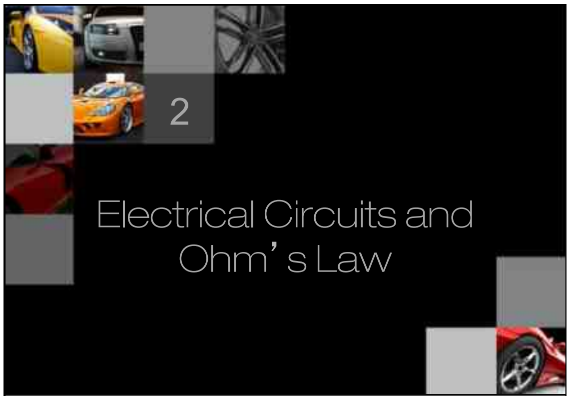


FIGURE 2.1 All complete circuits must have a power source, a power path, protection (fuse), an electrical load (light bulb in this case), and a return path back to the power source.

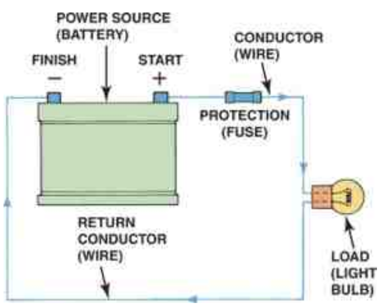


FIGURE 2.2 The return path back to the battery can be any electrical conductor, such as a copper wire or the metal frame or body of the vehicle.

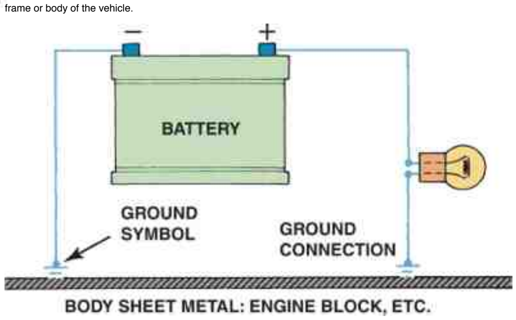


FIGURE 2.3 An electrical switch opens the circuit and no current flows. The switch could also be on the return (ground) path wire.

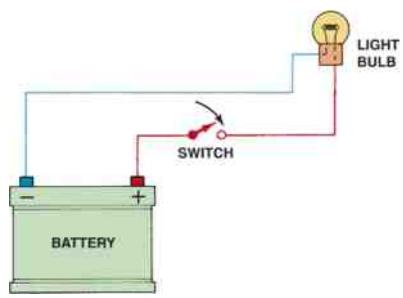
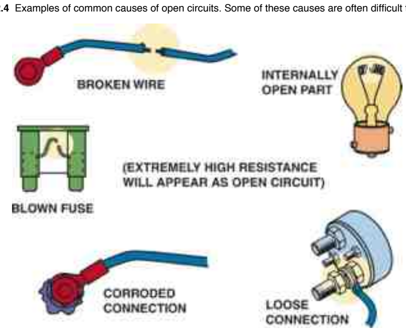


FIGURE 2.4 Examples of common causes of open circuits. Some of these causes are often difficult to find.



TECH TIP

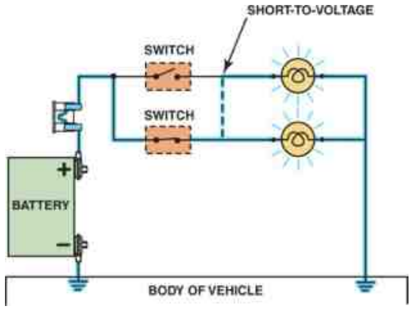
"Open" Is a Four-Letter Word

An open in a circuit breaks the path of current flow. The open can be any break in the power side, load, or ground side of a circuit. A switch is often used to close and open a circuit to turn it on and off. Just remember,

Open = no current flow
Closed = current flow

Trying to locate an open circuit in a vehicle is often difficult and may cause the technician to use other four-letter words, such as "HELP"!

FIGURE 2.5 A short circuit permits electrical current to bypass some or all of the resistance in the circuit.




REAL WORLD FIX

The Short-to-Voltage Story

FIGURE 2.6 A fuse or circuit breaker opens the circuit to prevent possible overheating damage in the event of a short circuit.

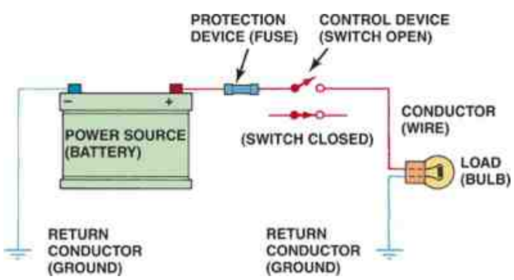
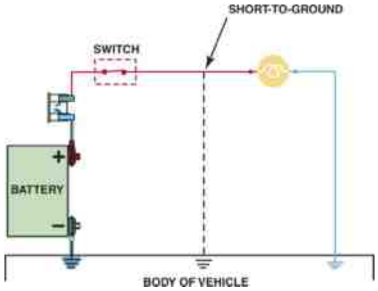


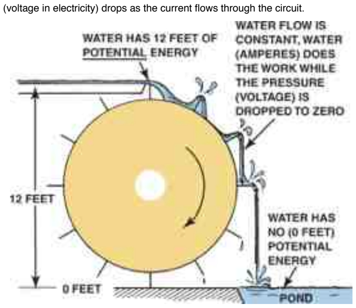
FIGURE 2.7 A short-to-ground affects the power side of the circuit. Current flows directly to the ground return, bypassing some or all of the electrical loads in the circuit. There is no current in the circuit past the short. A short-to ground will also cause the fuse to blow.




TECH TIP

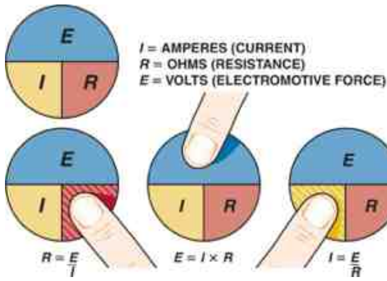
Think of a Waterwheel

FIGURE 2.8 Electrical flow through a circuit is similar to water flowing over a waterwheel. The more the water (amperes in electricity), the greater the amount of work (waterwheel). The amount of water remains constant, yet the pressure (voltage in electricity) drops as the current flows through the circuit.



Electrical Circuits and Ohm's Law

FIGURE 2.9 To calculate one unit of electricity when the other two are known, simply use your finger and cover the unit you do not know. For example, if both voltage (*E*) and resistance (*R*) are known, cover the letter *I* (amperes). Notice that the letter *E* is above the letter *R*, so divide the resistor's value into the voltage to determine the current in the circuit.



Electrical Circuits and Ohm's Law

CHART 2.1 Ohm's law relationship with the three units of electricity.

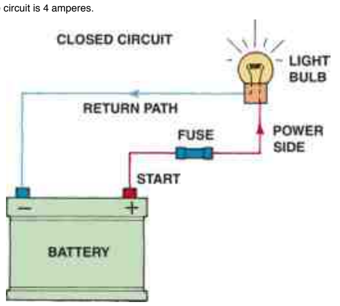
VOLTAGE	RESISTANCE	AMPERAGE
Up	Down	Up
Up	Same	Up
Up	Up	Same
Same	Down	Up
Same	Same	Same
Same	Up	Down
Down	Up	Down
Down	Same	Down

CHART 2-1

NOTE: Before applying Ohm's law, be sure that each unit of electricity is converted into base units. For example, 10 KΩ should be converted to 10,000 ohms and 10 mA should be converted into 0.010 A.

Electrical Circuits and Ohm's Law

FIGURE 2.10 This closed circuit includes a power source, power-side wire, circuit protection (fuse), resistance (bulb), and return path wire. In this circuit, if the battery has 12 volts and the electrical load has 4 ohms, then the current through the circuit is 4 amperes.



TECH TIP

Wattage Increases by the Square of the Voltage

The brightness of a light bulb, such as an automotive headlight or courtesy light, depends on the number of watts available. The watt is the unit by which electrical power is measured. If the battery voltage drops, even slightly, the light becomes noticeably dimmer. The formula for calculating power (P) in watts is $P = I \times E$. This can also be expressed as Watts = Amps × Volts.

According to Ohm's law, $I = \frac{E}{R}$. Therefore, $\frac{E}{R}$ can be substituted for I in the previous formula resulting in $P = \frac{E}{R} \times E$ or $P = \frac{E^2}{R}$.

E^2 means E multiplied by itself. A small change in the voltage (E) has a big effect on the total brightness of the bulb. (Remember, household light bulbs are sold according to their wattage.) Therefore, if the voltage to an automotive bulb is reduced, such as by a poor electrical connection, the brightness of the bulb is greatly affected. A poor electrical ground causes a voltage drop. The voltage at the bulb is reduced and the bulb's brightness is reduced.

FIGURE 2.11 To calculate one unit when the other two are known, simply cover the unknown unit to see what unit needs to be divided or multiplied to arrive at the solution.

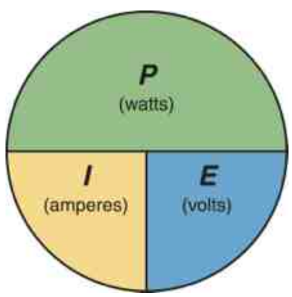


FIGURE 2.12 "Magic circle" of most formulas for problems involving Ohm's law. Each quarter of the "pie" has formulas used to solve for a particular unknown value: current (amperes), in the upper right segment; resistance (ohms), in the lower right; voltage (*E*), in the lower left; and power (watts), in the upper left.