Learning Objectives (1 of 2)

1.1 Prepare for the Manual Drivelines and Axles (A2) ASE certification test content area “C” (Transmission/Transaxle Diagnosis and Repair).
1.2 Explain the characteristics of electricity.
1.3 Differentiate between conductors, insulators, and semiconductors.
1.4 Explain the units of electrical measurement.
1.5 List the parts of a complete circuit.

Learning Objectives (2 of 2)

1.6 Discuss the types of electrical circuit faults.
1.7 Explain how to detect and measure electrical voltage, current, and resistance.
1.8 Discuss the purpose of terminals, connectors, relays, and switches.
1.9 Explain the operation of speed sensors and throttle position (TP) sensors.
1.10 State the need for networks and discuss network classifications.
Introduction

- Electricity may be difficult for some people to learn for the following reasons:
  - It cannot be seen.
  - Only the results of electricity can be seen.
  - It has to be detected and measured.

Electricity (1 of 2)

- Electricity is the movement of electrons from one atom to another.
  - Nucleus
    - Protons, neutrons, and electrons
  - Automotive electricity uses the conventional theory that electricity flows from positive to negative.
  - Magnets and electrical charge
  - Electron orbits

Electricity (2 of 2)

- Conductors
  - Conductors are materials with fewer than four electrons in their atom’s outer orbit.
- Insulators
  - Insulators are materials with more than four electrons in their atom’s outer orbit.
- Semiconductors
  - Materials with exactly four electrons in their outer orbit are called semiconductors.
Electricity may be difficult for some people to learn for the following reasons.

- An atom consists of protons, neutrons, and electrons. Protons have a positive charge, and neutrons have no charge at all. They are both found in the nucleus just as planets orbit the sun in our solar system (right).

- Electrons orbit around the nucleus. Electrons orbit in rings and the outermost ring is called the "valence ring." An ordinary atom has exactly as many electrons as protons in the nucleus. Each atom contains an equal number of electrons and protons.

- In an atom (left), electrons orbit protons in the nucleus. Each atom contains an equal number of electrons and protons.

- As an example of the relative sizes of the parts of an atom, consider that if an atom were magnified so that the nucleus were the size of the period at the end of this sentence, the whole atom would be bigger than a house.

- By comparison, the diameter of an atom is made from slightly over 100 individual components called molecules.

- All matter is made up of atoms. The smallest particle that an element can be broken down to is known as the atom.

- An atom is made up of protons, neutrons, and electrons. Protons are positively charged, and neutrons are electrically neutral. Electrons have a negative charge.

- An atom is the smallest part of an element that can exist, and systems use electricity.

- How Electrons Move Through a Conductor

  - Current Flow
  - What is the difference between conventional theory and electron theory?
Units of Electricity

- The three fundamentals of electricity-related units include the ampere, volt, and ohm.
  - The ampere is the measure of the amount of current flow.
  - Voltage is the unit of electrical pressure.
  - The ohm is the unit of electrical resistance.

Resistance to the flow of current through a conductor—such as a battery, is connected to the ends of a conductor—a positive charge (lack of electrons) is placed on one end of the circuit and a deficiency of electrons at the opposite end.

Electrical Circuits

• All complete electrical circuits have:
  – A power source, a circuit protection device, a power-side wire or path, an electrical load, a ground return path, and a switch or a control device.

• Circuit testers include test lights and fused jumper leads.

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Figure 14–16 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.

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Electrical Schematics (1 of 2)

• All circuit schematics or diagrams include:
  – Power-side wiring of the circuit
  – All splices
  – Connectors
  – Wire size
  – Wire color
  – Trace color (if any)
  – Circuit number
  – Electrical components
Types of Circuit Faults (1 of 2)

• An open circuit is any circuit that is not complete, or that lacks continuity, such as a broken wire.

• A short-to-voltage occurs when the power side of one circuit is electrically connected to the power side of another circuit.

FIGURE 14–18 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 “BLU/WHT,” indicating a blue wire with a white tracer or stripe.
Types of Circuit Faults (2 of 2)

- A short-to-ground is a type of short circuit that occurs when the current bypasses part of the normal circuit and flows directly to ground.
- High resistance is resistance higher than normal circuit resistance.

FIGURE 14–24 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.

Fused Jumper Wire

- Purpose and function
  - Fuse
  - Alligator clip ends
  - Good-quality insulated wire

Fused jumper wire is used to check a circuit by bypassing the switch or to provide a power or ground to a component. A fused jumper wire, also called a fused test lead, can be purchased or made by the service technician. It should include the following features:

- Fuse: A typical fused jumper wire has a blade-type fuse that can be easily replaced. A 10-ampere fuse (red color) is often the value used.
- Alligator clip ends: Alligator clips on the ends allow the fused jumper wire to be clipped to a ground or power source while the other end is attached to the power side or ground side of the unit being tested.
FIGURE 14–25 A technician-made fused jumper lead, which is equipped with a red 10-ampere fuse. This fused jumper wire uses terminals for testing circuits at a connector instead of alligator clips.

Test Light

• Non-powered test light
• Use of a 12-volt test light
  – Electrical power
  – Grounds

FIGURE 14–26 Testing a fuse with a test light. If the fuse is good, the test light should light on both sides (power side and load side) of the fuse.
Digital Meters

- A voltmeter measures the pressure or potential of electricity in units of volts.
- An ohmmeter measures the resistance in ohms of a component or circuit section when no current is flowing through the circuit.
- An ammeter measures the flow of current through a complete circuit in units of amperes or milliamperes.

Figure 14–31 Using a digital multimeter set to read ohms (Ω) to test this light bulb. The meter reads the resistance of the filament

Terminals and Connectors

- A terminal is the metal end of a wire, whereas a connector is the plastic housing for the terminal.
- Servicing terminals
Wire Repair

- Soldering
  - Many manufacturers recommend that all wiring repairs be soldered. Why?
- What is the soldering procedure?
- Crimping terminals
- Heat shrink tubing
- Crimp-and-seal connectors
FIGURE 14–41 Always use rosin-core solder for electrical or electronic soldering. Also, use small-diameter solder for small soldering irons. Use large-diameter solder only for large-diameter (large-gauge) wire and higher-wattage soldering irons (guns).

FIGURE 14–47 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 amperes through the relay coil. The movable arm then closes the contacts (#30 to #87) and can often handle 30 amperes or more.

Relays

- A relay is a magnetic switch that uses a movable armature to control a high-amperage circuit by using a low-amperage electrical switch.
- Terminal identification
  - Coil
  - Other terminals used to control the load current
Switches

- An electrical switch opens the circuit and no current flows. The switch could also be on the return (ground) path wire.
- Ohmmeter checks
- Voltmeter checks

**FIGURE 14-52** A typical transmission range switch is also similar to the circuit used for electronic transfer case switches. In this example, power, usually 12 volts, is applied at pin 30 and pin 46 is an input to the PCM. The change in voltage at pin 46 indicates how much resistance the circuit has, which is used to detect the gear selected.

**Speed Sensors**

- A magnetic sensor consists of a notched wheel and a coil consisting of an iron core wrapped with fine wire.
- The notched wheel causes the magnetic strength changes enough to create a usable varying AC voltage signal.
- Speed sensor tests
**Throttle Position (TP) Sensors**

- TP sensor input determine the amount of throttle opening and the rate of change to determine shift points of an automatic transmission and for engine management.
- Parts and operation
- Testing a TP Sensor

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**FIGURE 14–54** A Hall-Effect sensor produces an on-off voltage signal whether it is used with a blade or a notched wheel.

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**FIGURE 14–55** The signal voltage from a throttle position increases as the throttle is opened because the wiper arm is closer to the 5-volt reference. At idle, the resistance of the sensor winding effectively reduces the signal voltage output to the powertrain control module (PCM).
Networks

• Need for network
• Modules communicate with each other over data lines or hard wiring.
  – The use of a network for module communications reduces the number of wires and connections needed.
• Types of communication
  – Differential
  – Parallel
  – Serial data
  – Multiplexing

Network Classifications

• The SAE communication classifications for vehicle communications system.
  – Class A
  – Class B
  – Class C
Controller Area Network

- Robert Bosch Corporation developed the CAN protocol, which was called CAN 1.2, in 1993.
- What is the CAN?
Summary (1 of 3)

- Electricity is the movement of electrons from one atom to another.
- Automotive electricity uses the conventional theory that electricity flows from positive to negative.
- The ampere is the measure of the amount of current flow.
- Voltage is the unit of electrical pressure.

Summary (2 of 3)

- The ohm is the unit of electrical resistance.
- All complete electrical circuits have a power source, a circuit protection device, a power-side wire or path, an electrical load, a ground return path, and a switch or a control device.
- Circuit testers include test lights and fused jumper leads.

Summary (3 of 3)

- A terminal is the metal end of a wire, whereas a connector is the plastic housing for the terminal.
- The use of a network for module communications reduces the number of wires and connections needed.
- The SAE communication classifications for vehicle communications system.