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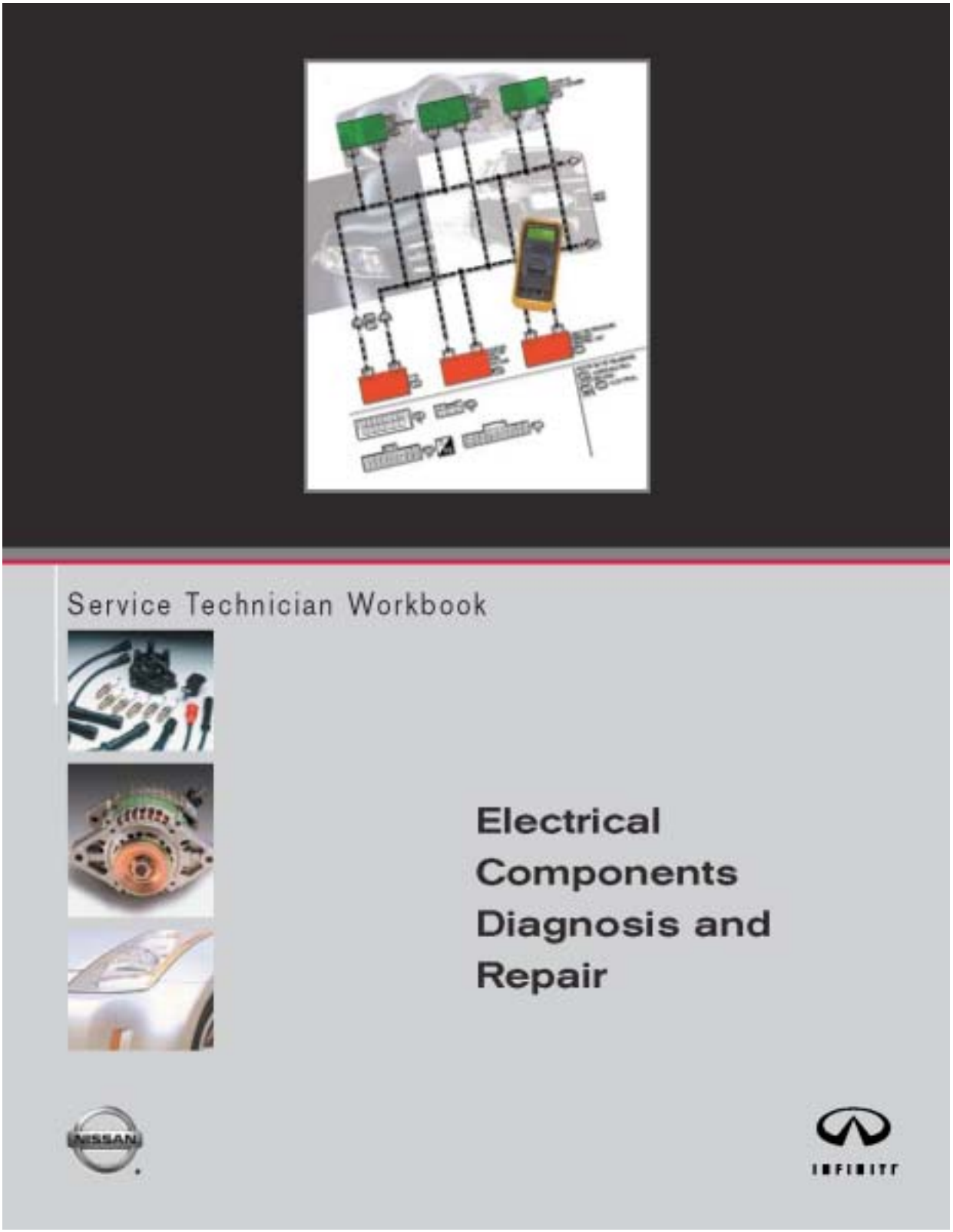

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THROUGH TECHNICIAN CERTIFICATION

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ELECTRICAL COMPONENT DIAGNOSIS AND REPAIR
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ELECTRICAL COMPONENT DIAGNOSIS AND REPAIR OBJECTIVES

Upon completion of this training program, you will be able to:

- Given an Electronic Service Manual (ESM), locate wiring diagram descriptions and interpret the information as stated.
- Given an ESM, interpret wiring information/diagram symbols and answer related questions.
- Given a multimeter, a circuit simulator and a windshield wiper motor circuit, measure available voltage at different points in a circuit and make comparisons for the purpose of diagnosing faults.
- Given a voltmeter and a test circuit, measure voltage drop as specified and evaluate the results against established specifications.
- Given a digital multimeter, a circuit simulator, a service manual, a fuel-injected vehicle and other components, measure resistance and compare to specifications.
- Given a digital multimeter, a circuit test kit with overlay #1, measure current flow through a circuit and evaluate the results.
- Given a combination switch and a combination switch circuit, read a combination switch chart and diagnose various combination switch circuits using a digital multimeter.
- Given a service manual (or ESM), a digital multimeter, a one transfer (1T) relay, circuit test kit with overlay #2, diagnose the operation of a 1T relay.
- Given overlay #3, a service manual and test equipment, test the operation of a vehicle with 1M relay circuit.
- Given a service manual, a digital multimeter, a two make (2M) relay and a circuit test kit with overlay #4, diagnose the operation of a 2M relay.
- Given a test kit with overlay #5, a service manual, digital multimeter and a one make-one break (1M-1B) relay, diagnose the operation of a 1M-1B relay.
- Given a customer's repair order, a service manual and digital multimeter, verify, isolate, repair and recheck the incident in question.
- Given a digital multimeter, electrical components and a car, identify the different meter features, connect the test leads, and perform voltage, resistance, amperage and continuity tests.

- Given a digital multimeter, service manual and an on-vehicle tank gauge unit, test the operation of the fuel tank gauge unit and evaluate the test results.
- Given an ASIST/ESM workstation, identify and interpret the symbols used in electrical wiring diagrams.
- Given a vehicle, digital multimeter and model 620 tester, test the battery, starter and charging system.

NOTES

TEXT

ELECTRICAL COMPONENT DIAGNOSIS AND REPAIR OVERVIEW

Vehicles use electricity to control and operate many systems such as headlights, windshield wipers and rear window defoggers. Today's vehicles also use sophisticated control units and circuits to add to driving comfort and the driver's control of the vehicle.

Despite the number of electrical circuits in a vehicle, troubleshooting and repair techniques used on all circuits are relatively basic and straightforward, given some basic skills. To repair an electrical problem correctly the first time, you must know how to troubleshoot and repair circuits. This course will provide you with the skills necessary to:

- Verify symptoms by attempting to operate circuits. Verify what is working and what is not working.
- Isolate the source of the malfunction by:

  - tracing current flow paths using wiring diagrams.

  - locating harness connectors using harness layout diagrams.

  - testing electrical circuits using a multimeter.
- Repair electrical problems by:

  - fixing broken wires and poor connections.

  - replacing broken components.

  - adjusting a switch or sensor.
- Recheck to make sure the symptom is fixed. Duplicate conditions that caused the problem, to be sure there are no new problems.

Introduction

The Electrical Component Diagnosis and Repair Course is a four day course covering diagnosis and repair of electrical systems. The Course begins with a review of electrical fundamentals followed by a series of shop exercises. The following skills are emphasized:

- Reading wiring diagrams
- Circuit testing techniques

Each of the exercises will challenge your troubleshooting skills. The objectives for this course were carefully chosen to help you learn a more efficient way to diagnose electrical malfunctions.

General Precautions

- Do not use electrical test equipment on any circuit related to the Supplemental Restraint System (SRS) unless instructed to do so by the service manual or your instructor. SRS circuits are identified by yellow insulation covering the wiring harnesses or yellow harness connectors.
- Do not operate the engine without adequate exhaust ventilation.
- Keep the work area well ventilated and free of any flammable materials. Take special care when handling any flammable or poisonous materials, such as gasoline, refrigerant gas, etc. When working in an enclosed area, be sure to properly ventilate the area before working with hazardous materials.
- Do not smoke while working on the vehicle.
- Before elevating the vehicle, apply wheel chocks or other tire blocks to the wheels to prevent the vehicle from moving. With the vehicle parked on level ground, support it with safety stands at the points designated for proper lifting or use a hoist to support and raise it if needed.
- Before starting repairs or circuit diagnosis which do not require battery power:

  - Switch the ignition OFF.

  - Disconnect the negative battery cable
- To prevent serious burns:

  - Avoid contact with hot metal parts.

  - Do not remove the radiator cap when the engine is hot.
- Before working on the vehicle:

  - Use fender covers, seat covers and floor mats.

  - Be careful that keys, belt buckles or buttons do not scratch painted surfaces.
- Do not touch the terminals of electrical components that are controlled electronically. Static electricity may damage internal electronic components.

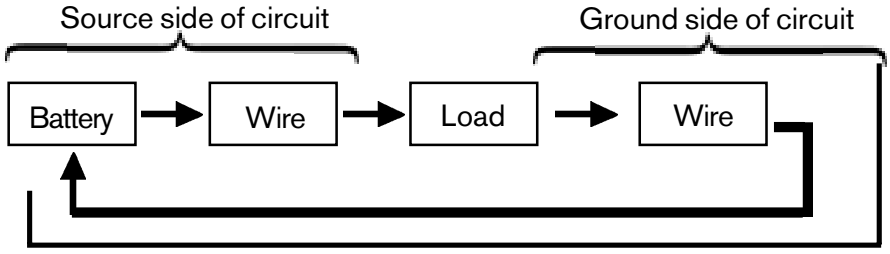
CIRCUIT REQUIREMENTS

Source, Load and Ground

The basis for discussing electricity in vehicles is the circuit. A circuit is a complete path for electricity to flow. Electrical circuits consist of wires, wire connectors, switches, circuit protection devices, relays and electrical loads and grounds. The conventional current flow theory traces current from the source to ground. Despite the complexity of the circuit or the number of parts in the circuit, there are three essential elements all circuits must have to operate:

- Source (voltage)—The battery and the electrical path from the battery to the load. This is the positive (+) side of the circuit.
- Load—Any electrical component that uses electrical energy to perform work. Examples are lights, motors and defroster grids.
- Ground—The electrical path from the load back to the battery. This is the negative (–) side of the circuit.

If any of these essential elements is missing or not working, there is no current flow and the circuit will not operate. Let's look at each of these elements.



Source (Voltage)

The source of voltage is the battery or alternator. The voltage source provides the energy to push current through the circuit, which makes it operate. The source side of the circuit includes all parts between the battery and the load. Refer to the battery rating charts (Page 46) at the end of the text section for recommended battery applications.

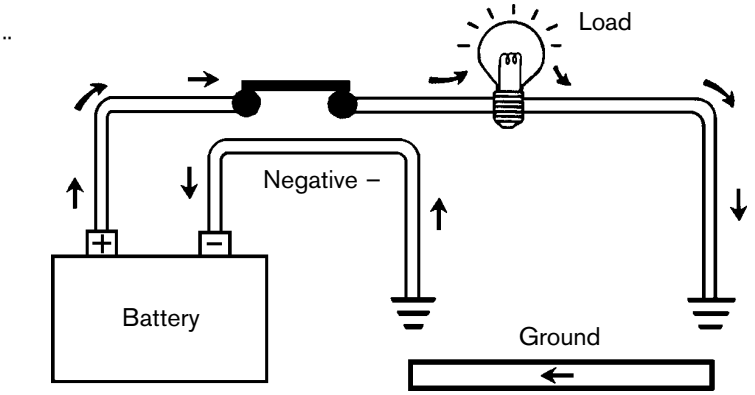
Load

A load is the device that produces heat, light, sound or motion when the circuit is operating. Light bulbs, motors and heating elements, such as cigarette lighters and rear window defoggers, are typical electrical loads. A load always has resistance and consumes (uses up) voltage when the circuit is ON.

Ground

A ground completes the circuit from the load back to the negative battery post. Notice that a ground path is always on the *other* side of the load. As important as the ground is, it is the part of the circuit that is most often overlooked.

Perhaps a reason for this is that technicians often think that circuit grounds consist of separate wires. Using a separate ground wire to connect each vehicle circuit to the battery is not practical. Most electrical circuits complete the ground path directly to the vehicle chassis or body.



When source, load and ground are all operating correctly, a complete path for current flow exists. This is a complete (or closed) circuit. An open circuit occurs when the electrical path is interrupted. This might occur when a switch is open, a light bulb burns out, a wire breaks or a wire connector becomes disconnected.

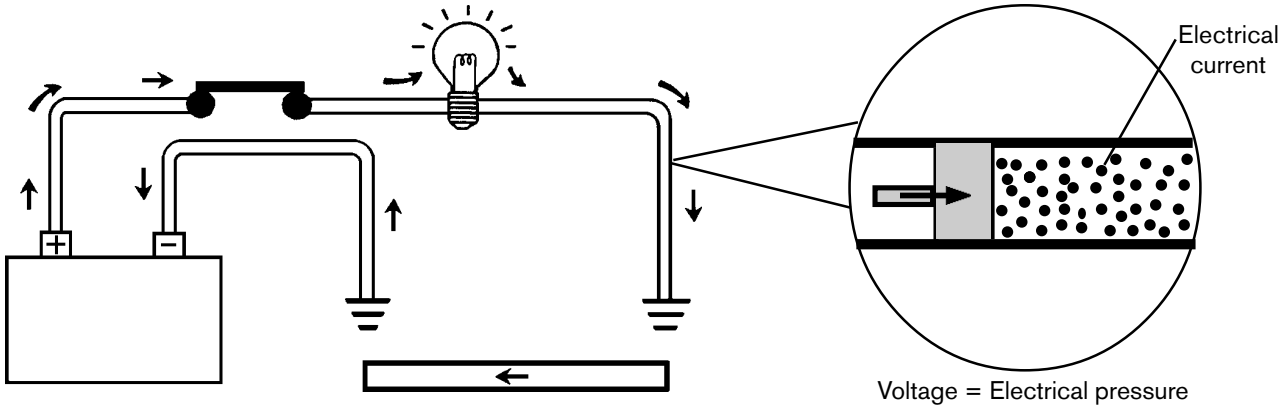
Voltage, Amperage and Resistance

Working circuits contain these three electrical elements:

- Voltage - The electrical pressure that pushes current through the circuit.
- Amperage - Flow of current moving in a circuit.
- Resistance - Opposition to the flow of current.

Voltage (Symbol: V)

Voltage is the electrical pressure that pushes current through a circuit. Nissan and Infiniti vehicles all use 12 volt batteries, but the system operates at up to 14.7 volts while the engine is running. The charging system provides the additional voltage to keep the battery charged.



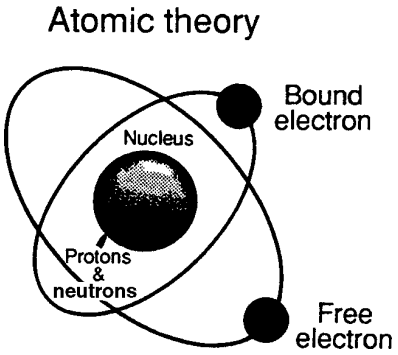
Amperage (Symbol: A)

Amperage is the measurement of current flow in a circuit. Current does not flow unless voltage is present to push it through a circuit.

Research in chemistry and physics has established the electron theory to help explain what electricity is and how it is used.

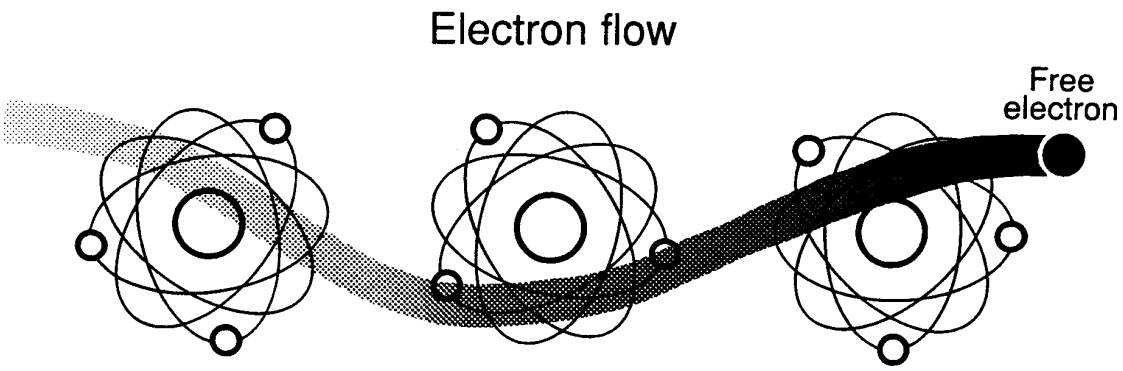
The electron theory states that all matter is made up of atoms. Atoms contain three types of smaller particles called:

- Protons
- Neutrons
- Electrons



Protons, which have a positive electrical charge, combine with neutrons (which have no electrical charge), to form the center or nucleus of the atom. Electrons have a negative electrical charge and orbit around the nucleus, much like the planets in our solar system orbit around the sun.

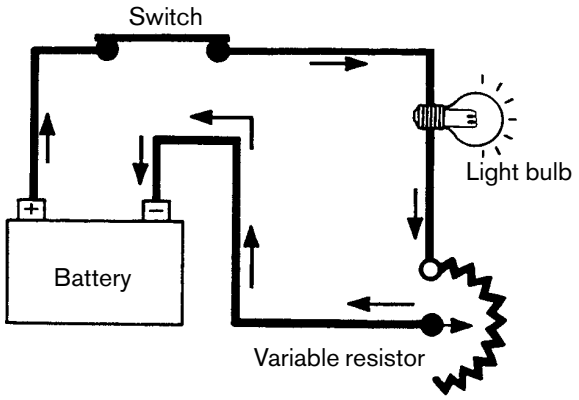
Certain materials such as copper and steel contain free electrons which can be pushed from one atom to the next. This movement of electrons occurs in one direction, creating a chain reaction. The chain reaction in which free electrons move from one atom to the next is called *current flow* or *electricity*.



Resistance (Symbol: Ω)

Resistance opposes current flow in a circuit and is measured in Ohms.

Resistors are electrical devices that restrict current flow in a circuit. Because they restrict current flow, voltage decreases as current is pushed through a resistor. Two types of resistors are used in automotive circuits. A fixed resistor has a set resistance in a circuit. A variable resistor, such as a dimmer control, changes the amount of current flow by mechanically changing its resistance.



Earlier, we spoke of a circuit's requirements for source voltage, load and ground. The load is the device that provides heat, light, or motion. When the resistance of the circuit load is in the normal range, with power applied and a ground connected, the circuit operates as designed. However, if either the source, load or ground is out of balance, the circuit will malfunction.

For example, suppose the battery voltage drops below the normal range. Circuits such as the starting circuit cannot operate as designed. In such cases, the customer may complain of hard starting.

- Malfunctions occur when resistance in a circuit increases or decreases abnormally.
- Increased circuit resistance can be caused by loose connections, corroded wire connectors or dirty switch contacts. These conditions create unwanted resistance that reduces the normal flow of current needed to operate the load. This causes bulbs to be dim and motors to turn slowly because voltage is used up by the unwanted resistance—the circuit has to work harder.
- Decreased circuit resistance increases current flow in a circuit. This can be caused by a partially shorted load. The result is a blown fuse. In some cases, higher than normal current flow can overheat and burn wires and connectors.

The following chart summarizes the terms we've just described. We'll discuss circuit diagnosis in a later section of this manual.

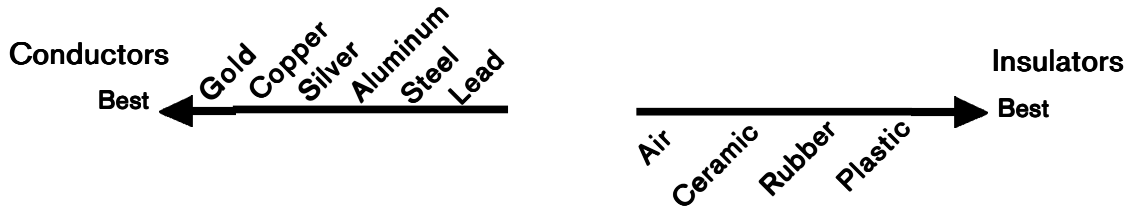
Term	Definition	Unit of Measure	Symbol
Voltage (E)	Electrical pressure	Volt	V
Amperage (I)	Current flow	Amp	A
Resistance (R)	Opposition to current flow	Ohm	Ω

Conductors

Conductors are devices such as wires, that provide a path for current to flow. Some materials conduct electricity much better than others. Copper and steel are good conductors. Gold and silver are even better conductors because they have even more orbiting electrons. Since gold and silver are quite expensive, they are used sparingly on circuits such as the Supplemental Restraint System (SRS).

Insulators

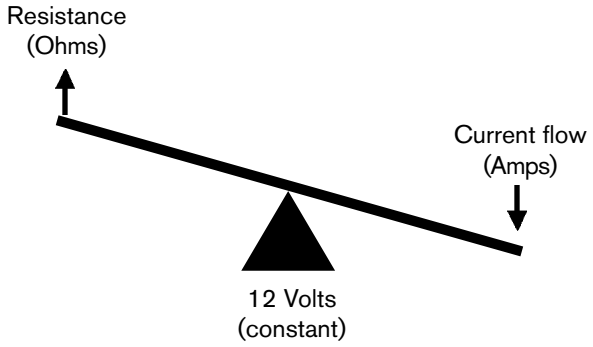
Materials which do not conduct electricity are called insulators. Materials such as wood, glass, rubber and plastic are some examples of insulators. These materials are made of atoms whose electrons are very tightly bound to the nucleus and cannot easily move to other atoms. In vehicle wiring harnesses, the insulation isolates each wire so current flows only through the intended path.



Ohm's Law

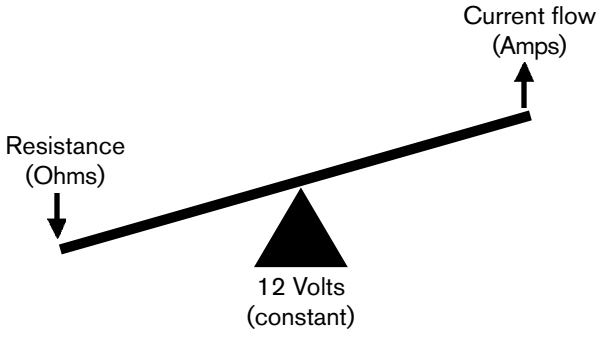
In 1826, a German physicist named Georg Ohm developed a theory about electricity. Simply stated, there is a relationship between voltage, resistance and amperage. To apply this in a practical sense, consider the following two examples:

1. If voltage (volts) stays constant and circuit resistance (Ohms) increases, current flow (amps) decreases.



Cause	Effect
Corrosion	Dim bulb
Loose ground	Fan runs slow

2. If voltage stays constant and circuit resistance decreases, current flow increases.



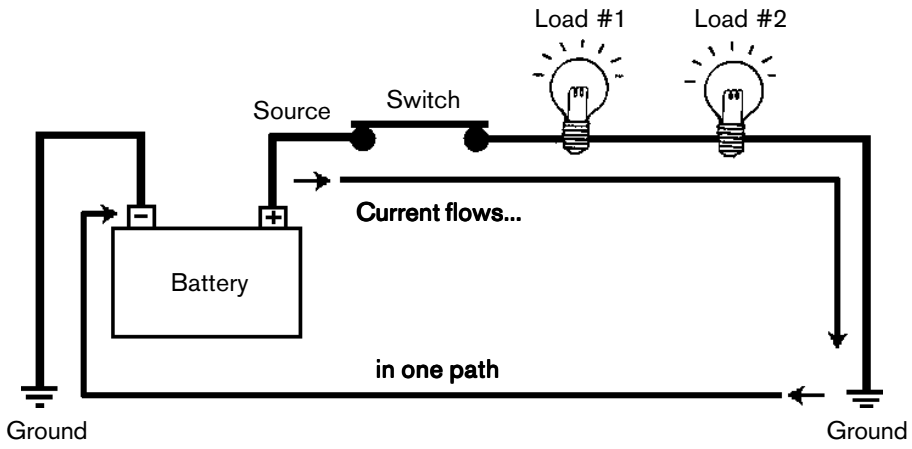
Cause	Effect
Short circuit	Fuse blows, circuit stops working

Circuit Types

As previously stated, all circuits must have source, load and ground to operate properly. The way in which these circuit elements are put together can be classified as either parallel, series, or series-parallel.

Series Circuits

In a series circuit, the source, load and ground are arranged so current has only one path through the circuit. Thus, the current flow (amps) will be the same no matter where it is measured in the circuit. However, voltage in a series circuit decreases as current passes through each load.



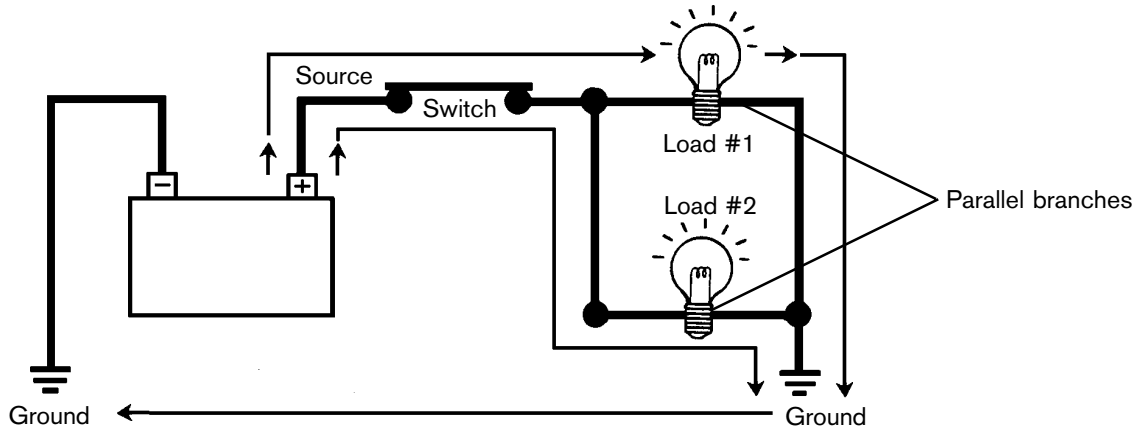
Note: If the resistance of the loads are equal, the available voltage divides equally between the loads.

A series circuit will operate if there are no opens in the circuit. In the circuit above, if the switch fails (creating an open circuit), no current will flow and neither bulb will light.

Troubleshooting Tip #1:
An open at any point in a series circuit will prevent the entire circuit from operating.

Parallel Circuits

In a parallel circuit there are two or more paths for current to flow to ground. The tail light circuit is an example of a parallel circuit. If one of the bulbs in a parallel circuit burns out, current will continue to flow through the other path in the circuit and the other bulb(s) will still operate. In the example below, if one of the bulbs does not work, current will continue to flow through the other path in the circuit and the other bulb will still light.

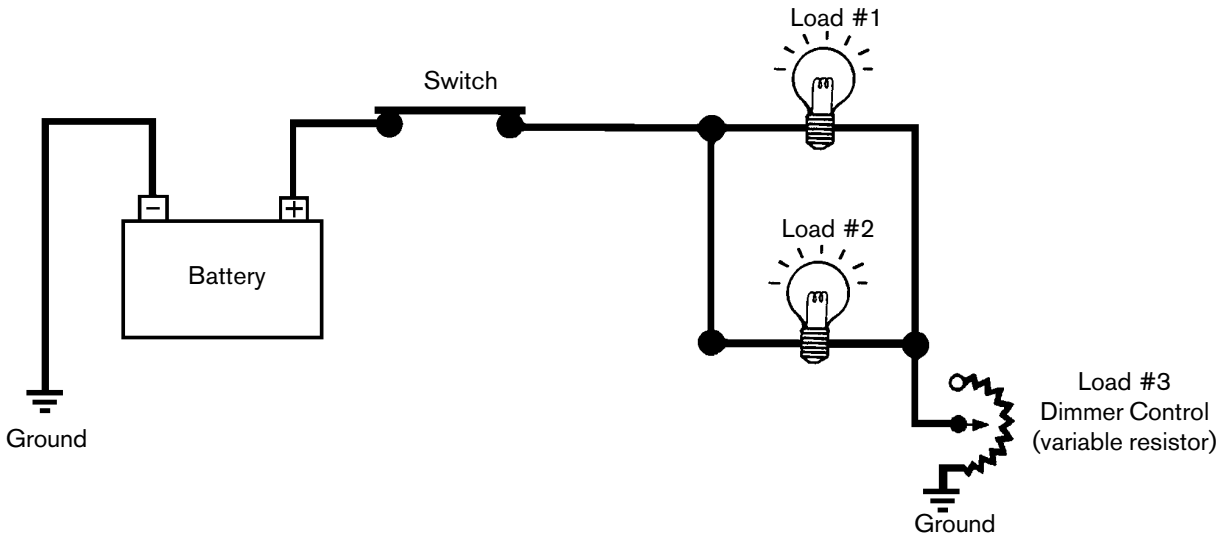


Troubleshooting Tip #2:

An open circuit in a parallel branch prevents only the load in the open path from operating.

Series-Parallel Circuits

Besides series and parallel circuits, some vehicles also have series-parallel circuits. A series-parallel circuit is a combination of the two circuit types. The parallel part of the circuit (load 1 and 2) can be diagnosed as a parallel circuit while the series part of the circuit (load 3) is diagnosed the same way as a series circuit.



Series-parallel circuits typically contain a dropping resistor either before the circuit branches or in the ground side of the circuit after the loads. One common example of a series-parallel circuit is the dash light circuit. The dimmer control (variable resistor) is installed in series between the parallel loads (bulbs) and the circuit ground.