TROUBLE-SHOOTING ANALYZER FOR AUTOMOTIVE ELECTRIC SYSTEMS

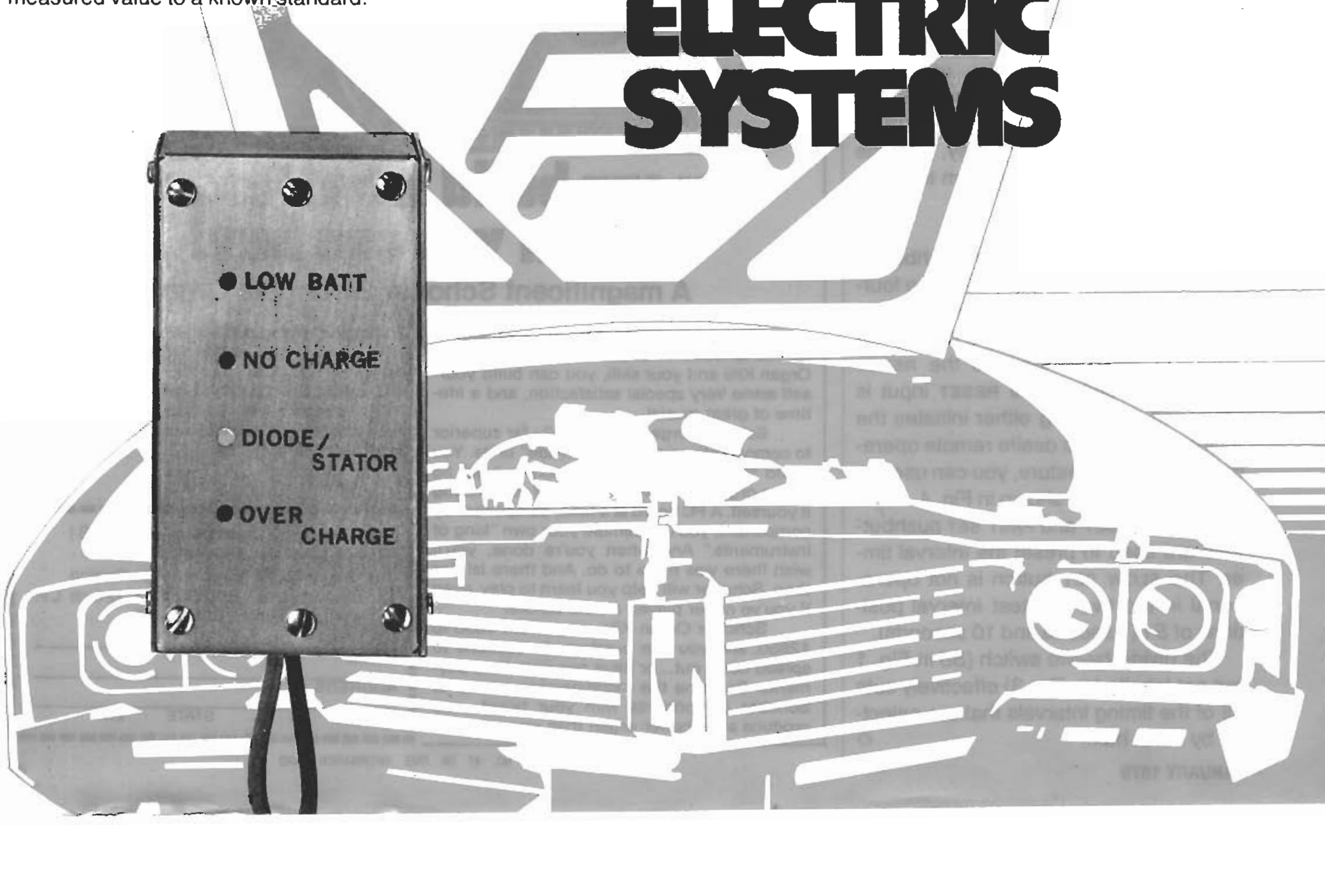
BY TONY CARISTI

Electronic diagnostic instrument for locating and identifying problems in battery or charging systems

THE AUTOMOTIVE industry has taken advantage of the latest techniques in modern electronics technology. As a result, many of the components in late-model automobiles have become more difficult to diagnose when trouble occurs. An example of this is in the automotive battery and charging system, where the old-style battery, dc generator, and electro-mechanical voltage regulator have given way to the sealed battery, alternator, and solid-state voltage regulator. These new components are superior to the ones they replaced, but they also require more sophisticated test procedures to analyze and isolate faults.

It seems only natural that electronics technology should provide the means to check these components. The automotive battery and charging system monitor described in this article, provides such a check. It can be constructed at low cost, yet gives the accuracy and dependability suitable for a professional as well as an amateur. The monitor uses four LED's to provide an indication if a fault arises and also indicates possible sources of trouble. This feature will eliminate unnecessary replacement of properly operating components.

Circuit Operation. The analysis of an automotive battery and charging system can be accomplished by monitoring the battery voltage under several operational conditions, then comparing the measured value to a known standard.



PARTS LIST

C1,C2 — 10-µF, 15-volt electrolytic
D1 — 1N2069 or similar
D2 — 1N4148 or similar
IC1 — µA 78GU adjustable regulator (Fairchild)
IC2 — LM339 quad comparator
LED1 through LED4 — Red LED
R1,R2,R4 — 1000-ohm, 1% resistor
R3 — 1000-ohm potentiometer, pc mount
R5 — 39,200-ohm, 1% resistor
R6,R11,R14,R18 — 100,000-ohm, 1% resistor
R7,R9,R15,R19 — 10,000-ohm, 10% resistor
R8,R12,R16,R20 — 1000-ohm, 10% resistor
R10 — 5900-ohm, 1% resistor
R13 — 25,500-ohm, 1% resistor
R17 — 19,600-ohm, 1% resistor
Misc. — Suitable enclosure, interconnecting leads, optional spst switch, mounting hardware, etc

Note: The following are available from: A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: etched and drilled pc board at $2.50; a set of 11 precision resistors at $2.50.

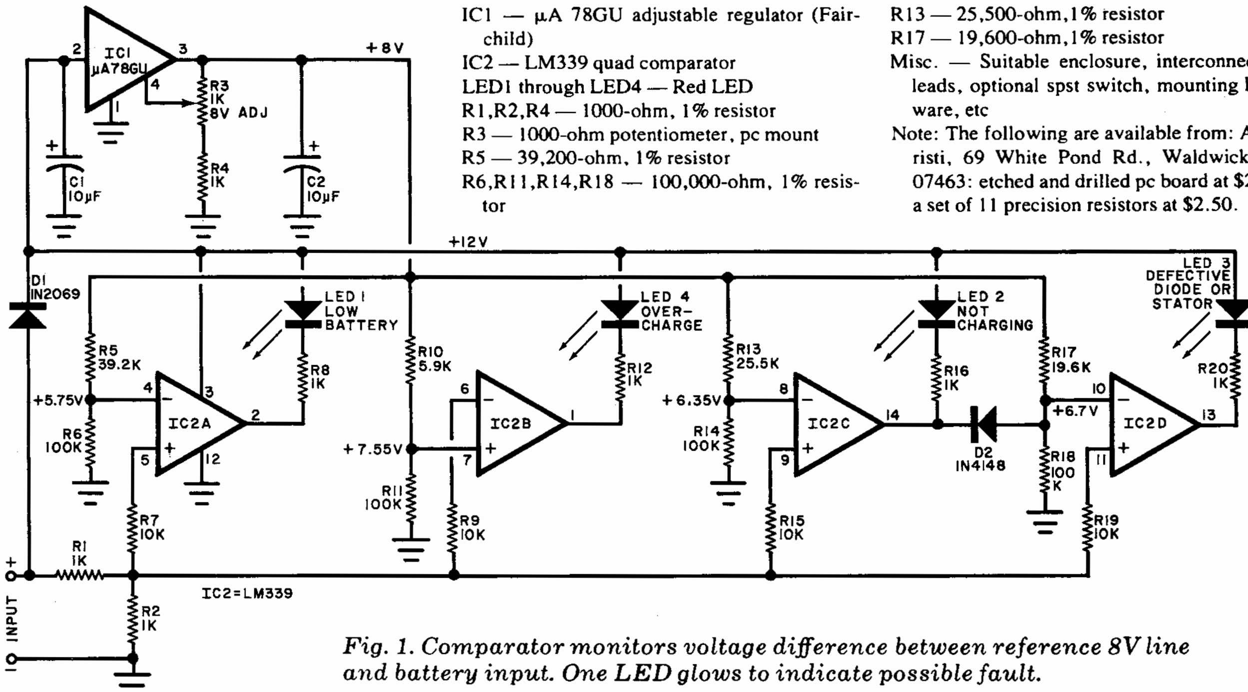


Fig. 1. Comparator monitors voltage difference between reference 8V line and battery input. One LED glows to indicate possible fault.

A properly operating battery and charging system will have a battery terminal voltage of about 12.6 volts when the engine has been turned off for some time, and between 13.5 and 15.0 volts when the engine is running and the battery is being charged.

If the battery voltage is below 11.5 volts with the engine not running, the battery is either in a very low state of charge or has a damaged cell. If the battery voltage is less than 12.7 volts with the engine running, the charging system is inoperative. If the voltage is less than 13.4 volts, then there is insufficient charging; if there is more than 15.1 volts across the battery terminals, overcharging is occuring.

The circuit shown in Fig. 1 constantly monitors the battery voltage, while LED displays indicate any improper electrical condition. The basic reference voltage for the monitor is formed by *IC1* which is an adjustable voltage regulator that is set to a precise 8-volt output.

This voltage reference is fed to four precision voltage-divider networks (*R5/R6, R10/R11, R13/R14* and *R17/R18*) that provide levels of 5.75, 7.55, 6.35 and 6.7 volts respectively), to individual sections of *IC2*. By feeding half the battery voltage to the noninverting input, the corresponding voltages then become 11.5, 15.1, 12.7 and 13.4 volts.

In *IC2A, C* and *D*, the precision reference voltage is fed to the inverting input (-) of the comparator, while half the system's battery voltage (via divider *R1, R2*) is coupled to the noninverting (+) input. As long as the voltage at the noninverting input is greater than the voltage applied to the inverting input, the output of the comparator is high. The associated LED is thus extinguished, indicating that the system is normal for that particular voltage level.

Should the battery voltage drop below the reference level, the comparator output drops to zero, causing the associated LED to indicate a malfunction.

Note that *IC2B* has its input terminals reversed; that is, the reference voltage is applied to the noninverting input while the battery voltage is applied to the inverting input. This causes its associated LED to glow if the battery voltage exceeds the reference level. This condition is also caused by a fault in the charging system. Diode *D2* is connected between the output of *IC2C* and the inverting input of *IC2D* to prevent *LED3* from lighting if *LED2* is glowing. This not only prevents the two indicators from lighting at the same time, but also provides a positive indication of a particular type of fault in the charging system.

Diode *D1* is connected in series with the positive input lead to protect the circuit against damage caused by an accidental reversal of the input leads.

Construction. The circuit can be assembled on a small pc board such as that shown in Fig. 2. Observe the polarities of the two diodes and two polarized capacitors. A 14-pin socket can be used for *IC2*. Pin 1 of *IC2* can be identified by a small dot or mark on the plastic case.

The four LEDs can be mounted where they are easily observed, and then connected to their respective pads on the pc board. Each LED must be clearly identified as to indicated fault.

A long length of insulated wire can be connected between the monitor positive input and the battery positive terminal The monitor's negative input may be connected to a chassis ground.

Test and adjustment. A 0- to 16-volt dc power supply and an accurate dc voltmeter are used to test the monitor.

Observing the correct polarity, connect the two monitor input leads to the power supply, and set the power supply for a 12-volt output.

Connect the voltmeter positive lead to *IC1* pin 3, and the negative lead to ground. Adjust *R3* until the voltmeter indicates precisely 8 volts.

Connect the voltmeter across the

power supply, then reduce the supply down to 11 volts. Both *LED1* (Low Battery) and *LED2* (Not Charging) indicators should be glowing. The other two LED's should be dark.

Slowly increase the power supply voltage until *LED1* is extinguished. This should occur between 11.4 and 11.6 volts. As the power supply output is increased, note that *LED2* should extinguish between 12.6 and 12.8 volts, and *LED3* (Defective Diode or Stator) should light when *LED2* goes out.

As the power supply output is further increased, *LED3* should go out when the voltage is between 13.3 and 13.5 volts. *LED4* (Overcharge) should glow when the supply voltage exceeds 15.1 volts. *Do not raise the power supply output above 16 volts!*

If any of the LEDs do not operate properly, check the 8-volt line, then make sure that the correct precision resistors are used at the proper comparator inputs.

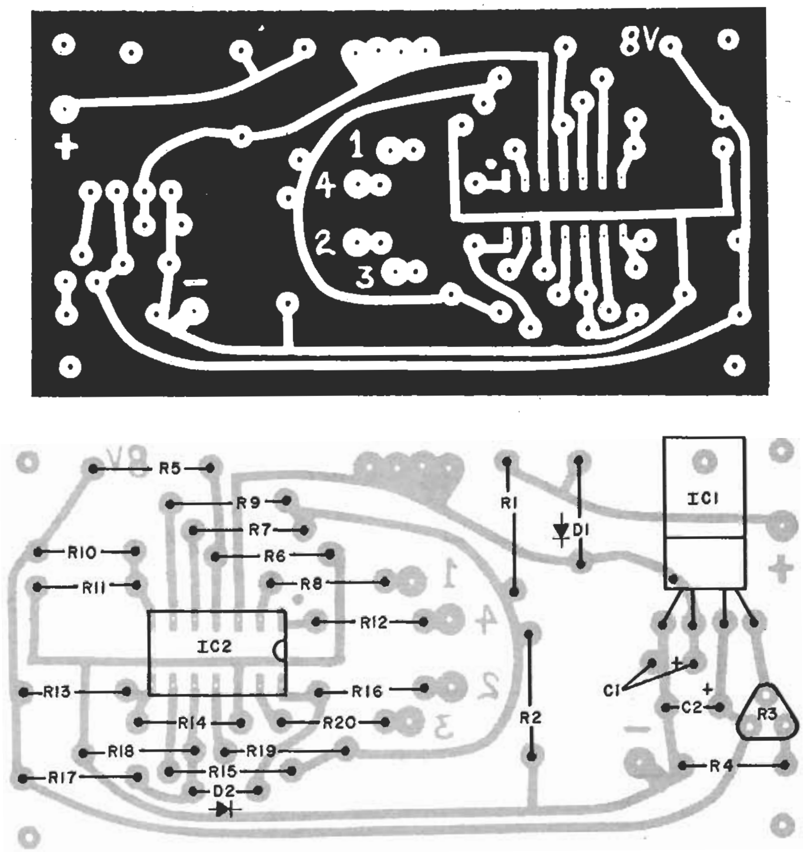


Fig. 2. Actual size etching and drilling guide for pc board is at top; component layout diagram below.

Using the Monitor. The following steps should be performed in sequence when checking an automotive battery and charging system. Connect the monitor to the vehicle's battery terminals, being sure to observe correct polarity for each terminal.

An spst switch can be connected between the monitor positive input lead and the battery so that the monitor can be disabled when not in use. Make sure that the alternator drive belt has the proper tension.

Before the engine is started, the Not Charging (*LED2*) or Defective Diode or Stator (*LED3*) will be lighted since the battery is not yet being charged. If the Low Battery (*LED1*) glows, the battery voltage is less than 11.5 volts. This can be caused by a state of deep discharge or a faulty cell. If this LED is glowing, investigate the battery before proceeding.

When the engine is started and everything is normal, all the LEDs should be dark. If there is an electrical malfunction, then one of the LEDs will glow.

If the Not Charging LED glows, the terminal voltage of the battery is less than 12.7. Thus, the alternator is not delivering any current to the battery. This can be caused by an open regulator circuit or open alternator field.

If the Defective Diode or Stator LED glows, the terminal voltage of the battery is less than 13.4 volts. This can be caused by a shorted diode or stator in the alternator, or an improperly adjusted regulator.

If the Overcharging LED glows, the terminal voltage of the battery is greater than 15.1 volts. This can be caused by a shorted or misadjusted regulator.

If no LEDs glow with the engine running, load the alternator by turning on the headlights' high beams, the air conditioner, the high-speed blower, the high-speed windshield wipers and the radio. Then moderately race the engine. All LEDSs should be extinguished.

If the Defective Diode or Stator LED is now lighted, but was extinguished with no load on the alternator, the most likely cause of the problem is an open diode in the alternator.

This low-cost, easy-to-use automotive instrument can save the builder many dollars of repair costs, making it a worthwhile investment in parts and labor. ◇

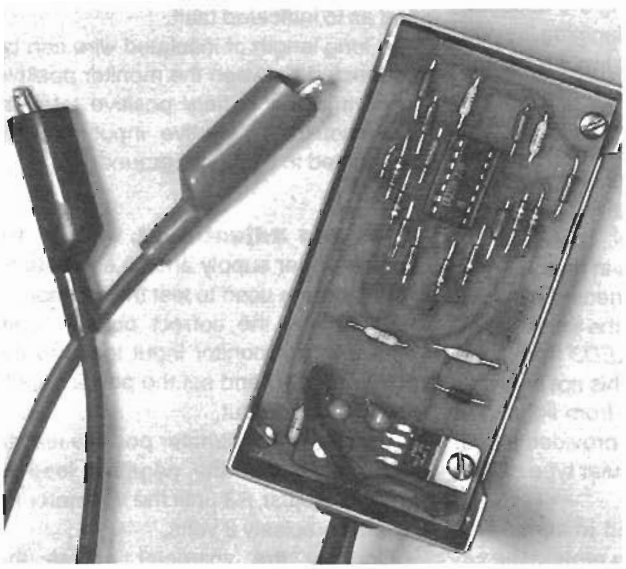


Photo of interior of author's prototype shows components mounted on printed circuit board and connections to enclosure.