

Lecture 2:

Electronic Fabrication
(ETB -3118)

General Course Information

➤ Textbooks / References:

- Class Notes
- Introduction to Micro Electronic Fabrication. Vol 5, Richard Jager, 2001
- Micro electronic Fabrication: A practical guide to semiconductor processing, Peter Van Zant
- ULSI design by Chang & Sze
- Science and Engg of micro electronic fabrication by Stephan A Campbell

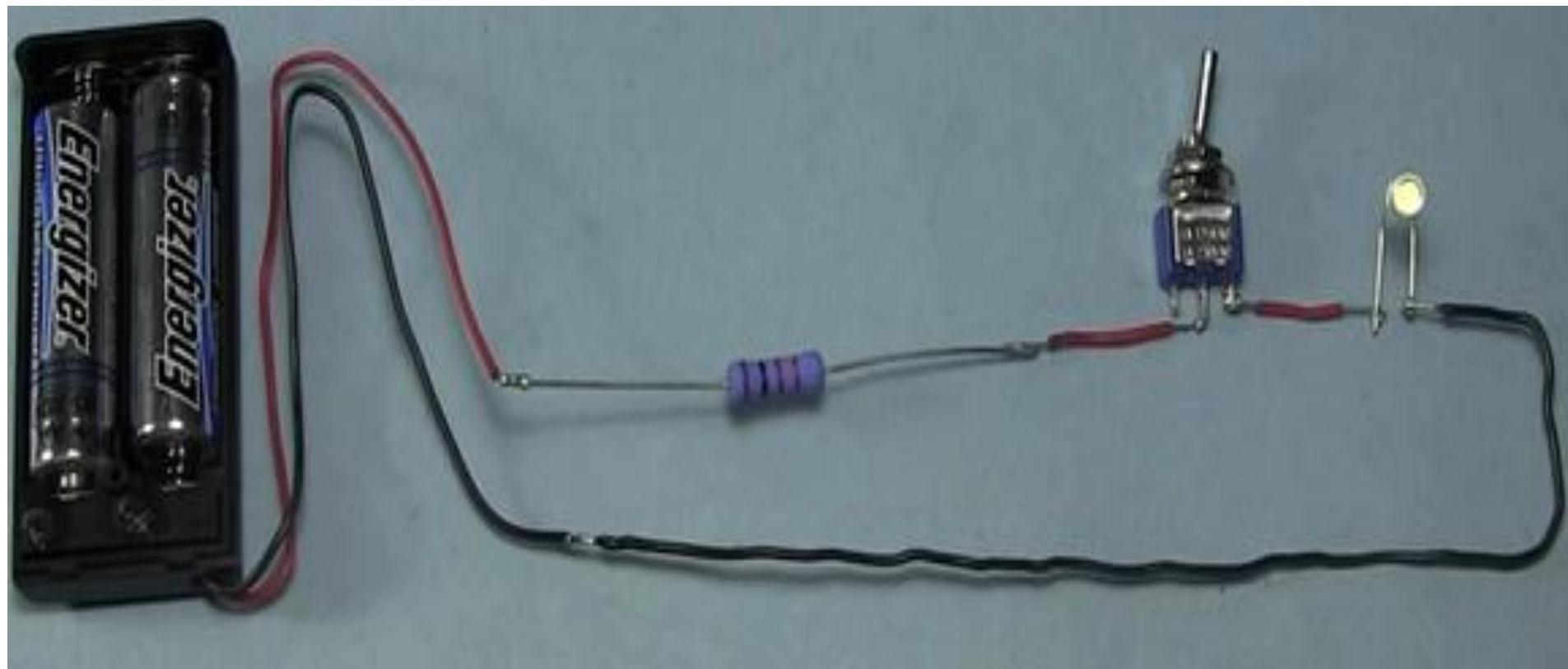
➤ INTERNET:

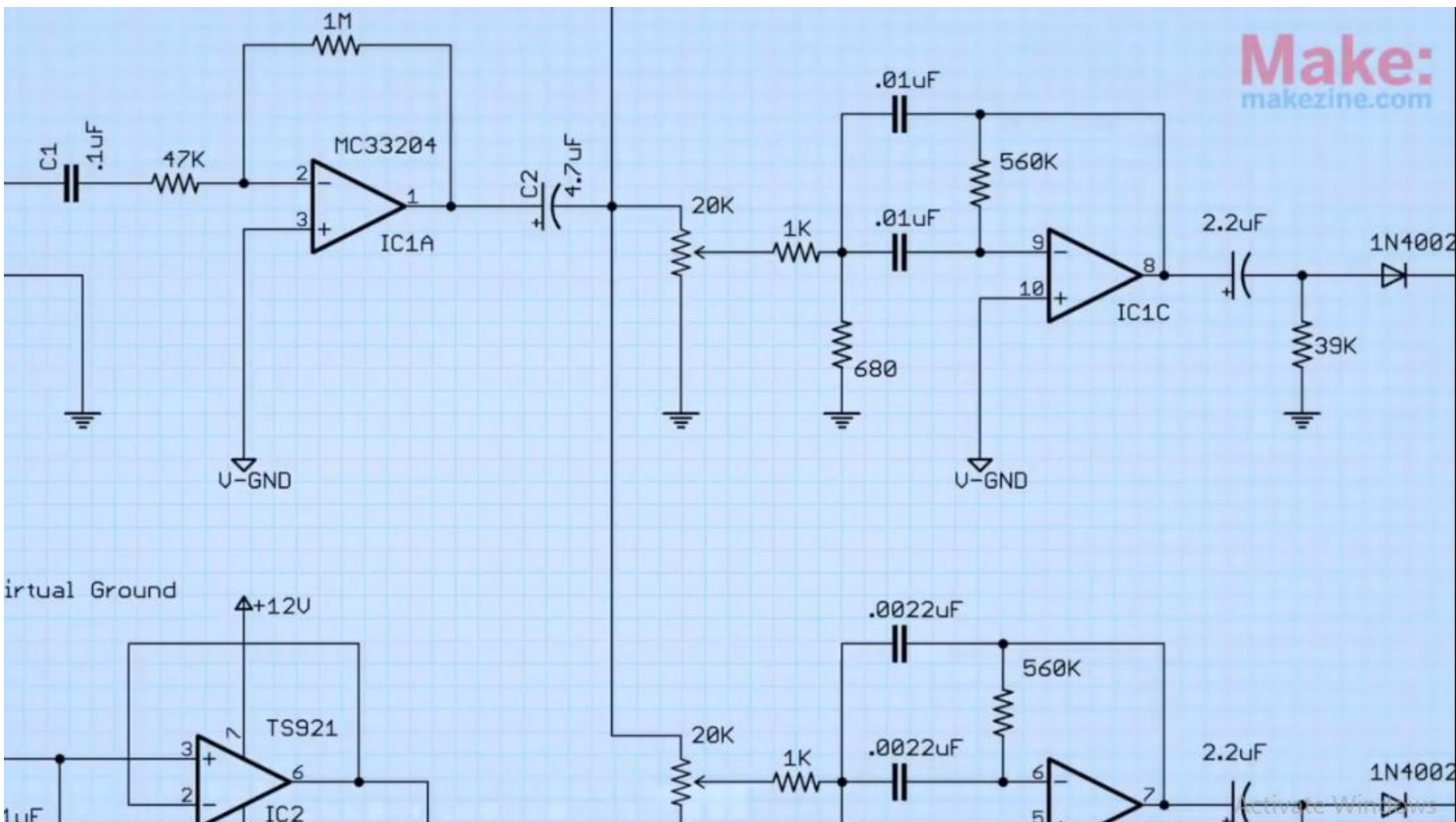
- www.semiconductor.net
- www.eedesign.com (mostly design related though)
- www.intel.com/research/silicon/

Learning Context

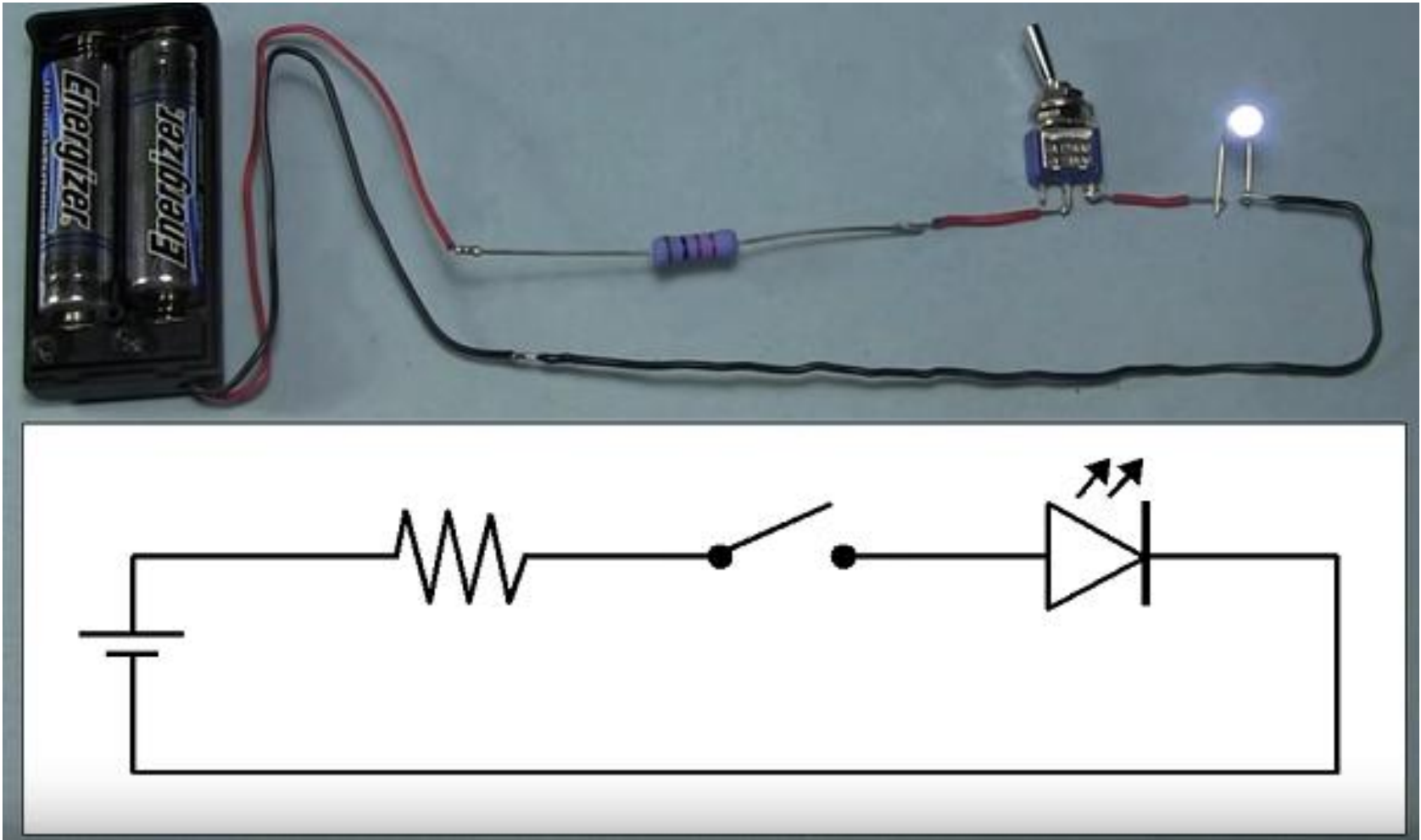
- Schematic design; schematic capture software: PCB board types; PCB design software: simulation software; etching agents; developers; part fields; schematic symbols; component standards and nomenclature; etching process, exposure machines; expose process; Development procedure; treatment process. Drilling practice; board dimensioning. Case design and fabrication; PCB assembly

Very Simple Circuit





What exactly is a schematic?



Schematic is a simple variable representation of electronic circuit designed to be easily read and understood.

- Schematic is not a physical map of the circuit board.

WIRING SCHEMATICS

- A **wiring schematic**, sometimes called a diagram, shows electrical components and wiring using symbols and lines to represent components and wires.

Wiring Schematics Circuit Information

- Many wiring schematics include numbers and letters near components and wires that may confuse readers of the schematic.

<i>Abbreviation</i>	<i>Color</i>
BRN	Brown
BLK	Black
GRN	Green
WHT	White
PPL	Purple
PNK	Pink
TAN	Tan
BLU	Blue
YEL	Yellow
ORN	Orange
DK BLU	Dark blue
LT BLU	Light blue
DK GRN	Dark green
LT GRN	Light green
RED	Red
GRY	Gray

Wiring Schematics Circuit Information

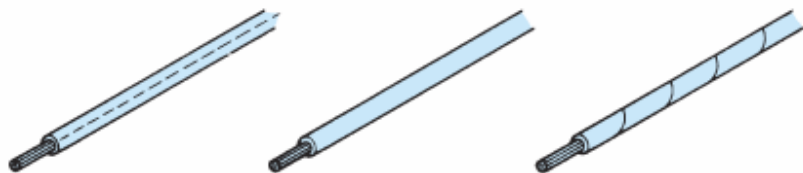


FIGURE 11-1 The center wire is a solid color wire, meaning that the wire has no other identifying tracer or stripe color. The two end wires could be labeled “BRN/WHT,” indicating a brown wire with a white tracer or stripe.

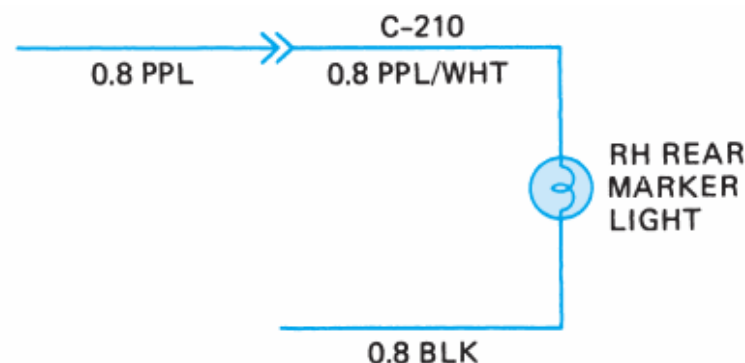


FIGURE 11-2 Typical section of a wiring diagram. Notice that the wire color changes at connection C210. The “.8” represents the metric wire size in square millimeters.

Wiring Schematics Circuit Information



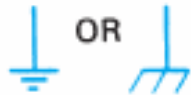
POSITIVE



NEGATIVE



BATTERY



GROUND



FUSE



CIRCUIT BREAKER



RESISTOR



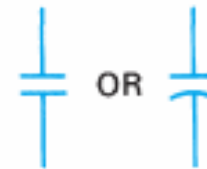
DIODE



ZENER DIODE



LIGHT-EMITTING
DIODE (LED)



CAPACITOR



MOTOR



CASE GROUNDED

Wiring Schematics Circuit Information

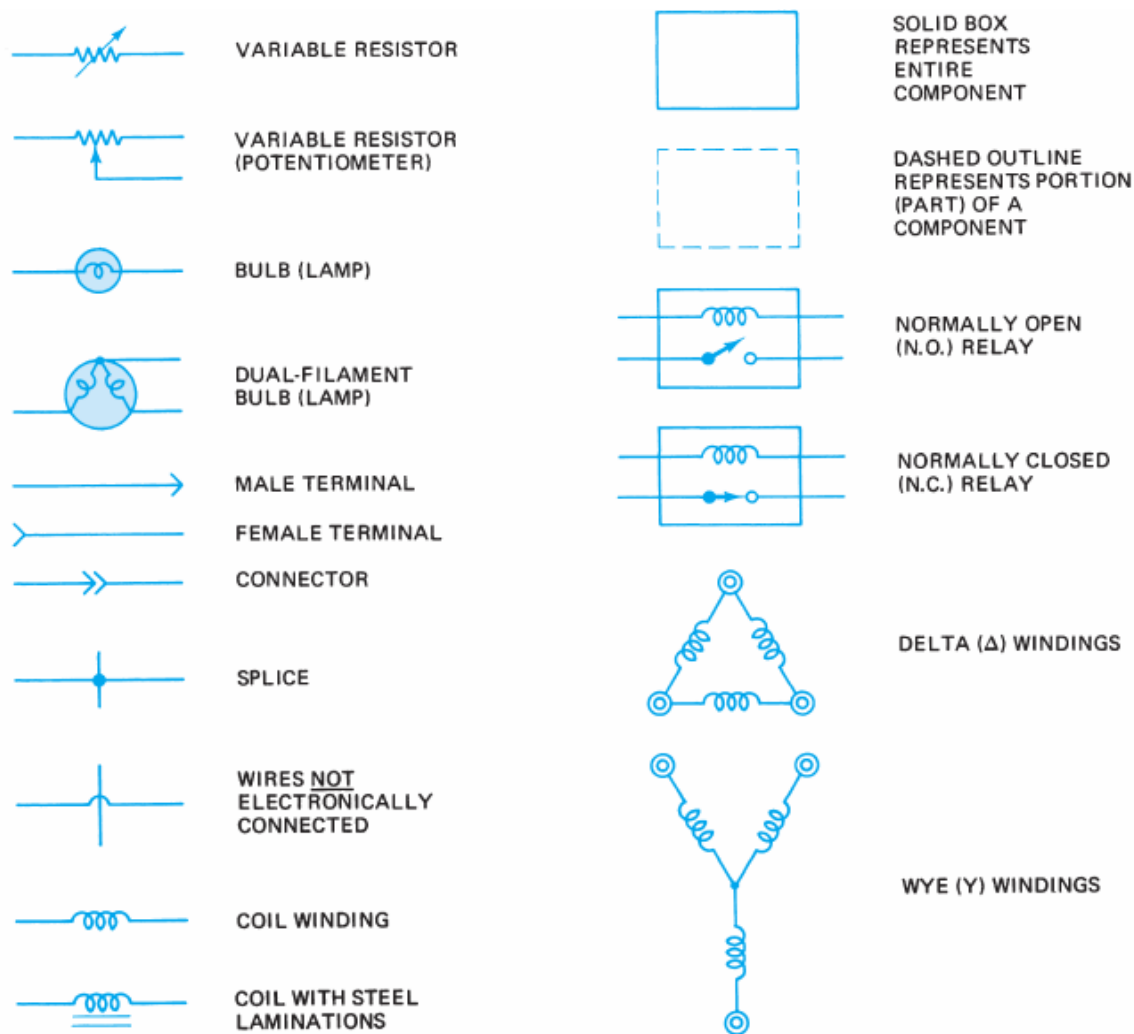


FIGURE 11-3 Typical electrical and electronic symbols used in automotive wiring and circuit diagrams.

READ THE ARROWS

- Wiring diagrams indicate connections by symbols that look like arrows.



FIGURE 11-4 In this typical connector, note that the positive terminal is usually a female connector.

SCHEMATIC SYMBOLS

- In a schematic drawing, photos or line drawings of actual components are replaced with a symbol that represents the actual component.

SCHEMATIC SYMBOLS -Battery

- The plates of a battery are represented by long and short lines.



FIGURE 11-5 The symbol for a battery. The positive plate of a battery is represented by the longer line and the negative plate by the shorter line. The voltage of the battery is usually stated next to the symbol.



FIGURE 11-6 The ground symbol on the left represents earth ground. The ground symbol on the right represents a chassis ground.

SCHEMATIC SYMBOLS -Wiring

- Electrical wiring is shown as straight lines and with a few numbers and/or letters to indicate the following:
 - Wire size
 - Circuit numbers
 - Wire Color
 - Terminals
 - Wire Connections
 - Connectors
 - Grounds and splices

SCHEMATIC SYMBOLS -Wiring

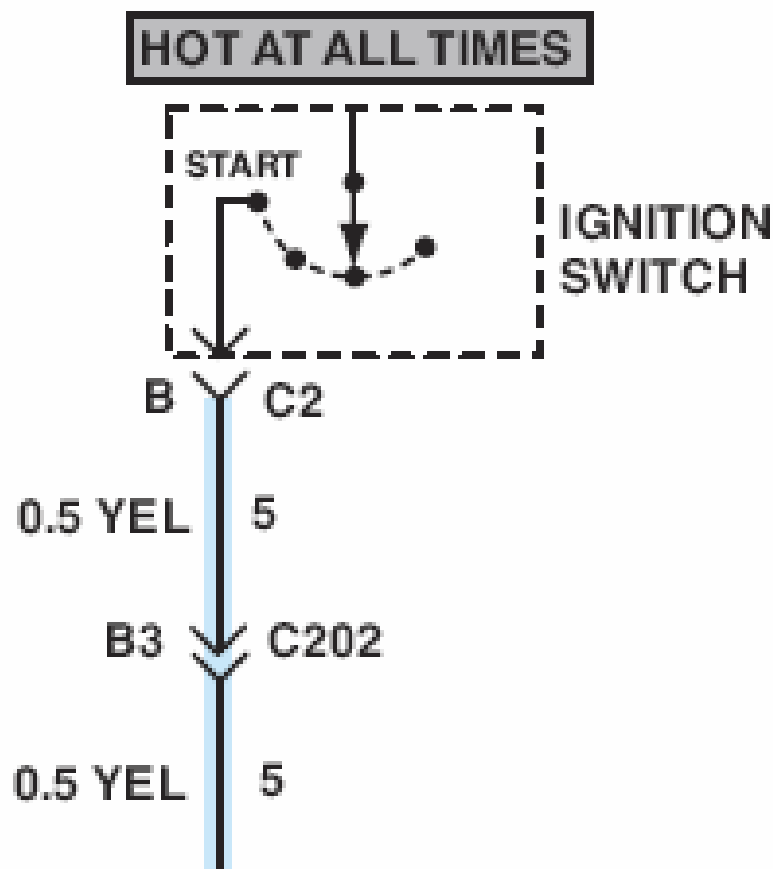


FIGURE 11-7 Starting at the top, the wire from the ignition switch is attached to terminal B of connector C2, the wire is 0.5 mm² (20 gauge AWG) and is yellow. The circuit marker is 5. The wire enters connector C202 at terminal B3.

SCHEMATIC SYMBOLS - Wiring

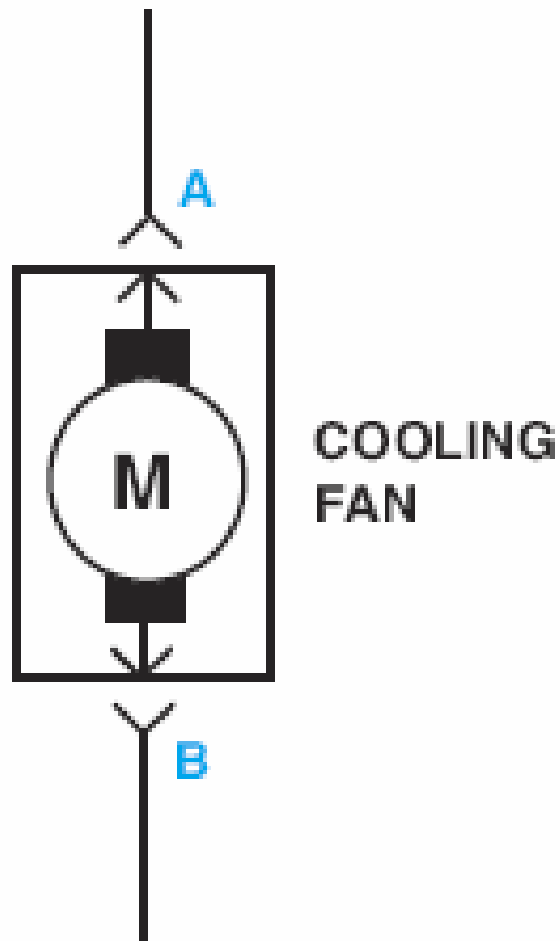


FIGURE 11-8 The electrical terminals are usually labeled with a letter, as shown on this cooling fan motor.

SCHEMATIC SYMBOLS - Wiring

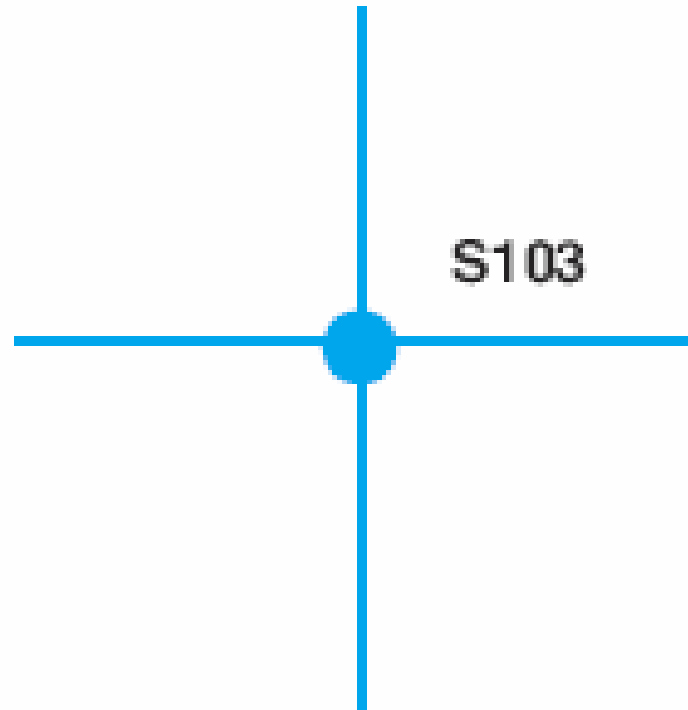


FIGURE 11-9 Two wires that cross at the dot indicate that the two are electrically connected.

SCHEMATIC SYMBOLS - Wiring

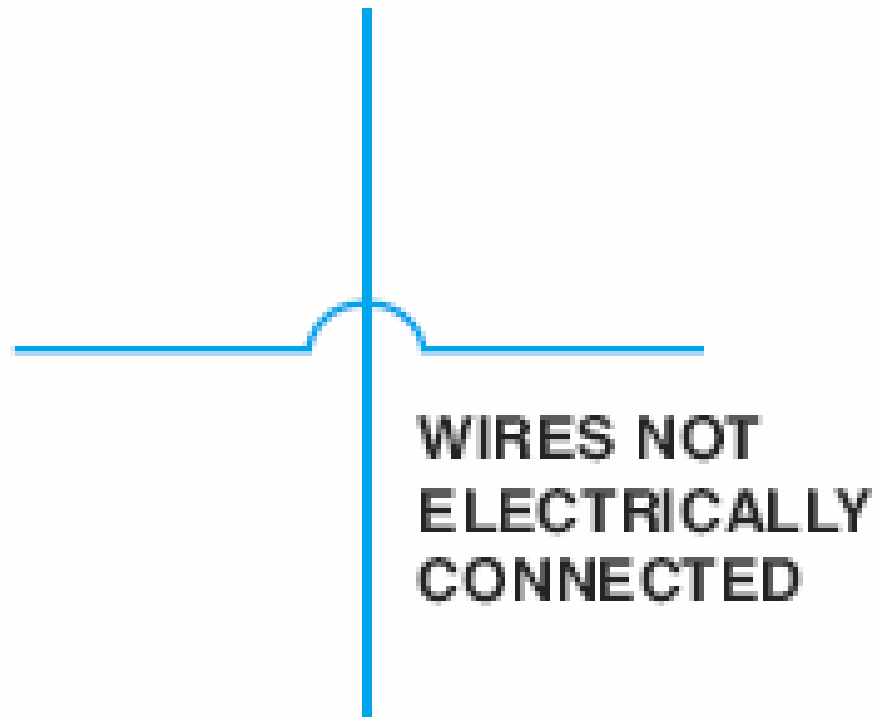


FIGURE 11-10 Wires that cross, but do not electrically contact each other, are shown with one wire bridging over the other.

SCHEMATIC SYMBOLS -Wiring

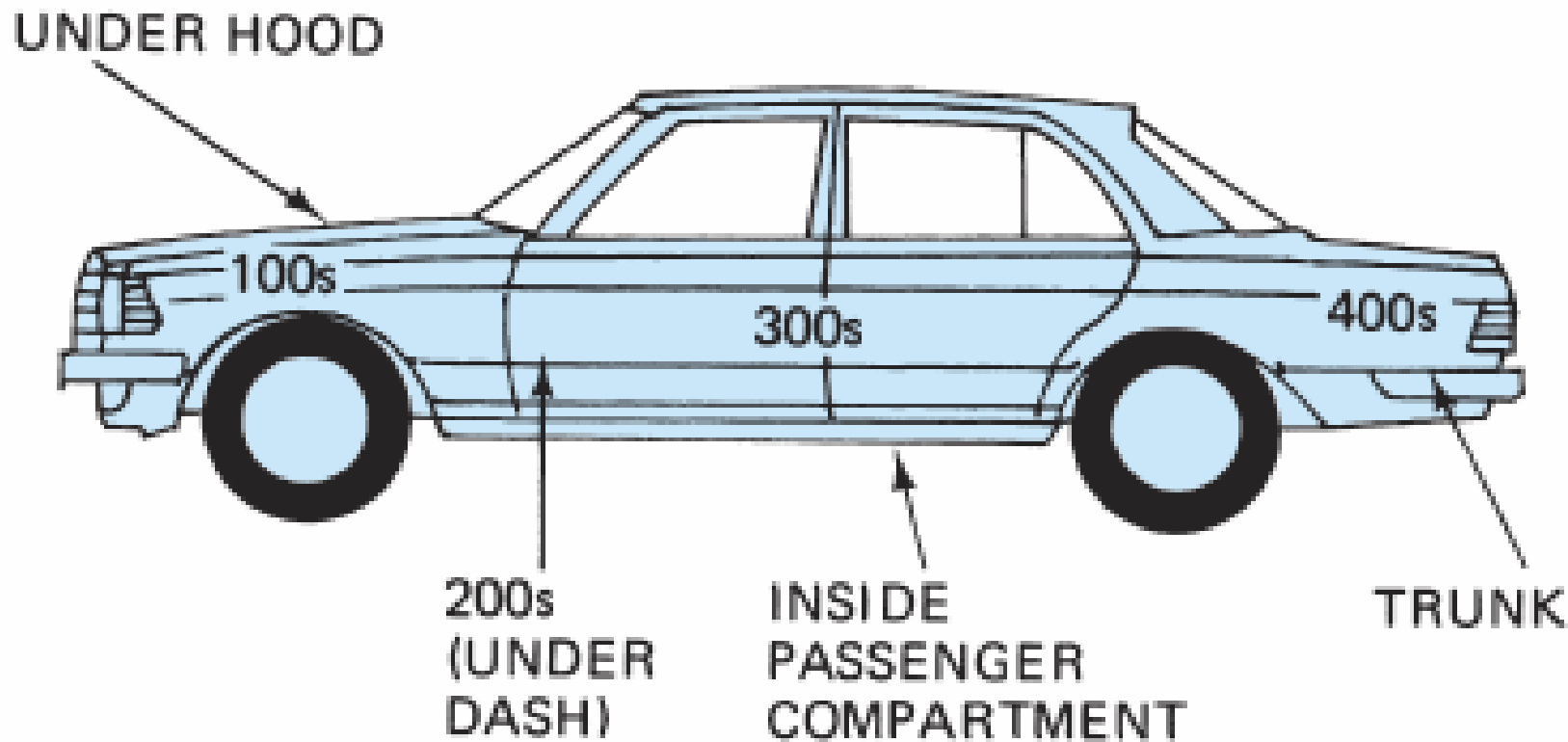


FIGURE 11-11 Connectors (C), grounds (G), and splices (S) are followed by a number, generally indicating the location in the vehicle. For example, G209 is a ground connection located under the dash.

SCHEMATIC SYMBOLS - Wiring

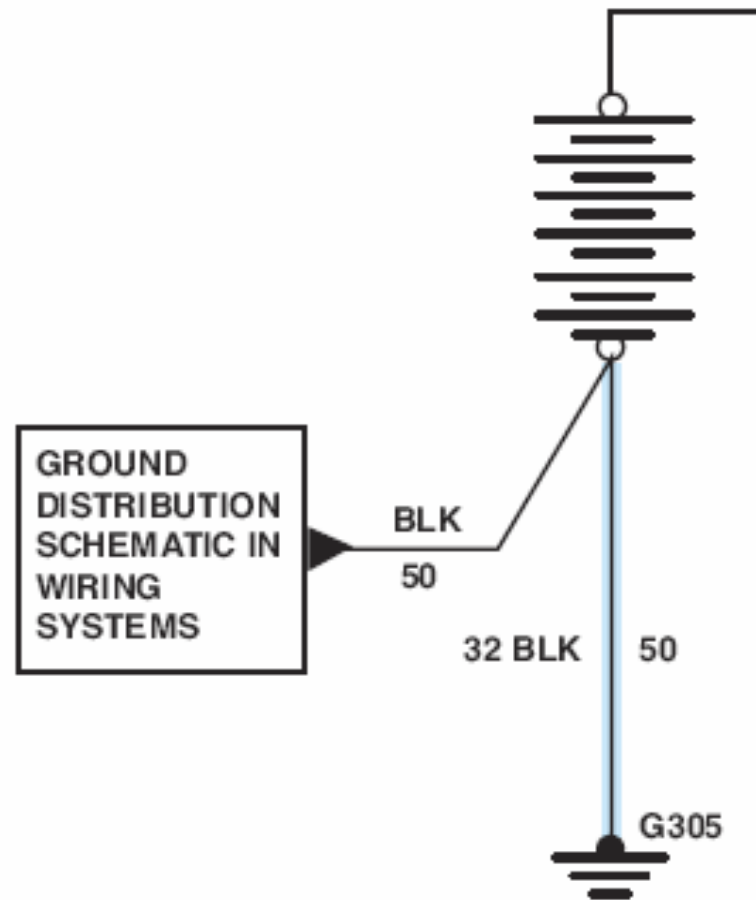


FIGURE 11-12 The ground for the battery is labeled G305 indicating the ground connector is located in the passenger compartment of the vehicle. The ground wire is black (BLK), the circuit number is 50, and the wire is 32 mm² (2 gauge AWG).

SCHEMATIC SYMBOLS- Electrical Components

- Most electrical components have their own unique symbol that shows the basic function or parts.
 - Bulbs. Light bulbs usually use a filament, which heats and then gives off light when electrical current flows.

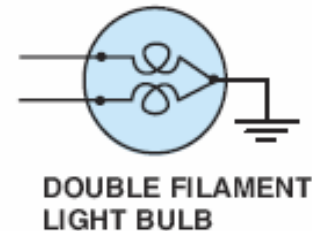
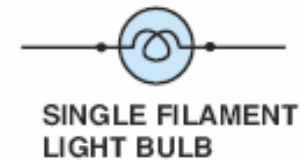


FIGURE 11-13 The symbol for light bulbs shows the filament inside a circle which represents the glass ampoule of the bulb.

SCHEMATIC SYMBOLS -Electric Motors

- An electric motor symbol shows a circle with the letter *M* in the center and two electrical connections, one to the top and one at the bottom.



FIGURE 11-14 An electric motor symbol shows a circle with the letter *M* in the center and two black sections that represent the brushes of the motor. This symbol is used even though the motor is a cross-flow design.

SCHEMATIC SYMBOLS - Resistors

- A resistor symbol is a jagged line representing resistance to current flow.

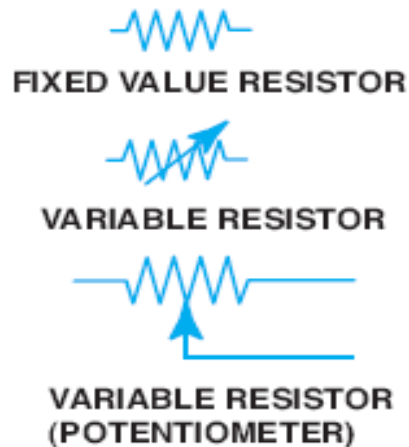


FIGURE 11-15 Resistor symbols vary depending on the type of resistor.

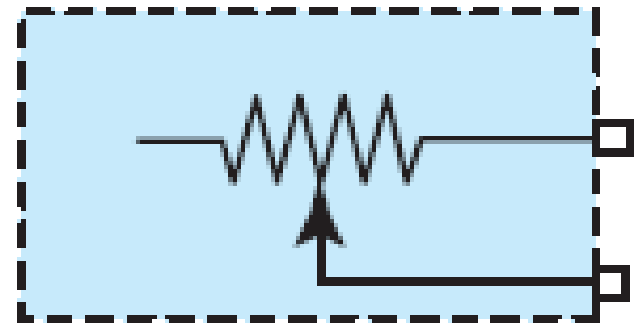


FIGURE 11-16 A rheostat uses only two wires—one is connected to a voltage source and the other is attached to the movable arm.

SCHEMATIC SYMBOLS - Capacitors

- Capacitors are usually part of an electronic component and not a replaceable component unless the vehicle is an older model.

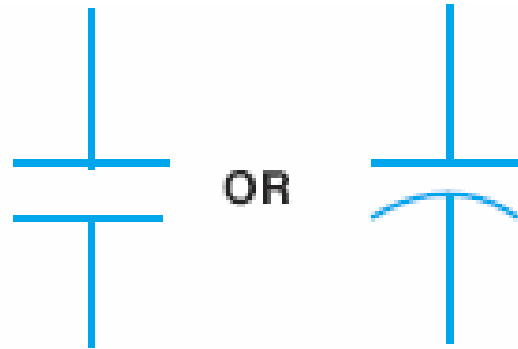


FIGURE 11-17 Symbols used to represent capacitors. If one of the lines is curved, this indicates that the capacitor being used has a polarity, while the one without a curved line can be installed in the circuit without concern about polarity.

SCHEMATIC SYMBOLS - Electric Heated Unit

- Electric grid-type rear window defoggers and cigarette lighters are shown with a square box-type symbol.

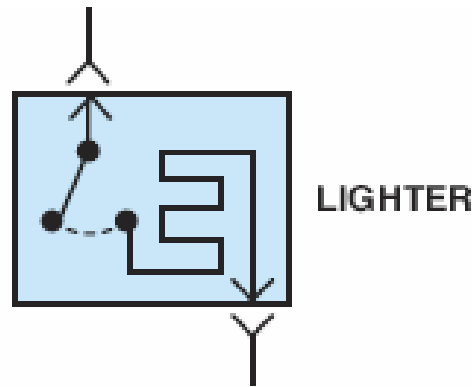


FIGURE 11-18 The grid-like symbol represents an electrically heated element.

SCHEMATIC SYMBOLS - Boxed Components

- If a component is shown in a box using a solid line, the box is the entire component.
- If a box uses dashed lines, it represents a part of a component.



FIGURE 11-19 A dashed outline represents a portion (part) of a component.



FIGURE 11-20 A solid box represents an entire component.

SCHEMATIC SYMBOLS - Separate Replaceable Part

- Often components are shown on a schematic that cannot be replaced, but are part of a complete assembly.



FIGURE 11-21 This symbol represents a component that is case grounded. Sometimes just the dot is shown to represent a ground connection.

SCHEMATIC SYMBOLS - Switches

- Electrical switches are drawn on a wiring diagram in their normal position.
- This can be one of two possible positions.
 - Normally Open
 - Normally Closed

SCHEMATIC SYMBOLS - Switches

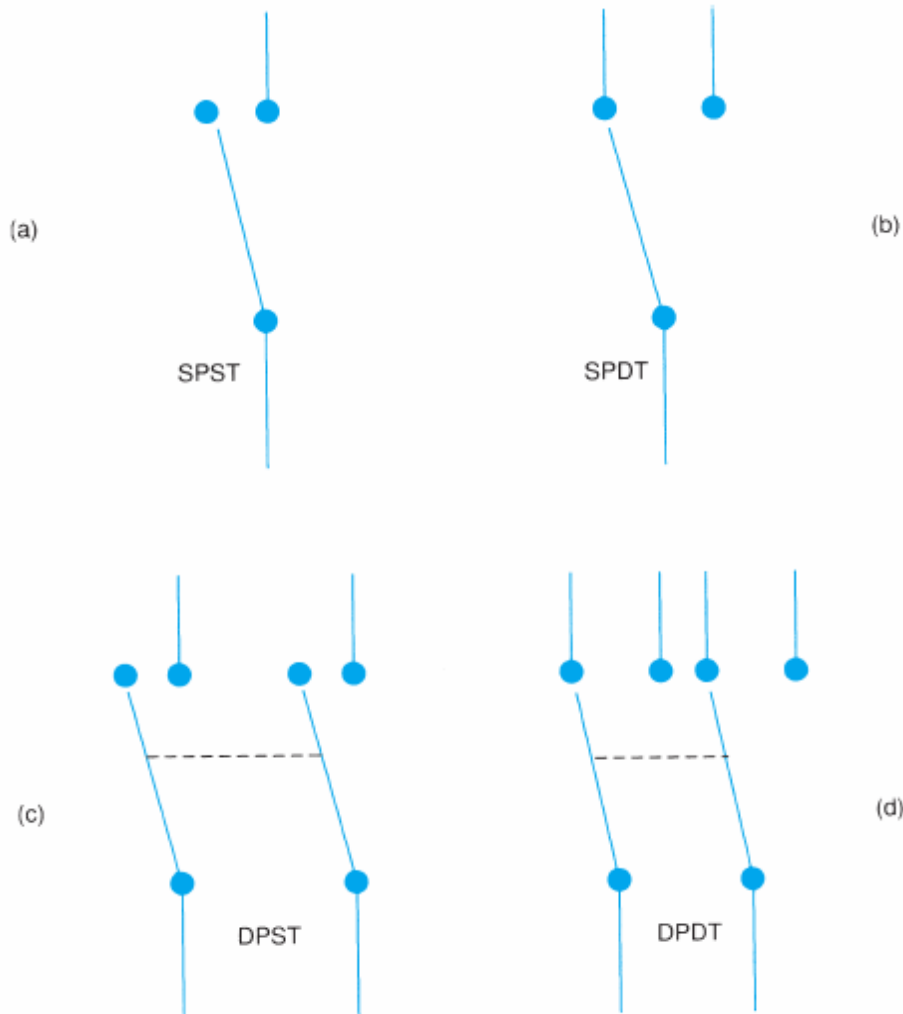


FIGURE 11-22 (a) A symbol for a single-pole, single-throw (SPST) switch. This type of switch is normally open (N.O.) because nothing is connected to the terminal that the switch is contacting in its normal position. (b) A single-pole, double-throw (SPDT) switch has three terminals. (c) A double-pole, single-throw (DPST) switch has two positions (off and on) and can control two separate circuits. (d) A double-pole, double-throw (DPDT) switch has six terminals—three for each pole.

NOTE: Both (c) and (d) also show a dotted line between the two arms indicating that they are mechanically connected.

RELAY TERMINAL IDENTIFICATION

- A **relay** is a magnetic switch that uses a movable armature to control a heavy electrical load by using a low-amperage electrical switch.

RELAY TERMINAL IDENTIFICATION

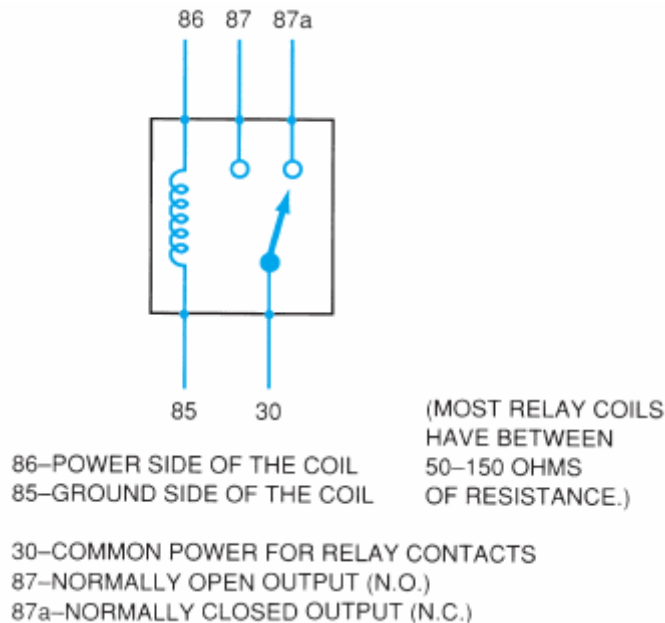


FIGURE 11-23 A relay uses a movable arm to complete a circuit whenever there is a power at terminal 86 and a ground at terminal 85. A typical relay only requires about 1/10 ampere through the relay coil. The movable arm then closes the contacts (30 to 87) and can relay 30 amperes or more.

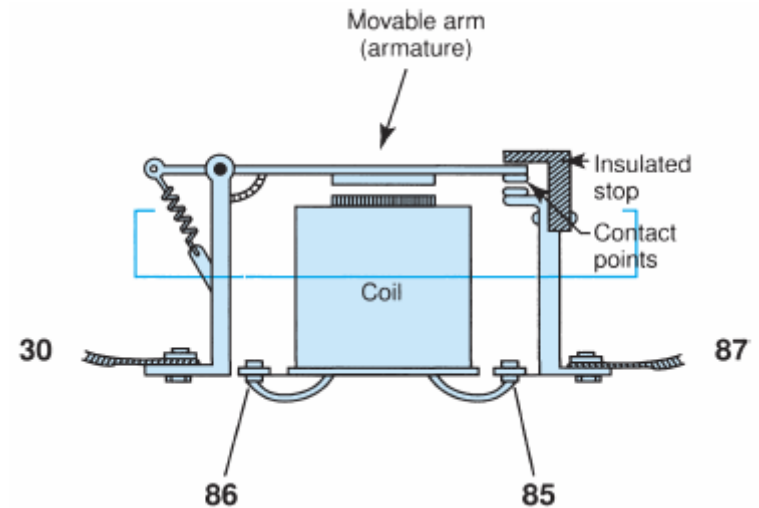


FIGURE 11-24 A cross-sectional view of a typical four-terminal relay. Current flowing through the coil (terminals 86 and 85) causes the movable arm (called the armature) to be drawn toward the coil magnet. The contact points complete the electrical circuit connected to terminals 30 and 87.

RELAY TERMINAL IDENTIFICATION



FIGURE 11-25 A typical relay showing the schematic of the wiring in the relay. Terminals 30 and 87 are electrically connected when the relay is energized.

RELAY TERMINAL IDENTIFICATION

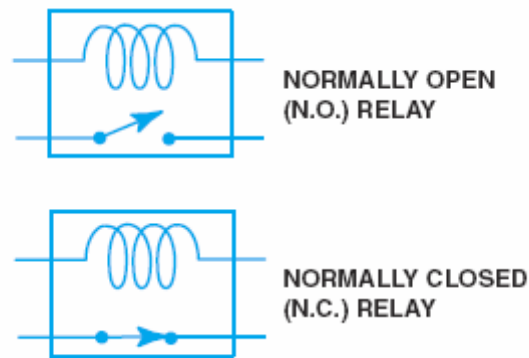


FIGURE 11-26 All schematics are shown in their normal, Non-energized position.

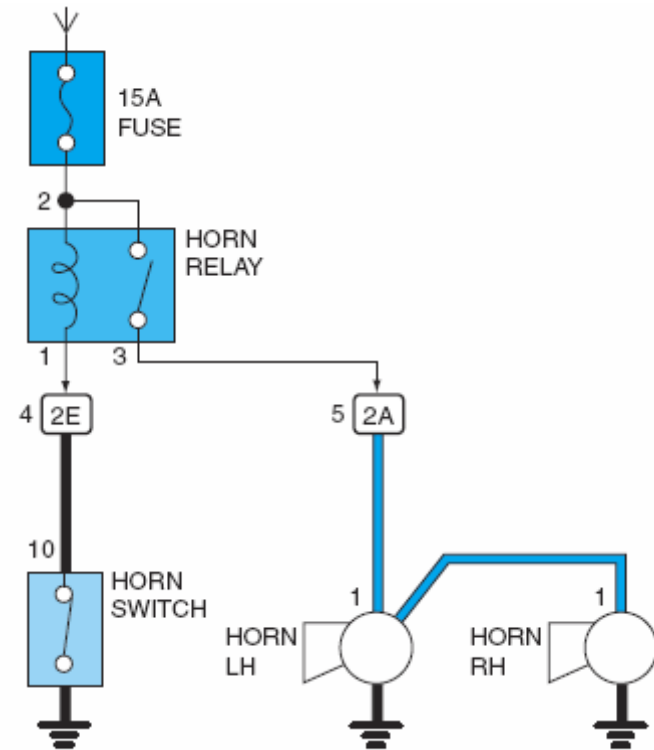


FIGURE 11-27 A typical horn circuit. Note that the relay contacts supply the heavy current to operate the horn when the horn switch simply completes a low current circuit to ground, causing the relay contacts to close.

RELAY TERMINAL IDENTIFICATION -Relay Voltage Spike Control

- Relays contain a coil and when power is removed, the magnetic field surrounding the coil collapses, creating a voltage to be induced in the coil winding.

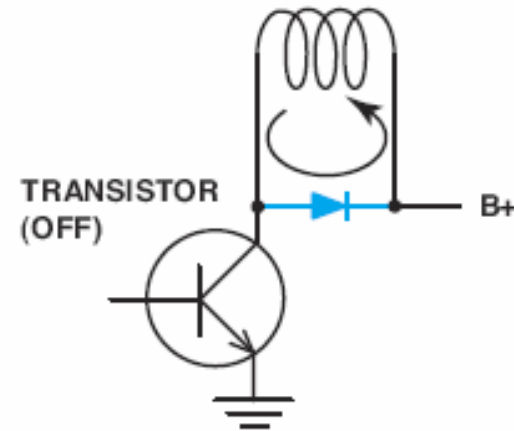


FIGURE 11-28 When the relay or solenoid coil current is turned off, the stored energy in the coil forward biases the clamping diode and effectively reduces voltage spike.

RELAY TERMINAL IDENTIFICATION

Relay Voltage Spike Control

- Most relays use a resistor connected in parallel with the coil winding.
 - The use of a resistor, typically about 400 to 600 ohms, reduces the voltage spike by providing a path for the voltage created in the coil to flow back through the coil windings when the coil circuit is opened.

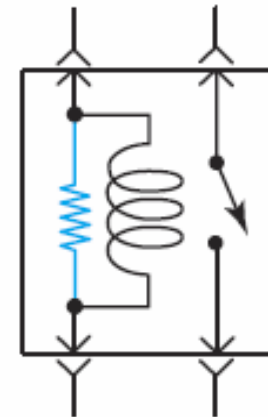


FIGURE 11-29 A resistor used in parallel with the coil windings is a commonly used spike reduction method used in many relays.

COMMON POWER OR GROUND

- When diagnosing an electrical problem that affects more than one component or system, check the electrical schematic for a common power source or a common ground.

COMMON POWER OR GROUND

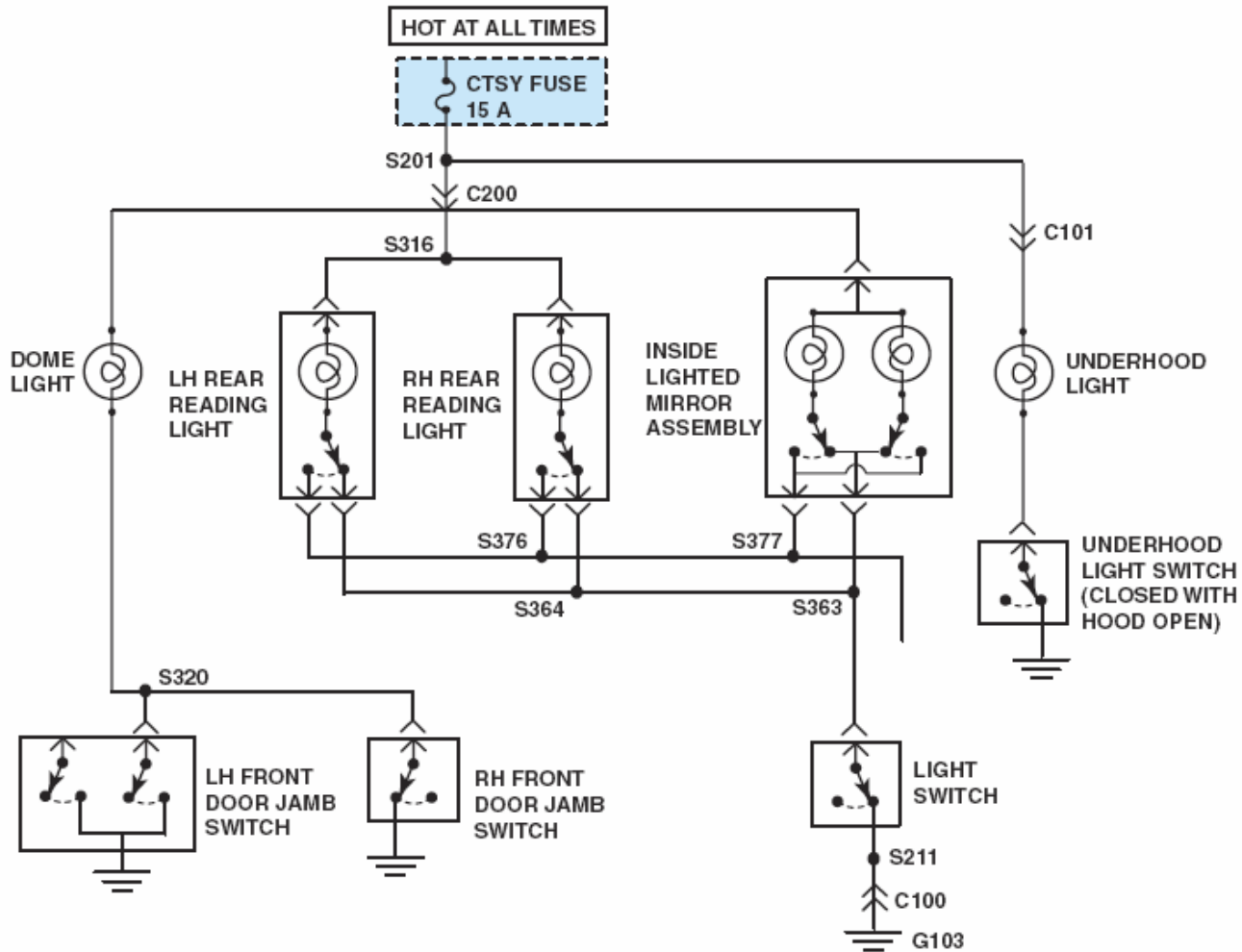


FIGURE 11-30 A typical wiring diagram showing multiple switches and bulbs powered by one fuse.

DO IT RIGHT-INSTALL A RELAY

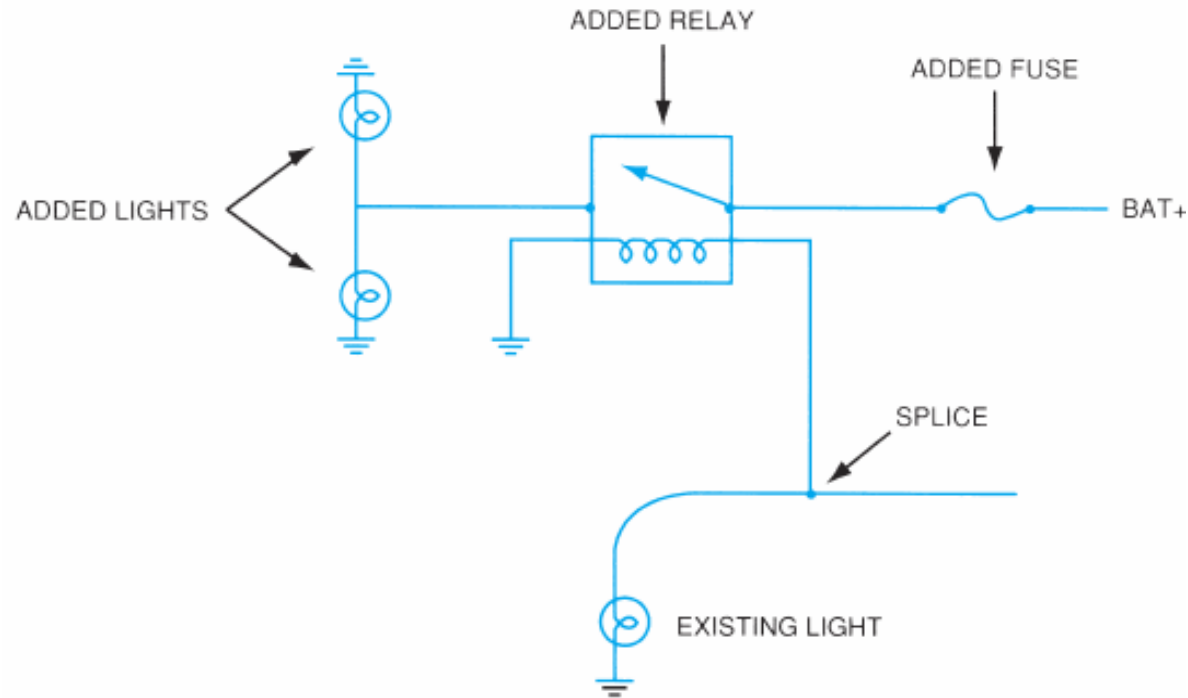


FIGURE 11-31 To add additional lighting, simply tap into an existing light wire and connect a relay. When the existing light is turned on, the coil of the relay is energized. The arm of the relay then connects power from another circuit (fuse) to the auxiliary lights without overloading the existing light circuit.

USING SCHEMATICS FOR TROUBLESHOOTING

- Follow these steps when troubleshooting wiring problems.
 - **Step 1** Verify the malfunction.
 - **Step 2** Check everything else that does or does not operate correctly.
 - **Step 3** Check the fuse for the backup lights.
 - **Step 4** Check for voltage at the backup light socket.

USING SCHEMATICS FOR TROUBLESHOOTING



FIGURE 11-32 Always check the simple things first. Check the fuse for the circuit you are testing. Maybe a fault in another circuit controlled by the same fuse could have caused the fuse to blow. Use a test light to check that both sides of the fuse have voltage.

LOCATING A SHORT CIRCUIT

- A short circuit usually blows a fuse, and a replacement fuse often also blows in the attempt to locate the source of the short circuit.
- A **short circuit** is an electrical connection to another wire or to ground before the current flows through some or all of the resistance in the circuit.

LOCATING A SHORT CIRCUIT

Fuse Replacement Method

- Disconnect one component at a time and then replace the fuse.
 - If the new fuse blows, continue the process until you determine the location of the short.
 - This method uses many fuses and is *not* a preferred method for finding a short circuit.

LOCATING A SHORT CIRCUIT

Circuit Breaker Method

- Another method is to connect an automotive circuit breaker to the contacts of the fuse holder with alligator clips.
- Visual inspection of all the wiring or further disconnecting will be necessary to locate the problem.

LOCATING A SHORT CIRCUIT

Test Light Method

- To use the test light method, simply remove the blown fuse and connect a test light to the terminals of the fuse holder (polarity does not matter).
- If there is a short circuit, current will flow from the power side of the fuse holder through the test light and on to ground through the short circuit, and the test light will then light.

LOCATING A SHORT CIRCUIT

Ohmmeter Method

- The fourth method uses an ohmmeter connected to the fuse holder and ground.
 - Connect one lead of an ohmmeter (set to a low scale) to a good clean metal ground and the other lead to the *circuit side* of the fuse holder.
 - The ohmmeter will read zero or almost zero ohms if the circuit is shorted.
 - Disconnect one component in the circuit at a time and watch the ohmmeter. If the ohmmeter reading goes to high ohms or infinity, the component just unplugged was the source of the short circuit.

LOCATING A SHORT CIRCUIT

Gas Gauge Method

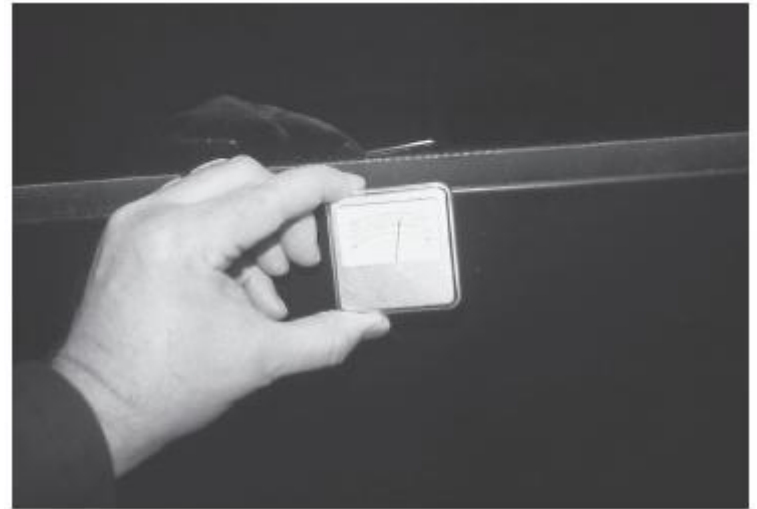
- If a short circuit blows a fuse, a special pulsing circuit breaker (similar to a flasher unit) can be installed in the circuit in place of the fuse.
- A **Gauss gauge** is a handheld meter that responds to weak magnetic fields.

LOCATING A SHORT CIRCUIT

Gas Gauge Method



(a)



(b)

FIGURE 11-33 (a) After removing the blown fuse, a pulsing circuit breaker is connected to the terminals of the fuse. (b) The circuit breaker causes current to flow, then stop, then flow again, through the circuit up to the point of the short-to-ground. By observing the Gauss gauge, the location of the short is indicated near where the needle stops moving due to the magnetic field created by the flow of current through the wire.

LOCATING A SHORT CIRCUIT

Gas Gauge Method

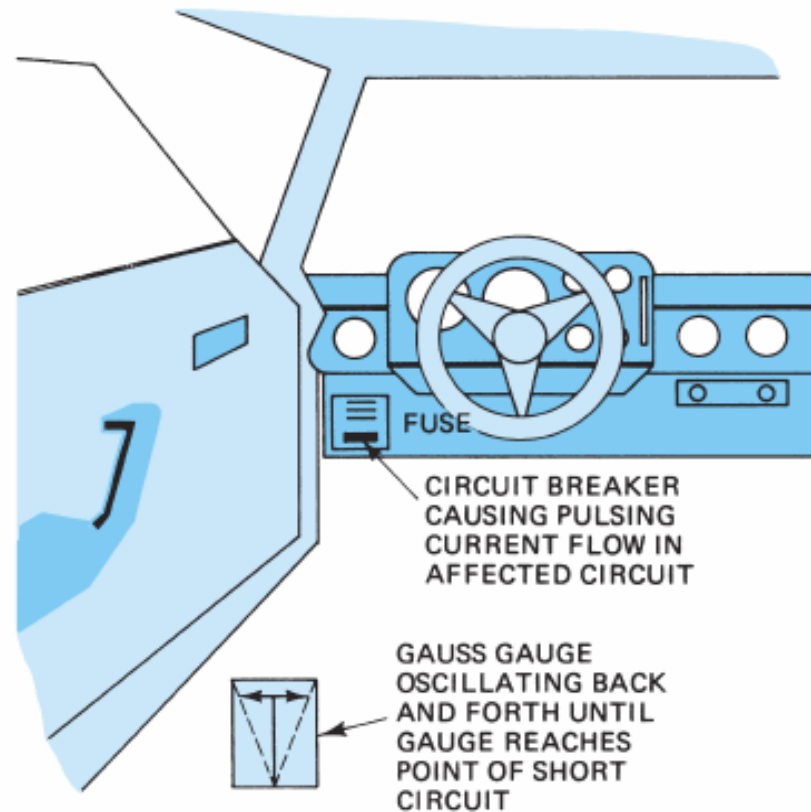


FIGURE 11-34 A Gauss gauge can be used to determine the location of a short circuit even behind a metal panel.

LOCATING A SHORT CIRCUIT

Electronic Tone Generator Tester

- Similar to test equipment used to test telephone and cable television lines, a **tone generator tester** generates a tone that can be heard through a receiver (probe).



FIGURE 11-35 A tone generator-type tester used to locate open circuits and circuits that are shorted-to-ground included with this tester is a transmitter (tone generator), receiver (probe), and headphones for use in noisy shops.

LOCATING A SHORT CIRCUIT

Electronic Tone Generator Tester

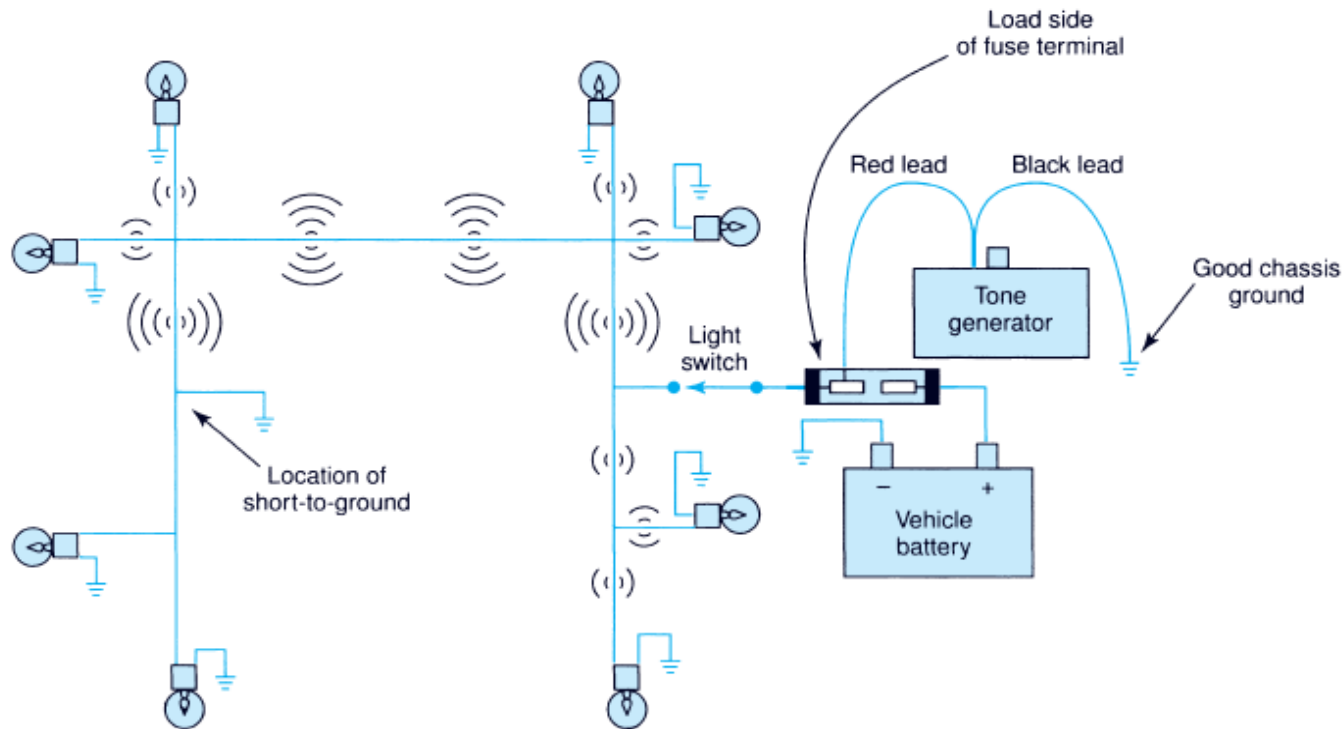


FIGURE 11-36 To check for a short-to-ground using a tone generator, connect the black transmitter lead to a good chassis ground and the red lead to the load side of the fuse terminal. Turn the transmitter on and check for tone signal with the receiver. Using wiring diagram, follow the strongest signal to the location of the short-to-ground. There will be no signal beyond the fault.

LOCATING A SHORT CIRCUIT

Electronic Tone Generator Tester

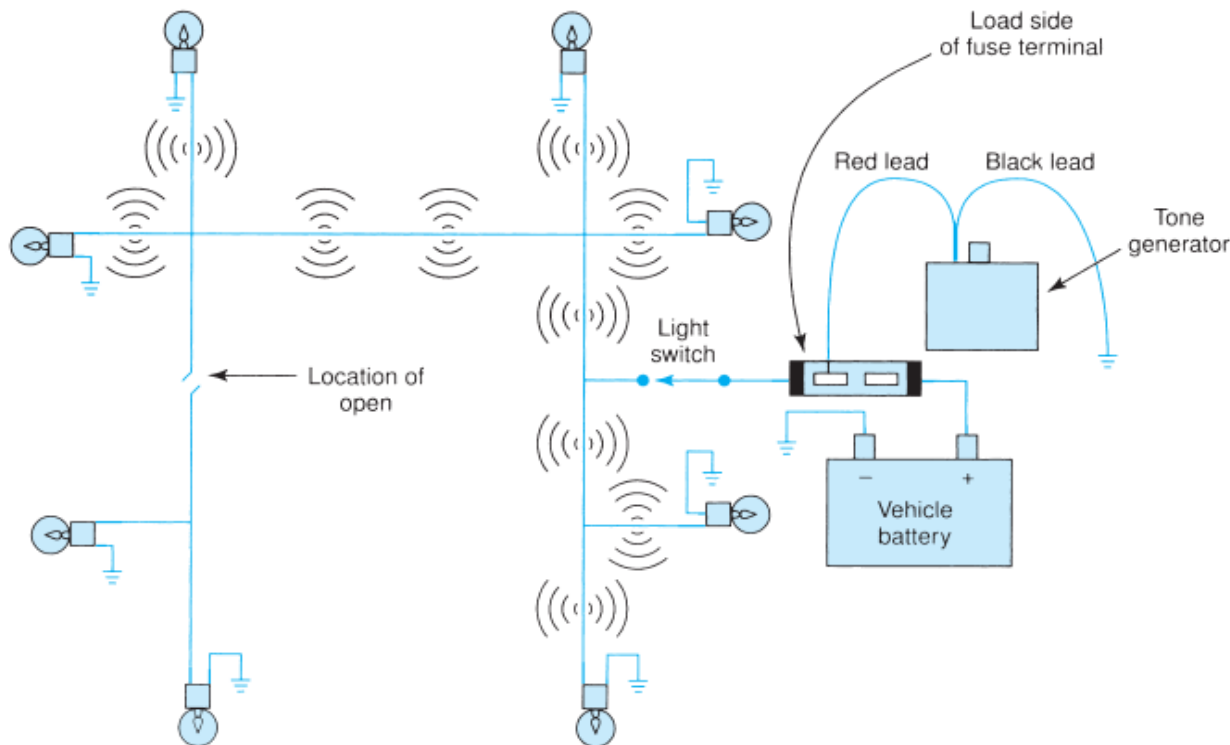


FIGURE 11-37 To check for an open (break), connect the red lead of the tone generator to the load side of the fuse terminal and the black lead to a good chassis ground. Turn on the transmitter and then listen for the tone signal with the receiver set in the open position. Using a wiring diagram, follow the signal along the circuit until the tone stops, indicating the location of the open.

ELECTRICAL TROUBLESHOOTING GUIDE

- When troubleshooting any electrical component, remember the following hints to find the problem faster and more easily.
 - **1.** For a device to work, it must have two things: power and ground.
 - **2.** If there is no power to a device, an open power side (blown fuse, etc.) is indicated.
 - **3.** If there is power on both sides of a device, an open ground is indicated.

ELECTRICAL TROUBLESHOOTING GUIDE

- **4.** If a fuse blows immediately, a grounded power-side wire is indicated.
- **5.** Most electrical faults result from heat or movement.
- **6.** Most noncomputer-controlled devices operate by opening and closing the power side of the circuit (power-side switch).
- **7.** Most computer-controlled devices operate by opening and closing the ground side of the circuit (ground-side switch).

STEP-BY-STEP TROUBLESHOOTING PROCEDURE

- **Step 1** Determine the customer concern (complaint) and get as much information as possible from the customer or service advisor.
 - a. When did the problem start?
 - b. Under what conditions does the problem occur?
 - c. Have there been any recent previous repairs to the vehicle which could have created the problem?
- **Step 2** Verify the customer's concern by actually observing the fault.
- **Step 3** Perform a thorough visual inspection and be sure to check everything that does and does not work.

STEP-BY-STEP TROUBLESHOOTING PROCEDURE

- **Step 4** Check for technical service bulletins (TSBs).
- **Step 5** Check the factory service information and follow the troubleshooting procedure.
 - a. Determine how the circuit works.
 - b. Determine which part of the circuit is good, based on what works and what does not work.
 - c. Isolate the problem area.
- **Step 6** Determine the root cause and repair the vehicle.
- **Step 7** Verify the repair and complete the work order by listing the three Cs (complaint, cause, and correction).

SHOCKING EXPERIENCE

- A customer complained that after driving for a while, he got a static shock whenever the door handle was grabbed when exiting the vehicle.



FIGURE 11-38 Anti-static spray can be used by customers to prevent being shocked when they touch a metal object like the door handle.

CONDUIT TELLS A LOT

- The color used on electrical convoluted conduit tells the technician a lot if some information is known such as:
 - Black conduit with a green or blue stripe
 - Blue or yellow conduit
 - Orange conduit

CONDUIT TELLS A LOT

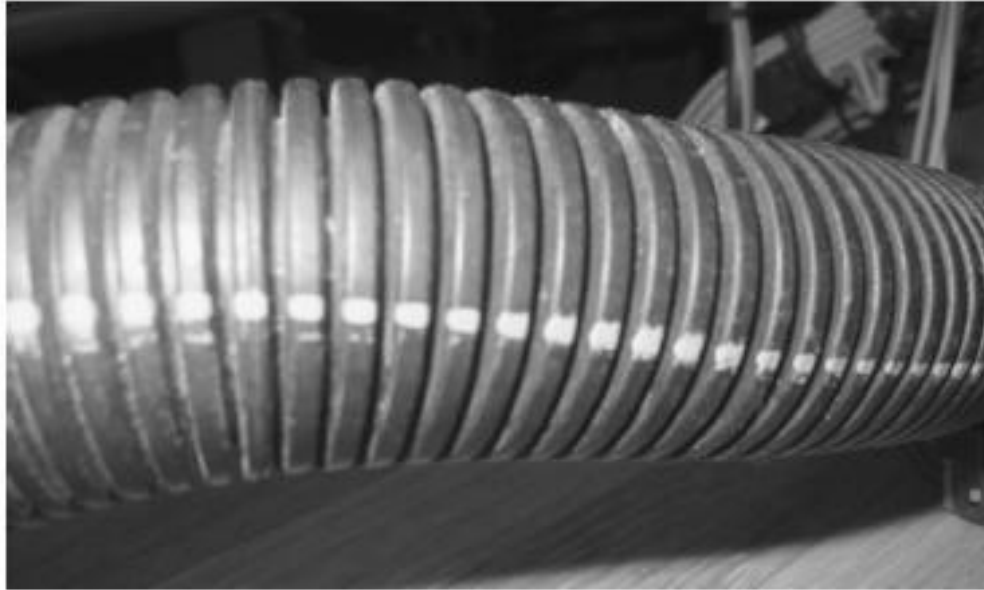
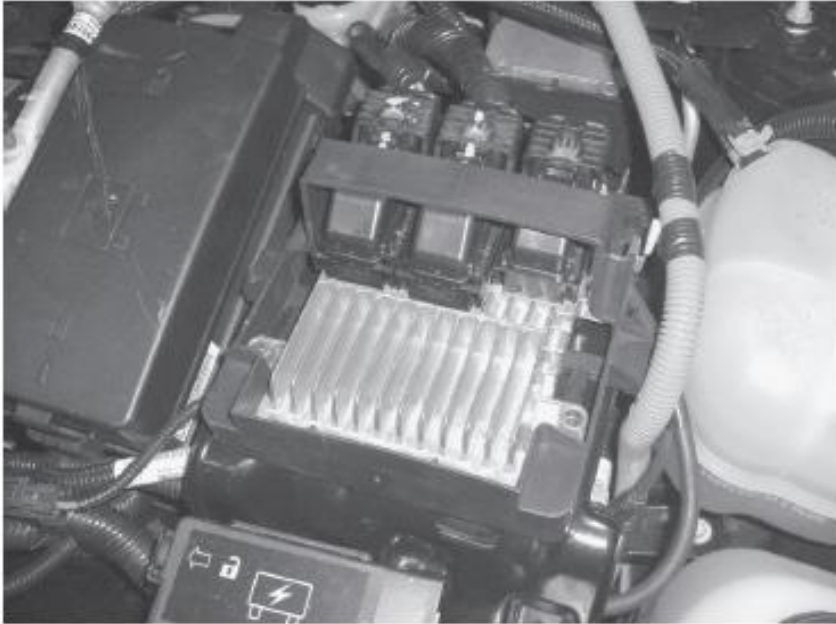
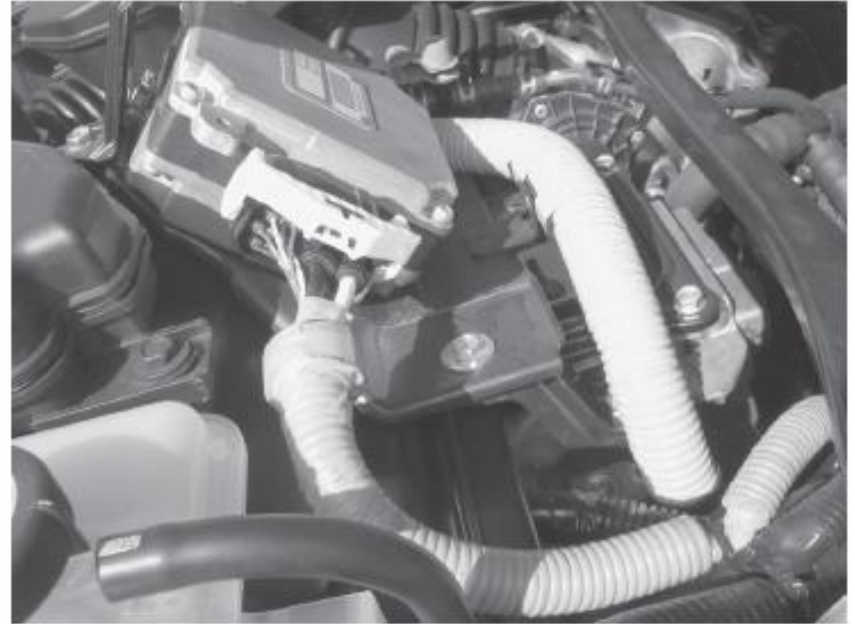


FIGURE 11-39 Conduit that has a paint strip is constructed of plastic that can withstand high underhood temperatures.

CONDUIT TELLS A LOT



(a)



(b)

FIGURE 11-40 (a) Blue conduit is used to cover circuits that carry up to 42 volts. (b) 42 volt wiring can also be covered in yellow conduit.

CONDUIT TELLS A LOT

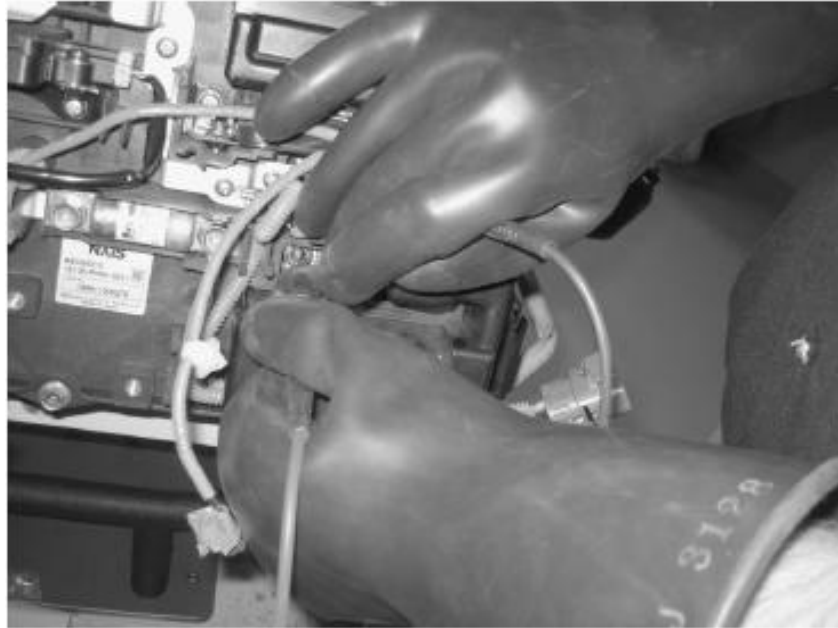


FIGURE 11-41 Always follow the vehicle manufacturer's instructions which include the use of linesmen's (high-voltage) gloves if working on circuits that are covered in orange conduit.

SUMMARY

1. Most wiring diagrams include the wire color, circuit number, and wire gauge.
2. The number used to identify connectors, grounds, and splices usually indicates where they are located in the vehicle.
3. All switches and relays on a schematic are shown in their normal position either normally closed (N.C.) or normally open (N.O.).
4. A short-to-voltage affects the power side of the circuit and usually involves more than one circuit.
5. A short-to-ground usually causes the fuse to blow and usually affects only one circuit.
6. Most electrical faults are a result of heat or movement.