Testing Electrical Systems with a Digital Multimeter

Perhaps the most important tool you'll use in troubleshooting auto electrical systems is the multimeter. Basic multimeters measures voltage, current and resistance, while more elaborate multimeters, such as the Fluke 78, or Fluke 88 have featues that can check things such as frequency, duty cycle, dwell, make diode tests, and even measure temperature, pressure and vacuum.

Alternator AC Leakage

An alternator generates current and voltage by the principles of electromagnetic induction. Accessories connected to the vehicles charging system require a steady supply of direct current at a relatively steady voltage level. You can't charge a battery with alternating current, so it must be rectified to direct current.

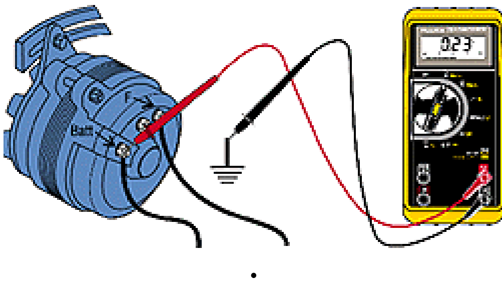

Fig 4 - Checking Ripple Voltage *Ripple voltage or (AC voltage) can be measured by switching your DMM to AC and connecting the black lead to a good ground and the red lead to the "BAT" terminal on the back of the alternator, (not at the battery). A good alternator should measure less than .5 VAC with the engine running. A higher reading indicates damaged alternator diodes.*

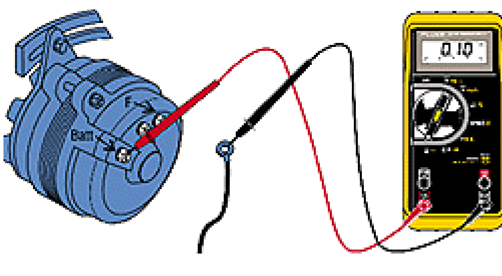

Fig 5 - Alternator Leakage Current *To check alternator diode leakage, connect the multimeter in series with the alternator output terminal when the car is not running. Leakage current should be a couple of milliamps at most; more often, it will be on the order of 0.5 milliamps. Use care when disconnecting the alternator output wire; make sure the battery is disconnected first.*

Batteries

Charging system problems often come to you as a "no-start" complaint. The battery will have discharged and the starter won't crank the engine. The first step is to test the battery and charge it if necessary (fig 1).

No-Load Test

Voltage	Percent Charge
12.60V to 12.72V	100%
12.45V	75%
12.30V	50%
12.15V	25%

Readings obtained at 80°F (27°C)

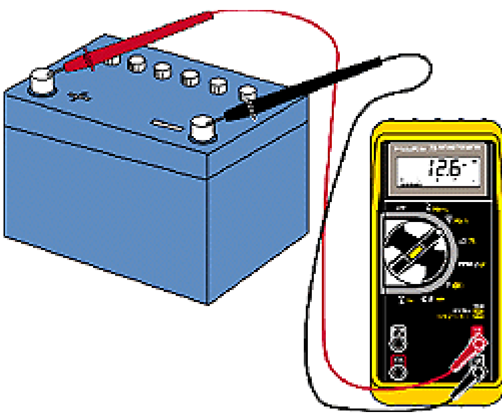

Fig 1 - Measuring System Voltage *Bleed the surface charge from the battery by turning on the headlights for a minute. Measure the voltage across the battery terminals with the lights off (see chart). When possible, individual cell specific gravity should be checked with a hydrometer. A load test should be done to indicate battery performance under load. Voltage tests*

Ford BP/MAP Sensor

The barometric pressure/manifold absolute pressure (BP/MAP) sensor is critical in determining fuel mixture and spark advance under varying loads. Much like a Throttle Position Sensor, it must provide a smooth, gradual change in output, or driveability problems can occur. In some instances, a BP/MAP sensor can deviate without setting trouble codes. To verify its operation, you need to check its output over its full operating range.

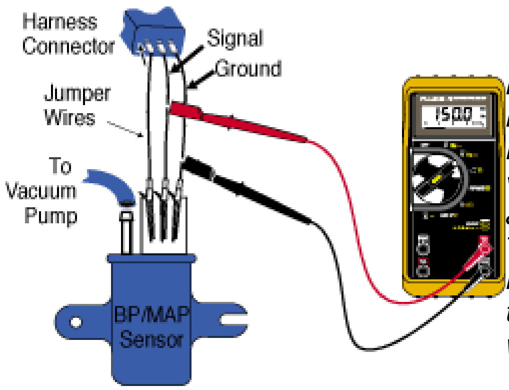

Fig 8 - Using DC-Coupled Hz to Check BP/MAP Sensors *To test the performance of a BP/MAP sensor, graph its frequency output at various levels of vacuum. Start with the sensor at 0" Hg (0 cm /hg) and read its frequency. Then note the frequency at each increase of 1" Hg (cm Hg). When you plot these frequencies, they should be in a straight line. The frequency will decrease with an increase in vacuum.*

Hall-Effect Position Sensors

Hall-Effect position sensors have replaced ignition points in many distributors and are used to directly detect crank and/or cam position on distributorless ignition systems (DIS), telling the computer when to fire the coils. Hall-Effect sensors produce a voltage proportional to the strength of a magnetic field passing through them, which can come from a permanent magnet or an electric current. Since magnetic field strength is proportional to an electric current, Hall-Effect sensors can measure current. They convert the magnetic field into millivolts that can be read by a DMM.

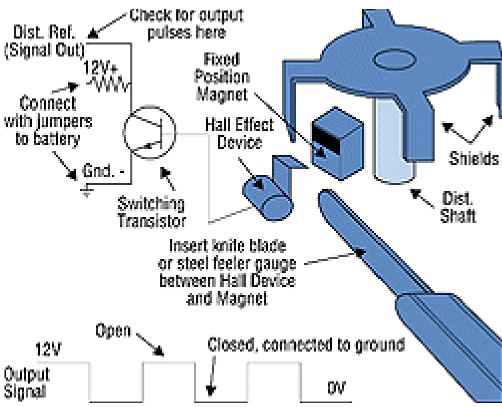

Fig 14 - Checking Hall-Effect Sensors *Check for reference voltage from battery at connector. Hall sensors require power where magnetic sensors do not. To test sensor: connect +12V from battery to power terminal, set DMM to measure volts and connect it between signal output and ground. Insert feeler blade between sensor and magnet while watching for the bar graph to move. Signal should vary from 12V to 0V.*

Magnetic Position Sensors

The magnetic type of position sensor is simply a magnet with a coil of wire wrapped around it. The clearance between the pickup and reluctor is critical. Be sure to check it. Specs are usually between 0.030" and 0.070" (0.8 mm to 1.8 mm).

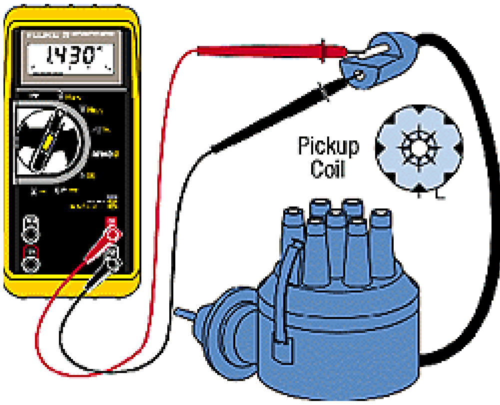

Fig 15 - Checking For Pulses from Magnetic Distributor Pickup *Disconnect the distributor from the ignition module. Connect the DMM across the pickup and set it to AC volts. When the engine is cranked, pulses should appear on the bar graph. If no pulses appear, it is likely the reluctor wheel or the magnetic pickup is faulty. Use this technique for other magnetic position sensors too. On GM cars, remove the distributor cap for access.*

Example of Ohm's Law

If you measure 0.5V across a ground connection in a starter circuit, and the starter draws 100 amps, calculate the resistance as follows:

Ohm's Law $E = I \times R$

$0.5V = 100A \times R$

Solve for R

$$R = \frac{0.5V}{100A}$$

Therefore R = .005 Ohm

.005 ohm is too much, so clean the connection. .5 Volts tells you the same thing—the connection is dirty or corroded.

Spark Plug Wires

Plug wires should be checked if your scope indicates that there may be a problem or if they're more than a couple of years old. Not all wires indicate the date they were manufactured. Due to the heat of the spark plug insulator, a spark plug boot may bond to the spark plug. Pulling a spark plug boot straight off the spark plug can damage the delicate conductor inside the insulated wire. Rotate the boot to free it before pulling it off. If you suspect bad wires, test the resistance of the wire while gently twisting and bending it. Resistance values should be about 10,000 ohms per foot (30,000 ohms per meter), depending on the type of wire being tested; some may be considerably less. You should compare readings to other spark plug wires on the engine to insure the accuracy of the test.

Throttle Position Sensor (TPS)

Throttle position sensors (TPSs) are a common source of faults in today's on-board computers. A TPS is simply a variable resistor connected to the throttle shaft. Some people think of it as a replacement for an accelerator pump on throttle body or port fuel injected engines. But it is much more. It tells the on-board computer how far the throttle is open, whether it is opening or closing—and how fast. As its resistance changes, so does the voltage signal returning to the computer. The TPS can be tested by watching either the voltage or resistance change, using the analog pointer on any Fluke DMM.

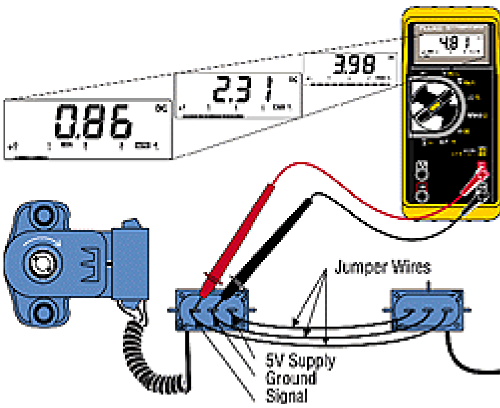

Fig 11 - Testing a Throttle Position Sensor *Use the Min/Max recording feature of the Fluke 78 to check your base TPS setting at idle; to get the maximum reading, depress the accelerator. By comparing these readings to those you get when you open the throttle by hand, you can verify whether the throttle cable and/or linkage is properly adjusted to allow full throttle opening. If it isn't, this may be the source of a problem with poor acceleration.*