on-screen whose result can be transferred to the current screen by pressing "P." Across the top of the main menu are seven options, one of which is always highlighted as the keyboard arrows are moved: Banks, Reconcile, Credit Cards, Invoices, Accounting, Print and Quit. Selecting a highlighted option produces the pertinent pull-down menu.

Accounting with Light means working with Bank, Credit Card, Accounting and Business files, shifting easily between them. Banking includes writing and printing checks and queued check-printing for batched checks, as well as deposits and withdrawals from various banks. You can reconcile bank accounts, view a bank account's register, mark off cleared or outstanding checks, etc. For credit card charges, you can run a directory of all the cards and see the balances before writing checks. In essence, Light is a very efficient home finances management system. But what's entered in these familiar files are really accounting transactions made to look easy.



Pressing Right or Left keyboard arrows moves highlighted bar across top of screen for file activation. Resulting pull-down menu gives user options within category chosen.



Choosing Credit Cards from the main menu sets the user up to enter transactions. A credit-card slip appears on screen for filling out. Light automatically assigns a slip number.

Chart of Accounts			
Number	Account Name	Type	Level
1	ASSETS	Asset	1
11	Current Assets	Asset	2
1101	Cash on Hand	Asset	3
110101	Petty Cash	Asset	4
1102	Savings Accounts	Asset	3
110201	Guaratee Savings & Loan	Asset	4
1103	Checking Accounts	Asset	3
110301	Grand National Bank	Asset	4
1104	Securities	Asset	3
110401	Herrill Lynch	Asset	4
1105	Accounts Receivable	Asset	3

F1 Help F3 Status F5 F7 F9 Esc Exit
 F2 Calculator F4 Date F6 F8 F10

A Chart of Accounts is shown, which lists the user's sources and uses of funds. This is the accounting environment that's used when "Business" is chosen during program installation.

Moving to the Accounting file, in fact, reveals that the program transferred your earlier entries into an accounting journal. Light applies transaction numbers to each account in order to track them. A structured Chart of Accounts is maintained and the accounts are grouped into types and levels, with each succeeding level giving more detailed information. The user's manual gives examples on how to use the file, including how to change an entered transaction if you decide that the customer will be a bad debt, if you cashed a check at the local grocery store instead of depositing it in the bank, etc. You can choose to use a cash or accrual method, of course.

Among Light's other features, it allows you to budget in advance for a 12-month period and compare forecasts with actual results. In spreadsheet fashion, it can print three rows of data for each account: budgeted, actual and the difference between the two. So each month you can see how well you've done for the month and for the period.

Lastly is the Business file, where invoice information is maintained for customers' names, addresses, sales terms, etc. Extended prices and sales tax are calculated automatically (they can be edited, if one wishes), form of payment can be entered (check, VISA, etc.), and so on.

Dac Software, Inc. is more than a computer software developer/marketer. It

has also developed and sells computer forms for use with its software. This includes checks, envelopes, invoices and statements. They can be ordered with imprinting, including a company's logo; multi-part sequence on carbonless paper, etc. And printing information from Dac-Easy Light is easily done.

Conclusion

I've worked with a few microcomputer accounting programs in the past. All were a hassle to one extent or another, requiring involved setting up and much getting used to. "Light," in contrast, was a pleasure to work with in all respects.

Its basic simplicity, whether entering or retrieving data, shifting to another file, or printing, ably supported by au-

Invoices																						
Inu No: 00001	Remarks																					
Customer	Jeffrey Houard																					
Accounts Receivable	200.00																					
<table border="1"> <tr> <td>Name...</td> <td>Jeffrey Houard</td> <td>e v</td> </tr> <tr> <td>Address:</td> <td>2000 Vine Street</td> <td>e Extended</td> </tr> <tr> <td>Address:</td> <td>Lincoln, NE 68014</td> <td></td> </tr> <tr> <td>Memo...</td> <td></td> <td></td> </tr> <tr> <td colspan="3">Balances</td> </tr> <tr> <td>Beginning:</td> <td>200.00</td> <td>Last Year...: 0.00</td> </tr> <tr> <td>Current...:</td> <td>200.00</td> <td>Credit Limit: 0.00</td> </tr> </table>		Name...	Jeffrey Houard	e v	Address:	2000 Vine Street	e Extended	Address:	Lincoln, NE 68014		Memo...			Balances			Beginning:	200.00	Last Year...: 0.00	Current...:	200.00	Credit Limit: 0.00
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Memo...																						
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Beginning:	200.00	Last Year...: 0.00																				
Current...:	200.00	Credit Limit: 0.00																				
PgUp PgDn F1 Alt-E Alt-D	0.00																					
Sub Total	0.00																					
Sales Tax	0.00																					
Total	0.00																					
Pmt. Ref.																						
Adu. Pmt.	0.00																					
Net to Pay	0.00																					

F1 Help F3 Status F5 View F7 Print F9 Messages Esc Exit
 F2 Calculator F4 Date F6 Cancel F8 Defaults F10 Process Alt-D Delete

Customer invoice information is created and maintained on the Business Light file. A customer selection window can be called up by pressing a function key (F5).

omatic features and an easy-to-understand manual, made it less formidable than other accounting programs.

Combined with its truly low cost, high company reputation for support, and convenient complimentary checks and forms availability, it's an excellent example of how personal computers can be effectively used. I highly recommend it for use in very small full-time or part-time businesses where up-to-the-minute financial information can be important, an external professional look is desirable, and financial forecasting will be helpful (or any of the three). Or even for home use if one has an unusually large number of regular transactions, though here personal discipline will dictate its effectiveness. **ME**

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Of Mice and Men . . .

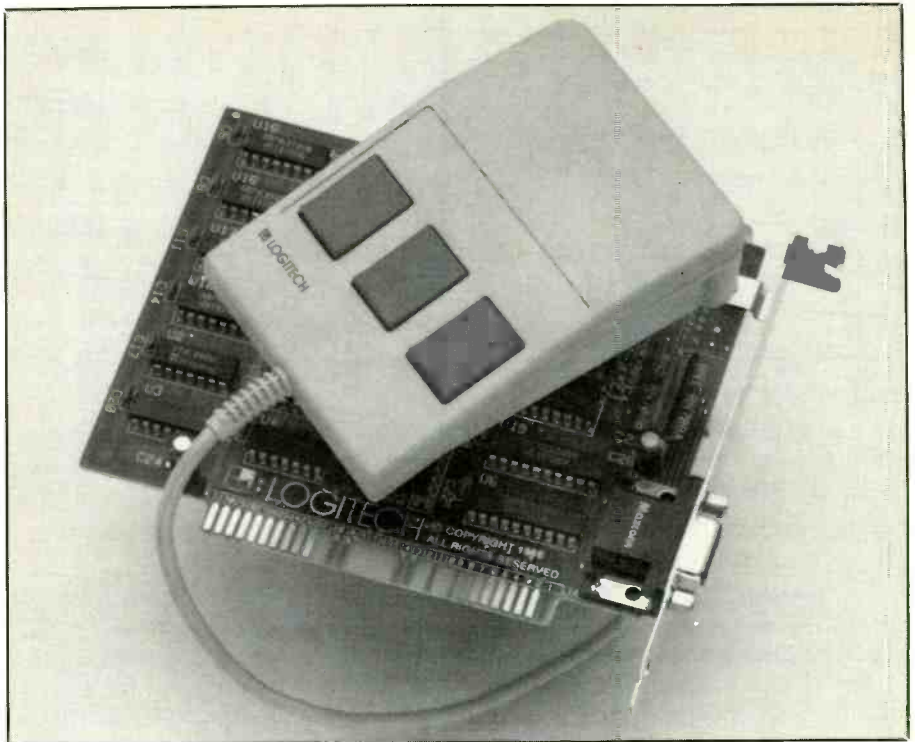
By Ted Needleman

There seems to be a fair amount of confusion among users over that growing number of peripheral/rodents used—the mouse. This has reflected itself in the number of times in the past few months I've been questioned about "the best mouse to buy" and the differences between the various offerings. Though they're increasingly popular, only largely because of the proliferation of visual interfaces such as the Mac's and MS-Windows, mice aren't all that new. Mice are, in essence, upside-down trackballs. Developed in the Sixties for graphics and military workstations, trackballs allow you to position a cursor at a specific point on the screen with very little manual manipulation. There is a direct correspondence between the movement of your finger and the movement of the cursor, unlike the more rigid travel when using cursor keys.

During the late 1970s, when Xerox was researching the use of visual interfaces at its Palo Alto Research Center (PARC), both trackballs, and their upside-down equivalents (mice) were made an integral part of the configuration. Apple's Steve Jobs, touring the PARC facility, was impressed with the interface/mouse combination, and the rest, as they say, was history—Microsoft has sold its millionth mouse, and many more in addition to this have been sold by Logitech, MSC, and other manufacturers.

Although there are three basic types of mouse (mechanical, optical, and optical/mechanical), and two basic types of interfaces (serial and bus), all mice have certain concepts in common. No matter how it accomplishes it, a mouse translates its position on a surface into an equivalent cursor position on the computer's screen. As the mouse is moved around, the screen cursor follows. The two major advantages this offers is that the cursor can be made to travel along a diagonal or curve, and it can be rapidly and accurately positioned on the screen.

Regardless of the particular mechanism a mouse uses, it accomplishes this cursor movement by translating the mo-



tion of the roller ball along a surface into resultant movement along X and Y axes. A strictly mechanical mouse uses two potentiometers, mounted at a 90-degree angle to each other.

Optical/mechanical mice use two drive shafts, again at 90 degrees difference, to drive light-choppers which code a location value. An optical mouse, such as those from MSC, uses a special pad, with precisely ruled parallel lines. Lines of one color make up the horizontal rules, while lines of a different color make up the vertical rules.

By bouncing a beam of light (generated by a LED in the mouse) off the pad, photodetectors in the mouse, each with a different color filter in front of it, can generate a signal which can be translated into movement. By summing the X-axis movement against the Y-axis movement, a resultant vector is obtained which represents the actual direction the mouse has been moved in.

This translation is done by a piece of software called a *driver*. Depending on

the particular mouse you buy, and the application you will be using it with, there are two ways to install a driver.

Most mice come with both a mouse installation program in the form of a small program (usually named `MOUSE.COM` or something similar) which is run before the mouse can be used. The most efficient way to use this approach is to run the program from the `AUTOEXEC. BAT` file.

The other way mouse use is enabled is to use the installable device driver facility of MS-DOS to install a different small program (usually called `MOUSE.SYS` or something similar) as the operating system is being loaded. This is accomplished by using an editor or word processor to insert a command line such as `DEVICE = MOUSE.SYS` into your `CONFIG.SYS` file. Either way will work with many programs, but some software requires that the `MOUSE.SYS` driver be installed in `CONFIG.SYS`.

A second way that mice differ is in the method they use to interface to your computer. Originally, all mice available for

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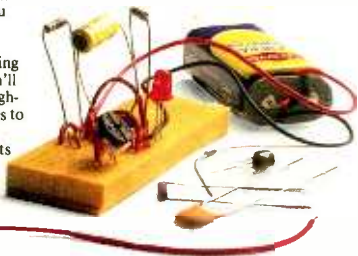
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PC CAPERS...

IBM PCs and compatibles were serial devices. They plugged into a COMM port with a DB-25 connector.

As more users started using the serial ports for other devices, such as a serial printer or modem, manufacturers, most notably Microsoft, started providing mice that attached to a small card that was plugged into one of the PC's expansion slots. These are called "bus mice," and offer the advantage of not tying up a COMM (serial) port. The small interface board is actually a simple, single-purpose serial interface that leaves the available COMM port addresses and connectors open for other uses.

The major disadvantages of using a bus mouse are that the card uses up an expansion slot, and moving the mouse to a different machine involves opening up both systems and swapping a card. A "serial mouse," on the other hand, while occupying a COMM port, can be moved simply by unplugging the DB connector from one computer and plugging it into the other machine. In the event there's only one serial port and a modem or other device is not being used in the working application, the mouse can be substituted.

One final area (aside from price) where mice differ is in the number of buttons they have. While Apple uses a single button, mice for IBM-compatible PCs have either two or three. These buttons send the equivalent of a sequence of key presses when they are depressed.

The actual result of a button press depends upon what software you are using the mouse with. Aside from application software such as word processors, CAD programs, and Desktop Publishing packages that support a mouse, most mice come with utility software that enables you to add mouse features, such as pull-down menus, to software that does not ordinarily support a mouse.

Now that you know all about mice, how do you decide which one to buy? The first thing to decide is whether you need a serial or bus mouse. If you have an open RS-232C serial port, and are short on expansion slots, the choice is easy—a serial mouse. Likewise, if you are short on serial ports, but have plenty of empty expansion slots, a bus mouse would make best

sense. If, however, you have neither an open expansion slot or Comm port, then a serial mouse, coupled with an A-B switch box would probably be your best bet.

The next step is to decide on the brand of mouse. Assuming that the software you intend to use the mouse with supports a large variety of mice, it boils down to personal preference. Most brand-name mice are well constructed, and are accompanied by good utility software. If you want an optical mouse, such as MSC's, make sure that your desktop has room for the special pad—the mouse won't work without it. Otherwise, almost any of the available mice will do the job.

On my own systems, I've used a variety of mice. One machine has the new Microsoft mouse. A two-button mechanical mouse, that's reliable, smooth rolling, and has a nice positive button "click." Another computer has an MSC optical mouse on it for the last year or so. This is a three-button mouse, though the applications I use it with don't support the center button. Having no roller, it is even smoother than the Microsoft mouse, but the special pad is sometimes awkward to find desk space for.

Most recently, I received the Logitech Publisher Package. This consists of a Logitech three-button mouse (bus version in my case), and a simple Desktop Publishing software package. As the software is actually the original version of Software Publishing's First Publisher, which I believe has been previously reviewed, I will concentrate on the mouse and its utility software.

The Logitech bus mouse is an optical/mechanical mouse, using a roller ball to drive an optical decoding system. It comes with a half-size circuit board which installs in an empty expansion slot. Two diskettes of software are also provided. The first contains the mouse installation program and required drivers, while the second has several utility programs.

One thing in the manual that I thought was clever was the way you determine the correct interrupt for the bus mouse. The documentation has a list of various computers and configurations, along with an interrupt number for each listing. If, for

example, you have an IBM AT, you cross out pin-set No. 5. If you also have an EGA adapter, you cross out No. 2. An Async Adapter on COM2 results in a cross-out of pin-set No. 3. As the available settings range only from 2 to 5, this procedure (at least for the above configuration) means you'd have to use setting No. 4. This is done by moving a jumper to the correct pin-set. The total installation time to put the board in my PC and install the software was under a half-hour (most of which was opening and closing the computer's case).

The installation software is easy to use, and practically self-explanatory. The installation disk also contains a special driver (LMOUSE.SYS) for Microsoft Windows. Inclusion of this driver saved me a considerable amount of time.

I recently installed two applications from Aldus: Snapshot (a program to manipulate video images) and PageMaker Version 3. The run-time version of Windows included with Snapshot listed the Logitech mouse as part of the installation procedure, but the driver was missing from the installation disk. A quick copy of LMOUSE.SYS from Logitech's disk, and the installation proceeded with no problems. Strangely enough, when I installed PageMaker later that day, I had no problem specifying the Logitech mouse.

It's the four utility programs Logitech includes that make the package different from "generic" mice. LOGIMENU allows you to "program" your own pull-down type menus using a variety of commands. These allow you to specify a label for a particular set of horizontal and vertical coordinates, and the action that will be taken when the software recognizes the cursor has been placed in this space and a mouse button "clicked." You can also define the equivalent keypresses that a button or combination of buttons (called a "chord") will produce.

Hackers will love this program, it even lets you define colors in the menu selections. I played with it for a little while, but quite honestly, I lack the patience to put in an hour or two's work just to get a fancy menu. The menus are created using a word processor or other text editor (such as the POINT editor which is part of

the collection) and compiled with the NEWMENU compiler included with LOGIMENU. Microsoft has a similar menu utility, and you can "compile" Microsoft menu definition files with NEWMENU to use them with the Logitech mouse.

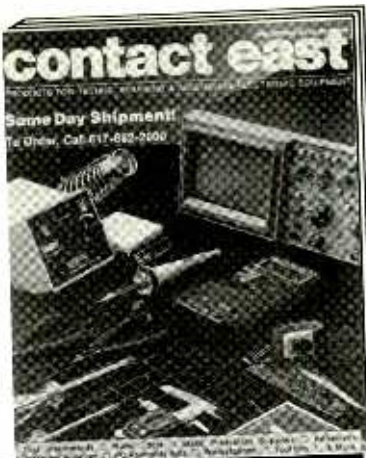
The second utility, CLICK, is a memory-resident program that allows the mouse to be used with programs that either don't specifically support the Logitech mouse (but do support other mice), or those such as Wordstar, WordPerfect, and SuperCalc which do not ordinarily offer mouse support. A special version, POINT & CLICK, makes Lotus 1-2-3 a mouse-driven program.

POINT, the last of the four utilities, is a mouse-based text editor. While it doesn't support all the features that a full-blown word processor provides, such as extensive text formatting, underlining, different fonts, etc., it is perfect for use for programming and notes. In fact, conceptually, it is very similar to the NOTEPAD provided in MS-WINDOWS.

To execute a command, you use the mouse to move the cursor over the command and "click." Like most mouse-based text editors, you can select sections of text to move or delete by holding down a mouse button while moving the cursor over the text to be moved or deleted. POINT also allows you to open up several different windows on the screen, each containing a different document, and move back and forth between them.

All things considered, the Logitech Mouse PLUS Package (mouse and software) is a good buy. At a list price of \$119 (and often available mail-order for considerably less) it offers solid construction, handy utility software, and compatibility with numerous applications.

As important as the above, the Logitech mouse also has a good "feel." It tracks well on most surfaces, and the buttons have a positive crisp press. There are less expensive mice available, and more expensive mice available. With the three-year warranty offered by the company, I feel quite comfortable recommending the Logitech product. For more information, contact the company at (415) 795-8500. **ME**



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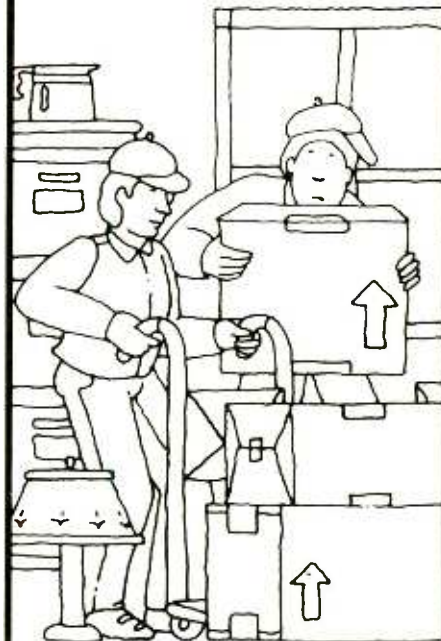
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Robotic Arm (from page 31)

checks for any key press. When a key is pressed, execution proceeds to line 160, where an OUT 888,0 is executed, deenergizing the PC/Armatron. Following a beep, execution loops back to line 100 for the next input.

A sufficiently accurate way of controlling the length of travel of the selected movement is by using BASIC's built-in TIMER function. By timing how long the WHILE/WEND loop remains active, the program could execute each function for a specific time. By calibrating how long full travel takes for each movement, you can expand the movement codes to the form HU 50 (Hand Up 50 percent maximum travel).

Further enhancements could include compiling of separate movement codes into a procedure, which can be stored, executed and retrieved from disk. With clever programming, you can even allow procedures to call other procedures so you can build basic movements and incorporate them into more intricate executions. These enhancements, and more, have been incorporated into a series of available programs (see the Note at the end of the Parts List.)

You can obtain good repeatable results by always executing commands in the same environment. For instance, if you worked out a series of commands with PC/Armatron on a carpeted surface, do not expect it to operate identically on a hard wood floor. Movement distance is determined by the time the motors are energized, not the physical distance moved. Variations in friction and inertia between different floor surfaces will result in performance variations.

Raising and lowering of the robot arm is affected by the load in the gripper. So if a different weight load is used, the arm will travel a different distance.

Make sure you do not exceed the maximum mechanical travel of the device. If all else fails and you cannot stop movement of the PC/Armatron, pull the plug on your power supply!

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ME

“on.” If all is well, you should hear the phasing effect described above. Adjust the CENTER, DEPTH and RATE controls in both directions and listen to the results to verify that each is working as it should. Now *slowly* rotate the REGENERATION control clockwise until the phaser just begins to oscillate. Then adjust *R21* so that oscillation just ceases when the REGENERATION control is set to maximum clockwise rotation.

Set the DEPTH and RATE controls fully clockwise and adjust *R15* for minimal noise. Finally, adjust *R2* for maximum gain short of clipping. For best possible signal-to-noise ratio, the phaser (and all audio processors, for that matter) should be fed as high an input signal level as possible short of distortion.

Bear in mind that the CEM3320 does not “hard clip” as do some other audio ICs. Consequently, its

distortion is not as easy to detect. However, excessive input signal levels tend to “wash out” the feedback signal with relatively large amounts of regeneration. Therefore, try reducing the setting of *R2* slightly if advancing the REGENERATION control’s setting does not seem to be producing much of an audible difference.

Before closing, it is interesting to point out that the basic phaser is designed to be easily modified for a variety of special purposes. REMOTE IN/OUT jack *J3* permits the phaser to be switched in and out by a remote foot switch. However, the basic use of this jack can be expanded simply by replacing the foot switch with an inexpensive relay, which can then be placed under computer control to allow you to concentrate on your performance rather than having to deal with foot-switching.

Even more intriguing are the possibilities of using the EXTERNAL CV INPUT to permit a variety of unusual effects in real time. An inexpensive digital-to-analog (D/A) converter IC can allow the phaser to be swept under computer control for a new class of effects that are not available from the phaser alone. Another use of this input is to use a modified inexpensive foot pedal to be used as a CV source. The modification consists of adding a 9-volt battery to the existing pedal, as illustrated in Fig. 6. If the pedal’s INPUT jack is not connected, the pedal operates as a foot-controlled voltage divider. Simply plugging into the INPUT jack permits the pedal to operate as before modification.

With a bit of practice and some experimentation, a number of variations on the basic phasing effect can be obtained. **ME**

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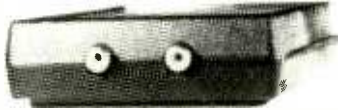
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NEW PRODUCTS ••• (from page 12)

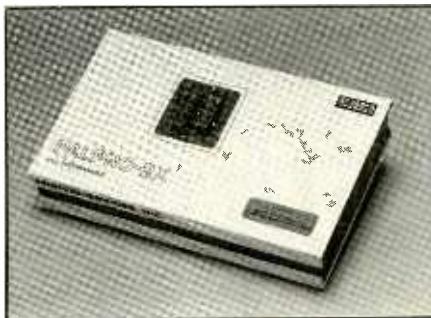
Accessory items available as extra-cost options include: a sun selector control that interfaces solar panels with an alternate source (ac line or a generator and inverter); Sun Selector Jr., a 30-ampere charge controller that expands a system from 12 to 120 volts; SBC 30, an inexpensive 30-ampere battery charge controller for 12 to 120 volts; M8-M16 charge controls for smaller systems rated at 12 and 24 volts and 8 or 16 amperes; linear current boosters that increase the performance of motors being run directly from solar panels. Other options include timers, dusk-to-dawn controls, mounting hardware, inverters, devices for providing fluorescent lighting, and electric pumps.

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PLD Programmiers

The Palpro-2X family of dedicated, stand-alone programmers from Logical Devices, Inc. (Ft. Lauderdale, FL) supports a wide range of 20- and 24-pin PLDs, EPLDs, PLAs, PALs and IFLs. The Model A is designed to be used with 20-pin devices from MMI, National and Texas Instruments; the Model B is for use with 24-pin devices from MMI, National and TI; and the Model C is for use with 20- and 24-pin AMD, Lattice, Cypress and Signetics devices.

Device selection is by manufacturer and device type. Average programming/verification time is said to be less than 5 seconds. As new devices become available, LDI will offer device upgrades to keep the programmers current. A microprocessor manages system operation. All device support programs are pro-



grammed into a socketed EPROM, which makes it easy to make device upgrades as needed.

Fuse maps are stored in an internal 8K x 8 RAM buffer, and production runs can be created from the RAM image. Built-in software features permit fuse map editing through an RS-232 serial interface port or an optional keypad/display.

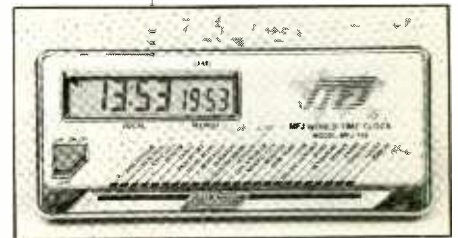
The programmers accept JEDEC data files and are compatible with such software logic compilers as PALASM, Amaze, Help, Plan, Abel, Cast and Cupl. (PALASM, Cupl and Amaze are available as options.) Firmware features include: device functions (load, verify, blank-check, program, secure and functional test); editor commands (examine/change, fill, checksum, formatted display fuse map and device selection); and fill commands (upload file and download file).

The programmers measure 12.25"W x 5.625"D x 2.25"H and weigh 4 lbs. \$595 Model A; \$695 Model B; \$995 Model C; \$175 keypad/alpha display.

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Telephone Equipment Tester (from page 51)

wish to test the CPC function (assuming that the machine has this feature), hang up the telephone. The answering machine should immediately stop recording. Many older machines do not have the CPC function and will, therefore, continue to record. Most machines have VOX (voice-operated record) and will stop recording after 8 seconds or so of silence.

You can check regular or cordless telephone instruments with the project simply by plugging them into the TEST jack and leaving the instrument plugged into the PHONE jack off-hook. A second person helps here to allow you to talk from one instrument to the other as you wiggle plugs and wires to check for intermittent connections. DTMF instruments will dial the Touch Tone signals, but the only way you can determine if they

are dialing correctly is to compare them audibly with the phone plugged into the PHONE jack, assuming that this instrument also has a DTMF dialing feature.

For those people who require visual indication of DTMF signals, Radio Shack's Cat. No. 276-1303 complete DTMF decoder IC needs only a crystal and resistor to decode DTMF signals to a hexadecimal output that can be sent to a 7447 or other seven-segment decoder chip to drive a digital display.

You will soon discover that with this telephone tester you can speed through troubleshooting a wide variety of telephone devices. If you service and repair telephone devices for a living, you will be glad you spent the modest amount of money to build this versatile instrument. **ME**

LETTERS... (from page 7)

may come in handy for repair work or, as an alternative, to wiping SMT pins in solder cream.

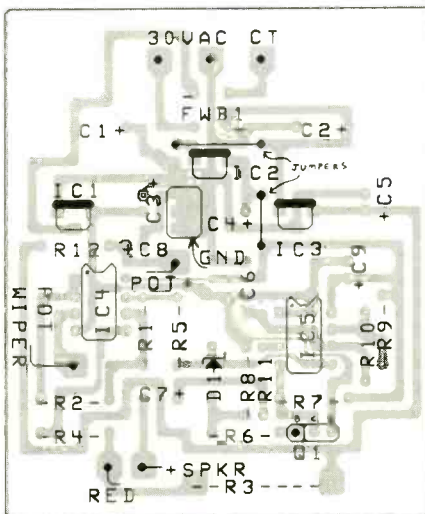
I also found that two parallel strips of masking tape on a piece of glass makes it easy to wipe a blade across the strips to get a uniform thickness of solder paste for dipping or wiping SMT pins. Additionally, I learned through experience that solder pads for J leaded SMT devices should extend well out from the package outline so that a fillet is formed on the outer surface of the pins, and so that a soldering iron can contact the pad if necessary.

Corrections

• I just got around to reading the May 1988 issue of *Modern Electronics* and noted that LED2 in the "Home-Built Brushless DC Motor" article appears to be connected backwards in the schematic. Other than this small error, I enjoy your magazine. Keep up the good work.

John Mullens
Scottsboro, AL

• Please note that D1 in the "Bus Line Tracer Troubleshooting Aid" (August



1988) should be a 12-volt, 1-watt zener diode, not the 5-volt unit specified. Also, I noticed that the Fig. 3 wiring diagram is incomplete. The artwork shown should be superimposed on a halftone of the foil pattern on the bottom of the board as shown here.

David Miga
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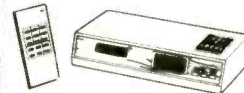
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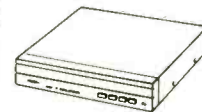


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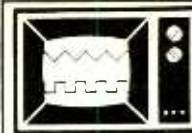
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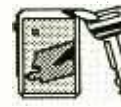


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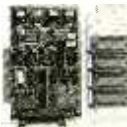
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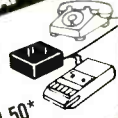
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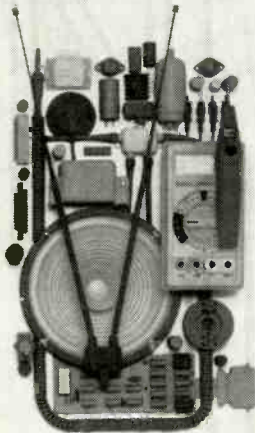
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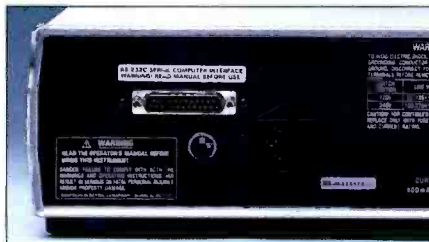
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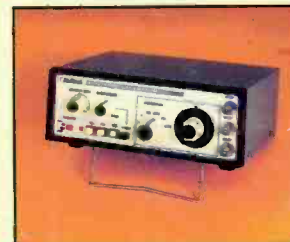
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94, 93, 90, 87, 71, 70, 66